APPENDIX B – NGI GoMRI Phase 2 Final Reports

Contents

11-BP_GRI-01: Dauphin Island Sea Lab: Quantifying the Effects of Oil on Carbon Cycling and Diversity of the Pelagic Microbial Community of Coastal Alabama

Alice Ortmann

SCIENCE ACTIVITIES

1. General Summary: The explosion and subsequent release of oil associated with the Deepwater Horizon platform may have substantially altered the pelagic ecosystem in the northern Gulf of Mexico. The effects, usually concentrated at the surface where much of the released oil accumulates, may also be felt within the water column. The effects on the deeper ecosystem may have been increased by the application of dispersants to the oil at the source, ~1200 m deep. Both the oil and the dispersants may have toxic effects, but may also alter the pelagic microbial community by stimulating growth in the portion of the community capable of metabolizing this carbon rich material. The growth of these microbes may be controlled by the availability of oxygen and nutrients such as nitrogen and phosphorous. The influx of carbon-rich, but nutrient poor, organic matter from the Deepwater Horizon oil spill could results in a shift in the diversity pelagic microbial community which could translate into a shift in the functioning of the microbial loop and carbon transfer to higher trophic levels.

Phase I of the NGI supported the examination of the effects of the Deepwater Horizon oil spill on the pelagic microbial community. Significant milestones from Phase I include the acquisition and optimization of a quantitative PCR instrument, the installation and preliminary optimization of a flow cytometer, completion of four sets of field experiments and the presentation of preliminary data at two separate meetings. The Phase II proposal sought to expand the sampling and analysis efforts to better characterize the microbial food web in the waters of the Alabama coast and detect the effects of the Deepwater Horizon spill.

To this end, samples were collected for DNA analysis through 2011, with dilution experiments carried out bimonthly from January through to the beginning of December. By including a second year of sampling, we were able to obtain a better measure of the interannual variability within our four sites. This helped us compare the patterns observed during 2010 with patterns seen in 2009 and 2011. Obtaining this extra year of sampling was invaluable due to the fact that 2009 was extremely dry, while 2010 was a very wet year. As the Alabama shelf is driven by river flow into Mobile Bay, direct comparisons of 2009 and 2010 may be confounded by differences in river flow. 2011 was intermediate between these years.

We addressed the same four questions in this phase as in the previous study:

1. 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.

2. 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?

3. 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?

4. 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

During 2011, six additional dilution experiments were carried out (Jan, Mar, May, July, Sept and early Dec). These experiments, along with the previous experiments have been analyzed to answer the four questions posed. The preliminary results for each question is presented below along with a description of remaining work.

1. 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.

Biomass: Chlorophyll a was significantly correlated with salinity, dissolved oxygen, inorganic nitrogen and silicate, suggesting that river discharge is the main driver of this estimate of phytoplankton diversity. Prokaryotes were significantly correlated with temperature, inorganic nitrogen and both chlorophyll a and HNFs. When grouped based on temperature into season, location and year, only the location (higher inshore vs offshore) and season (higher in spring vs summer or winter) were significant factors influencing the concentration of chlorophyll a, while season was the only factor for prokaryotes. The lack of a year effect suggests that the influx of oil did not have an impact on the abundance of either of these groups.

Growth rate: The growth rate of phytoplankton based on chlorophyll a was correlated with higher salinity and lower inorganic nitrogen, suggesting they may be drawing down the nitrogen. There was no significant effect of location, season or year. Prokaryote growth rate was correlated strongly with temperature, with higher rates in spring and summer compared to winter. Nutrient limitation of growth rates was found to correlate with higher growth rates only for phytoplankton and occurred most often during summer when river discharge (nutrient delivery) was lowest.

2. 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?

Grazing is the dominant process across the shelf (26/48 chl a and 30/50 prokaryotes), with few experiments having detectable viral lysis(13/48 chl a and 11/50 prokaryotes) . This raises interesting questions about lysogeny (which was undetectable in early trials, see Phase 1 report) or other viral 'lifecycle' processes that may be occurring as the abundance of viruses was high in all samples. Grazing rates were strongly correlated with the growth rates of the prey, showing higher removal rates when growth was faster. Season and location were not significant factors affecting the rates.

The two offshore sites received light oiling in June 2010, but experiments were run in May and July only. To try and determine if the oil had an effect on the microbial loop, samples were divided into Bay samples (no oiling) and Off shore samples (light oiling) and samples from July were compared for the 3 years (note: no T35 July 2009 samples were collected). From these comparisons, there was a weak indication that a shift in the microbial food web may have occurred during July 2010. For both chlorophyll a and prokaryotes, viral lysis was detected at T35 (most offshore, heaviest oiling) during July 2010. Offshore in July, CP in 2009 also had detectable viral lysis. In July 2011, viral lysis was not detectable, but grazing was. This is very weak evidence suggesting that oiling caused a shift from grazing to viral lysis in the offshore station.

3. 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?

The initial 24 samples screened for MGI genes indicated that during June and July 2010, the abundance of MGI (Thaumarchaeota) decreased, likely in response to oil, but then returned and were detectable in surface waters by September 2010. Since then, 48 surface samples from along the FOCAL transect have been analyzed using two different primer sets. From some comparisons, it appeared that the original MGI primers were detecting not only the Thaumarchaeota, but also many of the Euryarchaeota. New primers were chosen and tested that appear to only target either the Thaumarchaeota or the Euryarchaeota. A new picture of the archaeal response to the oiling event is emerging from this new analysis.

Based on the new data, the decrease in the Archaea detected in 2010 appears to be common for the Thaumarchaeota during the summer months. A bloom of Thaumarchaeota is seen in the late fall through winter in both 2010/11 and 2011/12. The abundances based on the new primers set are much lower than previously reported, with estimates of a few hundred/ml common throughout the warmer months. In contrast, the Euryarchaeota are much higher in abundance, averaging 104/ml. In 2011/12, a bloom of Euryarchaeota is observed during the fall and winter, similar to the pattern seen for the Thaumarchaeota, however this bloom is not present in 2010 at T35, possibly due to effects of the oiling. The bloom is seen at CP, a station closer to shore that received less oiling. The response of the archaeal community to oil appears to be complex, and the inclusion of deep sequencing of the 16S rRNA gene will hopefully help us to determine how different members of the Archaea did respond. Preliminary DGGE analyses of some of these samples suggests that the community did change, but sequencing will provide us with a clear picture of who succeeded and who did not.

4. 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?

Several different functional genes have been targeted to determine how oiling may have affected the functioning of the microbial food web. nifH was detected in most of the initial 24 samples analyzed from 2010. qPCR analysis of this gene show an increase in the abundance of nifH genes in surface waters collected along the FM transect in June (oil present when collected). The genes increase from a background of ~300 copies/ml to ~2000 copies/ml. This pattern suggests that the microbial community responding to the oil may have decreased the inorganic nitrogen, enabling nitrogen fixing organisms to increase.

DNA isolated from ~100 water sample collected from various sites in coastal Alabama waters have been screened for the presence or absence of hydrocarbon degradation genes. P450 genes were detected in most of the samples tested, including those from before the oil exposure. The Rieske fragment was detected in fewer samples. We expanded our PAH primer set to target specific groups of PAH degraders, specifically Acinetobacter, the PAH degrading Actinomycets, and the marine PAH degrader Cycloclasticus. The presence of the P450 genes in many of the samples was expected, as it degrades alkanes, which are abundant in crude oil. However, the alkB gene is also responsible for degrading alkanes, and it was surprisingly absent in most of the samples. This may be explained by the fact that the alkB gene is generally responsible for degrading somewhat longer chain alkanes, while the Deepwater spill largely released shorter chain alkanes. The BTEX genes that were screened for degrade several varieties of hydrocarbon rings, so it is more difficult to predict which may or may not be present, since crude oil may not contain all of these varieties of hydrocarbons. When taken as a whole though, the BTEX genes were also present before, during and after the spill. Of the group specific PAH degradation genes targeted, only the Acinetobacter gene was detected. It was also detected before, during and after the spill, but much less frequently than the alkane hydroxylase and BTEX genes. Surprisingly, the classic marine PAH degrader, Cycloclasticus, was not amplified.

With this initial presence/absence screening complete, the next step is to quantify the genes present in a subset of 28 samples from before, during, and after the spill. Representative genes are currently being cloned to serve as standards in qPCR analysis of a subset of the initially screened samples. To date, standards for P450, alkB and Rieske (PAH degradation) genes have been cloned and are currently being used to optimize qPCR reaction conditions. qPCR will allow us to tie gene abundance to the presence or absence of oil and give a quantitative assessment of the marine bacterial community response to the spilled oil. 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. The final phase of the project will be to perform a deep sequencing analysis of the samples exhibiting a strong response to the oil (high number of genes detected in the qPCR experiments) to assess the diversity of hydrocarbon genes present during periods of oil exposure.

3. Cruises & field expeditions

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
E. O. Wilson		DISL	Collect water samples across the FOCAL transect to carry out dilution experiments and extract DNA for gene quantification and diversity	January, March, May, July, September and December 2011

***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

The microbial community shifts in response to seasonal patterns across the Alabama shelf. ISME J, submission November 2012

5. Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Investigating patterns of growth, grazing and viral lysis of the phytoplankton along a salinity gradient influenced by oil from the Deepwater Horizon spill	A. C. Ortmann	A. C. Ortmann, R. C. Metzger, R. H. Condon and S. M. Ni Chadhain	NGI Annual Meeting, 2011	N	May, 2011
Microbial community response to the Deepwater Horizon oil spill, a functional gene approach	S. M. Ni Chadhain	S. M. Ni Chadhain, J. B. Finley, N. Ortell Cumbaa, L. Wang and A. C. Ortmann	ASM General Meeting, 2012	N	June 2012

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
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Jennifer	Anders	Technician	DISL	ja964@nova.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
Robert	Chang	MS	Assessment of oil degradation gene abundance and diversity in coastal Alabama waters before, during and after the Deepwater Horizon oil spill	University of South Alabama	S. M. Ni Chadhain	
J. Bradley	Finley	BS	Assessment of oil degradation gene abundance and diversity in coastal Alabama waters before, during and after the Deepwater Horizon oil spill	University of South Alabama		

10. Student and post-doctoral publications, if planned

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

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Response of archaeal communities to the Deepwater Horizon oil spill	N. O. Cumbaa	N. O. Cumbaa and A. C. Ortmann	NGI Annual Meeting, 2011	N	May, 2011
Microbial community response to the Deepwater Horizon spill, a functional gene approach	R. Chang	R. Chang, N. O. Cumbaa, L. Wang, S. M. Ni Chadhain and A. C. Ortmann	NGI Annual Meeting, 2011	N	May, 2011
Microbial food webs community shifts across the Alabama shelf	N. O. Cumbaa	N. O. Cumbaa, S. M. Ni Chadhain and A. C. Ortmann	NGI Annual Meeting, 2012	N	May 2012

12. Images
N/A

11-BP_GRI-02: Dauphin Island Sea Lab: Does the 'Priming Effect' caused by the Deepwater Horizon Oil-Spill Result in Increased Microbial and Zooplankton Consumption of Labile and Refractory Dissolved Organic Carbon

Robert Condon

SCIENCE ACTIVITIES

1. General Summary: The Deepwater Horizon (DwH) oil spill was unprecedented in the magnitude and extent of oil released into the water column. Regular two-week monitoring by the Fisheries Oceanography of Coastal Alabama (FOCAL) program as part of BP NGI Phase I funding (PI Graham), documented marked changes in labile carbon (C) pools, and in microbial and zooplanktonic processes in response to the presence of oil in coastal waters of Alabama. In particular, isotopically light C signatures in the micro-and meso-zooplankton fractions suggest that oil-derived C entered the planktonic food web on short time-scales, and that this shift was likely mediated by microbial metabolic processes. However, dissolved organic C (DOC) stocks remained very low (<100µM) compared to historical pre-spill conditions (typically >150µM), despite huge amounts of oil-derived C and high freshwater (humic) inputs into coastal waters. One possible explanation for sustained low DOC concentrations is the 'priming effect' hypothesis in which increased bioavailability of labile C sources will promote microbial diversity and cell activity, which in turn will stimulate high update of refractory DOM (e.g., humics, high fractionated components of crude oil). Assuming this effect occurred during the DwH oil spill, there are important implications of the priming effect for ecosystem functioning, including increased C bioavailability for planktonic food webs from both oil- and refractory/freshwater organic sources, which has consequences for fisheries production. In Phase 2 of NGI funding, we expanded our knowledge base and specifically examine the priming effect hypothesis and its implications for planktonic food web processes and fisheries production. We conducted a series of controlled mesocosm experiments in June and August 2011 using radio- and stable-isotopes, chromophoric dissolved organic matter (CDOM) spectra and other oceanographic techniques to measure microbial metabolism of oil (labile) and humic (refractory) material under various conditions and also how changes in microbial processes relates to changes in planktonic food webs. Experimental results will be compared to a six-years of historical baseline information generated by FOCAL to evaluate the relative interannual and seasonal variability of the priming effect under pre- and post-spill conditions. Statistical analyses will include Parallel Factor Analyses (PARAFAC), in which the main environmental variables driving changes in DCOM pools will be modeled. The major implication of our study is that it will allow us to observe and understand source-sink dynamics of oil and dispersant and how this relates to microbial and planktonic food web processes. In addition, results from this study may be used as a model for other aquatic systems exhibiting similar changes in ecosystem baselines. To this end, we have also developed a global database of oil spills to evaluate the magnitude and extent of oil-derived carbon as it relates to other food web processes on a global scale, such as:

2. Results and scientific highlights

Field Sampling: To examine the effects of the oil and dispersant on microbial community metabolism and the magnitude and extent of the priming effect we conducted field sampling and two mesocosm experiments in June and August 2011. DOC, inorganic nutrients and CDOM samples were taken on a monthly basis as part of the FOCAL program. Most samples have been processed and analyzed with the exception of CDOM samples that have been processed but excitation-emission matrices yet to be analyzed. Some scientific highlights from field measurements relating to increased metabolism of oil and the priming effect include:

1. Concentrations of DOC and DON (potentially humic material from terrestrial river discharge) were low (<70 uM) in 2010 during the DwH oil spill, despite high allochthonous inputs of oil-and dispersant-derived C during this period. These concentrations are equivalent to oligotrophic, open ocean environments. This suggests high uptake of refractory DOM occurred, potentially as a result of increased microbial activity and metabolism by microbial communities.

2. Relatively high concentrations of nitrite (> 4 uM) were found throughout the water column that were associated with reduced dissolved oxygen and hypoxia. Correlations between nitrite concentrations and depleted $DI^{13}C$ suggest that increased nitrite was associated with the metabolism of oil-derived material.

Mesocosm experiments: We used a controlled experimental approach in the DISL mesocosm facility to test the null hypothesis that addition of oil and oil-dispersant mix has no effect on microbial metabolic processes or the priming effect. We are employing an ANOVA style experimental design with treatments: control/no addition, control/glucose surrogate, oil only, dispersant only, oil-dispersant mix. A glucose addition treatment was added to this experiment as a labile organic carbon control. Each is replicated five times. This research examined two questions related to the core hypothesis: 1) what are the growth rates of the different components of the microbial fraction, and 2) what is the bacterial growth efficiency (simultaneous measurements of production and respiration) under oiled conditions and how does it relate to the uptake of labile and refractory organic material and the priming effect. To examine these questions I will monitor microbial metabolism by measuring microbial production, respiration and cell activity periodically over the incubation period.

Experiments were conducted over a 7 day period with samples collected at the following timepoints: 0, 0.5, 1, 2, 4 and 7 days. We are currently finalizing microbial production (leucine [protein synthesis] and thymidine [DNA synthesis] incorporation), dissolved organic carbon and inorganic nutrients, flow cytometry, CDOM, particulate and dissolved 13C analyses. Bacterial respiration measurements are being quality checked and will be included in the final report.

Fig 1 shows some preliminary findings of microbial abundance (flow cytometry), production (leucine and thymidine incorporation) and DOC (oil and control mesocosms only) from the mesocosm experiments. Some interesting findings include:

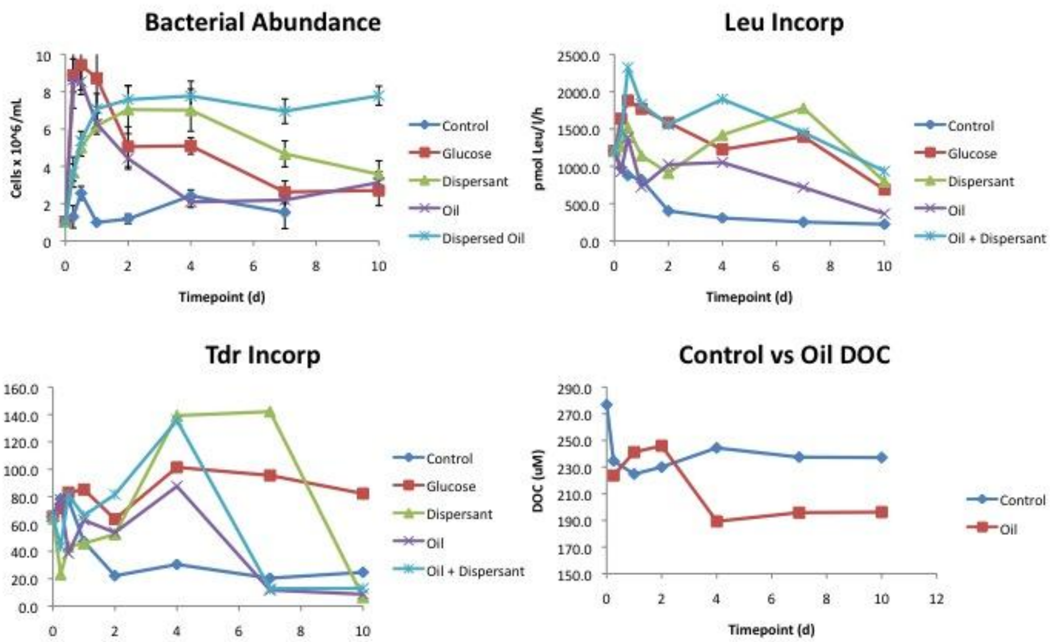
1. Highest increase in cells in the oil and glucose treatments over the first 6-12 hrs compared to a relatively delayed increase in cells in the dispersant treatments (both dispersant only and dispersed oil). Variations in leucine and thymidine incorporation rates complement these observations, in particular the decrease in thymidine but relatively high leucine incorporation in the dispersant treatments compared to other treatments and controls. At this stage, it is unclear whether these findings are the result of differences in the lability of crude versus dispersed oil or are mediated by the dispersant but bulk DOC was lower than control water after 2 days suggesting high DOC uptake and microbial metabolism of oil-derived C.

2. Sustained long-term (up to 10 days) microbial biomass in the dispersant treatments relative to the other treatments (see point 1 above) coinciding with a delayed increase in thymidine incorporation rates after day 2.

3. Similar rapid decline in microbial cells in the oil only and glucose addition mesocosms, possibly due to grazing.   Our next step will be to examine archived preserved microbial samples under the epifluorescent microscope focusing on whether heterotrophic nanoflagellates and other micrograzers are present in these treatments

4. High uptake of DON was observed in the glucose addition treatment during both June and August providing some evidence for the priming effect.

5. We attempted to measure the stable isotope signature of zooplankton communities at the conclusion of the experiment to determine whether uptake of refractory DOM by microbes under primed conditions translated to extra zooplankton production. Unfortunately zooplankton biomass was too low to obtain a reliable stable isotope signature. We would recommend seeding tanks with extra zooplankton at the start of the experiment to allow for adequate biomass to accumulate for stable isotope analysis.



Conceptual Model of Oil-mediated Ecosystem Metabolism: Based on observations from field sampling and large-scale mesocosm experiments, we have developed a conceptual model that can be used to interpret how estuarine community metabolism relates to DOC export in response to the PE (Fig. 2). In this model, we hypothesize that microbial communities are functioning under maximum thresholds due to a variety of ecosystem limitations (e.g., nutrients) and tight coupling between growth and loss terms (e.g., grazing) that restrict accumulation of biomass in the absence of oil-derived C. We hypothesize that the maximum metabolic threshold is dictated by intracellular maintenance energy requirements and saturation of cell membrane pumps and channels that restrict extracellular breakdown and uptake of nutrients. This conceptual model can be used to test our hypotheses and for evaluating future consequences of the priming effect under oiled and other conditions (e.g., increased terrestrial runoff). In turn, this is important for evaluating estuarine C export as any changes in functioning of the microbial loop mediated by human activities will likely alter source-sink dynamics of DOM pools that mediate these processes.

A brief description of the conceptual model is provided here in reference to Fig. 2. In the typical scenario (point A), the rate of DOC input is closely coupled to microbial carbon demand and growth efficiencies, and because DOC cannot accumulate there is no change in DOC export. However, under the priming effect (point B), metabolic activity and community metabolism increase with elevated allochthony resulting in increased DOC utilization within the estuary, which may lead to potential nutrient limitation and oligotrophication. In this case, DOC export from the estuary to the shelf might be expected to decrease, but this depends on the strength of the PE and whether metabolic shifts reach the critical point where community metabolism begins to plateau (see Fig. 3). In the extreme scenario (point C), DOC can accumulate and export of terrestrial DOM will likely increase. However, because evidence in the literature suggests the majority of reactive DOM is processed in the estuary with little export, we suggest scenario B is applicable under primed conditions. In addition, as increased microbial respiration will increase the size of DIC pools in all three scenarios, we hypothesize that net heterotrophy will increase at rates complementary to increases in respiration resulting in increased CO_2 flux to the atmosphere and localized regions of hypoxia where oil slicks exist. Field observations of $DI^{13}C$ support this notion.

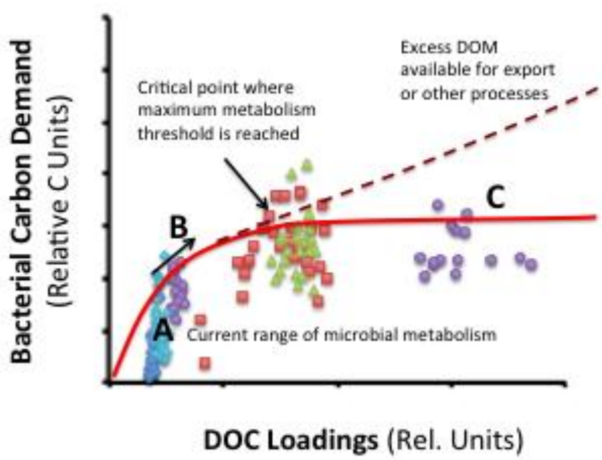


Fig. 2. Conceptual model of ecosystem metabolism response to increased DOC loadings to estuaries. Dots represent data from mesocosm experiments representing different C loading treatments. Letters ("A", "B" and "C") represent different community response scenarios to the PE. Red line is projected community metabolism based on results from the mesocosm experiments. Dashed line is excess DOC, with the distance between red and dashed lines representing potential DOC available for export.

Global Analysis of Oil Spills: We have also developed a database to relate our findings and to evaluate the impacts of global oil spills on ecosystem metabolism and planktonic food webs (see deliverable product section below). The database consists of over 2,500 records of hydrocarbon discharge primarily from the past 45 years (Fig. 3). Oil volumes have been converted to carbon units for comparison with primary production, allochthonous DOC inputs and natural seep discharge to evaluate the impacts of oil on ecosystem metabolism on regional and global scales. Some findings from initial database analysis include:

1. On a global scale, oil-derived C released from tanker accidents, oil spills, platform explosions and sunken vessels was insignificant representing less than 0.1% of annual primary production. However, on a regional scale this comparison was much higher suggesting that the impacts of oil spills may be more significant on localized or ocean basin scales.
2. High amounts of oil-derived C were released in regions of oil exploration and high shipping activity including the Persian Gulf, Gulf of Mexico, Alaska, North Sea, Mediterranean Sea, Brazil and Asia (Singapore, Japan and Malaysia).
3. Oil-derived C from DwH represents between 1 to 90 days worth of primary production, which corresponds to about 56% of the total areal coverage of the Gulf of Mexico (ca. 1.5 million sq. km). These results suggest that oil may have replaced or subsidized phytoplankton production at the base of the planktonic food web, with implications for commercial fisheries and the metabolic balance between net autotrophy and heterotrophy.
4. These analyses do not include oil spill records from Russia and Nigeria that are poorly documented and not available to include in the database.

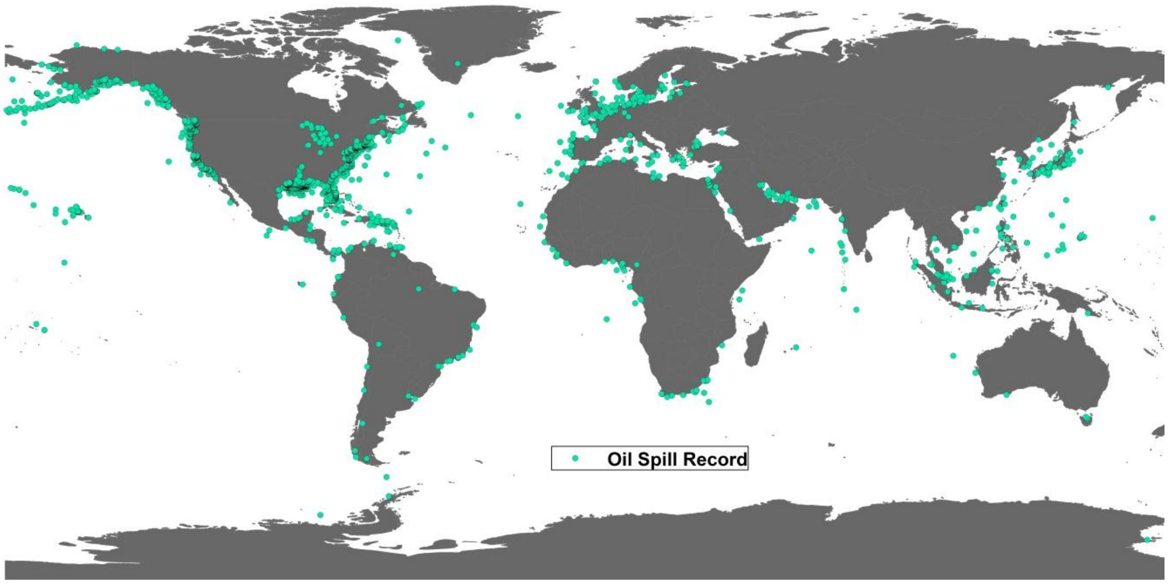


Fig. 3. Distribution of oil spill records in global database recorded between 1967-2011. Each dot represents a known volume of oil-derived C released into marine or major aquatic systems and their watershed. These metadata will be available to download from the DISL website.

3. Cruises & field expeditions

Field samples were conducted as part of the FOCAL program. This is a monthly field survey program

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
FOCAL	Small boat housed at DISL	Hernandez	Collect monthly samples for nutrients, DOC , CDOM and microbial production	Monthly during 2010-2011

4. Peer-reviewed publications, if planned

R.H. Condon, M. Bogeberg, C.M. Duarte, P.A. del Giorgio, S. Agusti & A.C. Ortmann. Hydrocarbons as an ancient energy source for planktonic food web production. *Nature*. To be submitted May 2012

R.H. Condon, A.C. Ortmann, N.L. Shelton, M. Bogeberg & W.M. Graham. Dispersed oil stimulates microbial metabolism toward ecosystem thresholds. *Science*. To be submitted August 2012

A.C. Ortmann, J. Anders, N. Shelton & R.H. Condon. Dispersants and dispersed oil disrupt grazing in the microbial food web in mesocosm experiments with Gulf of Mexico communities. *Proc. Nat. Acad. Sci. U.S.A.* To be submitted May 2012.

Several other publications are likely from this research following additional analyses of mesocosm and field samples. For example, we plan one publication based on PARAFAC analysis of CDOM samples. These analyses will be conducted in collaboration with Dr. Paul del Giorgio (UQAM, Canada).

5. Presentations and posters, if planned

Graham, W.M., **Condon, R.H.** et al. (Oct, 2010). Oil carbon entered the coastal microbial & planktonic food web during the *Deepwater Horizon* oil spill. IMBER Workshop. Poster presentation.

Graham, W.M., **Condon, R.H.,** Carmichael, R.H., D'Ambra, I., Patterson, H., Linn, L & Hernandez Jr., F. (Dec, 2010). Entry of oil (carbon) into the coastal planktonic food web during the *Deepwater Horizon* spill. AGU Conference, San Franscico, CA. Oral presentation.

Graham, W.M. & **Condon, R.H.** (April, 2011). Microbial-zooplankton linkages during *Deepwater Horizon*: a shift to heterotrophy? University of Southern Mississippi, Stennis Space Center, MS. Oral presentation.

Condon, R.H., Graham, W.M., Brandes, J., Kiene, R., Linn, L.J., Ortmann, A.C. & Shelton, N. (May, 2011). Hydrocarbons as subsidy energy for food web production in coastal Gulf of Mexico waters. NGI Conference, Mobile, AL. Poster presentation.

Ortmann, A.C., Metzger, R.C. & **Condon, R.H.** (May, 2011). Investigating patterns of growth, grazing and viral lysis of the phytoplankton along a salinity gradient influenced by il from the *Deepwater Horizon* spill. NGI Conference, Mobile, AL. Oral presentation.

Shelton, N.L., **Condon, R.H.,** Graham, W.M. & Linn, L.J. (Feb, 2011). Source-sink dynamics of oil-derived chromophoric dissolved organic matter in coastal Gulf of Mexico waters. ASLO Ocean Sciences Meeting, San Juan, PR. Poster presentation.

R.H. Condon, W.M. Graham, J. Brandes, A.C. Ortmann, L.J. Linn, N.L. Shelton, F. Hernandez Jr. (Feb, 2011). Hydrocarbons as subsidy energy for food we production in coastal Gulf of Mexico waters. ASLO Annual Conference, Salt Lake, UT.

6. Other products or deliverables

Protocols developed: This project supported an intern, Ms. Erin McParland, who developed a field technique and protocol for measuring microbial respiration using the PreSens Fibox Optode system. Initial trials focused on elimination of micro-bubbles in closed incubations, controlling temperature throughout the incubation period, and determination of appropriate correction factors for differences in salinity. The initial results are encouraging and a methods paper has been outlined based this work.

In addition, we are developing a method for measuring $DI^{13}C$ on small volume samples using the Picarro G-*i*2121 Stable Isotope Analyzer. This will result in another methods paper being produced. Dr. Jay Brandes (SkIO) was a collaborator on this project and ran the $DI^{13}C$ samples in-kind generated from the mesocosm experiments and collected from the field.

Global Oil Spill Database: We have developed a database of global oil spills based on publically available records of global oil spills downloaded from various sources such as NOAA and Environment Canada (http://www.etc-cte.ec.gc.ca/databases/TankerSpills/). The database consists of 45 years of records with over 2,500 records of oil spill, tanker accident, and dispersant hydrocarbon discharge. Oil volumes have been converted to carbon units for comparison with primary production, allochthonous DOC inputs and natural seep discharge to evaluate the impacts of oil on ecosystem metabolism on regional and global scales. The metadata will be made available through the Data Management section of the DISL website, and the global data analysis will be made available upon request following publication of the data. One paper is in preparation based on the analyses stemming from the oil spill database.

Toward Elementary Advancement Module in Science (TEAMS): As a key outreach component of this project we have made several school visits to 2nd grade and pre school students at Olive J. Dodge Elementary and Christ United Methodist Kidz Crossing Program, respectively. These outreach activities were conducted as part of a new education program called the TEAMS program, designed for elementary and early childhood school children. The aim of TEAMS is to improve student understanding of the process of science, focusing on elementary and pre school school students in order to capitalize on their existing interest and excitement about the natural world. One module was spent discussing the effects of the oil spill on the marine environment. Video demonstrations and experiments enhanced the learning experience by allowing students to become acquainted with tools used to conduct oil spill research, learn the critical role of measurements by experimentation and practice basic data formatting (graphing) thereby improving their quantitative skills. Students will present the findings of these classroom visits at PTA meetings.

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.

See attached spreadsheet

PARTICIPANTS AND COLLABORATORS

8. Project participants

First Name	Last Name	Role in Project	Institution
Alice	Ortmann	Scientific participant	USA/DISL
Naomi	Shelton	Research technician	DISL
Jay	Brandes	Collaborator	SkIO
Molly	Bogeberg	Research technician	DISL
Monty	Graham	Collaborator	USM
Erin	McParland	Intern	DISL
Jami	Ivory	REU Intrn	DISL
Tony	Moss	Collaborator	Auburn
Paul	Del Giorgio	Collaborator	UQAM
Susana	Agusti	Collaborator	IMEDEA

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

11-BP_GRI-03: Dauphin Island Sea Lab: Potential Impacts of the Deepwater Horizon Oil Spill on Fishery Resources: Will There Be reduced Recruitment of Economically Important Shrimp, Crab, and Finfish in Seagrass and Marsh Nursery Habitats of the North Central Gulf of Mexico.

Kenneth L. Heck, Jr., Just Cebrian

SCIENCE ACTIVITIES

1.General Summary

To understand the impact the Deepwater Horizon spill had on the juvenile fish community we continued our RFP-I sampling of two critical vegetated nearshore nursery habitats, seagrass meadows and salt marshes, along the north central Gulf Coast. Sites were chosen based on availability of baseline data for juvenile fish community, seagrass density and potential oil exposure at the time of the Phase I project. Data gathered during our Phase 1 sampling indicated that oil from the DwH event did not impact Alabama's coastal habitats with the severity seen in Louisiana.
As seagrass and marsh habitats serve a nursery function for many commercially important finfish and shellfish that migrate and spawn off shore, continued sampling allowed us to:

(1) Determine if the Deepwater Horizon spill caused depressed recruitment of finfish and shellfish to critical nursery habitats due to reduced reproductive fitness of the offshore adult populations.

(2) Respond to additional oiling of seagrass beds and marshes that might occur during the duration of this Phase II project (i.e., if noticeable quantities of oil arrive from offshore and persist in our study locations), by assessing its effects on seagrass and marsh plant abundance and species composition, as well as further impacts on juvenile and adult fish abundance and species composition

2. Results and scientific highlights

Oil from the DWH did not impact Alabama's coastal habitats with the severity seen in Louisiana nor was there any prolonged or continued oiling events during the study period; thus, despite the presence of tar balls and light sheens, major oiling did not occur in the locations studied. As a result, no significant loss of seagrass and marsh plants occurred at the three study sites.

Seagrasses exhibited a normal seasonal trend with increased production starting in the early summer, peaking around August and September, and then decreasing during the colder, winter months (Figure 1). Mean seagrass shoot density ranged from 2883 ± 373 to 5368 ± 509 shoots m^{-2} (± standard error), with the highest density of shoots typically found at the Long Island site (Figure 2). Shoot density also followed a seasonal pattern with the highest number of shoots found during the periods of greatest productivity (August – October). The high productivity and shoot density over the study period indicate that the structure provided by seagrass to the associated fauna remained largely unaffected by the low amount of oiling that occurred at the study sites.

Mean abundance of post settlement ichthyofauna collected from beam plankton trawls at the study sites did significantly decrease from Fall 2010 to Fall 2011 (T-test, $p<0.001$; Figure 3). Comparison of larger

juvenile fishes sampled by 5m otter trawl after the oil spill (2010 and 2011) with catches from trawls conducted pre-spill, between 2006 and
2009 (see Fodrie and Heck, 2011 PLOS One 6(7); e21609) showed a significant shift in species composition after the oiling event (Spearman p=0.604, p,0.0001; Wilcoxon: V=190, p=0.025 (Figure 4); however, no significant decrease was seen in overall abundance (Figure 5). The decrease in abundance seen in post settlement individuals but not for larger juveniles suggests lower recruitment to the seagrass habitat in 2011 but a high survival rate once individuals have settled into this vital nursery habitat.

Catches of resident grass shrimp, *Palaemonetes pugio*, within salt-marsh habitats were generally large--typically one to two orders of magnitude higher than all other species. In
2010 and 2011, total nekton abundance was highest during the late spring and summer
for salt-marsh habitats, with little variation among sites. Peak abundances of nekton were similar in 2010 and 2011(Figure 6). Seasonal patterns of abundance of blue crabs (Figure
7) and penaeid shrimp (Figure 8) in the salt marshes of Grand Bay corresponded to late- spring and late-summer recruitment events.

Blue crab and penaeid shrimp catches within the salt-marsh at each site were composed almost exclusively of juveniles. In contrast, collections of blue crabs from the adjacent seagrass beds consisted of subadult and adult size classes. Abundances of seagrass- associated blue crabs remained low throughout the study period compared to catches within the salt marsh. Abundances of seagrass-associated penaeid shrimp followed a similar seasonal pattern to that observed for salt-marsh associated shrimp. Blue crabs and penaeid shrimp leave coastal vegetated habitats and move offshore into deeper water during the cold winter months. Sporadic sightings of weathered tar balls were reported in Grand Bay prior to the start of the study but no oil was observed during the study period. As a result, no loss of salt- marsh vegetation or seagrasses, nor the structure they provide to juvenile nektonic species, was observed at any of the study sites, suggesting minimal impact to the area. The lack of large interannual variability in nekton abundances and congruence of this data with that of sites for which pre-spill data are available suggests minimal, or negligible, impact of the oil spill.

3. Cruises & field expeditions

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
RV Thalassia (19’ Carolina skiff)		Ken Heck, Ryan Moody	Sampling of seagrass associated juvenile fishes, seagrass density cores, sampling of marsh associated fishes	3/2/2011
RV Thalassia		Dorothy Byron	Sampling of seagrass associated juvenile fishes, seagrass density cores	3/24/ 2011
RV Thalassia		Sara Kerner	Sampling of marsh associated fishes	3/25/2011
25’ Carolina skiff (no formal name)		Sara Kerner	Sampling of marsh associated fishes	5/4/2011
RV Thalassia		Whitney Scheffel	Sampling of seagrass associated juvenile fishes, seagrass density cores	5/5/2011
25’ Carolina skiff		Sara Kerner	Sampling of marsh associated fishes	5/19/2011
RV Coquina (21’ Carolina skiff)		Whitney Scheffel	Sampling of seagrass associated juvenile fishes, seagrass density cores	5/19/2011
RV Thalassia		Whitney Scheffel, Joe Myers	Sampling of seagrass associated juvenile fishes, seagrass density cores	6/14/2011
25’ Carolina skiff		Sara Kerner	Sampling of marsh associated fishes	6/17/2011
25’ Carolina skiff		Sara Kerner	Sampling of marsh associated fishes	7/12/2011

RV Coquina		Joe Myers	Sampling of seagrass associated juvenile fishes, seagrass density cores	7/12/2011
25' Carolina skiff		Sara Kerner	Sampling of marsh associated fishes	8/24/2011
RV Coquina		Joe Myers, Whitney Scheffel	Sampling of seagrass associated juvenile fishes, seagrass density cores	8/24 & 8/25/2011
25' Carolina skiff		Sara Kerner	Sampling of marsh associated fishes	9/21/2011
RV Coquina		Whitney Scheffel	Sampling of seagrass associated juvenile fishes, seagrass density cores	9/21/2011
RV Coquina		Joe Myers, Whitney Scheffel	Sampling of seagrass associated juvenile fishes, seagrass density cores	10/26/2011
25' Carolina skiff		Sara Kerner	Sampling of marsh associated fishes	10/27/2011
25' Carolina skiff		Sara Kerner	Sampling of marsh associated fishes	11/15/2011
RV Coquina		Whitney Scheffel	Sampling of seagrass associated juvenile fishes, seagrass density cores	11/21/2011

4. Peer-reviewed publications, if planned

N/A

5) Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract Published	Date
Temporal dynamics of salt-marsh and seagrass utilization of commercial shellfish species in the northern Gulf of Mexico: Impact of the oil spill?	Sara Kerner	R. Moody, L. K. Biermann, J. Cebrian, K.L. Heck, and S. Powers	Poster at the Northern Gulf Institute Meeting	N	5/17-19/ 2011
Deepwater Horizon and temporal dynamics of nekton abundance in coastal fringing marshes	Ryan Moody	S. Kerner, L.K. Biermann, J. Howard, J. Cebrian, K.L. Heck, and S. Powers	Presentation at the Northern Gulf Institute Meeting	N	5/17-19/ 2011
Has the Deepwater Horizon oil spill had a negative impact on the seagrass communities and associated juvenile finfish and shellfish in the North Central Gulf of Mexico?	Whitney Scheffel	K.L. Heck, J. Cebrian, R.M. Moody	Poster at the Coastal and Estuarine Research Federation	N	11/7-11/2011

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
Dorothy	Byron	Technician	Dauphin Island Sea Lab, AL	dbyron@disl.org
Whitney	Scheffel	Technician	Dauphin Island Sea Lab, AL	wscheffel@disl.org
Joe	Myers	Technician	Dauphin Island Sea Lab, AL	jmyers@disl.org
Megan	Sabal	Technician	Dauphin Island Sea Lab, AL	msabal@disl.org
Sharon	Havard	Technician	Dauphin Island Sea Lab, AL	chavard@disl.org
Sara	Kerner	Technician	Dauphin Island Sea Lab, AL/Florida Institute of Technology, FL	skerner@disl.org
Jelani	Reynolds	Technician	Florida Institute of Technology, FL	jreyno01@my.fit.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
Ryan	Moody	Post Doc		Dauphin Island Sea Lab	Just Cebrian	June 2012
Matthew	Metcalf	BS	None- Intern	Dauphin Island Sea Lab	Just Cebrian	Nov 2011
Justin	McDonald	BS	None- Intern	Dauphin Island Sea Lab	Just Cebrian	June 2012
Nick	Tolopka	BS	None- Intern	Dauphin Island Sea Lab	Ken Heck	June 2011
Carolyn	Harris	BS	None- Intern	Dauphin Island Sea Lab	Ken Heck	Aug 2011
Courtney	Chupka	BS	None- Intern	Dauphin Island Sea Lab	Ken Heck	Aug 2011
Heather	McNair	BS	None- Intern	Dauphin Island Sea Lab	Ken Heck	Dec 2011

10. Student and post-doctoral publications, if planned

N/A

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

N/A

12. Images

Image 1: Joe Myers retrieving the 16' otter trawl after a 2 minute tow near West Point aux Pins, AL (30.37701, -88.31271) during the Phase I project. Photo taken by members of Ken Heck's lab on October 13, 2010.

Image 2: Intern measuring juvenile fish caught with the 16' otter trawl during the Phase I project near West Point aux Pins (30.37701, -88.31271). Photo taken by members of Ken Heck's lab on October 13, 2010.

Image 3: Whitney Scheffel and Megan Sabal preparing the beam plankton trawl to sample newly settled juvenile fish in the seagrass near Long Island, MS in Grand Bay (30.37594, -88.39188). A green fyke net used to sample marsh fauna can be seen in the background. Photo taken by members of Ken Heck's lab on March 24, 2011.

Image 4: Whitney Scheffel and Megan Sabal bagging the "catch" from the beam plankton trawl used to sample newly settled juvenile fish in the seagrass near Long Island, MS in Grand Bay (30.37594, -88.39188). A green fyke net used to sample marsh fauna can be seen in the background.). Photo taken by members of Ken Heck's lab on March 24, 2011.

Image 5: Whitney Scheffel holding up a Red Drum caught in the 16' otter trawl near AL (30.37701, -88.31271). Photo taken by members of Ken Heck's lab on October 26, 2011.

FIGURES FOR FINAL TECHINICAL REPORT FOR

DAUPHIN ISLAND SEA LAB: POTENTIAL IMPACTS OF THE DEEPWATER HORIZON OIL SPILL ON FISHERY RESOURCES: WILL THERE BE REDUCED RECRUITMENT OF ECONOMICALLY IMPORTANT SHRIMP, CRABS, AND FINFISH IN SEAGRASS AND MARSH NURSERY HABITATS OF THE NORTH CENTRAL GULF OF MEXICO.

Kenneth L. Heck, Jr. and Just Cebrian

Figure 1: Mean total above ground biomass for all seagrass species collected within a 7.6cm (inner diameter) core (n=3) at each study site. Species collected were *Halodule wrightii* and *Ruppia maritima*. Error bars are ± 1 S.E.

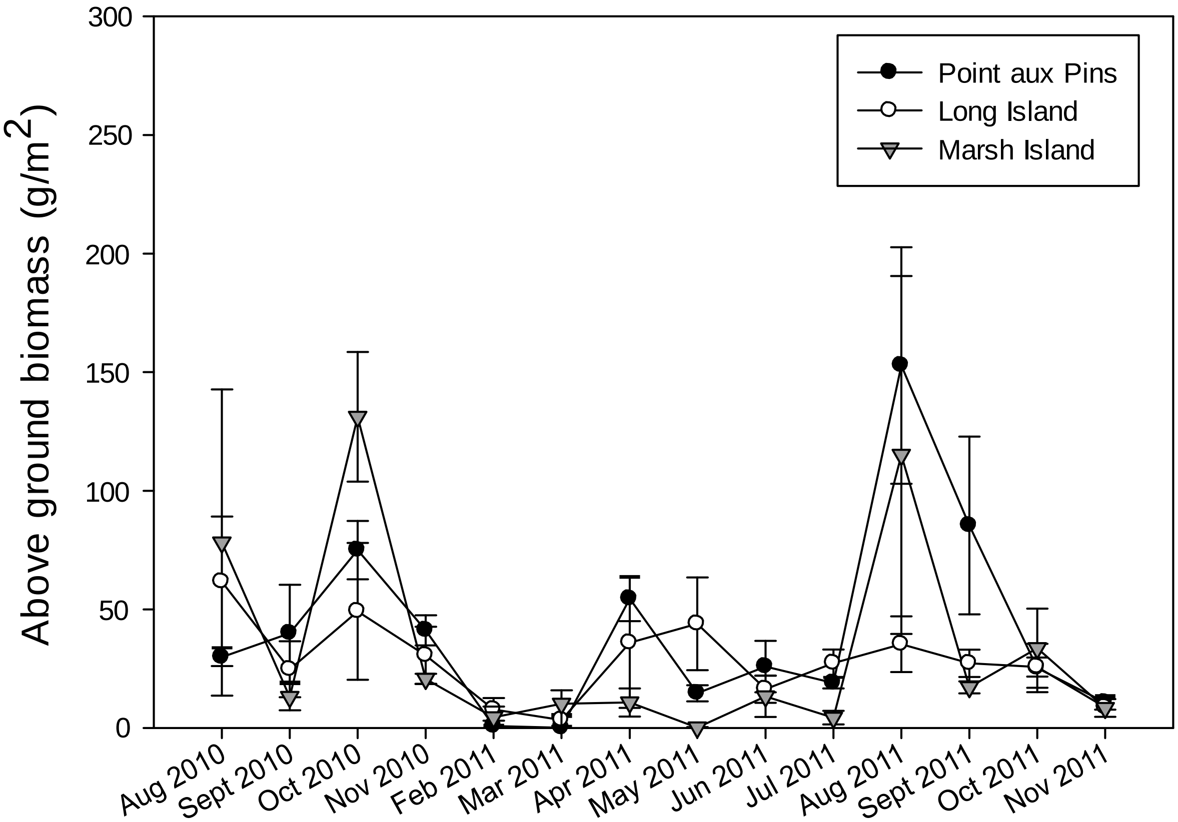


Figure 2: Mean total seagrass shoot density for all seagrass species collected within a 7.6cm (inner diameter) core (n=3) at each study site. Species collected were *Halodule wrightii* and *Ruppia maritima*. Error bars are ± 1 S.E.

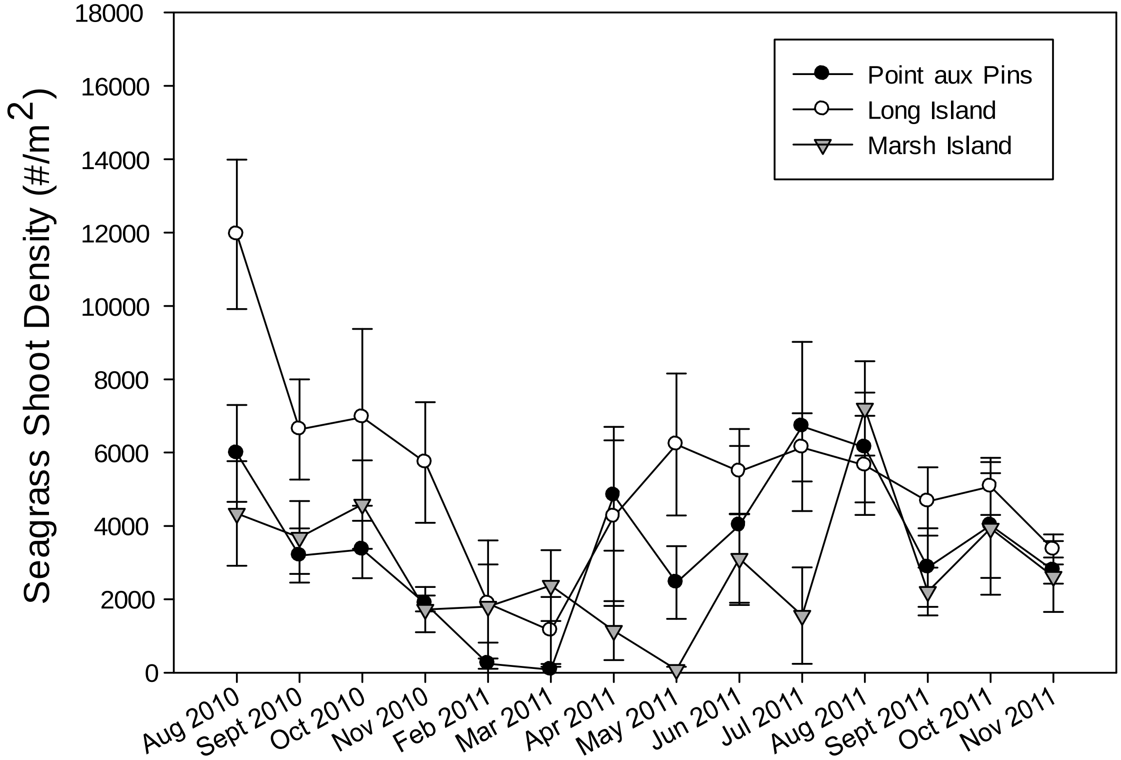


Figure 3: Mean CPUE (fish caught km^{-1} towed) of post settlement fishes collected by a beam plankton trawl. Error bars are ± 1 S.E.

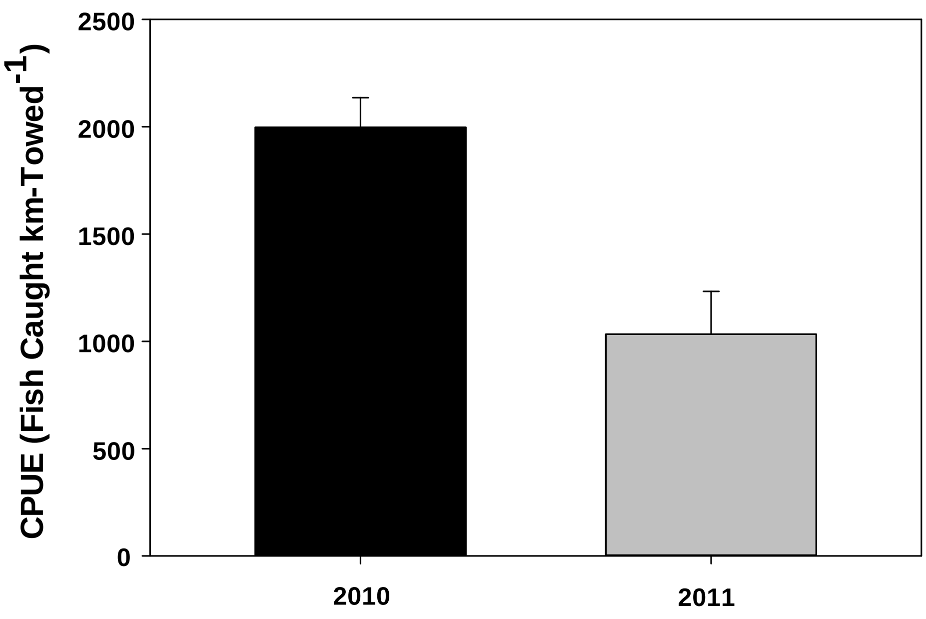


Figure 4: Frequency of species caught by otter trawl catches between 2006-2009 (Pre-oil) and 2010 – 2011 (Post-oil). After Fodrie and Heck, 2011. Response of Coastal Fishes to the Gulf of Mexico Oil Disaster. PLOS One 6(7): e21609

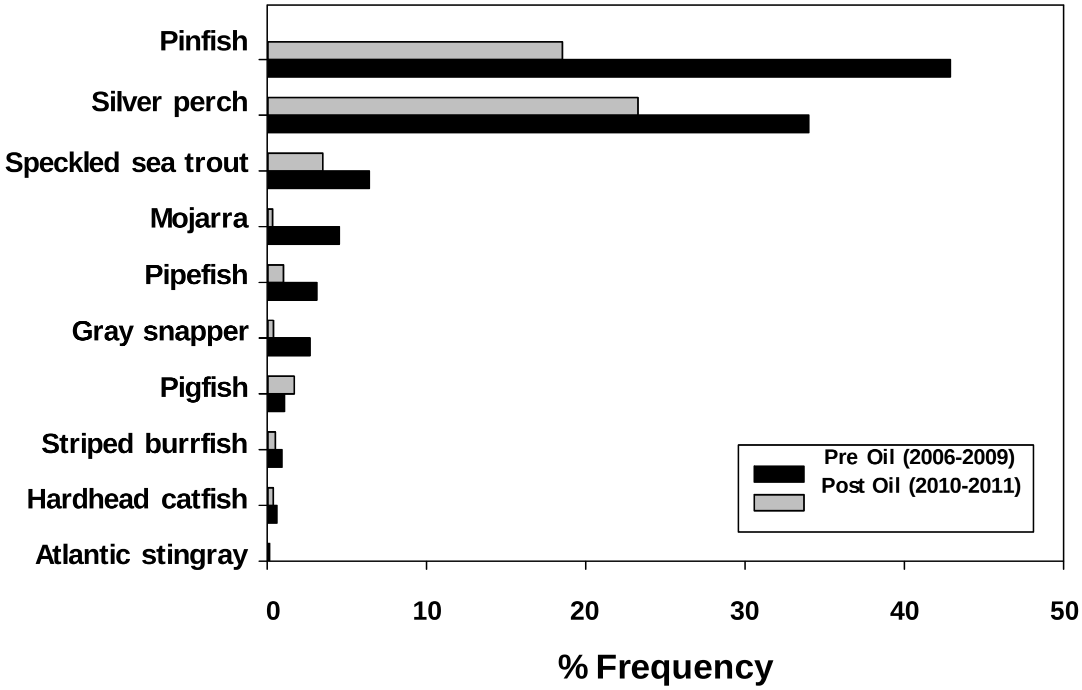
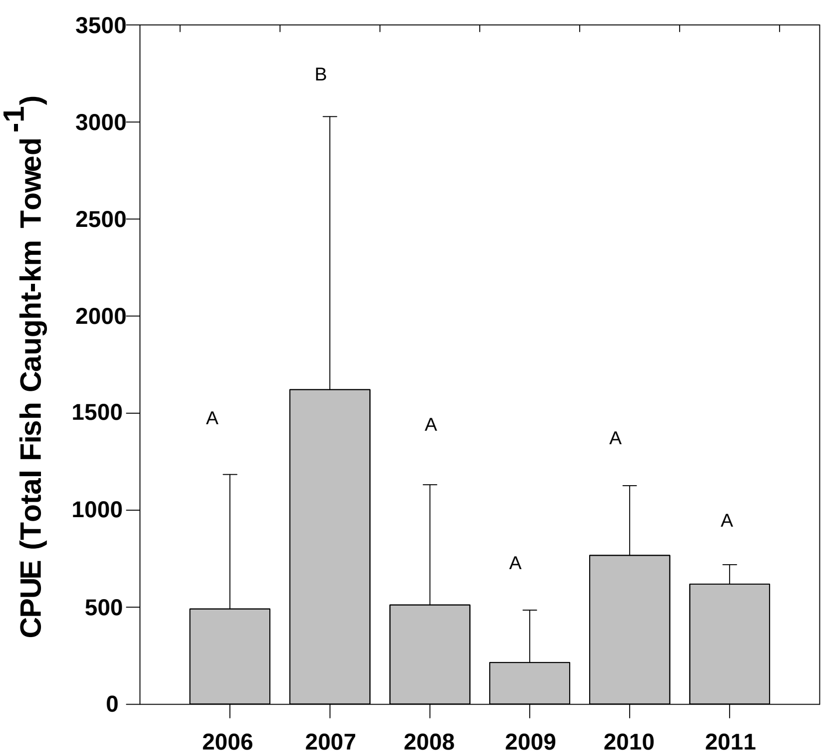


Figure 5: Yearly mean of fish caught with a 5 m otter trawl per km towed. Error bars are ± 1 S.E. Letters indicate significant difference. After Fodrie and Heck, 2011. Response of Coastal Fishes to the Gulf of Mexico Oil Disaster. PLOS One 6 (7): e21609



Sampling Year

Figure 6: Mean CPUE for total abundances of marsh-associated fish and invertebrates from Grand Bay, AL. The resident grass shrimp, *Palaemonetes pugio*, have been removed. Error bars: ± 1SE.

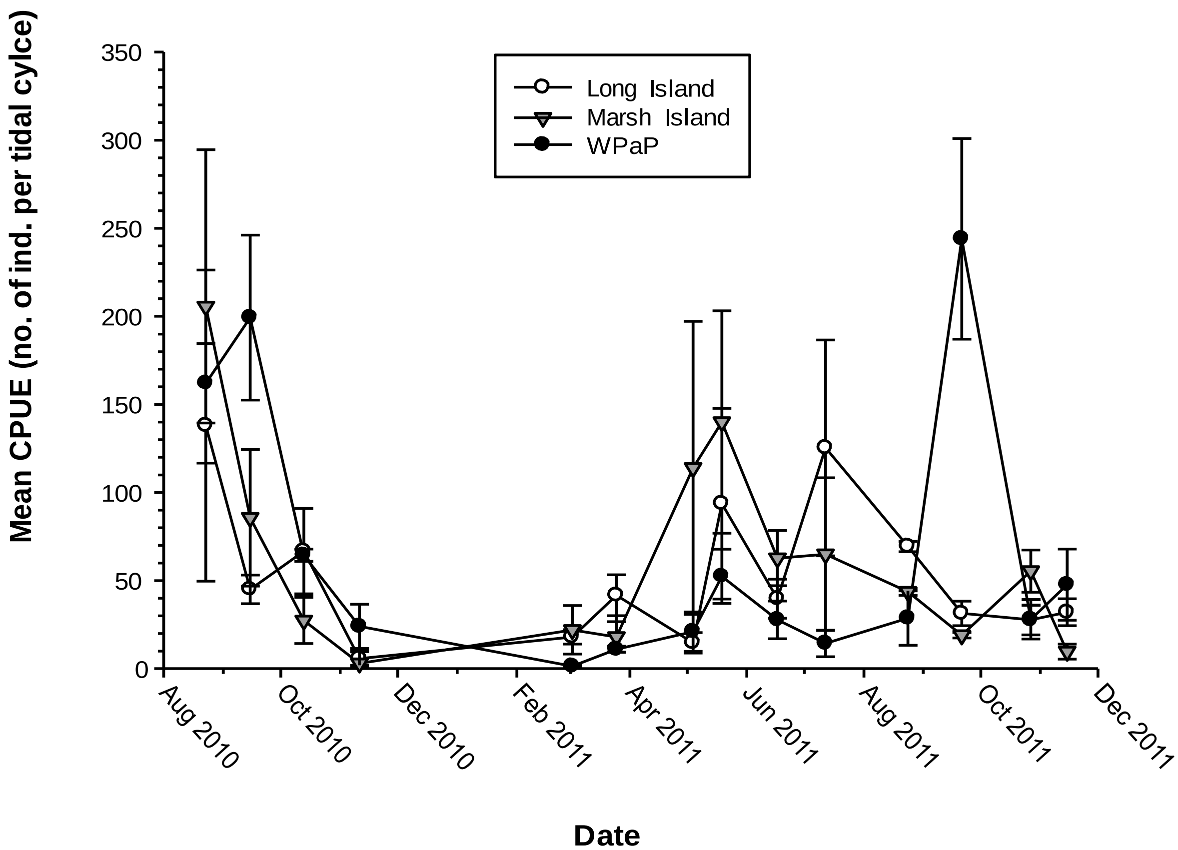


Figure 7: Mean CPUE for marsh-associated penaeid shrimp from Grand Bay, AL: Error Bars: ±1 SE.

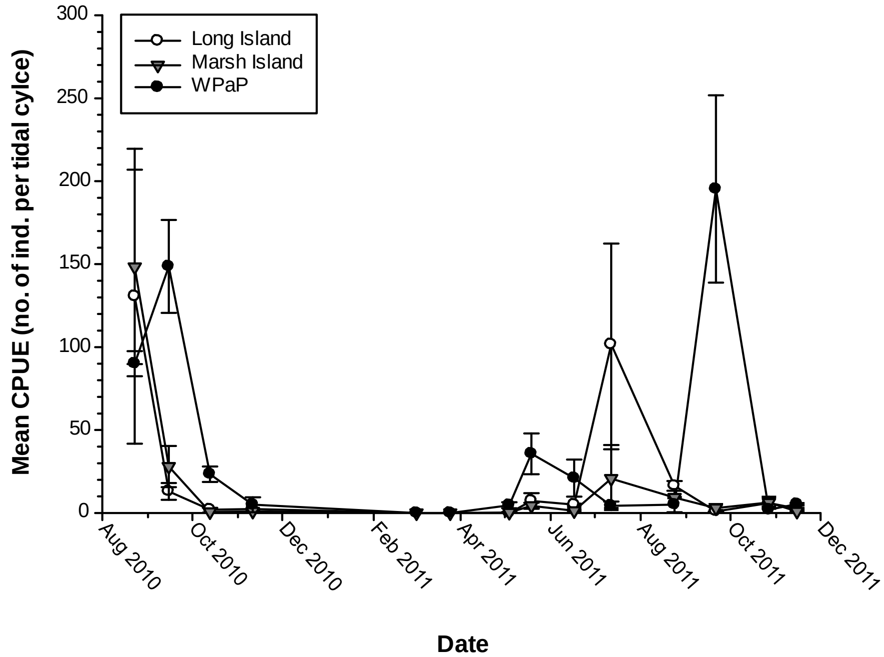
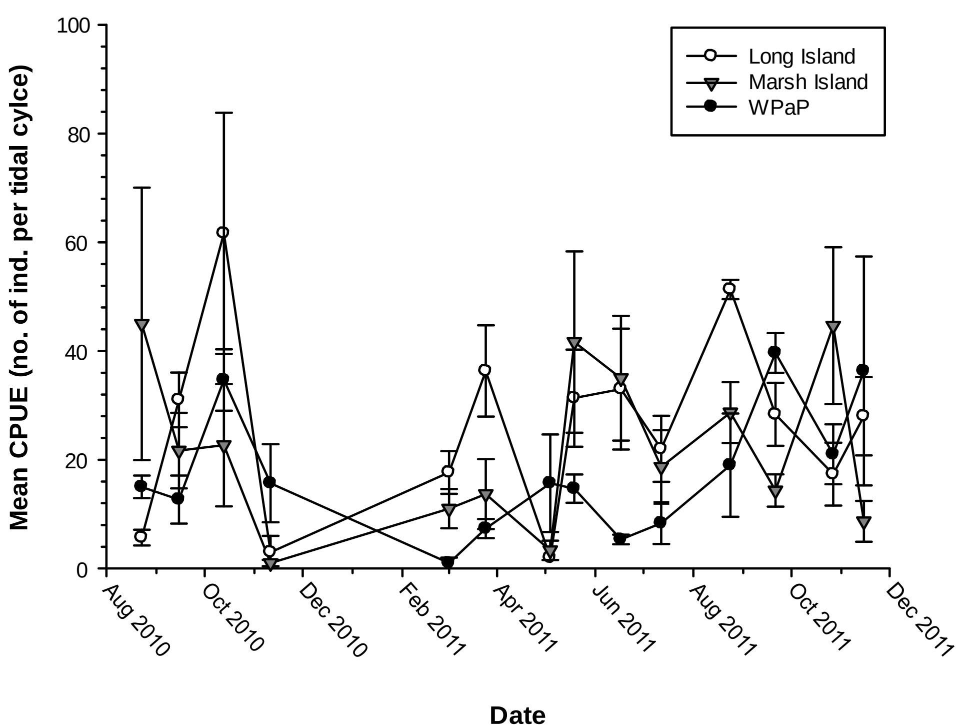


Figure 8: Mean CPUE for marsh-associated blue crabs (Callinectes sapidus) from Grand Bay, AL. Error bars: ±1 SE.



11-BP_GRI-04: Dauphin Island Sea Lab: Impacts of the Deepwater Horizon Accident on food web structure in the north-central Gulf of Mexico

John F. Valentine, Sean Powers, Charles Martin, and Marcus Drymon

SCIENCE ACTIVITIES

1. General Summary: Our results are totally unexpected, given the predictions made about the toxicity of the emerging oil from the DwH riser pipe and applied dispersant, and the impacts of the hydrocarbon-driven hypoxia in our nearshore waters (Graham et al., 2010). Specifically, comparisons of our post-DwH trawling data with long-term (10 year) historical data base generated from collections made in our study area during the SEAMAP monitoring program show that there were dramatic changes in food web composition, increases in the numbers and biomasses of fishes throughout the coastal waters of Alabama. We believe that the most plausible explanation for these results was the federally imposed region-wide closure of the northern Gulf of Mexico to fishing, both commercial and recreational, from May 2nd through November 15, 2010. Interestingly, the changes in food web composition and significant increases in abundance and biomass were not due to increases in the numbers and kinds of exploited species present in the study area. Rather the dramatic changes recorded during this element of our study, both during and following the DwH event, are the result of increases in the numbers and sizes of demersal, bottom-feeding fishes also known as “by-catch”. It should be noted that these increases have persisted for more than a year after the DwH riser pipe was capped.

Surveys of reef fishes similarly detected, albeit short-lived, greater abundances of larger predatory fishes than had been observed in weeks just after the DwH accident occurred. Noticeably, the numbers of tiger sharks and sharpnose sharks captured during the height of the DwH accident (and the time of the largest areal fishing closure) were substantially greater than were those collected prior to the fishing closure and in the days after fishing was reopened in the area. Interestingly, while the number of older large red snapper also increasing during the fishing closure, the abundances of new snapper recruits present in the sampled population decreased substantially. Likely, this represents a collapse of the 2010 recruitment class and is coincident with the presence of increased abundances of large piscivores of all kinds on the reefs.

Together these data suggest that any evaluation of the impacts of DwH on ecosystem structure and function in the northern Gulf of Mexico will also require assessments of the direct and impacts of state and federal government management actions taken in the region and the resultant indirect impacts of these actions on the strength and direction of food web interactions in the region.

2. Results and scientific highlights

Comparisons of the date collected from the trawl samples taken at stations located in the coastal waters of Alabama and Mississippi (Figure 1) with historical SEAMAP data collected from this area, using the same trawling technique in the ten years prior to the DwH

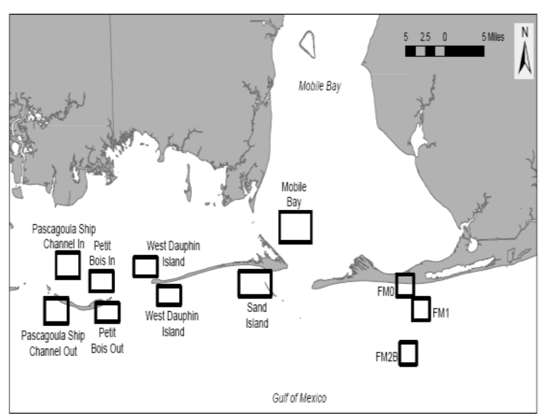


Figure 1. Boxes show locations of NGI-sponsored sample locations.

accident, indicated that a significant shift in the composition of fishes occurred in the region during and after designation of the NOAA-mandated fishing closure zone in the northern Gulf of Mexico (ANOSIM; Global R= 0.155; $p \leq 0.001$), regardless of season (ANOSIM 0.129, $p<0.004$; Figure 2). Subsequent analyses indicate that the differences in fish community composition were primarily the result of lower abundances of anchovies and increased abundances of croakers and hardhead catfish during and after the spill.

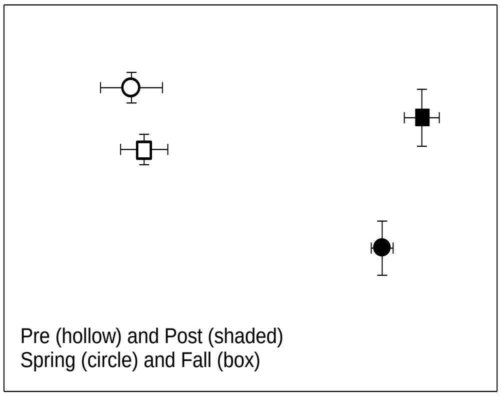


Figure 2. Multidimensional scaling plot of seasonal fish community structure pre-DwH and Post DwH.

Surprisingly, increases in total abundance ($F=4.33$, $p< 0.007$) and biomass ($F= 4.89$, $p= 0.004$) of fishes collected throughout the area continued to remain significantly greater after the reopening of the area to fishing, than they were in the ten years leading up to the spill (Figure 3). Because the numbers of exploited species captured did not differ significantly ($p= 0.44$) between the pre- and post-oil sampling events, we suggest the observed increases were due to reductions in by-catch harvests in the months following the spill. While commercially important shrimp and crabs did increase in abundance and total biomass after the spill, the proportional increase of these crustaceans was nowhere as great as those seen for the Atlantic croaker (*i.e.*, shrimps increased in abundance approximately 4x after the spill while croaker increased 8x).

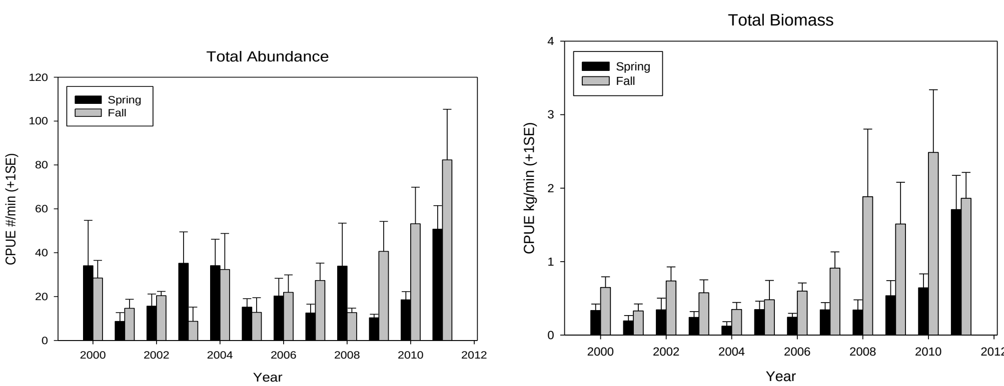


Figure 3. Changes in total fish abundance (left panel) and total biomass (right panel) in the 10 years prior to the DwH incident and in 2011.

Reef fishes and Sharks

From July 2010 through September 2011, 24 stations were sampled with vertical longline gear, and 13 stations were sampled with bottom longline gear (Figure 4). Vertical longline gear sampled almost exclusively teleost fish (n=10 species), the most common being red snapper (Lutjanus campechanus) (Figure 5). Grey triggerfish (*Balistes capriscus*) and vermillion snapper (*Rhomboplites aurorubens*) were also sampled, along with eight other species. We noted a reduction in the number of age 0 and 1 red snapper in 2011 compared to 2010 (trawls), indicating higher juvenile mortality. In contrast, we observed high abundance of older red snapper (bottom longline caught fish) in 2011 compared to 2010. These opposing trends could be explained by oil spill related mortality of younger fish and higher survivorship due to removal of fishing pressure for older fish. Equally plausible, is increased prey on young fish as a result of increase abundance of larger predators.

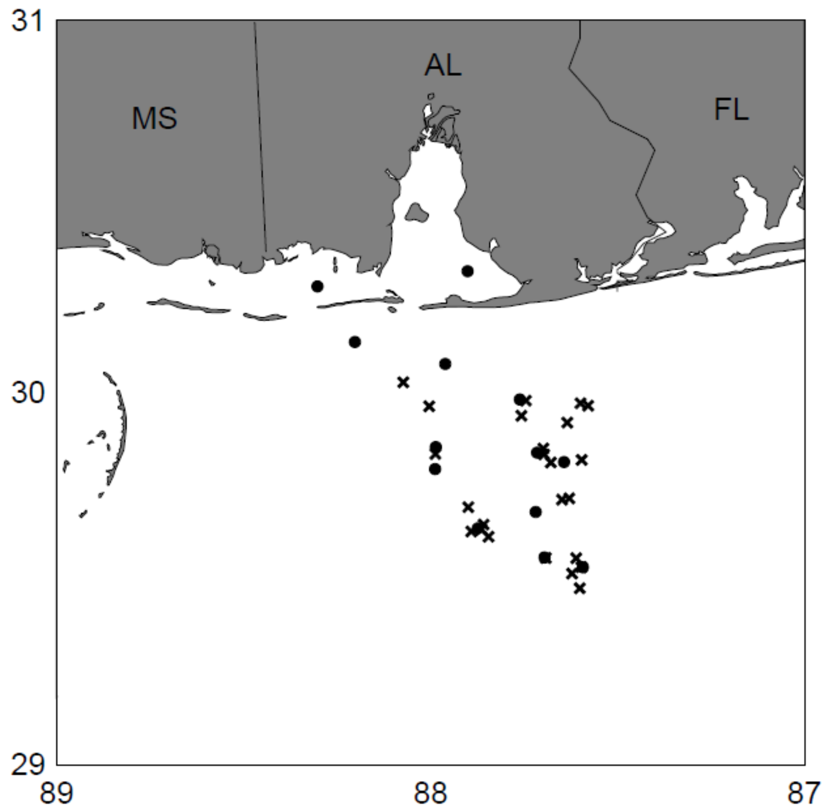


Figure 4: Location of vertical (x, n=24) and bottom (●, n=13) longline stations fished from July – September, 2010.

Data from ancillary vertical longline and trawl projects sampling in the same area strengthen the patterns observed from NGI supported work. Data from vertical longline surveys conducted from March through September show no significant decrease (F=1.415, p = 0.233) in CPUE of juvenile and adult red snapper from early spring throughout the fall (Figure 5). Typically, a decrease in CPUE throughout the year would be expected; however, the observed pattern suggests the mechanism normally responsible for the decrease in CPUE was not in place. However, trawl data from red snapper in the same area indicate a trend of decreasing abundance for age 0+ red snapper (Figure 5), without a concomitant increase in recruitment onto the reef by age 1 and 2+ snapper (Figure 5). These findings are counterintuitive, and require further investigation.

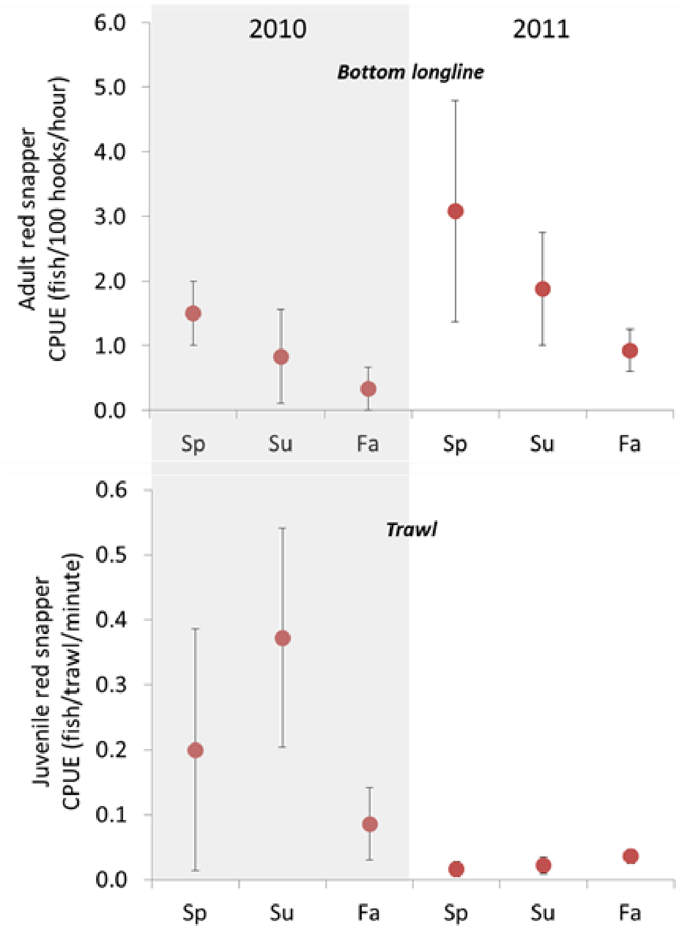


Figure 5. Mean monthly CPUE for adult (top panel) and juvenile (bottom panel) red snapper.

Bottom longline gear sampled predominately elasmobranch fish (n=11 species), the most common of which was Atlantic sharpnose shark (*Rhizoprionodon terraenovae*). In general, species composition and CPUE from the bottom longline was higher in 2010 than in 2009 or 2011 indicating that the fishery closure may have effects across multiple trophic levels. In particular, tiger shark (*Galeocerdo cuvier),* was higher in 2010 than at any point in our 2005-2011 data set (Figure 6).

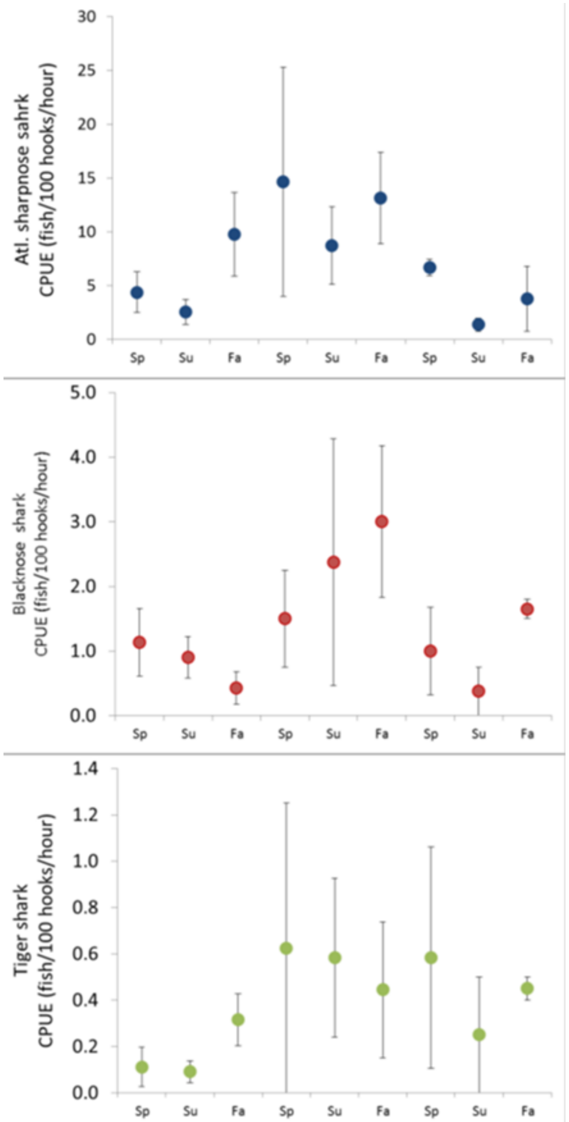


Figure 6. Mean monthly CPUE for Atlantic Sharpnose, (top panel), Blacknose (middle panel) and Tiger (bottom panel) sharks collected just prior to and after oiling in coastal Alabama.

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 Alabama Discovery	Marla Valentine	Characterize demersal fish composition in coastal Alabama and Mississippi waters	4/28/2010
DISL R/V Alabama Discovery	Marla Valentine	Characterize demersal fish composition in coastal Alabama and Mississippi waters	4/29/2010
DISL R/V Alabama Discovery	John Valentine	Characterize demersal fish composition in coastal Alabama and Mississippi waters	8/25/2010
DISL R/V Alabama Discovery	John Valentine	Characterize demersal fish composition in coastal Alabama and Mississippi waters	9/17/2010
DISL R/V Alabama Discovery	John Valentine	Characterize demersal fish composition in coastal Alabama and Mississippi waters	10/6/2010
DISL R/V Alabama Discovery	John Valentine	Characterize demersal fish composition in coastal Alabama and Mississippi waters	10/7/2010
DISL R/V Alabama Discovery	John Valentine	Characterize demersal fish composition in coastal Alabama and Mississippi waters	4/27/2011,
DISL R/V Alabama Discovery	John Valentine	Characterize demersal fish composition in coastal Alabama and Mississippi waters	5/5/2011
DISL R/V Alabama Discovery	John Valentine	Characterize demersal fish composition in coastal Alabama and Mississippi waters	5/24/2011
DISL R/V Alabama Discovery	John Valentine	Characterize demersal fish composition in coastal Alabama and Mississippi waters	5/26/2011
DISL R/V Alabama Discovery	John Valentine	Characterize demersal fish composition in coastal Alabama and Mississippi waters	9/19/2011,
DISL R/V Alabama Discovery	John Valentine	Characterize demersal fish composition in coastal Alabama and Mississippi waters	9/28/2011
DISL R/V Alabama Discovery	John Valentine	Characterize demersal fish composition in coastal Alabama and Mississippi waters	10/12/2011,
DISL R/V Alabama Discovery	John Valentine	Characterize demersal fish composition in coastal Alabama and Mississippi waters	10/13/2011
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

Valentine, J. F., S. Powers, C. Martin and M. Drymon. Impacts of the gulf-wide fishing closure on the Deepwater Horizon Assessment. Target Journal is Science. Target Date July 2012.

5. Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract Publish	Date
Field and Experimental Rapid Response Assessments of Ecosystem Resilience to Hydrocarbon Pollution and Dispersants in the northern Gulf of Mexico	J.F. Valentine		Public Presentation: Mobile Athelstan Club, Mobile, AL	No	6/6/10
Fisheries independent sampling program in the northern Gulf of Mexico: Alabama's reef permit zone	K. Gregalis	Kevan Gregalis, Sean Powers, Marcus Drymon, John Mareska	Mississippi/Alabama SeaGrant Consortium (MASGC) Bays and Bayous Conference, Mobile, AL	No	12/1/10
Overview of the Rapid Response of Sea Lab Projects	J.F. Valentine		Government Presentation: Bureau of Ocean Energy Management, Regulation and Enforcement Presentation- New Orleans, LA	Yes	3/24/11
Changes in Coastal Fish Communities Following Deepwater Horizon Oil Spill	J.F. Valentine		Government Agency: Bureau of Ocean Energy Management, Regulation and Enforcement Presentation, New Orleans, LA	Yes	3/24/11
Field and Experimental Rapid Response Assessments of Ecosystem Resilience to Hydrocarbon Pollution and Dispersants in the northern Gulf of Mexico	J.F. Valentine		Agency Presentation: Gulf of Mexico Alliance, New Orleans, LA	No	8/3/11
Field and Experimental Rapid Response Assessments of Ecosystem Resilience to Hydrocarbon Pollution and Dispersants in the northern Gulf of Mexico	J.F. Valentine		Public Presentation: Mobile County Retired FBI Agents Presentation, Mobile AL	No	2/16/12
Changes in Coastal Fish Communities Following Deepwater Horizon Oil Spill	J.F. Valentine		Alabama Academy of Science-Tuskegee AL	Yes	2/24/12
Field and Experimental Rapid Response Assessments of Ecosystem Resilience to Hydrocarbon Pollution and Dispersants in the northern Gulf of Mexico	J.F. Valentine		Public Presentation: Baldwin County Rotary Club Presentation, Bay Minette, AL	No	3/6/12
Field and Experimental Rapid Response Assessments of Ecosystem Resilience to Hydrocarbon Pollution and Dispersants in the northern Gulf of Mexico	J.F. Valentine		Public Presentation: Mobile County Audubon Club Presentation, Spanish Fort, AL	No	3/20/12
Field and Experimental Rapid Response Assessments of Ecosystem Resilience to Hydrocarbon Pollution and Dispersants in the northern Gulf of Mexico	J.F. Valentine		MENSA Society, Mobile, AL	No	5/19/12

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
John	Valentine	PI	DISL	jvalentine@disl.org
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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
Marissa	Dueker	MS	Seagrass Ecology	USA	Valentine	9/2012
Laura	Ellis	BS	Intern	DISL	Valentine	N/A
Lacey	Lee	MS	Coral Reef Ecology	USA	Valentine	9/2012
Shanna	Madsen	MS	Coral Reef Ecology	USA	Valentine	5/2012
Latina	Steele	PhD	Seagrass Ecology	USA	Valentine	12/2010
Charles	Martin	PhD/Post Doc	Ecology of Invasive Species	USA	Valentine	9/2010
Marcus	Drymon	Post-doc	Reef Fish Ecology	DISL	Powers	N/A
Andrea	Kroetz	MS	Reef Fish Ecology	DISL	Powers	2012
Christina	Walker	MS	Reef Fish Ecology	UNF	Gelsleichter	2011

10. Student and post-doctoral publications, if planned

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

Kroetz, A.K., J.M. Drymon and S.P. Powers. 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

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Changes to coastal fish communities following Deepwater Horizon oil spill	C.W. Martin	S. L. Madsen and J. F. Valentine	Poster presentation: Northern Gulf Institute Annual Meeting (Mobile, AL)	Y	5/17/2011
Changes to coastal fish communities following Deepwater Horizon oil spill	C.W. Martin		Updated poster presentation: Benthic Ecology Meeting (Mobile, AL)	Y	3/16/2011
Changes to coastal fish communities following Deepwater Horizon oil spill	C.W. Martin	S. L. Madsen and J. F. Valentine	Updated poster presentation: Mississippi-Alabama Bays and Bayous Symposium (Mobile, AL)	Y	12/1/2010
Changes to coastal fish communities following Deepwater Horizon oil spill	T.C. Kauffman	C.W. Martin, J.F. Valentine and L. Steele	Updated poster presentation: Benthic Ecology Meeting (Norfolk, VA)	Y	3/15/2011
Multiple Gear Fisheries Independent Assessment of the Red Snapper Population in Alabama's Reef Permit Zone	Lela Schlenker	Lela Schlenker, Kevan Gregalis, Marcus Drymon and Sean Powers	Annual Benthic Ecology Meeting	N	3/16/2011
Fisheries Independent Assessment of Red Snapper Populations in Alabama's Reef Permit Zone	Marcus Drymon	Lela Schlenker, Kevan Gregalis, Marcus Drymon, John Mareska and Sean Powers	Annual Northern Gulf of Mexico (NGI) Conference	N	5/18/2011
Assessing the impacts of the Deepwater Horizon Oil Spill on sharks caught off the coast of Alabama	Christina Walker	Christina Walker, Jim Gelsleichter and Marcus Drymon	Annual Meeting of the American Elasmobranch Society	N	7/7/2011

12. Images

N/A

11-BP_GRI-05: Florida State University: NGI BP Earth System

Eric Chassignet, Steve Morey and Dmitry Dukhovskoy

SCIENCE ACTIVITIES

1. General Summary: The purpose of this project was to develop components of an integrated earth system coupled model as a tool to support research into impacts of the Macondo 252 (BP) Oil Spill and the northern Gulf of Mexico physical and ecological marine systems. It is recognized that the eventual modeling system will be the product of a multi-year effort, so the objectives of this research were to develop the ocean, atmospheric, and oil spill modeling components that can be coupled into a system that includes: ocean physics, waves, atmosphere, sediment transport, marine biogeochemistry, and surface/subsurface oil.

A Regional Ocean Modeling System (ROMS) simulation of the Gulf of Mexico has been developed for multiple resolutions from 1/12° down to 1/50°. This model has a domain that is compatible for coupling with a 4 km resolution Weather Research and Forecasting (WRF) atmospheric model that has been developed through leveraging of other projects. A carefully hand-edited high-resolution (2 km) bathymetry and coastline data set has been generated for this ocean model, as well as for inclusion into the near-real-time Gulf of Mexico HYCOM (HYbrid Coordinate Ocean Model) nowcast/forecast system. Further, a parallelized surface oil transport model code has been developed along with validation algorithms based on satellite data. As a result of this recently completed project, the components are now ready for implementation into coupled modeling systems such as COAWST (Coupled Ocean – Atmosphere – Wave – Sediment Transport) to support ongoing GRI-funded efforts (e.g. Deep-C).

2. Results and scientific highlights

A ROMS-based simulation of the Gulf of Mexico has been developed as the oceanic component of the coupled modeling system. This model runs at horizontal resolution up to 1/50° with 50 vertical layers using a hand-edited bathymetry/coastline (described below). The Gulf of Mexico model is nested within the data assimilative 1/12° Global HYCOM nowcast/forecast system (www.hycom.org), which can be used to force both near-real-time model runs as well as hindcasts (for example, of the BP Oil Spill time period).

ROMS is the oceanic component of the COAWST coupled modeling system developed by J. Warner (USGS), which uses the Model Coupling Toolkit to couple ROMS with WRF, and includes the SWAN wave model as well as a Community Sediment Transport Model. A 4 km WRF atmospheric modeling component has been developed by R. Hart (FSU) leveraging additional funding resources, which, through collaboration with this project, is compatible for coupling with the ROMS domain. Thus, the core components (ocean and atmosphere) of the eventual earth modeling system are ready for transition into the coupled framework, so that implementation of the other components can commence.

A key task of this research was the development of a quality controlled bathymetry/coastline gridded data set for the Gulf of Mexico that is critical for accurate simulation near coastal areas in a high-resolution ocean model (Figure 1). Care was taken to ensure that the newly developed grid matches very well with a high resolution shoreline definition so that this modeling system can be used to study deep ocean to coast transport, and to provide boundary conditions for coastal and estuarine nested models. Two high-resolution bathymetry databases were used to produce the gridded model bathymetry: (a) the GEBCO 30-arc-sec global grid (http://www.gebco.net/data_and_products/gridded_bathymetry_data/) and (b) the National Geophysical Data Center's 3 arc-sec U.S. Coastal Relief Model database, volumes
1, 2, 3, 4 and 5 (http://www.ngdc.noaa.gov/mgg/coastal/crm.html). The water depths were determined using a natural-neighbor interpolation algorithm (http://rses.anu.edu.au/geodynamics/nn/nn.html), essentially a weighted area interpolation. The final bathymetric grid was fine tuned by slightly smoothing the water depths at selected areas so that the resulting bathymetry is appropriate for use in models with multiple vertical coordinate systems with minimal alteration of the seafloor depths. This newly developed bathymetry is publicly available at the HYCOM's web site (http://hycom.org/).

The computational grid was chosen to conform to the 1/25° (≈ 3500 m) and 1/50° Gulf of Mexico HYCOM domains that are run at NRL, and the grids have been made available for transition to those modeling systems. The purpose of this is to ensure consistency among the different ocean models so that the HYCOM can also be implemented in the earth system model to provide for multiple options to be used as the oceanic component.

Finally, algorithms have been developed to utilize the Synthetic Aperture Radar (SAR) derived oil slick maps produced by FSU collaborators MacDonald and Garcia for validating and calibrating surface oil models. To develop and test these metrics, a reduced-physics oil spill model was developed. This model can be readily coupled to the earth system model for development and testing purposes, and replaced with the more advanced oil spill models being developed under current GRI-funded research (Deep-C). This model consists of a basic particle tracking algorithm in which discrete particles representing a set volume of oil are advected in a velocity field constructed from surface currents from an ocean model. To the surface current is added a commonly-used wind drift parameterization: 3.5% of the wind speed directed at a wind-speed dependent angle to the right of the wind vector. Here, winds are taken from an atmospheric model. New oil particles are added to the system to simulate the surfacing of leaking oil (given estimates of the rate at which oil reached the surface, the quantity of oil represented by each particle can be easily calculated). As the oil is advected, a random walk algorithm is applied, increased near source to account for gravitational spreading. Particles are removed from the computation randomly based on a prescribed half- life to parameterize weathering processes. The time history of particle positions can be processed in the same manner as the SAR imagery to objectively compare the oil spill model to the observations.

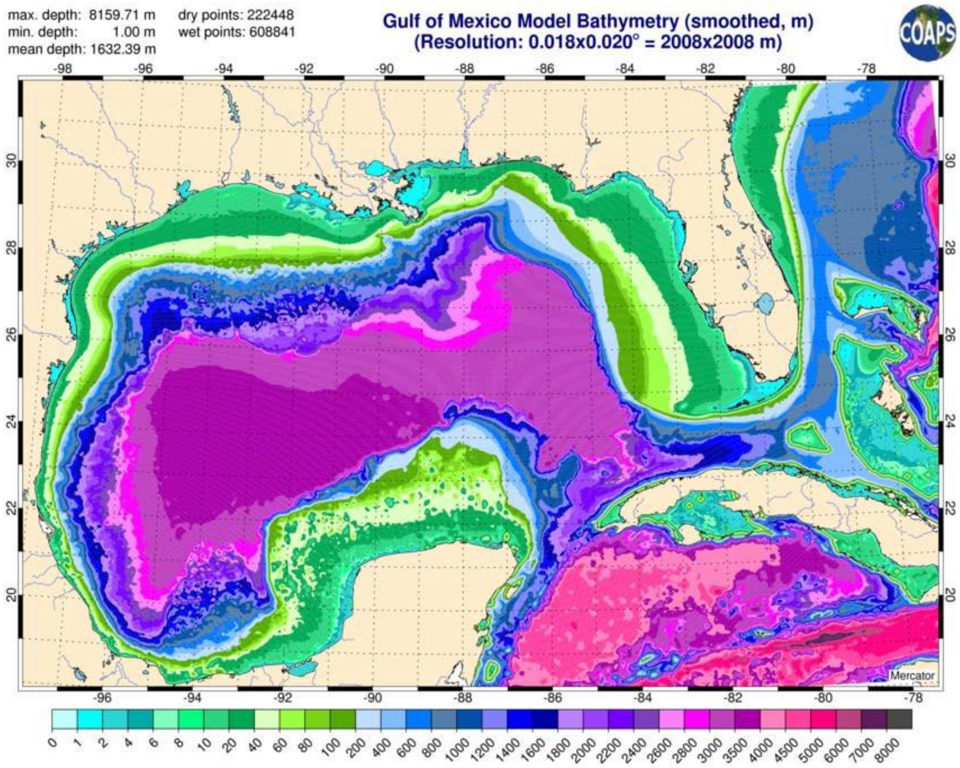

Figure 1. The 1/50° computational bathymetric grid for the Gulf of Mexico model domain.

3. Cruises & field expeditions

N/A

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
Objective evaluation of oil spill models using SAR imagery	Steve Morey	Steve Morey Dmitry Dukhovskoy Eric Chassignet Ian MacDonald Oscar Garcia	American Society of Limnology and Oceanography	Y	Feb 2011
Oil Spill Model Validation and Parameter Estimation using Remotely Sensed Data	Steve Morey	Steve Morey Dmitry Dukhovskoy Eric Chassignet Ian MacDonald Oscar Garcia	Gordon Research Institute Conference on Coastal Oceanography	N	June 2011
Objective Evaluation of Oil Spill Models using SAR Imagery	Dmitry Dukhovskoy	Dmitry Dukhovskoy Steve Morey Eric Chassignet Ian MacDonald Oscar Garcia	NGI Annual Workshop	N	May 2011

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
Eric	Chassignet	PI	FSU	echassignet@coaps.fsu.edu
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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

11-BP_GRI-06: Florida State University: Automated Mapping of Surface Oil Spill: Surface Physics and Remote Sensing Associated with Movement and Identification of a Slick

Mark A. Bourassa

SCIENCE ACTIVITIES

1. General Summary: Obtain both routine and high resolution scatterometer data (from ASCAT, and if available from the Indian OceanSat2 scatterometer). We obtained access to the high resolution ASCAT data. High resolution data from OceanSat2 is still not available.

Begin to test edge detection on areas where the oil slick modifies the satellite observations
A colleague's (Prof. David Long) research group at BYU had developed an effective technique for determining the location of the oil from ASCAT data. We used their results.

Successfully run the COAWST model: a coupled atmospheric, wave, and ocean model.
This objective was achieved only with the help of the developer of COAWST, and is still being worked on for the Gulf of Mexico domain needed for our study

Begin to examine the importance of transport of surface oil do directly to wind for, waves, and Ekman transport
We completed a preliminary study that examined how Ekman-related surface movement changed due to the oil. We compared these estimates to Stokes drift. When swell is substantial, Stokes drift can be large in comparison to Ekman motion.

Determine upper and lower limits of wind speeds for which the automated detection based on satellite data will accurately work
The technique worked very well for wind speeds >2.5m/s. For lower wind speeds (<2 m/s), the oil free surfaces were also smooth in large patches, resulting in false alarms.

Modify the flux algorithm in COAWST to utilize our flux model that can easily be modified to account for the influences of an oil slick on air/sea interaction
Algorithm developed above can be inserted in COAWST fluxes

Estimate the confidence (as a function of wind speed) for the automated detection based solely on satellite data. Determine importance of a time series,
Highly confident for DWH surface slick provided a time series was available

Improve the tuning of the modeled transport of surface oil
Stokes drift was found to be important, but tuning could not be evaluated

Complete the tuning of the combined satellite detection algorithm with the improved first guess from the modeled transport of oil
Uncompleted due to difficulties with working the coupled model in our domain

2. Results and scientific highlights

Given the problems mentioned above with the coupled model, we modified an atmospheric boundary-layer model (the University of Washington Planetary Boundary-Layer model; UWBPL) for this study. We coupled the UWPBL with a surface flux model (Bourassa 2006) that was further modified to account for oil-related changes in stress, and turbulent heat and moisture fluxes. We completed a preliminary study that examined how Ekman forcing changed due to the oil, and how these changes modified the movement of a surface slick. This simplified model was found to be effective for testing of the relative importance of some processes for moving oil.

We compared estimates of Ekman-related surface motion to Stokes drift. Swell seas are relatively rare in the Gulf of Mexico; however, when they are substantial, they are large in comparison to Ekman montion. Stokes drift is also likely to be an important mechanism for transporting oil from the shallow water to the shore.

We found that oil suppressed some short surface water waves even wind the winds were strong enough to create short waves on oil-covered waters. This finding indicates that even for high wind speeds, oil can be detected. The BYU technique worked very well for wind speeds >2.5m/s to 8m/s. For higher wind speeds, the DWH oil slick could still be clearly identified, even though the winds were strong enough to roughen the oil covered surface. For lower wind speeds (<2 m/s), the oil free surfaces were also smooth in large patches, which meant that individual snapshots could not be used to identify oil slicks. However, when the time series of areas with smooth surfaces was used, the oil locations were distinguishable from the oil free locations

The Bourassa (2006) surface turbulent flux parameterization was modified to change stress and latent heat fluxes for an oil-covered sea surface. The parameterization suppresses roughness due to short waves (capillary waves) and long waves (gravity waves) as a function of the wind speed. We used the observations of surface roughness from the ASCAT scatterometer to estimate the tuning for this model. While the physical concepts seem applicable to any oil spill, the tuning is particular to the DWH spill.

We examined oil trajectories (based on SAR and ASCAT data) to assess the tuning of wind drift in comparison to Stokes drift. For most of the limited number of cases available, the direction and magnitude of drift due to Stokes drift was more consistent with the observations. We are not confident that Stokes drift completely overwhelms wind drift; however, we do believe that Stokes drift should be included in oil trajectory models

3. Cruises & field expeditions

We used satellite data rather than cruise observations.

4. Peer-reviewed publications, if planned

a. Published, peer-reviewed bibliography
N/A
b. Manuscripts submitted or in preparation
Heath, N, M. A. Bourassa, and D. Dukhovskoy: Stokes drift as a mechanism for surface oil transport in the Gulf of Mexico, in preparation for GRL
Zheng, Y., M. A. Bourassa, P. J. Hughes: Influences of sea surface temperature gradient and surface roughness changes due to a slick on the motion of surface oil: A simple idealized study. In preparation for BAMS

5. Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
How temperature and roughness changes due to a slick influence the motion of a surface oil slick	Yangxing Zheng	Zheng, Y., M. A. Bourassa, and P. Hughes	Ocean Sciences 2012	Y	Feb. 2012
Determining the Effects of Stokes Drift on the Movement of Oil in the Gulf of Mexico	Nick Heath	Heath, N., M. Bourassa, and D. Dukhovskoy	Northern Gulf Institute Annual Conference 2011	Y	May 2011

6. Other products or deliverables

Code for considering oil modification of surface turbulent fluxes is available from Mark Bourassa (mbourassa@coaps.fsu.edu)
ASCAT maps of the oil spill were from our collaborator, Prof. David G. Long, at BYU (long@ee.byu.edu). We anticipate that the images will be more freely available when his student publishes the results

7. Data

ASCAT maps of the oil spill were from our collaborator, Prof. David G. Long, at BYU (long@ee.byu.edu). We anticipate that the images will be more freely available when his student publishes the results. The ASCAT data are freely available via NASA and KNMI websites.

PARTICIPANTS AND COLLABORATORS

8. Project participants

First Name	Last Name	Role in Project	Institution	Email
Mark	Bourassa	PI	FSU	mbourassa@fsu.edi
Nick	Heath	Undergraduate honors student	FSU	nheath@coaps.fsu.edu
Yangxing	Zheng	Postdoc	FSU	yzheng@coaps.fsu.edu
Paul	Hughes	Graduate Student	FSU	phughes@coaps.fsu.edu
David	Long	Collaborator	BYU	long@ee.byu.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
Nick	Heath	BS	Determining the effects of stokes drift on the movement of oil in the Gulf of Mexico	FSU	Bourassa	2011
Paul	Hughes	PhD	Loosely related	FSU	Bourassa	2012
Yangxing	Zheng	Post-doc	Surface Oil Slick Motion	FSU	Bourassa	2012

10. Student and post-doctoral publications, if planned

a. Published, peer-reviewed bibliography
N/A
b. Manuscripts submitted or in preparation
Heath, N, M. A. Bourassa, and D. Dukhovskoy: Stokes drift as a mechanism for surface oil transport in the Gulf of Mexico, in preparation for GRL
Zheng, Y., M. A. Bourassa, P. J. Hughes: Influences of sea surface temperature gradient and surface roughness changes due to a slick on the motion of surface oil: A simple idealized study. In preparation for BAMS

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

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
How temperature and roughness changes due to a slick influence the motion of a surface oil slick	Yangxing Zheng	Zheng, Y., M. A. Bourassa, and P. Hughes	Ocean Sciences 2012	Y	Feb. 2012
Determining the Effects of Stokes Drift on the Movement of Oil in the Gulf of Mexico	Nick Heath	Heath, N., M. Bourassa, and D. Dukhovskoy	Northern Gulf Institute Annual Conference 2011	Y	May 2011

12. Images

The high quality images are from a collaborator, and cannot be shared until his student publishes the results. Other images are included in the student presentations.

11-BP-GRI-07: Florida State University: Uncertainty Quantification in Oil Spill

Kyle A. Gallivan, Steve Morey

SCIENCE ACTIVITIES

1. General Summary: Uncertainty quantification has become a major concern for a wide range of communities. Simulation codes must account for uncertainty in some of the intrinsic parameters of the problem and provide confidence intervals and statistics of the outputs. We have developed a technique to characterize the relationship between a small number of quantities derived from the physical systems modeled by large-scale (differential) equations and parameters in the model. The technique combines ideas from a standard uncertainty quantification approach known as Polynomial Chaos and efficient representations of functions via compressed sensing. It does not require modification of legacy codes used to evaluate the governing equations for particular samples of the parameters and accurately approximates the relationship between the derived quantities and the parameters using far fewer model evaluations than standard techniques. It has been demonstrated using Shallow Water Equations to model the effect of an underwater seismic event on coastal sea heights in a recently published paper L. Mathelin and K. A. Gallivan , A Compressed Sensing Approach for Partial Differential Equations with Random Input Data, Communications in Computational Physics Vol. 12, pp. 919-954, 2012 (submitted before the beginning of this one year project). We propose to investigate the use of this technique for two main tasks: (i) to efficiently and effectively create functions describing the relationship between characteristics of the evolution of an oil spill (e.g., concentration of the oil at particular points in time and space) and particular model parameters; (ii) to investigate the potential for improving the efficiency and reduce the complexity of complicated simulation codes that evaluate physical models by using the functions generated in Task (i) to replace detailed simulations of portions of the models. We have successfully investigated Task (i) and developed an experimental code that shows that such the coefficients defining such a function could be done with a relatively small number of model evaluations. Additionally, we briefly explored characterizing the shape of the oil spill via an average shape defined by the Karcher mean of representative closed curves on the Riemannian manifold of closed curves in a plane.

2. Results and scientific highlights

Our starting point was a MATLAB-implemented model developed by co-investigator Steve Morey to provide daily forecasts through the State of Florida Oil Spill Academic Task Force in response to the BP crisis. The model has also been used collaboratively with other researchers to develop and test new model validation metrics using remotely sensed data. These model runs have been forced by surface currents from the 1/25° Gulf of Mexico HYCOM (HYbrid Coordinate Ocean Model) Nowcast/Forecast System (www.hycom.org) and surface winds from the NOAA/NCEP RUC (Rapid Update Cycle) model. It is an adaptation of that described in Samuels et al. (1982) in which oil on the surface is transported in a vector field formed as a linear combination of the ocean surface current vector field and the surface wind vector field with magnitude reduced by a multiplication factor of 0.035 rotated to the right at an angle given by a wind speed-dependent function. Surface oil is treated as discrete particles, with each oil “particle” representing a set mass of oil. The particles are advected using a fourth-order Runge-Kutta algorithm. The oil particles can be removed from the domain based on a number of factors such as age, but the most basic is random removal consistent with a prescribed half-life (typically between 3 and 7 days). New oil particles are added to the surface randomly distributed within a small region about the well site. Unresolved turbulent 2-D mixing processes are represented by Laplacian diffusion, and gravitational spreading is parameterized by increasing the diffusion coefficient for particles near the spill site. This model was appropriate from a scientific point of view but did not achieve sufficiently high performance in terms of an acceptable computing time to use as basis for our experiments. Therefore our first successful task was the development of a Fortran version that could be executed for several samples of the relevant parameters simultaneously on FSU's HPC system.This was supplemented by an optimization code developed for the work of Mathelin and Gallivan cited above and modified for this project. Both codes could be cleaned up to be a distributable piece of software.

The model parameters of interest were diffusion, oil half-life, viscosity and mixing. The viscosity was quickly eliminated as a parameter of interest for our data. The initial derived quantities were areas of an enclosing region of the oil spill at a specified point in time. A simple bounding rectangle, a bounding ellipse, and a compound ellipse were used. It was found that the areas of these shapes were not useful in describing the oil spill and did not lend themselves to the uncertainty quantification technique used. A second set of derived quantities involved discrete probabilities of the oil particles reaching specified areas of the Gulf of Mexico by a specific time interval. These areas were defined by an angular range relative to the center point of the spill and minimum and radial distances from the center. It was found that these probabilities did lend themselves to definition by the polynomial chaos based function with coefficients that could be determined with a relatively small number of model evaluations. The error between the function values generated from training data and test data over the same range of the input parameters was used to demonstrate effective approximation of the probabilities. Since these parameters are defined as inner products involving integration, we also compared the quality of sparse deterministic numerical quadrature schemes, i.e., Smolyak points-based methods, to approximate the coefficients. We found that the Compressed Sensing approach provided usefully accurate coefficients while when restricted to the same number of points the Smolyak approach produced very poor approximations of the coefficients. We conclude that the approach has promise in situations where rapid prediction of the location of oil is needed and predicted or observed values of the vector fields of current and wind are available. In situations where these vector fields are also influenced by the model parameters the approach would require that the large vector fields depend only a small number of such parameters.

We also began an initial consideration of using our experience in Riemannian manifold optimization and related manifold-based shape analysis to validate the model and possibly to generate a parameterized distribution characterizing the shapes of the oil spill. We successfully developed a simple algorithm that extracted a closed curve in the plane from oil particle sets produced by the model as a function of model parameters. We then computed the Karcher mean of the shapes. The initial results are promising but further work is needed comparing the shapes to the satellite observations of the oil spill and investigating the generation of a distribution.

3. Cruises & field expeditions

N/A

4. Peer-reviewed publications, if planned

a. Published, peer-reviewed bibliography

N/A

b. Manuscripts submitted or in preparation

None yet however collaborative discussions with M. Bourassa of COAPS/FSU continue on the use of these techniques in an application setting that could be the basis for an archival publication.

5. Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Uncertainty Quantification in Oil Spill Evolution	Gallivan	Gallivan, Morey, Eilertsen, Mathelin	NGI Annual Conference 2011		May 19, 2011

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
Kyle	Gallivan	Principal Investigator	FSU	kgallivan@fsu.edu
Steve	Morey	CoPrincipal Investigator	FSU/COAPS	morey@coaps.fsu.edu
Lionel	Mathelin	Scientific Participant	LIMSI-CNRS, France	mathelin@limsi.fr

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
Justin	Eilertsen	PhD	Efficient Simulation and Uncertainty Quantification	Florida State University	Gallivan	NA
Wen	Huang	PhD	Optimization	Florida State University	Gallivan	2013

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

11-BP_GRI-08: Florida State University: Deepwater Horizon Oil Deposition in Gulf of Mexico Beaches Phase 2: Recovery of the Beach Sedimentary Environment

Markus Huettel, Joel Kostka

SCIENCE ACTIVITIES

1. General Summary: In May/June 2010, large quantities of Deepwater Horizon crude oil were deposited on the sandy beaches in the northeastern Gulf of Mexico. While the more viscous components of the oil were deposited on the surface of the sand, other oil components that were dispersed through wave action and addition of detergent penetrated deeper into the sand. Storm activity during tropical depression Alex and longshore transport processes deposited sand on top of the beached oil generating buried oil layers and sediment zones mixed with dispersed oil. Concentrated tar layers were found at depth down to 65 cm and the layer with dispersed oil locally was 35 cm thick. In October 2010, clean up crews removed the upper 60 cm of the beach sediment and put this sediment through sifting machines that removed the concentrated tar but also disintegrated sand layers with lower tar content that therefore were not as cohesive ad the concentrated tar layers. The sifted sand with the small oil particles produced during the sifting process were redeposited on the beach forming an up to 30 cm thick layer of sand with dispersed oil particles. In this project, we investigated the transition from the beach with concentrated oil layers and the beach with dispersed oil particles.

The main goal was to characterize the degradation process under the influence of different environmental conditions and the impact of the cleanup procedures.

We quantified the degradation of dispersed Deepwater Horizon crude oil buried Gulf sand beaches at the transition and after the deep cleaning process and the response of the sedimentary microbial community to the changes in the beach.

Laboratory column reactor experiments were conducted to investigate the transport of crude oil within the beach sediment.

A long-term experiment was established at Pensacola Beach that addresses the degradation of crude oil buried at different sediment depth.

The microbial community in the sand and its spatial and temporal dynamics were investigated.

Our results indicate a relatively rapid recovery of the beach from the oil spill that was supported by the deep cleaning process and an active aerobic beach microbial community.

2. Results and scientific highlights

Buried oil degradation followed by oxygen consumption rates. We sampled the contaminated beach site at Pensacola beach at monthly to bimonthly intervals for analysis of the tar composition in the sand and the associated microbial community. With GCMS, fluorescence, oxygen and dissolved inorganic carbon (DIC) measurements, we quantified the processes at the transition from naturally layered sediment with embedded oil to the mixed sediment after the deep cleaning process. Before the deep cleaning process, the average beach oil concentrations reached up to 800 mg aliphatic hydrocarbons and 300 mg aromatic hydrocarbons per 1 kg beach sand. PAH concentrations ranged from 0.001 to 1 mg kg^{-1}. Oxygen consumption rates reached 5 µmol cm^{-3} d^{-1} in embedded tar layers, in contrast to 0.3 µmol cm^{-3} d^{-1} in the sediment with minor oil contamination. In control beach sediments, the oxygen consumption rate of clean sand, a proxy for the aerobic decomposition activity in the sediment, ranged from 205 to 245 mmol m^{-2} d^{-1}. Oil contamination increased this rate to 450 ± 130 mmol m^{-2} d^{-1}. These enhanced rates dropped within two months to 240 ± 180 mmol m^{-2} d^{-1}, the latter rate was reached before the deep cleaning process. These measurements revealed that even before the deep cleaning process, the beach microbial community had decomposed most of the highly degradable oil. The deep cleaning reversed the trend and increased oxygen consumption rates were recorded in the sand after the cleaning procedure. The values initially increased to 305 ± 40 mmol m^{-2} d^{-1} and further increased with the next two months to 335 ± 60 mmol m^{-2} d^{-1}. The next sampling, two month later suggested a decline of the consumption rates to 290 ± 100 mmol m^{-2} d^{-1}.

We conclude from these results that the dispersion of the oil due to the sifting process initially formed a large number of small oil particles and also exposed the central parts of tar layers and balls, that contained still highly degradable oil components, to the microbial community. The higher oxygen consumption rates after the cleaning process reflect the consumption of these newly exposed degradable oil components and the effect of the enhanced surface area after the sifting process.

Microbial community response: In order to characterize the microbial community involved in the oil degradation process, oil-degrading bacterial populations were enumerated by the three-tube most-probable-number (MPN) assay using 10-fold serial dilutions of beach sand in growth medium. Tubes were incubated at room temperature for one month and bacterial growth was monitored by culture turbidity and depletion of added oil at regular intervals in comparison to autoclaved controls. The MPN index was determined from statistical tables published by the American Public Health Association (1969). Strains of oil-degrading bacteria were isolated from the highest positive dilutions of the MPN enrichments as well as from parallel enrichments conducted in larger volumes of the artificial seawater medium or with filter-sterilized seawater as the enrichment medium. Bacterial community structure was initially assessed in DNA extracts by community fingerprinting using the automated ribosomal intergenic spacer analysis (ARISA) method (Ranjard et al. 2000). This technique allowed for the rapid comparison of a large number of samples and aided in identifying critical samples for pyrotag sequencing.

MPN counts of cultivatable hydrocarbon-degrading bacteria in oil-contaminated sands (2.4 x 10^{10} cells ml^{-1}) exceeded those from "clean" sands sampled in parallel by 3 to 4 orders of magnitude (2.4 – 9.3 x 10^{6} cells ml^{-1}). Bacteria in Pensacola Beach sands were on average 2 to 4 orders of magnitude more abundant in the presence of oil contamination. The bacterial abundance as determined by qPCR increased with the concentration of total petroleum hydrocarbons, especially the abundance of the known hydrocarbonoclastic group of *Alcanivorax* spp.. This response of the microbial community was relatively short lived. The dramatic increases declined after a period of approximately 3 months.

We conclude from these measurements that the microbial community in Pensacola Beach sand can rapidly respond to hydrocarbon input and the rapid increases of oxygen consumption rates revealed that aerobic oil degradation in these unsaturated sands can effectively decompose the degradable components of the buried oil.

Oil transport into and through the sand. For the investigation of the transport of oil components through the sand, laboratory column reactors were used that consisted of transparent acrylic core liners (Ø 3.5 cm) that were sealed at the bottom with gauze-covered stoppers. Oil-free sand from the upper part of the beach at Pensacola Beach, Florida, was sieved to remove shell hash and large organic debris, and the fraction smaller than 500 µm was filled into the core liners to produce 10 cm sand columns saturated with artificial seawater (S=33, created with Instant Ocean®). This procedure resulted in sand columns with similar permeabilities allowing comparison of the columns and quantifiable percolation rates. Three series of experiments were conducted that differed in the composition of the percolating water. We tested water with mechanically dispersed crude oil and water with chemically dispersed oil. The controls received water without oil. The main goal of this experiment was to assess the transport rates of mechanically and chemically dispersed oil through the sand and to assess whether this oil transport changes the degradation rates in the sand, which were quantified by measuring DIC production rates in the sediment. The experiment revealed that mechanically dispersed oil penetrates only a few centimeters into the Pensacola Beach sand, while the addition of detergent increased the penetration depth by an order of magnitude. Sediments that were flushed by oil-containing water responded with increased DIC production rates suggesting that the microbial community readily responded to the hydrocarbon input.

We conclude from these experiments that the oil-stained layers that we observed in Pensacola Beach sands were caused by chemically dispersed oil that reached the beaches and subsequently percolated into the permeable sand.

Long term buried oil degradation experiment. A long-term oil experiment was established at Pensacola Beach. The purpose of this experiment is to quantify the degradation of tar from the BP oil spill that is embedded at different depth in the beach sand at Pensacola Beach. Tar was collected from deep sand layers at Pensacola Beach and filled into small perforated stainless steel containers. Ten of these containers were attached to a 50 cm PVC pipe that keeps the tar at defined locations and defined sediment depths. Ten of these PVC pipes with attached tar samples were embedded at 1 m above the high tide line. Tar samples (one PVC pipe with attached tar samples) were removed at monthly intervals weighed and analyzed for their composition in order to follow the degradation of the tar. This experiment is still ongoing. Preliminary results indicate a leaching of oil components from the embedded tar balls into the surrounding sediment and degradation of the embedded oil that differs with sediment depth. This experiment will be concluded in July 2012.

The experiment is expected to produce quantitative information on the degradation of embedded oil at different sediment depth. Key variables that are influencing the sedimentary degradation are temperature, oxygen and moisture gradients.

3. Cruises & field expeditions

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
Beach sampling	Pensacola	Markus Huettel	Sampling of oiled sediments	1/19/11
Beach sampling	Pensacola	Markus Huettel	Sampling and measurements	3/2/11
Beach sampling	Pensacola	Markus Huettel	Sampling of oiled sediments	4/21/11
Beach sampling	Pensacola	Markus Huettel	Sampling of oiled sediments	6/16/11
Beach sampling	Pensacola	Markus Huettel	Sampling and measurements	7/28/11
Beach sampling	Pensacola	Markus Huettel	Sampling of oiled sediments	9/14/11
Beach sampling	Pensacola	Markus Huettel	Sampling of oiled sediments	12/7/11
Beach sampling	Pensacola	Markus Huettel	Sampling of oiled sediments	1/10/12
Beach sampling	Pensacola	Markus Huettel	Sampling of oiled sediments	1/19/11

4. Peer-reviewed publications, if planned

a. Published, peer-reviewed bibliography

Kostka, J.E., Prakash, O., Overholt, W., Green, S., Freyer, G., Canion, A., Delgardio, J., Norton, N., Hazen, T., Huettel, M. (2011). Hydrocarbon-degrading bacteria and the bacterial community response in Gulf of Mexico beach sands impacted by the Deepwater Horizon oil spill. Applied And Environmental Microbiology, Nov. 2011, Vol. 77, 7962–7974, doi:10.1128/AEM.05402-11

b. Manuscripts submitted or in preparation

Zuijdgeest, A., Huettel, M. (in prep.). Dispersants as used in response to the deepwater horizon spill lead to higher mobility of polycyclic aromatic hydrocarbons in oil-contaminated saturated beach sands. Plos one.

5. Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Penetration, Accumulation and Degradation of Deepwater Horizon Oil in Florida Sandy Beaches.	Huettel, M.	Huettel, M., Kostka, J.E., M Prakash, M., Overholt, W. A., Green, S., Freyer, G., Canion, A., Jonathan Delgardio, J., Norton, N.	Goldschmidt Conference 2011	Y	8/16/2011
What happened to the Deepwater Horizon oil that was washed onto Florida's beaches?	Huettel, M.	Huettel, M. Kostka, J.E., Prakash, O., Kaba, J., Hagan, C., Wells, B., Overholt, W., Green, S., Canion, A., Delgardio, J., Norton, N., Chipman, L., Cheng, C., Russell, L.,	Public lecture, FSU Coastal Marine Laboratory	N	9/8/2011
Deepwater Horizon oil in Florida sandy beaches	Huettel, M.	Huettel, M., Kostka, J., Hastings, D., Prakash, O., Kaba, K., Hagan, C., Wells, B., Overholt, W., Ruddy, B., Canion, A., Norton, N., Roeder, T.	Deepwater Horizon Oil Spill Conference, St. Petersburg, FL		10/25/2011
Deepwater Horizon Oil In Florida Sandy Beaches.	Huettel, M.	Huettel, M., Kostka, J. E.	21st Biennial Conference of the Coastal and Estuarine Research Federation	Y	11/8/2011

6. Other products or deliverables

N/A

7. Data

Sampling of oil contaminated and clean control sediments. Measurements of relevant environmental parameters						
Date	**PI**	**Sediment oil Investigation**	**Environmental Measurements**	**Oxygen Consumption**	**DIC Production**	**Oil Degradation Experiment**
1/19/11	Huettel	X	X	X	X	X
3/2/11	Huettel	X	X	X	X	
4/21/11	Huettel	X	X	X	X	
6/16/11	Huettel	X	X	X	X	X
7/28/11	Huettel	X	X	X	X	
9/14/11	Huettel	X	X	X	X	
12/7/11	Huettel	X	X	X	X	X
1/10/12	Huettel	X	X	X	X	

Sample collection					
Date	**Location**	**Core**	**Oil**	**Number**	**Activity**
1/19/11	Pensacola	X	X	6	Dry beach and vertical profile
3/2/11	Pensacola	X	X	6	Dry beach and vertical profile
4/21/11	Pensacola	X	X	6	Dry beach and vertical profile
6/14/11	Pensacola	X	X	6	Dry beach
7/28/11	Pensacola	X	X	6	Dry beach
9/14/11	Pensacola	-	-	6	Dry beach
1/10/12	Laguna Beach	-	-	3	Dry beach

PARTICIPANTS AND COLLABORATORS

8. Project participants

First Name	Last Name	Role in Project	Institution	Email
Markus	Huettel	PI	FSU	mhuettel@fsu.edu
Joel	Kostka	Co-Pi	Georgia Tech	joel.kostka@biology.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
John	Kaba	PhD	Oil and oxygen dynamics	FSU	Huettel	2014
Chris	Hagan	PhD	Polyaromatic hydrocarbons	FSU	Huettel	2015
Brian	Wells	PhD	Oil degradation in beach sands	FSU	Huettel	2015
Andy	Canion	PhD	Nitrogen dynamics in sediments	FSU	Huettel	2012
Ian	Hunter	BS	Oil fluorescence	FSU	Huettel	2012
Stacia	Dudley	BS	DOC release from oil	FSU	Huettel	2012
Nikita	Norton	BS	Oil degrading bacteria	FSU	Huettel	2013
Markietta	Butler-Hill	BS	Oil analysis	FSU	Huettel	2013

10. Student and post-doctoral publications, if planned

N/A

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

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
The Effect Of Deep Water Horizon Oil On Oxygen Consumption In North Florida Beaches.	Kaba, J.	Kaba, J., Hagan, C., Wells, B., Dudley, S., Huettel, M.	21st Biennial Conference of the Coastal and Estuarine Research Federation		11/8/2011

12. Images

Fig. 1. Machine for beach deep cleaning at Pensacola Beach (Photo: Huettel)

Fig. 2. Beach after deep cleaning (Photo: Huettel)

Fig. 3. Sediment core with oil layer (Photo: Huettel)

Fig. 4. Establishment of the tar ball degradation experiment (Photo: Huettel)

Fig. 5 Sediment coring at Pensacola Beach (Photo: Huettel)

Fig. 6 Sediment cores retrieved after the deep cleaning process showing layer of dispersed oil particles. (Photo: Huettel)

11-BP_GRI-09: Florida State University: Tracing the intrusion of the GOM-2010 oil spill on marine food webs with natural abundance radiocarbon (^{14}C) and stable isotopes

Jeffrey P. Chanton, Kevin Craig

SCIENCE ACTIVITIES

1. General Summary: The Deepwater Horizon oil spill was effectively a large-scale tracer release. The large pulse of carbon from the spill that entered the marine environment provides an opportunity to both better understand the functioning of coastal ecosystems and investigate the effects of the spill on coastal food webs and fisheries. It is estimated that some 780000 m^3 of oil and 205000 mT of methane were released into the northern Gulf of Mexico over the 85 day period of the spill (Adcroft et al., 2010). This material is unique in terms of its isotopic composition, both in terms of $\delta^{13}C$, $\Delta^{14}C$ and possibly $\delta^{34}S$. We hypothesized that this pulse of radiocarbon-free dead carbon will be assimilated into the sediments and the food web.

The objectives of our research were to:

1. Determine the $\Delta^{14}C$ ‰ radiocarbon content of organic material currently at equilibrium with atmospheric CO_2 which represents the “modern” endmember. The other endmember would be petro-carbon with a $\Delta^{14}C$ ‰ radiocarbon of -1000‰.

2. Determine the radiocarbon content of seafloor sediments with the goal of determining the location of impacts and the quantity of petro-carbon that affected the seafloor.

3. Determine the radiocarbon content of plankton to determine to what extent they reflected the input of petro-carbon relative to modern atmospheric inputs.

4. Determine the radiocarbon content of coastal fauna to determine to what extent they reflected the input of petro-carbon relative to modern atmospheric inputs.

2. Results and Scientific Highlights

With regard to objectives 1-4 above.

1. Gravin et al (2012) report measurements of tropsopheric CO2 in 2007 with a Δ14C value of 50.1 ± 4.2‰. They suggest that the rate of decrease of 14C in atmospheric CO_2 is 5.5‰ per year. This decrease is due to atmospheric nuclear testing in eh 1960’s which artificially elevated the $\Delta^{14}C$ value relative to “modern” values. The results of Gravin et al indicate that the current value of CO_2 in 2011 the year of our sampling should be 33 ± 5‰. We made sure of this value in three ways. We collected fish samples in areas of the Eastern Gulf unaffected by petro-impacts, we examined dissolved CO_2 in these areas, and we measured marsh macrophytes. The results are shown in Table 1.

Table 1. Results constraining the value of “modern” carbon in 2011. Samples obtained from unaffected areas. The *Spartina alterniflora* samples were above ground biomass. The mean values weights each series equally and is within the error of the estimate by Gravin et al (2012).

Material	□^{14}C‰	□	n
Fish muscle	36.7	5.6	10
Dissolved CO2	41.1	3.7	8
Spartina alt.	32.3	3.6	2
Mean	**36.7**	**4.5**	**3**

2. One of the main accomplishments of our project has been to produce a map of the radiocarbon content of seafloor sediments (Figure 1). Many of these samples have been analyzed for other oil constituents by other NGI supported groups and comparison of these results is still pending. We have made ^{14}C measurements at over 60 sites seafloor on the seafloor as depicted on this map. The brighter colors and more negative values on the □^{14}C scale indicate less radiocarbon (^{14}C) and thus more fossil (oil) carbon in the sediments. The SW trajectory of the plume is evident and the results show that the fossil carbon appears to have drifted as far as 150 km away from the oil blowout site which is marked with an x. Fossil carbon inputs are also observed in sediments to the north of the site towards Gulfport. The map has been supplemented with samples from additional funding but is shown here for completeness. The map is being used to guide current GRI sampling efforts in the C-Image and Deep-C consortiums field efforts.

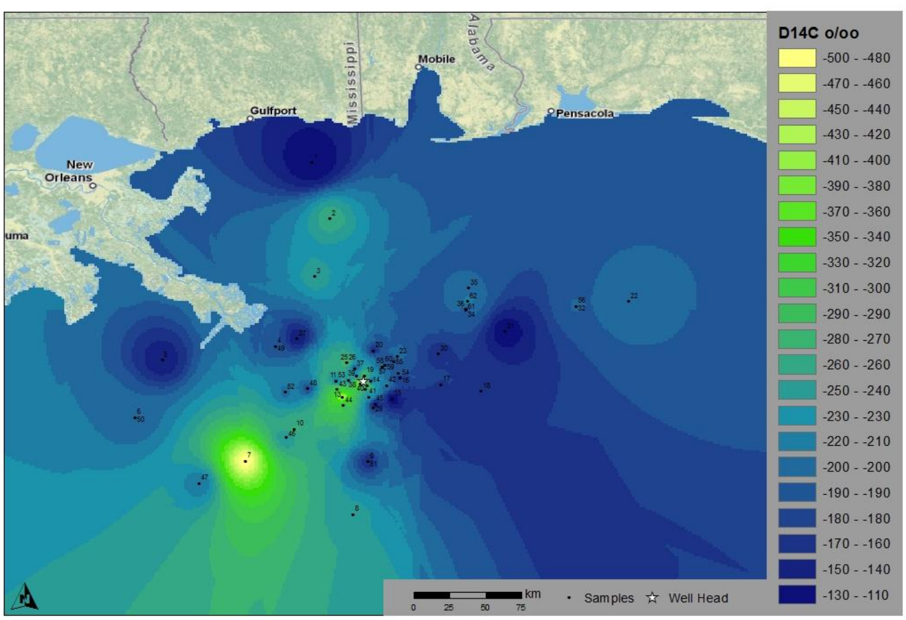
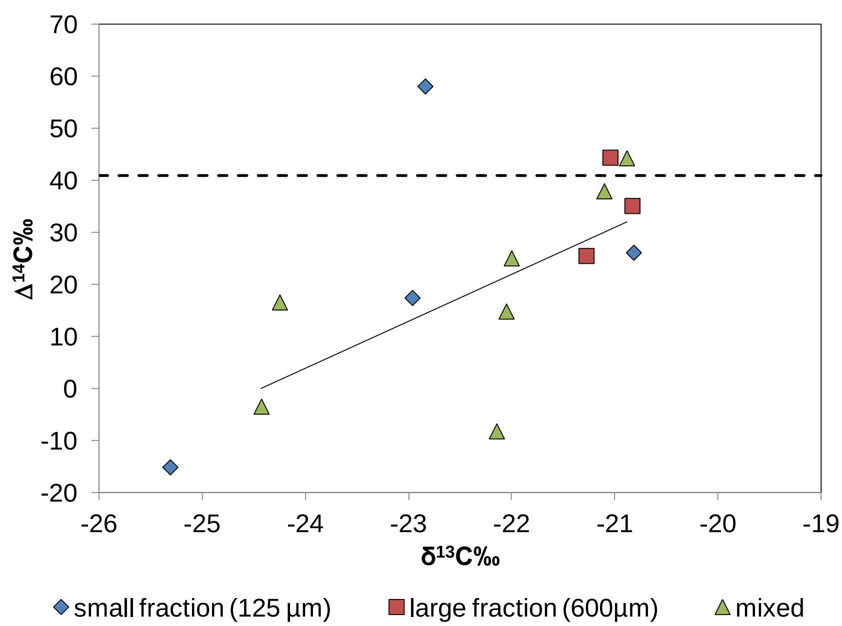


Figure 1. This map shows the radiocarbon content of sedimentary organic matter on the seafloor of the Gulf of Mexico. The brighter colors and more negative values on the □-^{14}C scale.

3. Surface ocean organic production and measured oil are separated by 5-7‰ in stable carbon isotope ($\delta^{13}C$) space, while in radiocarbon ($\Delta^{14}C$) space, these two potential sources are separated by more than 1000‰ (Chanton et al., 2012). Thus radiocarbon isotopes provide a more sensitive tracer by which to infer possible introduction of Macondo oil into the food web. We measured $\Delta^{14}C$ and $\delta^{13}C$ in plankton collected from within 100km of the spill site as well as in coastal and offshore DIC (Dissolved Inorganic Carbon or ΣCO_2) to constrain surface production values. On average, plankton values were depleted in ^{14}C relative to surface DIC and we found a significant linear correlation between $\Delta^{14}C$ and $\delta^{13}C$ in plankton (Figure 2). Cumulatively, these results are consistent with the hypothesis that carbon released from the Deepwater Horizon Spill contributed to the offshore planktonic food web. Our results support the findings of Graham et al. (2010), but infer that methane input may be important. This work was leveraged with funding from our FIO GRI project.



resent values for the smallest size
ize fraction plankton (600µm) and
vided into separate size fractions.
Radiocarbon isotopes ($\Delta^{14}C$) were
th $\delta^{13}C$ (r = 0.61, p<0.01). Lighter
he hypothesis of petro-carbon
: + 226.2.

4. Coastal fauna along an impact gradient from the East to the West along the northern gulf showed increasing radiocarbon depletion consistent with increasing impact and addition of petro-carbon to the food web of coastal embayments (Figure 3).

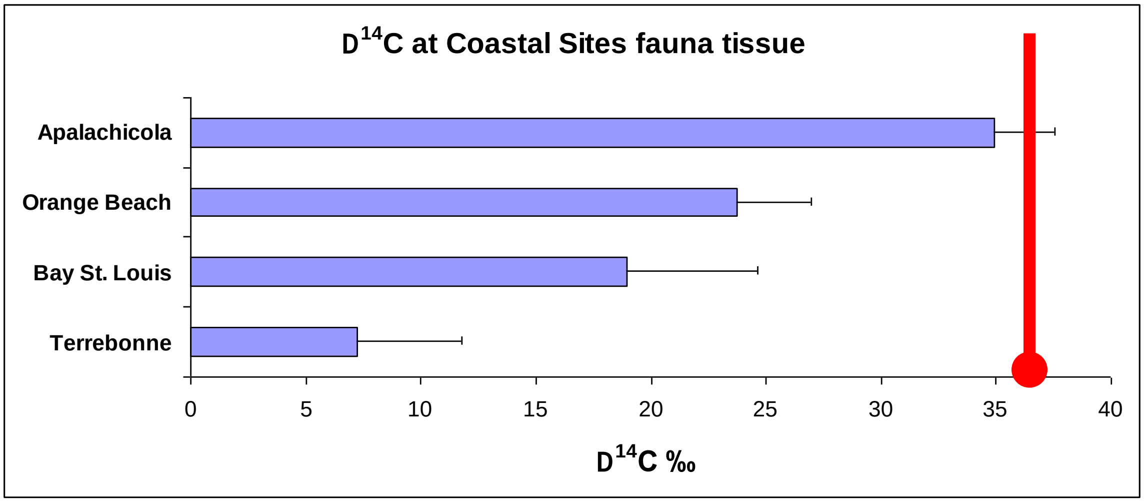


Figure 3. This figure illustrates increasing impact of petro-carbon along a coastal gradient from East to West going from Apalachicola, Florida, un-impacted, to Orange Beach, Alabama, to Bay St. Louis, Mississippi, to Terrebonne Bay, Louisiana. The red bar represents the value of modern carbon 36.7‰ reported in Table 1. Each site is significantly different from the others at $p = 0.05$.

References

Adcroft A, Hallberg R, Dunne J P, Samuels B L, Galt J A, Barker C H and Payton D 2010 Geophys. Res. Lett. 37 L18605

Chanton, J.P. J. Cherrier, R.M. Wilson, J. Sarkodee-Adoo, S. Boseman, A. Mickle, and W.M. Graham. 2012. Radiocarbon indicates that carbon from the Deepwater Horizon Spill entered the planktonic food web of the Gulf of Mexico, Environmental Research Letters, accepted for special issue.

Graven, H.D. T.P. Guilderson, and R.F. Keeling. Observations of radiocarbon in CO2 at La Jolla, Ca. USA 1992-2007. Analysis of the long term trend. JGR 117, doe: 10.1029/2011jd016533, 2012.

Graham, W.M. R. H Condon, R. H Carmichael, I. D'Ambra, H. K Patterson, L. J Linn and F. J Hernandez Jr. Oil carbon entered the coastal planktonic food web during the Deepwater Horizon oil spill. Environ. Res. Lett. 5 (2010) 045301 (6pp) doi:10.1088/1748-9326/5/4/045301

3. Cruises & field expeditions

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
Coastal Sampling		Nelson	Collect coastal fauna	October 2010
Coastal sampling		Bosman	Collect coastal fauna	April 2011
Weatherbird		Cherrier	Collect offshore plankton and DIC	May 2011
Cape Hatteras		Yager	Collect Offshore sediments	October 2010
Cape Hatteras		Yager	Collect offshore sedments	October 2011

4. Peer-reviewed publications, if planned

Published, peer-reviewed bibliography (Copies of the papers are requested)

Chanton, J.P. J. Cherrier, R.M. Wilson, J. Sarkodee-Adoo, S. Boseman, A. Mickle, and W.M. Graham. 2012. Radiocarbon indicates that carbon from the Deepwater Horizon Spill entered the planktonic food web of the Gulf of Mexico, Environmental Research Letters, accepted for special issue.

Chanton, J., S. Bosman, A. Mickel, S. Joye, C. Brunner, Marine Sciences, University of J. Cherrier and J. Sarkodee-Adoo, D. Hollander, Marine Sciences, University of South Florida. Radiocarbon analysis of the Gulf Oil Spill, in prep for Deep Sea Research.

5. Presentations and posters, if planned

Title	**Presenter**	**Authors**	**Meeting or Audience**	**Abstract published (Y/N)**	**Date**
Tracing the Deepwater Horizon Oil Spill Into Fauna Along Coastal and Offshore Contamination Gradients in the Gulf of Mexico Using Natural ^{14}C	Judith Sarkodee-Adoo[1]	Jennifer Cherrier,; Jeff Chanton	ALSO/ Ocean Science, Salt Lake City, Utah.	Y	2012

Biogeochemical Radiocarbon Analysis of the Gulf Oil Spill:	J. P. Chanton	J. Cherrier, J. Sarkadee-Adoo, S. Joye, D. Hollander, W.Graham, C. Brunner, S. Bosman, A. Mickel.	AGU fall meeting, San Francisco.	Y	2012

6. Other products or deliverables

Radiocarbon map. See Figure 1. This map is being used to guide current sampling efforts in the C-Image, Deep C, and Carthe GRI programs.

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.

Samples are archived at Florida State University and data are being prepared for input to Harte Institute.

PARTICIPANTS AND COLLABORATORS

8. Project participants

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First Name	Last Name	Role in Project	Institution	Email
James	Neslon	Grad student	FSU	jnelson@mbl.edu
Alejandra	Mickle	undergraduate	FSU	ale_mickle@hotmail.com
David	Canter	undergraduate	Wesleyan University	dcanter@wesleyan.edu
Samantha	Bosman	Tech	FSU	sbosman@fsu.edu
Jeff	Chanton	PI	FSU	jchanton@fsu.edu
Kevin	Craig	Copi	FSU	Kevin.craig@bio.fsu.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
James	Nelson	Phd	Food web	FSU	Chanton	2011
David	Canter	BS	none	Wesleyan	N/A	2011
Alejandra	Mickle	BS	none	FSU	N/A	2011

10. Student and post-doctoral publications, if planned

N/A

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

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Tracing the Deepwater Horizon Oil Spill Into Fauna Along Coastal and Offshore Contamination Gradients in the Gulf of Mexico Using Natural ^{14}C	Judith Sarkodee-Adoo[1]	Jennifer Cherrier,; Jeff Chanton	ALSO/ Ocean Science, Salt Lake City, Utah.	Y	2012

12. Images

Images have been submitted to main GoMRI website through Tracy Ipolito.

11-BP_GRI-10: Louisiana State University: Post Macondo Well Oil spill Water Quality Sampling – Barataria, Lake Pontchartrain, and Costal Waters, Part 2

R. Eugene Turner

SCIENCE ACTIVITIES

1. General Summary: The basic tasks were to collect monthly samples from the Baratria and Lake Pontchartrain estuaries, from January 2011 to June, 2011, make comparisons with the long-term data record (+10 years), and assess if the Deepwater Horizon oil 'spill' significantly affected water quality. Our focus was on dissolved nutrients, phytoplankton and oil. Below is a point-by-point summary of the present status. In brief, we are completing all sampling tasks on time and virtually all of the analyses are completed, with one exception.

Tasks: Monthly sample collections stations: Barataria watershed at 37 stations sampled since 1994 and eight stations sampled since 1999; 7 stations on the Causeway over Lake Pontchartrain

Status: All transects were sampled successfully, with only minor problems due to weather.

Tasks: Analyses of all samples for phytoplankton pigments, nutrients (nitrate+nitrite; phosphate, silicate, etc.), salinity, suspended sediments, inorganic carbon.

Status: All analyses were completed successfully.

Tasks: Subsamples for algal pigments (HPLC) and identification collected for LUMCON to analyze. The samples include 3 to 7 stations in Lake Pontchtrain and about 102 from both basins (total).

Status: Most samples are done, but equipment/analyst issues kept us from analyzing some samples. These are being processes this summer.

Tasks: The metabolic 'footprint' of the microbial community analyzed

Status: All analyses were completed successfully.

Tasks: Oil identification and quantification for about 102 samples.

Status: All analyses were completed successfully.

Lessons learned: The NGI funding provided an opportunity to assess if water quality changed as a result of the Macondo BP oil spill in Lake Pontchartrain and Barataria Bay only because there was 16 years of monthly data collecte before the oil spill. The excellent baseline data is recognized as essential, but only useful if timely funding is provided – why NGI did. There is no way to re-assemble a missed opportunity.

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. The time for this second stage of analysis takes longer than the data collection stage.

2. Results and scientific highlights

We can detect no changes in nutrient concentration, pigment concentration, or oil concentration as a result of the Macondo oil spill. There was oil, of course, in the Bay, but not dissolved oil – whatever was present was a mouse or on the bottom, and we did not sample either. We have not completed the analysis of the metabolic footprint data. There were differences found that seem to be related to the opening of the freshwater diversion into Barataria Bay or from the Bonnet Carré spillway opening into Lake Pontchartrain, but not the oil.

Some of this data was folded into a ms. analyzing the long-term data for Lake Pontchartrain that was submitted in April 2012 (Turner, R.E., E. M. Swenson, C. S. Milan, J. M. Lee, S. Bargu and E. Smith 2012. Water quality in transition: Lake Pontchartrain, LA (USA) from the 1980s to 2011. **Estuaries and Coasts).**

3. Cruises & field expeditions

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
Small boats		Lee	Sample Barataria Bay	Monthly
Vehicles on bridges		Swenson	Sample Lake Pontchartrain	Monthly

4. Peer-reviewed publications, if planned

Turner, R.E., E. M. Swenson, C. S. Milan, J. M. Lee, S. Bargu and E. Smith 2012. Water quality in transition: Lake Pontchartrain, LA (USA) from the 1980s to 2011. Estuaries and Coasts. Submitted 1 April 2012.

Turner et al. Oil concentrations in Barataria Bay and Lake Pontchartrain (La) during the Macondo oil spill. Anticipated summer/fall journal submission

Turner et al. the metabolic footprint of microbes before, during and after the Macondo Oil spill. Anticipated winter journal submission

5. Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Looking to the Future: Lessons in Prevention, Response, and Restoration from the Gulf Oil Spill	RETurner		U.S. Senate Committee on Commerce Science, and Transportation, Subcommittee on Oceans, Atmosphere, Fisheries, and Coast Guard; Hearing	Y	20 July 2011
Louisiana: What monitoring have they been doing and what is their long-term vision for coordinated monitoring?	RETurner		National Water Quality Monitoring Council	N	4 May 2011
Annual and seasonal patterns in phytoplankton biomass and nutrients in Lake Pontchartrain	RETurner	RETurner, NN Rabalais, E. Swenson, C. Milan, J.M. Lee S. Bargu-Ates, and W. Morrison	Basics of the Basin	Y	27 Oct. 2011

6. Other products or deliverables

N/A

7. Data

All data are on excel spreadsheets at LSU. No samples are archived (these were water quality data, not specimens). The data include nitrate+nitrite, ammonium, silicate, phosphate, phytoplankton pigments, aromatic and alkane concentrations and 30+ specific components (others could be determined from the archived printouts), and species ID.

PARTICIPANTS AND COLLABORATORS

8. Project participants

First Name	Last Name	Role in Project	Institution	Email
RE	Turner	PI	LSU	euturne@lsu.edu
NN	Rabalais	Co-PI	LUMCON	nrabalais@lumcon.edu
JM	Lee	Research Assoc.	LSU	jmlee@lsu.edu
E	Swenson	Research Assoc.	LSU	eswenson@lsu.edu
CM	Milan	Research Assoc.	LSU	cmilan@lsu.edu
W	Morrison	Research Assoc.	LUMCON	wmorrison@lumcon.edu
D	Richardi	Research Assoc.	LUMCON	Drichardi@lumcon.edu

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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
A	Tweel	Ph.D.	Geomorphology of coastal Louisiana	LSU	Turner	2014
G	McClenachan	Ph.D.	Impact of oil on fisheries	LSU	Turner	2015
P	Riekenberg	MS	Stable isotopes in food web research	LSU	Fry	2012

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

11-BP_GRI-11: Louisiana State University: Field Observation and Modeling of the impact of oil spill on marsh erosion in southern Louisiana

Q. Jim Chen, Guoping Zhang

SCIENCE ACTIVITIES

2. General Summary: An integrated experimental and computational study was conducted to investigate the impact of crude oil on marsh erosion in Southern Louisiana. The ultimate goal was to study and understand the fundamental science of oil-contaminated coastal marsh erosion through field experiments, laboratory testing, and numerical modeling. It was expected that these understandings can provide a predictive capability for coastal wetland protection and restoration if such events as oil spill contaminations occur in the future.

Collaborative research consisted of three major activities: (1) field measurements to acquire the first dataset on the erosional resistance and erosion rate of oil-contaminated coastal marshes, as well as wave measurement for subsequent modeling of erosion; (2) laboratory testing for the understanding of physical and geotechnical properties of marsh soil samples taken from the sites; and (3) modeling marsh erosion using the field and laboratory testing data and predicting the resilience of contaminated wetlands under storm and hurricane conditions.

Lessons learned:

Logistics: Access to the remote site of oiled wetlands is limited due to frequent cold front passages in the winter. High accuracy, efficient GPS survey system has limited access to mobile phone services in the remote site of oiled wetlands. Use of traditional surveying equipment, however, limits the survey coverage because of time-consuming operation.

Management: Short duration of this project was negatively impacted by the graduate student recruitment cycle, as new graduate students typically start working in August. It took longer time than expected to recruit a graduate student in geotechnical engineering for this project. For both logistic and duration reasons, a no-cost extension was requested and approved.

Non-homogeneity of marsh soils: it was not expected that the surface marsh soil (when compared with soils at depth) at shallow depths is highly heterogeneous at both spatial and temporal scales. This actually leads to the difficulty in interpreting the field data. Alternatively, a more extensive testing program would be needed to obtain a larger dataset for statistical analysis.

Sustainable funding is needed to continue such a field monitoring program.

Accomplishments:

A heavily oiled site was identified as the primary site for monitoring and testing in Bay Jimmy, Barataria Bay, Louisiana.

Long-term erosion rates from 1998 to 2010 prior to the oil spill were determined from historical aerial photography as the baseline for comparison.

Shoreline surveys of a heavily-oiled wetland in Barataria Bay, LA were conducted before and after Tropical Storm Lee (2011), and compared with the long-term erosion rate.

Wave gages were deployed adjacent to the oiled wetland to measure the wave power associated with winter cold front passages.

A cohesive strength meter (CSM) was successfully applied to field measurements of critical shear stress of surface marsh soils.

The erosional resistance profile along depth was also obtained for two sites with oil and without oil contaminants.

Interaction of waves and marsh edge was simulated by a phase-resolved nonlinear wave model.

2. Results and scientific highlights

Experimental Program

In-situ measurements of critical erosional resistance of marsh sediments were conducted on two sites located in Barataria Bay (Bay Jimmy, hereafter called BB) and Terrebonne Bay (hereafter called TB). The BB site is heavily oiled, and it appears that no effort was made to clean the site. The TB site, free of the spilled oil, was chosen to avoid the effect of oil contamination on the measurement of critical erosional resistance. For all field experiments, a MK IV cohesive strength meter (Partrac Ltd., UK) was used to conduct all these measurements.

Laboratory testing was conducted on 3-inch diameter tube samples obtained in the two sites mentioned above. Three types of tests were conducted in the laboratory: 1) critical erosional resistance using the cohesive strength meter along depth to obtain the sediment's erosional resistance profile along depth; 2) water content and organic matter content measurements; and 3) determination of other soil physical properties.

Observations of Oiled-Wetland Erosion and Wave Forcing

A field observation program to monitor the impacts of tropical and extra-tropical storms on the edge stability and erosion of oiled and unoiled marshlands has been developed and implemented in Barataria Bay (BB) and Terrebonne Bay (TB), Louisiana. Wave gages have been deployed seaward of the wetland edges at water depth of about 1-2 m to measure the wave power at each site. The measured waves in the BB are locally generated wind seas. By contrast, in TB the wave spectra are mostly bi-modal consisting of swell waves from the Gulf of Mexico and locally generated seas. Seasonal topographic surveys and post tropical storm surveys have been carried out to measure the marsh edge retreat rates. Observed shoreline rates are compared with historical long-term rates and correlated with measured wave power. Numerical modeling has been carried out to understand the interaction of waves and the marsh edge.

Significant Results

Two years after the oil spill, severe erosion and pockets of dark oil were observed on the wetland in Bay Jimmy in Barataria Bay, LA.

Vegetation killed by a large amount of heavy oil hardly regrows on highly contaminated wetlands. Without the vegetation, once the oiled top soil of the marshland was eroded, the underlying soft soil quickly disappeared.

Marsh soil that was highly contaminated by heavy oil (i.e., heavy oil is still on the soil surface or has partially seeped into the soil) shows a much higher erosional resistance than that of the clean, soft marsh sediments without vegetation. This is caused by the fact that heavy oil is very sticky and has a high viscosity, and hence tends to bond soil particles together and to consume more kinetic energy from the flowing fluid. However, this temporary “armoring” killed the salt marshes and prevented them from regrowth.

When heavy oil is still present on soil surface, a critical erosional resistance of 8.1 psi was measured; where the un-vegetated, un-oiled soil surface yields an erosional resistance of 0.35 psi.

The depth profile of erosional resistance (based on data from one site) shows that a weaker zone at a depth of about 1 foot is present, which may be the reason for the occurrence of undercutting erosion at the marsh edge.

Based on field observation, heavy oil and heavily oiling can significantly damage or even kill marsh vegetation for a growing season. Without the attenuation effect of marsh vegetation, soil is more prone to rapid erosion.

Based on the limited data available at present, there is no significant correlation between soil erosion resistance and organic matter content. Further analysis is required to obtain the spilled oil concentration in the future research.

Spatial variation in the erosional resistance of marsh soil is also significant. It seems a large dataset is required for statistical analysis of the results to isolate the influence of other factors, such as vegetation and root systems.

Soil organic matter content, water content, Atterberg limits, and particle size distribution for selected samples were also obtained.

It has been found from aerial photography (1998-2010) that the historical long-term shoreline erosion rate of the heavily-oiled marshland in BB was 1.2~1.5 m/year. This provides a baseline for comparison with the observed annual erosion rate (7/1/2011-6/30/2012).

3. Cruises & field expeditions

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
Small boat		Guoping Zhang	Site survey and selection of oiled sites; Marsh edge erosion measurements	7/1/2011
Small boat		Q. Jim Chen	Marsh edge erosion measurements; soil sampling	9/23/201 (two weeks after TS Lee)
Small boat		James Chatagnier Kyle Parker	Conduct 2 CSM tests Deployed wave gages	12/13/2011
Small boat		Q. Jim Chen and Guoping Zhang	Major field measurements; Replaced wave gages, sampling; In situ CSM tests (6)	3/5/2012
Small boat		Q. Jim Chen	Soil sampling Replaced wave gages 7 CSM tests	3/26/2012

4. Peer-reviewed publications, if planned

a. Published, peer-reviewed bibliography
Not available yet
b. Manuscripts submitted or in preparation
Effect of oil spill on marsh soil erosional resistance. Journal of Geotechnical and Geoenvironmental Engineering, ASCE (in preparation)

5. Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Field Monitoring of Oiled-Wetland Erosion in South Louisiana	Q. Jim Chen	Q. Jim Chen	SOST oil spill PI workshop in St. Petersburg	Y	October 25-26, 2011

6. Other products or deliverables

None at this time

7. Data

Reporting on Data and Archiving				
Date	Data type	Format	Location	Status
7/1/2011	Map	Summarized in a report	External hard drive	Archived
10/1/2011	Samples	Physical object	Lab	consumed
1/1/2012	Test results	Microsoft Excel	External hard drive	Archived
3/1/2012	Test results	Microsoft Excel	External hard drive	Archived

PARTICIPANTS AND COLLABORATORS

8. Project participants

First Name	Last Name	Role in Project	Institution	Email
Hem	Pant	Graduate Assistant/ Scientific Participant	Louisiana State University	hpant1@lsu.edu
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		Scientific Participant	University	gmail.com
Ranjit	Jadhav	Graduate Assistant/ Scientific Participant	Louisiana State University	rjadha1@tigers.lsu.edu
Q. Jim	Chen	PI	Louisiana State University	qchen@lsu.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
Hem	Pant	MS	Characterization of erosional resistance of marsh sediments with oil contamination	Louisiana State University	Guoping Zhang	2013
Kyle	Parker	MS	Correlation of Marsh Edge Erosion and Wave Power	Louisiana State University	Q. Jim Chen	2013
Ranjit	Jadhav	Ph.D.	Wave Attenuation by Saltmarsh	Louisiana State University	Q. Jim Chen	2012

10. Student and post-doctoral publications, if planned

N/A

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

N/A

12. Images

Image 1. Oil damaged marsh in Bay Jimmy, Barataria Bay, Louisiana.
Photo taken by James Chatagnier, July 1, 2011

Image 2. A CSM Testing being conducted in Bay Jimmy, Barataria Bay, Louisiana.

Photo taken by James Chatagnier, July 1, 2011.

Image 3: CSM sensor head close view (left) and the entire CSM setup (right).

Photo taken by Hem Pant, Terrebonne Bay, 3/5/2012

Image 4: CSM test in marsh soil (left) and the soil surface after being tested (right).

Photo taken by Hem Pant, Terrebonne Bay, 3/5/2012

Image 5: A student preparing the CSM test in marsh soil.

Photo taken by Guoping Zhang, Terrebonne Bay, 3/5/2012

Image 6: Shoreline survey on the oiled wetland

Photo taken by G. Zhang on July 1, 2011 in Barataria Bay

Image 7: Oiled-wetland erosion (looking east)

Photo taken by Q. Jim Chen on September 23, 2011 in Barataria Bay

Image 8: Oiled-wetland erosion (looking west)

Photo taken by Q. Jim Chen on September 23, 2011 in Barataria Bay

Image 9: Shoreline survey of oiled-wetland

Photo taken by Q. Jim Chen on September 23, 2011 in Barataria Bay

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Image 10: Small pocket of oil

Photo taken by Q. Jim Chen on September 23, 2011 in Barataria Bay

11-BP_GRI-12: LSU AG Center: Effect of Oil, Dispersant, and Remediation-Related Human Activities on Marsh Plants and Associated Insects and Mollusks

Linda M Hooper-Bui, R.E. Turner, L. Anderson

SCIENCE ACTIVITIES

1. General Summary: The PIs and their collaborators conducted coordinated efforts to address hypotheses about community change in coastal marshes resulting from presumed stressors linked to the Deepwater Horizon oil spill and response efforts. The coastal marshes impacted by this spill, and the effects of the spill itself, are complex both spatially and temporally. We established a means to accurately locate and assess lingering areas of impact. We analyzed water, air, and sediment samples for hydrocarbon contamination while in the field as well as funds to conduct stable isotopic and trace element analyses on biota collected from these field sites. We used these data to: (1) refine sampling site locations and sample number during our May and September 2011 post-spill field efforts, and, (2) establish sample sites for longer-term research efforts. We are now sharing 12 permanent field sites that we identified with up to 20 investigators and are collaborating to perform continuing, but not redundant, oil analyses as needed.

We expected to quantify and understand the effect of stressors – i.e., hydrocarbons, dispersants, freshwater diversion, and other remediation-related human activities – on marsh and adjacent open water communities. Specifically, we measured the effects of stressors on soil strength, marsh grass roots and above-ground biomass, insect and spider populations, and selected mollusk species (in the marsh and adjacent open waters) and these efforts have been leveraged for a GoMRI consortium grant to LUMCON. Stressors have both direct and indirect effects because, as hydrocarbons degrade, these compounds may enter food webs via primary consumers such as mollusks and insects/spiders. These primary consumers, in turn, serve as food sources for higher trophic levels such as frogs, fish, birds and, ultimately, humans. The effects of a stressor can cascade through the community as members of lower trophic levels undergo changes in growth rate, mortality, reproduction, and recruitment. As a result, species turnover occurs and food web configuration and stability are altered. Our goal is to provide a benchmark study in ecosystem change analysis, to identify precursors to ecosystem trajectories before alternative states are realized, and to address societal concerns about wetland stability.

We choose12 sites that show evidence of heavy, light or no oiling. We used this award to measure the TPHs in the field using sophisticated equipment on the R/V *Acadiana*. We also used this award to conduct in situ bioassays and collect biological data to correspond with the TPH data generated on the *Acadiana*. Our preliminary results indicate, however, that natural spatial variability may be larger than anticipated, and that documentation of site oil exposure is only grossly quantified by available NRDA data and that are sites have been adequately characterized. Air, pore-water, and sediment samples were taken and immediately analyzed (~15 min/sample) using two gas chromatographs (GC). Insects/spiders, mollusks and marshgrass also were sampled to calibrate biotic responses to measured hydrocarbon concentration and composition. We have samples of bird tissue, insects, spiders and crabs at a lab in New Zealand which is conducting trace element and stable isotopic analyses on a portion of the biota sampled to determine contamination exposure and document trophic effects of stressors.

2. Results and scientific highlights

Turner and McClenahan collected data on soil strength, shoreline erosion, and soil decomposition at 30 closely spaced oiled and non-oiled sites in Bay Batiste, Louisiana. These sites were sampled bi-monthly since November 2010 and compared to data from another 80 sites sampled in May and September 2010/2011. All oiled sites in Bay Batiste are contaminated with Macondo 252 oil (oil from the BP oil spill 20 April – 15 July 2010). Preliminary results suggest that the oil is weakening the soil and causing an accelerated rate of shoreline erosion. There is no 'threshold' effect where soil parameters change dramatically with a relatively small increase in oil concentration in the soil.

Shells of the economically and ecologically important oyster species *Crassostrea virginica* that lived through the spill were serially sampled through ontogeny and analyzed for oxygen isotopic ratios ($\delta 18O$) and concentrations of elements associated with hydrocarbon contamination to develop a chronology of the impact of oil contamination in the Gulf Coast over the past year. Concentrations of vanadium, barium, nickel, lead and manganese were measured using LA-ICP- MS and used as proxies for tracking levels of hydrocarbon contamination, as these elements are abundant in crude oil. Oxygen isotopic ratios were used to infer a formation date for each shell sample.

Concentrations of all detectable trace metals are higher in Gulf Coast specimens than in the North Carolina specimen. We hypothesize that the natural and anthropogenic release of oil is responsible for the elevated concentrations of trace metals in Gulf Coast samples.

Concentrations of all detectable trace metals are highest in August samples. We believe that the Deepwater Horizon oil spill may be responsible for these higher concentrations.

While average trace metal concentrations differ between May and August samples, no distinct trends are noticed within a single organism. We hypothesize that for the May shells, the entirety of the sampled region was precipitated before the spill, and for the August shells, the entirety of the sampled region was precipitated during/after the spill. Results of oxygen isotope analysis will support or oppose this hypothesis. It is expected that the results of this study will help to help clarify the mechanisms and timing of past and present hydrocarbon infiltration into Gulf Coast food webs.

The 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 estuarine food 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 lowuptake 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.

Engel used this funding to support genetic sequencing efforts and field work for the completion of two MS theses and one BS thesis in the Department of Geology & Geophysics at LSU. For one MS thesis, major shifts in the bacterial diversity from sediments in Louisiana coastal marshes were attributed to the presence and composition of alkane and aromatic hydrocarbon compounds in the marshes after the oil spill, as well as to salinity excursions associated with freshwater diversions of the Mississippi River. Prior to the spill, Proteobacteria (a major phylum of bacteria) dominated the bacterial communities, but communities impacted by oil significantly shifted to being Firmicutes-dominated and communities impacted by salinity excursions became Bacteroidetes-dominated. These results not only expand our understanding of the types of microbes colonizing and functioning in coastal marshes, but the results can be used to predict how communities and marsh ecosystems may respond and recover following disturbance. From the other MS thesis, the diversity of microbial communities in transects from supratidal to subtidal beach sediments perpendicular to two sandy beach coastlines were examined over the course of one year, starting in May 2010. The goal of the study was to document community composition and changes in composition linked to exposure to weathered oil or the impact of remediation efforts, such as sand washing. Microbial diversity was assessed from 16S rRNA genes that were analyzed following 454 tag pyrosequencing and diversity was statistically analyzed in conjunction with grain size characterization, organic carbon and water content, and pore water pH. For both sites, statistically significant shifts in microbial community composition could be linked to changing sediment grain size over time, predominately from where remediation efforts were the greatest to clean beaches after an oil spill, such as from sand washing.

Insects and spiders were dramatically reduced in 2010 after the oil penetrated the marshes as compared to reference sites. In 2011, when recovery was expected, further reduction in the populations of insects and spiders was measured. This was most evident in green seed bugs and ants. By the end of September 2011, we were unable to find ants at heavily oiled sites more than 20m from the oiled edge. In 2011, considerable efforts were expended on in situ bioassays. Hooper-Bui placed cages of crickets 20m into the marsh in oiled and reference areas on numerous occasions. When the tide was low, the sediment was exposed, and the air temperature was greater than 29C (85F), all the crickets in the oiled areas were dead or moribund with in 24 hrs as opposed to <30% dead in reference marshes. This bioassay lends evidence to the idea that volatile or semi-volatile toxic compounds are present in the oiled marshes that leads to mortality.

3. Cruises & field expeditions

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
R/V Acadian		Turner	Analyze hydrocarbons in situ	Sept 26-30
Small Boat Trip		Hooper-Bui	Collect samples including repeat sampling of pre-oil spill sites; Conduct in situ bioassays	5/27.28; 6/4-5; 7/15-16, 22-23, 29-30; 8/19-20, 27-27; 9/9-10

4. Peer-reviewed publications, if planned

a. Published, peer-reviewed bibliography

Engel, A.S. (2010) Incorporating the Deepwater Horizon oil spill into geomicrobiology courses. National Association of Geoscience Teachers e-News Magazine. Sept. 2010. http://nagt.org/nagt/enews/sep10/summers.html

Xuan C., B.J. Adams, and L. Hooper-Bui 2011. Effects of oil pollution on ant communities on coastal dunes in Louisiana. Proceedings of the National Red Imported Fire Ant (and other Invasive Ants) Conference. Galveston, Tx. April 2011.

Planned:

L. Hooper-Bui, R. Strecker, B. Hesson, O. Osisioma, X. Chen, B. Adams, G. Soderstrum, M. Accardo, A. Sabo,

RE Turner. Effect of hydrocarbons on saltmarsh ant biology and ecology. (To be submitted August 2012).

L. Hooper-Bui, B. Adams, X. Chen, O. Osisioma, R. Strecker, B. Hesson, E Overton, RE Turner. Terrestrial arthropod responses to Macondo 252 oil pollution in saltwater marshes in the northern Gulf of Mexico (To be submitted October 2012).

Turner, R.E. L.M Hooper-Bui, and 11 co-authors. 2011. Macondo Oil in Louisiana Salt Marshes: Belowground. Ms.

McClenachan, G. and R. E. Turner, Effects of oil on the rate and trajectory of Louisiana marsh shoreline erosion. Ms.

5. Presentations and posters, if planned

Linda M. Hooper-Bùi, RM Strecker, BJ Adams, X Chen, E Overton, RE Turner. Silent Spring Revisited: Insects and Spiders in Louisiana's Saltwater Marshes after the Macondo Blowout. Poster presented at INTECOL: International Wetland Symposium. June 3-9, 2012. Orlando, Florida.

Linda M. Hooper-Bui, Rachel M. Strecker, O. Osisioma, X. Chen, B. Adams. Impact of BP's Macondo oil disaster on salt marsh insect diversity and abundance in the northern Gulf of Mexico. Oral presentation at Southeastern and Southwestern Branch Joint Meeting of the Entomological Society of America. March 4-7, 2012. Little Rock, Arkansas.

Hooper-Bùi, LM, X Chen, BJ Adams, and RM Strecker. Effect of Macondo oil on insect & spider communities on coastal dunes and in saltmarshes in Louisiana. Invited oral presentation. GoMRI LUMCON Consortia All Hands Kickoff PI meeting Feb 2012. Presented by L. Hooper-Bui.

N. Rabalais, R.E. Turner, and L.M. Hooper-Bùi. The Effects of the Macondo Oil Spill on Coastal Ecosystems. LUMCON Consortia. Presented at the 2012 Oil Spill Response & Resotration R&D Forum. Jan 10-11, 2012.

Hooper-Bùi, LM, X Chen, BJ Adams, and RM Strecker. Effect of Macondo oil on insect & spider communities on coastal dunes and in saltmarshes in Louisiana. Invited oral presentation. Deepwater Horizon Oil Spill Principle Investigator 1-year Update Workshop. Sponsored by The White House National Science and Technology Council (NSTC) subcommittee on Ocean Science and Technology. St. Petersburg, FL. October 25-26, 2011. Presented by LM Hooper-Bùi.

Rabalais, N, RE Turner, and LM Hooper-Bùi. The Effects of the Macondo Oil Spill on Coastal Ecosystems. Invited oral presentation at 2011 BP GRI Consortia Kickoff Meeting. New Orleans, La. October 18-21. Presented by RE Turner. I helped make the Power Point slides.

Turner, RE**,** LM Hooper-Bùi, L Anderson, R DeLaune, AS Engel, B Fry, E Overton, B Sen Gupta, S Warny, and J White. **Community-level stressors, Northern Gulf of Mexico**. LSU Oil Spill Symposium. April 29, 2011. Hooper-Bùi contribution: made the poster; presented by L. Anderson.

Anderson, L.C., Roopnarine, P.D., Gillikin, D.P., Goodwin, D.H., Roopnarine, D. Trace element proxies for hydrocarbon exposure in oyster shells after the 2010 Deepwater Horizon oil spill. Geological Society of America annual meeting. Oct. 2011

Byrne, D., Gillikin, D.P., Anderson, L.C., Goodwin, D.H., Roopnarine, P.D., Roopnarine, D. Using oyster shells to track the 2010 Deepwater Horizon oil spill in the Gulf of Mexico. Geological Society of America annual meetinG. Oct. 2011.

Fry, B., Anderson, L.C., Riekenberg, P.H., Michael, C.J. Isotopic evidence for minimal food web use of Deepwater Horizon oil in Louisiana estuarine food webs. Geological Society of America annual meeting. Oct. 2011

Gupta, A., Engel, A.S. Longitudinal assessment of shifting microbial community composition in sandy beaches following the 2010 Deepwater Horizon oil spill and remediation efforts. Geological Society of America annual meeting. Oct. 2011.

Liu, C., Engel, A.S.Bacterial diversity and heterotrophic biodegradation rates from coastal marshes in the Gulf of Mexico. Geological Society of America annual meeting. Oct. 2011.

Spence, B., Gillikin, D.P., Goodwin, D.H., Byrne, D., Roopnarine, P., Anderson, L. Rapid age determination of oysters using shell Mg/Ca ratios. Goldschmidt Conference. Aug. 2011

G. McClenachan R. E. Turner. Effects of oil on the rate and trajectory of Louisiana marsh shoreline erosion. International Wetland Symposium, Orlando, FL

Planned:
Brooke Hesson, L.M. Hooper-Bui, G. Soderstrum, M. Accardo, R. Strecker, & X. Chen. Hula Hoops, High Wire Acts and Acrobats: Ant Density and Distribution in Saltwater Marshes. Talk to be presented by first author at the Annual Entomological Society of American Meeting in Knoxville, Tn. Nov 2012.

Benjamin Adams, Xuan Chen, Linda Hooper-Bui. Oil pollution-mediated mortality and behavior modification in coastal insects. Talk to be presented at the Annual Entomological Society of American Meeting in Knoxville, Tn. Nov 2012.

Xuan Chen, Benjamin Adams, Cody Bergeron, Linda Hooper-Bùi. Ant diversity and community structure on coastal dunes of the northern Gulf of Mexico. Talk to be presented by first author at the Annual Entomological Society of American Meeting in Knoxville, Tn. Nov 2012.

Gerald Soderstrum, L.M. Hooper-Bui, O. Osisioma, R. Strecker, X. Chen, B. Adams E. Overton, R. Turner. Silent Spring Revisited: Insects and Spiders in Louisiana's Saltwater Marshes after the Macondo Blowout. Talk to be presented by first author at the Annual Entomological Society of American Meeting in Knoxville, Tn. Nov 2012.

Theresa Crupi, L.M. Hooper-Bui, B. Hesson, M. Accardo, G. Soderstrum, R. Strecker, & X. Chen. Acrobat Ant Antics: The Secret Life of Ants in Louisiana's Salt Marshes. Talk to be presented by first author at the Annual Entomological Society of American Meeting in Knoxville, Tn. Nov 2012.

Linda M. Hooper-Bui, R. Strecker, B. Hesson, G. Soderstrum, M. Accardo, D. Aguillard, E. Thompson, and X. Chen. Putting the Canary Back in the Coal Mine: Crickets and Ants in the Saltmarshes Post-Macondo Blowout. Talk to be presented by first author at the Annual Entomological Society of American Meeting in Knoxville, Tn. Nov 2012.

6. Other products or deliverables
Hooper-Bùi, LM. *Not Yet*. 225 Magazine. 1 April 2011.
http://www.225batonrouge.com/news/2011/apr/01/not-yet/

7. Data

Data are being processed by individual PIs. Each of the PIs will secure their data until all manuscripts are exhausted. Environmental data are kept in duplicate in the labs of Hooper-Bui and Turner. The oil concentration data is being assembled, or is assembled within a larger data set under the direction of E. Overton and R.E.Turner at LSU.

PARTICIPANTS AND COLLABORATORS

8. Project participants

First Name	Last Name	Role in Project	Institution	Email
Linda	Hooper-Bui	PI	Louisiana State University Agricultural Center	Lhooper@agcenter.lsuledu
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Charlie	Milan	RA	LSU	Cmilan@lsu.edu
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Onyinye	Osisioma	Undergraduate	LSU	
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Desi	Stuart	Undergraduate	LSU	
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Brooke	Hesson	Undergraduate/ RA	LSU	

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
Xuan	Chen	PHD	Multi-stressors on ants in wetland ecosystems	LSU	Hooper-Bui	2014
Axita	Bupta	MS	Longitudinal assessment of shifting microbial community composition in sandy beaches following the 2012 Deepwater Horizon oil spill and remediation efforts	LSU	Annette Engel	2012
Chang	Liu	MS	Geomicro-biology of Louisiana coastal marshes before and after the Deepwater Horizon oil spill	LSU	A. Engel	2011
Erin	Anderson	BS	Microbial diversity in Grand Isle Marsh before and after the Deepwater Horizon oil spill	LSU	A. Engel	2011
Giovanna	McClenahan	PhD	Presented papers at professional meetings; several field trips	LSU	RE Turner	2014
Benjamin	Adams	MS	Ecological and behavioral affects of Macondo oil on saltwater marsh insects	LSU	Hooper-Bui	2012

10. Student and post-doctoral publications, if planned

a. Published, peer-reviewed bibliography

None yet.

b. Manuscripts submitted or in preparation

Gupta, A.G., and Engel, A.S. (IN PREP) Comparative sandy beach microbial communities and impact of remediation efforts following the 2010 Deepwater Horizon oil spill incident. ISME Journal. Planned submission July 2012.

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

X Chen, BJ Adams, LM Hooper-Bui. 2011, The effect of the BP oil spill on the ant community in coastal dunes. Dept Presentation.

12. Images

CD with selected presentations and images available upon request to Lhooper@agcenter.lsu.edu

11-BP_GRI-13: Louisiana State University: Aquatic Primary Productivity and spatial/temporal water quality variations of the Breton Sound Estuary and Impacts of Oil Pollution

John W. Day, Robert R. Lane

SCIENCE ACTIVITIES

1. General Summary: 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. The objectives of this study were 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.

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. 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.

2. Results and scientific highlights

Spatial and temporal patterns of water quality

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, 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

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.

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).

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 presence 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 ($F=17.41$, $p<0.0001$).

3. Cruises & field expeditions

N/A

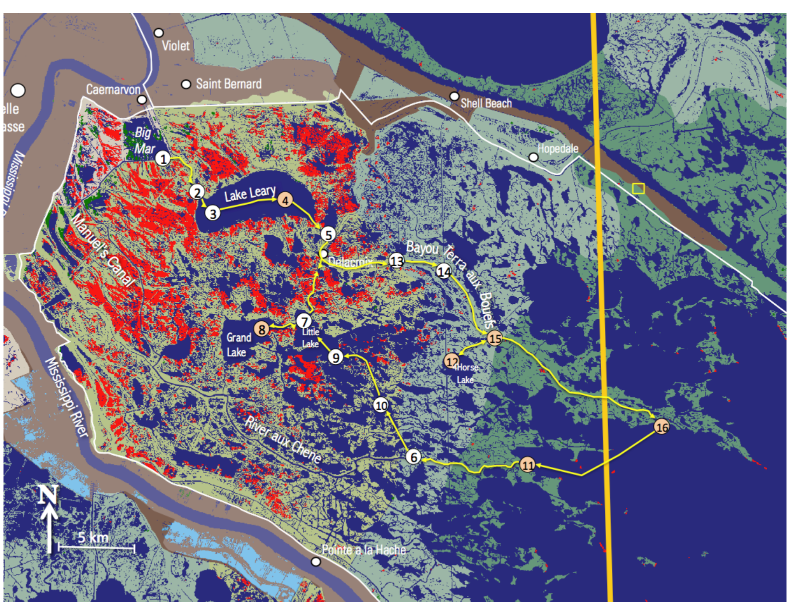
4. Peer-reviewed publications, if planned

N/A

5. Presentations and posters, if planned

N/A

6. Other products or deliverables



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

7. Data

Project Metadata for Gulf of Mexico Research Initiative Year One Funded Research	
Project Title	Aquatic Primary Productivity and spatial/temporal water quality variations of the Breton Sound Estuary and impacts of oil pollution
Principal Investigator	John W. Day
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Principal Investigator Phone	225-578-6358
Co-Principal Investigator(s)	Robert R. Lane
Co-Principal Investigator(s) Agency/Institution	Louisiana State University
Co-Principal Investigator(s) Email	rlane@lsu.edu
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Project Data Point of Contact	Robert R. Lane
Project Data Point of Contact Email	Day_Metadata
Project Data Point of Contact Phone	225-578-6092
Project Start Date	1-Jan-11
Project End Date	29-Feb-12
Project Extension Date (if applicable)	30-Jun-12
Project Locations(s)	Breton Sound Estuary

PARTICIPANTS AND COLLABORATORS

8. Project participants

First Name	Last Name	Role in Project	Institution	Email
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Rachael	Tessier	Student	LSU	rachelstessier@yahoo.com

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
Chris	Lundberg	PhD	Greenhouse gasses	LSU	John Day	2011
Matt	Moerschbaecher	PhD	Energy	LSU	John Day	2012

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

11-BP_GRI-14: Louisiana State University: Macondo 252 Oil Spill Impacts in Louisiana Coastal Wetlands: Effects on Soil-Microbial-Plant Systems

Irving A. Mendelssohn, Qianxin Lin, Aixin Hou

SCIENCE ACTIVITIES

1. General Summary: The Macondo 252 oil spill resulting from the blowout of the Deepwater Horizon (*DWH*) drilling platform on April 20, 2010 exposed the nation's largest and most productive wetland-estuarine environment to an unprecedented potential for environmental damage. Louisiana's fragile Mississippi River delta ecosystem bore the brunt of the damage, especially around the Bay Jimmy area in northern Barataria Bay, Louisiana. A suite of coastal wetland ecosystem services is primarily dependent on a healthy, functioning soil-microbial-plant system. The goal of the research was to determine the impact of the *DWH* oil spill on the plant-microbial-soil system in coastal wetland habitats in the northern Gulf of Mexico and their associated ecological functions. Effects of the oil on structure and function of vegetation and soil microbes and their recovery were investigated. Combined approaches of both field and mesocosm studies provided a more comprehensive analysis of effects of different oiling scenarios and processes controlling oil impacts on the coastal marsh soil-microbial-plant system and their subsequent recovery. Major accomplishments of the project are the following:

Field sampling stations in northern Barataria Bay have been established

Field sampling have been conducted accordingly

Samples for vegetation structure and function, soil oil chemistry, and soil physical and chemical properties have been analyzed to determine the impacts of the *DWH* oil spill on the coastal wetlands of northern Barataria Bay and their subsequent recovery

Soil microbial structure and function have been analyzed to determine the impacts of the *DWH* oil spill on coastal wetlands and their subsequent recovery

In parallel, a greenhouse mesocosm experiment was conducted to investigate the effects of the most common oiling scenarios and processes that control oil impacts and their subsequent recovery

Published peer-reviewed research papers in journals *Environmental Science & Technology* and *BioScience*

Presented research results in various conferences and scientific meetings

2. Results and scientific highlights

Field study on the *DWH* oil impacts and recovery of coastal salt marshes along northern Barataria Bay

The field study was carried out in coastal salt marshes in a large, approximately 8 km x 5 km, area in northern Barataria Bay of Louisiana, where marshes were oiled to various degrees. Seven field stations (replicates) were randomly selected from a larger population that received heavy, moderate and non-oiled conditions (totaling 21 field stations) and sampled. Oiling levels were based on SCAT data and our field observations. The results indicated that the oil impacts have been severe in some areas and moderate in others. Total petroleum hydrocarbon (TPH) concentrations of the surface soil in heavily oiled marshes were > 500 mg g^{-1} seven months after landfall of Macondo oil along shoreline salt marshes. However, TPH concentrations decreased by more than 60% twenty-two months after oil landfall. Heavy oiling almost completely killed marsh plants initially, and left many bare, un-vegetated shoreline marshes in the Bay Jimmy area of northern Barataria Bay. There has been variable recovery in heavily oiled marshes 22 months after oil landfall. Vegetation recovery was primarily from *Spartina alterniflora*; *Juncus roemerianus*, a co-dominant salt marsh plant species, contributed little to vegetation recovery in heavily oil marshes. However, live total aboveground plant biomass and live total belowground biomass in heavily oiled marshes were still significantly lower than those of unoiled references 16 and 22 months after oil landfall. In the absence of complete vegetation recovery, marsh surface soils developed lower shear strength in heavily oiled marshes compared to unoiled sites. Plant live belowground biomass generally helps in binding the soil and promoting soil structure and integrity. Limited live belowground biomass in heavily oiled marshes most likely contributed to decreased shear strength of the marsh soil, which could make the marshes more vulnerable to erosion and wetland loss.

The responses of moderately oiled shorelines were quite different from those more heavily oiled. The average TPH concentration was < 100 mg g^{-1} seven months after oil landfall and tended to decrease over time. Impacts to vegetation along moderately oiled marsh shorelines and their subsequent recovery were species-specific, with greater impact to *J. roemerianus* than *S. alterniflora* and greater recovery for *Spartina* than for *Juncus*. Detrimental effects to live aboveground biomass and live stem density were significantly greater for *J. roemerianus* compared to *S. alterniflora* 7, 16 and 22 months after oil landfall. Additionally, little recovery of *Juncus* had occurred, even more than 22 months after oil landfall. However, *Spartina* showed considerable recovery in moderately oiled marshes after only 7 months post-spill, and has continued to recover.

Microbial analyses of surface sediment showed that the ratio of oil degrading bacteria to total heterotrophic bacteria increased by approximately a factor of 50 and 25 at heavily oiled and moderately oiled sites, respectively, relative to reference sites 16 months after the oil spill. A significant positive correlation was found between oil degrading bacterial abundance and TPH concentration in the sediment ($r=0.630$, $P=0.002$, $n=21$). Total bacterial abundance remained similar across all sites, and thus the populations of non-oil degrading bacteria decreased correspondingly at oiled sites with a greater reduction in heavily oiled sites. GeoChip data indicated that oil input significantly changed the microbial community structure and function of the oiled sediments 7 months after oil landfall, including altering the diversity of bacteria and the relative abundance of the functional genes involved in the carbon degradation and nitrogen transformation categories.

Mesocosm study on the processes that control oil impacts and recovery

In the greenhouse, the effects of the most common oiling scenarios on two marsh types dominated by either *S. alterniflora* or *J. roemerianus* and their subsequent recovery were investigated. Separate unoiled *Spartina* and *Juncus* marsh sods with intact vegetation were used in the mesocosm study. The experimental design was a randomized block with 6 x 2 factorial arrangement of treatments (6 oil treatment levels applied to 2 marsh types). Six oil treatment-levels were: (1) control (no oil), (2) oil coverage of the lower 30% of shoot height of *Spartina* and *Juncus,* (3) oil coverage of the lower 70%*,* (4) 70% repeated oil coverage*,* (5) oil coverage of 100% of shoots, and (6) 8 L m^{-2} oil added to the soil surface and allowed to penetrate the soil. The oil used in this experiment was artificially weathered and emulsified Macondo 252 source oil. The effects of oiling on marsh plants varied with both oil treatment and marsh plant species. Oiling significantly affected vegetative structure, e.g., plant stem density. Oiling affected live stem density of *Juncus* more than that of *Spartina*. Live stem densities of *Juncus* in all oil treatments except the 30% oil coverage were significantly lower than that of the control 7 months after oil treatment. Eighteen months after oil treatment, live stem densities of *Juncus* in the 70% repeated coverage and 100% oil coverage were still significantly lower than that of the control. However, live stem densities of *Spartina* in the oil treatments, except the 70% repeated coverage and oiling to the soil, were equivalent to the control 7 months after oil treatment. The oiling also affected vegetation function, such as plant community photosynthetic rate. Plant community photosynthesis of *Spartina* recovered better than *Juncus*. Plant community photosynthetic rates of *Juncus* in all oil treatments except the 30% oil coverage were significantly lower than that of the control. In contrast, plant community photosynthetic rates of *Spartina* in all oil treatments, except oiling to the soil, were equal to the control 7 months after oil treatments. The greenhouse mesocosm study supported field results that recovery of *Spartina alterniflora* from oil coverage was better than *Juncus roemerianus*.

Conclusion

The present research indicated that heavily oiled marsh sediments had a significantly increased proportion of oil degrading bacteria but decreased bacterial diversity. Heavily oiled shoreline marshes often had significantly higher concentrations of soil TPH, complete mortality of marsh plants initially and subsequently variable recovery in almost 2 years after landfall of the Macondo oil. However, marsh plants have shown resilience and recovery especially in moderately oiled marshes and those dominated by *S. alterniflora*. Although various shoot oiling scenarios posed acute impacts to aboveground structure and function as shown in the greenhouse mesocosm study, oil shoot coverage, if not long-term repeated oiling, generally did not kill belowground rhizomes, especially for *Spartina*; marsh plants were able to recover to various degrees if oil on and in the soil was in the range from minimal to moderate. Repeated oiling caused greater impact to marsh plants than a single oiling event. The combination of repeated shoot oiling and oil penetrating into the soil likely caused initial high plant mortality along heavily oil shoreline marshes and variable recovery in northern Barataria Bay. Marsh type, e.g., dominated by *Spartina* or *Juncus*, likely plays a role in oil impacts and the subsequent recovery. Thus, attention should be paid to different marshes during oil spill cleanup and marsh restoration.

3. Cruises & field expeditions

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
Our Lab's boat (12 person capacity)		Lin	Collecting marsh sods for mesocosm study	Sept, 2010
Our Lab's boat		Mendelssohn and Lin	Field station establishing and sampling	Jan, 2011
Our Lab's boat		Mendelssohn, Lin and Hou	Field sampling	April and May, 2011
Our Lab's boat		Lin and Hou	Field sampling	Oct, 2011
Our Lab's boat		Lin	Field sampling	Nov, 2011
Our Lab's boat		Lin	Field sampling	Feb, 2012
Our Lab's boat		Lin and Hou	Field sampling	April, 2012
Our Lab's boat		Lin	Field sampling	May, 2012

4. Peer-reviewed publications, if planned

a. Published, peer-reviewed bibliography

Lin Q. and Mendelssohn I.A. 2012. Impacts and Recovery of the *Deepwater Horizon* Oil Spill on Vegetative Structure and Function of Coastal Salt Marsh in the Northern Gulf of Mexico. *Environmental Science & Technology*, 46(7):3737-3743.

Mendelssohn IA, Anderson GL, Baltz D, Caffey R, Carmen KR, Fleeger JW, Joye S, Lin Q, Maltby E, Overton E. Oil Impacts to Coastal Wetland: Implications for the Mississippi River Delta Ecosystem after the Deepwater Horizon Oil Spill, *Biosciences*, 62: 562-574

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
The Deepwater Horizon Oil Spill: The Bad News – Good News for Wetlands	Irving Mendelssohn	Irving Mendelssohn and Qianxin Lin,	Gulf Oil Spill SETAC Focused Topic Meeting		April 26-28, 2011
Effects of Deepwater Horizon oil spill on coastal salt marshes		Qianxin Lin and Irving Mendelssohn	Gulf Oil Spill SETAC Focused Topic Meeting		April 26-28, 2011
Oil impacts and recovery of wetland vegetation	Qianxin Lin	Qianxin Lin and Irving Mendelssohn	The Four University Consortium Deepwater Horizon Oil Spill Conference, Baton Rouge, LA		April 29, 2011
The Deepwater Horizon Oil Spill: Impacts to Coastal Wetland Vegetation	Irving Mendelssohn	Irving Mendelssohn, Qianxin Lin, Aixin Hou, Kevin Carman, John Fleeger, Scott Zengel, and Jacqui Michel	Conference of the Coastal and Estuarine Research Federation		Nov. 6-10, 2011
Impacts of the Deepwater Horizon oil spill and recovery of structure and function in coastal salt marshes	Qianxin Lin	Qianxin Lin and Irving Mendelssohn	The 9th INTECOL International Wetlands Conference		June 3-8, 2012
Recovery of Ecological Structure and Function of Coastal Marshes Impacted by the *Deepwater Horizon* Oil Spill	Qianxin Lin	Qianxin Lin and Irving Mendelssohn	Gulf of Mexico Oil Spill & Ecosystem Science Conference		Jan 21-23, 2013
Impacts of the *Deepwater Horizon* Oil Spill on Soil Microbial Communities of Salt Marsh in the Northern	Aixin Hou	Aixin Hou, Nabanita Bhattacharyya, Kris Ackoury,	Gulf of Mexico Oil Spill & Ecosystem Science Conference		Jan 21-23, 2013

Gulf of Mexico		Lauren Navarre, Jizhong Zhou, Qianxin Lin, and Irving Mendelssohn			

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
Irving	Mendelssohn	PI	Louisiana State University	imendel@lsu.edu
Qianxin	Lin	Co-PI	Louisiana State University	comlin@lsu.edu
Aixin	Hou	Co-PI	Louisiana State University	ahou@lsu.edu

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
Sean	Granham	Research Associate		Louisiana State University		
Baustian	Joseph	Research Associate		Louisiana State University		
Chad	Judy	Graduate student	Impact of *Deepwater Horizon* oil on *Phragmites australis*: A greenhouse mesocosm study	Louisiana State University	Aixin Hou (Chair) Irving Mendelssohn (Co-Chair)	2013
Nabanita	Bhattacharyya	Graduate student	Detection and Characterization of *Vibrio vulnificus* and *Vibrio parahaemolyticus* Isolates: Pentaplex PCR Assay and its Application	Louisiana State University	Aixin Hou	2012
Chengting	Hu	BS		Louisiana State University		2012

10. Student and post-doctoral publications, if planned

N/A

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

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Impacts and Recovery of the Deepwater Horizon Oil Spill on Vegetation Structure and Function of common reed *Phragmites australis*: A Mesocosm Study	Chad Judy	Chad Judy, Irving Mendelssohn, Qianxin Lin, and Aixin Hou	Gulf of Mexico Oil Spill & Ecosystem Science Conference		Jan 21-23, 2013

12. Images

Figure 1. Impacts of the Deepwater Horizon oil spill along shoreline marshes in northern Barataria Bay of Louisiana; photographed by Qianxin Lin on January 6, 2011.

Figure 2. Variable recovery along shoreline marshes in northern Barataria Bay, Louisiana almost two year after landfall of the Macondo oil; photographed by Qianxin Lin on April 18, 2012.

11-BP_GRI-15: Community Earth Modeling System for the NGOM

W. H. McAnally

SCIENCE ACTIVITIES

1. General Summary: The objective was to create a community earth system modeling framework that knits together useful numerical models for tracking the transport and fate of oil, oil residues, and oil-contaminated materials and their subsequent effects on the NGoM ecosystem, with consistent input and output data standards, common verification/validation standards, conserving solutions across multiple models domains with varying scales, and consistent expectations for model ability and limitations.

Individual models for each of the significant processes (atmospherics, hydrology/hydraulics, transport, water quality, biogeochemistry, and ecosystem impacts) were identified and entered into an online database. About 70 models were identified and information on 55 of those was compiled and mapped on the web site.

There are hydrologic models from EPA (HSPF) and the Corps of Engineers (GSHHA), ocean models from the Navy (NCOM) and NOAA (FVCOM), coastal models from EPA (EFDC) and the Corps (ADH) and ecosystem models from the private sector (TroSim) and NOAA (Atlantis). They become interconnected through Sulis Informatics Services, which also makes their results accessible to resource managers and stakeholders. A number of models have been incorporated into the SCEM and other models can be added through input/output converters within Sulis Information Services. Sulis web page: http://www.ngi.msstate.edu/sulis/

A NetCDF common data format was adopted for transferring output data from one model to another and to the Sulis Informatics Services.

Three workshops were held in partnership with the ecosystem modeling project.

2. Results and scientific highlights

Healthy Watersheds – Healthy Oceans – Healthy Ecosystems is the underlying goal of Sulis[1], a natural resource assessment system. It provides users ready access to natural resources information in a useful form to better understand aquascapes and their processes, to evaluate the probable consequences of management decisions and natural change, and to make informed assessments with a holistic perspective.

Sulis includes two major components -- ecosystem models (Sulis Community Ecosystem Models, described here) and tools for data assimilation and manipulation, modeling, visualization, and decision support (Sulis Informatics Services).

Sulis Community Ecosystem Models (SCEM) are a system of models providing quantitative and qualitative predictions of how geographically determined systems of organisms (including humans) interact with the biological, chemical, physical, and social conditions that surround them. For example, urbanization of a watershed may cause increased freshwater runoff with higher sediment and nutrient loads to estuarine

[1] Sulis is the Celtic mythological goddess of wisdom, usually associated with the hot springs at Bath, England.

waters, altering fish nursery habitat and shifting productive fisheries. Alterations to aquatic communities may harm fishing, and reduced fish landings can cause economic dislocation, subsequent social change, and urban decline. SCEM is designed to address these issues in an integrated manner so that management measures can be based on realistic outcome expectations.

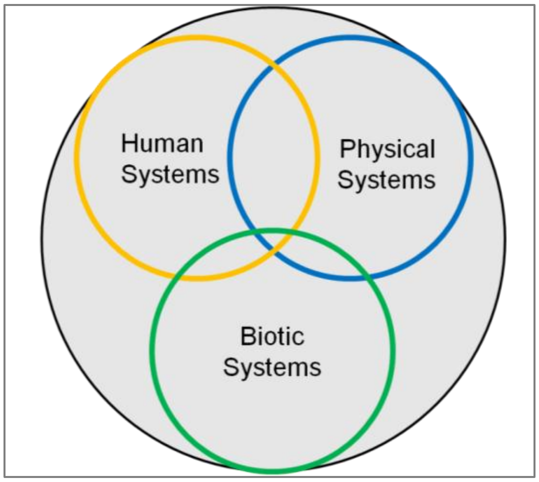

Figure 1. NGI Conceptual Earth Ecosystem Model

The SCEM is based on a Conceptual Earth Ecosystem Model developed by the Northern Gulf Institute and illustrated in Figure 1. Physical systems (including atmospheric, terrestrial, and aquatic physical, chemical and biological systems) overlap and interact with biotic systems (including organisms, their habitat and by-products) and both overlap and interact with human systems (including infrastructure, economic and social systems). Integrated, holistic evaluation of ecosystems requires that all of these aspects be considered over sometimes wide geographic areas.

The holistic view of overlapping, interacting sub-systems shown in Figure 1 has been expanded by NGI into two higher levels of granularity to provide (a) framework that guides research and (b) a collection of computer-based models that make up the SCEM. One perspective on that collection of models can be seen in Figure 2, in which individual models encompassing multiple processes feed, and are fed by, each other and by data.

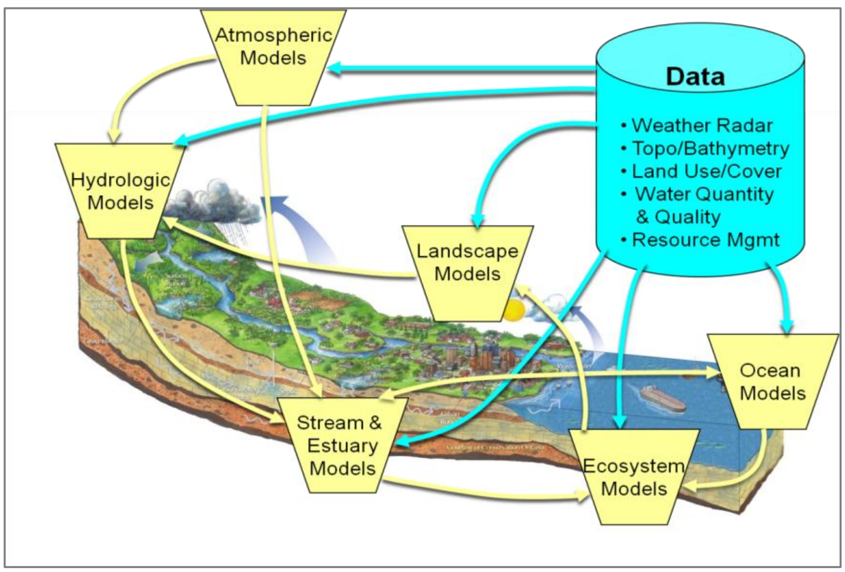

Figure 2. Example of Sulis Community Ecosystem Models implementation of CEEM

There are dozens of such individual models within SCEM. For example, there are hydrologic models from EPA (HSPF) and the Corps of Engineers (GSHHA), ocean models from the Navy (NCOM) and NOAA (FVCOM), coastal models from EPA (EFDC) and the Corps (ADH) and ecosystem models from the private sector (TroSim) and NOAA (Atlantis). They become interconnected through Sulis Informatics Services, which also makes their results accessible to resource managers and stakeholders. A number of models have been incorporated into the SCEM and other models can be added through input/output converters within Sulis Information Services. Sulis web page: http://www.ngi.msstate.edu/sulis/

3. Cruises & field expeditions N/A

4. Peer-reviewed publications, if planned N/A

5. Presentations and posters, if planned N/A

6. Other products or deliverables
Model Inventory and maps located at:
http://www.ngi.msstate.edu/sulis/apps/CommunityModels/index.html

7. Data
N/A

PARTICIPANTS AND COLLABORATORS

8. Project participants
NGI BP Earth System Modeling – FSU, Chassignet, (co-PI here), Morey and Dukhovskoy. Provides atmospheric-ocean coupling

Amount, Fate, and Transport of Oil – MSU, Alarcon. Provides nearshore circulation and oil and sediment transport models.

Weather Effects – MSU, Fitzpatrick, (co-PI here). Provides storm system modeling and air-sea interaction for surge and waves

Field and modeling of oil spill on marsh erosion in southern Louisiana – LSU, Chen (co-PI here) Provides modeling of marsh erosion.

Ecosystem modeling framework to examine ecological impacts – USM, Fulford and Milroy (co-PI here). Provides ecosystem model framework for incorporation

Sulis Mapping, John Cartwright and Rita Jackson, MSU

Model Framework and database, P. Amburn, J. Vanderzwagg, D. Irby

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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

11-BP_GRI-16: Mississippi State University: Extend Sulis Toolkit

Philip Amburn

SCIENCE ACTIVITIES

1. General Summary: During an emergency, water and land resources managers are required to make decisions quickly and often on the basis of information of poor quality, or needed data is inaccessible, and/or incomprehensibly displayed. Frequently, they need to ask a series of “what if” questions to rapidly determine the next actions to take and are often frustrated by not getting the help and information they need. Sulis is a computer-based decision support system to help decision makers of many types make not only routine decisions but also decisions needed in an emergency. This project continued the on-going research and development of Sulis by extending the current structure and starting research and development of the inference engine in support of the NGI effort to define the ecosystem perturbations caused by the Macondo 252 oil spill.

The first part of the work focused on extending and improving the infrastructure of the Sulis framework and is development work needed to expand the entire system. Critical to the success of this portion of the effort was involvement of subject-matter experts and two case studies that enabled testing and evaluation of the framework. The second part of the work was fundamental research into the use of advanced computer-based reasoning and decision techniques, incorporated into the part of Sulis informatics services referred to as the inference engine.

Sulis uses a systematic approach to holistic aquascape management, including tools for data assimilation and manipulation, modeling, visualization, and decision support. Sulis provides users with ready access to environmental and natural resources information in a useful form to better understand aquascapes. Some key words in this description include:

“users” are those who manage water resources at the Federal, state, and local level; stakeholders who want to understand the effects of natural and anthropogenic changes and be able to influence policy and implementation; and those who advise both groups.[2]

“ready access” which implies that a variety of users from technophiles to the technologically limited can operate the system at a simple level, at least, without having a computer specialist at their side.

[2] Federal agencies include, but are not limited to, Environmental Protection Agency, Corps of Engineers, and Bureau of Reclamation National Oceanographic and Atmospheric Administration and its agencies, including the national Weather Service, Natural Resources Conservation Service, Forest Service, Fish and Wildlife Service, Minerals Management Service, and Park Service. State agencies include those responsible for water and environmental quality such as Mississippi Department of Environmental Quality and Alabama Department of Environmental Management. Local agencies include regional water districts, city and county/parish planning and environmental quality offices.

"natural resources information" which indicates a variety of information types (e.g., water quantity and quality, land use, biotic health) and formats (spreadsheets, GIS shape files, etc.)

"useful form" which indicates that displays are informative and understandable, implying graphics.

"aquascape" is used to indicate that the perspective is that of the complete hydrologic footprint, including that of 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.

"holistic" is used to denote the fundamental interconnectedness of the water cycle, the physical environment, ecosystems, and human systems.

2. Results and scientific highlights

The project work completed is in three major categories: 1) data inventory for model identification and development, 2) rapid and effective access to data, provided by the database, GUI, and visualization capabilities of Sulis Informatics Services and 3) analysis support provided by advanced computer-based reasoning provided through techniques which are the basis of the inference engine.

Data Inventory for Model Development

Collecting, organizing, and preparing data from the previous oil spill related work was a significant part of the efforts of the team. Sources of the relevant data were contacted to arrange for a copy of their data. Additionally, metadata was created if it was not already prepared. A thorough list of the available environmental data, as well as information relevant to feedbacks with economical and societal issues, in three representative ecosystems of the nGoM, Barataria Bay (Lousiana), Mississippi Sound (Mississippi), and Perdido Bay (Florida) was compiled. The large data sets extending several years before the DwH oil spill and post-accident surveys, in combination with all the other DwH-related work done by many others, constituted a substantial data set to explore with rigor the environmental, societal and economic impacts of the accident. Ultimately, these data were used to focus the scope of an ecological model, specific to the MS Sound/Bight for initial model customizations.

A Regional Ocean Modeling System (ROMS) simulation of the Gulf of Mexico has been developed for multiple resolutions from 1/12° down to 1/50°.This model has a domain that is compatible for coupling with a 4 km resolution Weather Research and Forecasting (WRF) atmospheric model that has been developed through leveraging of other projects. A carefully hand-edited high-resolution (2 km) bathymetry and coastline data set has been generated for this ocean model, as well as for inclusion into the near-real-time Gulf of Mexico HYCOM (HYbrid Coordinate Ocean Model) nowcast/forecast system. Further, a parallelized surface oil transport model code has been developed along with validation algorithms based on satellite data. As a result of this recently completed project, the components are now ready for implementation into coupled modeling systems such as COAWST (Coupled Ocean -- Atmosphere -- Wave -- Sediment Transport) to support ongoing GRI-funded efforts (e.g. Deep-C).

Database Support, Visualization Capabilities, and User Interface

This aspect of the work enables scientist and resource managers to understand observed and modeled data in order to formulate their own assessment of ecosystem perturbations caused by the Macondo 252 oil spill. One innovation of the research and development efforts lies in its adherence to a user-centered design process used in developing Sulis. Such a process diverges from conventional development methods in that it focused on early and active involvement of users to define their needs, which in turn drive the user interface (UI) and system design. To focus our development efforts on the database, visualization, and user interface we involved research and resource managers with two use cases that we used to drive the work. A critical part of our approach was an iterative development effort. An iterative development effort takes particular advantage of this team which benefits from a strong combination of subject matter experts and computer scientists.

Use Cases - Establishing user requirements through use cases is a well-established software engineering technique. The team worked with Michael Shelton and Scott Phipps of the Alabama Department of Conservation and Natural Resources to help with the development of two use cases. The first use case dealt with historical/baseline data and its' application in events such as the Macondo 252 oil spill. The second use case addressed the need for situation assessment during an event such as the Macondo 252 oil spill. *The two use cases are included in Appendix A.*

Software Development - The team used two software environments from Esri were utilized, the Geoportal and associated web API's (Flex and Javascript) for viewer development (both are open source and are free to modify and distribute). These software tools provide a way to organize/manage data and metadata, customize a user interface for our particular applications, and visualize data. Additionally visualization within the Esri Geoportal package is enhanced with EnVIZ, a software package developed at Mississippi State University. The utilization and development of these software resources allow for an application of Sulis Informatics Services to be deployed within any agency given that they have a dedicated server for the installation. Additionally, the Esri Geoportal implementation in this system allows for network resources from outside entities to be registered and harvested with minimal overhead as the data resides within the originating agency, but is cataloged within the Sulis Informatics Services system. See Figures 1-4 for *Screen captures from the system.*

Inference Engine

The second part of the technical work was on the inference engine which is a technique that evaluates user requests, fetches data, performs analyses, and generates results for the user. The Inference Engine is a logic and computing module that:

Receives user queries
Processes those queries
Fetches data as needed or computes results
Evaluates requests and results for suitability
Returns a response to the User Interface

While the Inference Engine is designed primarily to avoid the steep time costs of additional model runs, it must also be sufficiently accurate. Initially, the project used linear regression as a lower bound on acceptable prediction accuracy. Now, however, a stricter definition of acceptable accuracy is needed, as more than one prediction method satisfies the initial requirements. As such, the current goal of the Inference Engine project is to determine whether any of the tested prediction methods are significantly more accurate than the other methods and to determine the conditions for which that accuracy remains stable.

Support vector regression was implemented using the LIBSVM software package. This implementation contains kernel parameters that, when optimized, increases prediction accuracy. Spline regression is implemented using the earth software package, from the R programming language. This package is based on the MARSPLINES techniques created by Thomas Friedman. Bayesian belief networks were considered as a possible prediction method for the Inference Engine. However, analysis indicates that Bayesian belief networks may be more useful for classification or decision problems than for regression problems.

Data Testing - Initial tests are based on EFDC Model outputs for the Mobile Bay area in Alabama. Both of these tests predict the temperature at the bottom of Mobile Bay, based on timestep and position (x, y, and z). All data is scaled between -1 and 1 before being used in either the training set or the test set. The x and y positions for each data point are distributed irregularly across a rectangular grid, but remain the same between timesteps. Both of these tests compare the mean squared error with the size of the test set, in timesteps. Each timestep contains 1,727 points of data. Note that each point in both tests is based on twenty data samples and that each prediction method is tested on the same samples.

Both support vector regression and spline regression are more accurate than linear regression, under current conditions. However, additional testing is needed to determine whether either method is significantly more accurate than the other. This analysis does indicate that interpolation and extrapolation using a single data set is practicable. Further testing should be done to determine whether interpolation between multiple data sets is feasible. *See Charts 1 and 2.*

3. Cruises & field expeditions
N/A

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
A Framework for Geospatial Applications and Decision Support for the Northern Gulf Institute	John Cartwright	John Cartwright William McAnally Julie Baca	NOAA CSC Coastal Geotools 2011 Myrtle Beach, South Carolina	Yes	3/21/2011-3/24/2011
Applications for Geospatial Technologies and Decision Support	John Cartwright	John Cartwright William McAnally Philip Amburn Rita Jackson	NGI Annual Conference 2011 Mobile, Alabama	Yes	5/17/2011-5/19/2011

6. Other products or deliverables
Sulis Informatics Services for the Macondo 252 Oil Spill
http://sulis-data.ngi.msstate.edu/geoportal/?project=dwh

*This provides access to all the data, viewers, and products that were generated and/or harvested in this project.

7. Data

DATA INVENTORY FOR NGI EXTEND SULIS TOOLKIT A.xls
DATA INVENTORY FOR NGI EXTEND SULIS TOOLKIT B.xls
DATA INVENTORY FOR NGI EXTEND SULIS TOOLKIT C.xls

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8. Project participants

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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

Sulis Informatics Services for the Macondo 252 Oil Spill

Sulis Informatics Services

Login Help About Feedback

DWH (BP) Oil Spill

HOME SEARCH BROWSE LAUNCH MAP VIEWER

Home

Deep Water Horizon (BP) Oil Spill

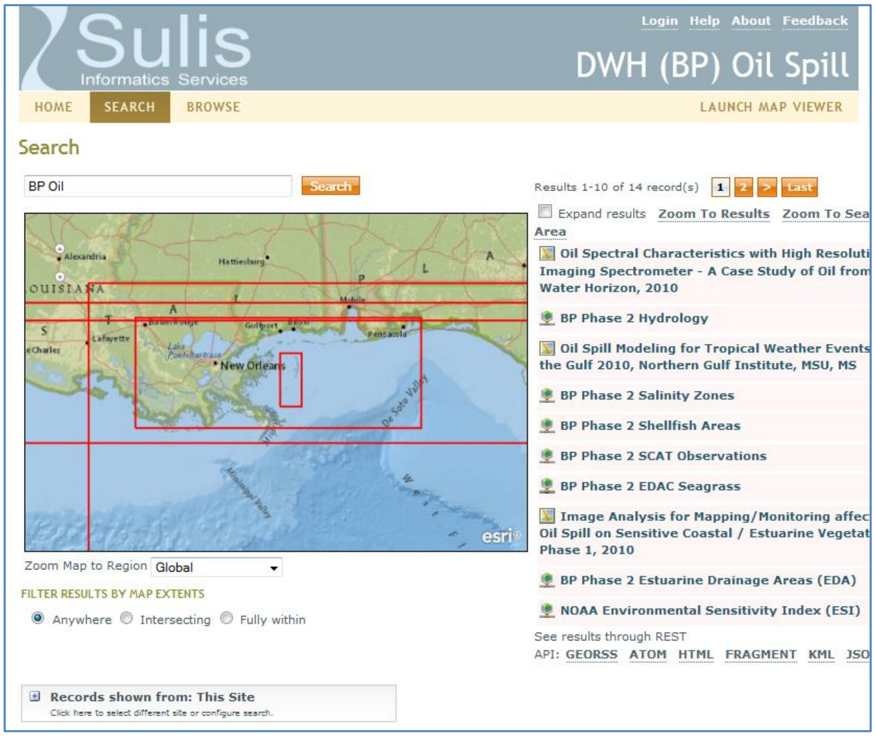
The Deepwater Horizon oil spill (also referred to as the BP oil spill, the Gulf of Mexico oil spill, the BP oil disaster, or the Macondo blowout) is an oil spill in the Gulf of Mexico which flowed unabated for three months in 2010. It is the largest accidental marine oil spill in the history of the petroleum industry. The spill stemmed from a sea-floor oil gusher that resulted from the April 20, 2010, explosion of Deepwater Horizon, which drilled on the BP-operated Macondo Prospect. The explosion killed 11 men working on the platform and injured 17 others. On July 15, 2010, the leak was stopped by capping the gushing wellhead, after it had released about 4.9 million barrels (780,000 m3) of crude oil. An estimated 53,000 barrels per day (8,400 m3/d) escaped from the well just before it was capped. It is believed that the daily flow rate diminished over time, starting at about 62,000 barrels per day (9,900 m3/d) and decreasing as the reservoir of hydrocarbons feeding the gusher was gradually depleted. On September 19, 2010, the relief well process was successfully completed, and the federal government declared the well "effectively dead". In August 2011, oil and oil sheen covering several square miles of water were reported surfacing not far from BP's Macondo well. Scientific analysis confirmed the oil is a chemical match for Macondo 252.

The spill caused extensive damage to marine and wildlife habitats and to the Gulf's fishing and tourism industries. Skimmer ships, floating containment booms, anchored barriers, sand-filled barricades along shorelines, and dispersants were used in an attempt to protect hundreds of miles of beaches, wetlands, and estuaries from the spreading oil. Scientists also reported immense underwater plumes of dissolved oil not visible at the surface as well as an 80-square-mile (210 km^2) "kill zone" surrounding the blown well. In late November 2010, 4,200 square miles (11,000 km^2) of the Gulf were re-closed to shrimping after tar balls were found in shrimpers' nets. The amount of Louisiana shoreline affected by oil grew from 287 miles (462 km) in July to 320 miles (510 km) in late November 2010. In January 2011, an oil spill commissioner reported that tar balls continue to wash up, oil sheen trails are seen in the wake of fishing boats, wetlands marsh grass remains fouled and dying, and crude oil lies offshore in deep water and in fine silts and sands onshore. A research team found oil on the bottom of the seafloor in late February 2011 that did not seem to be degrading. On May 26, 2011, the Louisiana Department of Environmental Quality extended the state of emergency related to the oil spill. By July 9, 2011, roughly 491 miles (790 kilometers) of coastline in Louisiana, Mississippi, Alabama and Florida remained contaminated by BP oil, according to a NOAA spokesperson

NGI Northern Gulf Institute

Figure 1: Sulis Informatics Services for the DWH (BP) oil spill. Built upon the ESRI Geoportal Extension 1.2 with added features and customizations for data search and exploration.

<u>**Sulis Informatics Services Data Search and Exploration**</u>



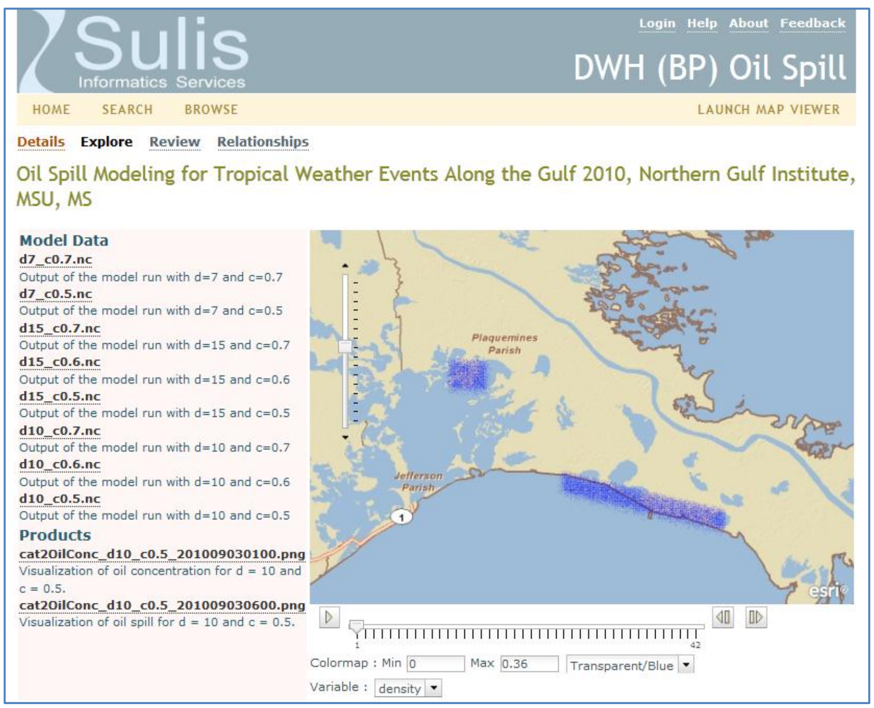


Figure 2 and Figure 3: Sulis Informatics Services data search and exploration interfaces. Search window highlighting data bounds based on ‘BP Oil’ data search and exploration of model results and associated products.

Sulis Informatics Services Map Viewer

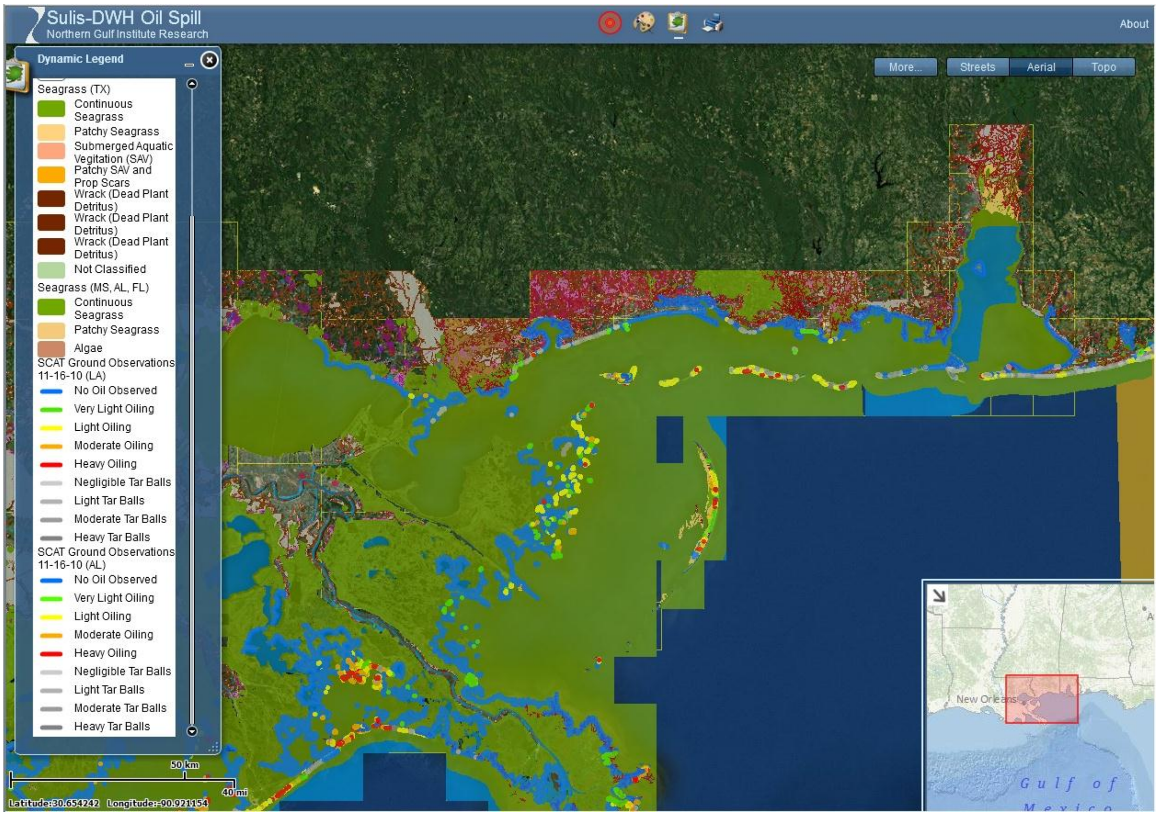
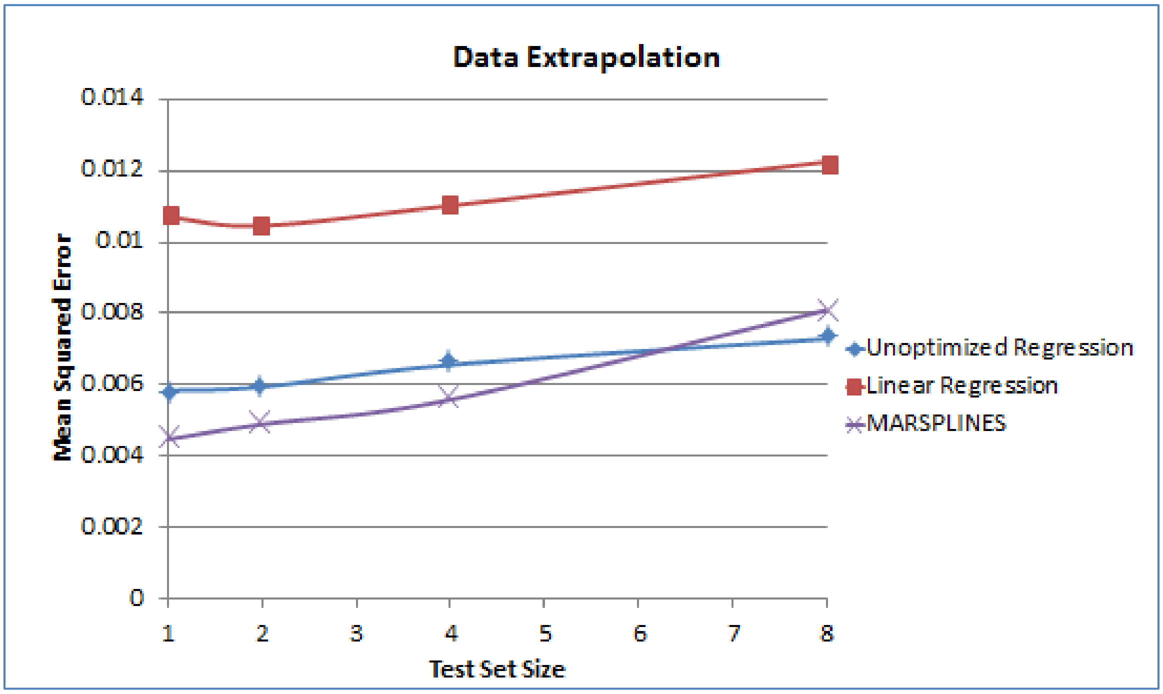
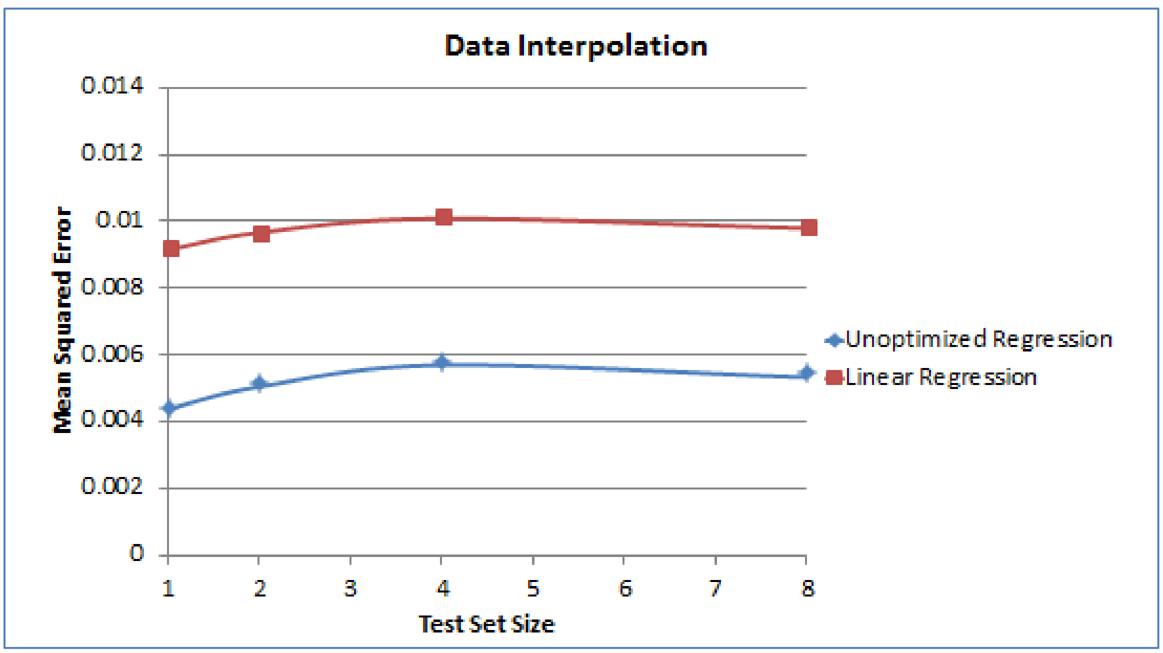


Figure 4: Sulis Informatics Services map viewer displaying observed oil coverage (Shoreline Cleanup Assessment Team observations) with environmentally sensitive areas (Environmental Sensitivity Index) in the northern Gulf of Mexico.





Extrapolation (Chart 1) and Interpolation (Chart 2): A model file is trained on a number of consecutive time steps, with a randomly selected start position. The test file is composed of a number of time steps immediately after the training set.

Appendix A: Use Cases

These are the two use cases used to design the Sulis interface for BP oil spill data.

Historical / Baseline Data Use Case

Description: The main goals of this use case are to describe the needs of decision makers at the start of a natural or man-made catastrophic event, such as the BP oil spill. Many critical decisions require historical and baseline data, but often this data is incomplete, hard to find, and difficult to gain access.

Actors: Personnel in State Emergency and Natural Resource Management agencies.

Background and Assumptions: When faced with a catastrophic event, people need to know what information has been previously collected on areas that are potentially impacted. This is particularly true for environmentally sensitive areas, such as Louisiana marshes and Gulf beaches during the BP oil spill

Steps:

1. What areas are potentially affected?

Using data from Federal Government organizations such as NOAA and the Coast Guard, predictions based on weather and ocean forecasts, emergency managers will need to develop a list of areas to be considered. These areas need to be described and displayed in a 2D GIS environment. Emergency managers will need to determine which areas will be impacted.

2. What information is available on the potentially affected areas?

Allow users to identify areas on maps through the GUI.

Respond to queries about these areas by searching available databases. This includes searching local and distant databases, such as NCDDC, NEON, etc.

Enable users to identify categories of affected areas, such as marshes, beaches, etc.

Provide a 2D GIS display of reported data (such as sightings of oil / tar balls / imagery)

Provide a 2D GIS display of locations of infrastructure and environmentally sensitive areas, with features such as water intakes, sewage plants, etc.

Indicate areas where requested data is not available.

Open Issues / Risks: Catastrophic events caused by human actions involve substantial legal issues which require decades to resolve. This use case does not address the issues of access to data, dissemination of data to the public and media, etc.

Situation Assessment Use Case

Description: The main goals of this use case are to describe the needs of decision makers at the start of a natural or man-made catastrophic event, such as the BP oil spill. It is critical that people up and down the chain of command understand the current situation and then develop plans to address the issues.

Actors: Personnel in State Emergency and Natural Resources Management agencies.

Background and Assumptions: When faced with a catastrophic event, as much as possible responsible personnel need to know:
1. What is happening now?
2. What is likely to happen in the near term?
3. Where are the areas that will likely need the most attention? (With the BP oil spill this included ecologically sensitive areas and water intake sites that might be affected. This task is addressed in another use case.)
This use case is oriented to the BP oil spill, and where possible specific issues related to this event will be used. Clearly the specifics would change substantially for a different type of event. For this use case we are going to concentrate on the impact of weather and ocean state.

Steps:
1. What is happening now?
Observational data needs to be collected by all available parties, and that data made available through the Unified Command Process, mandated by the Oil Pollution Control Act.

People on-site need to be directed to collect samples, make observations, etc. and report that information back to the appropriate authorities.

That information needs to be collected and made available.

Available data needs to be organized with tools to allow users to quickly find relevant data so that they can answer questions or make informed decisions.

Provide a 2D GIS presentation of this data to quickly identify where people are collecting data. This could lead to a desktop application and / or a mobile application.

2. What is likely to happen in the near term?
For weather the pertinent data will come from the National Weather Service in the form of weather forecasts as text, 2D maps, and 3D numerical model output from models such as the North American Mesoscale Model and the Weather Research and Forecasting model.

Identify the period of time for investigation, such as 24 or 48 hours.

Collect NWS forecasts and 2D maps for selected time period.

Gain access to NAM and WRF model output for the selected time period.

Provide access to text forecasts and 2D maps from the NWS

Prepare 3D representations of the weather for the selected time period.

Provide a search or browse interface to allow users to find the relevant data they need to make decisions.

For ocean state the pertinent data will come from the US Navy and their use of the Navy Coastal Ocean Model (NCOM).

Identify the period of time for investigation.

Collect NCOM output and US Navy ocean forecasts

Provide access to the Navy ocean forecasts

Prepare 3D representations of the NCOM output

Provide a search or browse interface to allow users to find the relevant data they need to make decisions.

3. Where are the areas that will likely need the most attention?
Based on the assessment of the current situation and historical data on environmentally (or ecologically) sensitive areas, plans need to be formulated to address the near-term situation. Reviewing historical data on environmentally (or ecologically) sensitive areas is described in a separate use case.

Open Issues / Risks: Catastrophic events caused by human actions involve substantial legal issues which require decades to resolve. This use case does not address the issues of access to data, dissemination of data to the public and media, etc.

11-BP_GRI-17: Mississippi State University: The influence of weather and ocean processes using numerical modeling on the fate and transport of the Deepwater Horizon Oil Spill

Pat Fitzpatrick

SCIENCE ACTIVITIES

1. General Summary: In the Phase 1 research, 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. We also developed storm surge 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. In the Phase 2 research – which is still ongoing - we expanded the oil spill simulation to cover the period May 25-July 31. Oil weathering algorithms are being added to the oil modeling efforts. An effort to consolidating oil observation databases to validate the oil spill simulations has begun. A journal paper on the Lake Pontchartrain pollution incident is in the final stages of preparation before submission for peer review.

2. Results and scientific highlights

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. Initialization was based on satellite imagery and oil trajectory maps. The 10-m wind and near-surface currents were provided from an operational, data assimilating forecast system run daily by the Naval Oceanographic Office called the Navy Coastal Ocean Model (NCOM). NCOM includes tidal components and a dynamic water surface which fluctuates from wind forcing even capable of capturing storm surge events. The Coupled Ocean-Atmosphere Prediction System (COAMPS) provided the atmospheric forcing.

Figure 1 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 (attached to report) include a pulsing action due to the diurnal tides. 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 (Fig. 2-8). We examined scatterometer data, satellite/radar imagery, high-frequency radar (HFR) currents, COAMPS wind fields, buoy data, and North American surface map analyses. A tropical system affected the Gulf as a tropical wave entered the region and eventually became Hurricane Alex. 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, 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, and slowly moved westward then stalling south of eastern Louisiana.

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. 9, 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.

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. 10 and 11, which simulated the hypothetical scenario of a category 2 hurricane making a September landfall in Fourchon, LA. In September 2010, the Sandy Point Beach region, as well as northeast Barataria Bay (near Bay Jimmy), contained oiled shorelines as well imbedded oil on the sea bottom. 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. Fortunately, this forecast system was never tested.

For Phase 2, the oil simulation was expanded to cover most of the oil spill period. Figures 12 and 13 show the simulation for the 25 May through the end of July, depicting many features of the oil transport. In this extended simulation, the oil spill "streamers" are clearer, and the intrusion into marsh and coastal regions is obvious.

To clarify the oil transport better, and to validate the simulations, a database based on the Shoreline Cleanup and Assessment Technique (SCAT) surveys. An example of the Louisiana SCAT data for 23-25 May is shown in Fig. 14, identifying tarball and oil pollutants (by category). Note this dataset also documents where no oil was observed. The SCAT data has been processed and plotted. These datasets should be useful not only for this project but to other researchers as well. Notification of these datasets availability has been emailed to Mike Carron at GOMRI, and thus far some researchers from Texas A&M have downloaded them. Monthly, daily, and accumulated 3-day plots have been performed. The latter have proven most useful to examine the oil spill evolution since often daily observations were not performed at individual locations, leaving datagaps.

To clarify the oil spill evolution, eleven region of interests were identified for additional analysis (Fig. 15). Timelines were developed for each region using the SCAT data. Figures 16-18 show examples of these timelines. Note how the Biloxi Marsh experienced an early impact, then was relatively oil-free for several weeks. The time period of late June for oil movement into Lake Pontchartrain is also clear. In contrast, note that Grand Isle and Fourchon were impacted fairly frequently during the entire event, more moderate to heavy oiling. Such data will be useful to our modeling studies as well as to other researchers.

Oil weathering processes are currently being added to the oil spill model. Spreading has been coded, while methods for evaporation and emulsification are currently being studied.

3. Cruises & field expeditions
NA

4. Peer-reviewed publications
Fitzpatrick, P. J., Y. Lau, H. Karan, C. M. Hill, J. Harding, and D. S. Ko, 2011: The influence of cyclones on the Deepwater Horizon oil spill. To be submitted to *Journal of Geophysical Research*

5. Presentations and posters
Presentations partially or completely focused on the oil spill research

Fitzpatrick, P. J., 2011: AMSEAS meteorological forcing evaluation – progress & plans. SURA Shelf Hypoxia Face-to-Face Meeting, March 3-4, Washington, D.C.

Fitzpatrick, P. J., Y. Lau, and C. M. Hill, 2011: An overview of GRI-SSC research. Univ. of Southern Mississippi, Dept. of Marine Sciences Seminar Series, April 1, Stennis Space Center, MS [invited].

Fitzpatrick, P. J., Y. Lau, and C. M. Hill, 2011: An overview of GRI-SSC research. Univ. of South Florida, Dept. of Marine Sciences seminar series, April 22, St. Petersburg, FL [invited].

Fitzpatrick, P. J., Y. Lau, and C. M. Hill, 2011: An overview of GRI-SSC research. Louisiana State University, Dept. of Civil Engineering, April 8, Baton Rouge, LA [invited].

Lau, Y., P. Fitzpatrick, C. Hill, and H. Karan, 2011: The influence of cyclones on the Deepwater Horizon oil spill. 5th Annual Northern Gulf Institute Conference, May 23-27, Mobile, AL.

Fitzpatrick, P. J., 2011: Assessing fate and transport issues of the DWH oil spill using simulations and merged datasets. DWH Oil Spill Principal Investigator's One Year Update Workshop, October 25, St. Petersburg, FL [invited].

Fitzpatrick, P. J., Y. Lau , C. M. Hill, and H. Karan, 2012: The influence of cyclones on the Deepwater Horizon oil spill. 92nd American Meteorological Society Annual Meeting, January 22-26, New Orleans, LA.

Fitzpatrick, P. J., Y. Lau, H. Karan, and C. M. Hill, 2012: An overview of meteorology research at GRI-SSC and WorldWinds, Inc. Louisiana State University, Dept. of Civil Engineering, March 19, Baton Rouge, LA [invited].

In Table format:

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
AMSEAS meteorological forcing evaluation – progress & plans	Fitzpatrick	P. J. Fitzpatrick	SURA Shelf Hypoxia Face-to-Face Meeting, Washington, D.C.	N	March 3, 2011
An overview of GRI-SSC research	Fitzpatrick	P. J. Fitzpatrick Y. Lau C. M. Hill	Univ. of Southern Mississippi, Dept. of Marine Sciences Seminar Series, Stennis Space Center, MS.	N	April 1, 2011
An overview of GRI-SSC research	Fitzpatrick	P. J. Fitzpatrick Y. Lau C. M. Hill	. Louisiana State University, Dept. of Civil Engineering, Baton Rouge, LA.	N	April 8, 2011
An overview of GRI-SSC research	Fitzpatrick	P. J. Fitzpatrick Y. Lau C. M. Hill	Univ. of South Florida, Dept. of Marine Sciences seminar series, St. Petersburg, FL.	N	April 22, 2011
The influence of cyclones on the Deepwater Horizon oil spill	Fitzpatrick	P. J. Fitzpatrick Y. Lau C. M. Hill H. Karan	5th Annual Northern Gulf Institute Conference, Mobile, AL.	Y	May 19, 2011
Assessing fate and transport issues of the DWH oil spill using simulations and merged datasets	Fitzpatrick	P. J. Fitzpatrick	DWH Oil Spill Principal Investigator’s One Year Update Workshop, St. Petersburg, FL.	Y	Oct 25, 2011
The influence of cyclones on the Deepwater Horizon oil spill	Fitzpatrick	P. J. Fitzpatrick Y. Lau C. M. Hill H. Karan	92nd American Meteorological Society Annual Meeting, New Orleans, LA	Y	Jan 23, 2012

An overview of meteorology research at GRI-SSC and WorldWinds, Inc.	Fitzpatrick	P. J. Fitzpatrick Y. Lau H. Karan C. M. Hill	Louisiana State University, Dept. of Civil Engineering, Baton Rouge, LA.	N	March 19, 2012

Posters partially or completely focused on the oil spill research

Fitzpatrick, P. J., Y. Lau, C. M. Hill, and H. Karan, 2011: The influence of cyclones on the BP oil spill. 65th Interdepartmental Hurricane Conference, February 28-March 3, Miami, FL.

Wiggert, J. D., J. M. Harding, F. L. Bub, P. J. Fitzpatrick, and K. C. Woodard, 2012: Evaluation of the AMSEAS Gulf of Mexico/Caribbean regional forecast system: A SURA super-regional modeling testbed activity. 2012 Ocean Sciences Meeting, February 20-24, Salt Lake City, UT.

In Table Format:

Title	**Presenter**	**Authors**	**Meeting or Audience**	**Abstract published (Y/N)**	**Date**
The influence of cyclones on the BP oil spill	Fitzpatrick	P. J. Fitzpatrick Y. Lau C. M. Hill H. Karan	65th Interdepartmental Hurricane Conference, Miami, FL	Y	Feb 28 – Mar 3, 2011
Evaluation of the AMSEAS Gulf of Mexico/Caribbean regional forecast system: A SURA super-regional modeling testbed activity	Wiggert	J. D. Wiggert J. M. Harding F. L. Bub P. J. Fitzpatrick K. C. Woodard	2012 Ocean Sciences Meeting, Salt Lake City, UT	Y	Feb 20 - 24, 2012
The influence of cyclones on the BP oil spill	Fitzpatrick	P. J. Fitzpatrick Y. Lau C. M. Hill H. Karan	5th Annual Northern Gulf Institute Conference, Stennis Space Center, MS.	Y	

6. Other products or deliverables

Fitzpatrick, P., Y. Lau, C. Hill, and H. Karan, 2011: COAMPS wind validation in the NCOM Intra-American Seas (AMSEAS) domain in the Gulf of Mexico during 20 June to 10 July 2010, and the use of NCOM and COAMPS data to examine the impact of cyclones on the Deepwater Horizon oil spill, Mississippi State University technical report, 24 pp plus appendix graphics. Available at http://testbed.sura.org/publications.

7. Data

Metadata on the oil spill model data is provided as attachment, please open with a web browser (see oil_spill_model_metadata.htm). The SCAT and Louisiana Bucket Brigade data has been provided to GOMRI.

PARTICIPANTS AND COLLABORATORS

8. Project participants

First Name	Last Name	Role in Project	Institution	Email
Pat	Fitzpatrick	PI	Mississippi State University	fitz@gri.msstate.edu
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Haldun	Karan	Research Associate	Mississippi State University	karan@gri.msstate.edu
Chris	Hill	Research Associate	Mississippi State University	hillcm@gri.msstate.edu
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Dong	Ko	Collaborator	Naval Research Laboratory	ko@nrlssc.navy.mil

9. Student and post-doctoral participants

N/A

10. Student and post-doctoral publications

N/A

11. Student and post-doctoral presentations and posters

N/A

12. Images

<u>Phase 1</u>

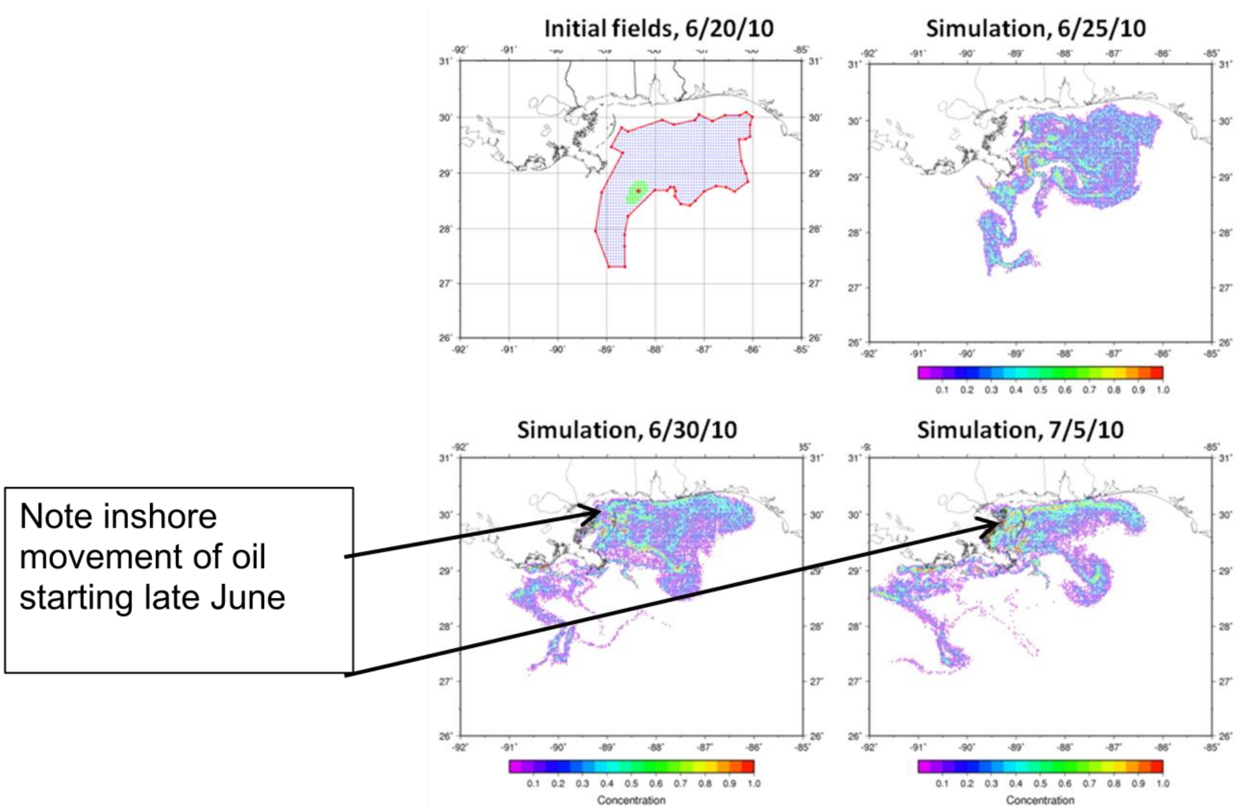


Figure 1. Snapshot images of the Deepwater Horizon oil spill simulation from 0000 UTC 20 June 2010 to 0000 UTC 10 July 2010. Note the inshore incursion into the Mississippi Sound and Lake Borgne regions starting in late June. Concentrations are computed as the ratio of parcels near a gridded point divided by the number of parcels originally released at each point (25).

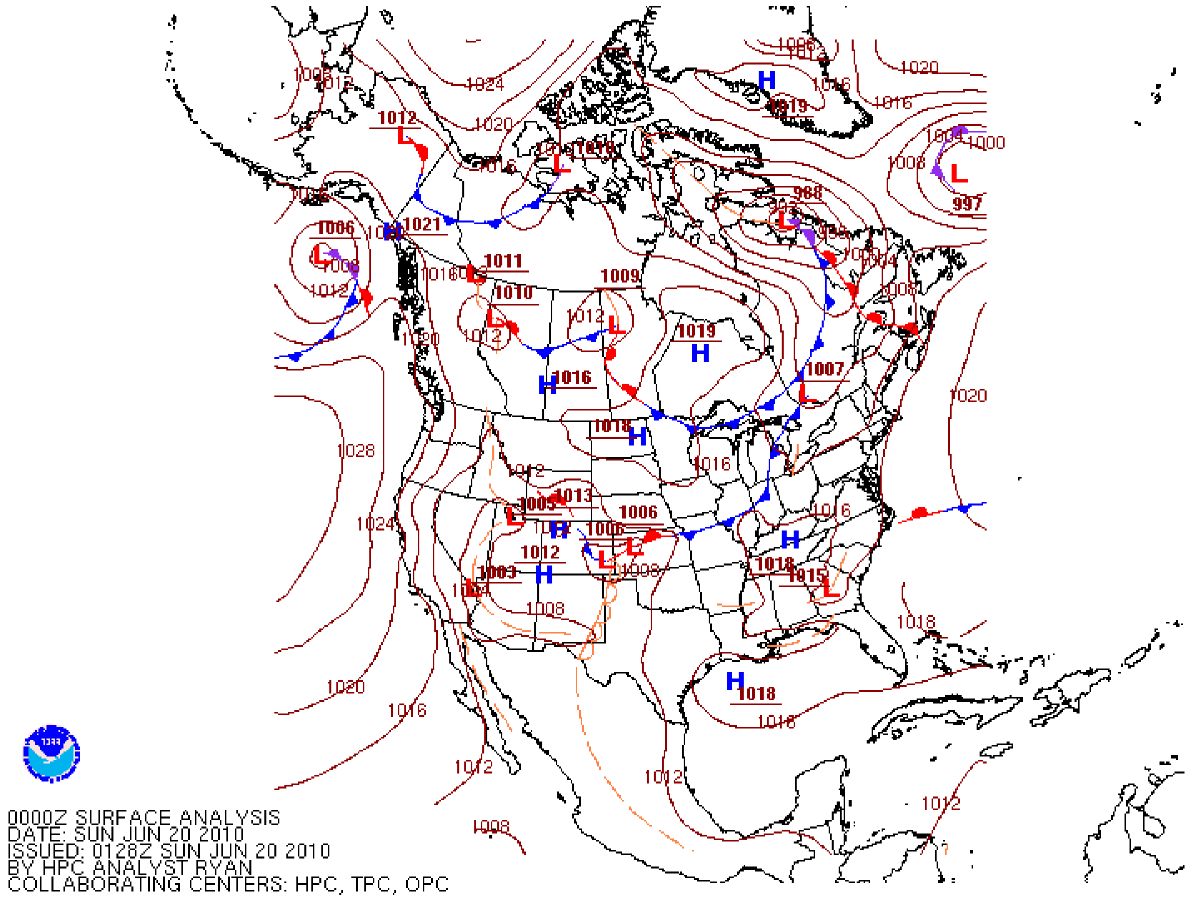


Figure 2. Hydrometeorological Prediction Center (HPC) North American surface analysis for 0000 UTC 20 June 2010 (available at http://www.hpc.ncep.noaa.gov/html/sfc_archive.shtml). HPC is part of the NOAA/National Weather Service National Centers for Environmental Prediction.

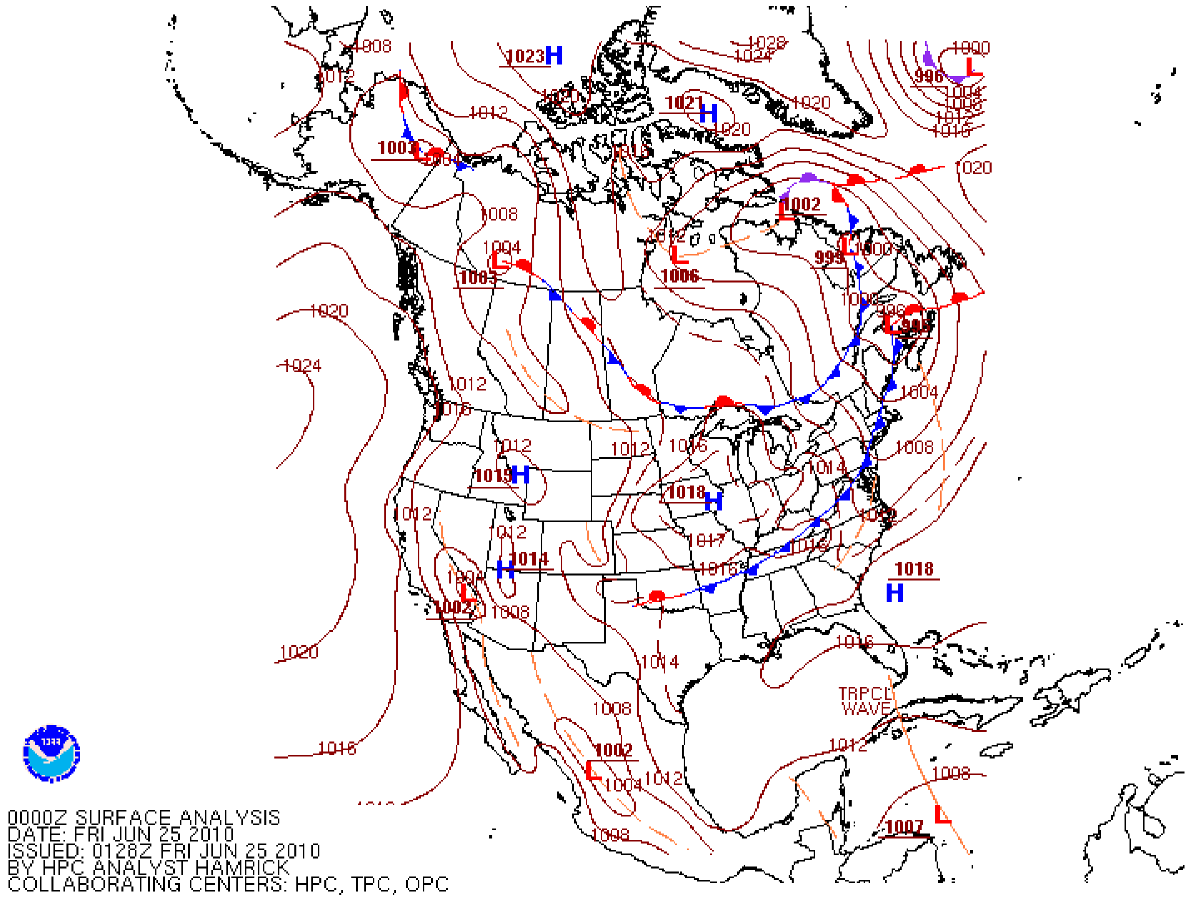


Figure 3. As in Fig. 2, but for 0000 UTC 25 June 2010.

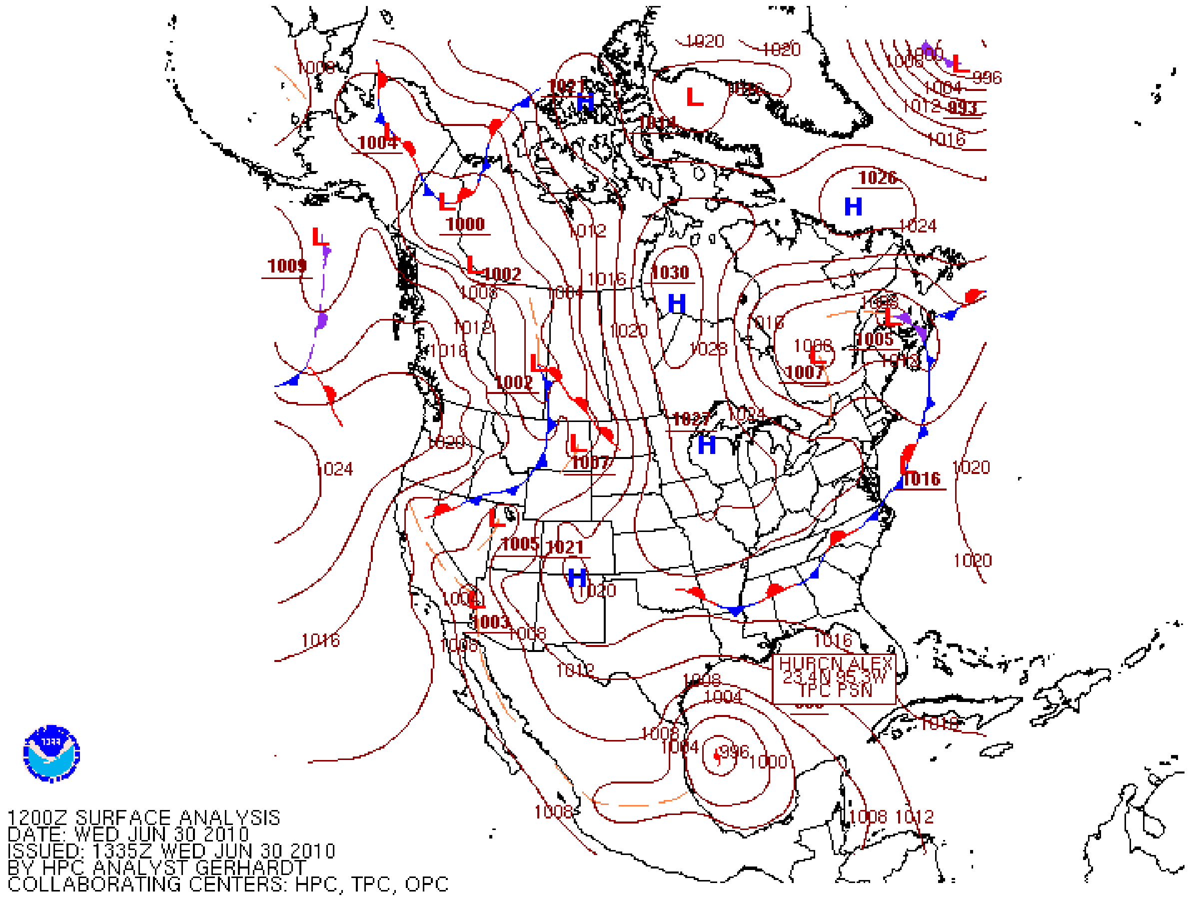


Figure 4. As in Fig. 2, but for 1200 UTC 30 June 2010.

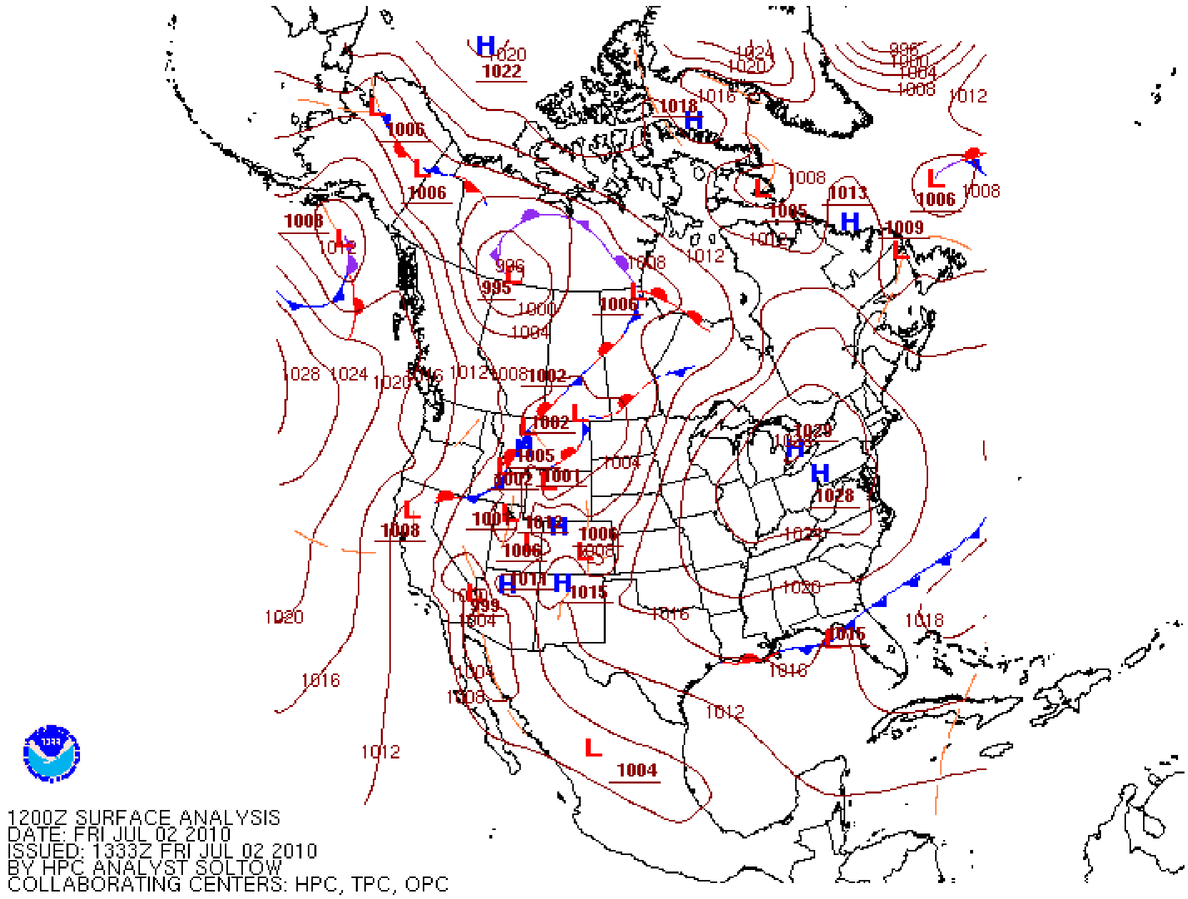


Figure 5. As in Fig. 2, but for 1200 UTC 2 July 2010.

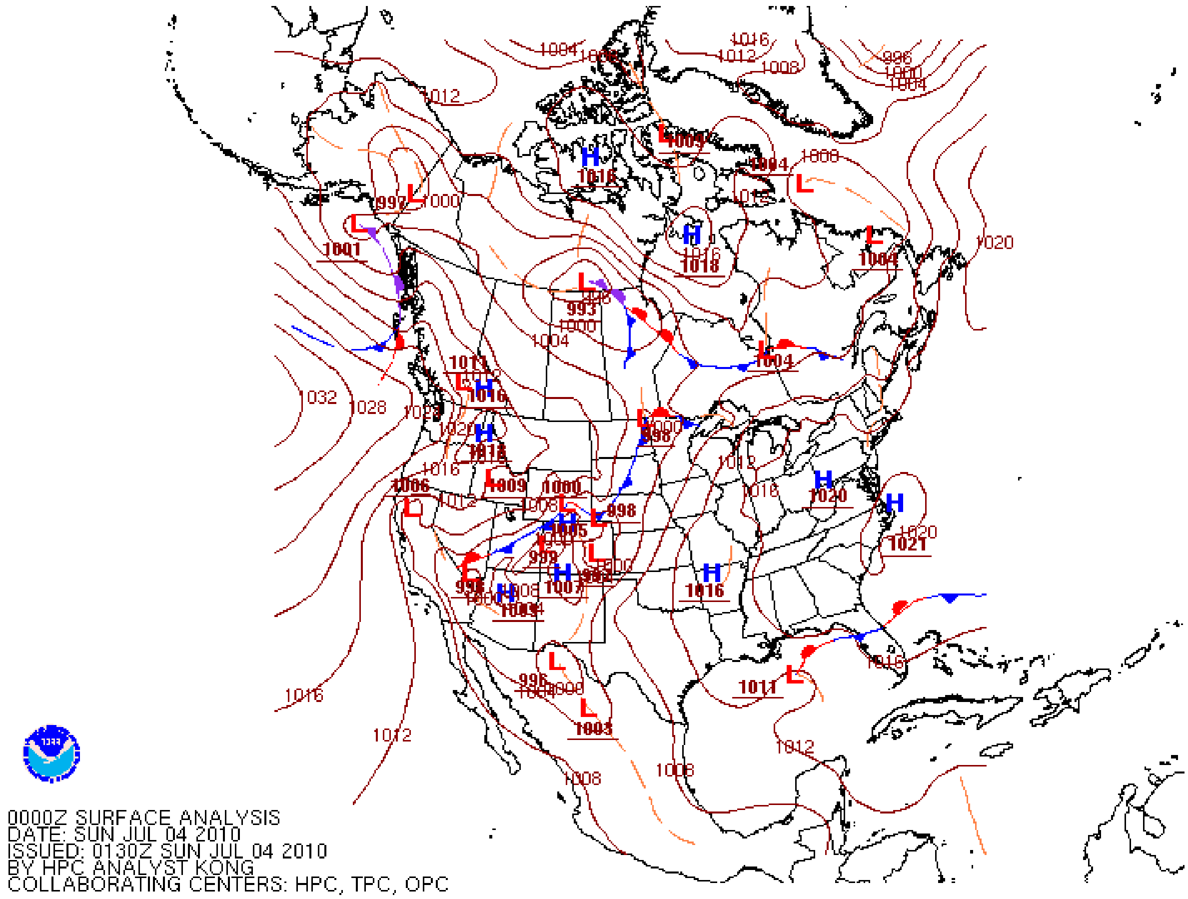


Figure 6. As in Fig. 2, but for 0000 UTC 4 July 2010.

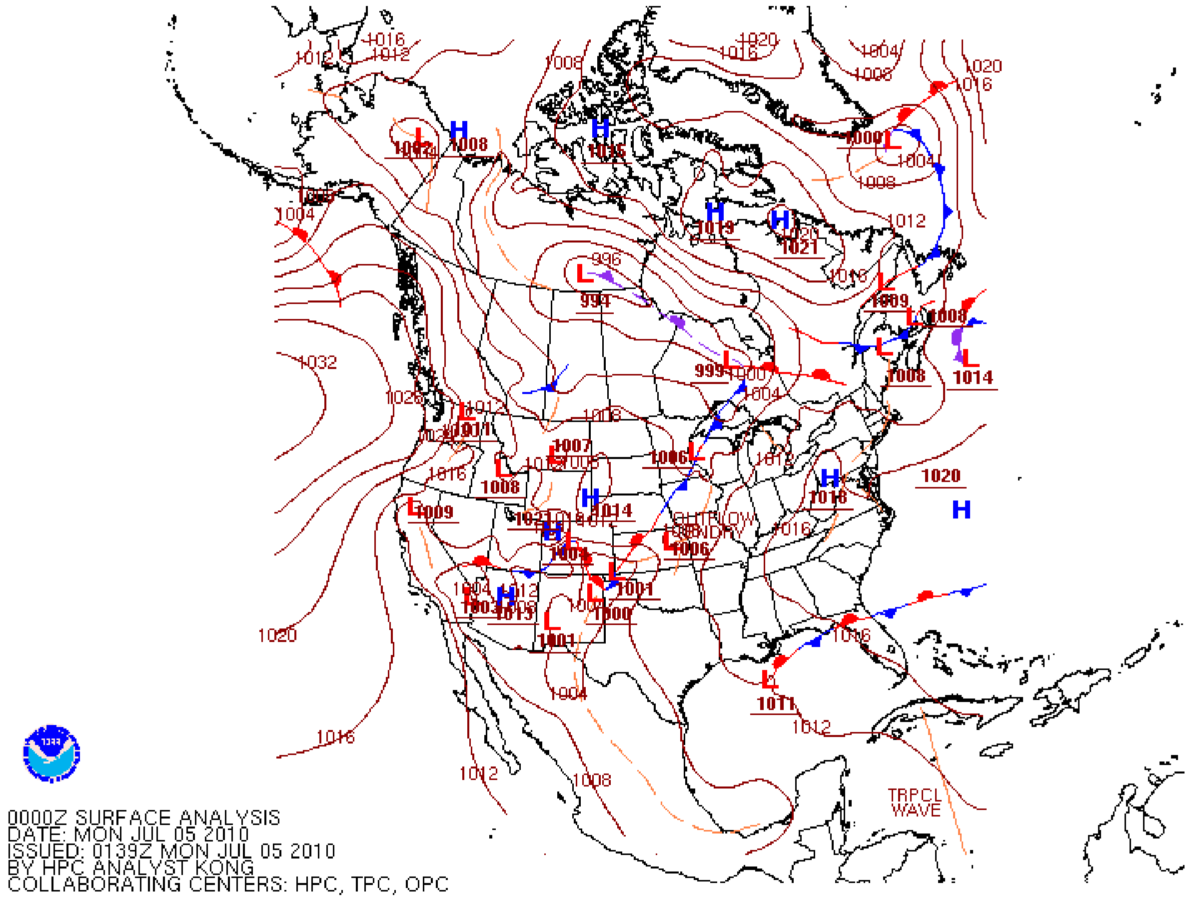


Figure 7. As in Fig. 2, but for 0000 UTC 2 July 5010.

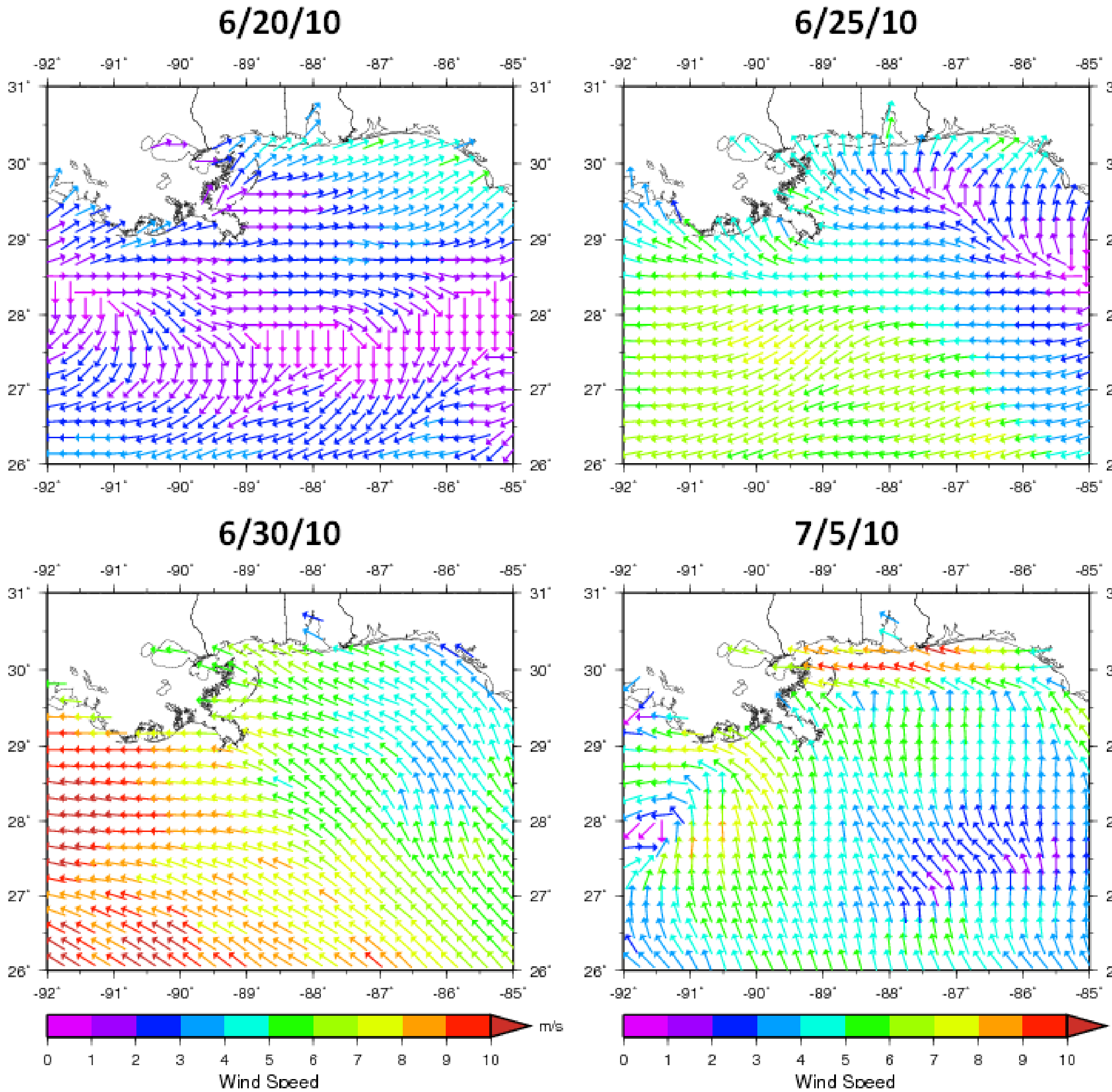
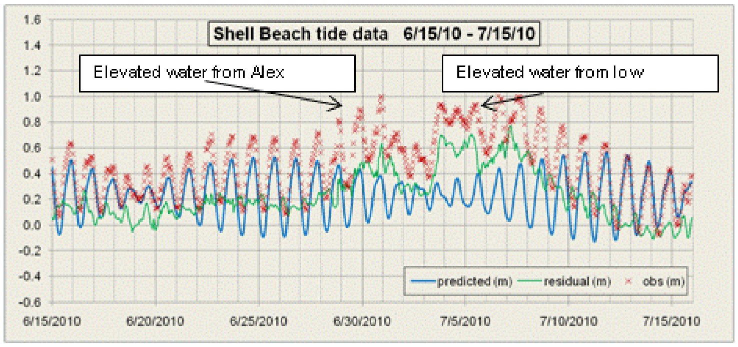


Figure 8. COAMPS winds for 0000 UTC 20 June, 25 June, 30 June, and 5 July 2010, depicting the weather regimes during this period. The period begins with typically weak summertime winds associated with a high pressure ridge (top left), then winds off of Mississippi becoming easterly associated first with 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).



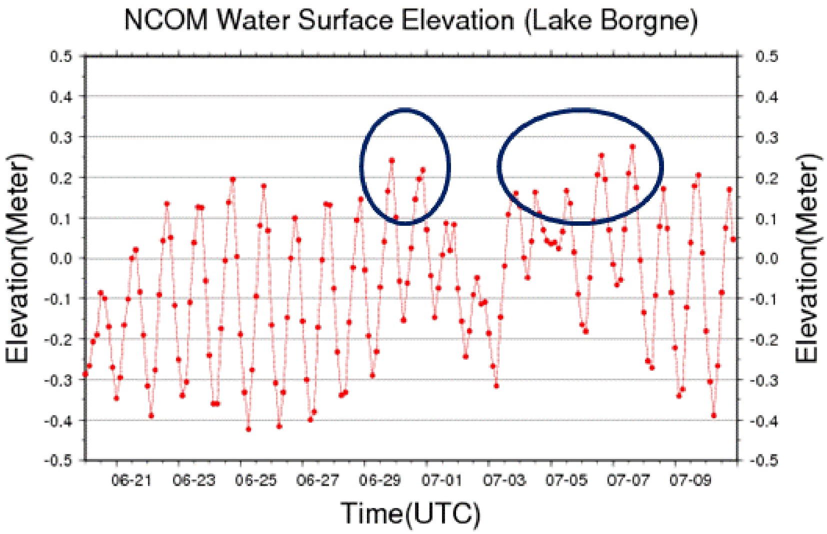


Figure 9. Top: Observed water level (red), tide prediction (blue), and residual (observed minus tide, in green) for Shell Beach CMAN station in Lake Borgne, LA, during 0000 UTC 15 June to 0000 UTC 15 July 2010. Bottom: NCOM surface elevation data for Lake Borgne from 0000 UTC 20 June to 0000 UTC 10 July 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").

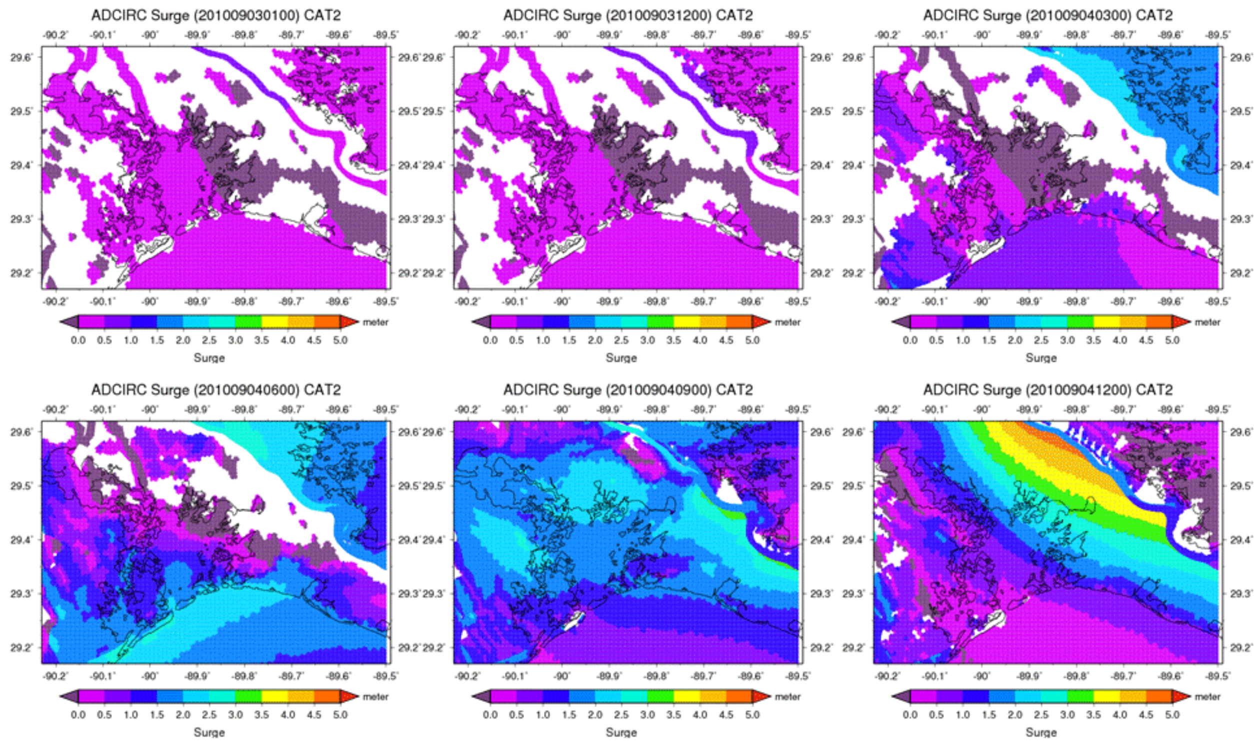


Figure 10. ADCIRC storm surge simulation of hypothetical category 2 hurricane making landfall in Fourchon, LA.

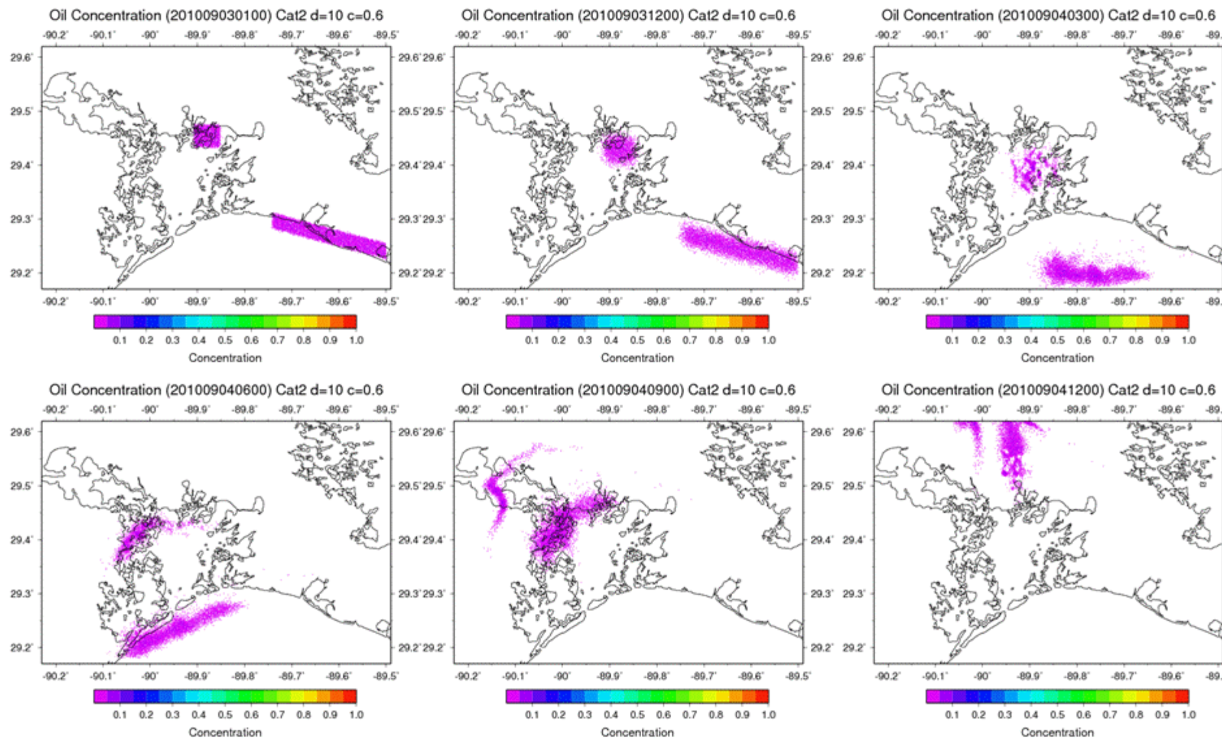


Figure 11. Displacement of oil from Sandy Point Beach and Bay Jimmy during storm surge depicted in Fig. 10.

Phase 2

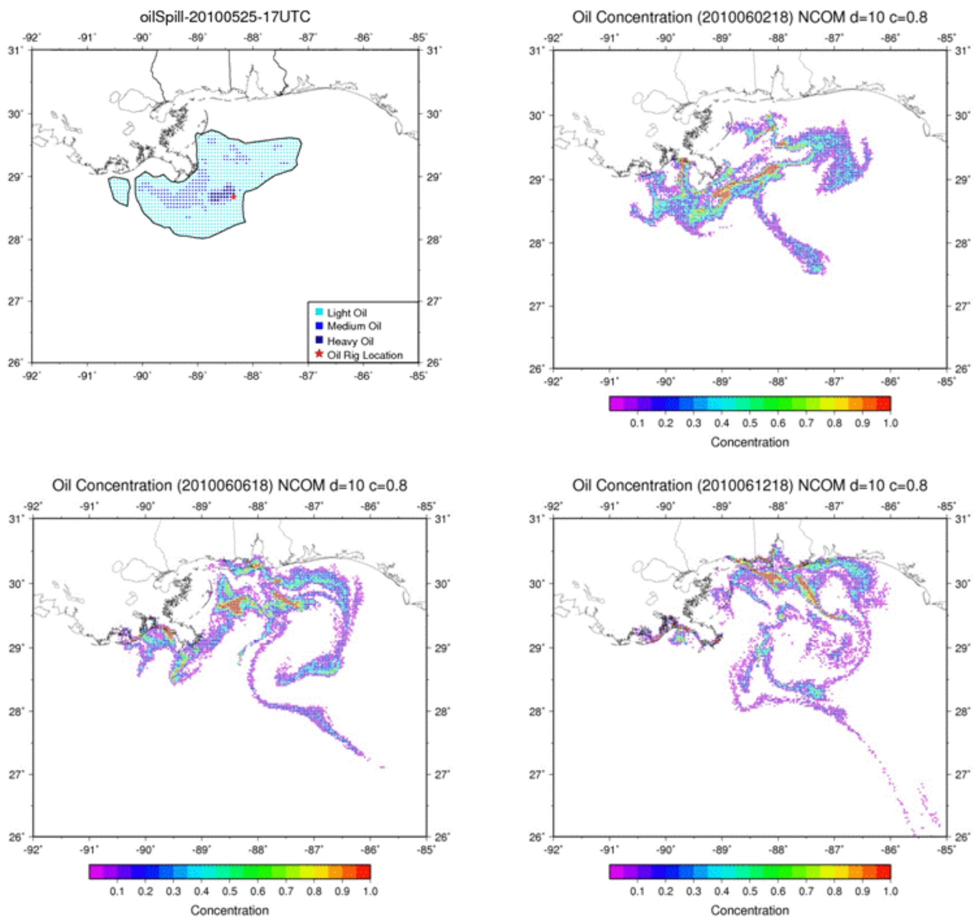


Figure 12. Initialization and simulation of spill from 25 May to 12 June.

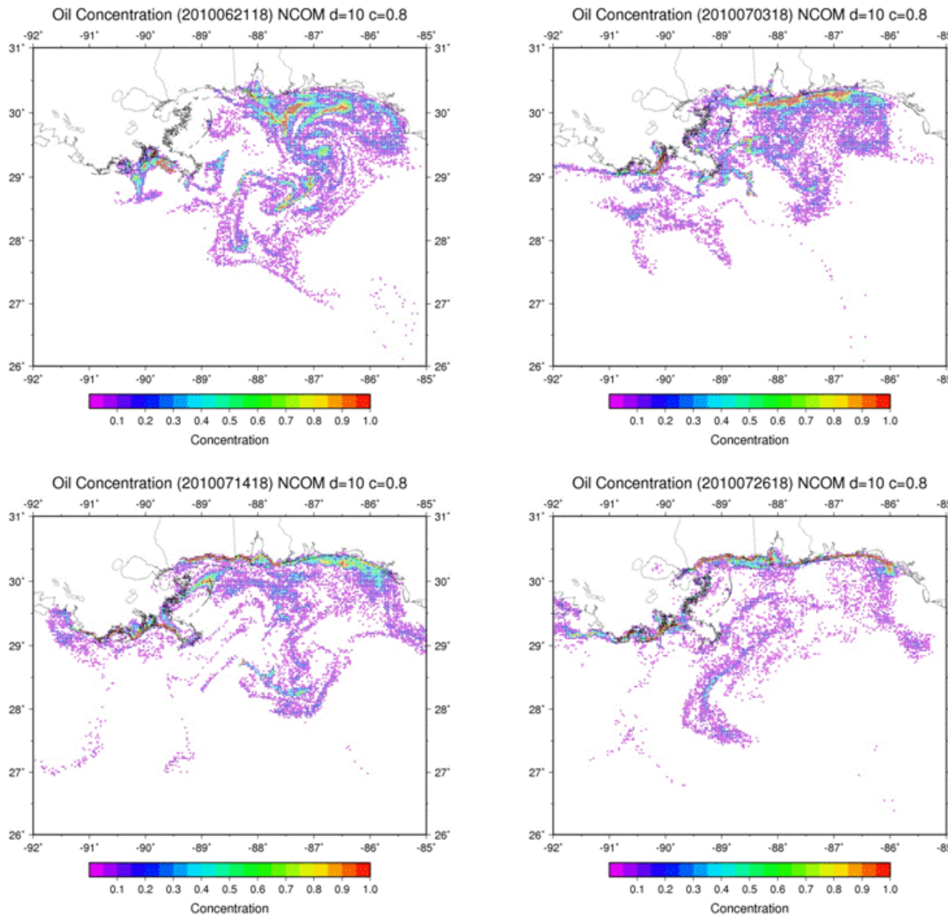
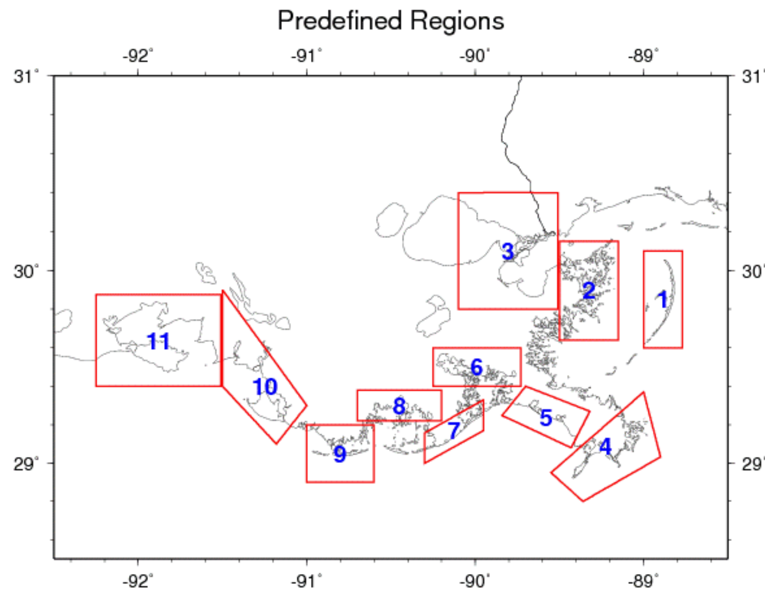


Figure 13. As in Fig. 12, but the oil spill simulation through the end of July.

Figure 12. Example of Louisiana SCAT database for 25-28 May.



1. Chandeleur Islands
2. Eastern Biloxi Marsh
3. LakeBorge / LakePontchartrain
4. Mississippi River Mouth
5. Sandy Point
6. Barataria Bay North End
7. Grand Isle / Fourchon
8. Terrebonne Bay / Timbalier Bay North End
9. Last Islands
10. Atchafalaya Delta
11. Russell Sage Mash / Vermillion Bay / West Cote Blanche Bay

Figure 13. Locations of regions of interest for detailed timetable analysis.

Eastern Biloxi Marsh

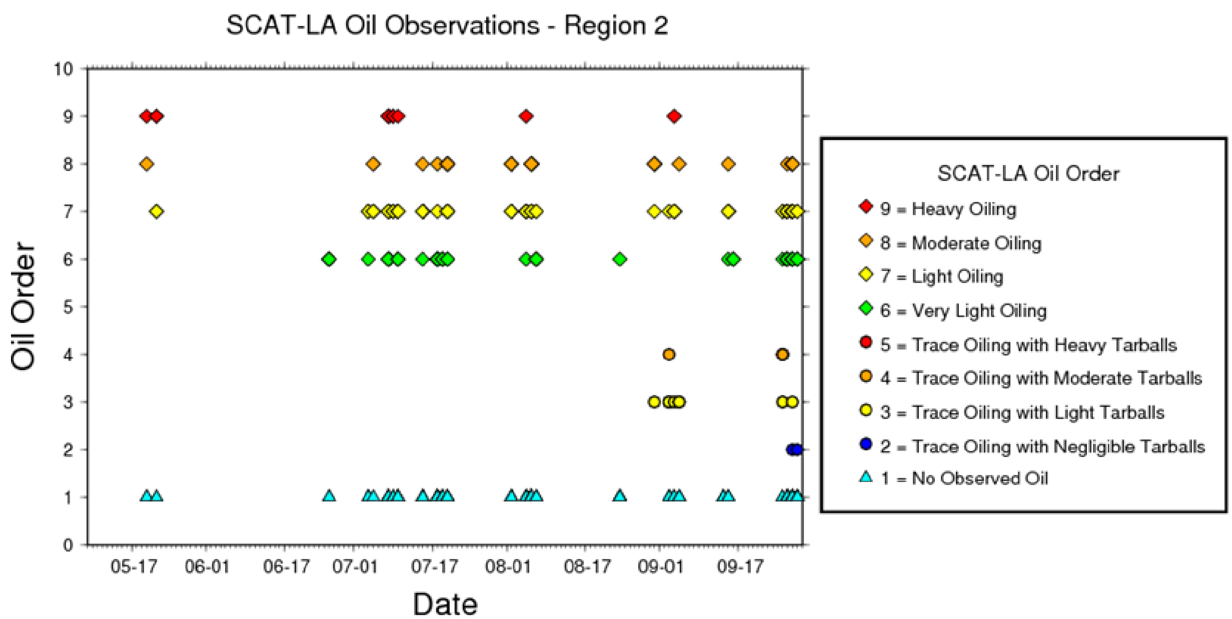


Figure 14. Example of a timetable analysis of Louisiana SCAT data for Region 2 (eastern Biloxi Marsh).

Lake Borgne and Lake Pontchartrain

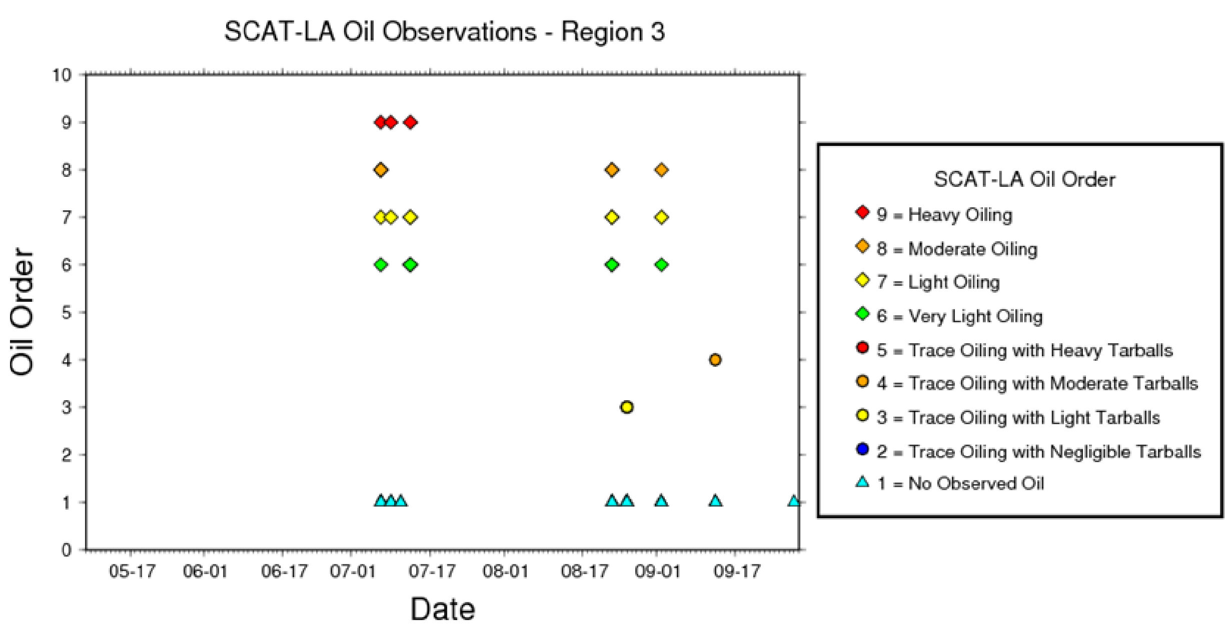


Figure 17. As in Fig. 16, but for Region 3 (Lake Borgne and Lake Pontchartrain).

Grand Isle and Fourchon

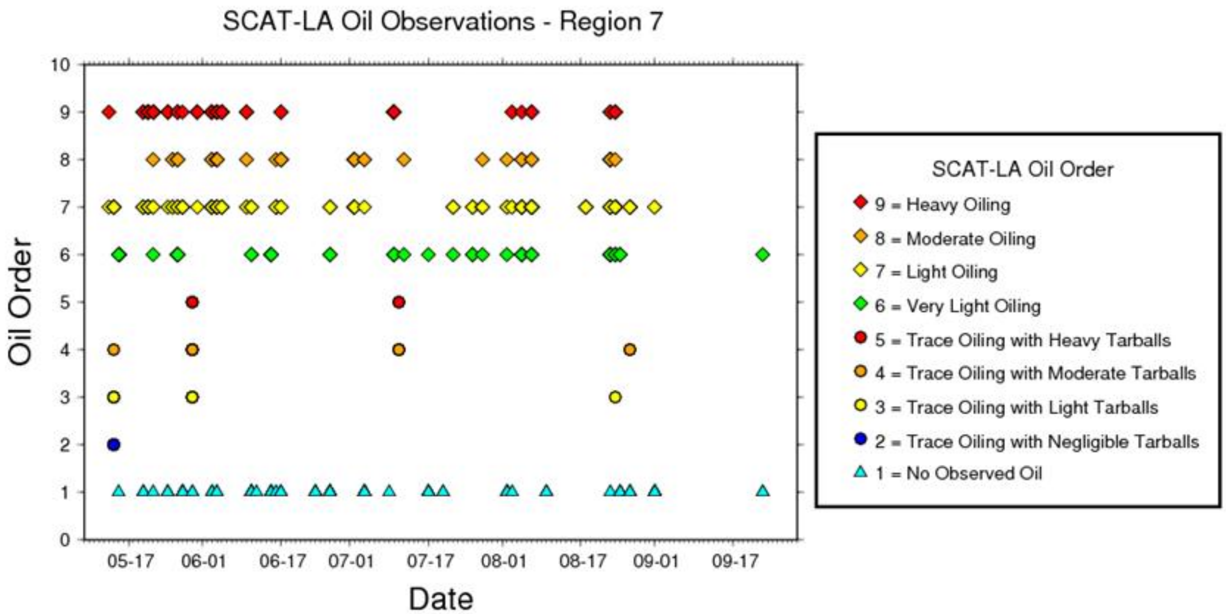
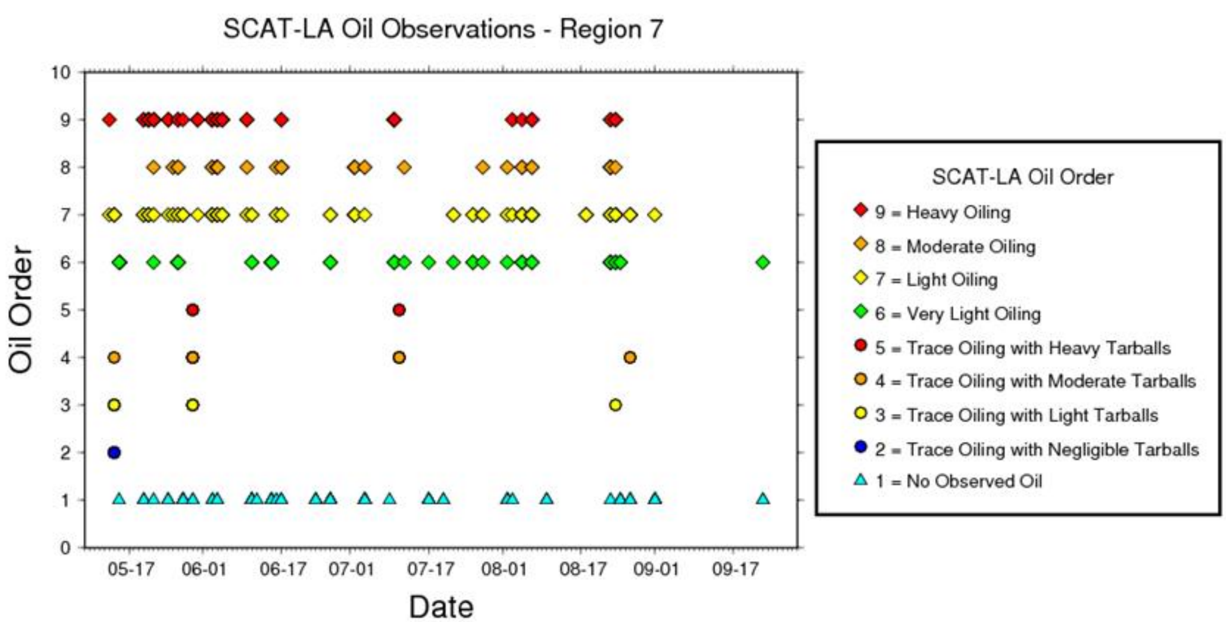


Figure 18. As in Fig. 16, but for Region 7 (Grand Isle and Fourchon).

Grand Isle and Fourchon



11-BP_GRI-18: Mississippi State University: Quantitative Studies of the Effects of Oil Exposure on the Pelagic Microbial Community and Sheepshead Minnow, Using a Global Proteomics Approach

Mariola J. Edelmann, Tibor Pechan

SCIENCE ACTIVITIES

1. *General Summary*

Our project contributes to answering the question whether the Macondo 252 Oil Spill resulted in large-scale perturbation of the NGoM ecosystem structure and function, by elucidating molecular responses of microbial communities and fish to the oil spill and to consequent decontamination efforts. Proposed research proves a deeper understanding of the complex interplay within microbial communities, as well as delayed, chronic and indirect toxic effects on the marine fauna. Achieving these goals will result in a stronger predictive capacity. Our objective has been to discover, quantify, and model changes in the pelagic microbial community and in sheepshead minnow as a consequence of oil exposure. The expected results help to address questions posed by NGI, specifically looking at the oil spill-modulated changes in the structure and function of the microbial community across the Alabama shelf, as well as the toxic effects of oil and dispersant on sheepshead minnow. We hypothesize that the diversity and abundance of specific groups of microorganisms as well as the proteomic profile of the fish liver will dramatically change in response to oil exposure, and that these modifications are measurable at the proteomics level. To attain our objective and test our hypothesis, we have been pursuing the following specific goals:

1. To determine diversity and abundance of pelagic microorganisms in response to oil exposure using a global quantitative proteomic approach
2. To quantify and model physiological effects of the oil spill on the pelagic microorganisms via systems biology approach and pathway analysis
3. To identify and quantify liver protein markers of sheepshead minnow exposed to sublethal concentration of the oil, oil dispersant, and combination thereof

We are analyzing microbial samples collected from surface waters before and after oil exposure (collaboration with Dr. A. Ortmann, Dauphin Island Sea Lab), as well as liver samples of sheepshead minnow exposed to oil and dispersant (collaboration with Dr. N. Garcia-Reyero, Jackson State University and Dr. N. Denslow, Florida State University), exploring the changes occurring at the proteome level. These qualitative and quantitative changes will reflect the oil- triggered modifications of cellular pathways in sheepshead minnow and pelagic microorganisms, as well as the dynamic changes in interspecies diversity of microbial communities. For analysis we are using the high throughput, label-free mass-spectrometry based quantitative proteomics. The results acquired at a proteome level will be soon integrated with the genomics data obtained by collaborators in order to obtain comprehensive systems biology analysis.

Due to lack of sufficient samples preparation methods, we had to design and optimize new workflows for analysis of both, filters containing microbial material, as well as fish tissue. Having obtained a good experimental method that can be used in our future NGI projects, we are currently finishing analysis of the experimental samples.

2. Results and scientific highlights

In order to address all the specific goals, appropriate proteomic methods had to be first established. Due to a novelty of our approach, suitable techniques had not existed to extract proteins from the pelagic microorganisms collected on the filters, as well as from highly lipidic sheepshead minnow's livers. We first tried the sample preparation method based on using the Barocycler NEP 3229 PCT (Pressure Biosciences) sample preparation system, in concert with the ProteoSolve–SB kit (Pressure Biosciences) and homogenization via the PCT Shredder Tubes. Despite the fact that we had successfully used this method in our previous work, in this particular case, the Barocycler technology was found to be labor intensive and time consuming and, for instance, did not completely remove the lipidic residues from the fish liver or muscle, which then interfered with the proteomic analysis.

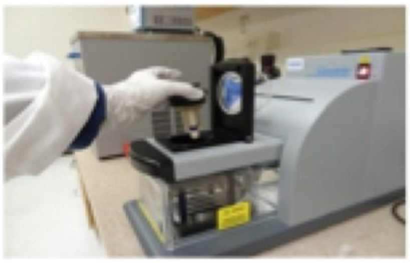


Figure 1. Covaris instrument, which uses technology based on Adaptive Focused Acoustics (AFA). This method has been used to prepare protein lysates from the biological material in this study.

We therefore tested a novel lysis technique patented by Covaris, which is based on sonication of the biological material. The principal advance in this decades' old method lies in Adaptive Focused Acoustics (AFA) Technology. The AFA works by sending high frequency acoustic energy waves from a dish-shaped, spherical transducer to converge in a small, localized area creating a zone of precisely controlled kinetic/mechanical energy. Conventional low frequency (20kHz) sonicators have longer wavelengths (~10cm) than the Covaris acoustic transducer which operates at 500kHz with a wavelength of ~1mm. This enables the acoustic energy to be applied to samples in closed sample containers in a non-contact and isothermal mode, avoiding both contamination, and thermal energy sample degradation. In addition to cell lysis, we experimented with several methods of protein purifications in order to obtain contaminant-free sample (i.e. free from lipids, salts and other low mass molecules), ready to be processed by nano- LC-MS/MS without column and spray needle clogging.

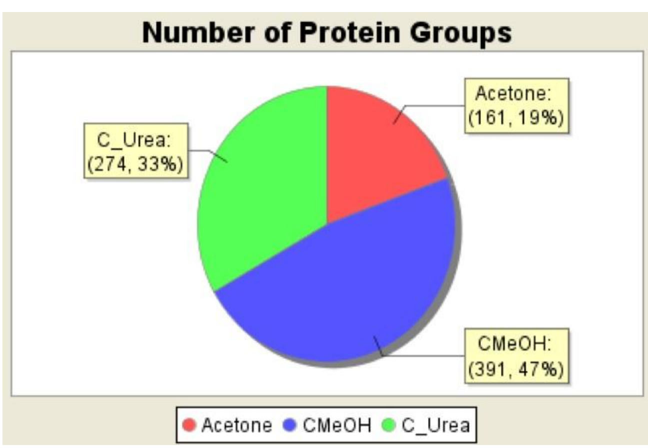


Figure 2. Optimizing sample preparation methods for the LC-MS/MS analysis of the fish muscle tissue exposed to the Macondo 252 oil and dispersant. The graph illustrates numbers of obtained proteins in different sample-prep techniques, including Acetone precipitation ('Acetone'), Chloroform-methanol precipitation (CMeOH) and delipidation using delipidation buffer C ('C_Urea'; Pressure Biosciences). As demonstrated, the best method for proteomic analysis of this sample is technique #(3), where the samples were lysed by a Covaris sonication-based technology, followed by chloroform/methanol precipitation, and LC-MS/MS analysis.

The tested methods can be in principle categorized by a choice of cell lysis instrumentation, type of lysis buffer and sample clean-up methods (Figure 2-4). The nano-LC-MS/MS was performed using acetonitrile gradient on C18 column, employing the Dionex 3000 Ultimate HPLC system and on-line Orbitrap Velos (Thermo) mass spectrometer working in linear trap mode. The MS/MS data were matched against the selected marine microorganism, as well as the Ictalurus and Danio taxonomic databases of NCBI protein database. The peptides identified were filtered using the Xcorr values and the results are summarized below.

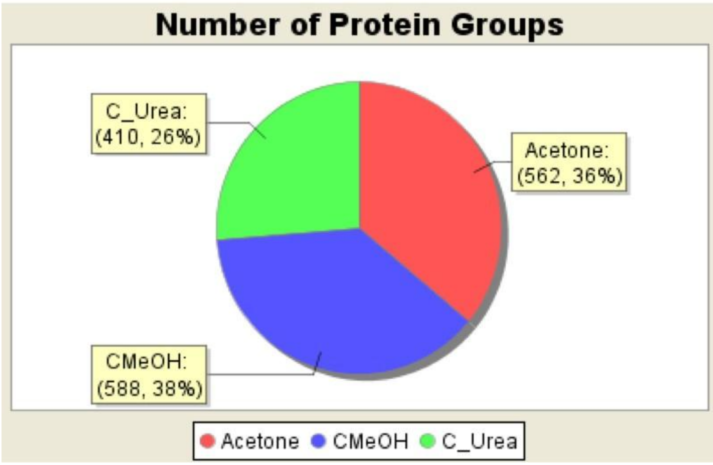


Figure 3. Optimizing sample preparation methods for the LC-MS/MS analysis of the fish liver tissue exposed to the Macondo 252 oil and dispersant. The graph illustrates numbers of obtained proteins in different sample-prep techniques, including Acetone precipitation ('Acetone'), Chloroform-methanol precipitation (CMeOH) and delipidation using delipidation buffer C ('C_Urea'; Pressure Biosciences). As demonstrated, the best method for proteomic analysis of this sample is technique #(3), where the samples were lysed by a Covaris sonication-based technology, followed by chloroform/methanol precipitation, and LC-MS/MS analysis.

Further, to design a new workflow for analysis of samples from ocean consisting of filters with microbial material, we used four different sample preparation techniques, including chloroform- methanol precipitation of obtained proteins, acetone precipitation, methanol precipitation, or we omitted the clean-up step altogether. As shown on Figure 4, again the best approach was the chloroform-methanol precipitation of the protein samples extracted from the filter.

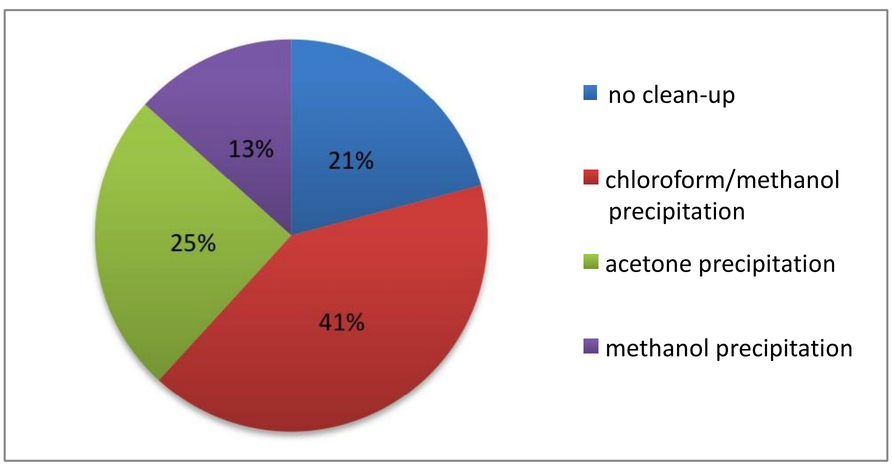


Figure 4. Optimizing sample preparation methods for the LC-MS/MS analysis of the filters containing microorganisms obtained from the pelagic zones affected by the Macondo 252 oil spill. The graph illustrates numbers of proteins obtained in four sample-prep techniques, including acetone precipitation, methanol precipitation or no clean-up method. As demonstrated, the best method for proteomic analysis of this sample is technique, where the samples were cleaned-up using chloroform-methanol precipitation, tryptic digestion and LC- MS/MS analysis by the LTQ OrbiTrap.

In summary, the amounts of proteins recovered from both, pelagic microorganisms and minnow's tissue were encouraging and are suitable for subsequent quantitative studies analyzing effect of crude oil and dispersant on both sample types. These experiments have been already performed, the samples have been prepared, and are currently being analyzed on our proteomic software. Furthermore, this optimization is crucial for our next projects concentrated on oceanic fish and microbial material collected on filters.

3. Cruises & field expeditions

N/A

4. Peer-reviewed publications, if planned

a. Published, peer-reviewed bibliography

N/A

b. Manuscripts submitted or in preparation

Optimization of sample preparation for fish tissue proteomics using Covaris technology.

Target journal: *Journal of Proteome Research* Anticipated date of submission: May 1st 2012

Quantitative proteomic studies on sheepshead minnow exposure to crude oil and dispersant reveal important environmental biomarkers

Target Journal: *Journal of Proteomics* Anticipated date of submission: Sept 1st 2012

5. Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Optimization of sample preparation for fish tissue proteomics using Adaptive Focused Acoustics technology	Tibor Pechan	Jennifer Patterson; Taylor King; Mariola Edelmann; Tibor Pechan	60th ASMS Conference on Mass Spectrometry and Allied Topics	TBD	May 20 - 24, 2012

6. Other products or deliverables

N/A

7. Data

The data will be submitted to peer-reviewed journals followed by submission to PRIDE – a public repository for the proteomic datasets.

PARTICIPANTS AND COLLABORATORS

8. Project participants

First Name	Last Name	Role in Project	Institution	Email
Mariola	Edelmann	PI	Mississippi State	Mje100@mafes.msstate.edu
Tibor	Pechan	Co-PI	Mississippi State	pechan@ra.msstate.edu
Jennifer	Patterson	Technician	Mississippi State	jpatterson@mafes.msstate.edu
Taylor	King	Lab Assistant	Mississippi State	tak80@msstate.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
Taylor	King	BS	Veterinary Science	Mississippi State University	N/A	2014

10. Student and post-doctoral publications, if planned

N/A

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

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Optimization of Sample Preparation for Fish Tissue Proteomics Using Adaptive Focused Acoustics Technology	Taylor King	Jennifer Patterson; Taylor King; Mariola Edelmann; Tibor Pechan	Undergraduate Research Symposium	TBD	April 18, 2012

12. Images

N/A

11-BP_GRI-19: Mississippi State University: Comprehensive Study of Impact of the Deepwater Horizon Oil Spill on the Health and Productivity of Gulf Coast Salt Marshes

Deepak R. Mishra, Karen McNeal, Andrew Mercer, Bill Cooke

SCIENCE ACTIVITIES

1. General Summary: This study intended to allow the identification of 'hotspots' of marsh degradation and the extent of recovery (if any) post Deepwater Horizon Oil Spill, which can only be delineated by evaluating marsh biophysical characteristics including distribution of chlorophyll content (Chl), green leaf area index (GLAI) (a ratio of green foliage area vs. ground area), green vegetation fraction (VF) (percent green canopy cover), and green biomass (GBM). We aimed to combine field data with the Landsat 30-m datasets to retrieve the biophysical characteristics in salt marshes across three Gulf States (LA, MS, and AL) before and after the spill. The overall goal of the proposed research was to quantify and map the ecological impact of the oil spill on the photosynthetic activity, physiological status, and primarily productivity of the coastal salt marshes to facilitate the prioritization of future restoration actions. The specific questions to be answered through study were: (1) Which wetland patches (location) are most degraded due to the spill? (2) Which salt marsh species is the most vulnerable to the spill? (3) What is the degree of damage and extent of recovery in the spill impacted marsh habitats? (4) Is the damage due to sedimentary biogeochemical processes resulting from the degradation of the oil and increased microbial production of reduced chemical species such as sulfide? (5) Was some of the damage due to local climatic perturbation and early senescence rather than the spill?

A change in biogeochemical processes in marsh sediments affects the health of vegetation. Increased carbon due to oil contamination is primarily degraded through microbial processes leading to an increase in microbially mediated sulfide. In order to analyze the biogeochemical response to contamination, cores were collected from MS and LA sites and sediment electrode profiles (H_2S, O_2, pH, and Eh) and microbial community substrate level carbon utilization profiles were completed. In addition to profiles, sediments were analyzed for degree of hydrocarbon contamination (GC), total organic carbon, and particle size. Examining the previously mentioned parameters provided insight on how oil contamination alters the biogeochemistry of salt marsh sediments and in turn stresses salt marsh vegetation leading to marsh health deterioration.

The scope of the climate portion of the proposal was to analyze climate shifts in the region relative to marsh health to assess the impact of annual climate fluctuations on the total overall health of the marsh. This was completed in two phases; first, North American Regional Reanalysis (NARR) data were downscaled to the spatial resolution of the available marsh data to directly compare the two sets. Since the period of record of available marsh health data was small (2009-2011), particularly prior to the oil spill, it was not possible to formulate a skillful model that isolated localized climate impacts of marsh health. To overcome this issue, a second time-series analysis of average climate conditions over the study region was conducted for the full period of record of the NARR dataset (1979-present). These analyses were compared with relationships known to be good or detrimental for marsh health (e.g. average solar radiation, average temperature, average rainfall, etc.) to determine if the 2010-2011 post-spill period had significantly anomalous climate patterns.

2. Results and scientific highlights

Funds were primarily used for field data collection (remote sensing and biogeochemical) efforts. Four intensive field campaigns (Jun-July- Aug-Oct 2011) were conducted in LA-MS recording precise *in situ* remote sensing reflectance (Rrs) and other biophysical and biochemical parameters from salt marsh areas with different degree of contamination. Sediment cores were also collected from MS contaminated sites for biogeochemical analysis. A comprehensive time series remote sensing and biophysical parameters database has been developed as part of the study from 81 sampling locations in LA, AL, and MS. Products developed through this project will be used in combination with the biogeochemical and climatological data for assessing and evaluating the productivity of marshes that are impacted by the massive oil spill, thus providing state regulators important information for restoration and managements.

Three datasets were acquired/created as a part of this project.

First dataset (*salt marsh biophysical parameters*) was developed for assessing and evaluating the productivity of marshes that are impacted by the massive oil spill, thus providing state regulators important information for restoration and management.

Second dataset (*biogeochemical data from beach sediment, water salinity and temperature*) was collected based on biogeochemical parameters measured in sediment impacted by the DWH spill.

Third dataset (*climate data: temperature, humidity, pressure, wind characteristics*) involved climate record from 2009 and 2010 used to identify relationships between climate features and marsh characteristics. Used to isolate the impacts of the oil spill from the typical climatic impacts.

Data types in the four datasets include a combination of physical samples and digital data. First dataset includes physical samples collected include marsh biophysical parameters such as chlorophyll content, vegetation fraction, leaf area index, and green biomass. Digital photos of several sites were also acquired. Second dataset include digital data from physical samples. The data was collected from physical sediment samples and stored in electronic formats. Third dataset was generated using numerically processed gridded climate data (the North American Regional Reanalysis dataset downscaled to 500 m resolution, native is 32 km resolution).

First dataset: Marsh biophysical data were collected in the field using several instruments such as Minolta SPAD 502 chlorophyll meter (Spectrum Technologies), AccuPAR LP-80 Ceptometer (Decagon Devices) and LAI-2000 Plant Canopy Analyzer (LICOR Biosciences), digital camera, and some destructive sampling.

Second dataset: A combination of field measures and laboratory measurements from collected samples

Third dataset: WRF model initialization downscaled the data to a high resolution to be compared to the marsh characteristics

Remote sensing and biogeochemical analysis results were very promising. The field data collected during the study were being used in satellite model calibration and validation through a remote sensing mapping protocol to generate time-series map products for the salt marsh biophysical properties along the LA-MS-AL coast. The best-fit models were applied to 2011 LANDSAT 30-m datasets to analyze the post-spill magnitude of recovery in Chl and GBM levels. In addition, 2011 phenological analysis were conducted to observe the variations in the levels of Chl and GBM, for fringe and inland salt marshes and compared with 2009 and 2010 results. Monthly composites were prepared for the salt marshes for pre-, during and post-oil-spill growing season. Results showed significant recovery in the growth of salt marshes in the 2011 growing season compared to 2010. (Figure 1 and 2)

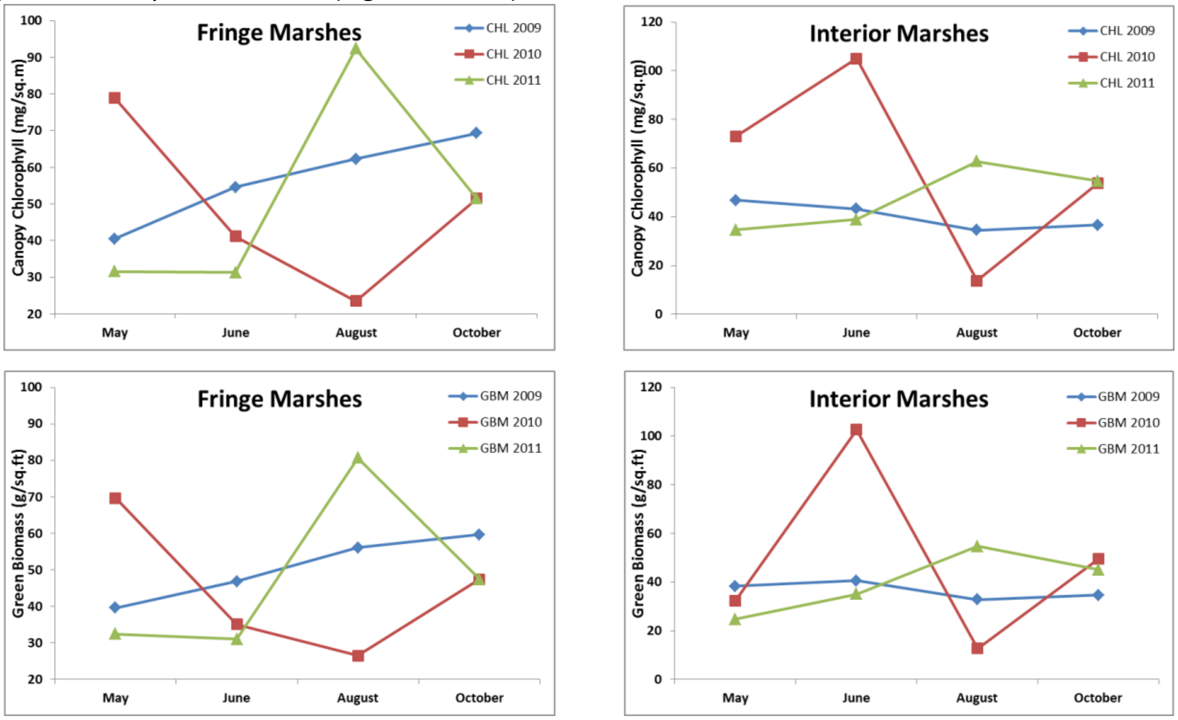


Figure 1: Phonological plots showing a significant recovery in salt marsh health during the post-spill growing season in 2011.

Biogeochemical studies indicate that sulfide concentrations were elevated due to oil contamination in sediments. As oxygen depleted with depth in sediment cores, sediments became more reduced, sulfide concentrations increase, and pH became more acidic (Figure 3). Elevated sulfide concentrations can be attributed to increased sulfate reducing microbial activity. Sulfide is toxic for marsh grasses and can be detrimental to grass health, thus, the chances for dieback are higher in contaminated areas. Storms can be a chance for sediments to be re-oxygenated and fresh sediments to be deposited however, increased sulfide levels would be expected to return as oxygen is depleted in fresh sediments and oil and sulfide migrate upward through sediments. From 2010 to 2011 sulfide concentrations increased in the sediments as effects of the spill set in however, from 2011 to 2012 sulfide concentrations decrease indicating that the marsh ecosystem is attempting to equilibrate.

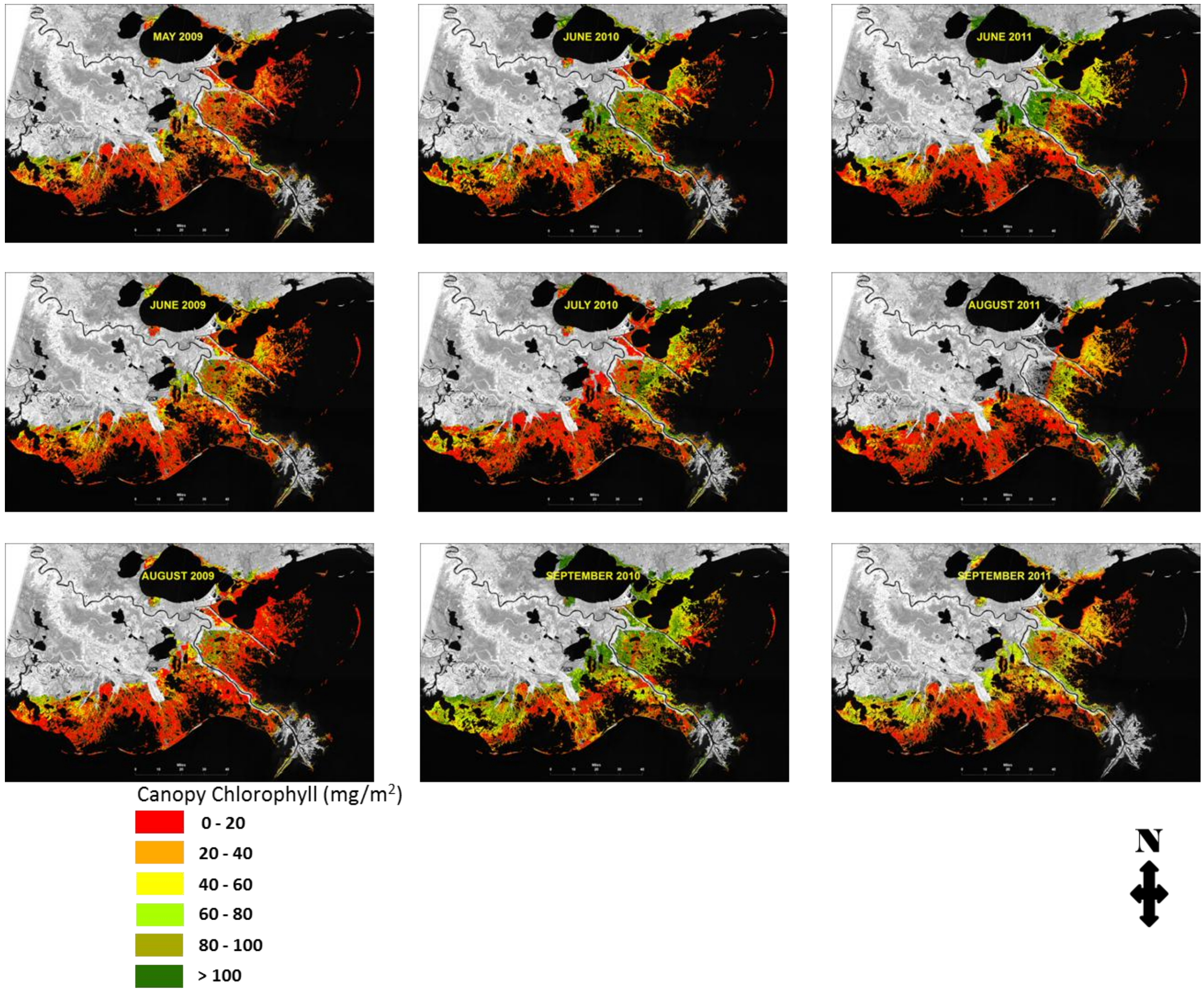


Figure 2: Pre-during-post (2009-2010-2011) spill maps of canopy chlorophyll and green biomass distribution along the LA coast

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<u>NGI Program Office Inquiry to PI</u>: Text above indicates that "Results showed significant recovery in the growth of salt marshes in the 2011 growing season compared to 2010. (Figure 1 and 2)." This appears so for figure 1. Figure 2 qualitatively does appear to show this for June 2010 to 2011. However it appears one could say the same for 2009 to 2010. One interpretation could be that a three year recovery is occuring from June 2009 to 2010 to 2011, not related to the DWH. For August there is no 2010 to compare but if one uses July 2010 as a proxy for August 2010, 2010 appears to healthier, not 2011 Finally, if one looks at September, 2010 appears healthier than 2011.

<u>PI Response</u>: First, when we say a significant recovery was observed, we actually mean that for the marsh patches that were directly affected by the spill. Phenology plots were created by averaging out the pixels with a gradient of oiling observed on the ground. I know that the maps tell a different story for the overall system. But looking at the maps alone can be problematic because of few things, first, maps don't incorporate model errors which is around 15%, therefore I always use the change detection products (date2-date1) with some kind of threshold to compensate for the model errors. That's why in our change detection results there are so many marsh patches that showed a decrease in greenness from 2009 to 2010.

There might be few other reasons. First, our hypothesis is that 2009 might have a lot of residual damage from hurricane Gustav and maybe on a recovery trend, second, I have asked my students to generate similar products of local dryness index to check if some of the browning that we see in 2009 maybe be due to some localized drought, and third, we are working on introducing some changes in the color coding system such that it is a little biased towards the lower scale. What I mean by that is plants with chlorophyll concentration of 5 might be totally brown compared to plants with chl conc. of 19 or 20 which might be pale green, but now they are all clumped into one color that is red. We will be able to interpret the results in a better way after making these changes. We will incorporate all these changes and analysis in a manuscript for potential publication soon

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In case of the climatic data analysis, the downscaled regression model did not reveal skillful relationships between climate variables and marsh health measures, this was attributed to the short period of record of available high-resolution marsh health data. Training a statistical algorithm requires a long period of record that was not sufficient to develop a skillful model. However, the climate variable time series plots revealed that conditions were actually somewhat unfavorable for marsh health, relative to known relationships between climate variables and their impacts on the marsh. That is, solar radiation was a bit above normal, precipitation was a bit below normal, and temperatures were slightly above normal, suggesting a more productive marsh ecosystem. Certainly, the climate parameters were not so anomalous as to support the massive marsh health declines that were observed. This helped support the conclusion that marsh die-off that was observed was not due to climate fluctuations but instead due to the oil spill impacts. The figure attached below shows some of these results (Figure 4).

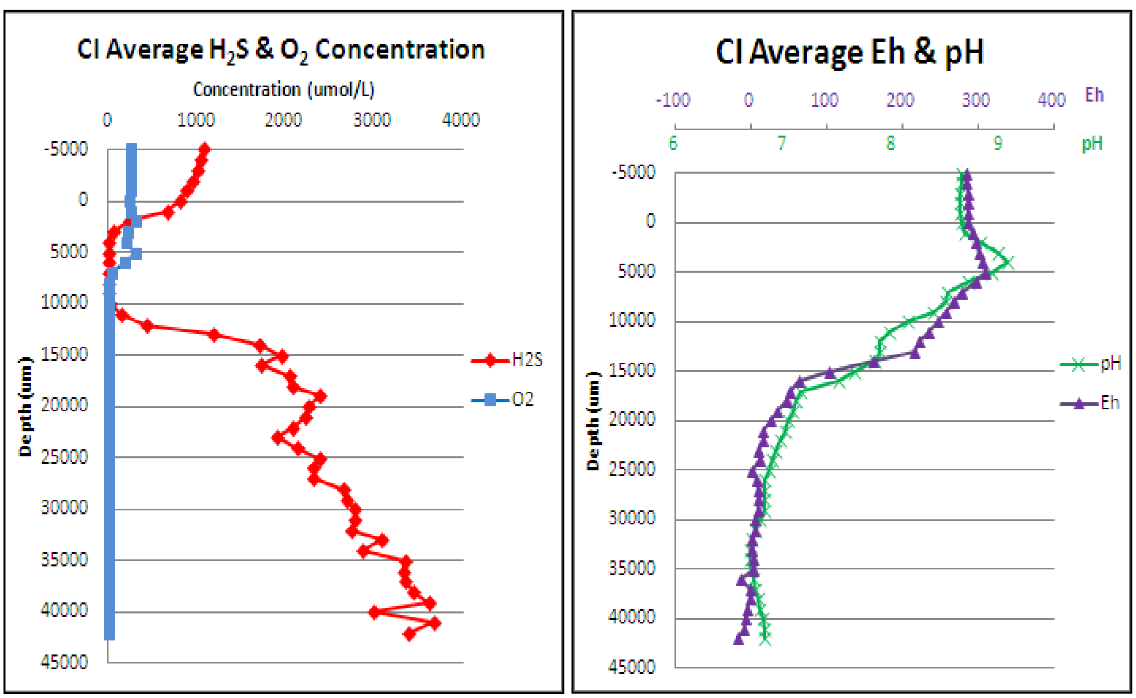

Figure 3(a) and (b): Electrode profiles of Cat Island, MS. 3a:O2 decreases and H2S increases 3b: Redox potential enters the range for sulfate reduction and pH decreases *Negative signal indicates the presence of H2S.*

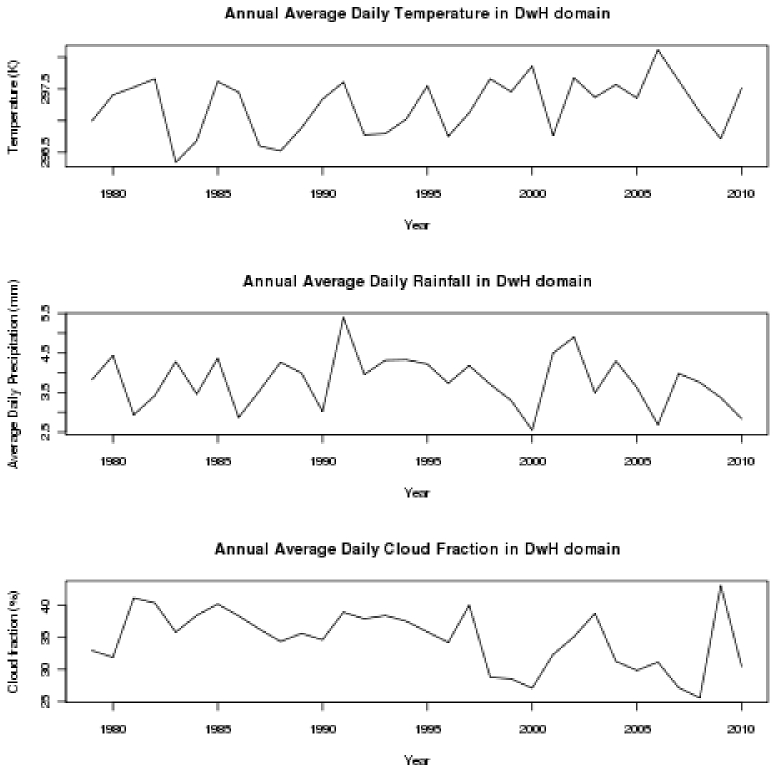

Figure 4: Climate conditions pre and post DwH oil spill

3. Cruises & field expeditions

Ship or Platform Name	Class (if applicable)	Chief Scientist	Objectives	Dates
Contract Vessel	N/A	Deepak Mishra	Proximal Sensing, Marsh Biophysical Parameters	09/2010
Contract Vessel	N/A	Deepak Mishra	Proximal Sensing, Marsh Biophysical Parameters	10/2010
Contract Vessel	N/A	Deepak Mishra	Proximal Sensing, Marsh Biophysical Parameters	05/2011
Contract Vessel	N/A	Deepak Mishra	Proximal Sensing, Marsh Biophysical Parameters	06/2011
Contract Vessel	N/A	Deepak Mishra	Proximal Sensing, Marsh Biophysical Parameters	07/2011
Contract Vessel	N/A	Deepak Mishra	Proximal Sensing, Marsh Biophysical Parameters	09/2011
Contract Vessel	N/A	Deepak Mishra	Proximal Sensing, Marsh Biophysical Parameters	10/2011
Contract Vessel	N/A	Deepak Mishra	Proximal Sensing, Marsh Biophysical Parameters	04/2012
Contract Vessel	N/A	Deepak Mishra	Proximal Sensing, Marsh Biophysical Parameters	06/2012
Contract Vessel	N/A	Karen McNeal	Electrode Profiling, Water parameters, sediment collection	10/2010

Contract Vessel	N/A	Karen McNeal	Electrode Profiling, Water parameters, sediment collection	11/2010
Contract Vessel	N/A	Karen McNeal	Electrode Profiling, Water parameters, sediment collection	8/2011
Contract Vessel	N/A	Karen McNeal	Electrode Profiling, Water parameters, sediment collection	9/2011
Contract Vessel	N/A	Karen McNeal	Electrode Profiling, Water parameters, sediment collection	7/2012

4. Peer-reviewed publications, if planned

a. Published, peer-reviewed bibliography (Copies of the papers are requested)

Mishra, D. R., Cho, H. J., Ghosh, S., Fox, A. A., Downs, C., Merani, P. B. T., Kirui, P., Jackson, N., Mishra, S. (2012) Post-spill state of the marsh: Remote estimation of the ecological impact of the Gulf of Mexico oil spill on Louisiana Salt Marshes. *Remote Sensing of Environment* 118:176-185

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
Impact of the Gulf of Mexico Oil Spill on the health and productivity of Louisiana Salt Marshes	Deepak Mishra	Mishra, D., Cho, H. J., Ghosh, S., Downs, C., Fox, A. A., McKibben, A.	39th COSPAR Scientific Assembly		07/14/2012 – 07/22/2012

6. Other products or deliverables

Maps of spatial distribution of canopy chlorophyll and green biomass for 2009, 2012, and 2011. They can be obtained by emailing the PI at dmishra@uga.edu

7. Data

Plot	Lat	Lon	SPAD	LAI	VF (%)	Biomass (g/sq.ft)	Canopy height
CI1	30.214500	-89.107975	30.7	0.92	46.49	71.93	49.40
CI2	30.214356	-89.107386	30.9	1.48	29.00	24.93	47.60
MP1	30.378389	-88.796083	26.6	1.28	38.36	65.52	33.40
MP2	30.378750	-88.796056	31.2	4.82	29.80	40.02	38.40
MP3	30.379111	-88.795944	23	3.13	52.27	60.31	35.80
MP4	30.379583	-88.795917	31.7	1.31	32.42	75.58	48.40
MP5	30.380222	-88.795806	37.2	1.09	23.84	46.79	27.40
MP6	30.380194	-88.795222	32.8	1.99	20.73	90.87	40.60
MP7	30.379833	-88.795750	41.8	2.56	27.19	158.54	43.20
MP8	30.379444	-88.796389	23.6	3.15	67.24	61.48	29.00
MP9	30.379111	-88.796778	26.7	2.88	45.32	49.49	
MP10	30.379056	-88.797111	30.5	2.49	35.81	41.92	19.80
STM1	30.115028	-84.208750	28.9	2.34	20.67	40.02	51.20
STM2	30.115278	-84.208833	53	3.37	12.60	61.3	52.00
STM3	30.115278	-84.211444	41.6	1.74	7.01	66.55	52.00
STM4	30.115500	-84.211667	44.1	1.34	11.16	30.04	56.00
STM5	30.096306	-84.212194	32.4	2.52	0.69	95.44	50.20
STM6	30.096583	-84.212389	55.8	2.42	1.43	55.08	53.80
STM7	30.096222	-84.206583	54.2	3.57	1.39	57.42	49.20
STM8	30.096444	-84.206861	26.7	2.27	0.72	70.36	50.40
STM9	30.019556	-84.354722	47.4	1.71	7.18	56.33	45.00
STM10	30.020000	-84.354806	39.9	1.98	8.43	48.41	40.40
STM11	30.020972	-84.356250	42.4	2.47	2.36	70.27	43.40
STM12	30.021306	-84.356333	32.5	2.59	2.26	51.07	38.60
STM13	30.050361	-84.345194	19.4	1.89	4.31	45.76	44.00
STM14	30.050167	-84.344833	33.8	2.95	2.11	47.16	47.60
STM15	30.050167	-84.343306	18.2	2.92	2.99	79.92	50.60
STM16	30.050389	-84.342944	36.3	2.66	1.49	41.32	44.00
L01	29.256056	-90.660833	46.6	2.54	36.42	59.18	36.60
L02	29.256417	-90.660833	42.2	5.13	24.13	63.95	34.00
L03	29.256444	-90.662111	41.3	5.31	10.81	37.63	33.40
L04	29.256889	-90.662222	41.7	2.78	45.99	60.46	39.60
L05	29.261917	-90.669111	39.6	4.52	15.06	42.74	36.40
L06	29.262250	-90.669056	39.5	5.20	15.87	28.85	45.60
L07	29.267972	-90.669222	34.4	4.03	20.46	32.93	38.40
L08	29.268444	-90.669056	36.3	4.38	27.31	43.12	47.40
L09	29.264722	-90.662139	31	3.63	22.64	45.3	49.40
L10	29.264306	-90.662222	40.4	2.86	17.61	89.34	44.20
MP1	30.382750	-88.195778	28.7	1.41	77.32	59.36	20.60
MP2	30.382639	-88.196278	27.5	1.08	55.57	50.67	24.20
MP3	30.382667	-88.196972	29.2	1.36	66.62	54.27	23.00
MP4	30.382667	-88.197528	22	1.44	47.54	57.48	28.40
MP5	30.383194	-88.197944	31.4	1.01	33.09	70.38	27.60
MP6	30.383917	-88.197889	30.6	1.1	65.12	113.89	31.00
IUS1	29.884389	-89.757917	38.3	1.85	15.59	15.21	19.00
IUS2	29.884250	-89.757667	23	1.93	9.59	20.13	21.60
IUS3	29.884167	-89.757472	21.4	2.27	11.64	43.68	17.60
IUS4	29.884175	-89.757083	35.1	1.5	3.72	23.75	20.00
IUS5	29.884278	-89.756806	29	1.3	4.62	29.35	20.60
IUS6	29.884222	-89.756528	17.4	2	7.19	32.14	20.00
SI1	29.867417	-89.736139	6.8	3.92	94.26	71.24	17.20
SI2	29.867500	-89.736000	20.3	2.39	86.75	80.55	19.00
SI3	29.867694	-89.735806	29.3	2.8	20.34	34.1	26.60
SI4	29.868167	-89.735944	32.6	2.68	5.84	49.77	20.80
SI5	29.868472	-89.736167	31.6	1.84	4.84	7.37	25.00
SI6	29.868556	-89.735722	33.9	2.86	7.79	46.17	29.80
BJ01	29.454056	-89.894139	10.7	2.85	24.36	82.78	14.40
BJ02	29.454194	-89.894472	12.5	2.83	81.96	160.64	10.40
BJ03	29.454500	-89.895167	28.1	2.75	15.05	23.35	45.80
BJ04	29.454694	-89.895667	37	2.21	10.16	59.71	43.20
BJ05	29.454528	-89.892750	22.8	1.81	41.95	54.56	40.00
BJ06	29.454500	-89.893083	25.4	2.11	21.67	40.28	37.20
BJ07	29.446028	-89.936000	39.5	1.79	24.90	109.94	44.40
BJ08	29.446333	-89.935750	27.8	1.52	36.50	50.38	26.20
BJ09	29.446694	-89.935944	26.3	3.05	23.81	76.65	47.40
BJ10	29.447111	-89.935806	24.7	1.44	13.64	7.95	25.00
BJ01	29.477083	-89.842833	33.7	3.76	24.57	67.75	25.00
BJ02	29.477750	-89.842972	27.6	4.92	22.00	65.14	36.40
BJ03	29.478167	-89.843194	30	3.42	46.02	128.82	36.60
BJ04	29.478556	-89.843667	31.9	3.59	14.32	44.55	34.80
BJ05	29.478722	-89.843083	32.1	3	45.87	70.52	36.60
BJ06	29.478500	-89.842472	29.4	4.52	29.23	71.27	33.00
BJ07	29.478667	-89.841917	16.4	5.05	51.36	51.78	33.80
BJ08	29.478667	-89.841389	32.6	4.32	9.80	38.12	35.80
BJ09	29.478194	-89.841278	31.3	3.45	10.07	70.52	29.00
BJ10	29.477944	-89.841972	24.1	3.1	14.43	45.44	32.40
DC01	29.352611	-90.031306	15.7	2.73	26.60	21.5	19.40
DC02	29.353333	-90.031389	27.6	3.04	18.71	62.34	35.40
DC03	29.354194	-90.031361	30.9	3.61	24.18	72.57	39.40
DC04	29.353583	-90.030750	16.9	2.43	22.74	38.79	24.60
DC05	29.352889	-90.030861	20.9	2.64	33.42	51.45	28.20

PARTICIPANTS AND COLLABORATORS

8. Project participants

First Name	Last Name	Role in Project	Institution	Email
Deepak	Mishra	Salt Marsh Biophysical	Mississippi State University (now at University of Georgia)	dmishra@uga.edu
Karen	McNeal	Biogeochemical Study	Mississippi State University	ksm163@msstate.edu
Andrew	Mercer	Climate Study	Mississippi State University	mercer@hpc.msstate.edu
Bill	Cooke	Fire Risk Analysis	Mississippi State University	whc5@geosci.msstate.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
Shuvankar	Ghosh	PhD	Salt Marsh Biophysical Paramater Estimation using Remote Sensing	University of Georgia	Deepak Mishra	2015
Calista	Guthrie	MS	Salt Marsh Response to Oil Spill	Mississippi State University	Karen McNeal	2013
Erin	Thead	MS	Downscaling WRF for oil spill –climate relationship assessment	Mississippi State University	Andrew Mercer	2012
Chris	Downs	BS	Directed Individual Study	Mississippi State University	Deepak Mishra	2012

10. Student and post-doctoral publications, if planned

N/A

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

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Impact of the Gulf of Mexico Oil Spill on the Health and Productivity of Louisiana Salt Marshes: Preliminary Results	GHOSH, Shuvankar	GHOSH, S., Mishra, D., Cho, H. J., Fox, A. A., Downs, C., Merani, P. B. T., Kirui, P. and Jackson, N.	2011 Northern Gulf Institute Annual Conference		05/17/2011 – 05/19/2011
Salt Marsh Sediment Biogeochemical Response to Deep Water Horizon Oil Spill (Ocean Springs, MS)	GUTHRIE, Calista L.	GUTHRIE, CalistaL., MCNEAL, Karen S., and STAUFFENBURG, Henry	2011 Geological Society of America South Central Section Meeting		3/28/11
Salt Marsh Biogeochemical Response to the Deep Water Horizon Oil Spill (Ocean Springs, MS)	GUTHRIE, Calista L.	GUTHRIE, Calista L., MCNEAL, Karen S., and STAUFFENBURG, Henry	2011 Association of Environmental & Engineering Geologists		9/19/11 - 9/24/11
Temporal Salt Marsh Sediment Response to the Deep Water Horizon BP Oil Spill at Marsh Point, MS	GUTHRIE, Calista L.	GUTHRIE, Calista L. , MCNEAL, Karen S. , MISHRA, Deepak R. , BLAKENEY, Gary A. , GHOSH, Shuvankar , and DOWNS, Christopher G.	2012 Geological Society of America Annual Meeting		11/4/12 - 11/7/12
Salt Marsh Sediment Biogeochemical Response to the Deep Water Horizon BP Oil Spill (Skiff Island, LA, and Cat Island, Marsh Point, and Salt Pan Island, MS)	GUTHRIE, Calista L.	GUTHRIE, Calista L. , MCNEAL, Karen S. , MISHRA, Deepak R. , BLAKENEY, Gary A	2012 American Geophysical Union Annual Meeting		12/3/12 - 12/7/12
Salt Marsh Sediment Biogeochemical Response to the Deep Water Horizon Oil Spill (Skiff Island, LA, & Cat Island, Marsh Point, & Salt Pan Island, MS)	GUTHRIE, Calista L.	GUTHRIE, Calista L. , MCNEAL, Karen S. , MISHRA, Deepak R. , BLAKENEY, GaryA.	2013 Gulf of Mexico Oil Spill & Ecosystem Science Conference		1/21/13 - 1/23/13

12. Images

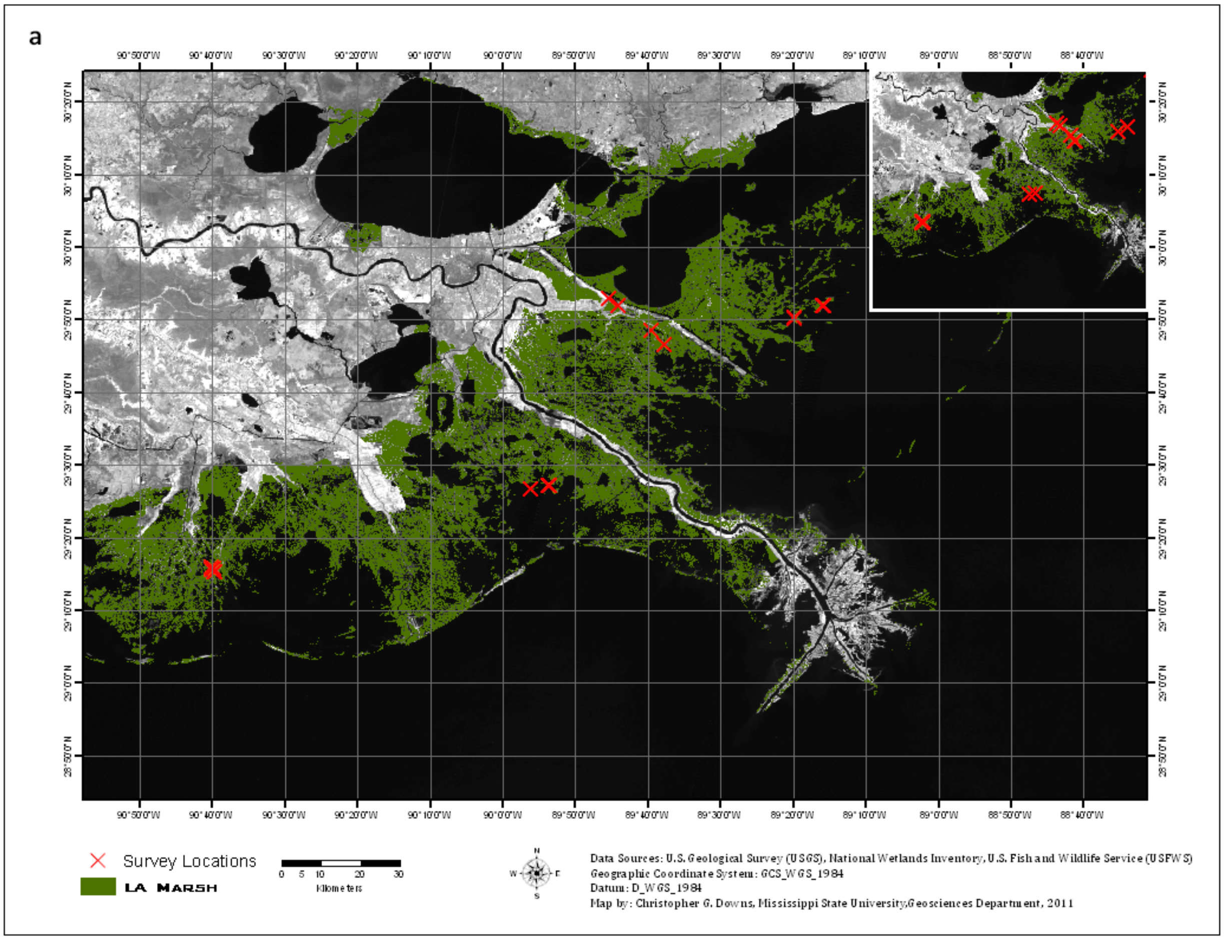

Figure 5: Map showing study area and survey locations.

Figure 6: Top of Canopy reflectance measurement using OceanOptics USB4000 spectroradiometer, c: Measurement of leaf level chlorophyll using Konica-Minolta SPAD 502 chlorophyll meter, d: Leaf Area Index (LAI) measurement using AccuPAR LP-80 Ceptometer, e & f: Vegetation Fraction measurement using vertical digital photograph, g: Above ground biomass collection from a 1 sq. ft plot within the IFOV of the sensor, h, i and j: Residual oil and dispersant observed in survey locations.

11-BP_GRI-20: University of Southern Mississippi: An Ecosystem Modeling Framework to Examine Ecological Impacts of the Deepwater Horizon Oil Spill (Phase II – Progress to-Date)

Scott P. Milroy, Ph.D.

SCIENCE ACTIVITIES

1. General Summary: The broad goal of this project was to capitalize on the vast array Northern gulf Institute (NGI) partners' research in an effort to build an ecosystem modeling framework to make use of ongoing research and monitoring related to the Deepwater Horizon (DwH) oil spill. This modeling framework would thus be available to researchers and management professionals to provide a holistic and integrated analysis of DwH impacts on the hydrography, chemistry, and biology of the northern Gulf of Mexico (nGoM) region, to include the implications on and feedbacks from the society and economy of the region.

One of the primary goals of the developing this ecosystem modeling framework was to design a framework flexible enough so that it could be applicable and employed within several different coastal ecosystems throughout the nGoM. Such an ambitious modeling framework requires: 1) the existence of large and diverse data sets encompassing biological, physical, ecological aspects of several different nGoM ecosystems; and 2) coordination among multi-disciplinary approaches and perspectives. Fortunately, with previous funding from NGI, the NGI Integrated Ecosystems Assessment (IEA) Team has been working for several years to compile the available biological, physical, and ecological data in four representative nGoM ecosystems: Barataria Bay (Louisiana), Galveston Bay (Texas), Mississippi Sound (Mississippi), and Perdido Bay (Alabama/Florida). Ultimately, the ecosystem modeling framework crafted from this project was used to develop a prototype Trophic Simulation Model (TroSiM) using the Mississippi Sound as a test-case region. In the future, we intend to utilize the TroSiM prototype model for model calibration/validation efforts within Mississippi Sound and ultimately to expand TroSiM for use in the other representative nGoM ecosystems (Barataria, Galveston, and Perdido Bays).

<u>Objectives & Milestones Met</u>

1) Use a workshop approach to interact with nGoM researchers to identify pathways for oil spill influence on important ecosystem drivers to be included in model development
Completed 26-27 January 2011 at the USM Gulf Coast Research Laboratory in Ocean Springs, MS.

2) Develop an ecosystem model specifically designed to address these ecosystem influences with respect to DwH oil spill impacts
Completed on 03 February 2012 at the Dauphin Island Sea Lab (DISL) on Dauphin Island, AL.

3) Use a workshop approach to refine model structure and input data, as well as a list of primary ecosystem drivers that will become the format for model output

Completed by and presented on 21 September 2012 at the Mississippi State University (MSU) High Performance Collaboratory (HPC) in Starkville, MS.

4) Develop a model-based tool that capitalizes on ongoing NGI-coordinated oil spill research
Included in the TroSiM model prototype presented on 21 September 2012 at the MSU HPC in Starkville, MS.

5) Integrate oil spill research into the NOAA efforts for an Integrated Ecosystem Assessment (IEA) of the nGoM
Ongoing; anticipated use of TroSiM in future IEA efforts within representative nGoM ecosystems.

2. Results and scientific highlights

Workshop/Conference 1: Model Development/Selection (Completed 26-27 January 2011)
This 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 nGoM 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. Ultimately, the results of this workshop were used to: 1) inform the process of selecting an ecological model appropriate for the IEA tasks; 2) identify the fundamental elements of the model which can be modified for tasks specific to IEA/EAM needs; and 3) assemble the data necessary to engage in a significant modeling effort, using the MS Sound/Bight ecosystem as a regional test-case.

Key Products of Workshop/Conference 1

1) "Off-the-shelf" models would not provide complete functionality; developing a comprehensive model from scratch would be too time- and resource-intensive. Decision made to engage in the basic customization of existing models (e.g. CASM), coupled with existing hydrodynamic models (e.g. FVCOM).
2) Decision to use a modular approach, beginning with a simplified test case as a proof-of-concept.
3) Model/data inventory for the representative nGoM ecosystems was needed.
4) Use of a flexible approach would require careful examination of feedback mechanisms on a limited geographic/temporal scale to maintain workability.
5) Significant effort was needed to quantify energetics and food web linkages for system-specific functional groups based on relevant and workable scales.
6) Input–Output variables must include estimates of ecosystem function and ecosystem services.

Subsequent to Workshop 1, a thorough list of the available environmental data, as well as information relevant to feedbacks with economical and societal issues, in three representative ecosystems of the nGoM, Barataria Bay (Louisiana), Mississippi Sound (Mississippi), and Perdido Bay (Florida) was compiled. The large data sets extending several years before the DwH oil spill and post-accident surveys, in combination with all the other DwH-related work done by many others, constituted a substantial data set to explore with rigor the environmental, societal and economic impacts of the accident. Ultimately, these data were used to focus the scope of the ecological model, specific to the MS Sound/Bight for initial model customizations.

Workshop/Conference 2a: Model Selection/Design (Completed 03 February 2012)
This workshop was held at DISL and included all project team members as well as several NGI IEA Team members. Based on power, scalability, and ease-of-use, the Fulford et al. (2010) Trophic Simulation Model (TroSiM) was selected as the ecological model for the MS Sound/Bight region. Main

TroSiM goals: 1) quantify impacts of the DwH oil spill on fisheries production; and 2) quantify impacts of the DwH oil spill on nearshore trophic structure.

Key Products of Workshop/Conference 2a
Selection of TroSiM model, including proposed modifications to the TroSiM code, focused on three main components: 1) Food web component (the existing TroSiM model would be optimized to contain only those functional groups germane to the initial simulation and calibration steps, offering dynamical food web interactions within MS Sound/Bight habitats, focusing primarily on the oyster reef habitat as the initial test case); 2) Hydrodynamic/water quality component (existing FVCOM model grid, boundary conditions, and hydrodynamical code for the MS Sound/Bight region would be utilized to produce estimated flowfields and other pertinent physical forcings, coupled to the ecological model); and 3) Fisheries component (an addendum to the food web component, to allow for commercial fishing pools as a mortality source for fishable functional groups).

Subsequent to Workshop 2a, a wide variety of competition parameters and diet matrices required definition and quantification for each functional group selected within the model simulation. A time-intensive review of regional data and literature values was performed to quantify each competition parameter, specific to each exemplar or each functional group within the simulation, using values in keeping with the regional context. TroSiM function groups included: Phytoplankton (3 exemplars), Periphyton (1 exemplar), Submerged Aquatic Vegetation (1 exemplar), Emergent Plants (1 exemplar), Zooplankton (3 exemplars), Zoobenthos (Eastern Oyster + 2 additional exemplars), Pelagic Omnivorous Fish (3 exemplars), Pelagic Piscivorous Fish (1 exemplar), Benthic Omnivorous Fish (2 exemplars), and Heterotrophic Bacteria (2 exemplars).

<u>Workshop/Conference 2b: Model Presentation/Refinement (Completed 30 July 2012)</u>
Workshop/Conference 2b provided an initial presentation of the TroSiM model structure to obtain feedback from workshop/conference participants. This workshop/conference was conducted at NGI Headquarters at Stennis Space Center, MS and was attended by a subset of attendees from Workshop/Conference 1, as well as the core project and IEA Team, and members of the DwH oil-spill research community. Feedback from Workshop/Conference 2b was used to further refine model structure, model output, and model input to maximize the integration of current research with model-based analyses to assist with final model refinements.

<u>Workshop/Conference 3: Release of TroSiM Prototype (Completed 21 September 2012)</u>
This workshop was held in Starkville, MS and included all project team members as well as several NGI IEA Team members. The prototype model framework and code were presented, primarily to judge the utility of model output, applicability for understanding ecosystem responses to the oil spill, and to further refine (calibrate) the model to increase this utility.

Key Products of Workshop/Conference 3
The TroSiM prototype is a fully functioning ecosystem model, developed specifically for the investigation of trophic interactions and ecosystem services within Mississippi Sound. TroSiM represents a functional, modular, proof-of-concept model that requires validation/calibration for operational functionality within Mississippi Sound. Future work is also needed to expand TroSiM's applicability to other representative nGoM ecosystems (e.g. Barataria, Galveston, and Perdido Bays); however, its modular design is intended to provide "ease-of-use", whereby researchers and/or resource managers may modify the regional functional groups and fundamental energetics/food web connections as simple read-in files, thereby eliminating the need for fundamental code revisions. We intend to leverage TroSiM to accomplish the aforementioned calibration and expansion goals, as well as to address the probable impacts of the DwH oil spill, such as: 1) trophic perturbations caused by functional group mortality due to oil exposure; 2) alteration in marine microbial processes

particularly due to the assimilation of petroleum-based carbon; 3) habitat loss and redistribution of important ecosystem component species; 4) recruitment impacts in apex predators caused by exposure of early life stages to surface oil; and 5) cascading effects of the near absence of fishing mortality during the summer-fall of 2010.

3. Cruises & field expeditions

N/A

4. Peer-reviewed publications, if planned

a. Manuscripts submitted or in preparation (Please note target journal, and anticipated date of publication or submission)
None yet

b. "Adaptation of a Chesapeake Bay Trophic Simulation Model (TroSiM) of Eastern Oyster (*Crassostrea virginica*) productivity for the Mississippi Sound", in preparation. Ecological Applications or Ecological Modelling, February 2013 anticipated submission date.

5. Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Progress towards a Model of Oil Spill Impacts on Oyster Production in the MS Sound Using the Integrated Ecosystem Assessment Model Approach (*q.v. Appendix A*)	Milroy, Scott	Scott Milroy William McAnally Just Cebrian Felicia Coleman Haosheng Huang	Northern Gulf Institute 2012 Annual Conference	N	23-24 May 2012
NGI TroSiM: Trophic Simulation Model (*q.v. Appendix B*)	Milroy, Scott	Scott Milroy	Northern Gulf Institute Eco-Modeling Workshop	N	30 July 2012

6. Other products or deliverables

"growthparam_mssound.docx": TroSiM read-in matrix of bioenergetics growth parameters for the MS Sound simulations
"preypref_mssound.docx": TroSiM read-in matrix of food web connection parameters for the MS Sound simulations
"FVCOM_stationname_year.docx": FVCOM hydrography model output (coupled to TroSiM) for 13 oyster reef locations within MS Sound, for 2010 & 2011 (26 files in toto).
"TroSiM_MS.f": TroSiM source code (including project-specific modifications) for MS Sound trophic simulations (Fortran95)

These files represent the source code and initialization files for TroSiM_MS. As these products are currently being leveraged for future publications, model validation, and model expansion to other nGoM systems, these resources are not yet openly available. However, once project researchers have had a reasonable time to publish results and pursue further model development opportunities, the model code and initialization files will be made available in wide release to NGI stakeholders.

7. Data

N/A

PARTICIPANTS AND COLLABORATORS

8. Project participants

First Name	Last Name	Role in Project	Institution	Email
Scott	Milroy	Principal Investigator (inherited from Richard Fulford, the project's initial PI	University of Southern Mississippi	Scott.milroy@usm.edu
Richard	Fulford	Scientific Participant (original PI before working @ EPA)	Environmental Protection Agency	Fulford.Richard@epamail.epa.gov
William	McAnally	Co-Principal Investigator	NGI/Mississippi State University	mcanally@ngi.msstate.edu
Just	Cebrian	Co-Principal Investigator	Dauphin Island Sea Lab	jcebrian@disl.org
Haosheng	Huang	Co-Principal Investigator	Louisiana State University	hhuang7@lsu.edu
Felicia	Coleman	Co-Principal Investigator (non-participatory post-award due to re-purposed effort within GoMRI Consortium)	Florida State University	fcoleman@fsu.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
Glenn	Miller	Post-Doc	TroSiM Bioenergetics and Food Web matrix parameterizations	Dauphin Island Sea Lab	Milroy/Cebrian	N/A

10. Student and post-doctoral publications, if planned

a. Published, peer-reviewed bibliography

N/A

b. Manuscripts submitted or in preparation

Glenn Miller is anticipated to be a co-author in the planned submission (see *Item 4b* above)

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

N/A

12. Images

N/A

11-BP_GRI-21: The University of Southern: Evaluating Changes in Fluorescence EEM and Size Spectra During the Degradation of Oil and Dispersant

Laodong Guo, Alan Shiller

SCIENCE ACTIVITIES

1. General Summary: The goal of our project was to evaluate systematically the dynamic changes in bulk dissolved organic carbon, optical properties, fluorescence excitation-emission matrices (EEM) spectra, and hydrocarbon and PAH composition during the degradation of oil and dispersant including microbial degradation and photochemical degradation, through controlled laboratory experiments. Our working hypotheses included 1) the crude oil from the Macondo well and addition of dispersant should significantly alter the optical properties and molecular size of natural organic matter in the water column in the Gulf of Mexico; 2) hydrocarbon composition and fluorescent DOM components should be fractionated chemically during oil degradation, leading to chemical evolution of oil components; and 3) the ratios of oil components or fluorescent DOM components should be linked to the degradation status of oil in the water column and could be used as an index/proxy to track the fate, transport and transformation of crude oil in the Gulf of Mexico.

During the project, we conducted degradation experiments, including photochemical degradation and biological degradation of oil, dispersant and oil-dispersant mixture, in the laboratory under natural sunlight and temperatures, to examine the variations in optical properties, concentration of carbon species, DOM size distribution, and hydrocarbon composition, using UV-visible spectroscopy, 3D fluorescence spectroscopy, flow field-flow fractionation techniques, and gas chromatography-mass spectrometry. We also measured field seawater samples collected from the northern Gulf of Mexico for comparisons between results from field samples and controlled laboratory experiments to test our hypotheses. Due to technical problems in keeping oil dissolved in seawater, the size distribution of oil during degradation could not be examined using our proposed flow field flow fractionation techniques. However, we were also able to add the measurements of samples from degradation experiments for hydrocarbon composition, such as, n-alkanes and polycyclic aromatic hydrocarbons (PAH's), and a field research component for the analysis of samples for fluorescence EEM spectra and other optical properties. Detailed results are described below.

Overall, based on results from our proposed research, we have revealed the chemical evolution of oil and dispersant system during photochemical and biological degradation. We have established oil fluorescence component ratios for tracking the fate, transport and transformation of oil in the water column and have provided a compelling alternative for monitoring degradation status of oil in the Gulf of Mexico. We also contributed to the knowledge of future instrument development.

2. Results and scientific highlights

Through laboratory studies, we examined the fluorescence characteristics, i.e., maximum excitation-emission wavelengths, of crude oil and weathered oil collected from the surface water during oil spill. The crude oil had its maximum fluorescence intensities centered on 226/340 nm, located under the excitation wavelength between 220–240 nm and emission wavelength between 320-360 nm. Another fluorescence component of the crude oil had an emission maximum located at 322 nm over the excitation wavelength range of 260 – 280 nm. The dispersant was characterized with an intensity peak at Ex/Em 234/376 nm and another emission maximum at 370 nm over an excitation range of 260-290 nm.

Results of laboratory degradation experiments using crude oil and oil/dispersant showed a rapid decrease in optical activity, change in fluorescence EEM spectra, and preferential loss of low-molecular-weight hydrocarbon components in the water-soluble fraction. Based on fluorescence EEM data and parallel factor (PARAFAC) modeling, three major oil components, component-1, component-2 and component-3, were readily identified during oil degradation, with their fluorescence intensity maxima at Ex/Em 226/328, 262/315, and 244/366 nm, respectively.

Kinetic results showed an average degradation half-life of 8-20 days for the oil components based on time-series fluorescence EEM and hydrocarbon composition measurements. The changes in optical properties, fluorescence EEM spectra, and hydrocarbon composition revealed a chemical evolution and dynamic transformation of oil during oil degradation. Dispersants appeared to change chemical characteristics of oil, shift the fluorescence EEM spectra, and enhance the degradation of low-molecular-weight hydrocarbons, but prohibit the overall remineralization of dissolved organic carbon.

Photochemical degradation played a dominant role in the transformation of oil components, and could be an effective degradation pathway of oil in the Gulf of Mexico. Results from laboratory degradation experiments should help the interpretation of field data and provide insights into understanding degradation pathways and mechanisms, and thus the fate and transport of oil components in the Gulf of Mexico.

Field data showed that DOM in the upper water column seemed to contain mostly natural organic matter in October 2010, three months after the oil spill was capped. However, anomalous DOM with high optical yields still resided in deep waters in the northern Gulf of Mexico even 15 months after the oil spill was capped, showing a persistent oil influence on optical properties in deep waters.

3. Cruises & field expeditions

Ship or Platform Name	Chief Scientist	Objectives	Dates
R/V Cape Hatteras	K. Yeager	Post-incident investigation of DOM and oil components in the water column	Mid-October 2010
R/V Cape Hatteras	K. Yeager	Post-incident investigation of DOM and oil components in the water column	October 2011

4. Peer-reviewed publications, if planned

a. Published, peer-reviewed bibliography

To be added

b. Manuscripts submitted or in preparation

Zhou, Z., Liu, Z., and Guo, L. Tracking chemical evolution of crude oil during degradation using fluorescence EEM and hydrocarbon composition. Submitted to *Marine Pollution Bulletin*, June 2012.

Zhou, Z., L. Guo, A.M. Shiller, S.E. Lohrenz, V.L. Asper, and C.L. Osburn. Characterization of oil components from the Deepwater Horizon oil spill in the Gulf of Mexico using fluorescence EEMs and PARAFAC modeling. Submitted to *Marine Chemistry*, June 2012.

Zhou, Z and Guo, L. Evolution of the optical properties of seawater influenced by the DWH oil spill in the Gulf of Mexico. *Environmental Research Letters* 7, 025301

doi: 10.1088/1748-9326/7/2/025301.

5. Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Characterization of oil components from Deepwater Horizon oil spill in the northern Gulf of Mexico using fluorescence EEMs and parallel factor analysis.	L. Guo	Zhou, Z., Shiller, A.M., Lohrenz, S., Asper, V.L. and Osburn, C.L	2011 NGI annual meeting, May 17-19, 2011, Mobile, AL	Y	May 17-19, 2011
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	Y	October 25-26, 2011

			Workshop, FL		
Variations in fluorescent DOM components during laboratory degradation of Macondo crude oil.	Z. Zhou	Zhou, Z. and Guo, L.	Deepwater Horizon Oil Spill Principal Investigator One Year Update Workshop, FL	Y	October 25-26, 2011
UV and fluorescence characteristics of DOM from the Gulf of Mexico five months after the Deepwater Horizon oil spill	Z. Zhou	Zhou, Z., Guo, L. and He, H	The 2012 Ocean Science Meeting, February 22-24, 2012, Salt Lake City, UT	Y	February 22-24, 2012

6. Other products or deliverables

N/A

7. Data

In general, data will be presented in peer-reviewed 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
Zhanfei	Liu	Collaborator	UT Austin	zhanfei.liu@mail.utexas.edu
Zhengzhen	Zhou	PhD student	USM	Zhengzhen.zhou@usm.edu
Hailong	Huang	Technician	USM	Hailong.huang@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
Huijun	He	Post-doc		USM	L. Guo	
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 (Copies of the papers are requested)
N/A

b. Manuscripts submitted or in preparation
See list above in section 4b. Three manuscripts are co-authored by graduate student, Z. Zhou (as a lead author).

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

All presentations listed in section 5 include student as a lead author or co-author (Z. Zhou).

12. Images

N/A

11-BP_GRI-22: Continuation of "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 fluorescence EEMs, 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 this second phase of our project, we participated in a research cruise (Oct. 2011) 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 in Year 1 due to the broad range of topics versus the limited time and funding. Continued funding in Year 2 has allowed us be more complete in pursuing our objectives. 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 have data showing nutrient consumption in the subsurface plume, which we link to microbial growth. 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 in Year 1 and a fourth cruise in

Year 2. The Year 2 cruise helped us confirm that there is not any continued detectable leakage from the Macondo well although there were still abnormal DOM components residing in deep waters showing the presence of oil (Zhou and Guo, 2012).

We have continued to examine fractionations in PAH composition relating to 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 are awaiting some final analyses of biomarker compounds to help verify our conclusions.

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. In fact, we estimate (from the nutrient and oxygen depletions) that a substantial portion of the hydrocarbons were initially converted to biomass.

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 suggests possible Fe limitation of methanotrophic organisms and 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.

During the October 2011 cruise, we also performed experiments examining the solubilization of metals out of the crude oil, with and without added dispersants. Experiments suggest that the surfactants from the dispersant can complex metals, but that in most situations this is a minor effect on metal distributions.

3. Cruises & field expeditions

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
R/V Cape Hatteras		K. Yeager	Post-incident investigation of water column chemistry & collection of sediments	Mid-October 2011

4. Peer-reviewed publications, if planned

a. Published, peer-reviewed bibliography

Zhou, Z. and L. Guo, 2012. Evolution of the optical properties of seawater influenced by the Deepwater Horizon oil spill in the Gulf of Mexico. Environ. Res. Lett. 7 025301 doi:10.1088/1748-9326/7/2/025301

b. Manuscripts submitted or in preparation (Please note target journal, and anticipated date of publication or submission)

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. Nature Geoscience, submitted.

Zhou, Z., L. Guo, A.M. Shiller, S.E. Lohrenz, V.L. Asper, and C.L. Osburn. Variations in oil components in the Gulf of Mexico as characterized by fluorescence EEMs and PARAFAC modeling. Marine Chemistry, submitted.

Shiller, A.M. and D. Joung. Nutrient depletion as a proxy for microbial growth in Deepwater Horizon subsurface oil/gas plumes. Environmental Research Letters, submitted.

Joung, D. and A.M. Shiller. Trace element distributions in the water column affected by the Deepwater Horizon blowout. Environmental Science and Technology, submitted.

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. In preparation for Environ. Sci. Technol.

5. Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
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.	2012 Ocean Sciences Meeting	Y	Feb. 2012

		Louchouarn			
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
Barium, iron, copper, nickel, manganese, cobalt and nutrient distributions in the water column affected by the Deepwater Horizon oil spill	D. Joung	Joung, D., Shiller, A.M.	2012 Ocean Sciences Meeting	Y	Feb. 2012
UV and Fluorescence Characteristics of DOM from the Gulf of Mexico 5 Months after the Deepwater Horizon Oil Spill	Z. Zhou	Zhou, Z., Guo, L., He, H.	2012 Ocean Sciences Meeting	Y	Feb. 2012

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/

Zhou., Z., Ph.D. Dissertation, The University of Southern Mississippi, in preparation.

Joung, D., Ph.D. Dissertation, The University of Southern Mississippi, in preparation.

7. Data

In general, data is/will be presented in publications, theses, and dissertations listed above. (Note that water column CTD data has been submitted to relevant archiving databases by the cruise chief scientists and was not the responsibility of Shiller/Guo.) 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	2013
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

The published paper listed in 4a has a student as 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).

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
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
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
Barium, iron, copper, nickel, manganese, cobalt and nutrient distributions in the water column affected by the Deepwater Horizon oil spill	D. Joung	Joung, D., Shiller, A.M.	2012 Ocean Sciences Meeting	Y	Feb. 2012
UV and Fluorescence Characteristics of DOM from the Gulf of Mexico 5 Months after the Deepwater Horizon Oil Spill	Z. Zhou	Zhou, Z., Guo, L., He, H.	2012 Ocean Sciences Meeting	Y	Feb. 2012

12. Images

N/A

11-BP_GRI-23: University of Southern Mississippi: Impacts of the Deepwater Horizon oil spill on the health and growth of estuarine fish and ecosystem functionality.

Rich Fulford, Robert J, Griffitt, Nancy Brown-Peterson

SCIENCE ACTIVITIES

1. General Summary: To assess potential impacts of the BP Deepwater Horizon oil spill on estuarine fish, laboratory assays of survival, gene expression, and growth as a function of dispersed oil concentration were conducted using Cynoscion nebulosus. Larval and juvenile Cynoscion nebulosus were exposed to sublethal concentrations of either Water Accommodate Fraction (WAF), Chemically Enhanced Water Accomodated Fraction (CEWAF, or dispersed oil) or dispersant alone in an acute exposure. Exposures were evaluated within these fish using qPCR to examine the hepatic expression of cytochrome P450-1A (CYP1A) levels. Evidence of endocrine disruption was evaluated using qPCR to examine the hepatic expression of vitellogenin (VTG) and estrogen receptor alpha (ERα). There was a trend of upregulation of CYP1A for all treatments when compared to the control treatment. No evidence of endocrine disruption was observed in these exposures. A reduction in total length was observed in all of the larval treatments. Significant reductions in total length were observed in the juvenile exposure for the WAF and dispersant treatments.

2. Results and scientific highlights

In this research, the effects of waterborne oil and dispersant were observed on two life history stages of *C. nebulosus*.

Larval exposures.

After the 96 hour exposure, larval Spotted seatrout (*Cynoscion nebulosus*) exposed to CEWAF showed the greatest upregulation of CYP1A, followed by the WAF treatment (Figure 1A). The dispersant treatment expressed CYP1A at levels equal to the control treatment. There were significant differences in observed expression of CYP1A between treatments (ANOVA $p<0.001$). Tukey's HSD test showed that the WAF and CEWAF treatments were significantly different from the control and dispersant treatments and each other. There was no difference in relative VTG (Figure 1B) and ERα (Figure 1C) levels between treatments (p values = 0.908 and 0.550 respectively).

At the conclusion of the 96-hour larval exposure, C. nebulosus in the control treatment had greater mean TL than did fish in the WAF, CEWAF or dispersant treatments (Figure 2). The data was not normally distributed, so means were compared with a Kruskal-Wallis one-way analysis of variance by rank ($n=16$, $p<0.001$). Post-hoc analysis with Dunnett's Multiple Comparison Test (MCT) showed that the TL (mm) of the fish from the CEWAF and dispersant treatments were significantly different from the control treatment. As compared to the TL of the control treatment, the CEWAF treatment had a 13.52% reduction, while the dispersant treatment had a 10.40% reduction.

Juvenile exposures.

After 72 hours of exposure, the WAF treatment showed the highest expression of CYP1A (Figure 3), and when all treatments were compared pairwise (Tukey's MCT) it was significantly different from the other treatments (p=0.001). There was no difference of VTG or ERα expression between treatments (p values= 0.929 and 0.6 respectively).

At the initial measurement (3 days depuration), mean TL per treatment was: 40.75 ± 2.83 mm (control), 38.35 ± 3.76 mm (WAF), 39.65 ± 2.70 mm (CEWAF), and 38.15 ± 2.96 mm (dispersant). This is a reduction in TL of 6.82% for the dispersant treatment, and 6.26% for the CEWAF treatment (Figure 4). Dunnett's MCT showed the TL of the WAF and dispersant treatments were significantly different from the control (ANOVA p=0.032). At Week 4, mean TL per treatment was: 48.61 ± 4.24 mm (control), 49.75 ± 4.26 mm (WAF), 49.22 ± 3.43 mm (CEWAF), and 50.63 ± 4.13 mm (dispersant). The treatments were no longer significantly different (ANOVA p=0.51). This represents a mean change in TL between Week 1 and 4 of: 7.86 mm (Control), 11.4mm (WAF), 9.57 mm (CEWAF), and 12.48 mm (dispersant). The lack of a significant effect of length after Week 4 is most likely a result of the fact that the fish were housed in individual tanks, and fed ad lib for the duration of the experiment. Had the fish been housed together, it is likely that the larger control fish would have outcompeted the smaller, exposed fish, and the difference in lengths would have remained, or been exacerbated as the exposed fish were unable to compete with the larger fish for resources.

Cynoscion nebulosus exposed to waterborne oil and dispersant exhibited altered expression of biomarkers when compared to unexposed fish. Larval fish upregulated CYP1A when exposed to both WAF and CEWAF, but the CEWAF treatment showed the greatest fold-change of CYP1A expression. In the juvenile growth assay, the WAF treatment showed the highest upregulation of CYP1A. Neither age class nor treatment showed evidence of endocrine disruption using VTG and ERα as biomarkers. In both life history stages examined, growth was affected. CEWAF and dispersant treatments showed significantly reduced TL in larvae. Additionally, the WAF treatment's mean TL was lower than the control treatment's, but the difference was not significant.

3. Cruises & field expeditions
N/A

4.Peer-reviewed publications, if planned
Gene expression and growth as indicators of effects of the BP Deepwater Horizon oil spill on Cynoscion nebulosus. Brewton, RA, RS Fulford, RJ Griffitt. In prep. Submission planned to Marine Environmental Research Fall 2012.

Impacts of the Deepwater Horizon Oil Spill on the Reproductive Biology of Spotted Seatrout (Cynoscion nebulosus). Brown-Peterson N., RA Brewton, RJ Griffitt, RS Fulford. In prep. Book chapter

5. Presentations and posters, if planned

Griffitt, R.J., NB Brown-Peterson, I Boube, S Manning. 2012. Effects of crude and dispersed oil on estuarine fish species. Invited Platform presentation, 51st Annual Society of Toxicology Conference. San Francisco, CA, Mar. 11-15.

Brewton, R, R. Fulford and R. J. Griffitt. 2011. Gene expression and growth as indicators of effects of the BP Deepwater Horizon oil spill on *Cynoscion nebulosus*. **Poster** presentation. Society of Environmental Toxicology and Chemistry North America Meeting. Boston, MA.

Brewton, R, R. Fulford and R. J. Griffitt. 2011. Survival and growth of estuarine fish following exposures of chemically enhanced dispersed oil from the *Deepwater Horizon* oil spill. **Platform** presentation. Coastal and Estuarine Research Federation International Meeting. Daytona Beach, FL.

Brewton, R, R. J. Griffitt and R. Fulford. 2011. Impacts of Deepwater Horizon oil spill on the health

and growth of estuarine fish and ecosystem functionality. Northern Gulf Institute Annual Meeting.

Mobile, Alabama.

Brewton, R.A., R. J. Griffitt, and R.S. Fulford . 2010. *Impacts of Deepwater Horizon oil spill to estuarine fish growth and ecosystem functionality*. American Fisheries Society Southern Division Spring Meeting. January 14, 2010. Tampa, Florida.

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
Robert	Griffitt	Co-PI	USM	Joe.griffitt@usm.edu
Richard	Fulford	Co-PI	USM	Richard.fulford@usm.edu
Nancy	Brown-Peterson	Co-PI	USM	Nancy.Brown-peterson@usm.edu
Rachel	Brewton	MS student	USM	Rachel.brewton@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
Rachel	Brewton	MS	Effects of WAF/CEWAF on spotted seatrout	USM	Griffitt	2012

10. Student and post-doctoral publications, if planned

See above

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

See above

12. Images

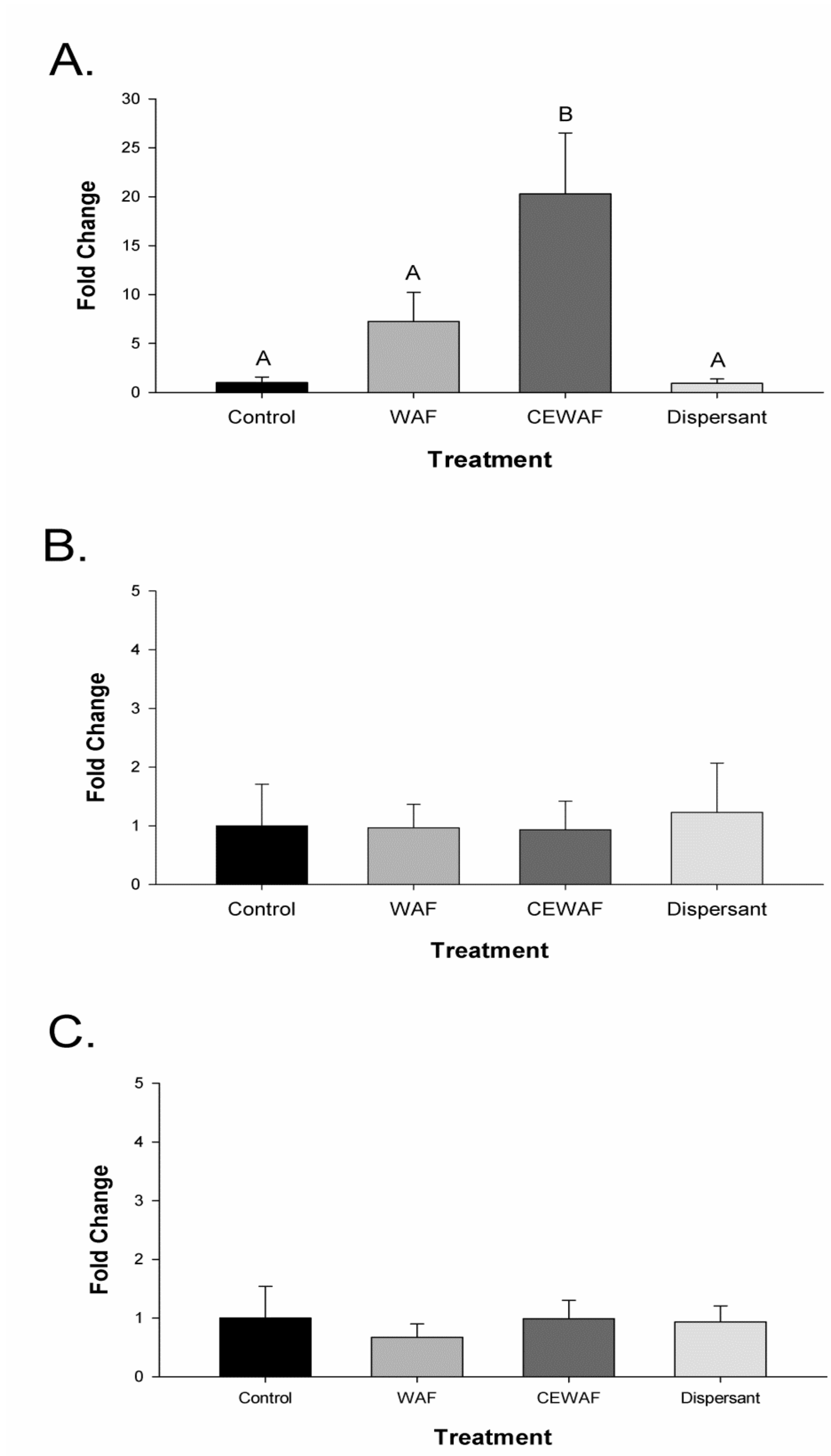

Figure 1: Expression levels of larval C. variegatus genes following 96h exposure. A. Cytochrome p450 1A (CYP1A). B. Vitellogenin (VTG). C. Estrogen Receptor alpha (Era)

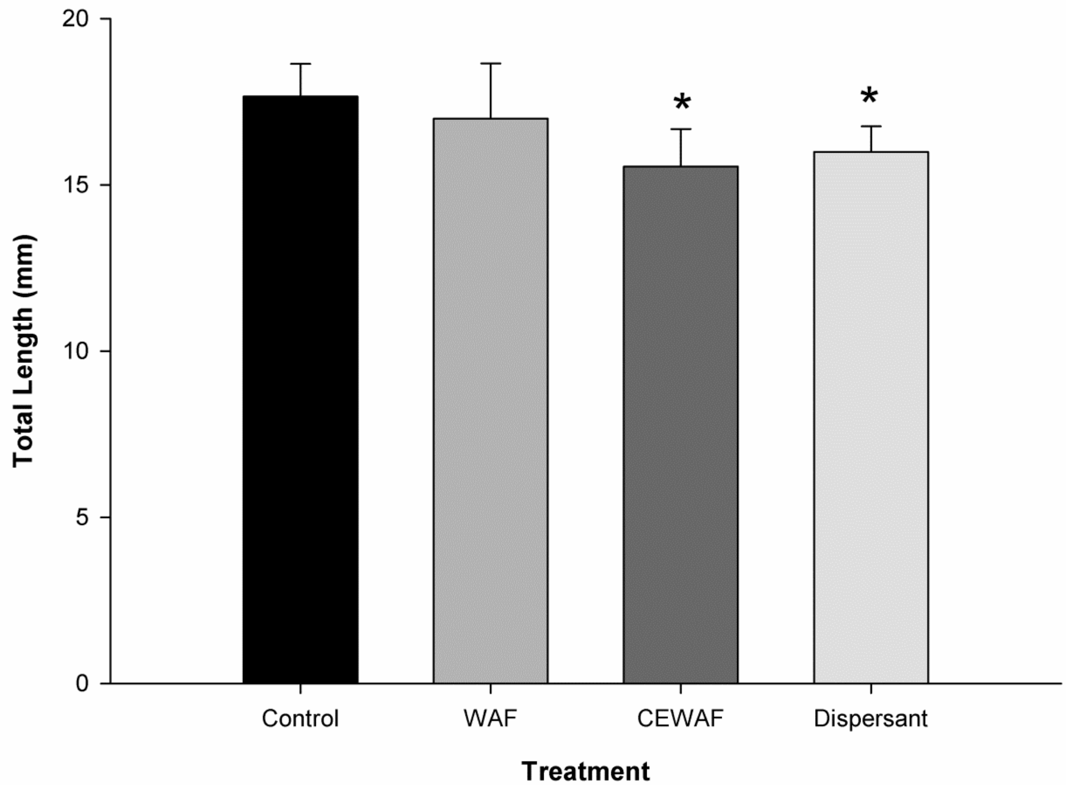

Figure 2. Effects of 96 hour exposure on growth lf larval C. nebulosis.

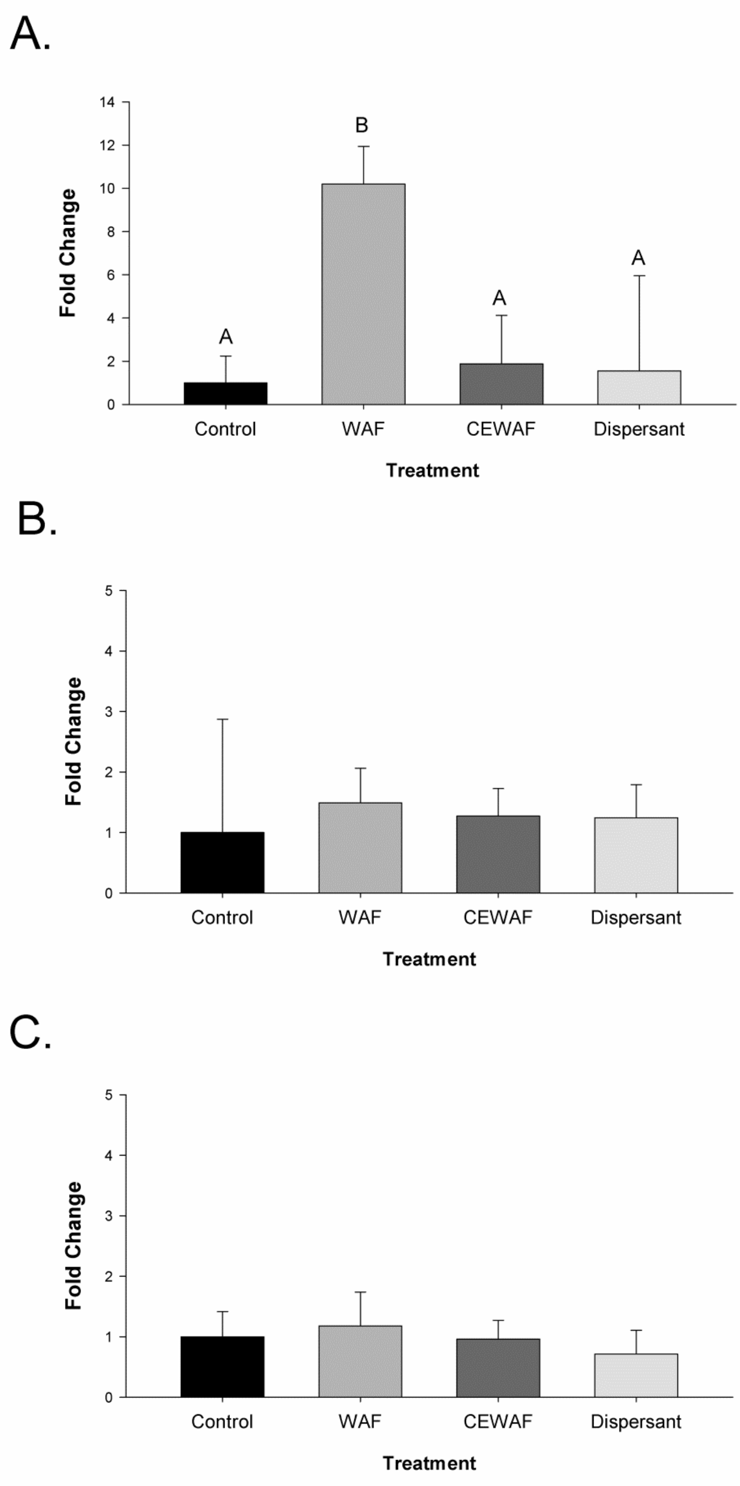

Figure 3. Expression levels of juvenile C. variegatus genes following 72h exposure. A. Cytochrome p450 1A (CYP1A). B. Vitellogenin (VTG). C. Estrogen Receptor alpha (Era)

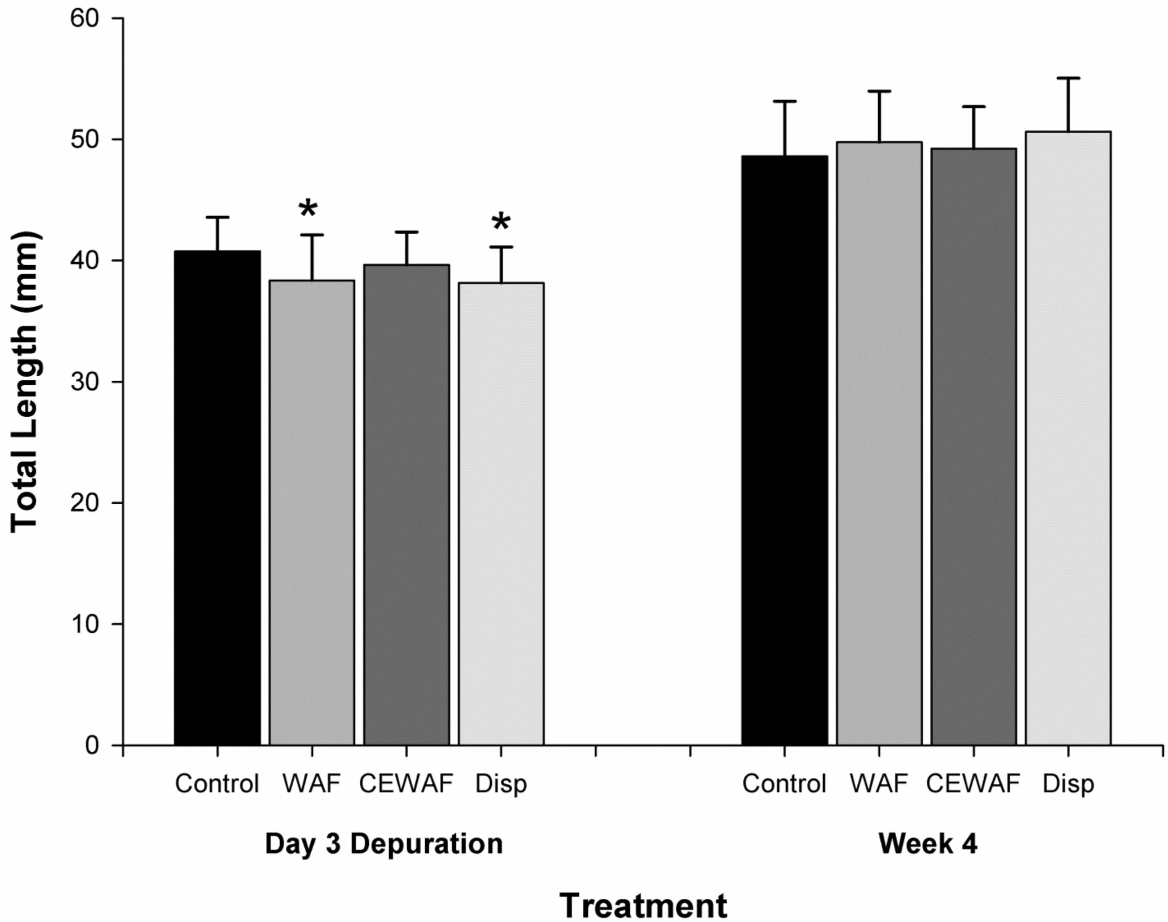

Figure 4. Effects of 72 hour exposure on growth of juvenile C. nebulosis.The left side is length at the termination of the initial exposure. The right side (Week 4) is after four weeks growth in uncontaminated water in individual tanks. Stars indicate significant differences from control fish (alpha = 0.05).

11-BP_GRI-24: The University of Southern Mississippi: Responses of Benthic Communities and Sedimentary Dynamics to Hydrocarbon Exposure in Neritic and Bathyal Ecosystems: Phase II

Charlotte A. Brunner, Kevin M. Yeager

SCIENCE ACTIVITIES

1. ***General Summary***: We built upon a successful NGI Phase I project, which focused on determining if and where Deepwater Horizon (DWH) oil has reached the seafloor below the intertidal zone and if at these sites DWH oil has affected benthic ecosystems. In 2010, oil was observed over large areas of the ocean surface and was reported in thin, discrete layers on subsurface isopycnals. To date, there have been a number of qualitative observations and limited but suggestive quantitative reports (OSAT-1 Report, 2010) indicating that some oil reached the sea floor at neritic to bathyal depths. However, comprehensive and conclusive quantitative data on this and related subjects remain lacking. Consequently, the crucial questions remain unanswered: if, where, and to what degree has petroleum hydrocarbon and chemical dispersant contamination impacted sediment ecosystems in the northeastern Gulf of Mexico (GOM).

Our research is comprehensive and strongly multi-disciplinary by necessity. 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 water environments of the continental slope and upper rise surrounding the Macondo Well. Analytical elements have included

1. Organic geochemistry to characterize the distribution and concentration of total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAHs) and various biomarker compounds to assist in determining the source, primary degradation pathways, and degradation rates of the hydrocarbons;

2. Sedimentology to determine how hydrocarbon contamination may alter sediment textures, geotechnical properties, and carbon storage capacity;

3. Radiochemistry to quantify sediment mixing, rates of sediment accumulation and chronology, which together will allow calculation of fluxes of oil to the seafloor; and

4. Censuses of meio- and macrofauna to assess the impacts of hydrocarbon contamination on ecosystem health through changes in and recovery of overall biodensity/biomass, species diversity, and community structure.

All of these objectives principally support the theme: "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 secondarily support other themes.

2. Results and scientific highlights

In support of an earlier report (OSAT, 2010), hydrocarbon (HC) and PAH concentrations in surficial sediments of the northern GOM decrease exponentially within a few kilometers away from the Macondo wellhead (MW). However, our results also show several stations with concentrations of PAHs that are well above background (>1,000 ng/g) at stations located 10-20 km away from the wellhead, and others considerably farther afield (> 100 km; Figs. 1, 2). The far-field sites are separated from the Macondo wellhead by bathymetric barriers, supporting input by settling from the water column plumes and surface slicks rather than solely from dispersal on the seafloor.

The compound ratio signatures of HCs at sites with above background concentrations (Table 1), suggest the predominance of highly weathered compounds rather than unweathered oil. The HCs could be extensively transformed from fresh DWH oil during water-column transport and deposition. However, forensic approaches applied to the distribution of hydrocarbon molecules cannot eliminate other potential sources. Biomarker analysis funded largely by another project is currently underway to identify the sources.

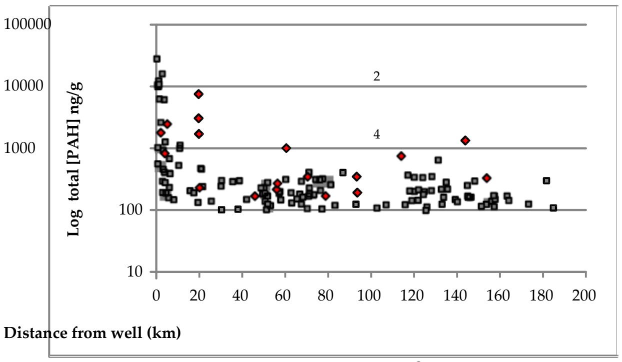

Figure 1. Total PAH concentrations in surficial sediments (0-1 cm) of the northern GOM *vs*. distance from the well head. Red data derived from R/V *Cape Hatteras* (2010) stations, grey data derived from OSAT-1 data set (OSAT, 2010), including data from "offshore" and "deepwater" samples (≥ 100 ng/g total PAHs).

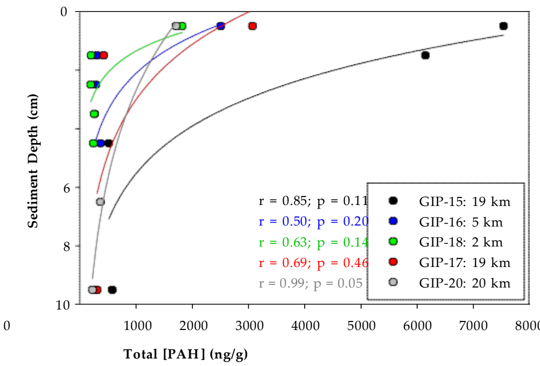

Figure 2. Total PAH concentrations at several GIP stations (2010) at a range of distances from the DWH well head. Logarithm best fits used to illustrate form of concentration distributions over depth ($y = y_0 + a\ln x$).

Table 1. Hydrocarbon concentrations (PAHs, TPHs) and signatures in surface sediments at four stations in the northern GOM (2010). Pery/5-PAHs: perylene to penta-PAH ratio; Pris/Phy: pristane to phytane ratio; n17/n29: 17C to 29C alkane ratio; n17/n35: 17C to 35C alkane ratio.

	PAHs (ng/g)	TPHs (ug/g)	Pery/5-PAHs	Pri/Phy	n17/n29	n17/n35
GIP-12 (1 cm)	272	48.6	0.41	1.84	0.09	0.16
GIP-15 (1 cm)	7552	693.3	0.08	1	0.72	0.84
GIP-16 (1 cm)	2512	341.9	0.51	0.76	0.07	0.09
GIP-19 (1 cm)	233	21.4	0.45	2.16	0.08	0.31
Macondo Oil	7.22[a]	75.1[a]	0.03	1.54	6.7	21.2

a. concentrations in mg/g

Collections of macro- and meiofauna in oiled and unoiled sites show that the infauna survived the addition of DWH oil to the substrate, and that by October of 2010 there was no clear evidence of mass mortality. Changes to the assemblages, however, were evident and quantifiable.

Macrofaunal analysis shows that, as hypothesized, the density, diversity, and assemblage composition are affected by PAH concentrations (Fig. 3). At sites with low, moderate and high concentrations of PAHs, these biotic terms are smaller than those from control site GIP 12, which had only trace concentrations of TPHs and PAHs. The Assemblage at oiled sites (Fig. 4B) was less diverse, and was dominated by polychaetes and other opportunistic taxa, whereas the control site had significant numbers of aplacophoran mollusca (Fig. 4A). The species composition shift is exemplified by families of polychaetes, which shift from abundant surface deposit-feeding Spionidae, Cirratulidae and Ampharetidae (control site) to subsurface deposit-feeding Maldanidae and Capitellidae and carnivorous Syllidae, Siglionidae, and Dorvilleidae (most heavily oiled sites).

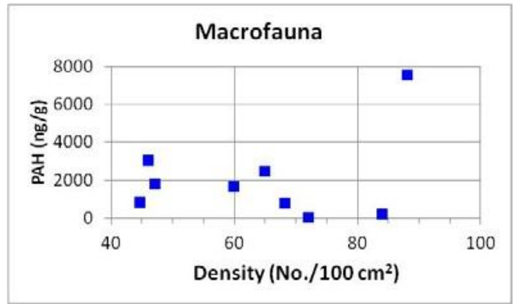

Figure 3. Macrofauna density generally decreases with increasing [PAH].

Meiofauna (benthic foraminifera) also responded to oiling. No clear difference in density between the control site and moderately oiled sites (Fig. 5) was apparent, but faunal density was 4 times greater and standing stock was 1.5 times greater at heavily oiled sites than at other sites (Fig. 6). Despite its greater standing stock, the depth of habitation at the heavily oiled site (~5 cm) was half that of the other sites (>10 cm).

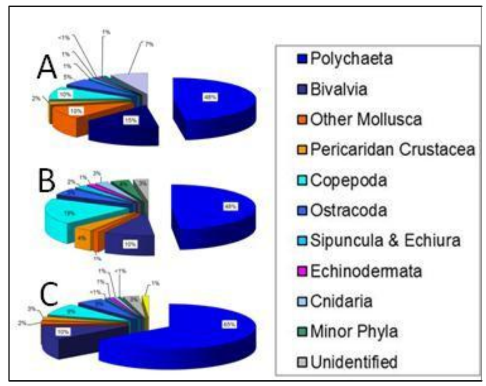

Figure 4. Macrofauna at A. control site GIP 12, B. a composite of moderately oiled sites GIP 16 and 17, and C. heavily oiled site GIP 15.

Site GIP 15 is anomalous in all variables. The site has the highest PAH level (7,553 ng/g), but it also has the highest vertically integrated density of both macro- and meiofauna in contrast to the other sites with high PAHs. Macrofauna and foraminifera were 1.3 and 1.5 times more abundant, respectively, than at the control sites and were far more abundant than live specimens at other polluted sites (Figs. 6, 7). PAHs at this locale suggest highly weathered oil consistent in its ratios of PAH compounds with DWH oil. However, pending biomarker analysis will apportion the contributions between DWH and other sources.

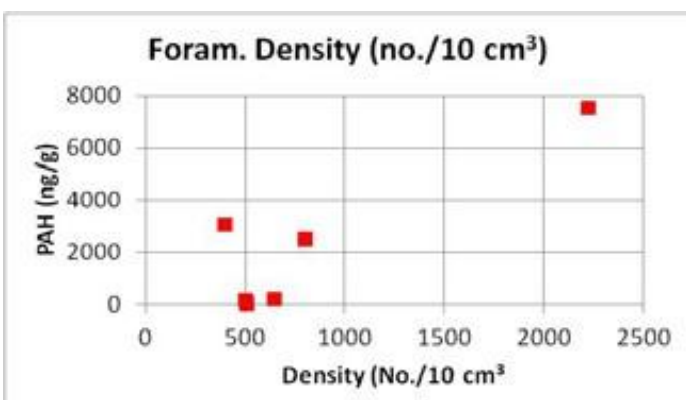

Figure 5. Density of foraminifera shows no trend with [PAH]. Note that density is high at the site with highest [PAH].

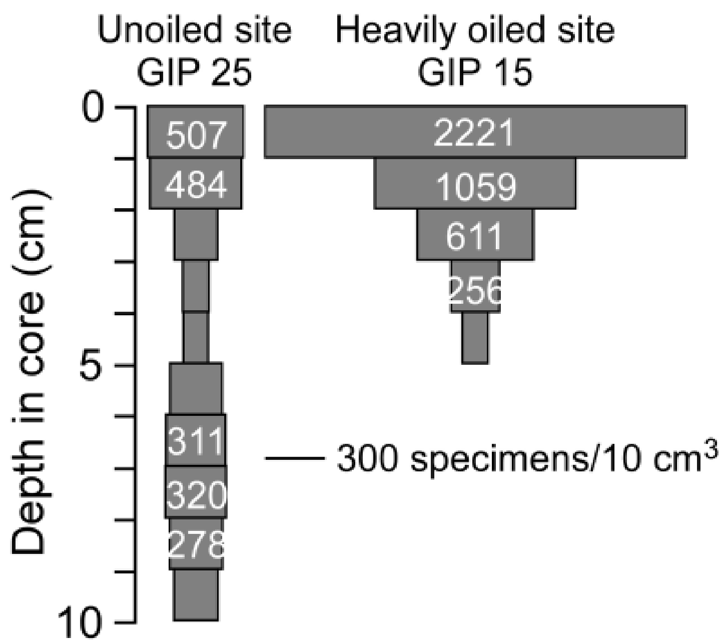

Figure 6. Foraminifera depth of habitation measured by density of specimens at control and heavily oiled sites.

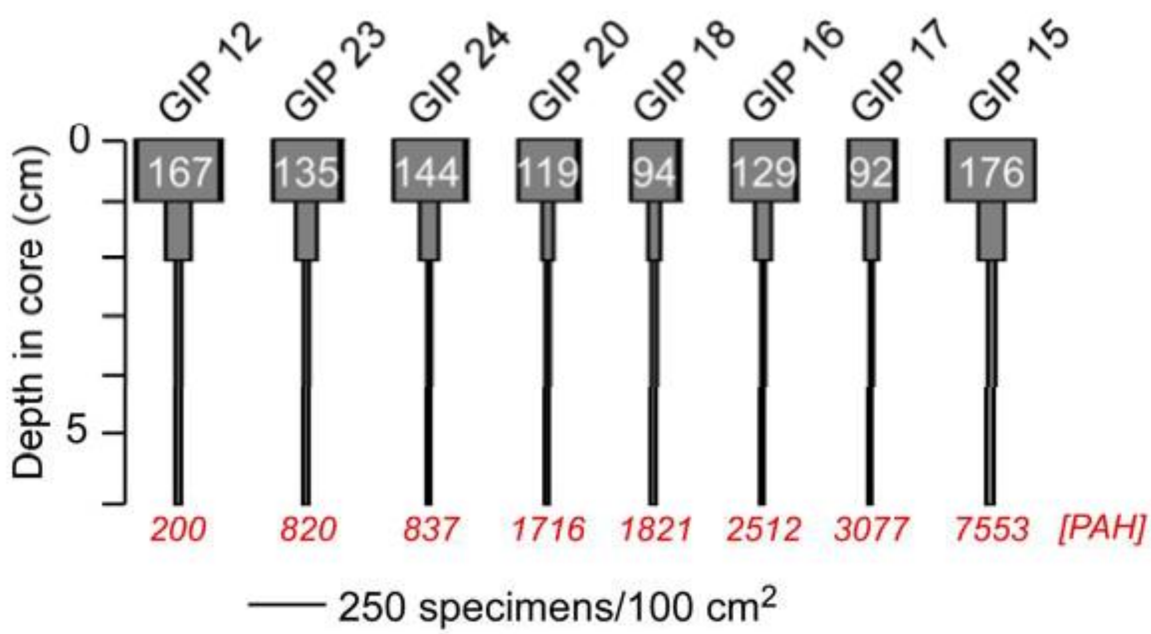

Figure 7. Density of macrofauna arranged by increasing [PAH] (red).

3. Cruises & field expeditions

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
R/V *Tom McIlwain*		Kevin Yeager and Charlotte Brunner	Collections of samples from Mississippi and Chandeleur Sounds	Sept. 12-16, 2011
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.	10/20-29/2011

4. Peer-reviewed publications, if

a. Published, peer-reviewed bibliography (Copies of the papers are requested)

Martínez, M.L., R.A. Feagin, K.M. Yeager, R. Costanza, J. Day, J.A. Harris, R.J. Hobbs, J. López- Portillo, P. Moreno-Casasola, J. Sheinbaum, I.J. Walker, A. Yáñez-Arancibia, E. Higgs, 2012. Artificial modifications of the coast in response to the Deepwater Horizon oil spill: Quick solutions or long term liabilities? *Frontiers in Ecology and the Environment* 10(1): 44-49.

b.Manuscripts submitted or in preparation (Please note target journal, and anticipated date of publication or submission)

Yeager, K.M., C.A. Brunner, K. Briggs, P. Louchouarn, T. Wade, A.M. Shiller, K.J. Schindler, J., Prouhet, M. Johnston, R. Hatch, 2012. Widespread distribution of Deepwater Horizon-derived hydrocarbons on the seafloor of the northern Gulf of Mexico. In preparation for submission to *Science*, spring of 2013.

Yeager, K.M., C.A. Brunner, K. Briggs, P. Louchouarn, T. Wade, K.J. Schindler, J. Prouhet, M. Johnston, R. Hatch, 2012. Flux rates and depths of vertical integration of Deepwater Horizon-derived hydrocarbons in deep-sea sediments of the northern Gulf of Mexico, 2010. In preparation for submission to *Environmental Science and Technology*, spring of 2013.

Yeager, K.M., C.A. Brunner, K. Briggs, P. Louchouarn, T. Wade, K.J. Schindler, J. Prouhet, M. Johnston, R. Hatch, 2012. The importance of complex seafloor bathymetry and gravity-driven processes in the re-distribution of Deepwater Horizon-derived hydrocarbons on the northern Gulf of Mexico slope. In preparation for submission to *J. of Geophysical Research - Oceans*, spring of 2013.

Brunner, C.A., J. Keim, K.M. Yeager,, P. Louchouarn, K. Briggs, (in prep.) Ecological effects of Deepwater Horizon oil on marsh foraminifera of the Mississippi and Louisiana coast. *Journal of Foraminiferal Research*.

5. Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Effect of oil contamination on infauna of Louisiana and Mississippi marshes with implications for marsh functioning	Brunner, C.A.	Brunner, C.A., Yeager, K.M., Briggs, K.B., Keim, J., Louchouarn, P., Hatch, R.S., Schindler, K. J.	Gulf Of Mexico Oil Spill and Ecosystem Science Conference, New Orleans	N	January 21-23, 2013
The effects of oil from the Macondo blowout on infaunal foraminifera of Louisiana and Mississippi marshes	Brunner, C.A.	Brunner, C.A., Yeager, K.M., Briggs, K.B., Keim, J., Louchouarn, P.	Mississippi-Alabama Sea Grant Consortium, Bays and Bayous Symposium, Biloxi, Ms.	N	November 14-15, 2012
Effect of oil contamination on infauna of Louisiana and Mississippi marshes with implications for marsh functioning	Brunner, C.A.	Brunner, C.A., Yeager, K.M., Briggs, K.B., Keim, J., Louchouarn, P., Hatch, R.S., Schindler, K. J.	Fall Meeting of the American Geophysical Union, San Francisco, Ca.	Y	December 3-7, 2012
Effect of oil from the Macondo blowout on infaunal foraminifera of Louisiana and Mississippi marshes	Brunner, C.A.	Brunner, C.A., Keim, J., Yeager, K.M., Briggs, K., Louchouarn, P.	Annual Meeting of the Geological Society of America, Charlotte, NC	Y	November 3-6, 2012
Widespread distribution of Deepwater Horizon-derived hydrocarbons on the seafloor of the northern Gulf of Mexico	Yeager, K.M.	Yeager, K.M., Brunner, C.A., Briggs, K., Louchouarn, P., Wade, T., Shiller, A.M., Schindler, K.J., Prouhet, J., Johnston, M., Hatch, R.	American Geophysical Union, Annual Meeting, San Francisco, CA	Y	December 3-7, 2012

Effects of spilled DWH oil on bathyal ecology surrounding the Macondo wellhead	Brunner, C.A.	Brunner, C.A., Cruz, V., Briggs, K.B., Louchouarn, P., and Yeager,K.M.	NGI Workshop, Stennis Space Center, MS	N	May 23-24, 2012
Deepwater Horizon polycyclic aromatic hydrocarbon distribution and modification from wellhead to coastal marshes	Shiller, A.M.	Shiller, A.M., Joung, D.-J., Wade, T.L., Sericano, J.L., Sweet, S.T., Yeager, K.M., Brunner, C.A., Louchouarn, P.	Ocean Sciences Meeting, Salt Lake City, UT	Y	February 20-24, 2012
Polycyclic aromatic hydrocarbon, trace element, and nutrient distributions as affected by the Deepwater Horizon Oil Spill	Shiller, A.M.	Shiller, A.M., Joung, D.-J., Wade, T.L., Sericano, J.L., Sweet, S.T., Yeager, K.M., Brunner, C.A., Louchouarn, P.	National Science and Technology Council (NSTC) Sub-Committee on Ocean Science and Technology (SOST) Workshop, St. Petersburg, FL	N	October 25-26, 2011
A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the Deepwater Horizon oil release	Lohrenz, S.	Lohrenz, S., Gundersen, K., Guo, L. A.M., Howden, S., Briggs, K., Brunner, C.A., Asper, V.L., Milroy, S., Yeager, K.M., Shiller,	NOAA-Northern Gulf Institute Annual Conference,Mobile, AL	N	May 17-19, 2011
Polycyclic aromatic hydrocarbon (PAH) contamination within Mississippi Sound Biota: Preliminary analyses of bioaccumulation, depuration, and likely routes of exposure	Milroy, S.	Milroy, S.P., Moshogianis, A.M., Brunner, C.A., Howden, S., Yeager, K.M.	NOAA-Northern Gulf Institute Annual Conference,, Mobile, AL	N	May 17-19, 2011

Deepwater Horizon: Marsh margin to deep ocean sedimentary impacts	Yeager, K.M.	Yeager, K.M., Brunner, C.A, Briggs, K.B., Louchouarn, P., Guo, L., Asper, V., Wade, T.L., Sericano, J.L., Schindler, K.J., Martin, K.M., Prouhet, J., Couey, N., Fortner, C., Loeffler, J.,	NOAA-Northern Gulf Institute Annual Conference, Mobile, AL	N	May 17-19, 2011
Deepwater Horizon: Coastal ocean to marsh margin sedimentary impacts	Yeager, K.M.	Yeager, K.M., Brunner, C.A., Briggs, K.B., Louchouarn, P., Guo, L., Asper, V., Schindler, K.J., Martin, K.M., Prouhet, J.	American Association of Petroleum Geologists (AAPG) Annual Conference and Exhibition, Houston, TX	Y	April 10-13, 2011
Deepwater Horizon: Coastal ocean to marsh margin sediment impacts.	Louchouarn, P.	Louchouarn, P., Yeager, K.M., Brunner, C.A., Briggs, K., Guo, L., Asper, V., Zhou, Z., Schindler, K.J., Martin, K.M., Prouhet, J., Loeffler, J., Couey, N., Fortner, C., Jung, A.	American Chemical Society National Meeting and Exhibition, Anaheim, CA	Y	March 27-31, 2011

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
Kevin	Yeager	Co-Principal Investigator	University of Kentucky	kevin.yeager@uky.edu
Kimberly	Schindler	Lab Technician	University of Kentucky	kimberly.schindler@uky.edu
Kevin	Martin	Marine Technician	University of Southern Mississippi	kevin.m.martin@u sm.edu
Charlotte	Brunner	Co-Principal Investigator	University of Southern Mississippi	Charlotte.brunner@usm.edu
Kim	Johnson	Grants Manager	University of Southern Mississippi	Kim.Johnson@us m.edu
Kevin	Briggs	Collaborator	NRL	kbriggs@nrlssc.navy.mil
Patrick	Louchouarn	Co-Principal Investigator	TAMUG	loup@tamug.edu
Terry	Wade	Collaborator	TAMU	t-wade@geos.tamu.edu
Jennifer	Brizzolara	Lab Technician	USM	Jennifer.brizzolara@usm.edu
Carlo	Fortner	Lab Technician	USM	Carlo.fortner@usm.edu
Joel	Loeffler	MS Student/Lab Technician	USM	Joel.Loeffler@e agles.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
Candis	Mallett	BS	NA	USM	Briggs	2011
Joseph	Keim	BS	Presentations on effects of oil on marsh foraminifera	USM	Brunner	2012
Valerie	Hartmann	MS	Hypoxia	USM	Briggs	2011
Shivakumar	Shivarudrapp	PhD	Hypoxia	USM	Briggs	2013
Valerie	Cruz	MS	Oil effects on live bathyal foraminifera	USM	Brunner	2013
Michael	Dalton	BS	NA	TAMUG	Louchouarn	2011
Lenai	Despins	BS	NA	TAMUG	Louchouarn	2011
Michelle	Johnston	MS	Deep sea sediment mixing as related to Deepwater Horizon oil input and benthic faunal responses	University of Kentucky	Yeager	2013
Rachel	Hatch	MS	Marsh sediment geotechnical properties as related to Deepwater Horizon oil input and benthic faunal responses	University of Kentucky	Kevin M. Yeager	2013
Chris	Rom	BS	Effects of oil on macrofauna	NRL	Briggs	2012
Korilyn	Baudoin	BS	Effects of oil on macrofauna	NRL	Briggs	2013

10. Student and post-doctoral publications, if planned

Cruz, V., Brunner, C.A., Yeager, K.M., Louchouarn, P., and Briggs, K.B., (in prep.) Ecological effects of Deepwater Horizon oil on bathyal benthic foraminifera. *Journal of Foraminiferal Research*.

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

Several student presentations are also planned for the 2012 Annual Meeting of the Geological Society of America in Charlotte, NC.

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Bathyal assemblages of live, benthic foraminifera near the Deepwater Horizon oil spill, northern Gulf of Mexico	Valerie Cruz	C. Brunner, K. Yeager, K. Briggs, P. Louchouarn	Gulf Of Mexico Oil Spill and Ecosystem Science Conference, New Orleans	N	January 21-23, 2013
Bathyal assemblages of live, benthic foraminifera near the Deepwater Horizon oil spill in the northern Gulf of Mexico	Valerie Cruz	C. Brunner, K. Yeager, K. Briggs, P. Louchouarn	Annual Meeting of the Geological Society of America, Charlotte, NC.	Y	Nov. 3-6, 2013
Assemblages of live benthic foraminifera near the Deepwater Horizon oil spill in the northern Gulf of Mexico.	Valerie Cruz	C. Brunner	76th Annual Meeting of the Mississippi Academy of Sciences, February 23-24, 2012, Hattiesburg, Ms.	Y	February 23-24, 2012
Benthic foraminifera in Barataria, La. marshes respond to the 2010 Deepwater Horizon oil spill.	Joseph Keim	C. Brunner	76th Annual Meeting of the Mississippi Academy of Sciences, February 23-24, 2012, Hattiesburg, Ms.	Y	February 23-24, 2012
Intertidal foraminifera of the Mississippi and Chandeleur Sounds: effect of Deepwater Horizon oil spill obscured by erosion.	Joel Loeffler	Brunner, C.A., Dedeaux, L., Yeager, K., and Schindler, K.J.	Geological Society of America, South-Central Section	Y	March 27-29 2011

Preliminary finding on the benthic biodiversity and abundance of macroinvertebrates around the Deepwater Horizon/Macondo well-head after the oil spill in 2010	Chris Rom	Chris Rom	Published in the NRL SEAP Report; Oral presentation at close of internship.	N	July 29, 2011
The Impact of the Deepwater Horizon Oil Spill on Macro-Invertebrate Ecosystems in the Gulf of Mexico	Korilyn Baudoin	Korilyn Baudoin	Published in the NRL SEAP Report; Poster presentation at close of internship.	N	July 27, 2012

12. Images N/A

11-BP_GRI-25: Mississippi State University: Analyses of the Effects of Crude Oil On Increased Disease Susceptibility and Physiological Responses of Selected Gulf of Mexico Fishes

Lora Petrie-Hanson, Peter J. Allen

SCIENCE ACTIVITIES

1. General Summary

This project was designed to determine if oil exposure during or after the Deepwater Horizon spill altered the immune system of fish in Gulf of Mexico, which may lead to increased risk of infection. Researchers at Mississippi State University have been studying fish immunology and infectious diseases for almost 30 years, in part because of the major aquaculture emphasis in Mississippi.

The results demonstrated that fish caught in the Gulf of Mexico, particularly spotted sea trout, had elevated levels of an enzyme that is induced when they are exposed to hydrocarbons, such as those in crude oil. The control fish for this experiment were reared in an inland facility and not exposed to Gulf water. We have numerous frozen tissue samples from various species of Gulf fish and controls and are still in the process of preparing section for microscopic analysis.

Because it was logistically difficult to get fresh cells from the Gulf to our flow cytometer, we also did controlled exposure of a common species that lives in the Gulf and in adjoining estuaries, the alligator gar. These fish were exposed to crude oil (supplied by BP) in tanks and the flow cytometer was used to evaluate the immunological cell types present in the blood and kidney (in fish, the kidney produces white blood cells and serves as a location for immune responses to begin). There were significant changes in cell distribution in the kidney depending on the amount of oil to which the fish were exposed. No significant changes were noted in the blood. The flow cytometer was used to sort leukocytes from both sources, and populations comparable to cell types reported in other fish were found. This was the first time such characterization has been done, and a manuscript for publication is in preparation.

In summary, Gulf fish harvested in November of 2010 show changes in an important biological end point that are consistent with continuing exposure to hydrocarbons. Such exposure under controlled conditions (performed during 2011) significantly altered the distribution of immune system cells in alligator gar, which could make them more susceptible to infection.

2. Results and scientific highlights

Controlled studies were carried out to understand acute, sub-lethal effects of exposure to crude oil. Studies were conducted on alligator gar. These sub-lethal effects could have considerable impacts on health of the fish. Osmoregulatory abilities were affected, and a number of metabolic changes were detected in the blood and tissues. Tissue concentrations of polyaromatic hydrocarbons (PAH) were related to treatment levels of crude oil that the fish were exposed to. The impact of these findings is a better understanding of sub-lethal effects of crude oil, and the finding of a need to continue to study effects of crude oil in loarger fishes than those utilized for most toxicity tests. Further, Field samples of alligator gar and other Gulf of Mexico and estuarine fishes were collected in oil-exposed areas. These fishes included: alligator gar, red snapper, Gulf killifish, seatrout and several other species. Tissue P AH levels were tested for in these fishes.

Results - percentage of various leukocytes in the blood and kidney.
The FACSAria III flow cytometer/cell sorter was used to analyze the leukocytes from blood and kidney (a hematopoietic organ with a major population of leukocytes in this species). Flow cytometric analyses involved forward scatter (FSC) and side scatter (SSC) determinations on a FACS Calibur (Becton-Dickinson), and were performed as previously described (Petrie-Hanson *et al.*, 2009). $DiOC_6$ was used to enhance cell properties for flow cytometric analyses (Inoue *et al.*, 2002). After establishing gates to separate the three most obvious cell populations based on differences in side scatter/forward scatter, these three populations were sorted using the FACSAria III. A 100µl sample from each of these populations was used to make cytospin preparations. The type of leukocytes represented in blood and kidney were determined by comparison to published results from teleosts by co-investigator for this project, Dr. Lora Petrie- Hanson (Petrie-Hanson and Ainsworth, 2000; Petrie-Hanson and Ainsworth, 2001; Petrie- Hanson, et al., 2009).

Results from these analyses are shown for kidney hematopoietic tissue in Figures 4 and 6, and peripheral blood in Figures 5 and 7. Forty-eight hours after oil exposure, the linear dose-response trend for population 3 in the kidney (Figure 4) was significantly ($p = 0.03$) decreased. This indicates that the neutrophil/macrophage population (population 1) and the unknown population presumed to be hematopoietic precursor cells (population 3) in kidney are significantly and dose- responsively affected by controlled exposure to oil. Following a 7 day recovery period, the percentages of population 1 in the kidney remained significantly altered (Figure 6), but other populations in the blood and kidney had returned to numbers that were statistically the same as before oil exposure.

It should be noted that the leukocyte populations in the alligator gar have not previously been characterized, so our results reported here are the first in this regard. Morphologically, these cells and populations are similar to those found in related teleost species, but additional work is needed to verify the identity of these cells by evaluated functions. This is feasible with the development of effective sorting methods in this project.

Conclusions

Results from this project indicate that one species of fish obtained from the Gulf of Mexico in November 2010 exhibited induction of EROD activity indicating exposure to hydrocarbon. It should be noted that water exposed to oil retains some of the hydrocarbons from the oil (water previously exposed to oil was used in the controlled exposure experiments), and these may be responsible for activation of EROD. Because flow cytometric analysis and cell sorting require freshly isolated cells, we could not perform these assays on the fish obtained from the Gulf of Mexico. However, we did do these analyses using freshly isolated cells from alligator gar exposed to oil under controlled condition in the laboratory. The percentage of leukocytes in two of the three populations isolated from kidney were altered by oil exposure; one after 48 hr and one after 7 days. This indicates the potential for oil spills to alter the function of the immune system and increase the risk of infections diseases.

3. Cruises & field expeditions

Ship or Platform Name	Class (if applicable)	Chief Scientist	Objectives	Dates
NOAA Oregon II		Lora Petrie-Hanson and Peter Allen	Collection of fish samples from offshore areas (Guf of Mexico) impacted by Maconda 252 oil spill	October and November 2010
Private vessel		Petter Allen	Collection of fish samples from coastal areas (marshes in LA)	August 2010

4. Peer-reviewed publications, if planned

a. Published, peer-reviewed bibliography (Copies of the papers are requested)

b. Manuscripts submitted or in preparation (Please note target journal, and anticipated date of publication or submission)

P. Allen,L. Petrie-Hanson, J. Rodriguez, M. Jablonsky. In preparation.
Physiological effects of crude oil on an estuarine fish, the alligator gar. Journal of Comparative Physiology.

5. Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract Published	Date
The effects of crude oil on disease susceptibility and physiological responses of Gulf of Mexico fishes	P. Allen	L. Petrie-Hanson, P. Allen, C. Hohn, S. Pruett	2011 Northern Gulf Institute Annual Conference	N	5/17/11-5/19/11
Physiological effects of crude oil on estuarine and marine fishes	P. Allen	P. Allen, L. Petrie-Hanson, J. Rodriguez, C. Hohn and S. Pruett	10^{th} International Congress on the Biology of Fish	N	7/15/12-7/19/12
Controlled exposure of alligator gar (Atractosteus spatula) to crude oil 0 a first	Hohn	Hohn, Omar-Ali, Allen, Petrie-Hanson	American Society for Microbiology Meeting, Monroe, AL		Dec. 2011

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
Peter	Allen	Co-Principle Investigator	Mississippi State University	pallen@cfr.msstate.edu
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Jose	Rodriquez	Scientific Participant	Mississippi State University	jrodriguez@msstate.edu
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Claudia	Hohn	Technician	Mississippi State University	Hohn@cvm.msstate.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
Ahmad	Omar-Ali	MS	Effects of oil exposure on tissues and health status of Gulf of	Mississippi State University	Lora Petrie-Hanson	2013
Daniel	Aboagye	PhD	Assisted with sample collection	Mississippi State University	Peter Allen	2014
Petra	Wesche	PhD	Effects of oil exposure on alligator gar respiratory	Mississippi State University	Lora Petrie-Hanson	2014

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 B