Northern Gulf Institute Final Report: Year 1 Gulf of Mexico Research Initiative Funding

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INTRODUCTION

The Northern Gulf Institute (NGI) is a National Oceanic and Atmospheric Administration (NOAA) Cooperative Institute, a partnership of five complementary academic institutions and NOAA addressing important national strategic research and education goals. Mississippi State University leads this collaboration, partnering with the University of Southern Mississippi, Louisiana State University, Florida State University, Alabama's Dauphin Island Sea Lab, and NOAA scientists at various laboratories and operational centers with interests in the northern Gulf of Mexico region.

The Institute contributes to NOAA's strategic interests in the four NGI research themes of Ecosystem Management, Geospatial Data Integration and Visualization, Coastal Hazards, and Climate Effects on Regional Ecosystems. The NGI institutional and management structure and recognized Gulf of Mexico science leadership in these theme areas positioned NGI as a key participant in the necessarily rapid monitoring and research response necessary in the immediate wake of the April 20, 2010 Deepwater Horizon Incident (DwH). The incident site is pictured in figure 1 as witnessed by NGI scientists aboard a Mississippi National Guard flight.

Figure 1. Deepwater Horizon incident site as viewed by NGI scientists aboard Mississippi National Guard flight on June 26, 2010. [Photo courtesy of Steven Lohrenz, then Chair of USM Department of Marine Science and NGI Fellow]

The situation called for a rapid reponse including continuation of existing as well as the initiation of new environmental monitoring and research prior to the influx of oil into northern Gulf ecosystems. Recognizing this immediate need, BP provided initial funding for the Gulf of Mexico Research Initiative to the affected states from Lousiana to Florida. Given its multi-state membership, NGI was granted $10M for rapid distribution to university researchers across the northern Gulf, primarily to maintain and expand monitoring efforts. Within the first months NGI provided NGI and non-NGI affiliated researchers, from the Gulf states and beyond, with ~ $4M rapid, phase 1, initial funding as selected by then NGI Acting Director, Dr. Michael Carron. Forty individual projects within nine overarching research efforts focused on the five original Gulf of Mexico Research Initiative (GoMRI) themes:

(1) physical distribution, dispersion and dilution of contaminants under the action of ocean currents and tropical storms,
(2) chemical evolution and biological degradation of the oil/dispersant systems and subsequent interaction with the marine and coastal ecosystems,
(3) 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,
(4) technology developments for improved mitigation, detection, characterization and remediation of oil spills, and
(5) fundamental scientific research integrating results from the other four themes in the context of public health.

Subsequent to the phase 1 rapid response, NGI conducted a call for proposals for the remaining ~$6M, again focused on the GoMRI themes. NGI solicited proposals from Investigators from the five NGI institutions with all proposals subject to an independent peer-review process. The peer review was conducted and award decisions for 25 projects completed by January 2011. Phase 1 investigators submitted final reports in early 2011 with Phase 2 final reports submitted by mid-2012.

PROJECT DETAILS

Specific details on the individual projects and their findings can be found in the final project reports in Appendix A for Phase 1 and Appendix B for Phase 2. The Phase 1 reports are primarily in an initial format designed by NGI. However, the GoMRI program office provided a common GoMRI reporting format in spring of 2012. NGI subsequently provided the opportunity to principal investigators to reformat their reports in this updated format so several of the Phase 1 reports appear in the GoMRI format. All Phase 2 reports, but one, are in the GoMRI format. A summary of project titles and lead principal investigators for Phase 1 and 2 projects is provided below. Additionally project initial synopses are available by clicking the links below or accessing http://www.northerngulfinstitute.org/ or http://research.gulfresearchinitiative.org/research-awards/block-grants-year1/northern-gulf-institute/. Electronic versions of all final project reports were also provided directly to the GoMRI project office for archival.

NGI BP GRI Year 1, Phase 1 Projects

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

Tasks:

1. Document the impacts of oil intrusion on economically and ecologically important fishes in Alabama s nearshore and coastal waters – (Lead: Sean Powers)
2. Document the impacts of oil intrusion on keystone sentinels in Mobile Bay waters – (Lead: Ruth Carmichael)
3. Document the impacts of oil intrusion on the health of critical nursery habitats and habitat utilization patterns of the young of economically important fishes - (Lead: Ken Heck)
4. Evaluate the impacts of oil, methane and dispersant on pelagic food web structure and organic matter cycling along the Alabama coast - (Lead: Monty Graham)
5. Evaluate the extent to which sedimentary biogeochemical cycles and specifically the nitrogen cycle have been changed by inundation of coastal waters by oil – (Lead: Behzad Mortazavi)
6. Quantifying the effects of oil on the microbial community structure and processes in Alabama coastal waters – (Lead: Alice Ortmann)
7. Evaluate the potential for along-estuary transport of oil-derived substances in surface and subsurface waters of the ship channel of the Mobile Bay Estuary – (Lead: Kyeong Park)

10-BP_GRI_FSU-01 - Impact of Crude Oil on Coastal and Ocean Environments of the West Florida Shelf and Big Bend Region from the Shoreline to the Continental Shelf Edge – (PI: Eric Chassignet)

Tasks:

(1) Oil & Layers on the Ocean: Impacts of Capillary Wave Damping on Remote Sensing & Air-Sea Fluxes (Leads: Mark Bourassa, Eric Chassignet, Dmitry Dukhovskoy, Oscar Garcia, Ian McDonald, Steve Morey)

(2) Effects of Oil Deposition on Coastal Sand, Beach, Dune, and Salt Marsh Environments (Leads: Markus Huettel, Randall Hughes, Dave Kimbro, Joel Kostka, Thomas Miller)
(3) Examining the Impact of Oil on Essential Fish Habitat and Food Webs (Leads: Jeff Chanton, Felicia Coleman, Kevin Craig, Markus Huettel, Christopher Koenig, Christopher Stallings)

10-BP_GRI_HRI-01 - Gulf of Mexico Research and Resource Support Tools (GulfBase, Gulf of Mexico Biodiversity Project, Gulf of Mexico books, etc.) – (PI: Larry McKinney)

10-BP_GRI_JSU-01 - Data Sampling and Modeling of Contaminant Dispersant – (PI: Gordon Skelton)

10-BP_GRI_LSU-01 - Impact of DwH Oil Spill on the Louisiana Coastal Environments – (PI: Susan Welsh)

Tasks:

(1) Barataria Estuary Water Quality (Lead: Gene Turner)
(2) Nutrient Dynamics and Primary Productivity in the Breton Sound Estuary as impacted by the Gulf of Mexico Oil Spill (Lead: John Day)
(3) Plankton Monitoring of the Barataria Bay and Breton Sound Transects (Lead: Malinda Sutor)
(4) Oil Spill Effects on Ecosystem Respiration for two Louisiana Estuaries (Lead: Brian Fry)
(5) Examining the biological uptake of highly carcinogenic polycyclic aromatic hydrocarbon - Benzo(a)pyrene - from Crude Oil Polluted Environments in the Gulf of Mexico (Lead: Sibel Bargu)
(6) Impact of the DHI on Vibrios in the Northern Gulf of Mexico (Lead: Aixin Hou)
(7) Physics, Oil and Fish: Modeling the Effects of Pulsed River Diversion on Oil Transport and Fish Distribution (Lead: Haosheng Huang)

10-BP_GRI_MSU-01 - Integrated Assessment of Oil Spill – (PI: William McAnally)

Tasks:

(1) Hurricane Effects (Lead: Pat Fitzpatrick)
(2) Fate and Transport of Oil and Dispersants (Lead: James Martin)
(3) Natural Systems (Lead: Gary Ervin)
(4) Technology and Data Integration (Lead: William McAnally)
(5) Innovations (Leads: Anantharaj, Ryan, Smulski, Brown)

10-BP_GRI_UM-01 - NIUST Deepwater Horizon Oil Spill Multi-Task Research Proposal - (PI: Ray Highsmith)

Tasks:

(1) Microbial Consumption of Oil and Gaseous Hydrocarbons in the Pelagic Waters of the Northern Gulf of Mexico (Lead: Samantha Joye)
(2) Implementing Sensor Technology to Monitor DwH Oil Spill Subsurface Plumes (Lead: Greg Easson)
(3) Measuring the Distribution of Oil and Oil Droplets Throughout the Water Column (Leads: Vernon Asper and Arne Diercks)

(4) Impacts of Oil Contamination to Seagrass Beds: Proteomic Responses (Leads: Marc Slattery, Deborah Gochfeld, John Rimoldi, Kristine Willett, Anne Boettcher)

10-BP_GRI_UNO-01 - Monitoring of Natural Resources in the Pontchartrain Basin Following the Deepwater Horizon Oil Spill: Processes, Habitats, and Fisheries – (PI: Denise Reed)

10-BP_GRI_USM-01 - A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the Deepwater Horizon oil release – (PI: Steve Lohrenz, transistioned to Stephan Howden)

Tasks:

(1) Coastal Observation Platforms in Support of Characterization of Oil Extent and Transport (Lead: Stephan Howden)
(2) Chemical effects associated with leaking Macondo well oil in the Northern Gulf of Mexico (Leads: Alan Shiller and Laodong Guo)
(3) Monitoring and Assessment of Potential Impacts of Oil Contamination on Coastal and Marine Ecosystems and Food Webs in the northern Gulf of Mexico (Leads: Stephan Howden and Scott Milroy)
(4) Assessing Possible Impacts of the Deepwater Horizon Oil Spill on Summer Plankton Assemblages of the Inner Continental Shelf in the North Central Gulf of Mexico (Leads: Harriet Perry and Bruce Comyns)
(5) Responses of Benthic Communities and Sedimentary Dynamics to Hydrocarbon Exposure in Neritic and Bathyal Ecosystems (Leads: Kevin Yeager, Charlotte Brunner, Vernon Asper, Kevin Briggs, Chet F. Rakocinski, Richard W. Heard, Harriet Perry, Don Johnson and Dick Waller)
(6) Monitoring the impacts of dispersed oil exposure on ecologically and economically important species in the northern Gulf of Mexico (Leads: Joe Griffitt and Robin Overstreet)
(7) Microbial Response to Macondo Oil and Dispersant (Leads: D.J. Grimes and Kevin Dillon)
(8) Salt marsh habitat sampling to delineate potential oil impacts from BP Deepwater Horizon spill (Leads: Patrick Biber, Wei Wu and Mark Peterson)
(9) Investigation of Juvenile Fishes Associated With Pelagic *Sargassum* Habitat in the North Central Gulf of Mexico (Leads: Jim Franks, Bruce H. Comyns, and Eric R. Hoffmayer)
(10) Public Health Impact of Gulf Oil Spill: Assessment of Risk and Health Education (Leads: Amal Mitra and James McGuire)
(11) Adaptation and Resilience of Mississippi Residents to the BP Oil Disaster (Lead: Tom Osowski, Tim Rehner, and Alan Bougere)

NGI BP GRI Year 1, Phase 2 Projects

DISL Lead

11-BP_GRI-01 - Quantifying the Effects of Oil on Carbon Cycling and Diversity of the Pelagic Microbial Community of Coastal Alabama – (PI: Alice Ortmann)

11-BP_GRI-02 - 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? – (PI: Robert Condon)

11-BP_GRI-03 - 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? – (PI: Ken Heck)

11-BP_GRI-04 - Impacts of the Deepwater Horizon Accident on Food Web Structure in the North-Central Gulf of Mexico – (PI: John Valentine)

FSU Lead

11-BP_GRI-05 - NGI BP Earth System Modeling – (PI: Eric Chassignet)

11-BP_GRI-06 - Automated Mapping of Surface Oil Spill: Surface Physics and Remote Sensing Associated with Movement and Identification of a Slick – (PI: Mark Bourassa)

11-BP_GRI-07 - Uncertainty Quantification of Oil Spill Transport – (PI: Kyle Gallivan)

11-BP_GRI-08 - Deepwater Horizon Oil Deposition in Gulf of Mexico Beaches Phase 2: Recovery of the Beach Sedimentary Environment – (PI: Markus Huettel)

11-BP_GRI-09 - Impact of Crude Oil on Coastal and Ocean Environments of the West Florida Shelf and Big Bend Region from the Shoreline to the Continental Shelf Edge: Radiocarbon and Stable Isotope Tracing – (PI: Jeff Chanton)

LSU Lead

11-BP_GRI-10 - Post Macondo Well Oil Spill Water Quality Sampling - Barataria, Lake Pontchartrain, and Coastal Waters, Part 2 – (PI: Gene Turner)

11-BP_GRI-11 - Field Observation and Modeling of the Impact of Oil Spill on Marsh Erosion in Southern Louisiana – (PI: Q. Jim Chen)

11-BP_GRI-12 - Effect of Oil, Dispersant, and Remediation-Related Human Activities on Marsh Plants and Associated Insects and Mollusks – (PI: Linda Hooper-Bui)

11-BP_GRI-13 - Aquatic Primary Productivity and Spatial/Temporal Water Quality Variations of the Breton Sound Estuary and Impacts of Oil Pollution – (PI: John Day)

11-BP_GRI-14 - Macondo 252 Oil Spill Impacts in Louisiana Coastal Wetlands: Effects on Soil-Microbial-Plant Systems – (PI: Irving Mendelssohn)

MSU Lead

11-BP_GRI-15 - Community Earth Modeling System for the NGOM – (PI: William McAnally)

11-BP_GRI-16 - Extend Sulis Toolkit – (PI: Phil Amburn)

11-BP_GRI-17 - The Influence of Weather and Ocean Processes Using Numerical Modeling on the Fate and Transport of the Deepwater Horizon Oil Spill – (PI: Pat Fitzpatrick)

11-BP_GRI-18 - Quantitative Studies of the Effects of Oil Exposure on the Pelagic Microbial Community and Sheepshead Minnow, Using a Global Proteomics Approach – (PI: Mariola Edelmann)

11-BP_GRI-19 - Comprehensive Study of the Impact of the Deepwater Horizon Oil Spill on the Health and Productivity of Gulf Coast Salt Marshes – (PI: Deepak Mishra)

11-BP_GRI-25 - Analyses of the Effects of Crude Oil on Increased Disease Susceptibility and Physiological Responses of Selected Gulf of Mexico Fishes – (Lora Petrie-Hanson)

USM Lead

11-BP_GRI-20 - An Ecosystem Modeling Framework to Examine Ecological Impacts of the Deepwater Horizon Oil Spill – (Rich Fulford; transitioned to Scott Milroy)

11-BP_GRI-21 - Evaluating changes in fluorescence EEM and size spectra during the degradation of crude oil and dispersant in seawater – (PI: Laodong Guo)

11-BP_GRI-22 - Continuation of "Chemical Effects Associated with Leaking Macondo Well Oil in the Northern Gulf of Mexico" – (PI: Alan Shiller)

11-BP_GRI-23 - Impacts of the Deepwater Horizon oil spill on the health and growth of estuarine fish and ecosystem functionality – (PI: Rich Fulford)

11-BP_GRI-24 - Responses of Benthic Communities and Sedimentary Dynamics to Hydrocarbon Exposure in Neritic and Bathyal Ecosystems: Phase II – (PI: Kevin Yeager; transitioned to Charlotte Brunner)

SELECTED KEY RESULTS

This section is not intended as a comprehensive synthesis of all the NGI-managed GoMRI research. It is rather an attempt to identify key points arising out of this research associated with each of the GoMRI themes illustrated by relevant examples from one or more of the projects. Detailed findings can be found in the individual reports and the resultant published literature.

GoMRI Theme 1: Physical distribution, dispersion and dilution of contaminants under the action of ocean currents and tropical storms.

Key Point: Synoptic variability is critical.

From GoMRI Theme 1 related to physical distribution, dispersion, and dilution, a key finding is the strong impact of synoptic variability of winds, waves, surge, and currents on the fate of the oil. Pat Fitzpatrick (Project 11-BP_GRI-17) provides an example (Figure 2) of Hurricane Alex in the southern Gulf resulting in the movement of oil into the western Mississippi Bight and Breton Sound.

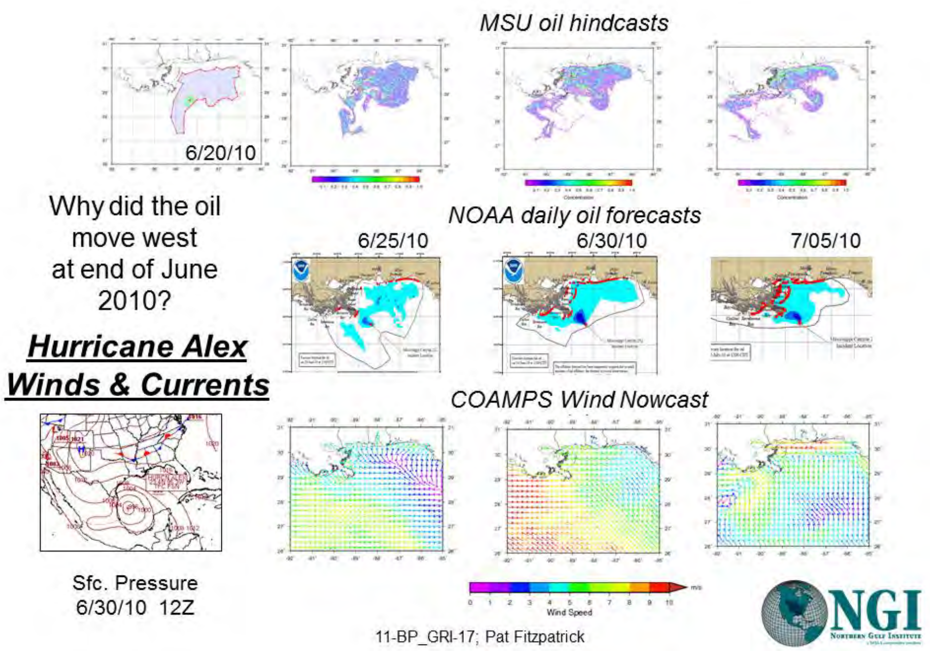

Figure 2. Oil hindcasts by Pat Fitzpatrick (top row) for 20 June, 25 June, 30 June and 5 July 2010 with the corresponding 25 June to 5 July 2010 daily oil forwcasts from NOAA (middle row). The location of Hurricane Alex on 30 June 2012 is shown (bottom left) with the corresponding winds for 25 June to 5 July 2010 (bottom row) used to drive the ocean model and winds used in the row 1 oil trajectories. Results show the westward movement of oil during this period associated with winds and currents affected by Hurricane Alex in the southern Gulf.

GoMRI Theme 2: Chemical evolution and biological degradation of the oil/dispersant systems and subsequent interaction with the marine and coastal ecosystems.

Key Point: DwH served as a large scale, trackable tracer release

From GoMRI Theme 2 related to chemical evolution and biological degradation and interaction with marine and coastal ecosystems, a key finding is that the DwH incident served as a large scale tracer release with increasing deep water impact from northeast to southwest and increasing coastal impact from east to west. By monitoring "petro" or "dead" carbon (carbon with low ^{14}C), Jeff Chanton and Kevin Craig (Project 11-BP_GRI-09) tracked the impact of DwH oil using marsh samples for the coastal measurements and deep sediments offshore (Figure 3).

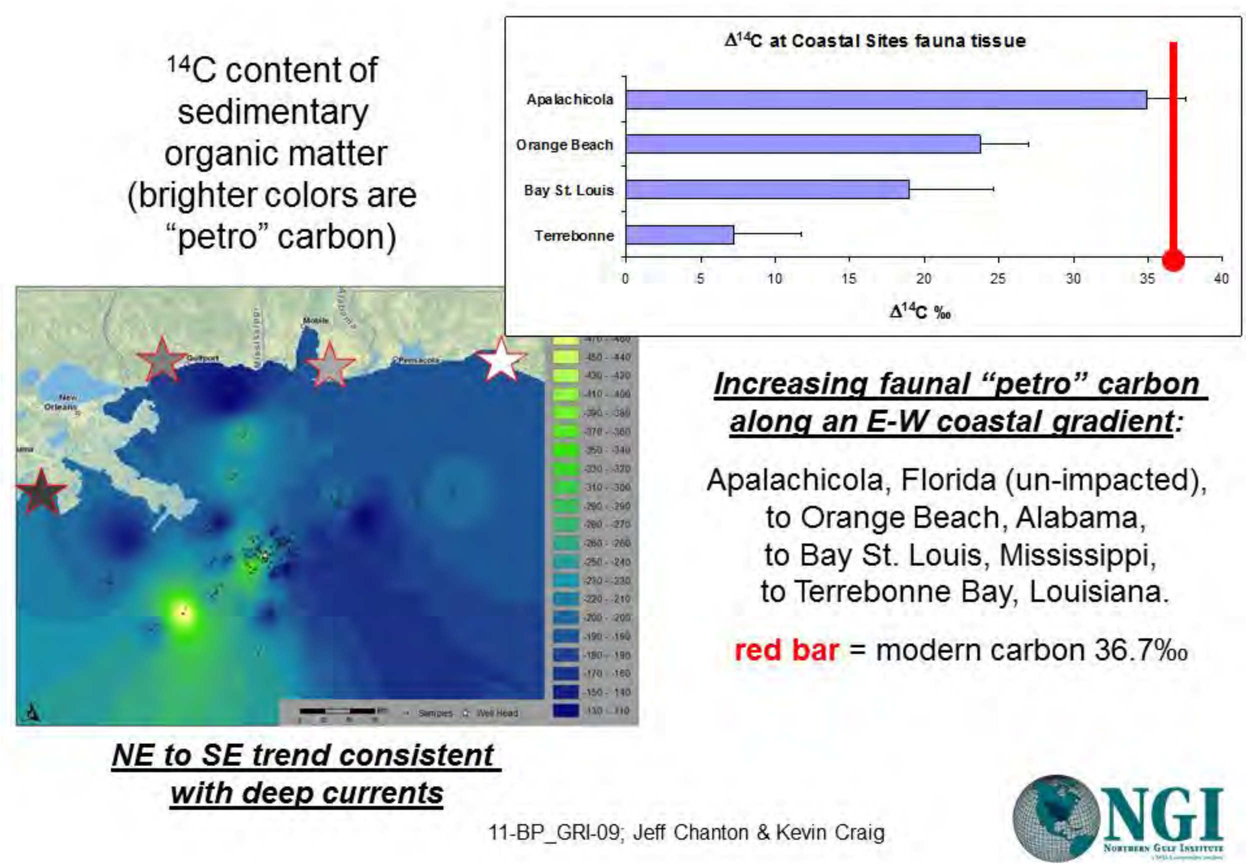

Figure 3. Increasing appearance of lowered ^{14}C 'petro' carbon in sediments shown as bright green colors to southwest of the DwH site (left figure) and the increasing "petro' carbon in coastal faunal east to west from Appalachicola to Terrebone Bay (right figure and starred coastal locations left figure) show the apparent tracer effect of the DwH oil and its directional degradation.

Key Point: Mobile Bay served as a tale of two sentinel species, one mobile, one sessile.

Mobile Bay appeared to be a tale of two sentinels. Ruth Carmichael and her colleagues (Project 10-BP_GRI_DISL-01) found in the initial aftermath of DwH that tagged manatees appeared unaffected while oyster samples indicated potential exposure.

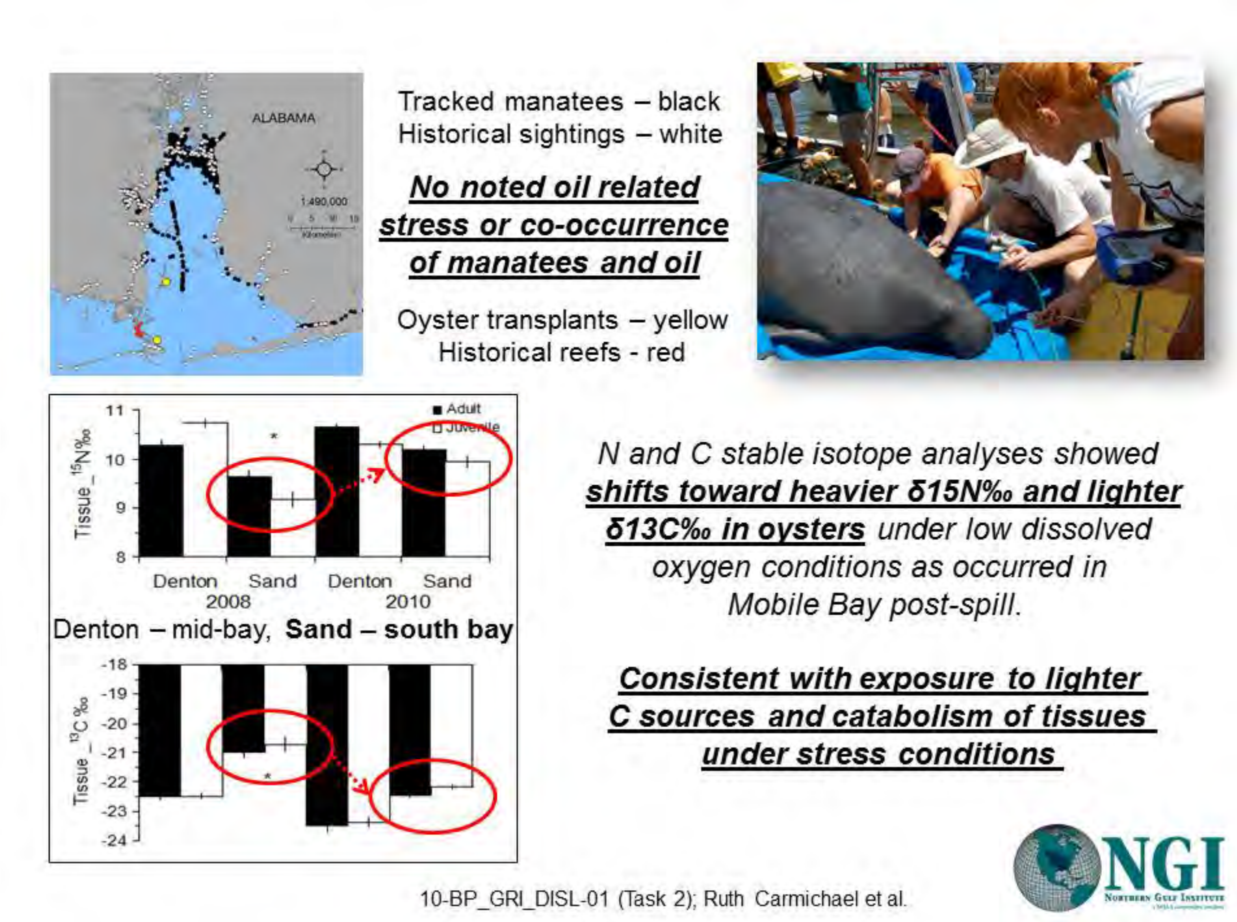

Figure 4. Monitored manatees in Mobile Bay were not found co-located with oil nor indicated oil-related stress (upper panel) however nitrogen and carbon isotope analyses of oysters suggested possible oil related exposure (lower panel)

Key Point: Hydrocarbon consuming microbes – Immune system for the Gulf?

Another key point relevant to GoMRI Theme 2 arose from several of the projects, namely the apparent impact of hydrocarbon consuming microbes on food webs. Monty Graham (Project 10-BP_GRI_DISL-01, Task 4) found dramatic increases in water column dissolved organic carbon levels from June-August, coincident with the introduction of oil to the northern Gulf off Alabama. The timing of these increases was also consistent with decreased bottom water oxygen levels, increases in colored dissolved organic matter (CDOM) and shifts in ^{13}C values. This indicates that carbon from the oil was likely respired by the microbial communities with the added microbial production serving as an important trophic pathway for this new carbon to pass to larger net-sized zooplankton.

GoMRI Theme 3: 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,.

<u>Key Point</u>: Moderately oiled marsh could be resilient though species specific

GoMRI Theme 3 relates to environmental effects with Irv Mendelssohn and colleagues (Project 11-BP_GRI-14) finding that moderately oiled marsh can be relatively resilient though species specific. *Spartina alterniflora* was found to be more resilient than *Juncus roemerianus*, two co-dominant salt marsh plant species of the northern Gulf of Mexico (Figure 5). Consistent with the previous discussion on the importance of hydrocarbon consuming microbes, 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.

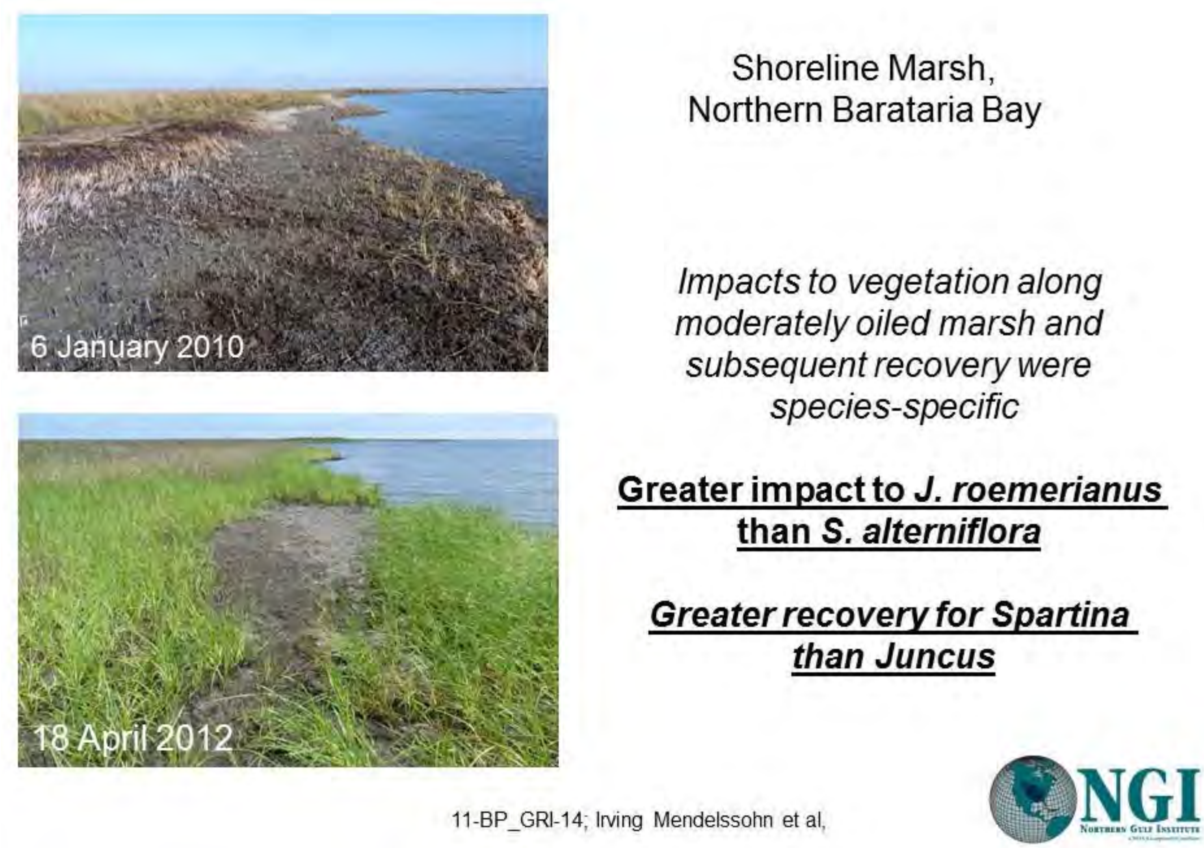

Figure 5. Shoreline marsh in northern Barataria Bay illustrating partial recovery of *S. alterniflora* from 6 January 2010 to 18 April 2012.

Key Point: Oiled marsh resilience Part 2 – Heavily oiled marsh not as fortunate.

Continuing with the environmental effects of Theme 3, heavily oiled marshes were not as fortunate as those lightly or moderately oiled. Jim Chen and Guoping Zhang (Project 11-BP_GRI-11) work in the heavily oiled Bay Jimmy area within the Barataria basin found that vegetation killed by the heavy oiling barely regrew after 2 years with resulting severe erosion and continued pockets of dark oil (Figure 6). This is consistent with the Mendelssohn's findings on heavily oiled marsh as well.

Figure 6. Shoreline marsh in Bay Jimmy in northern Barataria Bay (upper left) illustrating severe marsh erosion (middle right; original shoreline shown by stakes in the water) and continued pockets of dark oil (lower left) two years after DwH oil impacted the area.

Key Point: Uncertainty – Was it the oil or …?

One of the most significant points related to the environmental effects of GoMRI Theme 3 is that of uncertainty, namely unraveling the confounding and potentially interrelated variables yielding the observed effects. Was it the DwH oil and its by-products, either chemically or biologically derived, causing the impact or was it something else? John Valentine and colleagues (Project 11-BP_GRI-04) found the results of their sampling (Figure 7) to be "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."

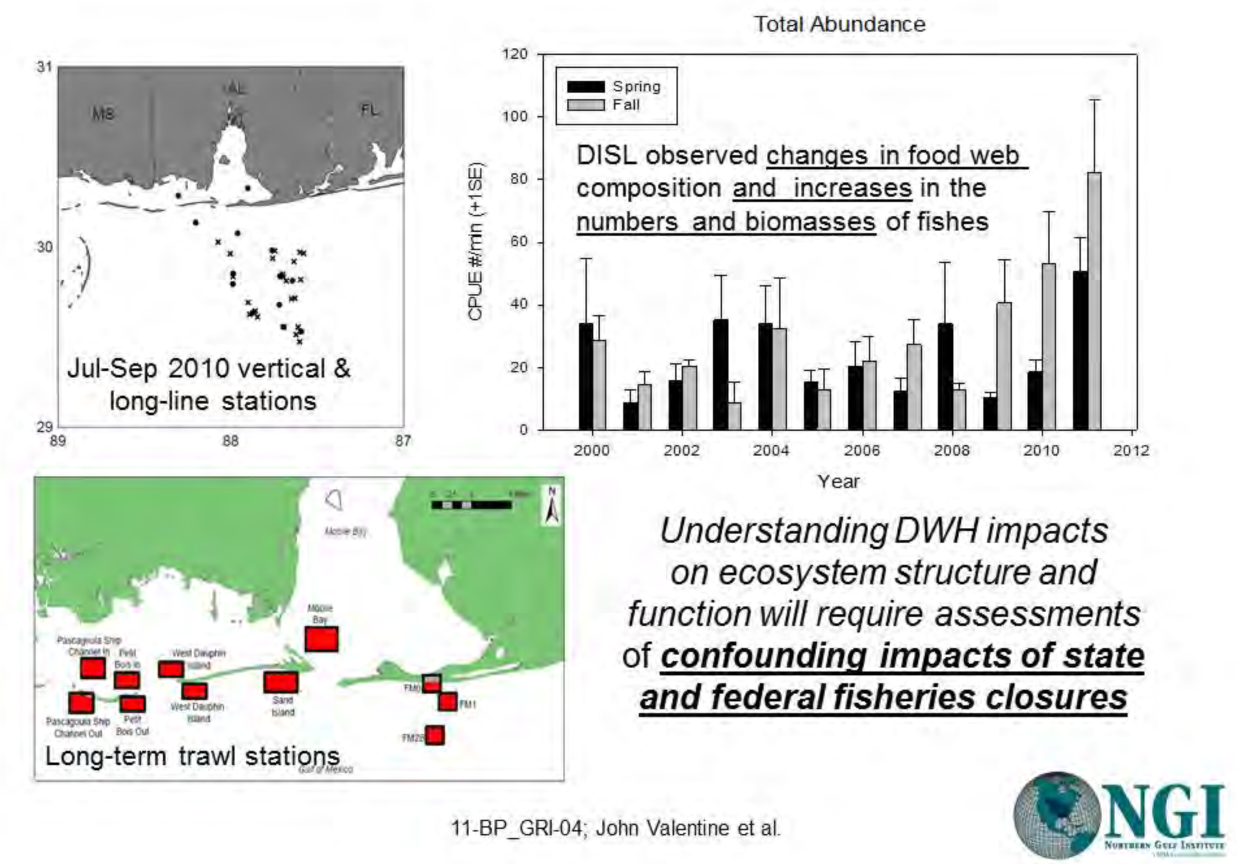

Figure 7. Vertical and long-line sampling and long term trawl stations (left panels) used to investigate DwH impacts on ecosystem structure and function in Alabama waters. Catch per unit effort (CPUE) changes before and after DwH (upper right) were unexpected and possibly a result of the DwH-induced fisheries closures.

This point is reinforced by Denise Reed and colleagues (Project 10-BP_UNO-01) sampling in Lake Ponchartrain and out into Mississippi Sound (Figure 8). Oysters in oiled areas showed impacts not seen in non-oil samples however salinity was also different in each area yielding significant uncertainty as to the DwH impact. Similarly, multi-dimensional scaling (MDS) analysis of beach seine collections that included samples before and after DwH, appear to cluster separately however assemblage composition was not significantly different.

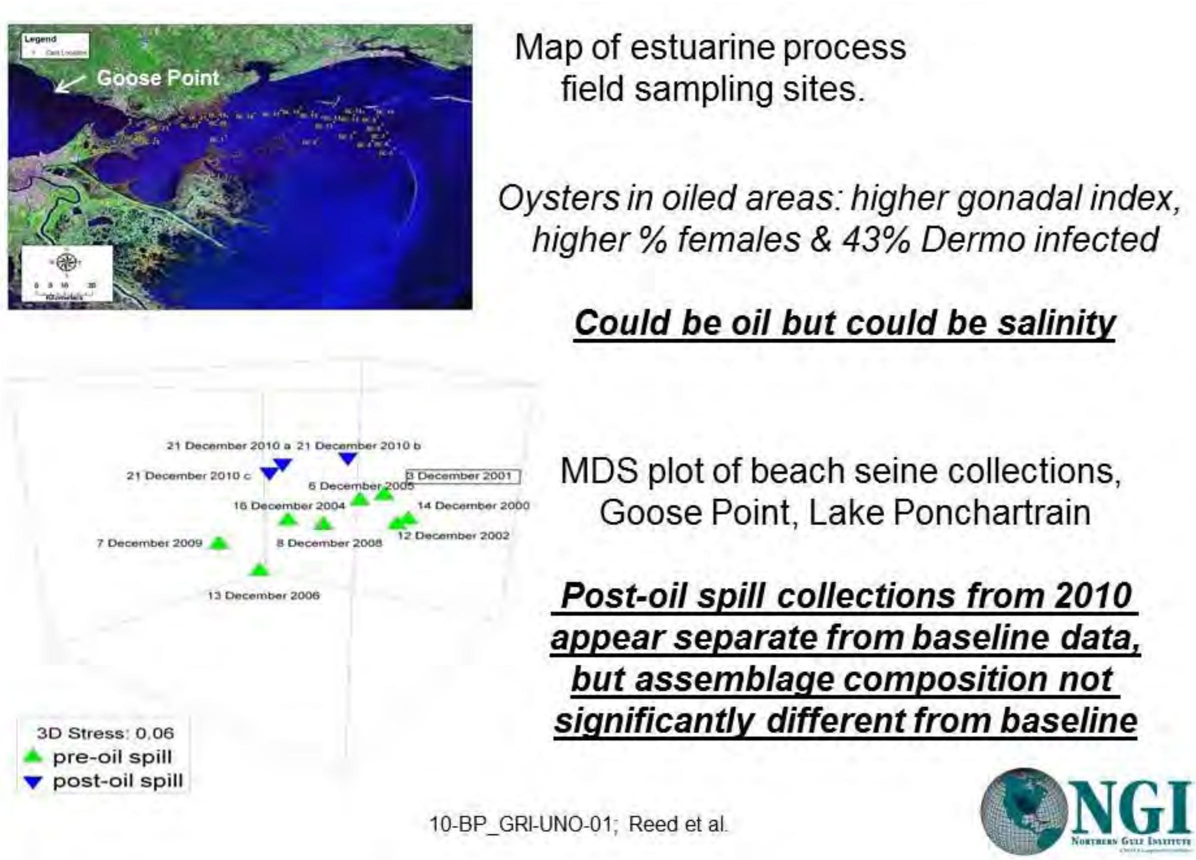

Figure 8. Sampling in Lake Ponchartrain and out into Mississippi Sound (upper left), yielded differences in oysters in oiled and unoiled areas however salinity in the two regions were also different, the oiled areas being of higher salinity. Similarly, the MDS plot lower left appears to indicate different clusters for pre and post spill samples but assemblage composition did not.

GoMRI Theme 4: Technology developments for improved mitigation, detection, characterization and remediation of oil spills.

<u>Key Point</u>: Mechanical beach cleaners worked – Kudos again to oil consuming microbes

Beaches along the northeast Gulf of Mexico had DwH crude deposited in May and June of 2010. Markus Huettel and Joel Kostka (Project 11-BP_GRI-08) investigated the results of this surface deposition and dispersal into the deeper layers in an attempt to characterize the degradation process and understand the impact of the cleanup procedures (Figure 9). Results indicate a relatively rapid recovery of the beach as a result of the deep cleaning combined with an active aerobic microbial community.

Figure 9. Deep-cleaning beach machinery (upper left) able to penetrate to deeper compressed tar layers (right panel) combined with active aerobic microbial community led to relatively rapid beach recovery from the May/June 2010 DwH contamination.

GoMRI Theme 5: fundamental scientific research integrating results from the other four themes in the context of public health.

<u>Key Point</u>: Mississippi Gulf Coast residents are resilient though with caveats.

Using an epidemiological descriptive approach, Tom Osowski (10-BP_GRI_USM, Task 11) investigated adaptation and resilience of Mississippi coastal county residents. Most persons living in coastal Mississippi did not have an increase in depressive symptoms as a result of DwH. However, "those persons who had less education, (defined as less than a college degree) tended to have higher levels of depression than those with higher levels of education. We infer this is likely due to employment variables that are more associated with the seafood industry, and/or tourism."

LESSONS LEARNED BEYOND THE SCIENCE

Finally, Alan Shiller and Laodong Guo (Project 11-BP_GRI-22) provided additional insights relevant to researchers finding themselves in a similar rapid-response research environment in the future. First, rapid response events require collegial discussion both prior to and during the research activity. A single researcher may miss key details or measurements that might need to be included as well as to avoid redundant activities. Second, the needs and agenda of the first responders must be respected even if they differ from the science responder. Sampling in the immediate area might be scientifically desireable but may interfere with the first responders' attempts to get the situation under control. Also the first responder may have immediate use for the scientific data being collected and not be sympathetic to a researcher wanting to hold it until publication. Finally, the public has a need and desire to understand what is happening in clear, consistent language without hyperbole.

ACKNOWLEDGEMENTS

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