DEEPWATER HORIZON OIL SPILL

PRINCIPAL INVESTIGATOR WORKSHOP

OCTOBER 25-26, 2011

FINAL REPORT

Sponsored by

National Science and Technology Council's

Subcommittee on Ocean Science and Technology

Hosted by

University of South Florida

Sirata Beach Resort and Conference Center, St. Petersburg, Florida

Table of Contents

Photo Credit: National Oceanic and Atmospheric Administration (http://www.gulfspillrestoration.noaa.gov)

Citation: Deepwater Horizon Oil Spill Principal Investigator Workshop: Final Report. 2012. National Science and Technology Council, Subcommittee on Ocean Science and Technology. Washington, DC. 91 pp.

EXECUTIVE SUMMARY

The Deepwater Horizon Mississippi Canyon 252 (DWH) oil spill focused unprecedented attention on the Gulf of Mexico ecosystem. During the response to the DWH event, resource managers and researchers from across the country partnered to conduct science, monitoring, and response activities to understand impacts from the spill. The data and information collected from those efforts have since been used to make progress towards the long-term goal of protecting and restoring public health and natural resources in the Gulf of Mexico.

During the spill response, federal coordination with the Gulf of Mexico academic community included joint work on subsurface monitoring of oil, as well as selection of research for direct support through mechanisms like the National Science Foundation's (NSF) Rapid Response Research grants program. Much of the early scientific knowledge gained from this work was presented during a National Science and Technology Council (NSTC), Joint Subcommittee on Ocean Science and Technology (JSOST) Principal Investigator Conference held October 5-6, 2010 in St. Petersburg, Florida.

To date, the restoration and research efforts emanating from the DWH spill and the October 2010 meeting continue. At the same time, a number of new efforts have been launched to better coordinate short- and long-term studies related to the DWH event and the Gulf of Mexico ecosystem as a whole to ensure that research informs restoration, recovery, and sustainability practices in the region[1]. These activities, and the many others like them, are dedicated to enhancing our understanding of the Gulf of Mexico ecosystem and ensuring its sustainable use for generations to come.

Given the important role the October 2010 workshop played in bringing scientists together and the numerous activities that have ensued since, the NSTC Subcommittee on Ocean Science and Technology (SOST) held a second workshop on October 25-26, 2011, again in St. Petersburg, Florida. This follow-on workshop provided an opportunity for researchers to share final (or near final) results of studies that were very much works in progress during the first coordinating conference in October 2010. It also provided an opportunity for researchers to participate who were unable to attend the first workshop because they were actively conducting research in the field. The 2011 workshop encompassed a wide diversity of scientific disciplines and reported on critical methodologies and findings resulting from ongoing DWH-related research.

This document highlights the results presented at the DWH Principal Investigator Workshop on October 25-26, 2011. It depicts the ongoing science advancements and coordination happening across all sectors to address our collective long-term goals and needs for restoring and effectively managing the natural resources in the Gulf of Mexico.

[1] Example efforts include: development of a long-term restoration strategy by the Gulf of Mexico Ecosystem Restoration Task Force; establishment of the BP-sponsored Gulf of Mexico Research Initiative; establishment of the Gulf of Mexico Universities Research Collaborative; updates to the stakeholder-driven Gulf of Mexico Research Plan; development of the Gulf of Mexico Report Card by the Harte Research Institute; and numerous planning activities within state and federal agencies and non-governmental organizations designed to better coordinate how each uses its existing Gulf of Mexico resources.

INTRODUCTION

WORKSHOP BACKGROUND

On October 25-26, 2011, the National Science and Technology Council's Subcommittee on Ocean Science and Technology (NSTC SOST) convened the second Deepwater Horizon Oil Spill Principal Investigator Workshop in St. Petersburg, Florida.

The workshop brought together scientific investigators and stakeholders from academic institutions, private research institutes, industry, and state and federal agencies active in Gulf of Mexico science and research. This workshop was an opportunity for scientific investigators to update results of studies that were in progress during the JSOST coordinating conference in October 2010; share results of more recent projects; provide input to future Gulf of Mexico research directions; and foster collaborative partnerships. Approximately 150 individuals participated in the workshop with representation from 18 states and five sectors (academia, federal government, private industry, state government, and non-profit organizations).

The two-day meeting was organized to include plenary talks, panel presentations, and discussion sessions within thematic breakout groups. As in the October 2010 JSOST workshop, the first day of the meeting featured plenary talks and concurrent oral breakout sessions focused on six themes:

- Oil and dispersant: Extent and fate
- Oil and dispersant impacts and mitigation in coastal environments
- Oil and dispersant impacts and mitigation in offshore environments
- Oil and dispersant impacts and mitigation on living marine resources
- Oil and dispersant impacts and mitigation on human health and socio-economic systems
- Use of in situ and remote sensors, sampling and systems for assessing impacts and mitigation of oil and dispersant

Additionally, a poster session provided an opportunity for participants to present and discuss their research with others working on similar projects.

On the second day of the meeting, the breakout groups were asked to consider the scientific issues discussed at the 2010 conference, brainstorm additional issues, and determine their current status (see Appendix 3). The afternoon concluded with a report and discussion presented by each breakout group and a workshop synthesis presented by Jerry Miller, the SOST co-chairperson.

The remainder of this document presents plenary and session summaries for each theme followed by a summary of scientific findings and overarching observations. The workshop agenda, participant lists, supplemental session information, and abstracts from presentations are included in the appendices. Additionally, many presentations are available on the workshop web page at http://www.marine.usf.edu/conferences/fio/NSTC-SOST-PI-2011/.

PLENARY AND SESSION SUMMARIES

OIL AND DISPERSANT: EXTENT AND FATE

Session Background Information

During the workshop's opening plenary, Dr. Tom Ryerson from the National Oceanic and Atmospheric Administration's (NOAA's) Earth Systems Research Laboratory provided an overview of the extent and fate of oil from the DWH event from the perspective of his research group's work on the atmospheric features of the spill and presented a review of published studies. The overview specifically focused on oil approximately one hour to two days following release and how atmospheric measurements can provide strong constraints against which transport models can be quantitatively evaluated. Atmospheric sampling indicated an evaporative source area roughly 1.6 km in diameter, offset approximately 1 km from the wellhead, implying a single, direct path to the surface with a surfacing time of three to ten hours after release with millimeter-scale droplets transporting most of the surfacing mass. Atmospheric data also indicated DWH hydrocarbon partitioning between soluble, volatile, and insoluble fractions after release, suggesting different ecosystems were exposed to different mixtures of hydrocarbons (e.g., minimal amounts of benzene reached the surface). Overall, insoluble oil compounds comprised approximately 75% of the leaking fluid mass but made up only about 31% of the deep plume mass. Available chemical data show very different hydrocarbon mixtures were transported along different paths. In addition, only about 15% of the leaked mass was expressed promptly at the surface with a calculated flow rate into the surface slick of approximately 1×10^6 kg/day, which agrees with slick estimates from airborne and satellite remote sensing data. After the first few days following release, transport became far more complex, and additional surface spreading, sinking, and beaching all occurred.

After the opening plenary concluded, the extent and fate breakout session began and included two components. On the first day, science presentations provided preliminary results of recent DWH oil spill-related research important to understanding the extent and fate of oil and dispersants. Beginning with presentations focused on subsurface processes (e.g., buoyant plume formation and the dispersal of oil droplets), the session then moved to presentations on surface processes (e.g., microbial respiration in surface waters and surface tar distribution) before finishing with presentations on atmospheric processes (e.g., aerosol formation) and tools available to help understand the extent and fate of the spill (e.g., numerical models and synchrotron-based techniques). On the second day, the breakout session participants reviewed the extent and fate science issues highlighted at the 2010 workshop and added several new ones before assessing the relative importance and amount of information available for these issues.

Participants (Table 2, Appendix 3) in the extent and fate session included representatives from federal and state governments, universities, and private industry. The majority of the participants were actively conducting research, while the remaining participants used research results in their profession.

Science Presentations

Oral presentations in the extent and fate session focused on the source characterization, transport processes, and fate (i.e., sink processes) of hydrocarbons from the DWH well with some discussion of how dispersant may have impacted transport and fate. Presentations primarily focused on the subsurface movement of hydrocarbons (two presentations), biogeochemical cycling of hydrocarbons in the subsurface and surface waters (three presentations), methods for and results of tracking oil (two presentations), aerosol formation as a result of the spill and the burning of oil (two presentations), modeling of the spill (three presentations), and the impact of the spill on summer hypoxia in the northern Gulf of Mexico. A list of speakers, their affiliation, and the titles and abstracts of their presentations can be found in Appendix 4.

Salient points from the presentations include:

- Lab experiments suggest buoyant plume formation occurs in stratified waters and that trapping timescales vary with the composition of the oil.

- The South Atlantic Bight and Gulf of Mexico/Larval TRANSport Lagrangian model system produced results which compare favorably with observations of a subsurface plume.

- Degradation rates of oil droplet diameters had a marked influence on oil dispersal and oil droplet interaction with the Gulf coast shoreline and the slope/shelf bottom.

- Methane was the most abundant hydrocarbon emitted from the DWH well. However, only an insignificant quantity of this methane was emitted into the atmosphere. The majority of it remained dissolved in a deep plume or in intrusion layers where its degradation produced a persistent oxygen anomaly in the deep Gulf of Mexico waters.

- The fate and transport of oil in the water column can be effectively tracked with ultraviolet-visible (UV-vis) and fluorescence excitation emission matrix (EEM) techniques.

- An analysis of the dynamics of bacterial populations at 1000-1300 m depth has shown that the growth of such populations helped diminish the impact of the dissolved hydrocarbons on the environment.

- The microbial community in the Gulf of Mexico supported unprecedented rates of oil respiration, despite their growth being limited by dissolved nutrients.

- Extensive surveys to characterize surface tar distribution have been conducted.

- A narrow plume of hydrocarbons was observed downwind of the DWH spill that is attributed to the evaporation of fresh oil on the sea surface. A much wider plume with high concentrations of organic aerosol (>25 micrograms per cubic meter) was attributed to the formation of a secondary organic aerosol from unmeasured, less volatile hydrocarbons that were emitted from a wider area around the well site.

- Approximately 4% of the combusted material from oil burns was released into the atmosphere as black carbon [$(1.35 \pm 0.72) \times 10^6$ kg].

- Modeling results suggest that the prevailing winds, through their ability to induce direct and wave drift, played a major role in pushing the rising oil toward the coastline along the northern Gulf and, in synergy with the surface currents, prevented the oil from reaching the Florida Straits.

- Model outputs predicted the formation of multiple stratified plumes.

- In hypoxic bottom waters in the northern Gulf of Mexico, there were indications of hydrocarbon oxidation.

- Modeling exercises suggest that surge events associated with tropical cyclones and non-tropical lows can push oil far into the marsh system.

- The burning of crude oil does not release metals into the atmosphere.

Breakout Group Discussion and Gap Analysis

On day two of the workshop, the individuals in the extent and fate session participated in a facilitated discussion on the science issues that had been or still needed to be addressed to increase our understanding of the extent and fate of oil and dispersant following an oil spill. During the discussion, participants reviewed the science issues identified at the 2010 workshop, identified new issues that have emerged, and assessed the importance and current state of knowledge for each of the issues.

Prior to the 2011 workshop, a facilitator collected and categorized the science issues identified at the 2010 workshop into 35 issues grouped into seven categories for discussion. The categories were:

- Big picture
- Modeling
- Atmospheric processes
- Interaction with sediment and resuspension
- Dispersant
- Detection
- Other

The 2011 participants combined the 35 issues identified at the 2010 workshop into 32 discrete issues and identified 12 new emerging science issues. These new science issues were placed within the categories noted above and rated on a Likert scale (0-4) for their importance in preparing for, responding to, and recovering from oil spills and the amount of information currently available for the issue. An issue was either rated after being selected for discussion by the group (20 issues) or by the completion of a survey at the end of the session without group discussion. Three of the emerging issues were not selected for discussion and received no rating because they were not included in the preprinted survey of issues from the 2010 workshop. A summary of the science issues discussed during the 2011 workshop for each category is presented below; the full set of issues and their ratings are included in Table 3 (Appendix 3) and plotted in Figure 1.

Big Picture

- A comprehensive Gulf observing system that includes sinks for hydrocarbons was considered key to improving the response to oil spills in the region with similar systems established in other regions. This gap needs to be recognized and addressed by funding agencies who should allow for infrastructure development as part of their granting programs. Such an observing system would help address existing data limitations which cut across multiple aspects of oil spill response and research.

- While oil budgets are useful after the fact, what is more important during an event is an understanding of the fates for released hydrocarbons.

- Long term chemical, biological, and ecological studies are necessary to establish baselines and assess recovery, with decadal timescales likely being the most important. Such studies could help determine if and where tipping points exist.

- When oil is in the water column, it gets dispersed by hydrodynamics, which affects the parts of a system that will be impacted. It is a very complex process that might not have been properly addressed during the DWH event. There is more known about horizontal versus vertical movement and, particularly for the latter, understanding diffusivity of the different hydrocarbon fractions is important.

- With the creation of the Gulf of Mexico Research Initiative (GOMRI) and the funding opportunities previously announced by various federal agencies, there is now a substantial amount of DWH-related research. This research needs to be transparent to avoid duplication and the results made available to a broad audience to increase their application and inclusion in the knowledge base. The mechanism for such coordination is unclear, although the Gulf of Mexico Alliance (GOMA) is one possibility.

- NEW ISSUE: Effects of hydrodynamic mixing on oil transport and mixing (observations and modeling).

- NEW ISSUE: Transparency of new research, e.g., a list of funded proposals and a timeline for deliverables (NSF, GOMRI, NOAA, Bureau of Ocean Energy Management [BOEM], American Petroleum Institute [API], International Association of Oil and Gas Producers [OGP], National Institute of Environmental Health Sciences [NIEHS], and others).

Modeling

- To better develop and validate numerical models, the parameters necessary to initialize and test the models and coordinate model and observing system development must be identified.

- Techniques for validating models and quantifying uncertainty have progressed, but the results are not routinely disseminated. There are large differences between transport and ocean circulation models (often used for oil spill models), and the latter needs to be validated.

- NEW ISSUE: Systematic validation techniques for quantifying uncertainties in ocean circulation and oil transport.

- NEW ISSUE: Data are needed for deep-sea models.

Atmospheric Processes

- No discussion.

- NEW ISSUE: Evaporative processes and the fate of evaporated oil.

Interaction with Sediment and Resuspension

- It is necessary to know how oil fractions will interact with marine snow particles and resuspended sediments, particularly following storm events, and to incorporate this information into models. Mechanically dispersed oil droplets are different from chemically dispersed oil droplets, which tend to interact much less with sediment.

- The fate of oil deposited in sediment and colloidal suspensions, especially its degradation rate, is important.

- NEW ISSUE: Fate of oil deposited in sediment and colloidal suspensions, especially its degradation rates in different types of sediment.

Dispersant

- There is a substantial amount of information available on the use of dispersants at the surface, but subsurface use remains a huge gap.

- Since efficacy may have a different meaning depending on your perspective (e.g., industry, response, restoration, etc.), it is preferable to focus on the effect of dispersant on deposition, partitioning, and degradation.

- Industry's goal is to treat the most volume of oil with the least dispersant so it's more efficient to apply dispersant at the wellhead. However, the effects of dispersant still need to be quantified to optimize dispersant application. One measure could be the amount of dispersant needed to get to baseline respiration rates.

- NEW ISSUE: Effect of dispersant on deposition, partitioning, toxicity, and degradation (deep sea and in the presence of high flow rates).

- NEW ISSUE: Effect of dispersant on deposition, partitioning, toxicity, and degradation (surface).

- NEW ISSUE: Measuring the efficacy of dispersant.

Detection

- A standard procedure for collecting water samples would be useful, especially for constructing large data sets.

- The academic community needs to take advantage of spills of opportunity to conduct new research, and effort needs to be invested into setting up plans or approaches for easily mobilizing people and equipment.

- The in situ detection of subsurface oil using fluorometry has been tested and is an accepted practice; however, due to a non-linear response, fluorometry cannot be used for quantification.

- Other techniques for oil detection such as in situ mass spectrometers and sonar (for rapid screening) should continue to be explored.

- Flow rate is a key parameter and, when determined, needs to be quickly disseminated to researchers to allow for faster confirmation or refutation. A diversity of assessment techniques is a good idea.

- Flow rate and the composition of the flowing hydrocarbons will change over time, and it is necessary to continually assess the rate of flow.

- A reliable measurement of droplet size is critical for initializing and validating models. There needs to be further development of in-situ techniques for the subsurface measurement of oil droplet size. Droplet size affects fate and, in some sense, is totally separate from chemical composition. For gases, bubble size is important.

- NEW ISSUE: Quantification of subsurface oil via in-situ techniques (fluorometry and others).

Other

- A federal database that lists the chemical composition of oil and natural gas from wells, and the quick release of this information when a leak occurs, is critical for ensuring an effective response, especially during the initial days of a leak. The integration of this information into the federal permitting process is likely the most seamless approach. It took months for this information to become widely available following the DWH event.

- Both industry and academia recognize their limited knowledge of microbial degradation rates of hydrocarbons in different environments. Determining the rate of microbial degradation is difficult because of the dependence on bacterial flora, temperature, and class of oil compounds, among other factors. It is recommended that general information on microbial degradation rates be made available, along with plans for how to collect more specific data in the event of a spill.

- While the most toxic oil compounds and metabolites comprise only a small fraction of the oil, they cause the most damage and are, therefore, the most important to track.

- NEW ISSUE: The capacity to determine rates of microbial degradation in different environments, both in preparation for a response and during a response (e.g., temperature-dependent rates, bioassays, and prioritized methods).

- NEW ISSUE: Routine monitoring for surface tarballs and tarball landings on beaches.

Of the 42 science issues rated, 16 fell within the Gap category, suggesting many high priority extent and fate science issues lack adequate information. Twenty issues were categorized into Good Work, meaning they are high priorities with a good to robust amount of information already available. Six issues fell on the line dividing the Gap and Good Work categories. No issues fell into the Rescale category, which suggests that there has not been an investment in increasing our understanding (information) of low priority extent and fate science issues. The Reassess category indicates that there is relatively little information available, but the issue is a low priority; hence, investment in this issue is not warranted. None of the issues rated fell into the Reassess category.

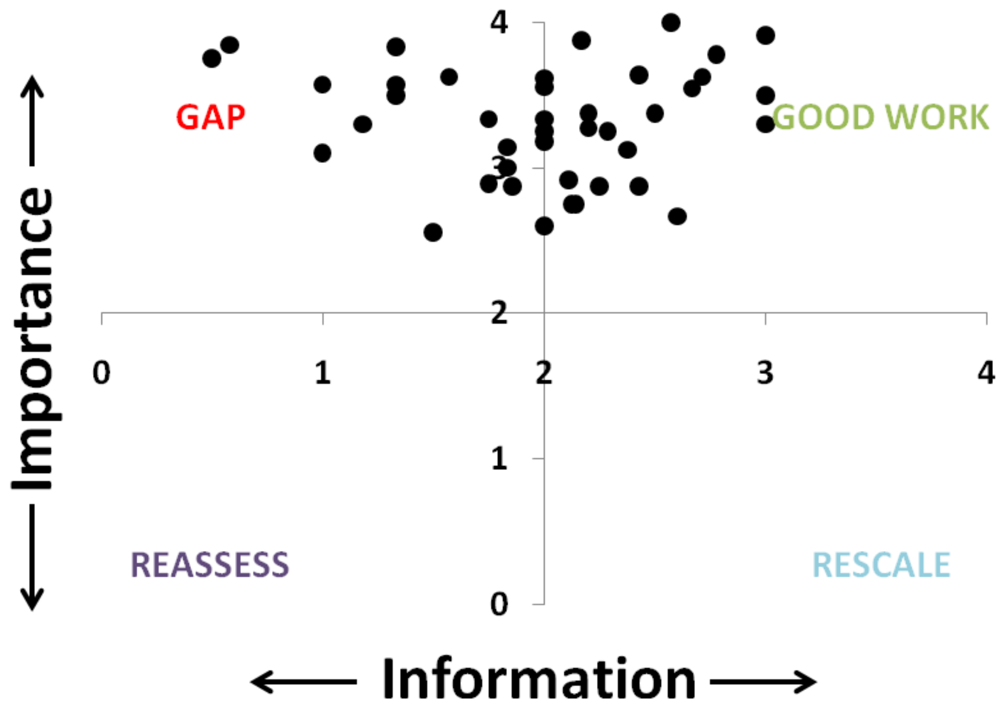

Figure 1. Plot of the 42 extent and fate science issues discussed during the 2011 workshop based on the two rating scales.

The extent and fate science issues in the upper left of the Gap category (least amount of information, most important) include (see Table 3, Appendix 3 for complete ratings):

- Effect of dispersant on deposition, partitioning, toxicity, and degradation (deep sea and in the presence of high flow rates).
- Federal database for the chemical composition of oil and natural gas from wells (part of the permitting process and immediate access for researchers in the advent of a spill).
- Capacity to measure the efficacy of dispersant injected at the wellhead.
- Capacity to determine rates of microbial degradation in different environments, both in preparation for a response and during a response (e.g., temperature-dependent rates, bioassays, and prioritized methods).
- Interactions of dispersed and non-dispersed oil components with marine snow particles and resuspended sediments (all pathways).
- Comprehensive observing system in the U.S. (includes natural baselines, e.g., seeps, and prioritizes oil-producing regions).
- Sampling and monitoring of oil transport in the subsurface.
- Quantification of subsurface oil via in-situ techniques (fluorometry and others).

- Effects of dispersants on toxic components of oil (e.g., whether dispersants increase the bioavailability of toxic oil compounds).

The extent and fate science issues in the upper right of the Good Work category (most amount of information, most important) include (see Table 3, Appendix 3 for complete ratings):

- Detection of subsurface oil via in-situ techniques (fluorometry and others).
- Assessment of techniques for measuring flow rates (gas and oil) during subsea release (NOTE: information access for responders and researchers is important).
- Systematic validation techniques for quantifying uncertainties in ocean circulation and oil transport.
- Increase remote sensing data resolution in the nearshore and inland seas and along coastlines.
- Sampling and monitoring of oil transport at the surface.
- Assessment of techniques for measuring the chemical composition and physical transformation of oil.
- Assessment and comparison of methods for collecting water samples for oil and oil detection.
- Fate and extent of the most toxic compounds and metabolites.
- Oil budget and partitioning of fractions (i.e., fractionation of the oil and its location).

Cross Cutting Themes

Overall, several themes were raised repeatedly during the breakout discussion. The importance of access to information by researchers, as well as responders, was cited as key to fully engaging the research community in the spill response. There was general agreement that a more complete understanding of the importance of microbial rates of hydrocarbon degradation was needed to fully understand the DWH spill and to plan for future events. The need to connect the collection of observations with modeling needs was also seen as critical. The capacity to model hydrocarbon transport is not limited by our understanding of physical processes, but rather is limited by the observations necessary to initialize the transport models (i.e., observations of where the oil is located and its chemical composition). It also became clear that for many of the science issues there is a much greater understanding of the issue in surface waters, but considerably less information for subsurface waters. While there have been a number of opportunities for researchers to solicit support for their research, the absence of a commitment to fund the infrastructure necessary to assemble a Gulf of Mexico observing network will continue to limit oil spill-related research, as well as oil spill response. Lastly, environmental differences, particularly in microbial decomposition rates, need to be more fully explored because the next spill might not be in the Gulf or from a deep well.

Recommendations for Moving Forward

The extent and fate session participants identified a few areas where the science community has made progress in addressing issues important to understanding the source, transport processes, and sinks associated with oil spills. Yet, considerable work remains to address the still numerous gaps that have been identified. Session participants noted that funding opportunities have existed and may continue to exist to explore key extent and fate questions, but that transparency and greater coordination is needed to move the field forward and to prepare for future spills. Given the community of researchers that has developed around the larger issue of understanding the extent and fate of the oil and dispersant from the DWH oil spill, it is likely that progress will continue to be made.

OIL AND DISPERSANT IMPACTS AND MITIGATION IN COASTAL ENVIRONMENTS

Session Background Information

Dr. Yonggang Liu from the University of South Florida (USF) provided an overview of the work of USF's Ocean Circulation Group in response to the DWH oil spill during the coastal plenary on the opening day of the workshop. He highlighted the role of the Coastal Ocean Observation System on the West Florida Shelf in providing current and circulation data for the DWH response. The system, built on a series of acoustic Doppler current profiler (ADCP) moorings, high frequency radars, bottom stationed ocean profilers, gliders, and drifters, allowed USF researchers to provide daily briefings and updates to stakeholders on oil spill progression and trajectory forecasts in the Gulf. Liu also discussed efforts to model subsurface oil dispersion and Loop Current evolution over the summer of 2010 and the value of ocean color indices during mid-summer when sea surface temperature measurements are less resolved.

After the plenary concluded, the coastal breakout session began and included two components. On the first day, science presentations provided preliminary results of recent DWH oil spill-related coastal research. A broad set of topics were presented, including oil spill-related impacts, coastal vegetation, microbial production, and beach sediment quality. On the second day, the breakout session participants discussed oil spill science issues and assessed the relative importance and amount of information available on these issues.

Participants (Table 4, Appendix 3) in the coastal section included representatives from federal and state governments and universities. Approximately 70% of the participants indicated that they primarily conduct research, while the remaining participants used research results in their profession or for recreational purposes.

Science Presentations

Oral presentations in the coastal session primarily focused on impacts to tidally-influenced ecosystems and microscopic organisms in coastal waters. Presentations specifically focused on marshes (three presentations), beaches (two presentations), microbial and zooplankton communities (three presentations), insects (one presentation), and biodegradation (one presentation). Appendix 4 includes a list of presentation speakers, titles, and abstracts.

Salient points from the presentations include:

- Oiled marshes remain nearly 15 months post spill, and marsh erosion has been rapid in some of these areas, especially as a result of tropical storm events (e.g., Tropical Storm Lee impact on Barataria Bay) (Chen).

- A bioremediation experiment showed that crude oil degradation is enhanced through fertilization with nitrogen, phosphorus, or organic matter (fish) (Mortazavi).

- The oil spill and subsequent disturbances (Tropical Storm Lee) had significant impacts on ant community composition in coastal dunes and salt marshes; some invasive ant species were able to gain a stronger foothold and displace native residents (Hooper-Bui).

- As time progresses, the percentage of light n-alkanes in ocean and coastal environments decreases, as these are the most easily degradable. However, polycyclic aromatic hydrocarbon (PAH) abundance in marsh sediments of Bay Jimmy remain high one year after the disaster (Deocampo).

- Broad oyster reef sampling indicates that there is no evidence of PAH contamination above background levels in oyster tissues (Proffitt).

- Extremely small amounts of Macondo oil (<25 µl oil l^{-1}) significantly reduced phytoplankton production (Jeffrey).

- While oil residue in the swash zone of coasts decreased over time on oiled beaches, Tropical Storm Lee resuspended material and increased the density of oil particles in the sands (Bell).

- The community composition of zooplankton was substantially outside the "envelop of typical composition" for nearshore and offshore sites during May–July 2010 (Graham).

- Oil emulsions (which are typically what wash ashore) are particularly difficult to degrade and require being broken down to significantly increase degradation rates (Pardue).

- Bacterial composition shifted substantially and rapidly in the presence of hydrocarbons (an increase in hydrocarbon metabolizers), and this composition changed over time (Sobecky).

- Pensacola beach sands were contaminated with oil to a depth of 65 cm. Hydrocarbon-decomposing bacteria strains were present in these sands and appeared to increase the oxygen consumption by two-fold (Huettel).

- Field measurements of chlorophyll-a production were used in conjunction with remotely-sensed data to parameterize model estimates of chlorophyll reduction in response to coastal oiling (Cho).

- The Mussel Watch Program continues to collect and store oyster tissues (with state, federal, and academic partners) to act as a baseline dataset for the Gulf of Mexico. A portion of these samples have been analyzed for the Natural Resource Damage Assessment (NRDA) process (Lauenstein).

<u>Breakout Group Discussion and Gap Analysis</u>

The participants in the coastal session focused on science issue priorities on day two of the workshop. Prior to the 2011 workshop, coastal section facilitators collected and categorized 38 science issues from the coastal section of the 2010 workshop for discussion. The categories were:

- Baselines
- Impact assessment
- Remediation and response
- Monitoring and modeling
- Coordination and science communication

The 2011 participants reviewed the 38 science issues and identified 25 more. The new science issues covered five broad headings. A summary of the science issues supporting each broad heading is presented below; the full set of priorities is included in Table 5, Appendix 3.

Education: Programs should educate the general public about how the scientific process works. Current and future scientists need to have more training on data management, communication with government agencies and the public, and disaster preparation.

Coordination: Coordination of the science response to disasters could be improved through: (1) developing pre-qualified teams of experts that are prepared to rapidly respond; (2) fostering mechanisms for integrating academics into the formal federal/state response; (3) increasing coordination from local officials to the federal government; (4) implementing a process to quickly approve acceptable cutting-edge science approaches to assess disasters; and (5) developing a platform for researchers to rapidly access data from disparate sources.

Communication: In general, scientists need to improve their capability to share scientific findings with the public. This includes explaining data uncertainty and other aspects of the scientific process. There is a need to clearly articulate science to policy makers and to share findings in non-traditional media outlets whose primary audiences are not scientists (e.g., *The Economist*, *New Yorker*).

Legislation and Resources: Legislation could enhance the scientific response to disasters. Such changes should include mechanisms to rapidly release funds for research and to improve access to data. These mechanisms should be established as soon as possible so that disaster response efficiency can be improved. Legislation should provide clear guidance and processes to encourage federal and state agencies to integrate the best available science into their response. Finally, science and scientific findings should be better incorporated into legislation and the decision-making process.

Science Support and Assessment: More work is needed to understand the transport of contaminants. This includes assessing the remobilization of oil spill materials after storm events and the transport of contaminants into water bodies after their placement in landfills. Additional efforts are needed to understand trophic relationships and the connectivity of species and habitats, including the ability to discern stressor impacts from natural variation. This can partially be addressed by improving the state of knowledge of baselines. For example, atmospheric composition baselines and baselines from under-studied regions are needed to better understand disaster impacts. Finally, risk assessments and models that incorporate socio-economic data are needed.

Once the new science issues were identified, the coastal breakout session rated the original 38 science issues from the 2010 workshop and the 25 new issues. There were several cases where the group decided to reword science issues from the 2010 workshop and then rate the re-worded science issue. Each issue was evaluated using two Likert scale questions: "How important is issue XX in preparing for, responding to, and recovering from oil spills?" and "How much scientific information is available for issue XX?" The Likert scale was from 0 (meaning none or very low) to 4 (meaning very high). TurningPoint, an interactive software package allowing participants to electronically record answers, was used to rate the questions. The results of the rating process are listed by category and level of importance within each category in Table 5 (Appendix 3). Figure 2 displays a plot of the 63 science issues based on the two questions the group answered for each issue.

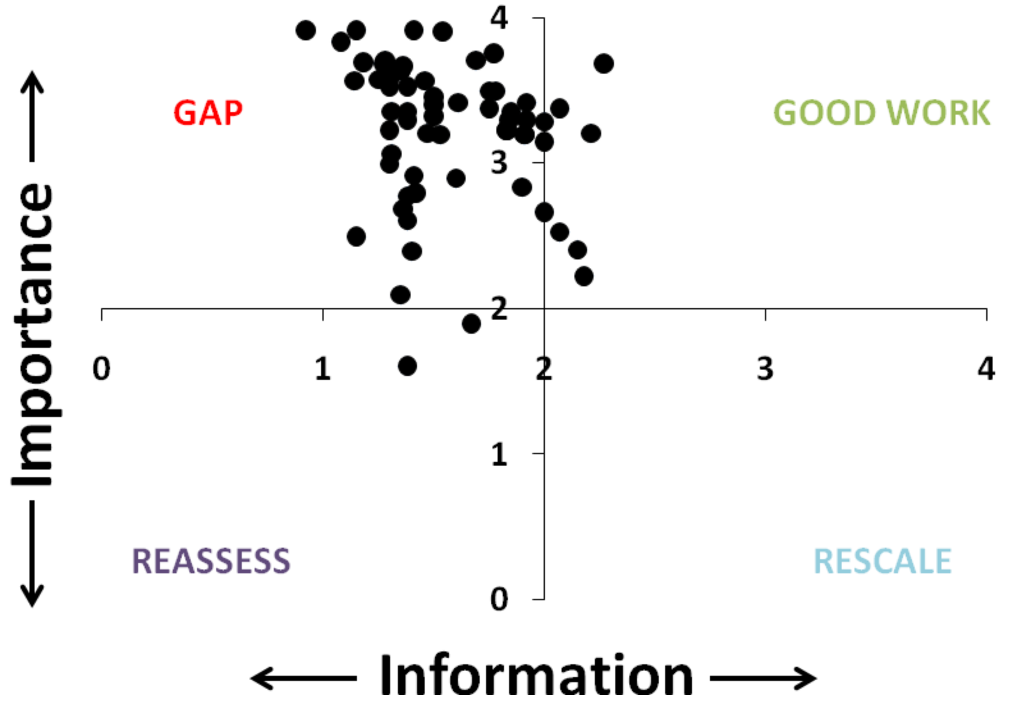

Figure 2. Plot of the 63 coastal science issues discussed during the 2011 workshop based on the two rating scales.

Of the 63 science issues, 55 fell within the Gap category, suggesting many high priority coastal science issues lack adequate information. No issues fell into the Rescale category, which suggests that there has not been an investment in increasing understanding (information) on low priority coastal issues. Six issues were categorized into Good Work, meaning they are high priorities with a high amount of information already available and it was a high priority issue. The coastal science issues in the Good Work category include:

- Collecting baselines for animal tissue contamination;
- Identifying impacts on ecosystems and ecosystem services that have already been observed;
- Improving remediation techniques;
- Identifying methods and techniques that are appropriate for monitoring and detecting contaminants in different coastal environments;
- Improving sensor technology; and
- Obtaining additional aerial surveys for examining the spatial heterogeneity of impacts.

The Reassess category indicates that there is relatively little information available, but the issue is a low priority; hence, further investment in this issue may not be warranted. Reassess issues were:

- Evaluating sensor technology and remediation techniques, perhaps with an intentional, controlled spill; and
- Identifying opportunities for other scientists to be involved in NRDA efforts.

<u>New issues identified by the coastal section participants at the 2011 workshop</u>

Education

1. There is a greater need for science, technology, engineering, and mathematics education: not everyone needs to be a scientist, but everyone should at least know how the scientific process works. There were trust issues with the American public during the DWH event due to a lack of knowledge about the scientific process. One model for this education is a consumer chemistry course for American high school levels.
2. Better training is needed for future scientists. Training should cover topics such as data management, communication with government agencies and the public, , and disaster preparation. This could also increase the pool of qualified people to assist the federal government in disaster response, which was stretched very thin scientifically during the DWH response. Examples of training programs include Chemcomm, the Woods Hole Oceanographic Institution (WHOI) training program, and SeaWeb (Aldo Leopold program).

Coordination

3. Rapid response science teams should be developed on a regional basis to assist other regions in emergencies, with scientists vetted and/or certified ahead of time. The process for science response is currently too slow.
4. There is a need for increased institutional awareness of the capacity of scientists to contribute to disaster response. Academics have a responsibility to educate the public, elected officials, government agencies, and others about the expertise available from academia.
5. There needs to be a better structure of leadership at the local to national levels. During the DWH spill, it appeared that many agencies were in charge at the local level. A better internal coordination between

higher and local levels is needed; legislation and policy issues should be clearly established about federal/state roles and responsibilities.

6. Federal, academic, and non-governmental organization (NGO) coordination needs to be improved.

7. There should clear guidance on the scientific methods that need to be used. A process needs to be developed to streamline approval of state-of-the-art scientific approaches. Expertise from all federal agencies needs to be mined for disaster response (better interagency sharing), and policies need to be responsive to disasters that go beyond national boundaries.

8. Some scientists should be using cutting-edge techniques to advance the science, while others should use the standardized techniques.

9. Infrastructure needs to allow for easy access of data from different sources. One option is the work the National Coastal Data Development Center of NOAA is completing (NOAA.ntis.gov).

10. Access to oil from BP for testing, a litigation issue. A "library" of oil and oil characterizations from different regions is needed (apparently NOAA's Office of Response and Restoration [OR&R] has a library of thousands of oil types). The use of actual versus surrogate oil.

Communication

11. Scientists at all career levels need training on how to communicate with the press and public.

12. There is a need to communicate science effectively with policy makers (print and non-print formats). Develop relationships with people who write in different formats (e.g., *The Economist, New Yorker*).

Legislation and Resources

13. Rapid response funding is needed for science:
    - Data and money need to be easily accessible; perhaps penalty phase funding should be put into a trust.
    - Mechanisms should be pre-established regarding how to use response funds and how to distribute them.
    - Allow rapid funding for disasters, regardless of whether they are technical or natural disasters (e.g., money for the Office of Science and Technology Policy [OSTP] to disseminate).
    - The federal government appears to have limited resources (funds) for science disaster response.
    - Understand how private money impacts decisions related to federal funding of science.

14. Disaster legislation should include science. Currently, science is marginalized and thus the National Contingency Plan should be revised. There is a lack of science input when major legislative decisions are made for disasters. The law should allow local and regional knowledge to be incorporated into the decision-making process.
    - The NRDA process needs to be streamlined. Slowness of process is compromising science.
    - NOAA subcontracting for the NRDA process has created issues.
    - Spirit of cooperation may have been compromised by threatening criminal charges against responsible parties.

15. There is a lack of state funding to respond to disasters.

16. Each federal agency has congressional mandates to protect different resources, which has resulted in different priorities and decisions made in response to the oil spill.

Science Support and Assessment

17. Examine the remobilization of oil after storm events.

18. Characterize oil transport and deposition in coastal environments.

19. Assess the signal-to-background-noise ratio in various environments so that the impacts from oil or other stressor(s) can be delineated from natural variation. This requires adequate sampling.

20. Conduct risk assessment in coastal environments and include data from a variety of sources to model environmental response.

21. Socio-economic data are linked to coastal issues, services, and valuation. Link resource availability to socio-economic data.

22. Examine linkages between systems, including life history information and trophic linkages. Take a holistic perspective.

23. Study trophic effects at higher organismal levels (beyond toxicity).

24. Groundwater contamination issues and baselines should explore the flooding of landfills and oil impacts.

25. Atmospheric baselines are needed to examine the exchange with the water surface. There is natural variability, e.g., how much methane is released from marsh systems. There is a need for the active monitoring of volatiles (e.g., H_2S).

26. Baseline data are needed in underrepresented environments including the Arctic (Chukchi Sea, Bristol Bay), particularly in areas that are likely to be developed for oil and gas extraction in the near to mid-term.

Recommendations for Moving Forward

The coastal section participants identified a few areas where the science community has been making positive progress to the extent that it can be considered Good Work; however, there is much work still to be done to address the Gap science issues. Participants indicated that there can be improvements in the response rate, funding opportunities, data access, and integration of science in the decision-making process through coordination and legislative actions. Additionally, the group indicated the immediate involvement of the scientific community is critical for rapid and effective response to disasters such as Deepwater Horizon. The group suggested several approaches to address these needs and appreciates the involvement in the decision-making process. There was optimism that these efforts are achievable but require collaboration amongst academia, federal agencies, state agencies, NGOs, and others.

OIL AND DISPERSANT IMPACTS AND MITIGATION IN OFFSHORE ENVIRONMENTS

Session background information

Dr. Ray Highsmith from the University of Mississippi provided an overview of the work in response to the DWH oil spill during the offshore plenary on the opening day of the workshop. Dr. Highsmith also updated the plenary session on the proposed research to be conducted as part of GOMRI, funded by BP.

After the plenary concluded, the offshore breakout session began and included two components. On the first day, science presentations provided preliminary results of recent DWH oil spill-related offshore research. A broad set of topics was presented from deep ocean circulation to oil spill-related impacts, sedimentation, and benthic habitats. On the second day, the breakout session participants discussed oil spill science issues and assessed the relative importance and amount of information available on these issues.

Participants (Table 6, Appendix 3) in the offshore section included representatives from federal and state governments and universities. Approximately 70% of the participants indicated that they primarily conduct research, while the remaining participants used research results in their profession/management responsibilities or for recreational purposes.

Science Presentations

Oral presentations in the offshore session primarily focused on the impacts to deep ocean benthic communities and sediments. Appendix 4 includes a list of presentation speakers, titles, and abstracts.

Salient points from the presentations include:

- There was significant Loop Current and Loop Current Eddy influence on the distribution of surface oil. The detachment and re-attachment of eddies from the Loop Current were observed to partially control the transport of the oil. Generally, the Loop Current Eddy did not make a clean break before its westward migration away from the Loop. Observations were made for the first time in the lower-layer depth range (1300–2000 m), indicating cyclone/anticyclone coupled pairs as the eddy began to separate. This was previously only predicted in models. The lower layer behavior seems to be an important mechanism for detachment. The mooring cruises provided hydrocarbon sampling in July 2010. During the cruises, no significant trace of oil in the northernmost part of the Loop Current was detected. The questions raised are: Why was there no entrainment across the Loop Current front? If oil did enter the Loop Current, were shear and mixing sufficient to dilute it beyond the detectability cutoff? (Hamilton)

- There have been six sediment coring cruises to date, with 60+ core samples. The cores were sampled using an eight-tube multicorer. There were samples taken for a set of radioisotopes including 210Pb and 234Th. The August 2010 cruise results showed petroleum hydrocarbons to be highly elevated in the top 1 cm or so of the cores, which were buried to a depth of 8-9 cm by February 2011. A large accumulation rate of very fine material, the "dirty blizzard" hypothesis, is apparent. The radioisotopic data suggest sediment accumulation rates increased 20–100x in mid 2010. Oiled sediments were found at 100–1500 m water depths near DeSoto Canyon. The elements nickel and vanadium, which are enriched in petroleum, indicated a slight enrichment in surficial sediments. The data do not yet allow for a differentiation between the "dirty blizzard" and "toxic bathtub ring" (TBR) hypotheses. (Flower)

- Sediment Quality Triad is a concept developed nearly 30 years ago.[2] The axes of the triad are: (1) measure chemical dose, biological response (toxicity test, Microtox was used here), and (2) measure ecological response (benthic community was used here). From historical Gulf of Mexico Offshore Monitoring Experiment results, it was assumed that effects should only be detectable within 100–200 km

[2] **Long E. and Chapman P.** 1985. A sediment quality triad: Measures of sediment contamination, toxicity and infaunal community composition in Puget Sound. Marine Pollution Bulletin. 16: 405-415.

of the rig.[3] From the Deep Gulf of Mexico Benthic Study results, there was no indication of anthropogenic trace metal input relative to aluminum, but there was for barium, nickel, lead, cadmium, arsenic, copper, and manganese. In a mission carried out by BP and NOAA from September 16 to October 24, 2011, samples were acquired from 169 stations with chemistry, Microtox, and infaunal analysis, with a primary desire to relate observed toxicity to the distribution of chemicals. One-third of the stations found Microtox toxicity, although there were no PAHs present. There was strong toxicity up to 25 km away and correlations between blowout/drilling and toxicity. (Montagna)

- Our group had previously studied methane (CH_4) dynamics in the water column over cold seeps at shallow and deep-water sites. Our sampling expanded from early May 2010 until early December 2010. Discrete layers of CH_4 and hydrocarbons between 900-1300 m were initially observed. These layers or plumes supported high rates of aerobic CH_4 oxidation and increased microbial abundance. The CH_4 and aerobic methanotrophic activity were distributed throughout the water column after July 2010; aerobic methane oxidation activity decreased sharply by late June 2010. (Crespo-Medina)

- There appeared to be subsurface zones of oxygen deficit that reflect where oil plumes had been previously located. Particulate carbon and particulate nitrogen were not observed to be consistently elevated in turbid layers. Some turbid layers tend toward lower δ13C, others toward higher. (Montoya)

- Work was begun in 2008 to study diversity, distribution, and genetic connectivity of coral ecosystems in the Gulf of Mexico prior to the spill. After the spill, we observed brown flocculent material on corals at some sites, underneath which there were dead polyps. Ophiuroids associated with corals appeared to be unhealthy (arms tightly wound rather than extended into the water column). (Cho)

- Cruises were conducted in early and late May 2010, late summer 2010, and August 2011. Although nickel and vanadium are commonly enriched in petroleum, they were not so in the DWH oil. Analyses were performed on iron, cobalt, barium, and copper; we noticed clear anomalies in cobalt and barium and a slight anomaly in copper. We found: (1) trace metal anomalies due to oil (cobalt) and drilling mud (barium); (2) iron is probably limiting for methane consumption but there does appear to be a benthic source; and (3) an indication from PAH distributions that oil ages as it moves away from the blowout site to shore (yielding apparent pyrogenic PAH distributions), which could be mistaken for burning. (Shiller)

- For sediments, we considered the "flocculent blizzard" (FB) and TBR hypotheses. (FB: aggregation/flocculation of hydrocarbons with biologic and lithogenic particles that increase sedimentation; TBR: subsurface oil moves along bathymetric contours and impinges on sediments). Evidence for TBR is (1) upper sediments are clearly laminated (millimeter scale), not bioturbated, and (2) water in the plume is enriched in toxic PAHs. Evidence for the FB is that the sediment includes terrestrial biomarkers overcapped by high molecular weight oil hydrocarbons. (Hollander)

- Samples at three of 14 stations were toxic to bacteria; three of 13 were toxic to phytoplankton; six of 14 were mutagenic by the Inductest. The Mictrotox assay is more sensitive to oil; QuikLite is more sensitive to dispersant. (Paul)

- Industry perspectives on the value of dispersants in responding to offshore oil spills were presented. It is the responsibility of industry to recover spilled oil. However, no more than about 15% of spilled oil has ever been mechanically recovered, spurring one of the strongest arguments for dispersants. The encounter rate is the key to offshore response. A single airplane can distribute dispersant over an entire slick in eight hours, whereas it would take days to weeks for a slow-moving skimmer barge to clean up a significant quantity of oil. Spill conditions limit response options. It is difficult to mechanically recover surface slick oil of sub-millimeter thickness. Unlike other methods, dispersant distribution can continue day and night. (Nedwed)

[3] **Green R. and Montagna P.** 1996. Implications for monitoring: Study designs and interpretation of results. Canadian Journal of Fisheries and Aquatic Sciences. 53: 2629-2636.

- Sperm whales, being top predators, can demonstrate behavior that indicate disturbance during a large oil spill, both in response to the noise of the increased vessel activity and the possibility of oiling of prey. Individual sperm whales can eat 4% of their body weight per day (approximately 1.6 tons of squid per day). Squid live for only one to two years. In regard to sperm whale ecology, it is reasonable to inquire about the impact of oil and dispersants on squid. Because of the large size of whales, they can survive serious changes in prey supply that may only manifest later as reduced calving rates or lower numbers of foraging attempts. If squid numbers have been substantially diminished, the impact on sperm whales may last for an extended period until enough squid larvae are recruited from adjacent areas and have time to mature to sustain local recruitment and offset predation. (Mate)

Breakout Group Discussion and Gap Analysis

The offshore section participants identified a few areas where the science community has been making positive progress; however, there is much work still to address other science issues. Participants indicated that there can be improvements in the response rate, funding opportunities, data access, and integration of science in the decision-making process through coordination and legislative actions. There was optimism that these efforts are achievable but require collaboration amongst academia, federal agencies, state agencies, NGOs, and others.

Gaps

- Neuston impacts.
- Plankton communities/young squid.
- Long term sedimentary fates, metals as well as hydrocarbons.
- Ecosystem modeling not yet at "system level."
- No action or consensus on observatories.

Good Progress

- Repeated characterization of petroleum fractionation and partitioning into different compartments in the water column and benthos.
- Lots of sampling and analyses are ongoing.
- Many issues are still at the data collection phase, but this is expected to change with time.

No Reassess or Rescale Issues

Summary

Did issues from last year move on the grid?

- Many issues moved forward on the grid as information/data became available.
- This did not reduce the number of gaps.

What are the new issues (all gaps)?

- Sediment impacts.
- Ecosystem models.
- Oil/gas transport mechanisms.
- Impact of dispersant use, fate of dispersant.
- Impacts on large, mobile, high trophic-position organisms.

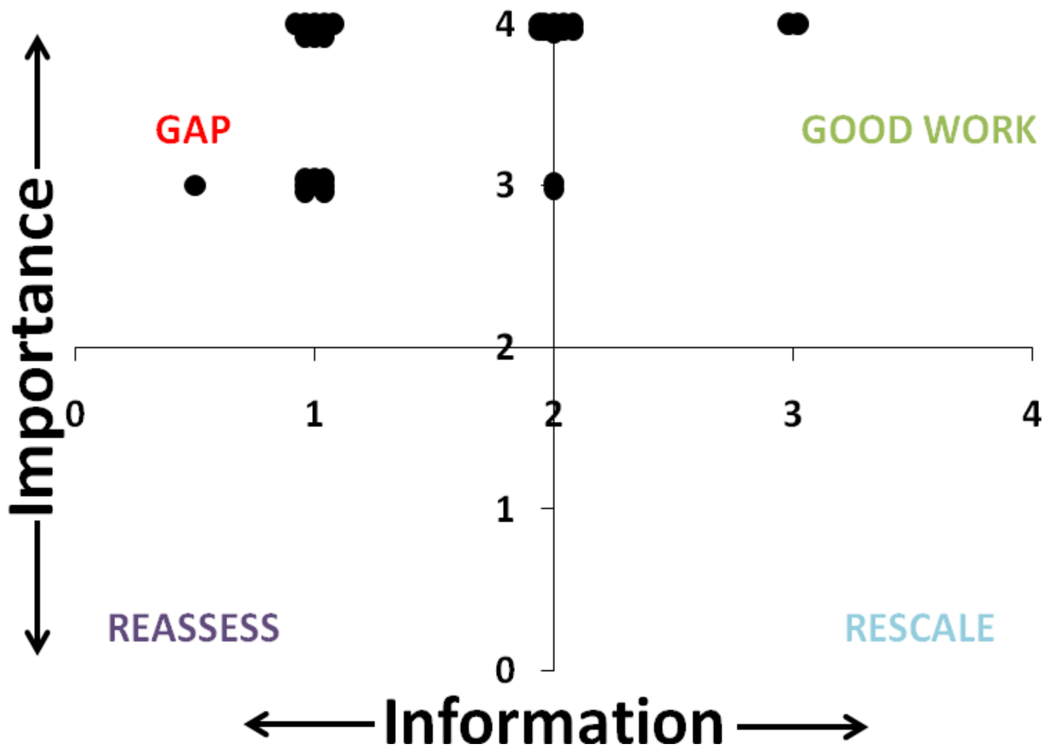

Figure 3. Plot of the 34 offshore science issues discussed during the 2011 workshop based on the two rating scales.

Oil and Dispersant Impacts and Mitigation on Living Marine Resources

Session Background Information

Dr. Steve Murawski from the University of South Florida provided an overview of living marine resources in the Gulf of Mexico in relation to the DWH oil spill. He outlined the science priorities that the research community identified in 2010 during the midst of the DWH oil spill (e.g., plankton assessments, fisheries abundance and distribution, integrated ecosystem assessment). He then recognized the numerous ongoing assessment and planning efforts since the oil spill (e.g., NRDA, Gulf of Mexico Ecosystem Restoration Task Force, National Academy of Sciences, Ocean Studies Board study on loss of ecosystem services in the Gulf).

Following this broad introduction, Dr. Murawski then discussed recent research on living marine resources that has been potentially impacted by the oil spill, including fish reproduction, ichthyoplankton, the plankton community, and marine mammals such as dolphins. He also discussed impacts to seafood safety in the context of the extensive sampling conducted during the oil spill to understand the effect of oil and dispersants on fish consumption. An additional area of potential impact discussed during this plenary talk was the emerging issue of fish diseases/lesions in relationship to the oil spill (both spatially and temporally).

Dr. Murawski highlighted the Integrated Ecosystem Assessment approach (including Atlantis modeling) as one analysis tool to develop an "end-to-end" ecosystem model that includes biology, physics, and chemistry data, and the ability to analyze varying scenarios around predator-prey dynamics and fisheries impacts. His talk concluded with a number of suggested next steps, including the need to consider how science developed for living marine resources can assist restoration planners to: (1) set achievable goals for restoration actions; (2) monitor progress in recovery efforts towards long-term goals; (3) help prioritize restoration efforts based on where the greatest potentials for recovery lie; and (4) provide ecosystem-level understanding of the linkages among individual restoration activities and the totality of ecosystem services improved through restoration.

Science Presentations

After the plenary session concluded, the living marine resources breakout session began and included two components – scientific results and science issue priorities. On the first day, science presentations provided preliminary results of recent DWH oil spill studies related to living marine resources. Presentations specifically focused on overviews of the ecosystem and restoration policy components of the Gulf of Mexico (e.g., Gulf of Mexico biodiversity, the NRDA process, fishery closures), specific flora and fauna (e.g., plankton, *Sargassum*, turtles, marine mammals, whale sharks, bluefin tuna, killifish, and deep sea corals), and potential physiological and genetic effects (e.g., fish otoliths, killifish). Participants (Table 8, Appendix 3) in the living marine resources section included representatives from federal and state governments and universities.

Salient points from the presentations included:

- The Gulf of Mexico is a species-rich ecosystem, with 1,708 known species identified from a depth range of 1000–3000 meters in the general vicinity of the location of the DWH oil spill. (Moretzsohn)
- The Gulfbase.org/biogomx website is a research portal for the Gulf of Mexico. (Moretzsohn)
- Ongoing research on the DWH oil spill will generate a vast amount of biodiversity data which can be incorporated into the Biodiversity of the Gulf of Mexico database(BioGoMx), such as new records, range extensions, new species, conservation status, etc. (Moretzsohn)
- The ongoing NRDA process to assess environmental impacts from the DWH oil spill consists of multi-dimensional components, including analyzing effects to resources in open waters, deepwater habitats, nearshore and shoreline habitats, and human uses. (DiPinto)
- As of October 2011, NRDA co-trustees have collected over 70,302 samples and completed 42,354 contaminant analyses on these samples. (DiPinto)

- During the oil spill, 35% of the federal fishing area was closed. This closure began in May 2010 and ended in mid-April 2011. (Die)

- Federally managed fish stocks affected by the fishery enclosure included mackerel, snapper, grouper, tilefish, jacks, sand perch, gray triggerfish, hogfish, shrimp, lobsters, and stone crabs. (Die)

- Understanding impacts from oil spill fishery closures to the fishing effort on the West Florida Shelf include evaluating the static biomass for reef fish species within the closure area and comparing that to the predicted and observed fishing fleet behavior. (Die)

- Killifish were used as a study organism to track marsh fish health before and during oil exposure and during a recovery period to characterize oil spill impacts on exposed Gulf coast marshes. Killifish were used because they are widely distributed, have a limited home range, and are important to estuarine food webs. (Galvez)

- Study results found a large signal of hydrocarbon exposure in Louisiana marsh fish collected in situ. CYP1a protein expression was highly elevated in the gills, intestine, head, and kidney of killifish collected from oil-contaminated sites. Exposure to field-collected sediments increased time-to-hatch, reduced the percent hatch of killifish embryos, and affected heart form and function. (Galvez)

- No developmental abnormalities were observed in killifish exposed to field-collected waters, but very low concentrations of oil exposure during development, while insufficient to induce cardiovascular abnormalities in embryos, can impair cardiac performance in adulthood. (Whitehead)

- Divergence in genome expression coincides with contaminating oil and is consistent with genome responses that are predictive to exposure to hydrocarbon-like chemicals and indicative of physiological and reproductive impairment. (Whitehead)

- Pelagic *Sargassum* is an open water habitat for numerous flora and fauna in the Gulf of Mexico, including byrozoans, barnacles, hydroids, and juvenile and adult fish species. *Sargassum* may enhance overall food web productivity by serving as a substrate for epiphytic algae. (Hernandez)

- It is currently not known how much *Sargassum* was "oiled" during the oil spill. Studies are now underway to conduct realistic mesocosm experiments to complement field observations made during the oil spill to assess acute and chronic mortality of *Sargassum* and its animal associates by floating oil and dispersants. (Hernandez)

- Concurrent research separate from ongoing work on *Sargassum* suggests that changes in mesozooplankton and ichthyoplankton assemblage structure were identified as a result of the oil spill, but long-term fisheries impacts are yet to be determined. (Hernandez)

- Since 2003, over 475 sightings of whale sharks have been documented in the northern Gulf of Mexico. From 2005-2010, aggregations of 20-200 sharks were observed at Ewing Bank during June and July. Whale sharks are opportunistic feeders, but data suggest they are aggregating during the summer in the northern Gulf to feed primarily on little tunny eggs. (Hoffmayer)

- Whale sharks were observed near oil plumes during the oil spill, but the impact of this on the acute and chronic mortality of individuals has yet to be determined. (Hoffmayer)

- An analysis of the overlap between satellite-derived estimates of surface oil and predicted bluefin tuna spawning habitat in the northern Gulf of Mexico suggested that, although eggs and larvae were likely impacted by oil-contaminated waters in the eastern Gulf of Mexico, high abundances of larvae within suitable spawning habitat were located elsewhere, especially in the western Gulf of Mexico, away from the influence of the spill. (Lamkin)

- Overall, less than 10% of bluefin tuna spawning habitat was predicted to have been covered by surface oil, and less than 12% of larval bluefin tuna were predicted to have been located within contaminated waters in the northern Gulf of Mexico on a weekly basis. (Lamkin)

- Fish otoliths serve as a living record to understand exposure to the crude oil components, nickel and vanadium. Otolith profile comparisons of diseased (e.g., lesions and infections) and non-diseased fish will be compared to determine if elevated disease rates are associated with oil exposure. (Peebles)

- Deep sea corals (primarily *Paramuricea biscaya*) at a depth of 1370 m were exposed to oil from the DWH oil spill. Work continues to characterize oil in the Gulf of Mexico and monitor impacted and healthy coral sites. (White)

- Sperm whales were known to be in the vicinity of the oil spill. Tagging work was performed to track whales during and after the spill to better understand their movements and life history patterns. (Mate)

<u>Breakout Group Discussion and Gap Analysis</u>

The participants in the living marine resources session focused on science issue priorities on day two of the workshop. Two questions were discussed for each issue: "How important is issue XX in preparing for, responding to, and recovering from oil spills?" and "How much scientific information is available for issue XX?" Participants then assigned each issue to a quadrant: Gap, Good Work, Reassess, or Rescale. The 2011 participants reviewed the results from the 2010 living marine resources session and identified the following science and coordination gaps.

Gaps: Science Issues

1. **The Need for Baseline Data**: As in 2010, there is still a dearth of baseline information in the Gulf of Mexico for tracking short- and long-term species and ecosystem changes over time. Information is "spotty," depending on the species and geographic location. Baseline data are critical to understand short- and long-term health effects, synergistic interactions from oil/dispersants, and reproductive consequences (particularly those that could have missing cohorts, e.g., tuna and snapper); behavioral and physical impacts to long-lived species like sea turtles; and impacts on "open water habitats" like *Sargassum* that provide a habitat for numerous species in the Gulf of Mexico. Examples of data gaps include:

    - Mesopelagic, deepwater/corals, and microbial communities.

    - Southeast Area Monitoring and Assessment Program (SEAMAP) data – gaps in temporal resolution (data are collected in the spring and fall, but finer scale data collection is required to address impacts of oil spills).

    - Ocean observing in the Gulf of Mexico – the current system lacks continuity in data collection, storage, reporting, and funding.

    - In situ biological and chemical data (e.g., dissolved oxygen data in addition to the large dead zone in the Gulf of Mexico).

    - Fishery independent data – gaps for the pelagic environment (e.g., highly migratory species such as billfishes, tunas, sharks, and turtles).

    - Habitat use patterns – gaps exist especially for pelagic species, including data on horizontal, vertical, and seasonal movements (e.g., dusky and mako sharks)

    - Benthic habitat maps – there is a significant lack of mapping even for economically-important species like oyster beds. There is no comprehensive multi-beam mapping in the Gulf of Mexico. Territorial sea maps are also incomplete.

2. **The Need for a Gulf-wide Monitoring Program**: There is a lack of remote sensing data, inshore/offshore aerial and shipboard surveys, and satellite tag information to track ecosystem changes, including pelagic species and *Sargassum* monitoring. How can we loop the oil/gas industry into this work?

3. **The Need for Modeling**: Ecological models (Atlantis, trophodynamic models) and trajectory models for turtle movements are finally being developed for the Gulf of Mexico. Biophysical models like the Spill Impact Model Analysis Package (SIMAP™) are currently being used, but modeling gaps exist in trophic interactions, species behavior, and chemical data (e.g., oil distribution, behavior at depth, toxicity). Model development requires more funding and a "critical mass" of support by the research community to ensure its success. For example, Sea Grant and GOMRI have funded small projects, but better organization and integration are needed. How can we loop the oil/gas industry into this work?

4. **Improve Data Collection Technology**: Investments in satellite tags are needed to track animals and thus improve our understanding of spatial and temporal habitat use patterns. Oil rigs could be outfitted with sensors to provide ocean-observing data. How can we loop the oil/gas industry into this work?

5. **The Need for a Broad Assessment of Health Impacts**: There is no comprehensive health assessment for the Gulf of Mexico (throughout the food chain from plankton to marine mammals).

6. **Take an Ecosystem Approach to Understand the Gulf of Mexico**: Participants suggested that the response to the oil spill emphasized the need to look at the Gulf of Mexico ecosystem from the standpoint of resiliency. How has bioaccumulation (acute/chronic) of oil and/or dispersants within organisms occurred? This question needs to be considered from a food web perspective rather than just a single species level. The group also discussed the need to consider functional biodiversity. How did the impact of the oil spill cause reductions and loss of functional responses (e.g., trophic and nutrient cycling)?

Gaps: Coordination Issues

1. **Better Interactions across Disciplines are Needed:** More collaboration between economists and biologists on, for example, ecosystem services valuation, is needed to ensure that we can blend social science analyses with research on living marine resources. We also need continued and enhanced collaboration across scientific disciplines like hydrology, biology, ecology, and oceanography to understand the Gulf of Mexico as an ecosystem.

2. **Better Interactions across Countries** [NEW in 2011]: There are good examples of work between Mexico and the United States, such as the Large Marine Ecosystem program to build from. How can we collaborate to understand the population dynamics for highly migratory species like whale sharks, turtles, and fish larvae that share international waters? We need to explore how to work with Cuba, especially on the issues of developing a system of marine reserves and working with them as they develop oil/gas production.

3. **Better use of Management Tools like Marine Reserves/Marine Protected Areas** [NEW in 2011]: A network of marine reserves/marine protected areas should be explored as one way to protect "special places." These areas can be used as sources of biodiversity and reference areas for marine research.

4. **Transparency in Data Sharing**: Agencies like NOAA, BOEM, and the Navy, in coordination with academia, the fishing community, and the oil/gas industry, should work together to share Gulf of Mexico data.

5. **Regulatory Improvement**: The regulatory procedure needs to be improved to speed up the process to obtain research permits (e.g., protected species sampling permits).

Good Work: Strong datasets/programs exist or Good Work was accomplished over the past year.

1. There have been better and more regular interactions between NOAA and the academic community regarding NRDA research and Gulf of Mexico research in general. Collaboration on data and information sharing across sectors and scientific disciplines has increased. This includes meetings like this SOST

workshop designed to share data and information on the oil spill. Collaboration between GOMRI and federal agencies should be considered.

2. Significant recognition of and discussion about the need for a comprehensive ocean observing system has occurred.

3. There is good baseline information for brown shrimp.

4. Aerial surveys exist for certain species (e.g., manatee, red drum, marine mammals, *Sargassum)* and for oil trajectories. These are most often performed for very specific purposes, but provide important information.

5. Stock assessments are in place for specific target species.

6. The research community has done a good job in sampling for certain species, but there is still a need to elevate this to the ecosystem level to gain a more holistic understanding (units of biodiversity, trophic levels, trophic cascade).

7. The NRDA process is developing a library of genomic samples (e.g., plankton, *Sargassum*, oysters).

8. The Large Marine Ecosystem program provides a unique opportunity to share data and resources between the United States and Mexico.

9. The existing marine reserves in the Gulf of Mexico are great examples of cross-sector collaboration and a process that can be built on to create a system of marine reserves across the Gulf.

Reassess: These are new science or coordination issues that should be considered moving forward.

1. Improve interactions between social science and living marine resource managers.

2. Redefine how we examine PAHs. This includes impacts, toxicology tests, and analytical techniques.

3. Identify biomarkers unique to PAH and oils and translate them into effects analyses.

4. Refine precision and coverage in data collection to better understand the effects of a spill (e.g., SEAMAP). Finer scale issues need to be addressed.

5. Use and further develop existing fisheries models for federally-managed species to better understand the impacts of oil spills.

<u>Recommendations for Moving Forward</u>

The living marine resources section participants identified a few areas where the science community has been making positive progress to the extent that it can be considered Good Work. However, there is still much work to address the Gap science and coordination issues. Participants indicated that there can be improvements in the response rate, funding opportunities, data access, and integration of science in the decision-making process. The group suggested several approaches to address these needs. There was optimism that these efforts are achievable but require collaboration amongst academia, federal agencies, state agencies, NGOs, and others.

OIL AND DISPERSANT IMPACTS AND MITIGATION ON HUMAN HEALTH AND SOCIO-ECONOMIC SYSTEMS

Session background information

Dr. Lynn Grattan, Associate Professor of Neurology, Psychiatry, Epidemiology and Public Health, University of Maryland School of Medicine, provided an overview of her work on the health impacts to residents in east Gulf coast communities during and immediately after the DWH incident. Her key findings are as follows. First, the most significant health impact to residents of east Gulf coast communities during and immediately after the DWH oil spill was psychological. Clinically-significant depression was found in 35% to 55% of people examined in Florida and Alabama communities. Second, income loss after the spill had a greater psychological health impact than the presence of oil on immediately adjacent shorelines. Accordingly, depression and anxiety were significantly higher in people who suffered income loss versus those who did not across all study communities. Third, the psychological impacts of the oil spill extended beyond areas of direct oil exposure. Research findings suggest that income loss and economic uncertainty were the greatest contributors to distress.

The human health and socio-economic systems breakout session included two components. On the first day, science presentations provided preliminary results of recent DWH oil spill-related human health and socio-economic systems research. A broad set of topics were presented, including perceived and anticipated health impacts; impacts to women and children; an overview of BOEM research projects; and a seafood safety assessment. On the second day, the breakout session participants discussed human health and socio-economic systems issues and used the Importance Performance Analysis (IPA) tool to assess the relative importance and amount of information available on those issues. The use of the IPA grid tool allowed facilitators and participants to: (1) revisit the gaps identified at last year's meeting; (2) assess how well gaps have been addressed thus far; (3) Identify new gaps; and (4) highlight accomplishments in addressing gaps to this point. Participants (Table 9, Appendix 3) in the human health and socio-economic systems section included representatives from federal and state governments and universities.

Science Presentations

Appendix 4 include a list of presentation speakers, titles, and abstracts from the oil and dispersant impacts and mitigation on human health and socio-economic systems session. Salient points from the presentations include:

Changes in health and well-being in communities affected by the DWH disaster: Linking well-being with ecosystem services. Susan Lovelace. Hollings Marine Laboratory.

- To prepare for and respond to events like the DWH disaster, decision makers, resource managers, and other government officials need information about the social and economic aspects of their communities.
- Because the oil has a significant impact on important ecosystem services that people from the Gulf regularly enjoy, we want to understand how a change in these ecosystem services can affect the well-being of entire communities. The goal of this research project is to determine whether a meaningful set of social and economic indicators, compiled in an index or scorecard, can be developed to document changes in well-being that occur as a result of changes in ecosystem services.
- Having such indicators would allow NOAA and/or other government agencies to better evaluate the relative condition of coastal communities, as well as assess their degree of resiliency to significant social, economic, and ecological changes over time. Further, having such indicators could help officials to predict, anticipate, and prepare for the types of social disruption most likely to accompany acute changes to coastal environments, such as hurricanes and major oil disasters, or chronic impacts to the environment caused by human activities.
- As a result of this research project, we are building a database of social, economic, and public health data for the counties that had oiled shorelines, as well as for reference counties in the Gulf of Mexico and

along the east coast. From this database, we can develop county profiles that will provide information for planners and managers. Indicators and indices will allow us to retrospectively look at how changes in ecosystem condition affected well-being. If our models are robust, we hope to develop models that can predict changes in well-being for future events.

Status of BOEM socio-economic research and response to the DWH oil spill. John Primo and Harry Luton, BOEM.

- BOEM manages resources on the federal Outer Continental Shelf. Its Environmental Studies Program (ESP) provides research in support of sound decision making.

- ESP socio-economics reflect this situation by focusing research on the effects of normal offshore operations. At the time of the DWH oil spill, the ESP had performed relatively little work on spills or on such environmentally-dependent industries as fisheries, recreation, and tourism.

- Within days of the spill, BOEM was able to put well-trained field workers in place to document the socio-economic effects of the spill. This effort was facilitated by a nimble procurement office, a history of community-based research, and the ability to draw on researchers very familiar with and already working in the area.

- Because large oil spills are uncommon, because the outcomes of one do not predict those of the next, and because events occur and change rapidly, there is no substitute for reliable eyes on the ground to document the consequences as they develop.

- This ongoing BOEM field effort has already highlighted factors that are making the social and economic consequences of DWH very different from those of the Exxon Valdez oil spill, which for many people currently serves as a "model" for spill impacts. For example:

- The DWH follows close after one of the largest natural disasters in U.S. history, the 2005 hurricane season. This is a psychological factor, but also an economic one that limits the abilities and shapes the strategies of some businesses, communities, households, and individuals to recover.

- The DWH occurred in an area with a very large and diverse economy and population, and the economy and population varied greatly in size and composition across the geography that was impacted. Consequently, the type, magnitude, and causes of effects were highly variable, as were the contexts in which effects occurred.

- Because many individuals commute long distances (e.g., oil workers) or shorter distances (e.g., east New Orleans fishermen) for ocean-dependent work, some socio-economic impacts of DWH were very widespread but also often hidden by their surroundings. In contrast, because many coastal individuals commute inland to work, the direct impacts of DWH were somewhat mitigated.

- The area's complex ethnicity and ethnic relationships were also significant in shaping DWH social and economic impacts. For example, while the Vietnamese are highly involved in fisheries and fish processing, many in this community saw themselves as underrepresented in DWH mitigation processes.

- The DWH occurred in an area in which the oil industry and its support sectors are a significant part of the economy and social landscape. This meant the spill's impacts on oil industry operations and regulations also had effects on many households and will continue to do so. Since many households mix oil and fishery employment, these changes were a significant conduit for effects to the fishing industry.

- The DWH directly and indirectly impacted all five Gulf states and multiple local political jurisdictions that exhibited substantial differences in organization/function and in their response to the spill and its aftermath. One notable characteristic of DWH social and economic impacts was the geographic variability due to differences in state and local-level political contexts.

Interagency response and assessment of seafood safety in the aftermath of DWH. Robert Dickey, Food and Drug Administration (FDA) Gulf Coast Seafood Laboratory and Division of Seafood Science and Technology.

- The FDA operates a mandatory safety program for all fish and fishery products under the provisions of the Federal Food, Drug and Cosmetic Act, the Public Health Service Act, and related regulations. The FDA program includes research, inspection, compliance, enforcement, outreach, and the development of regulations and industry guidance. The FDA works closely with NOAA and the states whenever commercial fishing waters are closed for public health reasons and again when they are reopened to harvest.

- The DWH oil spill presented a threat to the health of Gulf seafood consumers due to the potential for aquatic species exposed to crude oil to bioconcentrate harmful crude oil constituents. When the Gulf of Mexico oil spill began in 2010, the FDA, National Marine Fisheries Service (NMFS), Environmental Protection Agency(EPA), U.S. Coast Guard, and the Gulf coast states took unprecedented steps to ensure that the seafood harvested from the Gulf was safe.

- The initial seafood safety hazard was mitigated by the closure of oil-spill impacted waters, and waters expected to be impacted by oil, to commercial and recreational boat traffic and fishing.

- State and federal inspections of primary seafood processors and wholesalers across the Gulf coast were performed to assure that seafood entering the market was obtained only from oil-free and open waters.

- Seafood from oil-free and open waters was collected and tested to verify that fishery closures of oil-impacted waters were protective and to perform baseline testing.

- A unified Gulf-wide fisheries reopening protocol was developed to specify procedures and criteria for the collection and testing of seafood from Gulf areas being considered for reopening once oil had dissipated.

- Seafood was tested for the harmful constituents of crude oil known as PAHs. Testing methods included sensory assessment and chemical analyses using liquid chromatography–fluorescence detection and/or gas chromatography–mass spectrometry. Seafood was also tested for the key dispersant constituent, dioctylsulfosuccinate (DOSS), using liquid chromatography–mass spectrometry.

- During the period from June 2010–August 2011, more than 10,000 seafood specimens were collected and tested from federal and state territorial waters of the Gulf of Mexico. Approximately 50% of all specimens were also tested for dispersant residue.

- Seafood testing results from June 2010–August 2011 revealed that PAH levels in all test samples were 100 to 1,000 times below levels of concern specified in reopening protocol criteria. Testing results also revealed that dispersant residue in all tested samples was >1000 times below levels of concern specified in reopening protocol criteria.

- Defined areas of the Gulf were reopened for fishing only after testing had shown that associated fisheries were safe for consumption. The duration of closures ranged from 16 days for areas that received minimal to no oil impact to >18 months for areas that were significantly impacted by DWH oil.

- The visible impacts of the DWH oil spill on coastal and Gulf-dependent communities, industries, and ecosystems caused significant public distress. Science-based information related to Gulf fisheries and seafood safety was not widely disseminated during the initial phases of the spill response, resulting in significant discrepancies between real and perceived hazards and situational awareness. The resiliency of communities, cultures, and industries impacted by events such as DWH can be strengthened by improved coordination and means of communicating human health risks and situational status. Better communications can also minimize negative impacts on public health, socio-economic systems, and the environment.

Breakout Group Discussion and Gap Analysis

The initial list of human health and socio-economic systems issues to be addressed were generated from the 2010 workshop report. A great deal of the session time was spent refining the wording of the list, adding items to the list, and removing redundant items. This resulted in a final list of 30 issues to be rated using the IPA tool. The issues were grouped into three categories: a broad social science category, human/environmental health, and integrative and holistic approaches to issues. The breakout group used a consensus process for assigning numerical ratings to the two questions for each issue. Each issue was evaluated using two Likert scale questions: "How important is issue XX in preparing for, responding to, and recovering from oil spills?" and "How much scientific information is available for issue XX?" The Likert scale was from 0 (meaning none or very low) to 4 (meaning very high).

General observations from the discussion include the following:

- The table adequately represents the social, economic, and human health research currently taking place in the Gulf of Mexico as a result of the DWH disaster. Since little work has been performed to analyze the social-ecological interactions in this region, an information gap exists. The compilation of current Good Work will benefit from soliciting the input of researchers conducting this type of work.

- Many of the socio-economic and health studies completed or in progress in the northern Gulf are at the place scale. Over time, a synthesis of these projects could provide information useful to making inferences about areas with similar social and economic characteristics. Regional monitoring of coastal counties will help us identify changes in the social and economic condition in response to changes in environmental condition.

The workshop's focus was skewed heavily towards the fate and distribution of the oil and the ecological aspects of the oil spill. Relatively little emphasis was placed on the human health and socio-economic considerations of the spill. This represents a general gap in the science process.

Of the 30 science issues, four were rated as moderately important, but not consistently considered, eight were important to consider in most cases, and 19 were very important in preparing for and responding to oil spills. One of the issues was identified as having no information at all. Twelve were rated as having information with high uncertainty or very limited in scope, scale, or functionality for decision making. Finally, 17 were rated as having a body of information that is expanding but with notable insufficiencies. A total of 13 issues fell clearly in the Gap quadrant, and 17 were on the line between the Gap and Good Work quadrants. None of the issues were located in the Reassess, Rescale, or directly in the Good Work quadrants.

Gaps: Thirteen issues fell in the Gap category:

1. Gulf of Mexico ecosystem services.
2. Cultural/historical resource preservation in the Gulf of Mexico.
3. Impacts to subsistence uses of the Gulf of Mexico (e.g., informal economy).
4. Further characterization of contaminant mixtures.
5. Biomarkers of exposure/effect/susceptibility.
6. Clinical evaluations, diagnostics, and documentation (e.g., case definition).
7. Tracking of disease at multiple geographic levels pre/post event; registries as needed.
8. Studies on the influence of litigation.
9. Individual and community vulnerability/resistance and adaptation to adverse health outcomes.
10. Health impacts of harmful algal blooms and toxins associated with the DWH oil spill.

11. Assessment of resilience across social-ecological systems.
12. Creation and evaluation of ecosystem models (e.g., a social-ecological system).
13. Research on the physical health effects of the DWH oil spill.

Gaps/Good Work: 17 issues fell on the line between the Good Work and Gap categories:

1. Secondary economic impacts.
2. Social and economic impacts of changes in all fishing sectors (baseline +/- impact).
3. Social and economic vulnerability in coastal communities.
4. Attitudes, perceptions, and beliefs about seafood.
5. Attitudes, perceptions, and beliefs about Gulf of Mexico tourism, recreation, and beach use.
6. Risk perception and risk communication of the DWH oil spill.
7. Communication and outreach regarding the DWH oil spill, e.g., media, government agencies, academia, and NGOs.
8. Impacts to subsistence uses of the Gulf of Mexico (e.g., informal economy).
9. Social and economic impacts to coastal communities.
10. Social and economic impacts to disproportionately-affected populations.
11. Institutional multilevel analysis of policies and regulations and the capacity of agencies and organizations.
12. Multilevel analysis of the institutional response to an oil spill (e.g., governance).
13. Toxicity testing, e.g., animal models.
14. Genetic toxicity and gene environment interaction.
15. Research on the behavioral and mental health effects of the DWH oil spill.
16. Health impacts to disproportionately-affected populations.
17. Economic impact of non-use value (e.g., cultural, existence).

<u>Recommendations for moving forward</u>

A number of future research needs and recommendations for moving forward were identified and expanded upon in the session. They include:

- Research aimed at describing and assessing selected socio-economic consequences of the spill to local government, businesses, communities, and families as they unfold in the middle- to longer term.
- Biomarkers of exposure, effect, and human health concerns related to direct exposure to the oil and potential exposure through contaminated seafood.
- Measurements of human vulnerability or resiliency to the spill and its economic impacts at the individual or community level.

- Longitudinal studies that can monitor changes in the same population group. Some of these questions may be answered by the NIEHS Gulf Long-term Follow-up Study and the NIEHS Deepwater Horizon Research Consortia, but improved communication between SOST and these efforts might be in order.

- It is important to consider the northern Gulf as a social-ecological system. Coastal communities are reliant on ecosystem services for their livelihoods. The interaction of people with coastal and ocean waters through the removal/harvest of mineral and living resources, recreation and social activities, cultural traditions, and daily life are often inseparable. Continued work to understand these connections will allow managers to better plan for disasters. Assisting scientists from many disciplines to share information will promote the development of frameworks necessary for a comprehensive understanding of the regional ecosystem. Creating teams of researchers, community leaders, health and environmental managers, and planners will help focus projects to best benefit the needs of communities.

- Although we realize that there are significant *social and economic impacts from changes in fishing, social, and economic vulnerability in coastal communities,* we have little knowledge about how to facilitate adjustment and adaptation (or resilience) on the part of individuals, families, and communities. These are significant gaps with respect to human health and public health with which very little information is known.

    - Recommendations for Moving Forward: In depth clinical studies of individual processes and mechanisms of adjustment and coping are needed to supplement large scale epidemiological studies for the development of rationally-based interventions.

- Studies of the *influence of litigation* on human recovery need to be given a higher level of importance. People who see an opportunity for secondary financial gain are more likely to malinger (feign illness) or exaggerate their symptoms than those who do not. Therefore, this is an important consideration in research or surveillance of symptoms.

    - Recommendations for Moving Forward: Studies are needed that facilitate the detection of malingering or symptom exaggeration, as well as studies of medically-unexplained symptoms in the Gulf coast population and their relationship to affective, personality, and economic factors.

- Attitudes, perceptions, and beliefs about seafood safety continue to differ between regulatory and scientific agencies (e.g., the FDA) and residents of Gulf coast communities.

    - Recommendations for moving forward: Albeit frustrated with the situation, scientists and community leaders need to develop a better appreciation of *perceived risk* and the factors that contribute to discrepancies between risk perception and actual risk. Studies of risk perception that include multiple levels of participation (scientists, government agencies, community members) are needed to better understand the dynamics and tensions between the groups and develop rationally-based programs for risk communication and management.

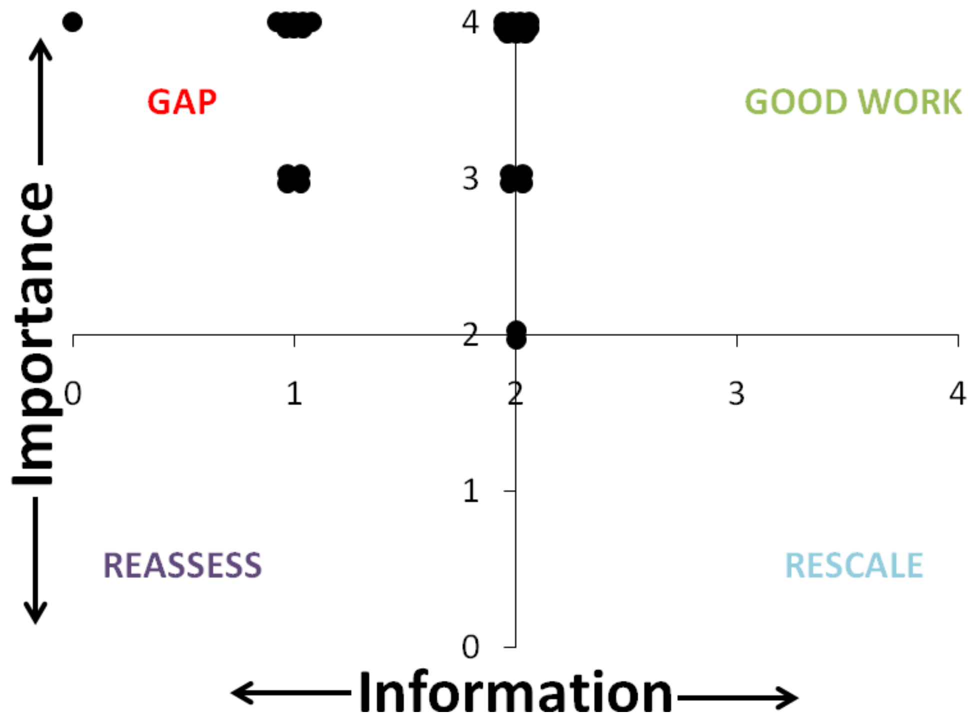

Figure 4. Plot of the 30 human health and socio-economic systems issues discussed during the 2011 workshop based on the two rating scales.

USE OF IN SITU AND REMOTE SENSORS, SAMPLING AND SYSTEMS FOR ASSESSING IMPACTS AND MITIGATION OF OIL AND DISPERSANT

Session Background Information

The use of in situ and remote sensors, sampling and systems (IRSSS) session addressed a wide swath of research areas related to the detection, tracking, and analysis of spilled and dispersed oil. Building on the IRSSS discussion held in 2010, the 2011 IRSSS session was organized around four activities: (1) a plenary IRSSS presentation; (2) individual speaker presentations providing IRSSS research updates; (3) a breakout group review and evaluation of IRSSS gaps identified in 2010; and (4) a breakout group discussion to identify new IRSSS gaps in 2011. Participants of the 2011 IRSSS session are listed in Table 9, Appendix 3.

Science Presentations

Dr. Mitch Roffer of the Roffer's Ocean Fishing Forecast Service, Inc., (ROFFS) provided the IRSSS plenary overview. His presentation gave the audience a broad overview of the different capabilities and resources available for detecting and tracking spilled oil, as well as the latest research gaps. After the plenary, the IRSSS Breakout Group convened to listen to individual presentations made by its members. These presentations provided important research updates and helped to stimulate further discussion for the follow-on IRSSS gap review activities. Illustrating the broad nature of the IRSSS topics, the subjects that were presented included:

- Aircraft surveys of Loop Current variability observed during the DWH oil spill. (Shay)
- Mapping oil spills. (Garcia-Pineda)
- Applications of high frequency radar surface currents for response to the DWH oil spill. (Howden)
- Utilizing in situ observations and satellite measurements to examine the extent and variability of the DWH oil spill. (Smith)
- Fluorescence-based detection of oil and oil-dispersant mixtures in seawater. (Abercrombie)
- Aerial dispersant monitoring using SMART protocols during the DWH spill response. (Levine)
- Wave glider monitoring of the Gulf of Mexico. (Hine)
- GOMRI information and data cooperative. (Gibeaut)

Abstracts for these presentations are available in Appendix 4, and slides are available at http://www.marine.usf.edu/conferences/fio/NSTC-SOST-PI-2011/talks.shtml.

Breakout Group Discussion and 2010 Gap Analysis

The IRSSS Breakout Group of the 2010 SOST conference identified 22 research gaps which were assigned to five general themes. To prepare a more simplified discussion and reduce subject overlap in 2011, the IRSSS Session Planning Committee reorganized the 2010 output into four themes with 19 gaps. The reorganized IRSSS subject themes are: operational and data coordination needs/issues; networks with sustained observations; role of aerial and satellite observations; and in-situ measurements at the surface and subsurface. Within the four themes, the IRSSS Breakout Group discussed and evaluated the 19 gaps, focusing specifically on whether advances had been made in a particular gap or if the gap was still relevant in 2011. The following summarizes these discussions.

Operational and Data Coordination Needs/Issues

GAP: There are very limited real-time observations to allow for the generation of daily, weekly, or even monthly maps of surface and subsurface oceanographic conditions.
DISCUSSION: This gap is still valid. Satellites are aging, and there are no continual subsurface observations.

GAP: There is a lack of coordinated effort between various communities (government, academic, and private) to carry out observations; the result is that the available human capacity and research infrastructure are not effectively used.

DISCUSSION: This situation is improving with the advent of the NOAA repository. There is a greater understanding of where assets and capabilities lie today than pre-DWH, particularly in the Gulf region. It should be recognized that redundancy can be a positive thing and does not necessarily indicate a lack of coordination. However, there is still room for improvement when coordinating efforts between various communities (government, academic, and private) in carrying out observations. A major part of this problem is the time lag before data are published and the reality that it may take months or years for data to be released. Access to data is more difficult for non-government entities than government entities. Although we have made progress in terms of a coordinated response post-DWH, there is still much work to be done on coordination of post-response science.

GAP: There is no mechanism to coordinate with international partners (e.g., Cuba, Mexico, Bahamas).
DISCUSSION: International communications are improving in academia. When necessary, coordination is occurring, but the mechanisms for coordination are either non-existent or unadvertised. Examples of successful international coordination include the Mexico/U.S. Joint Contingency Plan, Gulf of Mexico Coastal Ocean Observing System (GCOOS), and GOMA. There is still room for improvement with international coordination. Often the coordination is unofficial, and mechanisms for coordination are either non-existent or unadvertised. There is a need to improve access to data from international satellites.

GAP: There is a lack of coordination for satellite monitoring efforts.
DISCUSSION: This situation is improving. There is easier access to everything except synthetic aperture radar (SAR) data. The National Aeronautics and Space Administration (NASA) and NOAA have better coordination today than last year because of the National Polar-orbiting Operational Environmental Satellite System Preparatory Project. There is still room for improvement in coordinating satellite monitoring efforts. Funding is often an issue.

GAP: The processes for funding monitoring projects are awkward and unclear.
DISCUSSION: This situation may improve slightly with GOMRI funding of long-term research. There is still room for improvement in the processes available for funding monitoring projects. Funding is often non-existent. There are no funding sources for long-term monitoring activities. One reason why long term-monitoring is so difficult to fund is that it has no end date, which tends to discourage donors and investors.

GAP: There is no unified operational system for data acquisition and open data distribution.
DISCUSSION: This situation is improving. It is better today than during DWH. The NOAA repository should help fill this gap. There is still a need for a unified operational system for data acquisition and open data distribution. A key limiting factor is the lack of access to raw data. There are multiple data repositories, but they are not necessarily unified or aligned. The idea of a unified system may be an unattainable goal due to restricted data access policies.

GAP: There is no standard process for communicating metadata details (origin and calibration of data) collected from autonomous and other platforms (e.g., gliders).
DISCUSSION: This situation is improving because we are now aware of the importance of having a data-management plan and the hardware to enact it. DWH gave us a better understanding of the need to make data available in a usable, public-friendly format. The Integrated Ocean Observing System (IOOS) has done a lot of work on how to handle large datasets. However, there is still a need for a standardized process to communicate metadata details from autonomous and other platforms. One challenge is that there is no national server for glider data. To move forward, there needs to be better coordination between the government and the data providers. One way to improve coordination would be for the data providers to create a summary of their data before furnishing it to the government. This summary information would be useful because the Unified Command doesn't have enough personnel to perform data analysis.

GAP: There is no appropriate baseline information for several key parameters.
DISCUSSION: This situation may be improving. However, there is still a lack of appropriate baseline information for key parameters. In addition, there now appears to be funding or support for a large, centralized data clearing house to make data available to everyone.

Networks with Sustained Observations

GAP: The Gulf of Mexico has an underfunded ocean observing system.
DISCUSSION: No improvements. The Gulf of Mexico still has an underfunded ocean observing system.

GAP: Gaps exist in current observing networks (e.g., high frequency radar) in several geographical regions (e.g., no sustained observations in the Florida Keys, Florida Bay, Florida Straits, and West Florida Shelf).
DISCUSSION: Gaps still exist in current observing networks (e.g., high frequency radar) in several geographical regions (e.g., no sustained observations in the Florida Keys, Florida Bay, Florida Straits, and West Florida Shelf).

GAP: There is a need for one robust ocean observing system for continued monitoring and resulting ecosystem changes (biological, physical, and chemical properties in the atmosphere, water column, and sediment).
DISCUSSION: This gap is still very valid.

Role of Aerial and Satellite Observations

GAP: There is a lack of access to satellite resources because of the declining number of satellites available and access complexities for international satellite resources.
DISCUSSION: This gap is still very valid.

GAP: There is an insufficient number of U.S. researchers/students familiar with space-based ocean observing sensor design and data acquisition.
DISCUSSION: There is still an insufficient number of U.S. researchers/students familiar with space-based ocean observing sensor design and data acquisition. The problem is two-fold: student interest and funding costs. Firstly, students want to study topics they believe will lead to high-demand careers. A prevailing sentiment today is that this need can be met through modeling and simulation study programs rather than the more hands-on data collection and interpretation programs associated with in-situ measurements and remote sensing. Secondly, agencies are funding more modeling programs than remote sensing programs at universities due to the cost savings associated with the former.

GAP: There is no clear mechanism to merge satellite data with other remote sensing and in situ data collection methods.
DISCUSSION: This situation is improving based on the experiences from the DWH spill where oceanographers developed an appreciation for the need to model processes in three dimensions. However, there is still no clear mechanism to merge satellite data with other remote sensing and in situ data collection methods. DWH revealed the need to make connections between this data, but it is still a manual process performed on a case-by-case basis.

GAP: There is a lack of standardized processes for groundtruthing, evaluating, and validating aerial/satellite observations with surface/subsurface sampling and in-situ measurements.
DISCUSSION: This gap is still very valid.

GAP: There are no concise methods to determine the thickness of oil surface layers using satellite data.
DISCUSSION: There are still no concise methods to determine the thickness of oil surface layers using satellite data.

In-situ Measurements at the Surface and Subsurface

GAP: There is a need for more data from multi-parametric sondes that include fluorescence excitation/emission wavelengths, backscattering, and absorption observations.
DISCUSSION: One example of a project to help fill this gap is Chris Reddy's work on developing an in-situ method to analyze oil with gas chromatography-mass spectroscopy. There is still a need for more data from multi-parametric sondes such as fluorescence excitation/emission wavelengths, backscattering, and absorption observations. There is also a need to educate researchers on how to avoid false positives when using their instruments. Improved communications with instrument manufacturers are needed to obtain

better calibration information. There doesn't appear to be many people asking the manufacturers for this type of information.

GAP: There is a need to better incorporate multi-parameter (and multi-wavelength) sensors across a range of delivery platforms including moored buoys, aircraft, and ship-deployed expendable current profilers (XCPs), expendable current-temperature-depth (XCTD) profilers, expendable bathythermograph (XBT) profilers, and other dropsondes.
DISCUSSION: There is still a need to better incorporate multi-parameter (and multi-wavelength) sensors across a range of delivery platforms, including moored buoys, aircraft, and ship-deployed XCPs, XCTDs, XBTs, and other dropsondes.

GAP: There is a need for robust sensors that can accurately function in oil-contaminated environments.
DISCUSSION: There is still a need for robust sensors that can accurately function in oil-contaminated environments.

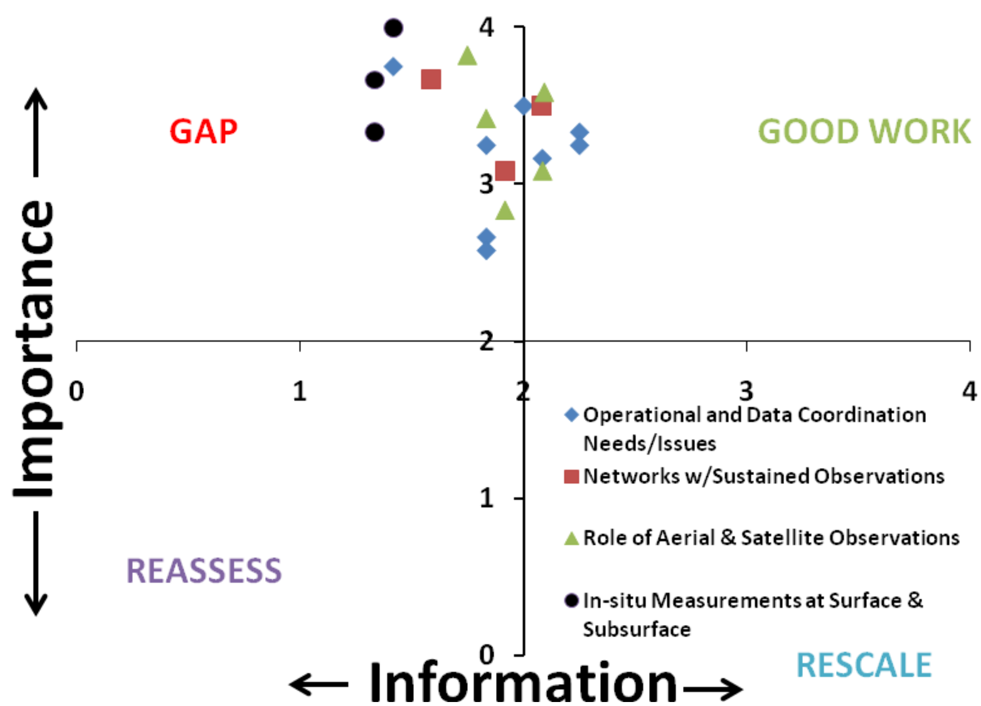

Figure 5. Plot of the 19 IRSSS gaps discussed during the 2011 workshop based on the two rating scales.

Once the 19 gaps were explored and discussed, the members of the IRSSS breakout session individually evaluated each of the 19 gaps using two Likert scale questions: "How important is gap XX in preparing for, responding to, and recovering from oil spills?" and "How much scientific information is available for gap XX?" The Likert scale is from 0 (meaning none or very low) to 4 (meaning very high). The results of the rating process are listed by category and level of importance within each category in Table 12 (Appendix 3). Figure 5 displays a plot of the 19 IRSSS gaps based on the two questions the group answered for each issue.

Of the 19 gaps evaluated by the IRSSS session, 12 gaps fell within the Gap category, suggesting many high priority IRSSS science issues lack adequate information. Six gaps were categorized into Good Work, meaning they are high priorities with a high amount of information already available. One issue (very limited real-time observations to allow for the generation of daily, weekly, or even monthly maps of surface and subsurface oceanographic conditions) bordered the Gap and Good Work categories.

Breakout Group Discussion: New Issues

After reviewing and evaluating the existing 2010 IRSSS gaps, the breakout session closed with a discussion of potential new issues and gaps. The group identified 33 new gaps and provided recommendations on how to begin to fill them. The 2011 IRSSS gaps covered five broad themes and are summarized as follows:

Usability, Access, and Quality Control of Existing Data

1. New Gap: There is a need for a process to *assess the quality of information* from new technology/ instruments. The new technology/instruments may provide important information, but may not have been rigorously vetted.

2. New Gap: There is a need to make data *repositories intuitive*. The resources are currently cumbersome and not user-friendly.

3. New Gap: There is a need for *inter-calibration* of instruments.

4. New Gap: It is difficult to get *access to subsea data*.

5. New Gap: There is a need to *include marine boundary layer* information in data *access*/user considerations.

6. New Gap: There is a need for an *automated way of getting data collection* into a usable fusion product. This is important for decision makers.

7. New Gap: There is a need to make *data repositories computer accessible,* even without high speed internet or high tech computer systems.

8. New Gap: This is needed to *calibrate imagery and sensors and to test existing response plans in a more realistic manner*. This could including practicing with spilled oil outside of laboratory tank environments (spills of opportunity), a capability that does not currently exist and is not allowed in the U.S.

New Data/Process Needs

9. New Gap: There is a need for a *chemical repository of all oil* from all wells, as well as from all dispersants.

10. New Gap: There is a need to *understand dispersants*. NOAA just released interim guidance on subsea dispersant monitoring.

11. New Gap: There is a need to find ways to *measure spill impacts on the ecosystem.*

12. New Gap: There is not enough funding on *studies for socio-economic costs of oil spill*s. This is important because it is tied to oil spill funding. There needs to be a study on the true costs of the spill and what can be saved by different mitigation methods.

13. New Gap: There is a need for a clear process to get *new technology such as a new sensor package to the market*.

Networks with Sustained Observations

14. New Gap: There is a need for *more complete coverage*. A geospatial multi-spectral satellite would help fill this gap. The community needs to push for this.

15. New Gap: There is a *need for longer-term funding* intervals for observations. Without long-term funding, we can't bring in graduate students and do strategic planning. We also can't run a sustained observational network on incremental funding. The current system is inefficient and wasteful. Either fund it all the way or not at all. A ten-year funding system would be a good starting time frame.

16. New Gap: There is a need for a *complete high frequency network in the areas near Cuban drillin*g. This is a funding issue.

17. New Gap: There is a need for *coverage in the Gulf of Mexico, as well as in the Beaufort Sea*. We need to consider different environments, cloud cover, ice, and hurricane-force conditions.

18. New Gaps: There is a need *for baseline information* from the Florida Straits to North Carolina.

19. New Gaps: There is a need for an *underwater cable observatory in the Florida Straits*. The Florida Straits is a pinch point for what comes out of the Gulf.

Role of Aerial and Satellite Observation

20. New Gap: There is a need to *increase appreciation of remote sensing*. We need data to model data.

21. New Gap: There is a need for *high resolution microwave sensor research.*

22. New Gap: There is a need to include *three-dimensional coverage in models*.

In-situ Measurements at the Surface and Subsurface

23. New Gap: There is a need to *increase the stamina of measurement platforms* (vessels, personnel). They need service before instruments do.

24. New Gap: There is a need to train and educate graduate students under the guise of OPERATIONAL oceanography (data collection). To address this gap, there needs to be a shift in perceived need at the agency level. The graduate education path needs to be clearly linked to available employment (NOAA).

25. New Gap: There is a need for *alternative sensor technology* for oil. GOMRI has a category for this (Tulane).

26. New Gap: There is a need to *characterize subsurface particles*.

27. New Gap: There is a need for *shallow water gliders* that can transit large vertical density gradients.

28. New Gap: There is a need to investigate ideas for using *acoustics to track subsurface plumes.*

29. New Gap: There is a need for *sensors for pressure and composition (to be built into Ops) to improve flow modeling*. Video analysis would help as well. There are existing sensors, but they need to be implemented.

30. New Gap: There is a *need for a drift buoy that follows the oil*.

31. New Gap: There is a need for a *mechanism to use vessels on-scene* (e.g., Coast Guard cutters) to perform assessments, particularly in the Florida Straits. This would require the vessels to carry a sensing package. This might also require pre-set packages to be stored at fishing piers for ready deployment.

32. New Gap: There is a need for *collaborative studies incorporating airborne and in-situ observations*; few studies look at the benefits of combining the two data types. This gap acknowledges the value of adding in-situ data to remote-sensing data.

33. New Gap: There is a need for *surface moorings in the Florida Straits*, but the high velocity jet makes this very difficult. There is a need for more understanding of the Florida Straits, powerful eddies, gyres, and vortices which can carry pollution in various ways. High frequency radar could fill the void in this strong current regime.

Recommendations for moving forward

The IRSSS participants identified a few areas where the science community has been making positive progress to the extent that it can be considered Good Work; however, there is clearly much work to be done on existing and new gap areas. The Gap discussions from this report should be compared to other lessons learned and the final reports from DWH and other incidents. Comparing the various report outputs and discussions will help to further understand where research funding should be prioritized. The time invested in such an activity will also improve our ability to communicate these specific issues within the loud chorus of different oil pollution research needs.

SCIENTIFIC FINDINGS, OVERARCHING OBSERVATIONS, AND RECOMMENDATIONS

When reviewing the findings of the plenary and breakout sessions, it is clear that significant progress has been made in understanding the oil spill, its fate in the marine environment, and the broad scale impacts to multiple sectors. Moreover, it is possible to break these findings into three distinct categories: scientific findings, overarching observations, and recommendations for the future. This closing section of this document will focus on each of these three items independently with an emphasis on highlighting the most salient findings from the meeting.

Summary of Scientific Findings

The following summary of scientific findings is drawn from the combination of science accomplishments presented in the plenary session, breakout session discussions, and in the submitted abstract, presentations, and posters. These findings are examples from the workshop that are representative of the many findings presented and discussed by the group as a whole and should not be considered the only findings from the workshop. Additional details on these findings can be found along with additional findings in each of the session summaries (See above), supplemental session information (Appendix 3), the supplemental abstracts and speaker information (Appendix 4), and in the presentations provided on the meeting website (http://www.marine.usf.edu/conferences/fio/NSTC-SOST-PI-2011/). Some salient examples of scientific findings include:

Extent of Oil Spreading: Analysis of observations and use of numerical models showed that wind forced ocean currents dominated the oil transport away from the spill site and that a hurricane or other low-pressure system could have dramatically altered ocean pathways of oil (see Fitzpatrick, *et al.*; Hamilton, *et al.*; Smith, *et al.*; and Paris, *et al.*).

Oceanic Fate of Oil: Observational analysis of research cruise data revealed unprecedented microbial respiration rates and oxygen consumption leading to full respiration of all released methane by methantrophic bacterial communities and the possibility of using naturally occurring marine substrates as effective bioremediation tools (see Kessler, *et al.*; Du, *et al*.; Sobecky *et al.*; Van Mooy *et al.*; Huettel *et al.*; and Mortazavi *et al.*).

Oceanic Fate of Oil: In addition to the cruise data above, state of the art equipment and models used to examine the impact of plumes on marsh, beach, and benthic found changes in chemical bonding nature, dramatic increases in sediment accumulation ("Dirty Blizzard"), and the likelihood that hydrocarbons will persist in poorly oxygenated swamps, beaches, and benthic areas for many years (see Deocampo *et al.*; Flower *et al.*; Srinivasan *et al.*; and North *et al.*).

Atmospheric Fate of Oil: Ship and aircraft data revealed that there was no measureable loss of methane to the atmosphere and that 40% surface oil evaporated within 2 days, leading to minimal downwind impact from aerosol plume landings (see Kessler, *et al.*; and De Gouw, *et al.*).

Impact on Living Marine Resources: Research demonstrated severe histological damage fish communities, contamination in coastal beach communities, toxicity induced changes in microbial and plankton community structure, and tissue loss and sclerite enlargement in deep coral communities (See Galvez, *et al.*; Bell, *et al.*; Jeffrey, *et al.*; White, *et al.*; Graham, *et al.*; and Montoya, *et al.*).

Impact on Human Health & Socio-Economics: Researchers presented early results indicating both direct and indirect human health and socio-economic impacts of the spill on Gulf Coast communities, including the aggregated impact of natural and man-made disasters in the Gulf over the last decade *(*see Peters, *et al.*; Abramson, *et al.*; Grattan, *et al.*; and Lovelace, *et al.*).

Use of In Situ Sensors and Systems: Researchers demonstrated a need for both calibration of sensors used in oil spill analysis (e.g. fluorometers) and the need for a robust system, integrated, and interdisciplinary system that integrates data to produce user friendly fusion products in an automated manner (see Roffer, *et al.*; Abercrombie, *et al.*; Howden, *et al.*; and Smith, *et al.*).

Overarching Observations

In addition to the more specific scientific observations and recommendations identified by the breakout groups relevant to their thematic areas, a number of more general, overarching observations were also identified. When reviewing these findings, it is important to consider that the primary objectives of the workshop were to bring together scientists from academic institutions, private research institutes, industry, state and federal agencies, and stakeholders active in the Gulf of Mexico to report recent scientific advances, explore scientific data and information needs, and further develop collaborative partnerships. The general overarching observations from the 2011 Deepwater Horizon Oil Spill Principal Investigators Workshop were:

We are making a lot of progress: We know a lot more about the oil spill, its impacts to the Gulf of Mexico ecosystem and surrounding communities, and our long term restoration needs than we did one year ago;

Gaps in our knowledge are closing but still remain: While we are making excellent progress collectively as a scientific community, many unknowns exist, and we have a lot of work to conduct to fully understand Gulf of Mexico ecosystem and its responses, both short and long term, to this iconic event;

New gaps in our understanding have emerged: Although we have conducted many studies and collected a lot of data to improve our understanding of the gaps identified in the 2010 workshop, many gaps still remain, and scientific discovery is identifying even more gaps that need to be addressed;

Resources have been used effectively: We have learned that success critically depends on collaboration across scientific disciplines, geographic boundaries, and traditional sectors. The events of the past year have maximized the use of resources across these arenas to raise the level of understanding of the Gulf of Mexico to unprecedented levels. Future advancements will require the same collaborative approach; and

Long-term monitoring and research are critical to long-term success: Our understanding of the Gulf of Mexico ecosystem and our ability to plan for, respond to, and recover from similar events in the future, whether in the Gulf of Mexico or beyond, critically depend on long-term monitoring and research.

Recommendations

Finally, the workshop discussions also led to a number of observations about gaps and needs for continued research and possible avenues the scientific community could explore together to further our scientific partnerships and understanding of Gulf of Mexico science issues. These recommendations include:

Establishment of an ecosystem-wide baseline is critical to future success: It is important to recognize the scientific community, academic, and Federal and state partners efforts to establish baseline information on select species (e.g., commercially important fish species) but that more emphasis needs to be placed on establishing ecosystem-wide baselines to help support future management in the Gulf of Mexico.

Timely access to information is needed for response, restoration and research efforts: The need for detailed response plans, trained personnel, and access to information when and where it is needed is critical to not only the response teams but also the research community routinely called upon to support response and restorations efforts and connect the collection of observations with model based results and on-the-ground response efforts.

Improving understanding of impacts requires complete knowledge of the ecosystem: There is still a need to evaluate the Gulf of Mexico at the ecosystem level to gain a holistic understanding of impacts from the Deepwater Horizon oil spill and the potential for restoration of target species like turtles, important open water habitats like *Sargassum*, and species that form the base of the food web like ichthyplankton.

Research is needed to improve understanding of health and economic impacts: We still lack a broad assessment of the health impacts on organisms (e.g. plankton, marine mammals, humans) resulting from the Deepwater Horizon oil spill; an understanding the acute and chronic effects of oil and dispersants on individual species and the overall ecosystem; and the overall economic impact to the communities served by the ecosystem.

Improved understanding of the fate of oil in the marine environment is needed: Notable gaps identified in the meeting included: understanding how dispersed and non-dispersed oil components interact with marine snow particles and re-suspended sediments; understanding the effect of dispersant on the fate and transport of oil in the deep sea when applied to a high flow rate leak; and the need for a Federal database of chemical composition of oil and natural gas from permitted wells.

Better training is needed for future scientists: Training should cover topics such as data management, communication with the public and agencies, and disaster preparation. This could also increase the pool of qualified people to assist in disaster response and assist the federal government, which was stretched very thin scientifically during the response.

Partnering is essential to our combined success: Our efforts in the Gulf of Mexico have shown the importance and impact of partnering across sectors. As we continue to move forward on Gulf of Mexico research and restoration, we also need to keep in mind that we share these waters and the species that occupy them with other countries (Mexico and Cuba) and international partnering will be important as we continue to understand this important ecosystem.

Appendix 1: Workshop Agenda

Day 1: What have we learned?

7:00-8:00 AM	***Registration (Continental Breakfast Provided)***	***Majestic Atrium***
8:00-8:10 AM	***Welcome and General Introduction*** *Jerry Miller (OSTP), SOST Co-Chair*	***Majestic Palm Ballroom***
8:10-8:50 AM	***Keynote: "Deepwater Horizon -- The Next Chapter"*** *Larry Robinson (NOAA)* *Assistant Secretary of Commerce for Oceans and Atmospheres*	***Majestic Palm Ballroom***
8:50-9:15 AM	***Workshop Goals and Objectives*** *Paul Sandifer (NOAA), SOST Co-Chair* *Rudy Schuster (USGS), Program Committee*	***Majestic Palm Ballroom***
9:15-10:00 AM	***Plenary: Overview of the Issues – Part I*** *Moderated by David Conover (NSF), SOST Co-Chair* • Oil/dispersant - ***extent and fate*** *Tom Ryerson, NOAA* • Oil/dispersant - impacts and mitigation in ***coastal environments*** *Yonggang Liu, USF*	***Majestic Palm Ballroom***
10:00-10:30 AM	***Break (Coffee and light refreshments provided)***	***Majestic Atrium***
10:30 AM – 12:00 PM	***Plenary: Overview of the Issues – Part II*** *Moderated by David Conover (NSF), SOST Co-Chair* • Oil/dispersant - impacts and mitigation in ***offshore environments*** *Ray Highsmith, University of Southern Mississippi* • Oil/dispersant - impacts and mitigation on ***human health and socio-economic systems*** *Lynn Grattan, University of Maryland* • Oil/dispersant-impacts and mitigation on ***living marine resources*** *Steve Murawski, USF* • Use of ***in situ and remote sensors, sampling and systems*** for assessing extent, fate, impacts, and mitigation of oil/dispersant *Mitch Roffer, Roffer's Ocean Fishing Forecasting Service, Inc.*	***Majestic Palm Ballroom***
12:00-1:00 PM	***Lunch (Provided)***	***Majestic Atrium***
1:00-3:00 PM	***Concurrent Science Sessions***	
	• Oil/dispersant - ***extent and fate***	***King Palm Room***
	• Oil/dispersant - impacts and mitigation in ***coastal environments***	***Queen Palm Room***
	• Oil/dispersant - impacts and mitigation in ***offshore environments***	***Date & Blue Palm Room***
	• Oil/dispersant - impacts and mitigation on ***human health and socio-economic systems***	***Sable & Canary Palm Room***
	• Oil/dispersant-impacts and mitigation on ***living marine resources***	***Royal Palm Room***
	• Use of ***in situ and remote sensors, sampling and systems*** for assessing extent, fate, impacts, and mitigation of oil/dispersant	***Majestic Palm Room*** *(Rear Third)*
3:00-3:15 PM	***Break (Coffee and light refreshments provided)***	***Majestic Atrium***
3:15-5:00 PM	***Concurrent Science Sessions (continued)***	
5:00-5:30 PM	***Break***	
5:30-7:30 PM	***Poster Session and Social Reception***	***Royal Palm Room***

Day 2: Where do we go from here?

8:00-10:00 AM	***Breakout Groups: Gaps and Future Direction Discussion*** *Facilitated group discussion with the goal of identifying short-term knowledge gains, continued knowledge gaps, and high priority science and research needs.*	
	• Oil/dispersant - ***extent and fate*** *Julien Lartigue (NOAA), Facilitator*	***King Palm Room***
	• Oil/dispersant - impacts and mitigation in ***coastal environments*** *Steven Sempier (MS/AL Sea Grant), Facilitator*	***Queen Palm Room***
	• Oil/dispersant - impacts and mitigation in ***offshore environments*** *Walter Johnson (BOEM), Facilitator*	***Date & Blue Palm Room***
	• Oil/dispersant - impacts and mitigation on ***human health and socio-economic systems*** *Rudy Schuster (USGS) and Allen Dearry (NIH), Facilitators*	***Sable & Canary Palm Room***
	• Oil/dispersant-impacts and mitigation on ***living marine resources*** *Cathy Tortorici (NOAA), Facilitator*	***Royal Palm Room***
	• Use of ***in situ and remote sensors, sampling, and systems*** for assessing extent, fate, impacts, and mitigation of oil/dispersant *CDR Eric Miller (U.S. Coast Guard), Facilitator*	***Majestic Palm Room*** *(Rear Third)*
10:00-10:15 AM	***Break (Coffee and light refreshments provided)***	***Majestic Atrium***
10:15 AM - 12:00 PM	***Breakout Groups: Gaps and Recommendations (Continued)***	
12:00-1:00 PM	***Lunch (Provided)***	***Majestic Atrium***
1:00-3:30 PM	***Plenary: Report Outs from Breakout Groups*** *Moderated by Paul Sandifer (NOAA), SOST Co-Chair* • Oil/dispersant - ***extent and fate*** • Oil/dispersant - impacts and mitigation in ***coastal environments*** • Oil/dispersant - impacts and mitigation in ***offshore environments*** • Oil/dispersant - impacts and mitigation on ***human health and socio-economic systems*** • Oil/dispersant-impacts and mitigation on ***living marine resources*** • Use of ***in situ and remote sensors, sampling, and systems*** for assessing extent, fate, impacts, and mitigation of oil/dispersant	***Majestic Palm Ballroom***
3:30-3:45 PM	***Break (Coffee and light refreshments provided)***	***Majestic Atrium***
3:45-5:00 PM	***Plenary: Synthesis, Group Insights, and Next Steps*** *Moderated Jerry Miller (OSTP), SOST Co-Chair*	***Majestic Palm Ballroom***
5:00 PM	***Adjourn***	

APPENDIX 2: WORKSHOP PARTICIPANTS

Last Name	First Name	Organization
Abercrombie	Mary	USF College of Marine Science
Abramson	David	Columbia University
Allen	LaTrisha	Florida A&M University
Allen*	Mike	NOAA
Baker	Kyle	NOAA Fisheries
Baldera	Alexis	Ocean Conservancy
Bell	Susan	USF Department of Integrative Biology
Boland	Gregory	Bureau of Ocean Energy Management
Booth*	LT Sara	U.S. Coast Guard
Bostater	Charles	Florida Institute of Technology
Bourque	Jill	USGS
Brannock	Pamela	Auburn University
Brooks	Allen	Cardno ENTRIX
Chen	Q. Jim	Louisiana State University
Cho	Walter	Woods Hole Oceanographic Institution
Cho	Hyun Jung	Bethune-Cookman University
Clarke	Lora	NOAA
Conover	David	NSF
Coolbaugh	Thomas	ExxonMobil Research and Engineering
Craig	Leslie	NOAA
Crespo-Medina	Melitza	University of Georgia
D'Elia	Christopher	LSU School of the Coast and Environment
Daly	Kendra	University of South Florida
de Gouw	Joost	NOAA Earth System Research Laboratory
Dearry*	Allen	National Institutes of Health
Declerck	Alan	Liquid Robotics
Deocampo	Daniel	Georgia State University
Dickey*	Robert	FDA/CFSAN
Die	David	University of Miami
Dietl	Gregory	Paleontological Research Institution
DiPinto	Lisa	NOAA
Dixon	Jacqueline	USF College of Marine Science
Doyle	Thomas	US Geological Survey
Du	Mengran	Texas A&M University
Dzwonkowski	Brian	Dauphin Island Sea Lab
Eastham	Samuel	New College of Florida
Elferink	Cornelis	University of Texas Medical Branch at Galveston
Farris	Kali	Florida A&M University
Fitzpatrick	Pat	Mississippi State University
Flower	Benjamin	University of South Florida
Ford	Mark	National Park Service
Gallagher	Tim	NOAA
Galvez	Fernando	Louisiana State University; Biological Sciences
Garcia-Pineda	Oscar	Florida State University
Ge	Yufeng	Texas A&M University

Last Name	First Name	Organization
Geiger	Stephen	Florida Fish and Wildlife Commission
Gibeaut	Jim	Gulf Research Initiative
Gielazyn	Michel	NOAA
Gowlinowski	Greg	ROFFS
Graham	William	University of Southern Mississippi
Grattan	Lynn	University of Maryland School of Medicine
Green*	Rebecca	Bureau of Ocean Energy Management
Guo	Laodong	University of Southern Mississippi
Halanych	Kenneth	Auburn University
Hamilton	Peter	SAIC
Harry	Luton	BOEM Gulf of Mexico Region
Hart	Kristen	USGS
Hastings	David	Eckerd College
Haus	Brian	University of Miami
Hernandez Jr.	Frank	Dauphin Island Sea Lab
Highsmith	Ray	NIUST, University of Mississippi
Hine	Graham	Liquid Robotics, Inc.
Hoffmayer	Eric	NOAA Fisheries
Hogarth	William	USF Florida Institute of Oceanography
Hollander	David	USF College of Marine Science
Holzinger	Chloe	Eckerd College
Hood	Peter	NOAA Fisheries
Hooper-Bui	Linda	LSU A&M and LSU AgCenter
Howden	Stephan	University of Southern Mississippi
Hu	Xinping	University of Georgia
Huettel	Markus	Florida State University
Jagoe	Charles	Florida A&M University
Jeffrey	Wade	University West Florida
John	Chandy	Cardno ENTRIX
Johnson*	Walter	Bureau of Ocean Energy Management
Kessler	John	Texas A&M University
Kiene	William	NOAA Office of National Marine Sanctuaries
Kinner	Nancy	Coastal Response Research Center
Kirsch	Kevin	NOAA OR&R
Klemm	Dennis	NOAA-Southeast Region
Kovach	Charles	Florida Department of Environmental Protection
Lamkin*	John	NOAA Southeast Fisheries Science Center
Lartigue*	Julien	NOAA
Lauenstein	Gunnar	NOAA National Centers for Coastal Ocean Science
Leonardi*	Alan	NOAA Atlantic Oceanographic & Meteorological Laboratory
Levine	Ed	NOAA OR&R
Lewis	Christopher	IEc
Liu	Yonggang	University of South Florida
Lovelace	Susan	NOAA/NOS/NCCOS Hollings Marine Laboratory
Luton	Harry	Bureau of Ocean Energy Management
Lymperopoulou	Despoina	Florida A&M University
Magdol	Zachary	Coastal Response Research Center
Malinowski	Richard	NOAA National Marine Fisheries Service

Last Name	First Name	Organization
Mate	Bruce	Oregon State University
McLaughlin	Richard M	UNC Chapel Hill
McLean	Craig	NOAA Office of Oceanic and Atmospheric Research
Mezic	Igor	University of California Santa Barbara
Miller*	CDR Eric	U.S. Coast Guard
Miller	Jerry	NOAA Office of Oceanic and Atmospheric Research
Montagna	Paul	Texas A&M University – Corpus Christi Harte Research Institute
Montoya	Joseph	Georgia Tech University
Moretzsohn	Fabio	Texas A&M University-Corpus Christi
Morrison	Melissa	CDC/Alabama Department of Public Health
Mortazavi	Behzad	University of Alabama
Moses	Christopher	NOAA
Muller-Karger	Frank	USF Florida Institute of Oceanography
Murawski	Steve	University of South Florida
Nedwed	Tim	ExxonMobil Upstream Research Company
Nikhil	Mehta	NOAA NMFS - Southeast Region
North	Elizabeth	University of Maryland Center for Environmental Science
O'Connor	Brendan	University of South Florida
Ogden	John	University of South Florida
Package	Christina	NOAA
Pardue	John	Louisiana State University
Paris	Claire	UM RSMAS
Passow	Ute	University of California Santa Barbara
Paul	John	University of South Florida
Peebles	Ernst	University of South Florida
Perring	Anne	NOAA Cooperative Institute for Research in Environmental Sciences
Peters	Edward	LSUHSC-NO School of Public Health
Pierce	Richard	Mote Marine Laboratory
Primo	John	Bureau of Ocean Energy Management
Proffitt	Ed	Florida Atlantic University
Reed	Dave	USF Florida Institute of Oceanography
Reynolds*	Kevin	Department of the Interior
Rice*	Donald	National Science Foundation
Rindone	Ryan	Gulf of Mexico Fishery Management Council
Robertson	Boakai	Alabama State University
Robinson	Larry	NOAA
Roffer	Mitchell	ROFFS
Ross	Katherine	
Roy	Amitava	Louisiana State University
Ryerson	Tom	NOAA
Sandifer	Paul	NOAA
Schrope	Mark	
Schuster*	Rudy	USGS
Sempier*	Steve	Mississippi-Alabama Sea Grant Consortium
Serafy	Joseph	NOAA
Shay	Lynn (Nick)	UM RSMAS

Last Name	First Name	Organization
Shiller	Alan	University of Southern Mississippi
Simoniello	Chris	Institute for Marine Mammal Studies
Smith	Ryan	NOAA Atlantic Oceanographic and Meteorological Laboratory
Sobecky	Patricia	University of Alabama
Srinivasan	Sesha	Tuskegee University
Taylor	Caz	Tulane University
Thomas	Glenn	Louisiana Department of Wildlife and Fisheries
Tortorici*	Cathy	NOAA Fisheries
Van Mooy	Benjamin	Woods Hole Oceanographic Institute
Virmani	Jyotika	USF Florida Institute of Oceanography
White	Helen	Haverford College
Whitehead	Andrew	Louisiana State University
Wood	Michelle	NOAA Atlantic Oceanographic and Meteorological Laboratory
Wu	Yejun	Louisiana State University
Zhou	Zhengzhen	University of Southern Mississippi

*Denotes Member of the Planning Committee

APPENDIX 3: SUPPLEMENTAL SESSION INFORMATION

WORKSHOP FORMAT

An IPA tool was used to organize information from the DWH workshop. IPA was originally employed to measure customer satisfaction and to refine marketing strategies associated with specific products. It was conceptualized as a tool to provide an understanding of the needs and desires of clients as part of the management decision-making process. The overall goal of IPA is to provide managers and decision makers with information to facilitate efficient resource allocation. IPA does not make final decisions; IPA is a tool that helps conceptualize the problem and inform decisions about how institutional resources can be allocated. The IPA method has been adapted to include quantitative (e.g., survey questionnaire) and qualitative (e.g., focus group) data collection and used in contexts such as tourism and hospitality,[4] education,[5] health care,[6] and park visitor use, ecotourism, and related management.[7]

Recently, the IPA approach has been adapted to address natural resource management. Lemieux et al. (2012)[8] used it to assess natural resource managers' perceptions about agency institutional performance in adapting public land management policies with respect to climate change. The IPA approach was also used during a series of expert consultation workshops conducted by the United States Geological Survey as part of an evaluation of the science needs to inform decisions on outer continental shelf energy development in the Chukchi and Beaufort seas in Alaska.[9]

IPA uses two questions rated on five-point scales to evaluate the importance of an issue or attribute and the institutional performance on that attribute. The results are displayed on a four-quadrant grid. Each of the quadrants is labeled based on the results of the importance and performance questions. The initial lists of issues to be rated at the 2011 workshop (one for each theme) were generated from the final report of the 2010 workshop. Those lists were presented to workshop participants who were asked to review the list, identify issues not listed, and revise and rate all issues. The two questions and response scales used at the DWH workshop are shown in Table 1.

The four grid quadrants created based on these questions are labeled in Figures 1-5. Very important issues lacking in information landed in the *Gap* quadrant. A gap is an area where focusing attention should be considered. An important issue for which robust information is available was placed in the *Good Work* quadrant. These are issues where resources meet needs and might be areas where resources could be reallocated. Issues of low importance with robust information were located in the *Rescale* quadrant. Resources being spent in the rescale quadrant

---

[4] **Vaske V., Beaman J., Stanley R. and Grenier, M.** 1996. Importance-performance and segmentation: Where do we go from here? Journal of Travel and Tourism Marketing. 5: 225-240.
Go F. and Zhang W. 1997. Applying importance-performance analysis to Beijing as an International meeting destination. Journal of Travel Research. 35: 42-49.
Oh H. 2001. Revisiting importance-performance analysis. Tourism Management. 22: 617-627.
Ziegler J., Dearden P. and Rollins, R. 2011. But are tourists satisfied? Importance-performance analysis of the whale shark tourism industry on Isla Holbox, Mexico. Tourism Management. 33: 692-701.

[5] **Alberty S., and Mihalik B.** 1989. The use of importance-performance analysis as an evaluative technique in adult education. Evaluation Review. 13: 33-44.
O'Neill M. and Palmer A. 2004. Importance-performance analysis: A useful tool for directing continuous quality improvement in higher education. Quality Assurance in Education. 12: 39-52.

[6] **Hawes J. and Rao C.** 1985. Using importance-performance analysis to develop health care marketing strategies. Journal of Health Care Marketing. 5: 19-25.
Dolinsky A. and Caputo R. 1991. Adding a competitive dimension to importance-performance analysis: An application to traditional health care systems. Health Marketing Quarterly. 8: 61-79.

[7] **Hammit W., Bixler R. and Noe F.** 1996. Going beyond importance-performance analysis to analyze the observance-influence of park impacts. Journal of Park and Recreation Administration. 14: 45-62.
Wade D. and Eagles P. 2003. The use of importance–performance analysis and market segmentation for tourism management in parks and protected areas: An application to Tanzania's national parks. Journal of Ecotourism. 2: 196-212.
Tonge, J. and Moore, S. 2007. Importance-satisfaction analysis for marine-park hinterlands: A Western Australian case study. Tourism Management. 28: 768-776.

[8] **Lemieux C., Thompson J. and Schuster R.** (in review). Resource manager perceptions of institutional performance on climate change adaptation: a parallel case study analysis of two mid-western U.S. regions. Environment and Planning C. Government and Policy.

[9] **Holland-Bartels, L. and Pierce, B., eds.** 2011. An evaluation of the science needs to inform decisions on Outer Continental Shelf energy development in the Chukchi and Beaufort Seas, Alaska. U.S. Geological Survey Circular 1370. 278 p.

might be reallocated or the scientific questions being asked might be reconsidered to better address needs. Issues found in the *Reassess* quadrant were rated as not important and with little information available. The process does not ignore these issues. Decision makers should ask if issues in the Reassess quadrant are being accurately framed to ensure that important issues are not overlooked.

The use of the IPA grid tool allowed facilitators and participants to: (1) revisit the gaps identified in last year's meeting; (2) assess how well gaps have been addressed thus far; (3) identify new gaps; and (4) highlight accomplishments in addressing gaps to this point.

Table 1: Importance-Performance Science Needs Grid Questions

How much scientific information is available for issue XX				
No information available at all	Information with high uncertainty or very limited in scope, scale, or functionality for decision making	Body of information expanding but with notable insufficiencies	Good body of Information across most aspects of issue with limited uncertainty. Data gaps may exist for minor elements	Robust information and functional for decision making
0	1	2	3	4

How important is issue XX in preparing for, responding to, and recovering from oil spills?				
Not important at all	Slightly important, but not a primary consideration	Moderately important, but not consistently considered	Important consideration in most cases	Very important in preparing & responding
0	1	2	3	4

OIL AND DISPERSANT: EXTENT AND FATE

Table 2. List of participants for the extent and fate session at the 2011 workshop.

Participant	Affiliation
Coolbaugh, Tom	Exxon Mobil Research and Engineering
de Gouw, Joost	NOAA
Du, Mengran	Texas A&M University
Dzwonkowski, Brian	Dauphin Island Sea Lab
Green, Rebecca	Bureau of Ocean Energy Management
Guo, Laodong	University of Southern Mississippi
Hahn, Daniel	NOAA
Haus, Brian	University of Miami
Hu, Xinping	University of Georgia
Kessler, John	Texas A&M University
Kinner, Nancy	University of New Hampshire
Kovach, Charles	Florida Department of Environmental Protection
Liu, Yonggang	University of South Florida
Mezic, Igor	University of California Santa Barbara
North, Elizabeth	University of Maryland Center for Environmental Science
Paris, Claire	University of Miami
Perring, Anne	NOAA Cooperative Institute for Research in Environmental Sciences
Roy, Amitava	Louisiana State University
Ryerson, Tom	NOAA
Van Mooy, Benjamin	Woods Hole Oceanographic Institution
Wu, Yejun	Louisiana State University

Table 3. Mean scores and standard deviations of the rating of "How important is issue XX in preparing for, responding to, and recovering from oil spills" (Importance) and "How much scientific information is available for issue XX" (Amount of Information) for science issues identified in the 2010 and 2011 (indicated by a *)workshops. Italics denote scientific issues for which participants submitted ratings via a written scoring sheet after the session without the issue being discussed within the session (10 of 20 participants turned in a scoring sheet).

Scientific Issues	Importance		Amount of Information	
	Mean	Std. Dev.	Mean	Std. Dev.
Big Picture				
Comprehensive observing system in the U.S. (includes natural baselines, e.g., seeps, and prioritizes oil-producing regions)	1.33	0.47	3.83	0.37
Assessment of data limitations	*2.29*	*0.45*	*3.25*	*0.83*
Assessment of coordination and communication	*2.43*	*0.49*	*2.88*	*0.60*
Assessment of data management	*2.25*	*0.43*	*2.88*	*0.78*
Systematic assessment of the capabilities and methods used to detect oil and oil degradation products and development of best practices	*2.20*	*0.40*	*3.38*	*0.70*
Oil budget and partitioning of fractions (i.e., fractionation of the oil and its location)	2.17	0.37	3.88	0.33
Long-term studies on chemical, biological, and ecosystem processes	2.00	0.00	3.33	0.47
Sampling and monitoring of oil transport in the subsurface	*1.57*	*0.73*	*3.63*	*0.48*
Sampling and monitoring of oil transport at the surface	*2.71*	*0.70*	*3.63*	*0.48*
Sampling and monitoring of atmospheric processes	*1.86*	*0.64*	*2.88*	*1.05*
*Effects of hydrodynamic mixing on oil transport and mixing (observations and modeling)	2.00	0.67	3.18	0.83
*Transparency of new research, e.g., list of funded proposals and timeline for deliverables (NSF, GOMRI, NOAA, BOEM, API, OGP, NIEHS, and others)	2.11	0.31	2.92	0.49
Modeling				
Identify optimal data streams (e.g., parameters and locations) for monitoring to better develop and validate numerical models	2.38	0.48	3.13	0.60
Modeling of oil transport in the subsurface	*2.50*	*0.87*	*3.38*	*0.70*
*Systematic validation techniques for quantifying uncertainties in ocean circulation and oil transport	2.57	0.73	4.00	0.00
**Model data needs for deep-sea models*	*2.00*	*0.71*	*3.56*	*0.50*
Validate and develop models that have the potential to model three-dimensional dispersal	*1.75*	*0.43*	*3.33*	*0.67*
Atmospheric Processes				
Improve efforts to collect adequate time series of atmospheric chemistry measurements	*1.83*	*0.69*	*3.14*	*0.99*
Improve understanding of how oil burning at the surface influences the fate, extent, and transformation of petroleum	*2.14*	*0.83*	*2.75*	*0.97*
**Evaporative processes and fate of evaporated oil*	---	---	---	---
Modeling of atmospheric processes	*2.60*	*0.49*	*2.67*	*1.11*
Interaction with Sediments and Resuspension				
Interactions of dispersed and non-dispersed oil components with marine snow particles and resuspended sediments (all pathways)	*1.00*	*0.00*	*3.10*	*0.30*
Resuspension of oil products and transport after a spill	*1.75*	*0.43*	*2.89*	*0.57*
**Fate of oil deposited in sediment and colloidal suspensions, especially degradation rates in different types of sediment*	*2.00*	*0.71*	*3.25*	*0.43*
Evaluate and model the impact of hurricanes and tropical storms on oil/dispersant extent and fate	*1.50*	*0.50*	*2.56*	*0.83*

Table 3. (Continued)

Scientific Issues	Importance		Amount of Information	
	Mean	Std. Dev.	Mean	Std. Dev.
Dispersant				
Identifying dispersant Corexit 9500 in the subsurface environment using DOSS as a target analyte and ultra-high resolution mass spectrometry	*1.83*	*1.07*	*3.00*	*0.93*
Capacity to measure efficacy of dispersant injected at the wellhead	*1.00*	*0.58*	*3.57*	*0.49*
Investigate dispersant delivery systems and their effectiveness with regard to surface oil	*2.00*	*1.10*	*2.60*	*0.49*
*Effect of dispersant on deposition, partitioning, toxicity, and degradation (deep sea and in presence of high flow rates)	0.58	0.49	3.85	0.36
*Effect of dispersant on deposition, partitioning, toxicity, and degradation (surface)	2.00	1.05	3.62	0.49
**Measuring the efficacy of dispersant*	---	---	---	---
Effects of dispersants on toxic components on oil (e.g., whether dispersants increase the bioavailability of toxic oil compounds)	*1.33*	*1.25*	*3.57*	*0.49*
Detection				
Assessment and comparison of methods for collecting water samples for oil and oil detection	3.00	0.00	3.30	0.46
Detection of subsurface oil via in-situ techniques (fluorometry and others)	3.00	0.00	3.91	0.29
*Quantification of subsurface oil via in-situ techniques (fluorometry and others)	1.33	0.47	3.50	0.50
Understanding of how sonar and other geophysical techniques detect oil	2.13	0.33	2.75	0.66
Increase remote sensing data resolution in the nearshore and inland seas and along coastlines	*3.00*	*0.00*	*3.50*	*0.76*
Assessment of techniques for measuring flow rates (gas and oil) during subsea release (NOTE: Information access for responders and researchers is important)	2.78	0.42	3.78	0.42
Assessment of techniques for measuring droplet and bubble sizes for subsurface release	2.20	0.75	3.27	0.45
Assessment of techniques for measuring the chemical composition and physical transformation of oil	2.67	0.67	3.55	0.50
Other				
Functional attributes of the microbial organisms that are degrading oil products	*1.83*	*0.69*	*3.00*	*0.93*
Fate and extent of the most toxic compounds and metabolites	2.43	0.49	3.64	0.64
Federal database for chemical composition of oil and natural gas from wells (part of permitting process and immediate access for researchers in the advent of a spill)	0.50	0.87	3.75	0.43
*Capacity to determine rates of microbial degradation in different environments, both in preparation for a response and during a response (e.g., temperature-dependent rates, bioassays, prioritized methods)	1.18	0.39	3.30	0.64
**Routine monitoring for surface tarballs and tarball landings on beaches*	---	---	---	---

OIL AND DISPERSANT IMPACTS AND MITIGATION IN COASTAL ENVIRONMENTS

Table 4. List of participants for the coastal section at the 2011 workshop.

Participant	Affiliation
Allen, Mike	NOAA
Bell, Susan	University of Southern Florida
Brannock, Pamela	Auburn University
Chen, Qin Jim	Louisiana State University
Cho, Hyun Jung	Bethune-Cookman University
D'Elia, Christopher	LSU School of the Coast & Environment
Deocampo, Daniel	Georgia State University
Geiger, Steve	Florida Fish and Wildlife Commission
Graham, Monty	University of Southern Mississippi
Hargrove, Don	National Park Service
Hooper-Bui, Linda	Louisiana State University
Huettel, Markus	Florida State University
Jeffrey, Wade	University of West Florida
Kirsch, Kevin	NOAA
Kunzelman, Jennifer	NOAA
Lauenstein, Gunnar	NOAA
Lymperopoulou, Despoina	Florida A&M University
Mortazavi, Behzad	Dauphin Island Sea Lab
Pardue, John	Louisiana State University
Proffitt, C. Edward	Florida Atlantic University
Reynolds, Kevin	Department of Interior
Sempier, Steve	Mississippi-Alabama Sea Grant Consortium
Sobecky, Patricia	University of Alabama

Table 5. Mean scores and standard deviations of the rating of "How important is issue XX in preparing for, responding to, and recovering from oil spills" (Importance) and "How much scientific information is available for issue XX" (Amount of Information) for science issues identified in the 2010 and 2011 workshops.

Scientific Issues	**Importance**		**Amount of Information**	
	Mean	Std. Dev.	Mean	Std. Dev.
Baselines				
Baselines for sediment contamination	3.91	0.29	1.54	0.52
Baselines for water contamination	3.76	0.44	1.77	0.60
Baselines for animal tissue contamination	3.69	0.48	2.27	0.65
Baselines in underrepresented environments (e.g., Arctic)	3.57	0.65	1.14	1.10
Baseline for atmospheric composition	2.92	0.86	1.41	1.00
Impact Assessment				
Potential for oil remobilization in coastal and nearshore environments	3.64	0.84	1.35	N/A
Linkages between systems, including life histories and trophic linkages (holistic perspective)	3.61	0.51	1.31	0.75
Look at trophic effects	3.57	0.65	1.46	0.88
Access to oil for analysis and experimentation	3.50	0.76	1.75	1.14
Identify and quantify oil and dispersant contamination in coastal regions	3.46	0.78	1.50	0.67
Characterize impacts on ecosystems and ecosystem services	3.42	0.67	1.92	0.76
Predict impacts on ecosystems and ecosystem services at given levels of contamination	3.38	0.51	1.75	0.97
Assess the signal relative to background noise in various systems	3.36	0.74	1.38	0.77
Quantify impacts of oil on nutrient cycling	3.33	0.65	1.50	0.67
Quantify the dynamics of oil exposure	3.23	0.73	1.83	0.83
Link socio-economic data to coastal issues	3.23	0.60	1.83	1.03
Understand seasonality as a factor influencing impacts in coastal habitats	3.20	0.83	1.53	0.78
Quantify associated impacts on sea grass and marsh vegetation	3.20	0.83	1.91	0.67
Quantify impacts of oil on carbon cycling	2.84	0.82	1.90	0.83
Use more sensitive standards and more streamlined approval processes for methodologies for field and lab work	2.80	1.23	1.42	1.16
groundwater impacts	2.78	0.97	1.38	1.04
Quantify atmospheric contamination and impacts on coastal environments	2.50	1.09	1.15	0.69
Identify impacts on ecosystems and ecosystem services that have already been observed	2.41	1.24	2.15	0.80

Table 5. (Continued)

Scientific Issues	Importance		Amount of Information	
	Mean	Std. Dev.	Mean	Std. Dev.
Remediation and Response				
Identify potential negative impacts of response and mitigation strategies	3.64	0.63	1.35	1.01
Determine the extent of buried oil	3.36	0.63	1.31	1.11
Identify the effectiveness of different mitigation strategies	3.30	1.11	1.84	0.99
Improve remediation techniques	3.21	0.89	2.21	0.97
Understand potential implications of oil contamination for borrowing/dredging of sand for beach re-nourishment	2.40	0.63	1.40	1.12
Monitoring and modeling				
Develop a better understanding of short-term versus long-term effects, i.e., the need for sustained ecosystem observations and modeling to understand impacts on coastal biota and ecosystem function and structure	3.69	0.63	1.27	1.10
Conduct sustained ecosystem observations	3.58	0.90	1.25	1.06
Identify methods and techniques that are appropriate for monitoring and detecting contaminants in different coastal environments	3.38	0.96	2.07	1.19
Need infrastructure to easily access data from different locations	3.29	0.73	2.00	0.65
Develop better means of assessing nearshore subsurface oil, i.e., submerged or sediment-entrained oil	3.21	0.89	1.47	1.13
Effectively monitor and detect contamination in different environments	3.20	0.93	1.91	1.22
Understand long-term impacts through modeling	3.15	1.21	2.00	0.95
Conduct risk assessment in coastal environments	3.07	1.19	1.31	1.18
Characterize oil transport and deposition in coastal environments	3.00	1.04	1.30	0.63
Characterize oil transport by waves and associated oil exposure and distribution on shorelines	2.90	0.95	1.60	1.12
Improve sensor technology	2.53	1.13	2.07	0.86
Obtain additional aerial surveys for examining spatial heterogeneity of impacts	2.23	1.09	2.18	1.25
Evaluate sensor technology and remediation techniques, perhaps with an intentional, controlled spill	1.90	1.24	1.67	0.98

Table 5. (Continued)

Scientific Issues	Importance		Amount of Information	
	Mean	Std. Dev.	Mean	Std. Dev.
Coordination and Science Communication				
Establish rapid response disaster funding/trust	3.92	0.28	0.92	0.76
Improve data-sharing and communication between federal and non-federal scientists	3.92	0.28	1.15	1.07
Enable rapid response of scientists	3.92	0.28	1.41	1.16
Include science in disaster legislation	3.84	0.38	1.08	1.31
Improve federal, academic, and NGO coordination	3.71	0.47	1.28	0.83
Improve the means of conveying information about toxicity of oil in the coastal zone to the public	3.71	0.61	1.69	0.85
Increase awareness of the institutional capacity of scientists	3.70	0.47	1.18	0.75
Communicate science effectively with policy makers (print and non-print)	3.67	0.62	1.36	1.01
Mission coordination and need to work in complement with operational framework	3.53	0.66	1.30	0.95
Improve structure of leadership from local to national levels	3.53	0.64	1.38	1.04
Establish an oil spill research clearing house to link data bases, share information, review previous work, coordinate field work, etc.	3.50	0.65	1.78	1.05
Educate the American public on the process of science	3.42	0.65	1.61	0.96
Allow for independent findings and observations to be assimilated into the overall response and sampling strategy	3.41	1.00	1.50	0.67
Provide training for scientists for talking with the public/press	3.36	0.81	1.85	0.80
Establish state availability of funds	3.30	0.87	1.38	1.04
Provide training for future scientists	3.30	0.74	1.92	0.92
Standardize methodologies and facilitate inter-laboratory comparisons	3.23	0.83	1.30	1.06
Address the large inventory of samples that have no immediate funding for analysis	2.69	1.18	1.36	1.01
Determine how federal lands are managed differently due to different mandates	2.67	1.07	2.00	0.95
Identify methodologies being used by the different NRDA Technical Working Groups	2.61	1.45	1.38	1.26
Evaluate the difference between both NRDA and non-NRDA methodologies in studying spill impacts	2.10	1.51	1.35	1.22
Identify opportunities for other scientists to be involved in NRDA efforts	1.61	1.33	1.38	1.39

OIL AND DISPERSANT IMPACTS AND MITIGATION IN OFFSHORE ENVIRONMENTS

Table 6. List of participants for the Human Health and Socio-economic Systems section at the 2011 workshop.

Participant	Affiliation
Allen, LaTrisha	Florida A&M University
Baldera, Alexis	Ocean Conservancy
Boland, Gregory	Bureau of Ocean Energy Management
Bourque, Jill	USGS
Brannock, Pamela	Auburn University
Brooks, Allen	Cardno ENTRIX
Cho, Walter	Woods Hole Oceanographic Institution
Crespo-Medina, Melitza	University of Georgia
Daly, Kendra	University of South Florida
Dixon, Jackie	University of South Florida College of Marine Science
Farris, Kali	Florida A&M University
Flower, Benjamin	University of South Florida
Halanych Ken	Auburn University
Hamilton, Peter	SAIC
Hastings, David	Eckerd College
Highsmith, Ray	NIUST, University of Mississippi
Hollander, David	University of South Florida College of Marine Science
Holzinger, Chloe	Eckerd College
Jagoe, Chuck	Florida A&M University; NOAA ECSC
Johnson, Walter	Bureau of Ocean Energy Management
Kiene, Bill	NOAA Office of National Marine Sanctuaries
Lewis, Topher	IEc
Mate, Bruce	Oregon State University
McLean, Craig	NOAA OAR
Montagna, Paul	Texas A&M University – Corpus Christi
Montoya, Joe	Georgia Tech University
Nedwed, Tim	ExxonMobil Upstream Research Company
Passow, Ute	University of California Santa Barbara
Rice, Don	National Science Foundation
Ryerson, Tom	NOAA
Shiller, Alan	University of Southern Mississippi
White, Helen	Haverford College

Table 7. Mean scores and standard deviations of the rating of "How important is issue XX in preparing for, responding to, and recovering from oil spills" (Importance) and "How much scientific information is available for issue XX" (amount of Information) for science issues identified in the 2010 and 2011 workshops.

Scientific Issues	**Information** Mean	**Importance** Mean
Offshore Environments		
Overarching Issue - Effects and fates of dispersants	2	4
Impacts on benthos and pelagic species	2	4
Impacts on neuston	0.5	3
Indicator species/communities	1	4
Develop genetic tools to monitor offshore environments	2	4
Develop transcriptomic tools to monitor offshore environments	2	4
Determine persistent sublethal effects and estimate recovery	1	4
Estimate exposure and impacts, based on observations	2	4
Observe the changes in nutrients	2	3
Observe the changes in plankton communities	1	4
Observe changes in the biogeochemistry of offshore waters	2	4
Impacts on sediments	1	4
Assess ecosystem impacts via data assimilation and modeling	1	4
Transport and depositional mechanisms	1	4
Distribution of mobile higher trophic level species	2	4
High pressure studies of impacts	1	4
Monitoring Plans		
Revisit existing monitoring sites	1	4
Augment with new sites for different habitats – coral, seep, etc.	1	4
Conduct transect studies for soft bottom	1	4
Strive for consistent data sets	1	3
Determine complete set of sensors	1	3
Provide dedicated infrastructure of ships and submersibles	1	4
Improve coordination among existing efforts and data sets	2	4
Continue discussion among different agencies	2	3
Make multibeam data sets available	3	4
Release industry three-dimensional seismic data	3	4
Integrate databases	2	4
Offshore Deepwater Observatories		
Eastern, central, western Gulf	1	3
Nearshore to deep-water swaths	1	3
High-resolution mapping at each monitoring site	1	3
Instrumented site for each habitat type	1	3
Regularly revisited	1	3
Long term ecological research	1	3
Database Needs		
Operationalize distribution of real-time data and quality-controlled data	2	4
Continued collaborative approach including government, academia, and industry	2	4

OIL AND DISPERSANT IMPACTS AND MITIGATION ON LIVING MARINE RESOURCES

Table 8. List of participants for the Living Marine Resource section at the 2011 workshop.

Participant	Affiliation
Baker, Kyle	NOAA
Baldera, Alexis	Ocean Conservancy
Cho, Walter	Woods Hole Oceanographic Institution
Clarke, Lora	NOAA
Die, David	University of Miami
DiPinto, Lisa	NOAA
Galvez, Fernando	Louisiana State University
Geiger, Steve	Florida Fish and Wildlife Conservation Commission's Research Institute
Gielazyn, Michel	NOAA
Hart, Kristen	Unites States Geological Survey
Hernandez, Frank	Dauphin Island Sea Lab
Hoffmayer, Eric	NOAA
Jagoe, Chuck	Florida A&M University
Kiene, Bill	NOAA
Klemm, Dennis	NOAA
Lamkin, John	NOAA
Malinowski, Rich	NOAA
Moretzsohn, Fabio	Harte Research Institute
Murawski, Steve	University of South Florida
Peebles, Ernst	University of South Florida
Pierce, Rich	Mote Marine Laboratory
Reed, Dave	Florida Institute of Oceanography
Sandifer, Paul	NOAA
Serafy, Joe	NOAA
Taylor, Caz	Tulane University
Tortorici, Cathy	NOAA
White, Helen	Haverford College
Whitehead, Andrew	Louisiana State University

OIL AND DISPERSANT IMPACTS AND MITIGATION ON HUMAN HEALTH AND SOCIO-ECONOMIC SYSTEMS

Table 9. List of participants for the human health and socio-economic systems section at the 2011 workshop.

Participant	Affiliation
Abramson, David	Columbia University
Dearry, Allen	National Institutes of Health
Dickey, Robert	FDA
Elferink, Cornelis	University of Texas Medical Branch-Galveston
Grattan, Lynn	University of Maryland School of Medicine
Lovelace, Susan	NOAA/NOS/NCCOS Hollings Marine Laboratory
Luton, Harry	Bureau of Ocean Energy Management
Miller, Eric	US Coast Guard
Morrison, Melissa	CDC/Alabama Department of Public Health
Peters, Edward	LSU School of Public Health
Primo, John	Bureau of Ocean Energy Management
Schuster, Rudy	USGS

Table 10. Scores for the rating of "How important is issue XX in preparing for, responding to, and recovering from oil spills" (Importance) and "How much scientific information is available for issue XX" (amount of Information) for science issues identified in the 2010 and 2011 workshops.

Scientific Issues	Information Mean	Importance Mean
Social Sciences		
Secondary economic impacts	2	3
Economic impact of non-use value (e.g. cultural, existence)	2	2
Gulf of Mexico ecosystem services	1	4
Social and economic impacts of changes in all fishing (baseline +/- impact)	2	4
Social and economic vulnerability in coastal communities	2	4
Attitudes, perceptions, and beliefs about seafood	2	4
Attitudes, perceptions, and beliefs about Gulf of Mexico tourism, recreation, and beach use	2	4
Risk perception and risk communication of the DWH oil spill	2	4
Communication and outreach about the DWH oil spill, e.g., media, government agencies, academia, NGOs	2	3
Cultural/historical resource preservation in the Gulf of Mexico	1	3
Impacts to subsistence uses of the Gulf of Mexico (e.g., informal economy)	1	4
Social/economic impacts to coastal communities	2	4
Social/economic impacts to disproportionately-affected populations	2	4
Institutional multilevel analysis of policies and regulations and capacity of agencies and organizations	2	4
Multilevel analysis of institutional response to an oil spill (e.g., governance)	2	4

Table 10. (Continued)

Human/Environmental Health		
Toxicity testing, e.g., animal models	2	3
Further characterization of contaminant mixtures	1	3
Genetic toxicity/gene environment interaction	2	3
Biomarkers of exposure/effect/susceptibility	1	4
Adaptive response to toxic insult (organ, cell)	2	2
Clinical evaluations, diagnostics, documentation (e.g., case definition)	1	4
Research on behavioral/mental health effects of the DWH oil spill	2	4
Research on the physical health effects of DWH oil spill	1	4
Tracking of disease at multiple geographic levels pre/post event; registries as needed	1	4
Studies on the influence of litigation	1	3
Individual and community vulnerability/resistance and adaptation to adverse health outcome	1	4
Health impacts to disproportionately-affected populations	2	4
Assessment of resilience across social-ecological systems	0	4
Integrative, Holistic Approach		
Create and evaluate ecosystem models (social-ecological system)	1	4
Health impacts of harmful algal blooms and toxins associated with theDWH oil spill	1	3

USE OF IN SITU AND REMOTE SENSORS, SAMPLING AND SYSTEMS FOR ASSESSING IMPACTS AND MITIGATION OF OIL AND DISPERSANT

Table 11. List of participants for the in situ and remote sensors, sampling, and systems at the 2011 workshop.

Participant	Affiliation
Abercrombie, Mary	USF College of Marine Science
Booth, LT Sara	U.S. Coast Guard
Gallagher, Tim	NOAA
Garcia-Pineda, Oscar	Florida State University
Ge, Yufeng	Texas A&M University
Gibeaut, Jim	Gulf Research Initiative
Gowlinowski, Greg	Roffer's Ocean Fishing Forecasting Service, Inc
Hine, Graham	Liquid Robotics, Inc.
Howden, Stephan	University of Southern Mississippi
Levine, Ed	NOAA OR&R
Miller, CDR Eric	U.S. Coast Guard
Muller-Karger, Frank	USF Florida Institute of Oceanography
O'Connor, Brendan	University of South Florida
Roffer, Mitch	Roffer's Ocean Fishing Forecasting Service, Inc
Ryerson, Tom	NOAA
Shay, Nick	University of Miami
Smith, Ryan	NOAA Atlantic Oceanographic and Meteorological Laboratory
Virmani, Jyotika	USF Florida Institute of Oceanography

Table 12. Mean scores and standard deviations of the rating of "How important is issue XX in preparing for, responding to, and recovering from oil spills" (Importance) and "How much scientific information is available for issue XX" (amount of Information). Mean values were calculated from the scores (1 to 4) assigned to each gap by the 2011 IRSSS members.

Scientific Issues	**Importance**		**Amount of Information**	
	Mean	Std. Dev.	Mean	Std. Dev.
Operational and Data Coordination Needs/Issues				
There are very limited real-time observations to allow for the generation of daily, weekly, or even monthly maps of surface and subsurface oceanographic conditions.	3.50	0.67	2.00	1.13
There is a lack of coordinated effort between various communities (government, academic, and private) to carry out observations. The result is that human capacity and research infrastructure available are not effectively utilized.	3.33	0.65	2.25	0.75
There is no mechanism to coordinate with international partners (e.g., Cuba, Mexico, Bahamas).	2.67	0.78	1.83	1.03
There is a lack of coordination for satellite monitoring efforts.	3.17	0.72	2.08	0.90
The processes for funding monitoring projects are awkward and unclear.	2.58	1.0	1.83	0.83
There is no unified operational system for data acquisition and open data distribution.	3.25	0.62	2.25	0.97

Table 12. (Continued)

There is no standard process for communicating metadata details (origin and calibration of data) collected from autonomous and other platforms (e.g., gliders).	3.25	0.62	1.83	1.03
There is no appropriate baseline information for several key parameters.	3.75	0.45	1.42	1.31
Networks with Sustained Observations				
The Gulf of Mexico has an underfunded ocean observing system.	3.67	0.65	1.58	1.31
Gaps exist in current observing networks (e.g., high frequency radar) in several geographical regions (e.g., no sustained observations in the Florida Keys, Florida Bay, Florida Straits, and West Florida Shelf).	3.08	0.79	1.92	0.79
There is a need for one robust ocean observing system for monitoring extreme events and resulting ecosystem changes (biological, physical, chemical properties in the atmosphere, water column, and sediment).	3.50	0.67	2.08	1.16
Role of Aerial and Satellite Observations				
There is a lack of access to satellite resources because of the declining number of satellites available and access complexities for international satellite resources.	3.08	0.79	2.08	0.90
There is an insufficient number of U.S. researchers/students familiar with space-based ocean observing sensor design and data acquisition.	2.83	0.83	1.92	0.90
There is no clear mechanism to merge satellite data with other remote sensing and in-situ data collection methods.	3.58	0.51	2.09	1.17
There is a lack of standardized processes for groundtruthing and validating aerial/satellite observations with surface/subsurface sampling and insitu measurements.	3.82	0.40	1.75	1.14
There are no concise methods to determine thickness of oil surface layers using satellite data.	3.42	0.90	1.83	1.34
In-situ Measurements at the Surface and Subsurface				
There is a need for more data from multi-parametric sondes that include fluorescence excitation/emission wavelengths, backscattering, and absorption observations.	3.33	0.49	1.33	0.78
There is a need to better incorporate multi-parameter (and multi-wavelength) sensors across a range of delivery platforms, from CTDs and buoys to aircraft and ship-deployed XCTDs, XBTs, and other dropsondes.	3.67	0.49	1.33	1.07
There is a need for robust sensors that can accurately function in oil-contaminated environments.	4.00	0.0	1.42	1.16

Appendix 4: Abstracts and Speaker Information

Note that presenters are listed in bold, followed by co-authors.

Plenary Speakers

Grattan, Lynn. University of Maryland. LGrattan@som.umaryland.edu
Overview of oil and dispersant impacts and mitigation on human health and socio-economic systems

Roffer, Mitchell. ROFFS. roffers@bellsouth.net

Use of in situ and remote sensors, sampling and systems for assessing the extent, fates, impacts and mitigation of oil/dispersants during the Deepwater Horizon oil spill episode

A review of major issues associated with in situ and remote sensors, sampling, and systems was conducted through an outreach effort to more than 100 responders and researchers from government, academia, industry, and non-governmental organizations. As a result, common themes, considering both operational and research aspects, emerged. The presentation provides some examples, raises major issues, indicates the major lessons learned, and presents some of the continuing needs regarding sampling systems. The subject was organized around near field, far field, surface and subsurface sensors, and sampling systems. A major finding was the need to improve the methods for detecting recoverable oil from non-recoverable oil, especially determining oil thickness, concentration, and age. Identification of real oil versus false positives from algal blooms, fish oil, and petroleum from other sources is part of this issue. While such airborne sensor systems (e.g., AVIRIS, UAVSAR, multispectral VNIR, LIDAR) are useful for near-field identification and monitoring, more research is needed. Polar-orbiting satellite sensor systems (e.g., SAR, multispectral infrared, Vis) were useful for near field and far field identification and monitoring. It became apparent that a robust system which combines airborne, satellite, and in-situ observations, that integrates data in near real-time to produce and distribute user friendly fusion products in an automated manner is needed. The critical importance of mapping both the recoverable and other non-recoverable oil – dispersant related pollution in the near and far fields was identified.

Liu, Yonggang. University of South Florida. yliu@marine.usf.edu
Co-author(s): Robert H. Weisberg (lead).

Response to the Gulf oil spill from USF ocean circulation group: A review

Scientists from University of South Florida rapidly responded to the Deepwater Horizon oil spill incident in the Gulf of Mexico. A trajectory forecast system using ocean circulation models and satellite imagery was implemented immediately upon spill onset. An ensemble of models was reinitialized daily with satellite imagery-inferred oil locations, and virtual particles were then tracked using forecast currents. Subsurface trajectories were also forecast on the basis of continual release from the well site. Timely trajectory forecasts were used to plan scientific surveys and other spill response activities. In addition to the existing moored ADCP and shoreline-based high frequency radar arrays for ocean circulation monitoring on the West Florida Shelf, satellite-tracked drifters were deployed in both the Gulf of Mexico Loop Current and the shelf regions, and subsurface gliders were manipulated to observe the ocean circulation and to sample the ocean water properties on the West Florida Shelf. The integrated ocean observing and modeling systems were demonstrated to be very useful in the rapid response. Some preliminary results are highlighted in this presentation.

Highsmith, Ray. NIUST, University of Mississippi. ray@olemiss.edu
Overview of oil and dispersant impacts and mitigation in offshore environments

Murawski, Steven. University of South Florida. smurawski@usf.edu
Overview of oil and dispersant impacts and mitigation on living marine resources

Ryerson, Tom. NOAA. thomas.b.ryerson@noaa.gov
Overview of oil and dispersant: extent and fate

OIL AND DISPERSANT: EXTENT AND FATE

de Gouw, Joost. NOAA Earth System Research Laboratory. Joost.deGouw@noaa.gov

Formation of aerosol in air masses downwind from the Deepwater Horizon oil spill

A National Oceanic and Atmospheric Administration (NOAA) WP-3D research aircraft made airborne measurements of the gaseous and aerosol composition of air over the Deepwater Horizon (DWH) oil spill in the Gulf of Mexico that occurred from April to August 2010. A narrow plume of hydrocarbons was observed downwind of DWH that is attributed to the evaporation of fresh oil on the sea surface. A much wider plume with high concentrations of organic aerosol (>25 micrograms per cubic meter) was attributed to the formation of secondary organic aerosol from unmeasured, less volatile hydrocarbons that were emitted from a wider area around DWH.

Fitzpatrick, Pat. Mississippi State University. fitz@gri.msstate.edu

Validation of an oil spill simulation using SCAT and Louisiana Bucket Brigade data

The Deepwater Horizon explosion reopened debate on the role of synoptic weather features versus ocean currents in transporting oil spills. Lagrangian models generally assume oil concentrations travel largely proportional (80-100%) to ocean currents' speed and direction, plus an additional 3% contribution from surface winds, diffused with each time step. However, cyclones are known to highly perturb water pollutants with positive and negative results. A midlatitude cyclone expanded the Exxon Valdez oil spill over a large region while, in contrast, Hurricane Henri (1979), in combination with a non-tropical low, cleansed the oil-polluted south Texas beaches (Gundlach et al. 1981). We identified the late June to early July timeline as a period of interest since oil briefly impacted the Rigolets, Lake Borgne, and western Mississippi coast, and represented the innermost penetration of oil pollution east of the Mississippi River. An important component to understanding the oil transport is to distinguish the influences behind this apex moment. An oil spill simulation was conducted for the period 20 June to 10 July 2010 to understand this inland transport. Meteorology and ocean data, as well as synoptic maps, also facilitated this analysis. Results from the cyclonic weather systems' influences will be discussed. Recent work is also focusing on the evolution of oil degradation and their penetration into the Louisiana wetlands. Databases from the SCAT teams, the Lousiana Bucket Brigade, state Departments of Environmental Quality, and the Lake Pontchartrain Basin Foundation are being assembled to understand this issue. This data will be used for validation of the oil spill model weathering terms.

Haus, Brian. University of Miami. bhaus@rsmas.miami.edu

Consortium for Advanced Research on Transport of Hydrocarbons in the Environment (CARTHE)

The Consortium for Advanced Research on Transport of Hydrocarbons in the Environment (CARTHE) was recently selected by the Gulf Research Institute board for funding. The goals of CARTHE are to better understand and predict the transport and distribution of petroleum from the deep ocean, continental shell, to shoreline, as well as in the atmosphere using a cutting edge modeling system that includes a source model in the water column, a multi-phase model near the ocean's surface, a fully coupled atmosphere-wave-ocean circulation model across the air-sea interface, coastal models with very high resolution of the shoreline, and a dedicated model for the surf zone dynamics. CARTHE will take on the challenge of developing a comprehensive modeling system that provides a four-dimensional description of oil and gas transport in the Gulf of Mexico and in its coastal environment. The system will bridge a wide spectrum of multi-scale processes, ranging from microscale to mesoscale, in the ocean and atmosphere, including: rise of the oil, gas, and dispersant mixture in the water column and subsurface; dispersion due to turbulent interactions with deep-ocean stratification; surface dispersion affected by mixed layer dynamics, mesoscale currents, and surface waves under various weather conditions including tropical storms; release of gas into the atmospheric boundary layer by air-sea interaction processes and wave breaking; transport of gas and aerosol in the atmosphere and transport of surface and subsurface oil across the inner shelf and the surf zone.

Hu, Xinping. University of Georgia. xhu@uga.edu

Hydrocarbon remineralization in the hypoxic zone of the northern Gulf of Mexico in July 2010

It is still unknown whether the DWH oil spill has affected the 2010 summer hypoxia in the northern Gulf of Mexico, since the area of the hypoxic region in 2010 was not particularly larger than the average of those from the previous five years. Based on bottom water inorganic carbon and oxygen data collected during the 2010 Summer Hypoxia Cruise and organic carbon remineralization stoichiometry, we found that in part of the bottom waters there were indications of hydrocarbon oxidation, which caused the correlation between dissolve oxygen and dissolved inorganic carbon to deviate from the consistent relationship observed from previous summer hypoxia events. Furthermore, stable carbon isotopes of dissolved inorganic carbon collected during the 2011 Summer Hypoxia Cruise indicated that remineralization of algal material was the predominant driving force for bottom water oxygen consumption this year.

Kessler, John. Texas A&M University. jkessler@ocean.tamu.edu

The biogeochemical cycling of dissolved methane and oxygen associated with the Deepwater Horizon disaster

Methane was the most abundant hydrocarbon emitted from the Deepwater Horizon disaster. Due to its mass dominance, relatively high solubility, and stoichiometric relationship with oxygen, the respiration of methane had the potential to impart the greatest influence on dissolved oxygen levels. We found that insignificant quantities of methane were emitted to the atmosphere, but instead remained dissolved in deep plume or intrusion layers. The respiration of this methane proceeded at unprecedented rates, imparting a persistent oxygen anomaly in the deep Gulf of Mexico waters. Here we report recent results on the dissolved oxygen anomaly determined from over 1000 measured profiles spanning May through October 2010. We further present analyses based on these oxygen anomalies that suggest both the fate and extent of methane and other hydrocarbons emitted.

Kovach, Charles. Florida Department of Environmental Protection. Charles.Kovach@dep.state.fl.us

Surface tar distribution in Eastern Gulf of Mexico 2010-2011

Over one hundred neuston tows were completed between June 2010 and September 2011 from Key West to the Mocando 252 wellhead site to characterize surface tar distribution in the aftermath of the release from the wellhead. A summary of the distribution encountered and its relationship to Loop Current behavior, along with historical perspective, will be presented.

McLaughlin, Richard M. UNC Chapel Hill. rmm@email.unc.edu

Trapping and escape of buoyant plumes in stratified water

An abstract for this talk is not available.

Mezic, Igor. University of California Santa Barbara. mezic@engineering.ucsb.edu

Methods for oil spill tracking leading to accelerated containment and cleanup

When large oil spills occur, such as the Deepwater Horizon oil spill in the Gulf of Mexico in 2010, it is important to deploy disaster mitigation resources swiftly and with precision. Unfortunately, neither was true in the initial response to the Gulf oil spill. This was partially due to lack of predictive analytical tools that can pinpoint the location of the oil slick on the surface of the ocean and any underwater plumes robustly in real time. Using new dynamical system theory results, we have started development of such tools. The numerical tool, called the Hypergraph Map, enables real time prediction of the robust propagation direction of such oil slicks. Additionally, we have designed coverage algorithms that enable thorough coverage of such oil slicks by skimming vessels. To analyze the fate of dissolved hydrocarbons, we have analyzed the dynamics of bacterial populations at 1000-1300 m depth and shown that, in a fortunate turn of events, growth of such populations helped diminish the impact of the dissolved hydrocarbons on the environment. In combination, these three pieces of research offer a set of new tools to be deployed in the unfortunate event of future oil spills and can enable prevention of the type of pollution we have seen in the earlier case of the Exxon Mobil spill in Alaska and the Gulf oil spill.

North, Elizabeth. University of Maryland Center for Environmental Science. enorth@umces.edu

Simulating the subsurface dispersal of oil droplets with a Lagrangian approach

The objective of our program is to investigate the far field subsurface and surface dispersal of different size classes of oil released from the Deepwater Horizon well. We use the Lagrangian transport model LTRANS, an open source model, to simulate the trajectories of oil droplets as they age over time. This Lagrangian approach incorporates the effects of differences in initial droplet characteristics, as well as time-varying droplet behavior. Hydrodynamic predictions were provided by a Regional Ocean Modeling System (ROMS) based South Atlantic Bight and Gulf of Mexico (SABGOM) circulation model, while initial droplet elevations were provided by multi-phase plume modeling. We ran the SABGOM/LTRANS model system for the time period of the Deepwater Horizon oil spill. Results compare favorably with observations of a subsurface plume made by Camilli et al. (2010). Model sensitivity studies indicate that oil droplets with diameters greater than 100 microns rise quickly to the surface. Droplets with diameters of 50 microns or less have subsurface dispersal trajectories, and those 10 micron in diameter have behaviors similar to passive particles. Degradation rates of oil droplet diameters had marked influence on oil dispersal and oil droplet interaction with the Gulf coast shoreline and the slope/shelf bottom. Model predictions and sensitivity analyses will be presented and discussed. LTRANS v2, including new oil algorithms, will be released as open source code, allowing simulations and forecasts to be made throughout the U.S. coastal waters.

Paris, Claire. UM RSMAS. cparis@rsmas.miami.edu

Three-dimensional evolution of the Macondo well blowout: What can we learn from numerical modeling?

A multi-scale numerical framework, the Connectivity Modeling System (CMS) was developed to nest the highest resolution Ocean Predictions Systems available for the region. In addition, an oil-fate stochastic module was created to simulate the oil behavior bounded by time-varying uncertainties on the oil spill. The coupled model was ran to simulate the transport of the Macondo oil mixed with dispersants and its pathways to the Loop Current. Results suggest that the prevailing winds, through their effect to induce direct and wave drift, played a major role in pushing the rising oil toward the coasts along the northern Gulf and, in synergy with the surface currents, prevented the oil from reaching the Florida Straits. Moreover, this study reveals hitherto unexplored mechanisms of local and prevailing basin-wide hydrodynamic processes that influence the subsea oil transport and predicts the formation of multiple stratified plumes. The model outputs agree well with a series of independent and punctuated observations, providing a baseline for further assessment of the transport and fate of oil products and the effectiveness of dispersants.

Perring, Anne. NOAA Cooperative Institute for Research in Environmental Sciences. anne.perring@noaa.gov

Characteristics of black carbon aerosol from a surface oil burn during the Deepwater Horizon oil spill

Black carbon (BC) aerosol mass mixing ratio and microphysical properties were measured from the NOAA P-3 aircraft during active surface oil burning subsequent to the Deepwater Horizon oil rig explosion in April 2010. Approximately 4% of the combusted material was released into the atmosphere as BC. The total amount of BC introduced to the atmosphere of the Gulf of Mexico via surface burning of oil during the nine-week spill is estimated to be $(1.35 \pm 0.72) \times 10^6$ kg. The median mass diameter of BC particles observed in the burning plume was much larger than that of the non-plume Gulf background air and previously sampled from a variety of sources. The plume BC particles were internally mixed with very little non-refractory material, a feature typical of fresh emissions from fairly efficient fossil-fuel burning sources and atypical of BC in biomass burning plumes. BC dominated the total accumulation-mode aerosol in both mass and number. The BC mass-specific extinction cross-section was 10.2 ± 4.1 and 7.1 ± 2.8 m^2/g at 405 and 532 nm, respectively. These results help constrain the properties of BC emissions associated with DWH and other large spills.

Roy, Amitava. Louisiana State University. reroy@lsu.edu

Synchrotron-based techniques for the study of degradation of crude oil

An abstract for this talk is not available.

Van Mooy, Benjamin. Woods Hole Oceanographic Institution. bvanmooy@whoi.edu

Rapid microbial respiration of oil from the Deepwater Horizon spill in offshore surface waters of the Gulf of Mexico

The goal of this study was to constrain the microbial degradation of the oil in the offshore oligotrophic surface waters near the Deepwater Horizon site. As the utilization of organic carbon by bacteria in the surface waters of the Gulf had been previously shown to be phosphorus limited, we hypothesized that bacteria would be unable to rapidly utilize the oil released from the Macondo well. Although phosphate was scarce throughout the sampling region and microbes exhibited enzymatic signs of phosphate stress within the oil slick, microbial respiration within the slick was enhanced by approximately a factor of five. A large fraction of this enhanced respiration was supported by hydrocarbon degradation. These observations refuted our hypothesis. However, a concomitant increase in microbial abundance or biomass was not observed in the slick, suggesting that microbial growth was nutrient limited. Our study shows that the microbial community of the Gulf of Mexico supported unprecedented rates of oil respiration, despite their growth being limited by dissolved nutrients.

Zhou, Zhengzhen. University of Southern Mississippi. zhengzhen.zhou@eagles.usm.edu

Optical properties of dissolved organic matter from the Gulf of Mexico after the Deepwater Horizon oil spill

UV-vis absorbance spectroscopy, fluorescence EEM technique, and parallel factor analysis PARAFACmodeling were used to characterize dissolved organic matter and to track the fate and transport of oil in the northern Gulf of Mexico after the Deepwater Horizon oil spill in April 2010. Water samples were collected in mid-May, late May to early June and October to cover a time series for up to five months after the oil spill. During the outbreak of the oil spill, elevated dissolved organic carbon concentrations, higher ultraviolet-vis absorbance, and higher inferred molecular weight dissolved organic matter were found in the water column. Two major types of dissolved organic matter were found, one with low abundance but high optical activity and the other with high mass concentration yet low optical activity. Fluorescence EEM spectra of seawater samples strongly resemble those of crude and weathered oil. In contrast, dramatically decreased oil characteristics were found in samples taken in October. Two major types of dissolved organic matter were found in the water column: one with a positive correlation between dissolved organic carbon concentration and SUVA254 values showing natural dissolved organic matter characteristics for upper water column samples; the other with anomalously high optical yields and a negative correlation between SUVA and dissolved organic carbon found exclusively in deep waters with a characteristic salinity of 34.96 ± 0.03, showing the influence by oil. PARAFAC analysis of samples from all the three cruises reveal three major oil components with maximum fluorescence intensity at Ex/Em wavelengths of 226/340 nm, 226/320 and 275/320 nm, and 234/353 nm, respectively. We hypothesize that the third component (234/353) is a degraded product from both microbial and photochemical degradation, while the second component (226/320 and 275/320) is mostly derived from photochemical degradation of oil. The fate and transport of oil in the water column can be effectively tracked with ultraviolet-vis and fluorescence EEM techniques.

Oil and Dispersant Impacts and Mitigation in Coastal Environments

Bell, Susan. USF Department of Integrative Biology. sbell@usf.edu

Documenting and characterizing oil in swash zone sediments of beaches impacted by the DWH oil spill: A short and long term view

Visible signatures of oil that originated from the DWH spill were widespread on sandy beaches in the Florida Panhandle and vicinity in summer 2011 as oil and tar washed ashore in early June 2010 and accumulated over the next weeks. Onshore clean-up efforts in fall 2010 were directed at removal of oil from beach sands but oil removal was not attempted in the swash zone, a tidal area with active wave run up and backwash. These intertidal sediments may represent a largely overlooked or underestimated site of oil contamination, serving as a source or depository of remnant oil. We quantified oil products found within swash zone sediments by taking 10 cm diameter cores throughout the swash zone of four oiled beaches through September 2011, within one week of passage of Tropical Storm Lee. Oil products recovered from cores included small tarballs, up to 9 cm in diameter, as well as flimsy, generally smaller particles, many of which were attached to shell hash. The number and size of oil products varied across different beaches but, overall, were most often found in the lowest swash zone areas. In three of the four beaches examined, oil products increased in size and abundance in samples collected post Tropical Storm Lee compared to samples collected in July 2011. Although extensive clean-up efforts were conducted on the oiled beaches, including sifting of oil products from beach areas adjacent to the swash zone, our study reveals a reservoir of oil products that contributes to maintaining oil contamination of the lower swash sediments through at least 18 months after the initial spill.

Chen, Q. Jim. Louisiana State University. qchen@lsu.edu

Field monitoring of oiled-wetland erosion in south Louisiana

A field observation program to monitor the edge stability of oiled and unoiled marshlands under the impact of tropical and extra-tropical storms have been developed and implemented in south Louisiana. Regular topographic surveys and post tropical storm surveys have been carried out to measure the marsh edge retreat rates. Vegetation and topographic changes along controlled cross-shore transects and along marsh edges have been recorded. Results from the impact of Tropical Storm Lee (2011) will be presented at the conference.

Cho, Hyun Jung. Bethune-Cookman University. choh@cookman.edu
Co-author(s): Deepak Mishra, Mississippi State University.

Impact of the Gulf of Mexico oil spill on the health and productivity of Louisiana salt marshes

One year after the worst oil spill in U.S. history, we present the first quantitative assessment on the impact of the spill on the salt marsh habitats. This research combined satellite and ground data to quantify the impacts of the oil and dispersant on the salt. Two of the most important marsh biophysical characteristics including, canopy chlorophyll content and above ground green biomass, were monitored across the southeastern Louisiana coast during the marsh growing season (May-October) of 2009 (pre-spill) and 2010 (post-spill) to compare and isolate the spill-impacted areas. The initial assessment showed that there was a significant post-spill increase in areas with reduced biomass and chlorophyll (> 400 km2) during the 2010 growing season compared to 50-65 km^2 during the 2009 growing season. Phenological analysis of the post oil-spill data revealed a significant decrease in the magnitude of biomass and canopy chlorophyll during the 2010 growing season. June of 2010 was consistently found to be the worst month in terms of salt marsh health across Louisiana, followed by the initial signs of recovery along the fringing marsh areas proximal to the shoreline that were first impacted by oil. Interior marsh patches exhibited persistent signs of stress towards the end of the growing season. Extensive reduction in photosynthetic activity was observed during the peak of the 2010 growing season. The products generated through this study successfully delineate the critical hotspots of marsh stress so that prioritization of areas needing immediate restoration can be performed.

Deocampo, Daniel. Georgia State University. deocampo@gsu.edu

Persistence of Deepwater Horizon n-alkanes and polycyclic aromatic hydrocarbons, Bay Jimmy marshes, Barataria Bay, Louisiana: Compositional changes over Year 1

Here we present the results of gas chromatography-mass spectroscopy analyses showing the persistence and composition of Macondo-1 Well/Deepwater Horizon petroleum hydrocarbons in Bay Jimmy marshes, northern Barataria Bay, Louisiana. The compositions reported here provide a snapshot of the status of oils at sea in May 2010, and in Barataria Bay marshes during sampling events in October and December 2010, and in February, March, May, and September 2011. Sampling sites coincide with those established as DWH oil by SCAT direct observation and by previously published biomarker analyses (Rosenbauer et al., 2010). The relative abundances of n-alkanes show significant loss of shorter chain compounds but persistence of the longer chain compounds. Pristane/phytane ratios are lower in the marshes (~0.7) than those reported from offshore (~1.2); since landing, they have remained unchanged over the past year. PAH compositions onshore reflect loss of the most volatile compounds (e.g., naphthalenes) prior to landing; alkylated homologues continue to dominate the signature, with gradually lowering C2/C3 ratios among some of the compounds (e.g., dibenzothiophenes and naphthobenziothiophenes). Total sediment PAH concentrations in persistent petroleum hydrocarbon accumulations are in some cases over 50,000 µg/kg. Model calculations of equilibrium vapor pressures representing the assemblage of detected PAHs demonstrate an overall loss of lower molecular weight PAHs, likely due to the combined effects of dissolution, evaporation, photo-oxidation, and biodegradative processes. Substantial levels of petroleum hydrocarbons will likely persist in the poorly-oxygenated swamps of Barataria Bay for many years.

Graham, William. University of Southern Mississippi. monty.graham@usm.edu

Zooplankton community change and biomass reduction during Deepwater Horizon

The continuous deep subsea release of oil and gas during Deepwater Horizon ushered in a new paradigm for understanding ecological responses to oil spills in the sea. Because of the nature of the pelagic foodweb's exposure to hydrocarbons, the impact of Deepwater Horizon on zooplankton communities of the Gulf of Mexico may have been profound. However, our ability to resolve changes to zooplankton impacts is confounded by high background noise and a general lack of historical perspective of appropriate resolution. The Fisheries Oceanography of Coastal Alabama (FOCAL) Program has been collecting monthly zooplankton samples at mid-shelf stations since 2004. Despite large year-to-year and seasonal variability of zooplankton assemblages and biomass, we documented a large community composition shift and a biomass reduction outside of anything previously measured in our study. We present a scenario that could have generated such shifts based on water column productivity switching transiently from net productivity to net heterotrophy during the summer 2010.

Hooper-Bui, Linda. LSU A&M and LSU AgCenter. Lhooper@agcenter.lsu.edu

Effect of Macondo oil on insect and spider communities on coastal dunes and in saltmarshes in Louisiana

An abstract for this talk is not available.

Huettel, Markus. Florida State University. mhuettel@fsu.edu

Deposition and degradation of Deepwater Horizon oil in Florida sandy beaches

We report the fate of MC252 oil that was washed onto and embedded in Florida sandy beaches, and the impact of this oil on the microbial communities in the oiled beach sands. Oiled sand layers showed elevated rates of potential oxygen consumption and dissolved inorganic carbon production, indicative of ongoing degradation of the sedimentary oil deposits. Twenty-four bacterial strains from 14 genera were isolated from oiled beach sands and confirmed as oil-degrading microorganisms.

Jeffrey, Wade. University of West Florida. wjeffrey@uwf.edu
Co-author(s): Jessie Rosanbalm, Tiffany Baskerville, Ashvini Chauhan, and Jennifer Cherrier

The effect of oil on microbial production in the Northern Gulf of Mexico

Oil from the Deepwater Horizon spill may have competing effects on microbial production in the Gulf of Mexico. On the one hand, oil may serve as a dissolved organic carbon source and might stimulate bacterioplankton production, especially by those organisms capable of direct degradation of hydrocarbons. In contrast, oil and/or dispersed oil may be directly toxic to microorganisms, both autotrophic and heterotrophic. Both of these processes may change microbial community structure and alter biogeochemical cycles. Direct effects of oil and dispersed oil on bacterioplankton (3H-leucine incorporation) and phytoplankton production (14C-bicarbonate production) were examined. In addition, we examined the effect of oil and dispersed oil on extracellular release of carbon by phytoplankton and subsequent uptake by bacterioplankton in three locations in the northern Gulf of Mexico. In general, phytoplankton production was more sensitive to oil and dispersed oil than was bacterioplankton production. While oil reduced carbon fixation, it had minimal effect on extracellular release of fixed carbon but bacterioplankton took up less of the released carbon, perhaps as a result of substrate competition with oil carbon.

Lauenstein, Gunnar. NOAA National Centers for Coastal Ocean Science. gunnar.lauenstein@noaa.gov
Co-author(s): Dennis Apeti and Andrew Mason.

Deepwater Horizon oil spill: National Status and Trends (NS&T) response: Oil-related compounds in oysters and sediments and dispersants in water samples (collaboration with USGS)
In response to the Deepwater Horizon event, NS&T scientists participated in several research efforts aimed at characterizing the extent of the spill and impacts of oil and dispersant-related contaminants on benthic and coastal resources. Using the NS&T ecosystem-based approach to assessing coastal environmental quality, oyster and sediment samples were collected before and after landfall at more than 80 Mussel Watch sites around the Gulf of Mexico to assess changes in levels of oil-related contaminants, including metals such vanadium and nickel. Oysters' overall health condition and changes in benthic community assemblages were also evaluated based on the NS&T Bioeffects Program's approach with the aim to assess damage to coastal resources. Results for these assessments are currently being processed, and the data will be compared to the NS&T long-term dataset. Other efforts by the NS&T Program involved scientists' participation in several research cruises aboard of ships such as the *Ocean Veritas* and NOAA Ship *Thomas Jefferson*. During these cruises, NS&T scientists assisted in the analysis and interpretation of moving vehicle profiler and conductivity-temperature-depth results and provided expert advice critical for the adaptive mission planning. Also, as a part of these cruises hundreds of water samples were collected from around the wellhead to the coastal areas to assess the presence and extent of a submerged oil plume, evaluate concentration of dispersants and that of oil-related contaminants in the water column. This latter work was done in collaboration with the U.S. Geological Survey.

Mortazavi, Behzad. University of Alabama. bmortazavi@ua.edu

Enhancing the biodegradation of Macondo well (MC252) crude oil in nearshore coastal Alabama ecosystems with marine organic substrates: Evidence from stable isotopes and biomarkers
Rates of aerobic degradation of the Macondo crude oil (fresh and weathered) by naturally-occurring microorganisms were determined in sandy beach environments and the extent to which the rate of crude oil degradation was enhanced by supplying the microbial community with naturally-occurring marine organic matter was determined. We then compared these results to those from similar experiments but with additions of fertilizers (nitrogen and phosphorus). Replicated mesocosms consisted of four treatments: (i) controls (beach sand); (ii) sand contaminated with crude oil (4000 mg/kg); (iii) sand plus organic matter (340 mgC/kg of fish tissue [Atlantic bumper], or marsh cordgrass); and (iv) sand plus crude and organic matter. Carbon dioxide (CO_2) production was measured daily over a six-week period in all treatment and the carbon isotopic ratio of respired CO_2 (*13CO_2) was used to determine the fraction of respired CO_2 that was derived from respiration of the crude oil. The overall mineralization rate was 66% higher in the organic matter amended crude oil treatment compared to crude only additions. The lower n-C17/pristine and n-C18/phytane ratios in crude plus organic matter treatment compared to the crude only indicated enhanced biodegradation. The 13C of respired CO_2 in the crude plus organic matter treatment showed that crude oil was mainly used as a cometabolite and respired. Naturally-occurring marine substrates supplied at significantly lower doses compared to fertilizers were more (or as) effective in enhancing the degradation of the crude oil. These results suggest that naturally occurring marine substrates can be used as an effective tool in bioremediation of the coastal zone.

Pardue, John. Louisiana State University. jpardue@lsu.edu

Biodegradation of emulsified MC252 oil in coastal salt marshes
An abstract for this talk is not available.

Proffitt, Ed. Florida Atlantic University. cproffit@fau.edu

Oyster ecology and population genetics in the Gulf of Mexico following the Deepwater Horizon oil spill
The Deepwater Horizon oil spill in the spring of 2010 affected oceanic and estuarine ecosystems. The eastern oyster, *Crassostrea virginica*, is important as a fishery and because it forms reefs that serve as resident and hunting habitat for many fish and invertebrate species. They produce extensive reef habitats that include "reef flats" (as intertidal and shallow subtidal structures), intertidal "fringing reefs" (near marshes or mangroves) on red mangrove prop roots and other structures, and as submerged, deeper reefs. The goal of our two-year (2010-2012) project is to assess oyster reefs at replicate sites in the Florida Panhandle, Tampa Bay area, southwest Florida (Pine Island Sound, San Carlos Bay), and within the Rookery Bay National Estuarine Research Reserve (see maps below) using identical methodologies. In this multidisciplinary and multi-institutional effort, we are assessing 60 natural oyster reefs for multiple metrics: (1) abundance and size; (2) resident reef communities; (3) recruitment onto deployed uniform oyster shell substrates; and (4) and growth and survival of deployed (caged) individual oysters (<40 mm). We are also sampling tissues at the above sites and oyster reefs in areas likely to have been exposed to DWH oil for both PAH concentrations and genetic diversity. A second major focal point was the study of population genetics of populations throughout the Gulf of Mexico. The preliminary data from this study suggest that there are weak differences among populations at various spatial scales in the Gulf of Mexico. Our future studies will address pre- and post-spill genetic and ecological assessments of oyster communities.

Sobecky, Patricia. University of Alabama. psobecky@ua.edu

Coastal Alabama microbial community responses to the DWH oil spill
The coastal microbial community responses to the Deepwater Horizon oil spill of April 2010 have been investigated using state-of-the-art molecular microbial ecology methods that include Phylochip and Geochip analyses for microbial population and functional gene responses, respectively. We have detected specific microbial community and functional gene changes that correlate with the presence of DWH oil that impacted our coastal Alabama study site. Changes in microbial communities include increases in known hydrocarbon-degrading phyla as a result of oil in coastal sediments, as well as changes in metal resistance genes, antibiotic resistance genes, and hydrocarbon-degrading gene responses.

OIL AND DISPERSANT IMPACTS AND MITIGATION IN OFFSHORE ENVIRONMENTS

Cho, Walter. Woods Hole Oceanographic Institution. wcho@whoi.edu
Co-author(s): Timothy M. Shank

Assessing the potential impact of the Deepwater Horizon oil spill on invertebrates associated with deep-water coral communities in the Gulf of Mexico

Deep-water coral communities are thought to be vulnerable to disturbance due to their low rates of colonization, growth, and the high levels of host-specificity for associated invertebrates. A major concern resulting from the Deepwater Horizon oil spill is the vulnerability of these deep-water coral communities to the oil spill. Research cruises in 2008 and 2009 established a comparative baseline for changes in benthic community structure. Research cruises in 2010 and 2011 returned to some of the sites visited prior to the Deepwater Horizon oil spill and also explored new areas that may host deep-water coral communities. We assessed the potential impact of the Deepwater Horizon oil spill on coral-associated invertebrates (including ophiuroids, crabs, shrimp, barnacles) and the level of genetic connectivity between populations in the Gulf of Mexico, Caribbean, and North Atlantic.

Crespo-Medina, Melitza. University of Georgia. mcrespo1@uga.edu

Water column methane dynamics in response to the Deepwater Horizon hydrocarbon spill

An abstract for this talk is not available.

Flower, Benjamin. University of South Florida. bflower@marine.usf.edu
Co-author(s): G.R. Brooks, E.A. Brown, L.S. Collins, E. Goddard, D.W. Hastings, D.J. Hollander, R.A. Larson, and P. Hallock Muller.

Assessing the impact of the Deepwater Horizon Oil spill on sediments and benthic communities on the West Florida Slope

A major unknown from the 2010 BP oil spill is the distribution, fate, and effect of hydrocarbons in the deep-sea environment. Early evidence indicated that hydrocarbons were concentrated in subsurface plumes, including one at 1000-1200 m water depth that spread to the southeast and northeast of the Macondo wellhead. Therefore, one of our first goals was to assess the impact of hydrocarbons on sediments and benthic communities in the northeast Gulf of Mexico. We focused on the West Florida Slope and Shelf because of the potential for impact on sensitive fisheries in this region. With funds from the NSF RAPID program for an MC-800 multicore sediment sampling system and the BP-FIO Grants Program, we have sampled >50 sites on 6 R/V *Weatherbird II* cruises. This sediment coring system captures the sediment surface with minimal disturbance and, therefore, is the best tool to document sediment conditions before, during, and after the BP blowout, including the recovery phase. Some of our preliminary findings are as follows. Oiled sediments were documented at water depths of 900, 1000, and 1520 m near DeSoto Canyon. At Site DSH10 (1520 m) between the BP wellhead and DeSoto Canyon, a <1 cm dark brown surface layer that was clearly oiled in the August core was overlain by a light brown layer 2-3 cm thick in December, and 8-9 cm thick in February 2011. Similar findings within and near DeSoto Canyon revealed a 20-100x increase in sediment accumulation rates in mid- to late 2010. Sediments in this region are commonly laminated, which suggests a lack of benthic organisms to stir up the sediment (bioturbation). The percentage of deformed benthic foraminiferal shells increases from a background rate of ~1% to 19% in mid-2010 at the DSH10 site. Grain size data from just east of DeSoto Canyon and from the West Florida Slope indicate dramatic decreases in the coarse fraction (>63 mm) from >4% to <1% in the upper 10 mm and from >20% to <3% in the upper 4 mm, in these respective locations. Nickel and vanadium concentrations are elevated (4-22% and 10-32%, respectively) in surface sediments relative to 5 cm depth at sites southeast of DeSoto Canyon. Overall, sediments within and to the east of DeSoto Canyon accumulated at very high rates in mid- to late 2010 and consisted of fine plankton skeletal debris, particulate oil, fresh organic matter, and sparse benthic biogenic sediment, leading to the "Dirty Blizzard" hypothesis. However, our existing cores cannot rule out the possibility that oiled sedimentation and its effects were restricted to the DeSoto Canyon. Additional cores are critical to (1) test the "Dirty Blizzard" hypothesis vs. the "DeSoto Canyon conduit" hypothesis and thereby help assess the fate of BP hydrocarbons, (2) document the geographic extent and duration of the pulse in accumulation rates that occurred in mid- to late

2010, and (3) quantify the effects of BP hydrocarbons and enhanced sedimentation on benthic communities and ecosystems in the eastern Gulf of Mexico.

Hamilton, Peter. Science Applications International Corporation. phamilton@raleigh.saic.com

Loop current dynamics from remote and in-situ observations: April 2009 to July 2010

The Bureau of Ocean Energy Management (BOEM) has funded a series of observational and numerical modeling studies into the dynamics of the Loop Current involving scientists from the Universities of Rhode Island, Colorado and Princeton, along with Mexican colleagues from CICESE. Arrays of moored current meters and bottom mounted pressure equipped inverted echo sounders centered near 26°N, 87°W were deployed in April 2009. Further arrays of moored current meters and ADCPs were deployed in the Yucatan Channel and over the Campeche Bank in May-June 2009. Data from the U.S. array were recovered via mooring rotation or telemetry in July and November 2010 and will ultimately be recovered in November 2011. During the first 15 months, circulation was dominated by the interactions between the Loop Current (LC) and Eddies Ekman (separated September 2009) and Franklin (separated October 2010). From a historical perspective, both eddies were notable for deep intrusions into the northern Gulf, large initial eddy sizes, and southern detachment zones close to the Florida Straits. Lower-layer flows were not generally visually coherent with upper-layer LC flows, and the mean circulation evinces a west-east pattern of an anticyclone-cyclone pair predicted by numerical models as the lower-layer response to a westward-propagating, upper-layer anticyclone. A marked increase in lower-layer kinetic energy was coincident with the development of large-scale meanders along the northern and eastern parts of the Loop Current front for both Ekman and Franklin, with lower-layer eddies developing patterns consistent with baroclinic instabilities. In July 2010, measurements of hydrocarbons from water samples collected at stations within and around the northern Loop Current front, and analyzed by Texas A&M (Terry Wade, PI), showed no significant concentrations. This is notable because surface slicks were observed in satellite data in a large cyclone located just north of the LC front in May and June 2010. The apparent lack of entrainment into the LC seems to be a more significant factor in the lack of oil transport towards the Florida Keys than the first detachment of Franklin from the LC in May-June 2010.

Hollander, David. USF College of Marine Science. davidh@marine.usf.edu

Deposition, distribution, and fate of Macondo oil in the sediments of the northern Gulf of Mexico

Although mechanical recovery is often favored for its ability to directly remove oil from the environment, it has long been recognized that for large offshore spills this technology has significant limitations. In addition to known operational limits in the presence of currents and waves, the dynamic nature of offshore oil slicks, i.e., rapid spreading and movement, has resulted in mechanical recovery only treating a small fraction of spilled oil in the past. Because of these limitations, the oil industry has worked to develop alternative response tools that can be used in addition to mechanical recovery to more effectively treat large offshore oil spills.

Mate, Bruce. Oregon State University.

Sperm whales: Trophic effects indicators

An abstract for this talk is not available.

Montagna, Paul. Harte Research Institute, Texas A&M University-Corpus Christi. paul.montagna@tamucc.edu

Sediment quality triad in the deep sea during fall 2010

In response to the Deepwater Horizon incident, samples were taken offshore in September and October 2011 for sediment quality triad (SQT) analyses as part of the subsurface monitoring plan developed by the Unified Area Command. The SQT is a three-pronged approach to assess pollution dose, associated biological response, and associated impacts on ecological integrity by measuring (1) contaminant concentrations,(2) in situ toxicity using the Microtox test, and (3) benthic communities. There is widespread oil and toxicity on the bottom of the deep-sea within 25 km of the incident site, and within this zone there are relationships between contaminants, toxicity, and benthic response. The views expressed are mine and not attributable to NOAA.

Montoya, Joseph. Georgia Institute of Technology. montoya@gatech.edu

The Deepwater Horizon oil spill and pelagic foodwebs in the northern Gulf of Mexico

The Deepwater Horizon (DWH) released some five million barrels of oil in offshore waters of the Gulf of Mexico. The release of oil under high pressure at a depth of about 1500 m led to formation of significant surface slicks, plume-like layers containing dispersed oil at depth, and bottom deposits of oil-derived materials through road reaches of the northern Gulf of Mexico. During cruises to the region shortly after the flow of oil was halted (OC468, 21 Aug-16 Sep 2010) and about 10 months later (EN496, 2-27 July 2011), we collected samples of suspended particles and zooplankton for elemental and isotopic analysis. In 2010, we found multiple subsurface features with low beam transmittance, distinct spectral fluorescence signatures, and high particle concentrations that appeared to form coherent layers at depths ranging between roughly 150 and 1400 m and extending in all directions around the DWH wellhead. Although these layers appear spatially linked to the DWH oil spill, they did not consistently show the high concentrations of methane or low δ13C values associated with the hydrocarbons released by the DWH spill. At the same time, many of our zooplankton samples, particularly gelatinous animals, had an unusual brown to black coloration. These features were absent during our repeat visit in 2011. We will discuss the hydrographic context of our samples and their elemental and isotopic composition, which provide an index to the biogeochemical impact of the spill on pelagic foodwebs in the northern Gulf of Mexico.

Nedwed, Tim. Exxon Mobil Upstream Research Company. tim.j.nedwed@exxonmobil.com

The value of dispersants for oil spill response

Oil spill response strategies are designed to minimize environmental impacts to the extent possible. Each response option must be evaluated for operational limitations (e.g., sea state), potential effectiveness, environmental impacts of the response option itself, and applicability under various oil spill scenarios (e.g., size and location of the spill) in addition to health and safety of the responders.

Paul, John. University of South Florida. jpaul@marine.usf.edu

Toxixity and mutagenicity of waters contaminated by the Deepwater Horizon oil spill

The Deepwater Horizon oil spill represents an environmental disaster of unprecedented dimension. We participated in two research cruises in the Gulf of Mexico to measure the toxicity of the oil-contaminated waters. The first cruise (July 2010) sampled stations on the West Florida Shelf, while the second cruise sampled stations in the northeastern Gulf of Mexico in August of 2010. Two assays of toxicity were employed, the Microtox assay and the QwikLite assay. The general mutagenicity test Microscreen/Inductest was also employed. No waters on the West Florida Shelf sampled during the July cruise were toxic or mutagenic. The Microtox assay detected microbial toxicity in the surface waters of three of 14 stations. The QwikLite assay detected phytoplankton toxicity at three of 13 stations (23.1%) in subsurface waters (35-275 m deep). Strong mutagenicity was detected in six of 14 stations (42.9%) in surface and subsurface waters on the eastern/northeastern side of the Deepwater/Horizon blowout site. Even though surface waters were visibly clear of oil and tarballs were absent, toxicity and mutagenicity of roughly a third of the stations sampled persisted.

Shiller, Alan. University of Southern Mississippi. alan.shiller@usm.edu
Co-author(s): D. Joung, USM; T.L. Wade, J.L. Sericano, S.T. Sweet, Texas A&M University; K.M. Yeager, University of Kentucky; C.A. Brunner, USM; and P. Louchouarn, Texas A&M University at Galveston.

Polycyclic aromatic hydrocarbon, trace element, and nutrient distributions as affected by the Deepwater Horizon oil spill

Toxicity associated with PAHs is a concern in oil spills. The ratios of various PAHs have also been used as indicators of oil sources. Water samples from a subsurface Macondo well oil plume (~1100 m) and surface waters in the same vicinity were analyzed for PAHs. Additionally, PAHs were determined in sediments from both hemipelagic environments near the wellhead and affected coastal subtidal and marsh environments. Methylnaphthalenes in the water showed effects of preferential solubilization, as well as rapid destruction/removal. Various PAH ratios (e.g., P/A ratios, pyrogenic index, alkylated chrysenes) tend to become more indicative of pyrogenic sources in going from water column to hemipelagic sediments to marsh sediments. However, these changes likely result from progressive degradation and removal of certain PAH components, as exemplified by diminishing percentages of methylnaphthalenes. Overall, the data illustrate how environmental factors lead both to reduced concentrations and fractionation of the PAHs. Also in the water column, positive relationships between nutrient and dissolve oxygen anomalies in the subsurface plume suggest the effect of microbial oil/gas consumption. In surface waters, metal-salinity relationships suggest a dominant river influence. In the subsurface plume, elevated metal concentrations were observed during late May. However, separating the inputs from crude oil, dispersant, drilling mud, and bottom water resuspension, as well as biological removal, is problematic. Correlation with percent methylnaphthalenes in the plume indicates the increased cobalt is due to leaching from crude oil. Spatially, barium (and possibly copper) showed a peak within 10 km of the wellhead. Low concentrations of barium in the crude oil suggests that it was likely derived from drilling mud or fluids associated with the top kill attempt. We also observed a decreasing trend of iron toward the wellhead, suggestive of uptake; however, the data can also be interpreted as indicative of benthic iron input with the trend towards the wellhead being topographically controlled.

Oil and Dispersant Impacts and Mitigation on Living Marine Resources

Die, David. University of Miami. ddie@rsmas.miami.edu

Effects of oil spill related fishing closures on reef fish of the Florida west coast
An abstract for this talk is not available.

DiPinto, Lisa. NOAA. Lisa.Dipinto@noaa.gov

LMR assessment in the Gulf from the NRDA perspective
An abstract for this talk is not available.

Galvez, Fernando. Louisiana State University; Biological Sciences. galvezf@lsu.edu

The physiological effects of resident killifish impacted by the Deepwater Horizon oil spill
The gulf killifish, *Fundulus grandis*, is one of the most abundant and ecologically-important fish inhabiting coastal marsh habitats of the Gulf of Mexico; a region severely contaminated with oil from the BP Deepwater Horizon oil spill. Unlike most fish species in these habitats, killifish have high home range fidelity, making them a useful model organism to study the site-specific effects of environmental contamination. We have initiated two separate projects aimed at characterizing the integrated effects of crude oil exposure in situ to gulf killifish. In one study, five populations ranging from Grande Terre, Louisiana, to Fort Morgan, Alabama, were sampled pre-oil, and at two times post exposure to oil. This study involves a detailed integrated assessment of effects from the level of the whole animal to genomic-level effects, and includes detailed water chemistry analyses and satellite imagery to document the magnitude of exposure. The second study provides a detailed assessment of in situ effects on fish physiology in six reference and six heavily-oiled sites within Barataria Bay, Louisiana following the oil spill. Tissues from these fish are being analyzed for various indicators of oil exposure and effect, including the documentation of protein-level effects at the gills, intestines, livers, and kidneys. Results to date demonstrate severe histological damage and dramatic up-regulation of cytochrome P450 1A (CYP1A) protein expression in the gills and intestines of fish sampled from the most heavily-oiled sites. These results are consistent with previous studies describing the effects of polyaromatic hydrocarbon exposure in teleost fish, including killifish.

Hernandez Jr, Frank. Dauphin Island Sea Lab. fhernandez@disl.org

Sargassum, fish, invertebrates, and the oil spill
An abstract for this talk is not available.

Hoffmayer, Eric. NOAA Fisheries. eric.hoffmayer@noaa.gov

Occurrence, distribution, and movements of whale sharks in the northern Gulf of Mexico
Reports of whale sharks, *Rhincodon typus*, in the northern Gulf of Mexico date back to the 1930s; however, few studies have provided information beyond observational accounts. To address the lack of knowledge pertaining to whale shark biology, seasonal occurrence, distribution, and movements in the northern Gulf of Mexico, the University of Southern Mississippi's Gulf Coast Research Laboratory initiated the Northern Gulf of Mexico Whale Shark Research Program in 2003. One of the program's primary objectives was to document the distribution of whale sharks in the northern Gulf of Mexico via reports of sightings provided by collaborating fishers and offshore petroleum industry personnel. To date, nearly 500 sighting incidents have been reported with approximately one-third of those involving aggregations of up to 200 individuals. This research has revealed that whale sharks are relatively abundant in the northern Gulf of Mexico and their seasonal occurrence is highly predictable. Additionally, satellite tagging data and photo identifications have established connectivity among whale sharks in the northern Gulf of Mexico, southern Gulf of Mexico, and the Caribbean Sea. This presentation summarizes current knowledge on whale sharks in the northern Gulf of Mexico and addresses the topic of potential impacts to whale sharks of natural or human-related environmental perturbations.

Lamkin, John. NOAA Southeast Fisheries Science Center. john.lamkin@noaa.gov

Overlap between Atlantic bluefin tuna spawning grounds and observed Deepwater Horizon surface oil in the northern Gulf of Mexico

The 2010 Gulf of Mexico oil spill impacted the northern Gulf of Mexico during the spring spawning season of Atlantic bluefin tuna. An analysis of the overlap between satellite-derived estimates of surface oil and predicted bluefin tuna spawning habitat in the northern Gulf of Mexico was examined using stochastic models. Results suggested that although eggs and larvae were likely impacted by oil-contaminated waters in the eastern Gulf of Mexico, high abundances of larvae within suitable spawning habitat were located elsewhere, especially in the western Gulf of Mexico, away from the influence of the spill. Overall, less than 10% of bluefin tuna spawning habitat was predicted to have been covered by surface oil, and less than 12% of larval bluefin tuna were predicted to have been located within contaminated waters in the northern Gulf of Mexico, on a weekly basis. Our results provide preliminary but important initial estimates of the effects of the spill on larval bluefin tuna mortality, as concern continues over the appropriate management responses to impacts of the spill.

Moretzsohn, Fabio. Texas A&M University-Corpus Christi. fabio.moretzsohn@tamucc.edu

Biodiversity baseline and the Deepwater Horizon oil spill

One of the first projects at Harte Research Institute for Gulf of Mexico Studies, Texas A&M University-Corpus Christi, endowed and created in 2000, was a comprehensive biotic inventory of the Gulf of Mexico. The inventory was the result of a team of 140 taxonomic experts from 80 institutions in 15 countries, who compiled a checklist of 15,419 species living in the Gulf of Mexico. One of the original goals of the project was to produce an online database with the information from the inventory for free dissemination. Thanks to financial support from the Northern Gulf Institute, among others sources, the BioGoMx database was completed and posted on GulfBase.org in early 2011. Using the database, an analysis of the biodiversity indicates that there were 8,332 species recorded in the north-northeast octant of the Gulf of Mexico (second most diverse); more importantly, the 1000–3000 m depth class where the Macondo well is located was the most diverse in the Gulf, with 1,708 species recorded. Of the 81 Gulf species identified by taxonomists as either threatened or endangered, 76 occur in the northeast quadrant. The inventory completion in 2009 was timely regarding the Deepwater Horizon oil spill; it serves as a biodiversity baseline for the Gulf and may be useful to studies monitoring the impacts of the oil spill, the restoration of affected habitats, and other studies. As new biodiversity data from ongoing research becomes available, they may be added to BioGoMx.

Peebles, Ernst. University of South Florida. epeebles@marine.usf.edu
Co-author(s): David Jones, Elon Malkin, and Steve Murawski.

Otolith nickel and vanadium as lifetime markers of fish exposure to crude oil

High concentrations of nickel and vanadium in crude oil, relative to low concentrations in modern seawater, create the potential for using these trace metals as oil-spill indicators. During growth, fish incorporate a wide range of trace metals, including nickel and vanadium, into microscopic crystalline layers that sequentially accrete onto their otoliths (ear stones). This process produces stable, lifelong records of trace-metal exposure (profiles) for individual fish. Trace-metal profiles can be revealed through a combination of clean techniques and laser-ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). We are currently using LA-ICP-MS to create nickel and vanadium profiles for fish from various locations in the Gulf of Mexico as part of a larger investigation of disease incidence in red snapper and other economically important fish species. In this presentation, we review methodology and provide examples of preliminary nickel and vanadium profiles for diseased and non-diseased individuals. Metals within otoliths occur in trace amounts that do not pose direct risks to public health.

White, Helen. Haverford College. hwhite@alum.mit.edu

The impact of oil on deepwater coral communities in the Gulf of Mexico

To assess the impact of the Deepwater Horizon oil spill on Gulf of Mexico offshore environments, sites hosting deep-water coral communities were explored. Sites from a variety of locations were examined with the aid of underwater vehicles. At many sites, no visible evidence of impact was observed; however, 11 km southwest of the blowout, corals were observed with visible signs of stress. Coral communities at this site exhibited varying degrees of tissue loss, sclerite enlargement, excess mucous production, bleached ophiurids, and covering by an unusual brown, flocculent material. Analysis of petroleum biomarkers isolated from the brown material provides strong evidence that these communities were impacted by oil from the Macondo well.

Whitehead, Andrew. Louisiana State University. andreww@lsu.edu

Genome expression response of resident killifish impacted by the Deepwater Horizon oil spill

Gulf killifish (*Fundulus grandis*) are the most abundant vertebrate in coastal marsh ecological communities and are economically-important bait fishes. Large populations of killifish inhabit Gulf-exposed marsh habitats that are at high risk of contamination from oil spilled in the Gulf of Mexico; indeed, much habitat was oiled following the Deepwater Horizon oil spill. For these reasons, these killifish are strategic models for assessing contaminating oil impacts on Gulf coast marshes. We have launched a project intended to characterize oil spill impacts on the coastal marsh by integrating genomic and physiological indicators of response to oil exposure in situ and under controlled exposure conditions. In field studies, genome expression within livers of resident fish was tracked across space (contaminated and reference sites) and time (pre-oil, during oil, and after oil exposure). Genome expression was most distinct at our only field site out of six that was clearly impacted by oil, and at the peak of oil contamination documented by satellite imagery and analytical chemistry, showing a clear genomic footprint of oil exposure. This genomic response is similar to that observed following controlled polychlorinated biphenyl exposures to developing embryos, which caused developmental abnormalities and death.

Oil and Dispersant Impacts and Mitigation on Human Health and Socio-Economic Systems

Abramson, David. Columbia University. dma3@columbia.edu

Perceived and anticipated health impacts of the Deepwater Horizon oil spill

This study focused on the short- and potential long-term impacts of the disaster on local residents, particularly children. Using a random digit dial telephone survey, in July 2010 we interviewed 1,203 residents of Louisiana and Mississippi living within a 10-mile radius of the coastline. Respondents were asked about their exposure status, physical and mental health, and economic impact since the oil spill. Households with children were specifically oversampled and were asked about their child's emotional, behavioral, physical, and mental health. Multivariate regression and structural equation model analyses were conducted. Findings suggested that the social and economic consequences of the oil spill mediated the health effects, particularly those associated with mental health effects. The findings also suggested that traditionally vulnerable populations, i.e., women, African-Americans, and poorer populations, would be the most affected by potential long-term effects. This representative population study illustrates that economic and health concerns are widespread among coastal residents.

Dickey, Robert. U.S. Food and Drug Administration.

2010 Deepwater Horizon oil spill seafood safety assessment

An abstract for this talk is not available. See session summary for detailed notes.

Lovelace, Susan. NOAA Hollings Marine Laboratory. Susan.Lovelace@noaa.gov

Changes in health and well-being in communities affected by the Deepwater Horizon disaster: Linking well-being with ecosystem services

An abstract for this talk is not available. See session summary for detailed notes.

Luton, Harry. BOEM Gulf of Mexico Region. harry.luton@BOEM.gov
Co-author(s): John Primo.

Spill-related BOEM socio-economic research in the Gulf

An abstract for this talk is not available. See session summary for detailed notes.

Peters, Edward. LSUHSC-NO School of Public Health. epete1@lsuhsc.edu

Women and their children's health study

The LSU School of Public Health is conducting two studies aimed at addressing the mid- and long term health effects of the Gulf oil spill on southest Louisiana. Our focus is on 2,500 women and 800 children in seven parishes; two populations who have not been previously studied. Some of the women are wives of the male workers who were involved in the clean-up activities following the Deepwater Horizon incident, and others are women who are residents of the same communities. Children (10-17 yrs of age) in the households of women enrolled in our study will also be invited to participate. This prospective cohort study will focus on direct and indirect exposures to the oil. Because the parishes of Orleans, St. Bernards, Plaquemines, Jefferson, Lafourche, Terrebonne, and St. Marys have been subject to multiple stressors in terms of man-made and natural disasters in the last decade, our outcomes include both physical and psychological health. We will examine the moderating effects of resilience/social capital of the women and children on their health in response to oil spill exposures.

Use of In Situ and Remote Sensors, Sampling and Systems for Assessing Impacts and Mitigation of Oil and Dispersant

Abercrombie, Mary. USF College of Marine Science. mabercrombie@mail.usf.edu

Co-author(s): P.G. Coble, USF; P. Kepkay, Centre for Offshore Oil, Gas, and Energy Research (COOGER), Fisheries and Oceans, Canada; R.N. Conmy, EPA ORD/Gulf Ecology Division; J. Bugden, Z. Li, K. Lee, COOGER, Fisheries and Oceans, Canada; A.M. Wood, NOAA Atlantic Oceanographic and Meteorological Laboratory.

<u>Fluorescence-based detection of oil and oil-dispersant mixtures in seawater in the Gulf of Mexico and in a flow-through tank experiment</u>

Fluorescence spectroscopy has been utilized for decades to characterize colored dissolved organic matter (CDOM) and pigments in the marine environment. Due to the inherent sensitivity and selectivity of this method, it has also been used extensively by the petroleum industry for analysis and classification purposes. Following the recent Deepwater Horizon spill—the largest accidental petroleum release in history—researchers used fluorescence spectroscopy to monitor the rate and extent of petroleum hydrocarbon dispersion in subsurface waters. Various in situ fluorometers, calibrated to various excitation and emission wavelengths, were deployed to support the response and natural resource damage assessment operations. Discrete samples were also collected using Niskin bottles on a CTD rosette and analyzed using three-dimensioanal EEM spectra to determine the optimal wavelengths for detection of petroleum hydrocarbons. As the spectral properties of the residual petroleum hydrocarbons in the Gulf of Mexico were affected not only by concentration and weathering, but also by physical and chemical dispersion, a controlled experimental study was conducted at the Center for Offshore Oil and Gas Environmental Research at Bedford Institute of Oceanography in Canada. The sensitivity of seven different optical instruments, including in situ fluorometers deployed in the Gulf of Mexico following the Deepwater Horizon spill, was examined in 15 separate wave tank experiments conducted by adding 100 ml of artificially weathered or unweathered Deepwater Horizon source oil (MC252) with and without the addition of the dispersant Corexit 9500 (DOR 1:25). The final concentration of oil used in the experiment would be <7 ppm if fully dispersed. The core experiments were run with the wave tank in flow-through mode with real-time in situ data collected, as well as discrete samples taken at several time points for EEM spectra analysis using two different instruments (allowing for cross-instrument comparison) and for overall hydrocarbon analysis. Preliminary results indicate that all instruments were responsive to changes in oil concentration and were likely responding to different components of the oil. The unique configuration of each instrument used in the experiment, including differences in excitation and emission wavelengths, resulted in slightly different response results, with longer wavelength instruments showing more rapid decline with time. These results indicate short-term changes in composition which were more pronounced in the presence of dispersant.

Garcia-Pineda, Oscar. Florida State University. oscar.oggp@gmail.com

<u>Remote sensing overview of BP oil discharge from satellite SAR data</u>

Satellite remote sensing played a crucial role for monitoring BP's oil spill in the Gulf of Mexico . Oil discharged from the wellhead started to be detected by satellites on 23 April 2010, and oil slicks associated with this event were observed until 15 July 2010. To map the extent, location, and evolution of the spill, we used a previously developed image processing algorithm called TCNNA, which processes satellite SAR data. Monitoring of this event by processing 37 SAR images collected during the event allowed us to detect rafts of oil in the coastal zone as they separated from the much larger main spill that was centered around the BP well site. These oil rafts were detected moving at a rate of 15 miles per day and making landfall progressively as winds and tides pushed them along the coast. In deeper waters, drifting oil moved up to 45 miles per day and as far as 300 km away from the spill source. This happened when oil reached the Loop Current, which carried the floating layer of oil southeast from the wellhead. Repeated observations of floating oil increased with proximity to the oil source. By normalizing oil detections by the frequency that each area was sampled, we estimate that oil covered a mean daily area of 10,750 km^2. In total, oil covered a cumulative extent of 119,600 km^2 of the Gulf of Mexico surface waters.

Hine, Graham. Liquid Robotics, Inc. sarah.zweng@liquidr.com

Wave Glider – Monitoring the Gulf of Mexico
An abstract for this talk is not available.

Howden, Stephan. University of Southern Mississippi. stephan.howden@usm.edu

Applications of high-frequency radar surface currents for response to the Deepwater Horizon oil spill

The NOAA Integrated Ocean Observing System (IOOS) Office has made the deployment of high frequency radar systems for measuring surface currents throughout the coastal United States a high priority. The IOOS Surface Current Mapping Plan calls for full coverage of the U.S. coast with long-range systems, within a five-year time span. As part of the IOOS initiative for high frequency radar systems, a National High Frequency Server and Architecture Project was developed that ingests radial components of surface currents from systems around the nation, computes total surface currents, and serves both radials and totals from three redundant servers. These servers provide a one-stop shop for decision makers, such as the U.S. Coast Guard, which pulls currents from these servers when search and rescue operations are conducted in regions covered by high frequency radar.

Since its inception, the implementation of the IOOS has included integrated regional systems, termed Regional Associations, that determine regional priorities through stakeholder canvassing, integrate regional observing systems, and develop and implement plans for regional build-out of observing systems based upon regional and national priorities. The Gulf of Mexico Coastal Ocean Observing System (GCOOS) is the regional association with sole concern with the Gulf of Mexico. The West Florida Shelf is a region of overlap between GCOOS and the Southeast Coastal Ocean Observing Regional Association (SECOORA). GCOOS has developed plans for a long-range high frequency radar network in the Gulf, and it has worked with SECOORA on the planning for the portion of the network on the West Florida Shelf.

Although GCOOS and SECOORA have made attempts to obtain funding to expand the high frequency radar network in the Gulf, at the time of the Deepwater Horizon explosion on April 20, 2010 only two high frequency radar systems existed in the Gulf. To the east of the well site, on the West Florida Shelf, the University of South Florida had high frequency radar stations operating as part of the Coastal Ocean Monitoring and Prediction System (COMPS), and to the north and northeast of the well site the University of Southern Mississippi had stations as part of the Central Gulf of Mexico Ocean Observing System (CenGOOS), but two of the three sites were down at that time. One of the stations was in the process of being relocated from Gulfport, Mississippi, to Pascagoula, Mississippi, and the station at Orange Beach, Alabama, had been dissembled due to a dune replenishment project. The CenGOOS team, with assistance from CODAR (Coastal Ocean Dynamics Applications Radar) ocean systems, was able to restore the full CenGOOS high frequency radar system to an operational status by May 2, 2010.

The CenGOOS high frequency radar system monitors surface currents in the Mississippi Bight from the Mississippi River Bird's Foot Delta east to Destin, Florida, for waters deeper than 20 m. The coverage of this system included much of the region on the continental shelf affected by oil and so provided particularly valuable information for the response. At the time of the spill, the CenGOOS high frequency radar system was already integrated with the national servers.

The NOAA Office of Response and Restoration (OR&R) was able to readily obtain the surface currents from the CenGOOS and COMPS high frequency radar systems through the national servers and utilize them for their response to the spill. Without an operational Gulf circulation model that assimilates high frequency radar data, the NOAA OR&R used the high frequency radar data to help decide how much weight to give to the various available operational models when putting together a surface oil trajectory forecast. This critical role of high frequency radar data in the response to the oil spill has clearly demonstrated that an expansion of the Gulf high frequency radar network should be a high priority.

Post spill, the high frequency radar data are being utilized in several different ways. Most directly, studies of advection pathways in the Mississippi Bight during and after the event are being investigated, including examining integrated surface transport along selected transects. The data are also being utilized to help interpret changes in ecosystem data since the spill.

Levine, Ed. NOAA Office of Response and Restoration. ed.levine@noaa.gov

Updated result interpretation from the SMART dispersant monitoring program at the DWH incident

Since the completion of dispersant operations in August 2010, the SMART protocols and monitoring results have been reviewed. This presentation will focus on some of the lessons learned and interpretation of data collected.

Shay, Lynn (Nick). UM RSMAS. nshay@rsmas.miami.edu

Aircraft surveys of Loop Current variability observed during Deepwater Horizon

At the time of the Deepwater Horizon oil rig explosion, the Loop Current , a warm ocean current in the Gulf of Mexico , extended to 27.5°N just south of the rig. To measure the regional scale variability of the Loop Current, oceanographic missions, directed by UM RSMAS and NOAA's Aircraft Operations Center, were flown on a NOAA WP-3D research aircraft to obtain ocean structural data during the spill and provide thermal structure profiles to ocean forecasters aiding in the oil spill disaster at seven- to ten-day intervals. The aircraft flew nine grid patterns over the eastern Gulf of Mexico between May and July 2010, deploying profilers to measure atmospheric and oceanic properties such as wind, humidity, temperature, salinity, and current. Ocean current profilers sampled as deep as 1500 m, conductivitytemperature-depth profilers sampled to 1000 m, and bathythermographs sampled to either 350 or 800 m, providing deep structural measurements. Profiler data were provided to modeling centers to predict possible trajectories of the oil and vector ships to regions of anomalous signals. In hindcast mode, assimilation of temperature profiles into the Hybrid Coordinate Ocean Model improved the fidelity of the simulations by reducing root-mean-square errors by as much as 30% and decreasing model biases by half relative to the simulated thermal structure from models that assimilated only satellite data. The synoptic snapshots also provided insight into the evolving Loop Current variability, captured the shedding of the warm core eddy Franklin, and measured the small-scale cyclones along the Loop Current periphery.

Smith, Ryan. NOAA Atlantic Oceanographic and Meteorological Laboratory. ryan.smith@noaa.gov
Co-author(s): Gustavo Goni (lead).

Utilizing in situ observations and satellite measurements to examine the extent and variability of the DWH oil spill

In response to the Deepwater Horizon oil spill of 2010, several NOAA labs including OAR/AOML, NOS/OR&R, NESDIS/OSPO, and NMFS/SEFSC; NASA's Goddard Space Flight Center; academic institutions including UM, USF, USM, LSU, and UGA; and private industry (e.g., ROFFS) worked to conduct in situ observations and/or provide data products produced from in situ and satellite measurements to the research and response communities in near-real time. These tools aided in spill-monitoring efforts and provided data for model assimilation and validation purposes. Blended satellite observations were utilized to continuously monitor the surface oil extent and surface currents. Results indicate that the total surface oil extent reached a total cumulative area of 130,000 km^2 and document how both ocean surface current dynamics and surface winds influenced the surface coverage area. While tarballs collected as far south as 26°45.85'N during an AOML cruise in early June were sourced as Macondo oil, shipboard observations conducted in July 2010 found no evidence of surface or subsurface oil south of 28°N along the survey track. This additionally revealed that the mesoscale circulation features of the Gulf of Mexico were no longer conducive for direct transport of oil-related contaminants from the northern Gulf to downstream regions such as the Florida Straits.

Srinivasan, Sesha. Tuskegee University. srinivas@mytu.tuskegee.edu

Physico-chemical characteristics of soil and liquid samples collected from Gulf of Mexico and Deepwater Horizon oil spill site

In this project, we have extensively carried out the physico-chemical characteristics of soil and liquid samples which are collected from the Gulf of Mexico and, in particular, from the BP oil-spill site. The state-of-the-art tools such as Fourier Transform Infrared Spectroscopy (FTIR), ultraviolet-visible spectroscopy (UV-Vis), Physisorption using BET autosorb are employed to investigate the chemical and surface area characteristics of these samples. We have also built a Photocatalytic batch reactor with a UV-Vis lamp source for treating the water having contaminations such as the oil species and other organic compounds. From the FTIR analysis of the soil samples, it is discernible that the chemical composition at the oil spill and DWH sites had much variation in the chemical bonding nature in comparison to the samples from the shoreline. The physisorption using liquid nitrogen demonstrates the measo and micro- porous nature of these samples with an average surface area of about 15-30 m^2/g. For the liquid samples, a standardization procedure using Methyl Orange in aqueous water and its degradation has been carried out using UV-Vis spectrometer and photocatalytic reactor. The TiO2 catalyst concentration was optimized to obtain the greater photocatalytic decomposition rate. We will discuss the salient features and results of the investigation in this presentation.

POSTER SESSION

Abercrombie, Mary. USF College of Marine Science. mabercrombie@mail.usf.edu
Co-author(s): P.G. Coble, USF; P. Kepkay, Centre for Offshore Oil, Gas, and Energy Research (COOGER) - Fisheries and Oceans, Canada; R.N. Conmy, EPA ORD/Gulf Ecology Division; J. Bugden, Z. Li, K. Lee, COOGER - Fisheries and Oceans, Canada; A.M. Wood*, NOAA Atlantic Oceanographic and Meteorological Laboratory. *Corresponding Author: Michelle.Wood@noaa.gov

Fluorescence-based detection of oil and oil-dispersant mixtures in seawater

Fluorescence spectroscopy has been utilized for decades to characterize colored dissolved organic matter (CDOM) and pigments in the marine environment. Due to the inherent sensitivity and selectivity of this method, it has also been used extensively by the petroleum industry for analysis and classification purposes. Following the recent Deepwater Horizon spill—the largest accidental petroleum release in history—researchers used fluorescence spectroscopy to monitor the rate and extent of petroleum hydrocarbon dispersion in subsurface waters. Various in situ fluorometers, calibrated to various excitation and emission wavelengths, were deployed to support the response and natural resource damage assessment operations. The spectral properties of the residual petroleum hydrocarbons in the Gulf of Mexico were affected not only by concentration and weathering, but also by physical and chemical dispersion. In addition, instrument sensitivity and detection capabilities were likely to be highly wavelength dependent. To address this issue, a controlled experimental study was conducted to test the sensitivity of in situ fluorometers deployed in the Gulf of Mexico following the Deepwater Horizon spill. The source oil (MC 252), with and without the addition of dispersant, was first premixed in seawater in a shaker flask and then introduced into a flow-through wave tank under breaking wave conditions. The fluorescence responses of the instruments were recorded as a function of time. EEM) spectroscopy was also used to identify the regions of peak fluorescence intensity for MC 252 oil with and without added dispersant during the wave tank experiments.

Abercrombie, Mary. USF College of Marine Science. mabercrombie@mail.usf.edu
Co-author(s): P.G. Coble, USF; P. Kepkay, COOGER - Fisheries and Oceans, Canada; R.N. Conmy, EPA ORD/Gulf Ecology Division; J. Bugden, Z. Li, COOGER - Fisheries and Oceans, Canada; A.M. Wood, NOAA Atlantic Oceanographic and Meteorological Laboratory; K. Lee, COOGER - Fisheries and Oceans, Canada.

Tracking oil dispersion in the Gulf of Mexico by fluorescence spectroscopy

The Deepwater Horizon blowout on 20 April 2010 led to the worst accidental petroleum release in U.S. history, resulting in the delivery of an estimated 4.9 million barrels into the Gulf of Mexico by the time the wellhead was capped on 15 July 2010. Several factors produced novel transport and fate issues—the depth of the release (10,683 m), the force created by large volumes of methane and oil released under high pressure, and the application of an estimated 1.84 million gallons of dispersant (Corexit 9500) at the wellhead and at the surface. These factors supported the development of subsurface oil plumes, which were detected by a number of researchers using in situ instruments designed to measure ultraviolet fluorescence in the marine environment. These instruments were configured to measure fluorescence at different excitation and emission wavelengths, and analysis was further complicated by the changing spectral qualities of the petroleum due to physical and chemical weathering. Our laboratory analyzed discrete samples collected with Niskin bottles mounted on a CTD rosette on cruises on the R/V *Nancy Foster* in July 2010 and on the R/V *Weatherbird II* in May and August 2010 in the region to the northeast of the wellhead using Excitation Emission Matrix (EEM) Spectroscopy. We found evidence for a deep plume at ~1100 m, as well as at a mid-water depth of 300-450 m. A variety of EEM patterns were observed and compared well with a surface oil mousse sample and with samples of Deepwater Horizon source oil (MC252) with Corexit 9500 added (DOR 1:25) at a concentration of ~100 ppb, indicating the presence of oil and dissolved oil in the water column. EEMs typical of naturally occurring colored dissolved organic matter were also observed at some depths, indicating that the contamination was confined to discrete layers with limited depth distribution. Highest fluorescence intensities for the subsurface petroleum plume were observed at the excitation/emission = 280nm/340nm.

Bostater, Charles. Florida Institute of Technology. cbostate@fit.edu
Co-author(s): Gaelle Coppin, Heather Frystacky, Florian Levaux, James Jones.

Airborne imaging sensors for environmental monitoring and surveillance in support of oil spills and recovery efforts

Airborne remote sensing flights were funded by Florida Institute of Oceanography, and part of the funded four-dimensional remote sensing project. The airborne project began 10/1810. Airborne missions and flights were conducted during the first optimal weather conditions for imaging the water surface and subsurface features that occurred in March 2011. Imagery is available at www.bostater.info, along with metadata descriptions. Acquired imagery from five camera systems were flown (9 inch mapping camera, hyperspectral imaging system, high resolution digital camera, and two high definition video cameras). Weathered oil was observed in the Pensacola Bay region, along islands south of Alabama and Mississippi and in Barataria Bay, Louisiana. Littoral zone imagery along the Florida Panhandle and northern Gulf states during each mission and associated flights covered ~185 to over 350 nautical miles of littoral zone areas. Selected satellite image analysis was presented that show surface oil during the oil spill in pelagic fish spawning areas in the northern Gulf, and weathered oil in the littoral zones along the Gulf shore states in nearby islands and wetlands. The collected imagery is being used to develop new methods of littoral zone imaging from low flying aircraft, as well as from small vessels. These techniques include spectral-spatial sharpening using (1) advanced image fusion algorithms, (2) optimal spectral band and region selections using hyperspectral and multispectral imagery collected from small vessels, and (3) fixed platforms using newly developed remote sensing bi-directional reflectance distribution function algorithms. Optimally selected spectral regions for detecting weathered oil using the sensing systems acquired over the littoral zone areas (marshes and shorelines) include narrow channels in the ultraviolet and infrared portions of the electromagnetic spectrum.

Brannock, Pamela. Auburn University. pmb0010@auburn.edu
Co-author(s): Holly M. Bik (lead), University of New Hampshire; Kenneth M. Halanych, Auburn University; Jyotsna Sharma, University of Texas at San Antonio; W. Kelley Thomas, University of New Hampshire.

Shifts in marine meiofauna communities in response to the Deepwater Horizon oil spill

Oceanic sediments harbor the vast majority of the world's biodiversity, primarily comprised of meiofaunal communities (microscopic fauna such as nematodes, protists, diatoms, etc.) that perform key ecological functions such as nutrient cycling critical to biodegradation of hydrocarbons. Thus, incidents that impact these communities, such as the Deepwater Horizon oil spill, should be scientifically examined because of the great importance of meiofauna to ecosystem health. Herein, we examine meiofaunal diversity in both intertidal and offshore locations within the Gulf of Mexico, to assess how this anthropogenic disturbance has affected these communities. Using metagenetic and traditional taxonomic methods, we illustrate drastic shifts in intertidal meiofaunal community composition between pre- and post-spill samples. Most communities were heavily dominated by nematodes prior to the spill and changed to fungal-dominated systems after the spill. Two locations, Ryan Court and Dauphin Bay, were inconsistent with this trend because they did not switch to fungal communities, but they did show a change in community structure. We are in the process of examining the offshore sites in the Gulf of Mexico that may have been impacted by the Deepwater Horizon spill. We continue to sample both intertidal and offshore sites to follow the recovery of these communities to document the affects of oil exposure over time. This information is valuable in understanding these communities and will be beneficial in event a similar incident occurs.

Du, Mengran. Texas A&M University. mengrandu.carrie@gmail.com
Co-author(s): John Kessler.

Using dissolved oxygen anomalies to assess the spatial and temporal variability of hydrocarbon respiration in response to the oil spill event

The Deepwater Horizon oil spill event released gigamole quantities of methane to the deep Gulf of Mexico. This methane did not escape into the atmosphere, but stayed dissolved and suspended in discrete intrusion layers in the deep ocean. Reductions of dissolved oxygen within these discrete intrusion layers support the hypothesis that all released methane was respired by aerobic methanotrophs, thus prohibiting its eventual release to the atmosphere. To better define the spatial and temporal evolution of the hydrocarbon respiration, here we present dissolved oxygen data collected at 966 stations throughout the Deepwater Horizon event covering an area of 115,780 km^2 and a time period from May 11, 2010 tol October 16, 2010. The high temporal and spatial resolution of the data enables the estimation of rates of environmental release and respiration for the spilled hydrocarbons in addition to the magnitude, location, and timing of the highest dissolved oxygen anomaly. Combined with the end-member chemical composition analysis of the well fluids, a dissolved oxygen anomaly is found large enough to account for the respiration of all released methane, as well as most of the additional hydrocarbons in the deep ocean waters.

Dzwonkowski, Brian. Dauphin Island Sea Lab. briandz@disl.org

Subtidal circulation on the Alabama shelf during the Deepwater Horizon oil spill
Water column velocity and hydrographic measurements on the inner Alabama shelf are used to examine the flow field and its forcing dynamics during the Deepwater Horizon oil spill disaster in the spring and summer of 2010. Comparison between two sites provides insight into the flow variability and dynamics of a shallow, highly stratified shelf in the presence of complicating geographic and bathymetric features. Seasonal currents reveal a convergent flow with strong, highly sheared offshore flow near a submarine bank just outside of Mobile Bay. At synoptic time scales, the flow is relatively consistent with typical characteristics of wind-driven Ekman coastal circulation. Analysis of the depth-averaged, along-shelf momentum balance indicates that both bottom stress and along-shelf pressure gradient act to counter wind stress. As a consequence of the along-shelf pressure gradient and thermal wind shear, flow reversals in the bottom currents can occur during periods of transitional winds. Despite the relatively short distance between the two sites (14 km), significant spatial variability is observed. This spatial variability is argued to be a result of local variations in the bathymetry and density field as the study region encompasses a submarine bank near the mouth of major freshwater source. Given the physical parameters of the system, along-shelf flow in this region would be expected to separate from the local isobaths, generating a mean offshore flow. The local, highly variable density field is expected to be, in part, responsible for the differences in the vertical variability in the current profiles.

Guo, Laodong. University of Southern Mississippi. laodong.guo@usm.edu

Variations in fluorescent dissolved organic matter components during laboratory degradation of Macondo crude oil
To better understand the fate and transformation of oil in the Gulf of Mexico from the Deepwater Horizon oil spill, laboratory degradation experiments have been conducted using Macondo crude oil. UV-vis absorption and fluorescence spectroscopy and PARAFAC modeling were used to characterize oil components and their variations during photochemical degradation. Crude oil was dispersed into seawater or de-ionic water in light and dark bottles incubated in a water bath receiving natural sunlight for 120 days. Results from time series measurements show a dramatic decrease in UV-vis absorbance and fluorescence intensities of dissolved organic matter during oil degradation. The concentration of dissolved organic carbon in light bottles steadily increased in seawater during the first 40 days of oil degradation, with a negative correlation between dissolved organic carbon and SUVA, indicating production of water-soluble dissolved organic matter through photo-degradation and preferential degradation of optically active dissolved organic matter. Spectral slopes slightly increased in both light and dark bottles, suggesting preferential decomposition of higher molecular weight DOM. Based on PARAFAC modeling, three oil components were identified with Ex/Em maximum at 226/328, 260/315, and 246/366 nm, respectively. Fluorescence intensities of these components all decreased with time during degradation in the light bottles. However, the fluorescence intensity ratios of oil components, such as C2/C1 and C3/C1, consistently increased with time, suggesting a preferential degradation of C1 component. In black bottle treatments, the C2/C1 ratio did not vary significantly with time, suggesting little degradation of C2 or C1 without sunlight. In contrast, C3/C1 value increased slightly with time in black bottles, suggesting a rather slow degradation rate of C3 in dark bottles. The differences in fluorescence component ratios likely reflect the degradation status of oil in marine environments. The addition of dispersant, at an oil to dispersant ratio of 10:1, resulted in a shift in fluorescence EEM spectra with a characteristic Ex/Em maximum at 240/446 nm and seemed to enhance the degradation of oil. Photo-degradation is an effective degradation pathway of oil components, resulting in lower molecular weight dissolved organic matter with red-shifted fluorescence maxima. New results from laboratory degradation experiments should help the interpretation of field data and provide insights into degradation pathways and mechanisms and the fate and transport of oil components in the Gulf of Mexico.

Lovelace, Susan. NOAA NCCOS Hollings Marine Laboratory and JHT, Inc. susan.lovelace@noaa.gov

Co-author(s): Maria Dillard, NOAA NCCOS Hollings Marine Laboratory & JHT, Inc.; Theresa Goedeke, NOAA NCCOS Center for Coastal Monitoring and Assessment.

Changes in health and well-being in communities affected by the Deepwater Horizon disaster
To improve our understanding of the impacts of hazards such as the Deepwater Horizon oil disaster on the basic needs, health, economies, and social structure of coastal communities, we are exploring changes in the health and well-being of residents as they relate to changes in environmental health and the provision of ecosystem services. To do this, we are developing a method that will use indicators which were identified in collaboration with other Federal, state, and academic programs. We are focusing on coastal counties directly affected by oil-contaminated shorelines, as well as a selection of comparison counties. By establishing a way of monitoring changes in well-being around these hazards, we will be better able to assess the social impacts of environmental disasters and changing conditions, from oil spills and hurricanes to decreasing water quality and changing shorelines. This project will help local officials protect communities before the disaster by predicting potential social and economic changes and assist in recovery efforts afterwards through providing a way of assessing the impacts of the disaster.

Wu, Yejun. Louisiana State University. wuyj@lsu.edu

Interdisciplinary topic map and thesaurus for understanding the impact of oil spills
The goal of the project is to develop an interdisciplinary topic map to facilitate the understanding of the impact of the Gulf of Mexico oil spill incident. Two topic maps are to be developed, a general one for the public, journalists, and politicians, and an interdisciplinary one for oil spill researchers. The interdisciplinary topic map is expected to facilitate knowledge discovery through interdisciplinary knowledge fusion. Topic maps are a new semantic approach to information organization and were designed to enhance navigation and information retrieval in large sets of information resources. A topic map presents topics/concepts, their relationshps, and the documents that address those topics. Once developed, such a topic map can be used to display the major issues (concepts and relationships) related to the oil-spill incident and to navigate the information resources.

APPENDIX 5: ACRONYMS

ADCP	Acoustic Doppler Current Profiler
API	American Petroleum Institute
BioGoMX	Biodiversity of the Gulf of Mexico
BOEM	Bureau of Ocean Energy Management
CDC	Centers for Disease Control
DOSS	Dioctylsulfosuccinate
DWH	Deepwater Horizon Mississippi Canyon 252
ECSC	Environmental Cooperative Science Center
EEM	Excitation emission matrix
EPA	Environmental Protection Agency
FB	Flocculent blizzard
FDA	Food and Drug Administration
GCOOS	Gulf of Mexico Coastal Ocean Observing System
GOMA	Gulf of Mexico Alliance
GOMRI	Gulf of Mexico Research Initiative
IOOS	Integrated Ocean Observing System
IPA	Importance Performance Analysis
IRSSS	Use of In Situ and Remote Sensors, Sampling and Systems
JSOST	Joint Subcommittee on Ocean Science and Technology
LSU	Louisiana State University
LSUHSC-NO	Louisiana State University Health Sciences Center—New Orleans
NASA	National Aeronautics and Space Administration
NCCOS	National Centers for Coastal Ocean Science
NGO	Nongovernmental organization
NIEHS	National Institute of Environmental Health Sciences
NIUST	National Institute for Undersea Science and Technology
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRDA	Natural Resource Damage Assessment
NSF	National Science Foundation
NSTC	National Science and Technology Council
OGP	International Association of Oil and Gas Producers
OR&R	Office of Response and Restoration
OSTP	Office of Science and Technology Policy
PAH	Polycyclic (or polynuclear) aromatic hydrocarbon
PARAFAC	Parallel Factor Analysis
ROFFS	Roffer's Ocean Fishing Forecast Service
ROMS	Regional Ocean Modeling System
SABGOM	South Atlantic Bight and Gulf of Mexico Model
SEAMAP	Southeast Area Monitoring and Assessment Program
SIMAP™	Spill Impact Model Analysis Package
SAIC	Science Applications International Corporation
SAR	Synthetic aperture radar
SOST	Subcommittee on Ocean Science and Technology
TBR	Toxic bathtub ring
UM RSMAS	University of Miami – Rosenstiel School of Marine and Atmospheric Science
UNC	University of North Carolina
USF	University of South Florida
USGS	United States Geological Survey
UV-vis	Ultraviolet-visible
WHOI	Woods Hole Oceanographic Institution

XBT	Expendable bathythermograph
XCP	Expendable current profiler
XCTD	Expendable conductivity-temperature-depth