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Deepwater Horizon Oil Spill Principal Investigator (PI) Conference Final Report

Sponsored by the National Science and Technology Council's (NSTC) Joint Subcommittee on Ocean Science and Technology (JSOST)

Hosted by University of South Florida

Don CeSar Resort, St. Petersburg, FL

October 5-6, 2010

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Introduction

On October 5-6, 2010, the National Science and Technology Council's Joint Subcommittee on Ocean Science and Technology (NSTC JSOST) convened a workshop in St. Petersburg, Florida of Principal Investigators (PIs) actively involved in research, sampling, and monitoring activities in response to the Deepwater Horizon (DWH) oil spill.

This workshop brought together scientific investigators from academia, private research institutes, and agencies actively conducting DWH oil spill related research, monitoring, and sampling, as well as representatives from the JSOST agencies. This workshop was an opportunity for PIs to foster new collaborations, compare initial results, interact with federal agencies, and discuss recommendations for longer term research activities. The goal of the workshop was to gather input from researchers that could be used to help the JSOST federal agencies identify information needs and plan short and long term research directions. Approximately 155 participants from academia, private industry, and government agencies participated in the workshop.

The two-day meeting was organized around plenary talks followed by panel presentations and group discussion within thematic breakout groups. The six breakout sessions focused on: oil/dispersant fate and extent; oil/dispersant impacts and mitigation in the offshore; oil/dispersant impacts and mitigation in coastal areas; oil/dispersant impacts and mitigation on living marine resources; oil/dispersant impacts and mitigation on human health and socio-economic systems; and use of in situ and remote sensors, sampling, and systems for assessing extent, fate, impacts, and mitigation of oil/dispersant. The breakout groups were asked to consider the following questions to guide their discussion:

- What new research initiatives did this anthropogenically-induced incident provide?
- What worked well (what are we learning)?
- What would you do differently?
- What were the intersections/connections with other themes?

Poster sessions provided additional opportunity for participants to present and discuss their work and network with others working on similar projects.

The plenary sessions on Day 1 provided an overview of the objectives of the workshop and the federal response effort. Additionally, plenary speakers discussed key issues within each of the topical areas to provide the foundation for discussion within the breakout groups. On Day 2, the plenary speakers focused on on-going efforts, including the Natural Resource Damage Assessment (NRDA) process, the sub-surface monitoring program being conducted as part of the response effort, and an assessment of the Gulf of Mexico research needs. The workshop concluded with presentations from each of the breakout sessions, which described highlights from the group discussions, focusing on recommendations for future activities.

Overarching recommendations highlighted in many of the breakout groups are identified in the text that follows. Specific recommendations from each breakout group are presented in a summary of their respective session.

The workshop agenda, participant list, notes and discussion from the plenary sessions and full reports from each breakout group are provided in the attached appendices. The plenary presentations are available on the workshop web page http://www.marine.usf.edu/conferences/fio/NSTC-JSOST-PI/index.shtml

Overarching observations and recommendations from the breakout sessions

- Use the experience of this event and response, in concert with the experience of the U.S and other nations in previous oil spills, to **improve coordination and communication between industry, state, federal, and academic efforts** related to the surveying, monitoring, near-term and longer-term research activities;
- **Assess the roles and capabilities of agencies, institutions and industry**, with regard to including analysis of the appropriateness of the response efforts to help increase efficacy and cost effectiveness of future response activities. The group emphasized the need for mission agencies to develop mechanisms to rapidly fund independent research by other entities;
- **Improve data management** among the federal, state, academic and industry sectors, including open and timely sharing of information, the integration of the multiplicity of datasets, and adequate long-term archiving;
- There is a clear need for a **comprehensive observational system** (e.g., a much enhanced and expanded IOOS) in the Gulf of Mexico. Such a system already exists along the Atlantic and Pacific coasts. Costs of building and maintaining the GOM system should be shared by industry (e.g., oil and gas, transportation) and the federal government;
- **Improve communication with other countries** and their industries to learn from their experience and knowledge and **to optimize the emergency response efforts**;
- Assessment of long-term impacts will require **sustained sampling;**
- **Data limitations** are profound because the intensity of coastal research has declined significantly within the past 10-15 years due to lack of funding and subsequent loss of capabilities and disappearance of infrastructure, including loss of availability of research vessels in the GOM;
- **A retrospective assessment** of the DWH incident would be useful to assess overall response (official, academic, data management, communication, etc).

Breakout Session Summaries

Summary: Oil/dispersant-extent and fate (e.g., air, surface water, water column, beaches, marshes)

This breakout group consisted of approximately 27 participants from academia, government and private industry. The group emphasized the following recommendations with regard to the emergency response to this disaster and how to improve the efficacy of future responses:

- **Assess the response efforts** directly related to understanding the extent and fate of the spilled petroleum and dispersants;
- **Develop tools for future emergency responses** that include legislation, observation, surveying, monitoring and research efforts;
- **Identify needed parameters to monitor** in order to better develop and validate numerical models needed in emergency response efforts and to improve long-term monitoring;
- **Carry additional long-term studies** on chemical, biological, and ecosystems processes needed to understand the extent and fate of the released petroleum and the dispersants. Re-suspension of oil products and transport long after a spill influences the ultimate fate of petroleum and its derivatives, as well as the impacts;
- **Vastly increase attention toward** improvements in sampling, monitoring and modeling of oil **transport in the subsurface** in future responses, **as well as** expand activities regarding sampling, monitoring and modeling of **atmospheric processes**;
- Stepping beyond the immediacy of a given spill, the group emphasized the need to **evaluate and model the impact of hurricanes and tropical storms on oil/dispersant extent and fate** as the Gulf of Mexico is an area prone to hurricanes and subjected to extensive oil exploration.

The group also had several **specific recommendations** related to identifying, sampling, monitoring and modeling the oil and dispersants. They emphasized the need to:

- **Identify petroleum to ascertain its extent and fate**. The group recommended enactment of legislation to require that chemical composition of the natural gas and liquid oil from wells be registered in a federal database for timely dissemination in the event of a spill, as well as the archival of samples to be made available if needed;
- Immediately **perform a *post hoc* assessment of the tools** (instruments, equipment and methods) available to detect important oil chemical constituents and degradation products, and the concomitant evaluation of the **need for development of new laboratory and in-situ measurement technology in order to improve future response efforts**;
- **Develop "best practices" for oil degradation product sample collection and analysis**, including guidance for adequate instrument/equipment operation;
- **Increase remote sensing data resolution in the near-shore and inland seas**, and along the coastlines, to guide response efforts in the coastal region;
- **Improve efforts to collect adequate time series of atmospheric chemistry measurements** as part of future spill monitoring to help complete the oil budget and to better assess human impacts. Air quality due to evaporative emissions of known or suspected carcinogens, especially **BTEX and PAHs, needs to be assessed**. Emissions from the ships responding to the spill need to be taken into account. On-line real time local weather conditions should be available to improve predictions of health effects;

- Improve understanding of **how oil burning at the surface influences the fate, extent, and transformation of petroleum** both in the water and in the atmosphere. In addition, the health effects associated with oil burning need to be better understood;
- **Validate and develop models** in advance of any future spill that has the potential for three-dimensional dispersal. In order to reach this goal, the group indicated that **more information is needed on the "bulk level**," i.e., fractions of oil that dissolved, was degraded, remained in the subsurface waters, sank to the bottom sediments, went to the atmosphere, or went to shorelines. In addition, there is the **need for chemical component information**, i.e., the fate/extent of the most relevant/dominant individual compounds that comprise the natural gas, liquid oil and dispersants. Finally, models to predict the fate and extent of the petroleum depend on process understanding, so there is a **need to determine the time-series of changes** in the rate of flow, droplet sizes, chemical composition, physical transformation, and quantity and efficacy of dispersant injected at the well head;
- **Investigate dispersant delivery systems, and their effectiveness** with regard to surface and subsurface oil. Research is needed on the **effects of dispersants on toxic components of oil**, answering questions such as whether dispersants increase the bioavailability of oil toxic compounds in habitats;
- **Explore interactions of oil components with marine snow particles and re-suspended sediments** to assess the role of particulate matter on potential aggregation and fate of oil and dispersants.

In the array of necessary research outlined, some **overlapped with recommendations of other groups**, such as the need to:

- **Investigate acute and chronic toxicity of oil constituents, and dispersants, on** economically or ecologically **important organisms**, using the water chemistry data for a basis for experimentation;
- **Evaluate oil spill impacts on the food web**. Research on food webs must include benthic filter feeders (including shellfish, reef-building corals, deepwater corals, shallow and deepwater sponges), zooplankton, phytoplankton, and other members of the food web, as well as early life history stages of fish and invertebrates to understand the cascading trophic effects;
- **Investigate the impacts of spills on whole ecosystem interactions** (e.g., biogeochemical processes) to answer crucial questions such as: (1) Has sub-surface oxygen depletion been exacerbated by the spill? (2) How do zones of hypoxia/anoxia influence the transformation and fate of oil/dispersants? (3) How have the carbon/sulfur dynamics and bulk properties of communities changed in the region and what influences in the ecosystem cascade from these changes?

Summary: Oil/dispersant-impacts and mitigation in coastal environments (e.g., near shore, shallow reefs, beaches, marshes)

This breakout group was attended by 30 participants representing academia, federal/state government and private industry. The group focused the discussion on addressing the following questions: What do we know about oil impacts on coastal environments? Where are the gaps in our knowledge?

Key areas of focus articulated by the group included the following:

- **Importance of Environmental Baselines.** Baselines are available for water, sediment and animal tissue contamination from ongoing monitoring programs. These allowed for rapid, initial analyses of petroleum hydrocarbon contamination, though rigorous statistical analysis is still underway. Data from NOAA, EPA, USGS, and several academic groups are available online allowing for sharing of resources between research groups;
- **Oil Impacts on Coastal Habitats.** Oil impacts were highly heterogeneous and localized, making it difficult to track and study. Reintroduction of oil is occurring but its origin is unclear. Marshes with limited exposure to oil show little impact on structural integrity. Chronic and persistent oiling increase chances that marsh will suffer damage. Re-oiling damages new growth;
- **Oil Impacts on Ecosystem Structure and Function.** Genetic studies, schlerochronology, food web impacts, and responses of the microbial community are being used to determine impacts of oil on eco-services. Sub-lethal effects may be occurring, however, studies on the time scale of generations will be required to fully understand these effects;
- **Effectiveness of Response Strategies and Potential Consequences.** Booms have been effective in containing and collecting oil; however utility is limited to calm sea state. Berms have not been proven effective in containing oil and may alter natural flow of water and sediments. Some efforts, including marsh/beach treatments and detached booms, may be more damaging to marshes than the oil. The effectiveness of dispersants was questioned.

The following gaps in knowledge were identified:

- Understanding of the dynamics of oil exposure and the associated impacts on sea grass and marsh vegetation;
- Identifying short- and long-term effects and the relative importance of each;
- Understanding of the impacts of oil on carbon and nutrient cycling;
- Characterizing oil transport by waves and associated oil exposure and distribution on shorelines.

Recommendations for future efforts:

- Improving data-sharing and communication between federal and non-federal scientists;
- Establishing an oil spill research clearinghouse to link data bases, share information, review previous work, coordinate field work, etc.;

- Conducting sustained ecosystem observations and modeling to understand long-term impacts and establish baselines;
- Investing in improved sensor technology and remediation materials, as well as proactive testing and evaluation, perhaps with an intentional, controlled spill;
- Conducting additional aerial surveys for examining spatial heterogeneity of impacts.

Summary: Oil/dispersant-impacts and mitigation in offshore environments (e.g., deep ocean habitats, deep coral systems, seep communities)

This breakout session considered the physical oceanography, sediment biogeochemistry, community ecology, genetics, and water column chemistry and biology of offshore and deep-water environments. This breakout session consisted of approximately 15 participants from academia, government, and private industry.

General considerations for offshore deepwater environments. From the initial discussions, it was clear that there remained large gaps in basic understanding of offshore, deep-water environments and that we would only understand the impact of the spill if we continued to add to this body of knowledge. The group emphasized the need to:

- Determine the impact of DWH oil on deepwater communities
  - Including benthic, pelagic, and neuston
  - Determine indicator species for each habitat
  - Develop genetic and transcriptomic tools to assess and monitor health
- Determine the persistence of impacts
  - Sublethal effects/recovery time
- Process the samples already in hand
  - Hydrocarbon concentrations (exposure)
  - Demonstration of actual impacts
- Determine the changes in nutrients and plankton communities
  - Biogeochemistry
  - Air-sea exchange

Recommendations for future progress in the field. In the short term, the next steps include continued examinations of impact and determination of cause-and-effect. In the longer term, observatories are needed to test for ongoing effects and to allow us to be in a better position to determine the impact of any future events.

- Implement a monitoring plan
  - Revisiting existing monitoring sites
  - Augment with new sites for different habitats – coral, seep, etc
  - Transect studies for soft bottom
  - Consistent data sets
  - Complete set of sensors to be determined
- Dedicated infrastructure of ships and submersible assets needed
  - Decline in these resources in recent years
- Coordination among existing efforts and availability of data sets
  - Continuing discussion among different agencies
  - Multibeam data sets made available

  - Industry 3D seismic should be released
  - Tie data sets together and integrate databases

Implementation of Permanent Observatories on the Seafloor. The group discussed the need to establish a series of observatories, including key sites that are instrumented and have continuous data sets collected from a suite of sensors, as well as sites that would be repeatedly visited to be imaged and sampled. Specific details would be determined at a later date, but some general recommendations include:

- Three sets of observatories
  - Eastern, Central, Western Gulf
  - Nearshore to deep-water swaths
  - High-resolution mapping at each monitoring site
- Each would contain:
  - Instrumented site for each habitat type
    - coral, natural seep, soft bottom
    - standardized set of instruments
    - additional, proposal driven add-ons
  - Monitoring sites
    - along a depth gradient
    - include all habitat types
    - to be regularly revisited
    - imaging as well-navigated photomosaics
    - sampling for snap-shot of transcriptome of key sentinel species

Database Needs. The collection of all of these data require a collaborative database to house the data and make it readily available to interested parties. There are numerous databases out there, and it is possible that this effort could leverage off of existing resources. There should also be a requirement for data submission by researchers working at the observatories.

- Fast, secure, and operationalized distribution of real-time data and quality control data to users and to data centers;
- Continued collaborative approach to include government, academia, and private industry.

Summary: Oil/dispersant-impacts and mitigation on living marine resources (e.g., protected and harvested species, essential food web)

This breakout session consisted of 19 participants from academia, government, and private industry. The group focused the discussion on addressing the following four questions: What new research initiatives did this anthropogenically-induced incident provide? What worked well (what are we learning)? What would you do differently? Where are the intersections/connections with other themes?

Key areas of focus articulated by the group included the following:

- **Sampling for PAHs, heavy metals (e.g., mercury), phosphates, nutrients or other chemicals, isotopes (nitrogen, carbon, sulfur).** In particular, as isotopic data collection becomes more routine, it will provide new opportunities for interdisciplinary collaborations, powerful case studies on a suite of different environmental impacts (including oil spills), and potentially allow for more effective tracking of bioaccumulation through trophic transfer;
- **Research on dispersants, oil, dispersant-oil combinations,** particularly with respect to the development of depth-specific toxicity tests and protocols for determining how long dispersants persist in animal tissues or what their ultimate impact might be on a species-by-species basis (e. g., shrimp and oyster versus crab and fish);
- **Building more comprehensive trophic mass-balance models**. This was recognized by the group as very important, though also a demanding undertaking that needs thorough parameterization. The Exxon Valdez oils spill and subsequent monitoring reinforces the importance of examining trophic structure coupled with large scale physical models;
- **Developing 3-dimensional biophysical models**. Models that include the behaviors of living organisms as well as the changing characteristics of the oil itself are critical to understanding food-chain dynamics and the biophysical mechanisms that could be impacted by oil spills, notably mechanisms affecting plankton aggregation and larval transport;
- **Adoption of ecosystem-level approach.** Implementing an ecosystem-based management approach and putting it into practice in a larger, integrated perspective on how to collect baseline information and assess impacts is critical at this point.

Areas of intersection with other themes:

- **Habitats should be prioritized for research, monitoring, and modeling.** We should focus on patterns and processes at the larger, more holistic spatial scale of the spill's impact, rather than limiting our attention to highly visible coastal habitats;
- **The relationship of sub-surface oil to living marine resources.** The subsurface oil plume at ~1,000-1,400 m is a feature that has never been encountered before, although similar plumes were observed during an experimental deep-sea oil spill created and monitored by Norwegian researchers. Oil contact with the benthos can occur wherever the plume depth coincides with the corresponding seafloor isobath, and also wherever surface or subsurface oil becomes heavy enough to settle to the bottom, which is most likely in quiescent areas with pre-existing

depositional tendencies. Researchers in the session indicated more effort needs to be spent on the biological implications of these subsurface interactions;

- **Education sorely needed.** Scientists must connect to the public to educate them. Film, printed and web-based products from NGOs such as National Geographic and similar entities may be the most useful means of achieving effective public education regarding connectivity among Gulf habitats;
- **Technological Problems.** Overall, the impression is that most of the scientific community was unprepared to sample at the depths at which the leak occurred because the available technology for sampling at these depths was not available to them. Off-the-shelf instrumentation was untested in such applications, despite the claims of the instruments' manufacturers.

Summary: Oil/Dispersant-impacts and mitigation-human health and socio-economic systems (exposure, community vulnerability and resilience)

This breakout session consisted of approximately 14 participants from academia and government. The discussion focused on overarching trans-disciplinary research opportunities followed by recommendations for research priorities that fit within two broad categories: Socio-economic systems and Human Health.

Overarching Challenges and Opportunities-

- **Need for baseline observations.** The ability to understand the social, economic and human health impact of a shock to the ecosystem requires accurate information on initial conditions and ongoing observations that can capture the changes and the recovery after the event;
- **Risk.** Better methods to characterize and reduce risk across the systems are needed. This must be coupled with a research program that seeks to understand how decision makers use and act upon probabilistic scientific information and how best to communicate risk. This includes understanding the influence and role of mass media;
- **Resilience.** The term resilience is used in many different contexts across systems. We need to understand what makes a reliable indicator of resilience and how resilience measures for health, community, regional economy, and ecosystem are interrelated;
- **Environment and Communities.** Models that integrate human health and activity with environment are needed so that we can trace how environmental changes affect economic drivers, physical and mental health, and social/cultural constructs. Of particular importance are vulnerable populations that have been historically under-resourced;
- **National Ocean Policy.** There is an opportunity to develop new models of integrated human/environmental systems under the priorities articulated in the NOP;
- **Quick response research.** Improve the mechanisms that facilitate, fund and coordinate quick response research on social, behavioral, health and economic impacts. IRB and OMB approvals must be streamlined or pre-approved to allow for the collection of ephemeral data.

Research Recommendations for Socio-economic Systems:

- Work to fully value the ecosystem services provided by the Gulf of Mexico large marine ecosystem is needed to inform resource management, policy and regulation;
- There is a need for research on the impacts on tourism and recreation-two important industries for the gulf region. Small businesses and independent operators comprise a major segment however little is known about the tourism and recreation industry infrastructure. We need to understand secondary impacts on businesses in the gulf region as well as the effects on related markets (sea food) in other regions;
- Changes in fishing regulations had major social and economic impacts. Social well-being and vulnerability indicators for fishing communities are needed. Further research to identify communities that were heavily dependent on employment in the oil industry and the fisheries and examine strategies to reduce vulnerability is recommended;

- Economic research has been hampered by the litigation sensitivity of NRDA-related economic studies. Economic impact findings for management and local policy decisions and economic effects unrelated to our public trust resources have been understudied;
- Research on the attitudes, perceptions and beliefs with respect to seafood safety and tourism opportunities in the Gulf will support strategies to rebuild trust and consumer preferences for these products and services.

Research recommendations for Human Health Systems:

- Relevant contaminant mixture(s), including those in water, air, and sediment, should be characterized. Toxicity testing of these mixtures may be conducted using, for example, in vitro or in vivo animal models. Gene-environment interaction could be a focus of such work;
- In human populations, there is a need to develop better biomarkers of exposure, effect, and susceptibility to allow earlier assessment of potential harm, including that associated with psychosocial stress;
- Protection of public health requires an infrastructure knowledgeable of the community's risks as well as its assets. Developing assessment methods for measuring vulnerability and resilience, their causes and consequences at a system level, should be a priority. Innovative technologies to enhance disaster preparedness, response, and recovery could be encouraged;
- There is evidence that vulnerable populations may be more susceptible to the effects of the DWH disaster and other stressors. Such groups may include subsistence fisherpeople and their families, the young and elderly, pregnant women, and environmentally and economically disadvantaged populations;
- There has been little research to characterize potential long-term health effects of oil spills. A long-term observation and human health monitoring and research program is needed to fully capture the impacts on physical and mental health that can persist long after the environmental event has occurred.

Summary: Use of in situ and remote sensors, sampling, and systems for assessing extent, fate, impacts, and mitigation of oil/dispersant.

This breakout session consisted of approximately 12 participants from academia, government, and private industry. Several common themes recurred in the presentations and ensuing discussions: 1) General considerations on in-situ and remote sensing observations in support of monitoring, assessments, and restoration, 2) Role of satellite observations, 3) In-situ measurements of oil, dispersants, and tar balls at the surface and subsurface, 4) Observing network with sustained observations, and 5) Data accessibility and distribution.

General considerations on in-situ and satellite observations in support of monitoring, assessments, and restoration. Given the nature of the DWH incident, an extraordinarily large suite of interdisciplinary observations was necessary to monitor the ocean conditions and assess the impact of oil in the diverse ecosystems present in the Gulf of Mexico area. The group emphasized the need to:

- Conduct observations in a coordinated fashion with all scientific and operational participants,, and measure parameters at appropriate spatial (in the near and far-field) and temporal scales, with clear scientific and operational justification;
- Make the most of quality controlled data in analysis, validation/assessment of numerical and theoretical models, and initialization of numerical models and reanalysis of Gulf conditions;
- Support ship time of the academic and government fleet; and provide a mechanism to update and cross-reference calibration equipment and technology on UNOLS and NOAA fleet as well as non-UNOLS or NOAA vessels.

Role of Satellite Observations. Satellite imagery of various kinds, covering different parts of the electromagnetic spectrum and a range of spatial, spectral and temporal resolution were used in a complementary fashion on a daily basis in an operational, research, and educational manner to inform responders, stakeholders, and the public. In addition to supporting strategic planning for satellites in general, the group emphasized:

- Continue strong support of satellite missions to measure sea height, sea surface temperature, and multi-spectral ocean color (able to resolve mesoscale and small scale features in the near shore and offshore regions); as well as scatterometer missions and SAR; Create new products using traditional and non-traditional visible and infrared spectra;
- Establishment of an optimal multiplatform monitoring of ocean dynamics to calibrate, validate and blend with satellite observations;
- Improvement of oil/dispersant detection by supporting studies of how parameters measured by satellites may be affected by oil/dispersant extension and thickness.

In situ Measurements of Oil, Dispersants, and Tar Balls at the Surface and Subsurface. There were extensive discussions on how various sensors and platforms are expected to perform at detecting subsurface oil based on their instrumental characteristics. The group emphasized the need to:

- Support enhancement of shipboard measurements, including observations from ships, AUVs, etc;
- Carry additional studies to evaluate different sensors and platforms that provide data for oil detection and recommend if more appropriate sensors should be installed in research and operational platforms, including ships, CTDs, gliders, etc.;
- Investigate any potential interference effects of oil on different physical and chemical measurements (e.g. oxygen, salinity, etc);
- Support technology development for measuring oil-detecting parameters, for example mobile platforms or moorings;
- Expand the use, assessment and validation of fluorometers and data generated;
- Carry out evaluation and validations of modeling efforts;
- Develop methods specifically for low-level hydrocarbon detection with other proxies.

Observing Network with Sustained Observations. Long term monitoring of the whole water column, with a suite of sensors to be determined, should be continued at the oil spill site. It was agreed that this network should monitor conditions, assess impacts, be able to help with the response to various extreme events (e.g. oil spills, tropical cyclones, harmful algal blooms, etc), respond to daily needs (e.g. navigation safety, search and rescue, etc), and investigate connectivity between different basins (e.g. Caribbean Sea) and Gulf regions (e.g. Florida Keys, western Gulf, Florida Bay etc). The group highlighted the following:

- Create and sustain one robust ocean observing system for monitoring extreme events and to monitor ecosystem changes due to extreme events. The system should be interdisciplinary, including biological, physical, chemical, in the atmosphere, whole water column, and sediments;
- Carry out Observing System Simulation Experiments (OSSE) to design the observing network and to provide scientific and operational justifications for its design.

Data Accessibility and Distribution. Observations, distribution of data, analysis, assessments of impact, and projections need to be done in collaboration among scientists of different institutions that include government, academia, and private industry. The group highlighted the following:

- Fast, secure, and operationalized distribution of real-time data and quality control data to users and to data centers;
- Continued collaborative approach to include government, academia, and private industry.

Appendices

Deepwater Horizon Oil Spill Principal Investigator (PI) Conference
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Final Agenda

October 5, 2010

What are we learning?

7AM-8AM — ***Ballroom Arcade***

Registration and Continental breakfast (provided)

[hang posters]

8AM-810AM — ***Grand Ballroom***

Welcome

[JSOST Co-chair-Dr. Jerry Miller (OSTP)]

810AM-830AM — ***Grand Ballroom***

Keynote "Deepwater Horizon: Science in Action"

[Dr. Larry Robinson-Assistant Secretary of Commerce for Oceans and Atmosphere-NOAA]

830AM-9AM — ***Grand Ballroom***

Conference Goals and Objectives

[JSOST Co-chairs-Dr. Steve Murawski (NOAA) and Dr. David Conover (NSF)]

- Objective: Bring together PIs actively conducting research in response to DWH oil spill
- Goal: What are we learning? Where are the gaps? What are the information needs and long-term research priorities to assess the ecosystem impacts of the DWH oil spill?
- Background: Federal response effort
- Deliverable: workshop write-up summarizing key results

915AM-1000AM — ***Grand Ballroom***

Plenary-Overview of the Issues -Part I

- Oil/dispersant-***extent and fate*** (e.g., air, surface water, water column, beaches, marshes) *[Dr. Chris Reddy-Woods Hole Oceanographic Institution]*
- Oil/dispersant-impacts and mitigation in ***coastal environments*** (e.g., near shore, shallow reefs, beaches, marshes) *[Dr. Sean Powers-Dauphin Island Sea Laboratory]*

1000AM-1015AM — ***Ballroom Arcade***

Coffee Break

1015AM-1200PM — ***Grand Ballroom***

Plenary-Overview of the Issues -Part II

- Oil/dispersant-impacts and mitigation in ***offshore environments*** (e.g., deep ocean habitats, deep coral systems, seep communities) *[Dr. Ian MacDonald-Florida State University]*

- Oil/dispersant-impacts and mitigation on ***human health and socio-economic systems*** (e.g., exposure, community vulnerability and resilience) *[Dr. Ed Trapido-Louisiana State University]*
- Oil/dispersant-impacts and mitigation on ***living marine resources*** (e.g., protected and harvested species, essential food web) *[Dr. Todd Gedamke-NOAA/NMFS Southeast Fisheries Science Center]*
- Use of ***in situ and remote sensors, sampling and systems*** for assessing extent, fate, impacts and mitigation of oil/dispersant *[Dr. Gustavo Goni-NOAA/OAR Atlantic Oceanographic and Meteorological Laboratory]*

Breakout Session-Charge

12PM-2PM ***Ballroom Arcade***

Lunch (provided) and Poster session

2PM-5PM (Coffee will be available between 300-330PM-Ballroom Arcade)

Breakout groups-State of the science (closed to media)

- Oil/dispersant-***extent and fate*** (e.g., air, surface water, water column, beaches, marshes) *[Session Chair-Dr. Elizabeth North-University of Maryland]*
  North Terrace Meeting Room
- Oil/dispersant-impacts and mitigation in ***coastal environments*** (e.g., near shore, shallow reefs, beaches, marshes) *[Session Chair-Dr. Steve Lohrenz-University of Southern Mississippi]*
  King Charles Ballroom
- Oil/dispersant-impacts and mitigation in ***offshore environments*** (e.g., deep ocean habitats, deep coral systems, seep communities) *[Session Chair-Dr. Walter Johnson-BOEMRE]*
  South Terrace Meeting Room
- Oil/dispersant-impacts and mitigation on ***living marine resources*** (e.g., protected and harvested species, essential food web) *[Session Chair-Dr. Cathy Tortorici, NOAA/NMFS]*
  Buena Vista Meeting Room
- Oil/dispersant-impacts and mitigation on ***human health and socio-economic systems*** (e.g., exposure, community vulnerability and resilience) *[Session Chair-Dr. Maureen Lichtveld-Tulane University]*
  Board Room 1
- Use of ***in situ and remote sensors, sampling and systems*** for assessing extent, fate, impacts and mitigation of oil/dispersant *[Session Chair-Dr. Vernon Asper- University of Southern Mississippi]*
  Grand Ballroom

5PM-7PM

Reception and Poster session ***Grand Ballroom***

October 6, 2010

What do we need to know?

7AM-8AM ***Ballroom Arcade***

Continental Breakfast (provided)

8AM-9AM ***Grand Ballroom***

Plenary - Broader Context

[JSOST Co-chair-Dr. Jerry Miller (OSTP)]

- Mabus Restoration and NRDA *[Dr. Robert Haddad, NOAA]*
- Sub-surface monitoring *[Dr. Steve Murawski, NOAA]*
- Gulf of Mexico Plans *[Mr. Steve Sempier, MS/AL Sea Grant]*

Breakout Session Charge

915AM-12PM (Coffee will be available between 1000-1030AM-Ballroom Arcade)

Breakout groups- Gaps and Long-term recommendations (closed to media)

- Oil/dispersant-***extent and fate*** (e.g., air, surface water, water column, beaches, marshes) *[Session Chair-Dr. Elizabeth North-University of Maryland]*
  North Terrace Meeting Room
- Oil/dispersant-impacts and mitigation in ***coastal environments*** (e.g., near shore, shallow reefs, beaches, marshes) *[Session Chair-Dr. Steve Lohrenz-University of Southern Mississippi]*
  King Charles Ballroom
- Oil/dispersant-impacts and mitigation in ***offshore environments*** (e.g., deep ocean habitats, deep coral systems, seep communities) *[Session Chair-Dr. Walter Johnson-BOEMRE]*
  South Terrace Meeting Room
- Oil/dispersant-impacts and mitigation on ***living marine resources*** (e.g., protected and harvested species, essential food web) *[Session Chair-Dr. Cathy Tortorici, NOAA/NMFS]*
  Buena Vista Meeting Room
- Oil/dispersant-impacts and mitigation on ***human health and socio-economic systems*** (e.g., exposure, community vulnerability and resilience) *[Session Chair-Dr. Maureen Lichtveld-Tulane University]*
  Board Room 1
- Use of ***in situ and remote sensors, sampling and systems*** for assessing extent, fate, impacts and mitigation of oil/dispersant *[Session Chair-Dr. Vernon Asper- University of Southern Mississippi]*
  Grand Ballroom

12PM-130PM ***Ballroom Arcade***

Lunch (provided)

130PM-330PM ***Grand Ballroom***

Plenary-Report-outs

- Oil/dispersant-***extent and fate*** (e.g., air, surface water, water column, beaches, marshes)
- Oil/dispersant-impacts and mitigation in ***coastal environments*** (e.g., near shore, shallow reefs, beaches, marshes)
- Oil/dispersant-impacts and mitigation in ***offshore environments*** (e.g., deep ocean habitats, deep coral systems, seep communities)
- Oil/dispersant-impacts and mitigation on ***living marine resources*** (e.g., protected and harvested species, essential food web)
- Oil/dispersant-impacts and mitigation on ***human health and socio-economic systems*** (e.g., exposure, community vulnerability and resilience)
- Use of ***in situ and remote sensors, sampling and systems*** for assessing extent, fate, impacts and mitigation of oil/dispersant

330PM-345PM ***Ballroom Arcade***

Coffee Break

345PM-5PM ***Grand Ballroom***

Plenary-Wrap-up

[JSOST Co-chairs-Dr. Steve Murawski (NOAA) and Dr. Jerry Miller (OSTP)]

- Highlights
- Next Steps

5PM

Adjourn

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Deepwater Horizon Oil Spill Principal Investigator (PI) Conference
Sponsored by the NSTC JSOST, hosted by University of South Florida,
Don CeSar Resort, St. Petersburg, FL, October 5-6, 2010

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Plenary Session Notes

Dr. Larry Robinson "Science in Action":

Many Americans depend on the Gulf of Mexico for their livelihoods. Healthy ecosystems provide many services and understanding how humans influence these services will help us to make informed decisions regarding the ecosystem. Two goals of the National Ocean Policy are ecosystem-based management and coastal and marine spatial planning, both of which have important implications for the Gulf of Mexico Large Marine Ecosystem.

The Deepwater Horizon Oil Spill has greatly impacted the Gulf and a long term science plan is needed to accompany restoration efforts. This plan will need to consider lessons learned from past events. The Gulf of Alaska Ecosystem Monitoring and Research Program provides a framework for making decisions and should be used as an example.

We are in need of a comprehensive understanding that begins with observations and monitoring. Modeling efforts are needed to understand the broader impacts of the oil spill. We will also need to consider the social science impacts. Humans are integral to the system and we will need to examine acute incremental changes.

The lessons we learn now should help the nation prepare and be better able to respond to future perturbations on this scale.

Conference Goals and Objectives

Conover:

The NSF Rapid Response Research Program awarded $19.4M which included 166 awards. The average project size was $117K. Another $5M was spent on ship costs. Over half of the awards went to the Gulf States and the remaining funds were spread throughout the nation. This is the largest NSF rapid investment ever. A wide range of topics were covered, including such things as instrumentation, plume flux, ecosystem and habitats, and microbial degradation. Biological oceanography and chemical oceanography were the largest disciplines. Three publications have already resulted from this work.

BP has made a $500 million commitment to research over the next 10 years and these funds will be distributed through the Gulf of Mexico Alliance.

This meeting is designed to bring together the science investigators involved in research surrounding the DWH Oil Spill. Key questions for this meeting include: What have we learned so far? What are the gaps? What are the long-term information needs and research priorities to assess ecosystem impacts?

Murawski:

This DWH Oil Spill Conference is being sponsored by the JSOST. The roles of JSOST include:

- providing science support for implementing the National Ocean Policy
- coordinating among federal ocean scientists – priorities, programming, outcomes
- interacting with wider academic-government-private research community to advocate community science priorities
- implementing joint planning and programming around issues of common priority
- updating the Ocean Research Priorities Plan, *Science for an Ocean Nation*

There are a number of necessary critical science collaborations that have formed in response to the DWH oil spill. Under the authority of the National Incident Command and Unified Area Command interagency groups have formed to address such topics as the enhanced subsurface monitoring plan and seafood safety monitoring. Enhanced scientific outreach and discussion sessions have been held and conferences are designed to provide a forum for sharing scientific results and encouraging collaborations. There is an interest in creating a more permanent structure to facilitate agency/academic/private collaborations and there is a continued effort to make information more available to and usable by the public.
There is a need to understand the lessons learned and the mechanisms that need to be in place in the event another spill occurs. We also need to develop a long term research strategy and discuss future workshop needs.

Key Discussion Points:
NOAA is actively involved in many activities related to the DWH oil spill. For example, NOAA is currently developing a subsurface monitoring plan. NOAA is also a trustee for Natural Resource Damage Assessment and is evaluating the impacts of the oil spill on the ecosystem and resources. 17 teams have been established to investigate various aspects of the spill. There are also a number of fisheries and living marine resources studies, as well as social science studies.

There is some consideration for using a trust fund for the BP research monies. However, this is not currently part of the National Ocean Policy. The MABIS Plan mentions this, but it would require an Act of Congress to implement.

The timing and length of the NRDA process is difficult to predict. It will largely depend on how quickly, and if, a settlement can be reached. The large scale of the oil spill is relatively new and makes things difficult to predict.

Plenary 1 – Chris Reddy – Oil/Dispersant Extent and Fate
Understanding the fate and extent of the spill is difficult and further complicated by the fact that the oil was released from a depth of 1500m. The sustained release resulted in mixed signals and multiple processes affecting the fate. Despite numerous research cruises only a small portion of the water has been sampled. It will take years for a refined estimate of the mass balance. There are thousands of samples in queue and many uncertainties to consider. It took five years for the fate of the Valdez oil to be published. This timescale highlights the complicated process that is involved.
The source oil from the Macondo well immediately became a mix of compounds and hydrocarbons. The chemical composition of the oil found throughout the water column is not likely to be the chemical composition of the oil that was immediately released. The mixtures of hydrocarbons are changing and this fact needs to be considered in research designs. Care should be taken to employ bulk analysis. Initial studies will be helpful in determining new regulations.

Key Discussion Points:

A chemical fingerprint can be used to differentiate oil that originated from the well versus oil that did not, but this is not a trivial process. One scientist mentioned having dozens of samples of reservoir fluid and struggling to grasp the actual composition of these samples. There needs to be a reference point for what is considered oil and what is not.

Natural gas will also play a role because there is a tremendous amount of reduced carbon. It will be important to understand the Gulf of Mexico as a system.

Plenary 2 – Sean Powers – Impacts and Mitigation in Coastal Environments

Despite great efforts oil has entered the nearshore environments of the Gulf of Mexico. This has resulted in a need to mitigate nearshore impacts in the face of scientific uncertainty. The Gulf of Mexico has extremely rich, productive habitats (reefs, mangroves, oyster beds, seagrasses), but habitat damage can limit the system's ability to recover. Experience gained from the Exxon Valdez spill has shown that habitat damage is responsible for long-term effects to the ecosystem. Potential mechanisms for habitat degradation include contaminant impacts (oil) and response associated impacts (dispersants, freshwater diversions, boom deployments, physical disturbances from clean-up efforts, deep beach excavation, human activity etc).

There are many scientific questions that need to be addressed concerning the coastal environment. Scientists need to examine the level of oil and dispersants that have been observed in the various coastal ecosystems and also determine how this can be more effectively monitored and detected. What alternate methods and techniques are appropriate? What impacts on the ecosystem and ecosystem services have been observed? What studies are needed?

Key Discussion Points:

After the Exxon Valdez oil spill it took approximately 2-3 years to see the direct effects of the spill and approximately 7-8 years to better understand the mechanisms involved.

There was also discussion on setting aside areas for study purposes and the appropriate size of such areas. It was decided that a statistician should be consulted, but 10-25% of areas may be reasonable. The National Park Service may be able to assist with this.

Freshwater and nutrient diversions were made to nourish the marshes. Typically this is only done in the spring, but due to the spill these diversions have been made continuously to prevent a freshwater plume of oil from coming onshore. There is a need for further studies to examine the cost effectiveness of this approach.

There are many studies underway to examine the ecological effects of the oil and dispersants.

Plenary 3- Ian MacDonald – Impacts and Mitigation in Offshore Environments

A few different approaches have been used to track the oil. One approach is use of satellite data, but this method is sensitive to weather conditions. Researchers are also using a texture classifying neural network algorithm to classify the oil. Natural seeps are found throughout the Gulf which can make it difficult to track and classify. Another consideration is that crude oil is a mix of different molecules and straight-chain alkanes are abundant. Microbes prefer alkanes and will consume them in the sediments. Deep-sea benthic samples from north and northeast of the well site indicate there are oil layers and dead organisms in the sediment. Shipek Grab samples from Station 1 and 2 show oil is widely distributed.

Many deepwater communities may be adapted to the natural seeps, but the effects are largely unknown. Both deep and shallow water communities could be affected. There have been noticeable megafauna impacts as well. Endangered sperm whales and sea turtles are found throughout the area in addition to various shark species found along the canyon.

Experiments with dose 0.8 teragram hydrocarbons are needed to examine the lasting ecological impacts. There is some concern for a fractional loss of productivity and biodiversity across a broad sector of ecosystem components. Tipping points are a concern because it may not be possible to recover from these. There is a need to identify and monitor key habitats and populations to verify ecosystem health.

Key Discussion Points:

Tar balls are washing ashore due to the spill. Given the large number of natural seeps in the Gulf, this is typical along the Texas coast, but not the current locations. They are washing up in these new places due to the location and magnitude of the spill. The well documented observations of oil on the surface indicate that the magnitude is vastly different than previous spills.

Plenary 4- Ed Trapido – Impacts and Mitigation on Human Health and Socio-Economic Systems

The Deepwater Horizon oil spill is now part of the daily existence for the residents of the Gulf of Mexico and its impacts are far reaching. OSHA is concerned with the presence of benzene and other chemicals associate with the oil and cleanup efforts. Fortunately, light crude oil contains lower amounts of benzene than heavier crude oil, but there is still room for concern. There have been some reports of carcinogens in the oil. Also, approximately 2 million gallons of Corexit 9527 were used and this is considered to be a carcinogen by some. The EPA is also monitoring air conditions and NOAA is monitoring seafood safety.

There is a need for longitudinal studies focused on mental health. NIH is launching a Gulf of Mexico Oil Spill Health Study to examine both the short and long term health effects of the spill. Over 100,000 potential participants have been exposed. Oil rig workers, clean-up teams, dispersant sprayers, families of workers are only some of the groups possibly affected. Additionally, physical injuries associated with the clean-up efforts and mental health and stress issues need to be considered.

There are many policy issues to consider. Communication and education will be an important component of human health issues. There has also been a tremendous economic impact.

Key Discussion Points:

The list of people exposed to the chemicals did not include researchers, but this should be added. The loss of funding to academics should also be considered.

Complexity is magnified in the human health issues and it is also harder to sample. Researchers missed the opportunity for baseline data.

The next conference should include a community member.

Plenary #5 – Todd Gedamke – Impacts and Mitigations on Living Marine Resources

NMFS has been involved in many aspects of the oil spill response. In regards to seafood safety, the goal of NMFS is to ensure both safety and quality and instill confidence in consumers. Both sensory and chemical testing have been used in the re-opening protocol. Currently, over 50% of the previously closed area has re-opened. Lab experiments have been conducted to investigate whether dispersants contaminate seafood. A workshop held at the NOAA Galveston lab established the protocols for this testing.

Protected species surveys are also being conducted to determine the changes in abundance and species distribution. These surveys started seven days after the spill and are conducted biweekly. There have been estuarine bottlenose dolphin population studies, Bryde's whale habitat studies, and midwater prey sampling. Additionally, there has been a stranding response for sea turtles, which has included necropsies. Other studies have investigated the probability of larval tuna occurrence and oil distribution. Plankton sampling and fishery-independent sampling are both ongoing.

Key Discussion Points:

The minimum PAH detection level for the sensory test is 1ppm.

Plankton and toxicity studies are not being conducted together at the present time

Plenary #6 – Gustavo Goni – Use of In situ and Remote Sensors, Sampling and Systems for Assessing Extent, Fate, Impacts, and Mitigation of Oil/Dispersants

Many observations have been used both in the water column and the sediment in the oil spill response, including platforms (ships, gliders, airplanes, satellites etc) and sensors (CTD, XBT, surface drifters, flurometers etc). The geoplatform.gov website contains all of the current data in real-time user friendly format.

Satellite observations were used to monitor the oil spill extensions. The connection between Eddy Franklin and the Loop Current was specifically monitored to determine the possibility of the oil entering the Loop Current. A map analysis was conducted for the surface currents and the E.G. Walton Smith Cruise (May-June) measured subsurface oil with CDOM and oxygen. CDOM indicated the presence of oil. The detection of oil may depend on the instrument used.

The sediments have also been monitored. Instruments used include CTD, core sampling, camera-tow observations, and mapping of hydrocarbons.

Key Discussion Points:

There is currently no evidence that the oil made it into the Florida Straits and the Gulf Stream.

Both chemical fingerprinting and fluorescence can be used to differentiate the BP oil from the natural seeps.

Robert Haddad – Mabus Restoration and NRDA

NRDA is a process that occurs parallel to the spill response. It is a structured process defined in regulations and focused on injured natural resources, including air, water, soil, sediment, ocean biota, and habitat. The primary authority is the Oil Pollution Act.

The NRDA framework includes release, pathway, exposure, and then injury. The OPA process is a 3-step process that includes a pre-assessment screen, restoration planning, and restoration implementation. The process cumulates in a final document titled the "Damage Assessment Restoration Plan" and will layout all damages and rationale for choosing certain restoration projects.

The responsible party will pay into an oil spill liability trust fund that will be administered by the United States Coast Guard. Agency appropriated funds are often used initially until reimbursement from the responsible party.

Restoration returns the injured natural resources to baseline conditions. It can include restoring, replacing, rehabilitating, or acquiring equivalent conditions. It is primary and compensatory. Restoration requires public involvement and approval.

NRDA is a restoration focused, cooperative, legal process. Over 240,000 environmental samples have been collected and over 6500 of these have been analyzed. There have been more than 70 offshore research cruises and over 2000 linear miles of shoreline have been analyzed. Teams have captured both live and dead oiled animals.

Secretary Mabis recommends Congress establish dedicated funds for restoration and create a Gulf Coast Restoration Council to manage funds. The Mabus plan also establishes a task force immediately and urges the focus to be on economic recovery. The Gulf Coast Ecosystem Restoration Task Force is established to support NRDA and coordinate non-NRDA ecosystem funds.

Key Discussion Points:

The original size of the Ecosystem Task Force was deemed too large with too many parties involved to be effective. The size was reworked and reworded.

It is unsure as to why the only state representative on the task force is an elected official. The reasoning is not clear and it eliminates university researchers from being involved.

Academics may be called to testify in court during the NRDA process if their data is used. NRDA is forbidden to spend money on research, but data in the literature can be used.

Steve Murawski – Sub-surface Monitoring

The Sub-surface Monitoring Plan was informed by 3 academic outreach sessions. The goals of the implementation plan are to: 1) monitor and assess the distribution, concentration, and degradation of oil; 2) evaluate the distribution of dispersants or breakdown products of dispersants, and 3) identify any additional response requirements that are needed. Sampling will need to continue until we understand all fates of the oil.

The plan includes three sampling domains –nearshore, offshore, and deepwater. It also includes six hypotheses or potential scenarios for oil in sub-surface areas. Water and sediment sampling has occurred throughout the coastal and offshore regions in the Gulf of Mexico.

This sampling plan also has relationships to other monitoring goals. It will provide a complete baseline of location and concentration of the oil and dispersants. It will also be used to inform NRDA and provide a baseline for long-term monitoring with regard to ecosystem restoration.

Key Discussion Points:

It is good to see that data are becoming available. This will be important for research.

This meeting is part of an effort to coordinate research between NOAA and academic efforts. This will likely be the first of a series of meetings and there needs to be a framework for these meetings.

Steve Sempier – Gulf of Mexico Research Plan

The Gulf of Mexico Research Plan was funded by Sea Grant and is a service to the research community. Guidance on the plan was received from four Gulf of Mexico Sea Grant directors and 26 members of the planning and review council. The research priorities are linked to the 2007 Ocean Research Priorities Plan. The end result is a product of the review of 117 strategic plans, web-based surveys, workshops, and more than 230 involved organizations.

The Plan was released in September 2009, approximately 8 months before the Deepwater Horizon Oil Spill. In order to add an addendum which includes the spill, a rapid response was established. Open-ended surveys were sent to 100 leaders in the region and results from other meetings were examined. Next steps include incorporating results from the additional workshops, analyzing survey results, and analyzing exiting plans for research projects. Gaps will need to be identified and an implementation plan developed.

Key Discussion Points:

In regards to the survey, true priorities will be differentiated from researchers' "wish lists" based on the number of responses listing that specific item. This can help ground priorities.

Plenary Report-Out - Extent and Fate – Elizabeth North

Key Discussion Points:

There was discussion over the time scale over which oil can be fingerprinted. Compounds examined are robust to degradation and can be traced for decades or even 100s of years. There are current investigations to examine whether the dispersant injected at the well head can be used as a tracer itself, but it is believed that the only appropriate tracer is the oil itself. The oil fractionates and ends up in multiple places, including the atmosphere and coastal onshore environments.

Plenary Report-Out - Coastal – Steve Lohrenz

Key Discussion Points:

It was mentioned that it might be important to consider the distribution of oil to coastal areas in fluids other than water.

Set aside areas were discussed. These may be important to understand the effects of oil and impacts of mitigation strategies.

Seasonality issues (mating seasons, migration timing) are another important consideration that need to be considered.

The need for more aerial surveys was indicated because they are an effective way to determine the overall health of the marsh.

International activities are another important consideration. We do not have control over the drilling policies of other nations near our borders (e.g. Cuba).

Plenary Report-Out – Offshore-Erik Cordes

There was some question as to whether or not the ROVs detected the oil plume. If the data exists, it may be hard to access. There have been some reports of videos showing the plume at depth.
It was asked why observatories would be connected into OOI versus IOOS and it was mentioned that OOI was involved in broader development of infrastructure and IOOS was appropriate for data.
The well head was highly controlled space and even the government didn't have access to it. NOAA planned to use sonar to detect the plume, but this wasn't allowed near the well-head because it was operating at the same frequency as the rig. There was some concern about the possible side effects.
Jerry Miller mentioned it would be useful if the report mentioned which research questions could be answered with observations in the summary. There is a need for more information on temporal change. Also, improved infrastructure will help us to be better prepared in the event this happens again.

Plenary Report-Out - Living Marine Resources – Felicia Coleman
There was no discussion of the potential positive impact of the fisheries closures but this should go into the report.
It will be difficult to differentiate the effects of the oil/dispersant versus simply a bad recruitment year. Some current studies are investigating the effect of oil/dispersant on fecundity, larval survival, and spawning. Larval development and gonad development are also important considerations. It can be difficult to determine the reasons and mechanisms.

Plenary Report-Out - Human Health and Socio-Economic Systems-Maureen Lichtveld
The economic impact on human well-being is not well-studied and has important implications. It has been studied in previous spills, but not to this extent.
There is a need to get fishers involved and there is a realization that this group may not typically trust the government.
Air quality data can still be useful for human health studies despite the fact that this type of data only provides a snapshot of the conditions. Researchers can predict exposure and determine which compounds are taken up into the human body. Epidemiologists regularly work with this type of data.

Plenary Report-Out - In situ and remote sensors, sampling and systems - Gustavo Goni
Real-time observations are necessary. Scientists will need to determine the research question and then decide on the appropriate parameters. Appropriate spatial and temporal scales for these observations will need to be determined.
One of the cross-cutting themes in all reports is the need to improve understanding on ocean circulation in the Gulf of Mexico through improved modeling capabilities. There is also a need for increased in situ and satellite observations.
Another key emphasis mentioned is the need for continued collaboration between government, academia, and the private sector.

Plenary Wrap Up

Jerry Miller:

One of the common themes across all breakout group recommendations appears to be the need for data. This includes improved access to existing data, increased baseline data, and database needs. Another common theme is the need for improved observing systems.

Steve Murawski:

There is a need to emphasize human impacts and risk assessments. There have been two major catastrophes in the Gulf of Mexico in the last five years (Katrina, DWH).

There are four general themes from the various breakout groups:

1- Need for additional data collections and science in the moment
2- Interpretation and reprocessing of data, integrating data
3- Collaborating and moving quickly to react
4- Improving observing systems

There is a need for a quantifiable modeling framework to incorporate all components and create decision support tools. We will also need to document lessons learned and share this information widely.

Key Discussion Points:

There is a need for biological baseline data, but each spill is unique and we need to consider what baseline data is appropriate.

There is a need for a robust observing system in the Gulf of Mexico and this is becoming increasingly obvious. This has been suggested in numerous documents and gap analyses. The Deepwater Horizon oil spill only underscores this.

The BP research funds will be used for local and state priorities, but this group should advocate for priorities that meet the needs of the Gulf of Mexico as a whole entity.

There is an archive of samples (the legacy collections) available at the AMNH that might be useful. Not all of these samples have been processed but this collection has been mentioned at several venues.

There is a need for congressional funding.

There is a need for better integration of government and academia. We should also consider the U.S. Ocean Commission Report. This Report suggested a trust fund and required a biannual report. This FOCAR report is still being produced, but could be made more comprehensive and useful.

NOAA has not kept all money within NOAA. The agency has executed over $140 million in funding. They are considering creating a Gulf Science Council to address research priorities and provide a mechanism for a rapid response.

There is a need for interoperable databases, platforms, and in situ systems. These are issues that have come up repeatedly. It might be worth considering having new leases require that oil platforms be outfitted with sensors.

Also need to consider other sources of oil, such as land runoff, colliding barges, ports, etc.

99% of the Gulf of Mexico is pristine and it should not be considered a degraded ecosystem. Damage needs to be kept in perspective.

There should be a plan for spills in the mid-Atlantic region. Plans are needed for all possible spill sights. The outcomes of this meeting should be taken very seriously.

Full Report: Oil/dispersant-extent and fate (e.g., air, surface water, water column, beaches, marshes)

This report summarizes the discussions and recommendation provided by the Oil/dispersants Fate and Extent group at the JSOST Deepwater Horizon Oil Spill Principal Investigator Conference on October 5-6, 2010. The objectives of this document are to 1) briefly summarize recent advances that have resulted from the studies associated with the Deep Water Horizon (DWH) spill, 2) describe the challenges and our recommendations associated with immediate, near- and long-term information needs to improve our understanding and future oil spill response actions, and 3) discuss the issues that intersect the subject matter of other breakout groups.

Members of this group include:

- Alan Blumberg (SIT)
- Daewon W. Byun (NOAA)
- Lia Chasar (USGS)
- Kuki Chin (GSU)
- Chris D'Elia (LSU)
- Dan Deocampo (GSU)
- Rebecca Green (BOEMRE)
- Rouying He (NCSU)
- David Hollander (UST)
- Marco Kaltofen (WPI)
- Liz Kujawinski (WHOI)
- Rick Luettich (UNC)
- Wade McGillis (Columbia)
- Elizabeth North (UMCES)
- Nels Olson (JHU)
- Claire Paris (RSMAS)
- A. R. Ravishankara (NOAA)
- Chris Reddy (WHOI)
- Bob Rosebauer (USGS)
- Tom Ryerson (NOAA)
- Scott Socolofsky (TAMU)
- Ajit Subramaniam (Columbia)
- David Valentine (UCSB)
- Priscilla Viana (NSF)
- Robert Weisberg (USF)
- Michelle Wood (NOAA)
- John Zimmerman (EPA)

The plenary speaker for this session was Chris Reddy (WHOI). Panel members were Ajit Subramaniam (Columbia Univ.), Robert Rosenbauer (USGS), Michelle Wood (NOAA), A. R. (Ravi) Ravishankara (NOAA) and Chair Elizabeth North (UMCES) who coordinated this report. Priscilla Viana (NSF) served as rapporteur and provided, along with Claire Paris (RSMAS), notes of breakout group discussions that facilitated the development of this report.

I. Advances

The understanding that the multitude of compounds that comprise oil and dispersants have different chemical signatures, solubilities, and physical properties is becoming a guiding principle for monitoring and modeling the fate and effect of oil/dispersants introduced to the environment by the Deepwater Horizon oil spill. These properties fundamentally control the transport, degradation and loss processes, and potential toxicity of oil/dispersant.

Technology is rapidly advancing. For example, detection of subsurface oil via fluorometry and backscatter is improving as better understanding of the strengths and weaknesses of the approaches are identified. Satellite views of the oil slick from space aided the response effort. Dioctylsulfosuccinate (DOSS), a chemical compound in the dispersant COREXIT applied at DWH, is now measureable as a target analyte for identifying dispersants in the sub-surface environment using ultrahigh resolution mass spectrometry.

There is an evolving data base of monitoring physical and chemical properties of water and oil/dispersants from the Gulf of Mexico, some components of which are available, or are becoming available, on line.

Other important advances include, but are not limited to:

- Fingerprinting of the MS252 oil released at the well head has been completed by different government, academic, and contract labs and comparisons to environmental samples are now possible.
- Atmospheric measurements of specific chemical compounds have been made and will help constrain the mass balance of different chemical constituents of oil.
- Physical mechanisms of subsurface plume formation have been described and modeled.
- Multiple 3D numerical modeling studies of ocean circulation and the transport of oil have been developed and will help 1) quantify the fate and extent of oil/dispersant transport and 2) guide future field sampling.

II. Challenges and recommendations

This section includes a description of challenges and recommendations related to A) immediate research needs for the DWH spill, B) near- and long-term research needs for the DWH spill, and C) actions to improve responses to oil spills in the future. From a funding agency perspective, near- to long-term research programs span 2 to 20 years in duration.

A. Immediate research needs

1. Without adequate observations we cannot answer fundamental questions about the fate and extent of oil/dispersants from the DWH spill. Sampling should continue over a broad enough domain, including critical shelf break habitats, to define the extent and fate of the remaining oil/dispersant degradation products. Improved coordination and communication between the ongoing industry, federal and academic monitoring efforts is needed. A subsurface sampling plan is needed now to guide these activities. Although the draft Subsurface Implementation Plan is currently being implemented, as presented by Steve Murawski at the JSOST DWH meeting, the plan has not been finalized and distributed. Numerical model results indicate that there could be other branches of the subsurface plume to the northeast/southeast, in addition to the southwestern plume. Additional monitoring in the region to the east of the DWH well would be warranted.
2. Monitoring data should be available online, as is already underway through the GeoPlatform. **Online data should include files of the raw data** (ASCII, CSV, or similar) available through direct hyperlinks (currently only PDF files of data plots are available for many datasets). Ideally, all online data should be accessible by URL so that languages such as Python can be used to extract input data for models automatically.
3. Systematic assessments of the capabilities of the instruments and methods used to detect oil degradation products should continue, and findings published rapidly. The planned fluorometry comparison experiments should proceed and results made available as soon as possible.

B. Near and long-term research needs

1. Although there have been significant advances in our understanding, there remains uncertainty regarding the fate of the liquid oil and gas released from the Macondo well, and the dispersants applied. This is such a large spill that small fractions are important, especially those that are toxic/carcinogenic. Even one percent of ~5,280,000 barrels is a large number. Information on the ‘rates, routes, reactions and reservoirs’ of the many oil/dispersal constituents is needed to help direct research on the impact and mitigation of the spill, for retrospective analysis of the appropriateness of the response effort, and to validate and develop models that are needed in advance of any future spill that has the potential for three-dimensional dispersal. A more widely accepted oil budget would provide answers to the following questions:

- What fraction is dissolved?
- What fraction remained/remains in the subsurface as small oil droplets?
- What fraction of the oil on the surface weathered and sank into the water column?
- What fraction of the oil is on the bottom sediments and how did it get there?
- What fraction is in the atmosphere (is it 20, is it 60%)?
- What is the fate of black carbon released into the atmosphere by burning?

- What are the gas phase chemicals produced in burning oil on the water surface and are there toxic chemicals to be considered?
- What fraction of labile hydrocarbons has been taken up by marine organisms?
- What fraction of oil is in the near-shore/marshes?

2. Understanding the distribution of oil on the bottom and sediment-particle interactions is a clear information gap. Many potential processes influence sediment-oil interactions. Research that evaluates the following topics is needed to enhance the quality of the oil budget and provide insight into rates, routes, reactions and reservoirs for the oil and dispersants:

- interaction with marine snow/orange snow
- interaction with resuspended sediment
- advection of oil plume into sediments (upwelling and interaction with topography)
- oiled sediment that gets resuspended
- interaction with drilling muds, sediment in convergence zones, etc.

3. Understanding near-field processes is important for making far-field predictions.

- The time series of changes in the rate of flow, the chemical composition of oil released from the well, the quantity of dispersant injected at the well head, and the type and efficiency of dispersant are fundamental to understanding the fate and transport of oil and dispersants. Some of this information is being assembled; more is needed.
- Identifying the droplet size distribution and the fraction of oil in each size class is critical to correctly quantify the fate of subsurface oil. Limited measurements have been taken, but the data is not yet fully QA/QC'd or publicly available. Understanding the droplet size distribution and how it varied in space and time is important for guiding further subsurface monitoring and modeling efforts.
- We need to understand the physical transformation and chemical reactions that took place when reservoir fluid was released into seawater, and the role of particulate matter (natural and introduced) on potential aggregation and fate of oil and dispersants.

4. Were the dispersants, and delivery system, effective? How did they work in the various regimes (esp., the subsurface)? If so, did they make toxic components of oil more bioavailable in habitats where the available fraction of oil is potentially more destructive?

5. Finding the oil (in all of its forms) is a time varying problem. As degradation progresses, the tools to detect the oil/dispersants need to be changed and it is important to understand what chemical constituents/degradation products we have and have not been able to detect from the Macondo oil. Systematic assessments of the capabilities of the instruments and methods used to detect oil degradation products should continue, and findings published rapidly. For example, the planned fluorometry comparison experiments should proceed and results made available as soon as possible. Additional considerations include:

Methodologies used for collecting water samples for oil need to be assessed and compared to identify the strengths/limitations associated with the different approaches. An integrated strategy is needed.

A better understanding of how sonar detects oil, what types of sonar are useful, and the best practices for applying this technology is needed.

The response of optical instruments such as backscattering sensors and beam transmissometers to oil and its degradation products need to be better understood. The combination of light scattering

signal and oxygen draw-down has been used to detect subsurface layers to sample for oil. A systematic understanding of what contributes to these signals and how they might change over time is needed.
6. Atmospheric measurements provide information on oil constituent partitioning between water and air over a wide range of solubility and volatility. Atmospheric measurements should be integrated with efforts to determine the transport and fate of oil constituents.
7. Degradation processes are compound- and habitat-specific. More information is needed about the processes governing the weathering/degradation of Macondo oil constituents and dispersants, and the persistence of the oil degradation products in different habitats. What are the functional attributes of the microbial organisms that have been identified?
8. It is important to balance efforts between understanding the bulk level processes (i.e., where major fractions of oil went) and understanding the fate and extent of the most toxic compounds. These compounds may exist only at trace amounts, are often harder to measure, can be more stable or soluble, or emulsified and still bioavailable. Toxicity studies need to be coordinated with water chemistry measurements, preferably with measurements on-board the sampling vessels. We need to know concentrations that have impact on different organisms, both in terms of acute and chronic effects.
9. Open access to the industrial (e.g., BP), federal and academic data related to the DWH oil spill is critical. There are multiple federal agencies collecting and serving this data. Coordination among the databases, efficient access to them, and clear stewardship is needed.
10. Other important questions include:

- How effectively does surface burning remove oil from the water? What remains, and where in the water column does it reside? What are the atmospheric impacts of burning?
- How would hurricanes influence oil/dispersant fate and extent?

C. Actions to improve responses in the future
1. One of the challenges of tracking the fate of oil from the Macondo well is knowing the chemical constituents of the reservoir fluid, i.e., natural gas plus liquid oil, released into the water. This information is known by the oil company. Legislation could be enacted to require, as part of the permitting process, that the chemical composition of the reservoir fluid be registered in a federal database for timely dissemination in the event of a spill. This information would permit a rapid-response assessment of the spill rate using atmospheric hydrocarbon measurements. Additionally, samples of liquid oil could be archived, and made available (and useable) as part of the permitting processes. Archived samples through the life span of the well would be useful.
2. We recognize that the linkages between the Northern Gulf of Mexico and the Florida Straits are variable and sometimes immediate, and oceanographic conditions related to the Loop Current could have rapidly transported oil to the Florida Straits if conditions had been different. Planning for the future requires recognition that there is frequent transport of material from the northern Gulf of Mexico to the Florida Keys and Florida Straits. Maintaining and developing the Gulf of Mexico observing system, including conductivity, temperature and depth (CTD) profiles and current velocity measurements in deep waters, is needed. Even more important than the deep ocean is **Maintaining and developing the**

Gulf of Mexico observing system for the coastal ocean, the region landward from the shelf slope and inclusive of the estuaries, as this is where spilled oil most directly impacts society. This information is important for assessing the potential impact of hurricane as well as potential international implications. Finally, including organisms from sensitive and unique habitats from the Florida Straits (e.g., coral reefs, mangroves) in toxicology assessments is recommended. Similar information is required in the event of a spill in other areas critical to the fishing and crabbing industries (e.g., Alaska Cook Inlet and North Slope).
3. High-resolution remote sensing data in the near-shore and along the coasts are needed to guide response efforts in marshes and along shorelines.
4. Time series of atmospheric measurements is needed to quantify atmospheric concentrations, help complete the oil budget, and assess human impacts, and should be part of future spill monitoring and assessment efforts. Air quality health monitoring on the coast and at the response site itself are needed to assess exposures of spill response personnel, especially close (within 1 km) of freshly surfaced oil. In addition, emissions from the ships responding to the spill can be significant and need to be taken into account.
5. During a response, better access to local weather conditions is needed to assess health effects. To help atmospheric models predict concentrations and exposure to response personnel, meteorological data should recorded at the spill site by response vessels and be made available on-line in real time.
6. An integrated strategy (e.g., best practices, new technologies) for in-situ measuring of oil degradation products and dispersants is needed for future response efforts.
7. An information-based, decision-tree system that is site-specific is needed for the application of dispersants.
8. 3D oil transport modeling in the subsurface and in the atmosphere should be included in future response efforts in addition to the surface modeling which was part of the DWH response effort. Multiple models should be parameterized with near-field measurements, evaluated with additional observations, and transitioned into operation. Using multiple models provides uncertainty estimates and supports rapid technology development. Information on oil fractions, gas-to-oil fraction, time series of flow rates, and droplet sizes at the ejection point is required to constrain subsurface model predictions. Efforts to estimate and measure droplet size and density distributions need to be a larger focus of future response efforts.
9. The efficacy and cost effectiveness of response activities should be assessed and used to suggest regulatory changes that would improve oil recovery.

III. Intersections

In this section, issues that intersect the subject matter of other breakout groups are discussed.
1. Air quality over the DWH site was not worse than over a very polluted city in terms of the concentration of aerosols BUT aerosols were mostly made of organics, which is not the usual composition of air quality in very polluted cities. Air quality due to evaporative emissions of known or suspected carcinogens, especially BTEX and PAHs, needs to be assessed. The health effects of breathing

high concentrations of airborne aromatic compounds within 1-2 km of freshly surfaced oil on spill response workers should be determined.

2. Toxicity is a complex problem due to variable types and rates of photo- and biodegradation. The low molecular weight alkanes are relatively easily metabolized, some higher molecular weight hydrocarbons get photo-oxidized, and oil and dispersant together are likely more toxic than each other alone. There is a major gap in our knowledge regarding the impact of dispersant and oil on the pelagic and benthic communities, especially on embryos and early life history stages. What is the detection limit for different chemical constituents and degradation products of oil and how do they compare with the levels that are toxic to marine organisms? If we cannot measure them, do we need to continue to try to understand where they go? Experiments on the effect of sub-acute exposure to oil and dispersants are needed, and the research should include benthic filter feeders (including reef-building corals, deepwater corals, shallow and deepwater sponges and shellfish), zooplankton, phytoplankton, and other members of the food web, as well as early life history stages of fish and invertebrates that were spawning in the Gulf of Mexico during the summer.

3. There is a significant gap in our knowledge about the impact of oil/dispersants on the food web and ecosystem. We need to understand material and energy transfer to living marine organisms to understand the fate of oil and dispersants. Which compounds are used (or absorbed) by phytoplankton, bacteria and protozoa, what are the cascading trophic effects, and what are the impacts of these transfers? In addition, the broader concept of ecosystem toxicity needs to be addressed. Has sub-surface oxygen depletion been exacerbated by the spill? How do zones of hypoxia/anoxia influence the transformation and fate of oil/dispersants? How have the carbon/sulfur dynamics and bulk properties of communities changed? Radioisotope data may help assess the fate of oil/dispersant degredation products in biota (microorganisms and consumers) as well as organismal- and ecosystem-scale toxicity.

4. Who will fund the fundamental research that is necessary to understand this spill and improve response to future spills? Mission agencies need to ***conduct fundamental research*** as well as ***fund independent research*** by other entities such as the academic community. They must have strategies in place to coordinate these efforts as a part of any disaster response plan for the most effective use of the nation's scientific capital. In addition, these efforts should be undertaken 1) in coordination with international research community to leverage the international knowledge base, and 2) with the goal of applying this knowledge to future spills in other locations or in the Gulf of Mexico under different physical conditions. Changes should be made to the Oil Pollution Act of 1990 or emergency preparedness legislation that would make it easier for agencies other than NSF to fund essential research in a rapid-response mode.

Full Report: Oil/dispersant-impacts and mitigation in coastal environments (e.g., near shore, shallow reefs, beaches, marshes)

Plenary Speaker – Sean Powers, Dauphin Island Sea Lab
Chair – Steven Lohrenz, University of Southern Mississippi
Rapporteur – Wade Jeffrey, University of West Florida
Coastal Panel Members
Virginia Engle (EPA Gulf Ecology Division) - Coastal monitoring and ecological effects
Gunnar Lauenstein (NOAA Center for Coastal Monitoring and Assessment) – Chemical contamination of oyster tissue, surrounding sediments, and water
Edward Profitt (Florida Atlantic University) - Assessing impacts on a critical habitat, oyster reefs and associated species in Florida Gulf estuaries
Just Cebrian (Dauphin Island Sea Lab) - Effects of the Deep Water Horizon oil spill on the nursery role of coastal marshes in the Northern Gulf of Mexico
Dawn Lavoie (USGS Gulf of Mexico Research Coordinator) - Impact of constructed berms used to control oil spill impacts on coastlines

Attendees:
Laurie Anderson
Jon Arthur
Susan Bell
Just Cebrian
Kuki Chin
Kim de Mutsert
Dan Deocampo
Lee Edmiston
Virginia Engle
David Fries
Erik Hankin
Matt Huddleston
Markus Huettel
Claudia Husseneder
Wade Jeffrey (Rapporteur)
Jerome LaPeyre
Susan Laramore
Gunnar Lauenstein
Dawn Lavoie
Steve Lehmann
Robert Lochhead
Steven Lohrenz (Chair)
Nels A. Olson
Sean Powers
Amy Prupen
Lorae Simpson
Hilary Stockton
Ping Wang
Susan Welsh
Henry Neal Williams

Deepwater Horizon Oil Spill Principal Investigator (PI) Conference
Sponsored by the NSTC JSOST, hosted by University of South Florida,
Don CeSar Resort, St. Petersburg, FL, October 5-6, 2010

Summary of Panel Presentations

Virginia Engle(EPA Gulf Ecology Division, Gulf Breeze, FL)

Sustained coastal monitoring and well defined environmental baselines were identified as absolutely critical to assessment of contamination levels related to the oil spill. The EPA conducted the National Coastal Assessment (2000-2006) to assess ecological conditions in Gulf estuaries. This was followed by the National Coastal Condition Assessment in (NCCA) summer 2010. These studies examined sediment quality, water quality, benthic condition, and tissue contaminants. This work provided a baseline of information about conditions prior to the spill. This was followed by post-impact monitoring Jun-Sep 2010 water and sediment chemistry and toxicity. Dispersant testing was also added.

The Subsurface Monitoring Plan or 60 day Plan will be released soon. EPA will revisit a subset of NCCA 2010 sites this fall. This will be reported at the National Water Quality Monitoring Council quarterly meeting in Pensacola, FL. The effort will be conducted in conjunction with the Gulf of Mexico Alliance. An EPA report is planned to be released in April 2011.

Questions included the issue of what additional data are available? The point was also raised that EPA Region 6 worked closely with state agencies in Louisiana, but there was not as good coordination with EPA Region 4 and state agencies.

Gunnar Lauenstein (NOAA Center for Coastal Monitoring and Assessment)

NOAA's National Center for Coastal Ocean Science operates the Mussel Water Contaminant Monitoring program as part of the National Status and Trends program. In the case of the Gulf of Mexico, this involves monitoring of oyster tissue contamination rather than mussels. Oysters concentrate lipophilic contaminants. The project was developed to analyze chemical and biological contaminant trends in sediments and bivalve tissues collected at over 300 coastal sites from 1986 to present. Parameters monitored include sediment and bivalve tissue chemistry for over 100 organic and inorganic contaminants; bivalve histology; and *Clostridium perfringens* (pathogen) concentrations. This project regularly quantifies PAHs, PCBs, DDTs and its metabolites, TBT and its metabolites, chlorinated pesticides and toxic trace elements. Sampling at the Deepwater Horizon site was performed on the NOAA Ships *Ocean Veritas* and *Thomas Jefferson*. The Bioeffects Assessment Program also conducted toxicity bioassays, chemical analyses, and benthic community analyses. This work will support the Natural Resource Damage Assessment (NRDA) process. Water chemistry has had priority and is being conducted by TDI Brooks. For NRDA, thus far the request has only been for polycyclic aromatic hydrocarbon (PAH) data. Trace element samples have been collected, but analytical results are not yet available. The first post spill samples (water, sediment and oysters) were collected during May 2010. The Mussel Watch program will again collect oysters and sediments from the Brazos River, TX to Tampa Bay, FL during November 2010. Reports and baseline data are available on the web (http://ccma.nos.noaa.gov/about/coast/nsandt/download.html).

Ed Profitt (Florida Atlantic University)

Ongoing research examining the oil impacts on Florida oyster reefs and estuaries was presented. Impacts include not only what oil comes into shore, but water column effects on juvenile forms. A goal will be to determine what the impacts are for oyster communities. Concerns include lingering effects on estuarine food webs and trophic structure. Dispersed oil droplets may potentially affect larvae and adults. Multiple paths for effects are possible (e.g., effects on predators, indirect impact on oyster larvae). Different populations experience different effects. Genetic analyses, genetic diversity in estuaries and influence of oil. A study design involving three sites with 5 reefs per site was described. Metrics included survivorship and growth, recruitment, and genetic analyses.

Just Cebrian (Dauphin Island Sea Lab)

Research related to coastal Environments and coastal fringe ecosystems was described. This included work on both marshlands and seagrass beds. Various ongoing projects were listed including work funded through the NSF Rapid program, NRDA, and BP Research initiative. Results to date indicate that there does not appear to be clear evidence of a decrease in marsh plant density or structural integrity. This does not preclude possible long-term significant impacts on processes and services. Where there was loss of plant density, marsh regrowth has been observed. So shoreline stabilization should not be severely impacted. Oil could be affecting other processes (e.g., nursery habitat, connectivity, carbon and nutrient sequestration). The oil-related influx of carbon could also disrupt nutrient cycles – effects could be seen in the coming spring. There is still active oil in the marsh on the surface and subsurface. Below ground biomass has generally appeared to survive, but re-colonization by different species is possible. Severity of impacts will be dependent on length of exposure and persistence. Chronic exposure may result in more severe impacts and damage.

Dawn Lavoie (USGS Gulf Research Coordinator)

The effectiveness of sand berms as a mitigation technique was examined. Berms have been constructed off the Chandeleur Islands – extensive data bathymetric and sediment data have been collected in this area using lidar (NASA EARL) and other geophysical techniques. The islands were heavily impacted by Hurricanes Katrina and Rita - lost 85% of sand volume. These islands provide important benefits and services including habitat, control estuarine circulation, and reduce storm surge to some extent. The sand berms were nominally constructed to limit penetration of oil. The construction of a long, continuous berm could restrict natural tidal flow and exchanges that affect salinity so this plan was modified to maintain some of the passes. Salinity control was further complicated by the diversion of freshwater into the marshes in an effort to minimize oil spill impacts. Effects of the berms on wildlife such as birds are also unclear. As a mitigation technique, the berms are probably not very effective. The construction took too long to be useful to oil spill mitigation. About 5700 m of berm has been constructed along the northern reach of the Chandeleur Islands. The berms provide the opportunity for a huge in situ coastal processes experiment that should be studied and monitored. BP is funding the berm construction and has agreed to have a portion of the $380 M used for coastal restoration. Since there are limited sand resources in Louisiana , this will allow some of the sand to be used in a more effective manner. Office of Coastal Protection (Governor's office) favored the berm construction and is weighing in on the restoration effort that will occur under BP funding.

Breakout Discussion

The group identified the following set of questions to guide discussion:

1) What oil and dispersant contamination has been observed in different coastal regions?
2) How can we more effectively monitor and detect contamination in different environments? Alternatively, what methods and techniques are appropriate for monitoring and detection in different coastal environments?
3) What impacts on ecosystems and ecosystem services have been observed or can be expected given levels of contamination? What types of studies are needed to better characterize these impacts?
4) What is the effectiveness of different mitigation strategies? What are potential negative impacts of response and mitigation strategies?
5) How can coastal monitoring efforts among federal and non-federal programs be better coordinated and information sharing be promoted?
6) What are the methodologies being used by the different NRDA Technical Working Groups and what are the opportunities for other scientists to be involved in NRDA efforts?

Environmental Baselines

An extensive baseline of information is available for water, sediment and animal tissue contamination from ongoing monitoring programs including NOAA, EPA and academic research efforts. Preliminary findings for water and sediment analyses indicate elevated levels of some petroleum hydrocarbon compounds at some sites, although rigorous statistical analyses have not been completed. The EPA data are available through the SCRIBE client (http://www.ertsupport.org/scribe_home.htm) although access to some EPA databases may be restricted. In addition, many samples have yet to be analyzed. Information about sampling information can also be accessed through the NOAA Environmental Response Management Application (http://gomex.erma.noaa.gov). The NOAA National Status and Trends program provides another source of information about coastal water quality (http://ccma.nos.noaa.gov/about/coast/nsandt/welcome.html). Efforts are also being made to provide metadata and data from academic research efforts.

Oil Impacts on Marsh Habitat Structure

Oil impacts on marsh structure have occurred in some coastal areas. These have been particularly severe in some Louisiana marsh sites, such as Bay Jimmy and sites in Barataria Bay. Reintroduction or redistribution of oil continues to occur at some locations, but the origin of this oil is unclear (i.e., whether it is oil moving in and out of the marsh or emerging from subsurface). Chronic and persistent oiling can increase the chances that marshes suffer more damage. Re-oiling of marshes after a period of recovery may actually be worse as it can result in damage to below ground biomass and new growth. Oil impacts are highly heterogeneous and localized, making it more difficult to track and deal with it. Sites with only limited exposure to oil have shown no visible impact on marsh structural integrity.

Oil Impacts on Ecosystem Structure and Function

Ongoing studies are evaluating the impacts on ecosystem function and potential loss of ecosystem services. Sublethal effects may be occurring and may require studies on time scales of generations to see decay. Various approaches are being used to determine impacts including genetic studies, sclerochronology (shell chemistry and growth studies), organismal and food web impacts, and responses of the microbial community.

Effectiveness of Response Strategies and Potential Consequences

The effectiveness of various response strategies was discussed. **Berms** have not proven to be effective as an oil spill mitigation approach and may alter natural flow of water and movement of sediment in coastal habitats. **Booms** have been used extensively, and have been effective in helping to contain and collect oil in some cases. However, their utility is limited to relatively calm sea state and detached booms can damage sensitive coastal habitat. **Marsh treatment efforts** have been used to remove or siphon oil in some more heavily impacted areas. The benefits of removing oil using these techniques must be weighed against any potential damage that may occur to the sensitive marsh habitat and such impacts must be systematically evaluated. Similarly, **beach treatment efforts** can be effective in removing oil embedded in sand, but will also disrupt the natural biota present in these environments. While it was generally agreed that the **use of dispersants** is justified if it reduces the direct impacts of oil on coastal environments, the effectiveness of dispersants was questioned. It was noted that effectiveness of large scale application of dispersants as occurred in this disaster is not easily assessed. **New technologies to selectively remove oil** were discussed including materials capable of adsorbing oil and being reused. The need was noted to provide improved means to transition such technology from experimental or research applications to approved use in spill response efforts. Finally, **freshwater diversions** were used extensively in the Deepwater Horizon oil disaster. Again, the effectiveness of this as a means of reducing impacts in coastal environments is difficult to systematically assess. Futhermore, diversions can have other impacts on coastal environmental conditions such as altered salinity and water quality and such impacts need to be carefully monitored and assessed through sustained studies.

Gaps and Recommendations for Future Efforts

The following gaps in knowledge in current efforts were identified along with recommendations for future efforts:

- Need for better understanding of dynamics of oil exposure and associated impacts on seagrass and marsh vegetation
- Need for better understanding of short term versus long term effects – need for sustained ecosystem observations and modeling to understand impacts on coastal biota and ecosystem function and structure
- Need for improved understanding of oil impacts on coastal biogeochemical cycles – carbon and nutrient cycling

- Need for improved remediation materials and proactive qualification process
  - Testing and evaluation strategies
  - Intentional spills with well defined treatments and controls
- Need for more aerial surveys to monitor status of different coastal habitats and elucidate spatial heterogeneity both for:
  - Support for response efforts
  - As an aid to research (e.g., mapping vegetative stress)
- Need for development of improved sensor technology for oil detection
- Need to address the large inventory of samples that have no immediate funding for analysis
  - Importance of standardization of methodology and inter-laboratory comparisons
  - Recognizing the importance of both NRDA and non-NRDA methodologies in studying spill impacts
- Need for better access to information about coastal monitoring activities by various agencies and institutions
- Need for an oil spill research clearinghouse of information
  - Currently multiple sites, but not always well linked or complete
  - Need for more detailed and, if possible, quantitative information about oil exposure at coastal sites for future response efforts
  - Need for review of work done previously – updated bibliography
- Need to understand potential implications of oil contamination for borrowing/dredging of sand for beach re-nourishment
- Need to determine extent of buried oil, particularly in sandy environments
- Need for better understanding of oil transport by waves and associated oil exposure and distribution on shorelines

Lessons Learned

The following "lessons learned" were identified:

- Need for improved communication between federal and non-federal scientists; encourage more cooperative relationship and data sharing – examine models for other regions and events that have worked
- Need for mission coordination and need to work in complement with operational framework
- Important to allow for independent findings and observations to be assimilated into the overall response and sampling strategy
- Media relations – avoiding media vetting of preliminary results and blindsiding public agencies to minimize adversarial nature between different science groups
  - Important opportunity to inform and educate public
  - Needs to be done in a responsible manner

- Avoid indiscriminant deployment of booms and potential damage resulting from unsecured booms
- Need for better means of assessing near shore subsurface oil - submerged or sediment-entrained oil
- Consideration of potential impact of other countries' activities
- Improved regulatory environment for enforcing effective and comprehensive response plans
- Better means of conveying information about toxicity of oil in coastal zone to the public

Additional Points Raised in Plenary

- Atmospheric contamination and impacts on coastal environments
- Seasonality as a factor influencing impacts in coastal habitats

Full Report: Oil/dispersant-impacts and mitigation in offshore environments (e.g., deep ocean habitats, deep coral systems, seep communities)

Offshore Environments Working Group

Walter Johnson, BOEMRE (chair)
Erik Cordes, Temple University
Ben Flower, University of South Florida
Ken Halanych, Auburn University
Peter Hamilton, SAIC
Ian MacDonald, Florida State University
Joe Montoya, Georgia Tech

Plenary Presentation – Ian MacDonald

Panel Presentations

Peter Hamilton gave an overview of the physical oceanography work being conducted in the deepwaters offshore in the Gulf of Mexico. This included a number of existing datasets as well as existing instruments in the water at the time of the spill. Future work will include a series of RAFOS floats and acoustic infrastructure that is funded by BOEMRE.

Benjamin Flower presented ongoing work on the sediment biogeochemistry and fauna of the northern Florida slope and DeSoto Canyon. The sediment work includes radiometric dating, concentration and toxicity of the oil in sediments, and changes in the foraminifera community at those sites.

Erik Cordes presented a summary of research on the deepwater hardbottom communities of the Gulf and some recent work related to the oil spill. The locations of known deepwater coral and cold seep communities were presented. Sampling from an NRDA cruise in July, an upcoming BOEMRE/NOAA OER cruise in Oct-Nov, and an upcoming NSF RAPID cruise in December was described. This sampling includes photographic monitoring through photomosaics and time-lapse cameras, sediment trap deployments at a number of sites, hydrocarbon load in tissues and sediments, and planned genetics/transcriptomics analyses.

Ken Halanych described the detection of sublethal effects of hydrocarbon exposure on organisms. This includes the development of genetic tools (primarily transcriptomics assays) to determine a stress response in the organisms. Indicator species should be selected, and those proposed for work include the tubeworms, hard and soft corals, and coral associates. This discussion included a summary of ongoing work with Holly Bik using next generation sequencing to conduct an assessment of impacts on the meiofaunal communities of the Gulf.

Joe Montoya presented some recent results from a series of cruises on the Oceanus and Cape Hatteras to the immediate area around the DWH incident. These cruises included a large amount of water column work including CTD casts, fluorescence, transmissometer, and ADCP data. Water samples were collected for nutrients, gasses, and particulate work. He described a series of features in the water column and on the seafloor that extended 10-20 nm from the wellhead. These features included high turbidity, high particle load (visible particles that have not yet been identified), no fluorescence signal, and some oxygen reduction (but this was not consistent in all samples). These features were temporally and spatially unstable. In addition to the water sampling, there were a series of Argos floats deployed, Mocness tows conducted and multicorer sediment sampling. The sediment trap and Mocness samples are being analyzed for hydrocarbons, stable isotopes, and elemental composition. The multicore samples taken by Mandy Joye contained a 3-4 cm orange-red flocculent layer that was very mucousy and hard to siphon off. This layer contained dead forams and pteropod sells, but larger burrowing macrofauna were found alive deeper in the core. This layer was present at all stations within 25 nm of wellhead, even SE of the site. Hydrocarbon analyses of this material are underway, but it smelled like oil and PAHs were present. It was suggested that previous studies with boxcores may have disturbed this layer and resulted in an inability to detect it.

Breakout Sessions

What has worked (or not)

- Frequent contact with UAC during cruises was very helpful and relatively easy
- Release of data was very slow
  - Especially QA/QC data
- Coordination among agencies came late
  - Redundant studies
- Can be good if coordinated
  - Sharing data
  - Access to offshore sites
  - Science Czar next time?
- Missed our chance for some studies
  - Sargassum
  - Following plume from source to surface
  - Early discharge rate measurements

Major Gaps in our Knowledge

- Baseline data

–Primary productivity in the Gulf
–Carbon transport rates

•Role of marine snow and aggregation
•Where did oil, oil/dispersant go?
–And how long does it last?
–How much is still left in subsurface?

•Work in eastern Gulf
•Benchmarks at select sites on the seafloor
•Pelagic fauna and larval distribution
•Databases and coordination
–Available metadata
–who is going where and collecting what

•Rates of processes and ecosystem change
•Toxicity studies
–Microbes, plankton, in addition to macrofauna
–Oil, Corexit (realistic exposure concentrations)

•Cost-benefit analysis of Corexit application

Short Term Needs

•Impact of DWH oil on deepwater communities
–Both benthic, pelagic, and neuston
–Can we determine indicator species
–How do you use them? Transcriptomics

•Persistence of impacts
–sublethal effects/recovery time

•Implementation of monitoring plan
–Revisiting existing monitoring sites
–Transect studies for soft bottom
–Consistent data sets

•Processing the samples we already have
–Hydrocarbon concentrations (exposure)
–Demonstration of actual impacts

•Changes in nutrients and plankton communities
–Biogeochemistry
–Air-sea exchange

•Studies as part of NRDA process not enough
–Snapshot vs rates of processes

Long Term Needs

- Dedicated Infrastructure – ships and subs
  - Resources have declined in recent years
- Coordination among efforts
- A few large-scale observatory stations
- Additional monitoring stations/transects
- Mapping
  - Multibeam coverage
  - Release of industry 3D seismic
- Continued exploration
- Database for curating all of these data
- Assessment tools
  - Toxicity, genetics, physiological assays

Establishment of Additional Observatories in the Gulf

- Eastern, central, western Gulf
- Nearshore to deepwater
  - Integrated as swaths across the Gulf
- Depth gradient
- Canyon vs outside
- Existing sites that are well known/instrumented
- Potentially use existing (or retired) platforms as power source and data transfer?
- Three regional transects
- Multiple temporal and spatial scales
  - Instrumented site
    - One site for each habitat type
    - Seeps, Corals, Soft bottom
    - Standard set of instruments
    - Additional proposal driven add-ons
  - Monitoring sites
    - Repeated time series sampling
- High resolution mapping efforts at each location
- Tie into OOI cyberinfrastructure

Database Needs

- Facilitating communication / data sharing
- Ongoing database efforts
  - So many out there – leverage off existing?

- –Requires large investment to be successful
- –Needs to be searchable
- –Include planned studies for coordination

•NCDDC and GulfBase.org may fill this role
•Need to tie existing efforts together
•Requirement for data submission

Full Report: Oil/dispersant-impacts and mitigation on living marine resources (e.g., protected and harvested species, essential food web)

Compiled by F. Coleman (FSU), C. Tortorici (NOAA), and E. Peebles (USF)

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The Questions

(1) What new research initiatives did this anthropogenically-induced incident provide?
(2) What worked well (what are we learning)?
(3) What would you do differently?
(4) Where are the intersections/connections with other themes?

Oil/dispersant impacts and mitigation

The Administrative Milieu

Disasters will continue to occur in a stochastic manner, whether natural (e.g., hurricane, fire, floods) or anthropogenically-induced (e.g., oil spill, paper mill effluent, agricultural runoff). Two primary questions arise from the recent Deepwater Horizon (Macondo) oil spill. Where will the next disaster occur, and who will be in charge when it does? We can't predict anything about where or when a disaster will occur. As a nation, though, we look for guidance from the agencies that have oversight on environmental issues and who typically serve as the first responders. In the case of the Deepwater Horizon Oil Spill, academic scientists largely looked to NOAA, EPA, and their state departments of natural resources for leadership, and as the days and weeks passed, many academics jumped into the field and started working in their own systems at their own (or their institution's) expense. Thus, the oil spill engendered a rushed and somewhat frenetic response wherein people found it difficult to define collaborations and ways to contribute to the federal and state responses. Even agency people felt impeded by the inability to obtain permits to work in new areas on protected species, creating missed opportunities to start sampling in heavily oiled areas. There clearly was a disconnect between academic and government agencies on how to approach the spill. There needs to be a response structure that enhances coordination of effort and collaboration among agency and academic scientists to fully address the problems without missing opportunities for research or creating needless duplication of effort. There also needs to be a mechanism for the rapid consideration of minor permit modifications, such as for geographic area, to facilitate already permitted researchers to work in the affected areas. The NRDA process – which is still unclear to many academic scientists – appeared to limit the way that NOAA and academic scientists could interact. Academics felt largely cut off from NOAA, and found that that there was a significant difference between what they understood NRDA wanted and what they (academicians) could deliver since they did not fit well within the NRDA grid. It was suggested that NRDA provide personnel to travel to universities and other non-NOAA institutions to assist with data and information uploads. Similarly, on-the-ground NRDA representatives could be used to help clarify for academics the NRDA constraints on sampling (e.g., water, sediments, tissues) and data handling/record keeping. In general, academic scientists felt better suited for reconnaissance and question-based science than NRDA work.

The recognition that long-term impacts will require long-term research made it clear that more funding is needed.

(1) What new research initiatives did this anthropogenically-induced incident provide?

- **Sampling for PAHs, heavy metals (e.g., mercury), phosphates, nutrients or other chemicals, isotopes (nitrogen, carbon, sulfur)** – Testing for these constituents is not routine when collecting baseline data for many species (e.g., protected species), so there is limited pre-spill data to use in determining post-spill impacts. An exception would be the baseline data obtained from routine SEAMAP cruises, including pre-spill isotopic signatures for king mackerel (*Scomberomorus cavalla).* As isotopic data collection becomes more routine, it will provide new opportunities for interdisciplinary collaborations, powerful case studies on a suite of different environmental impacts (including oil spills), and, as members of this breakout session suggested, allow for more effective tracking of bioaccumulation through trophic transfer.
- **Research on dispersants[1], oil, dispersant-oil combinations** – Researchers in the breakout session suggested that it is possible that dispersants cause greater uptake of PAHs as a consequence of breaking up the oil into smaller droplets, making those compounds more available for consumption or uptake at lower trophic levels. However, there was some doubt among some of the researchers that dispersants will show up in tissues and they expressed some uncertainty about the availability of analytical protocol to find it in tissues[2].

  The volume of the Deepwater Horizon oil spill (200 million gallons) was far greater than the volume of dispersants (1.8 million gallons) applied at the surface and at a depth of 1,500 m at the site of the spill. While it is important to focus on the oil, recent papers suggest that the influence of dispersing oil at depth has significant consequences[3], as does the presence of a large mass of trapped gases[4]. Researchers in the breakout session expressed interest in the development of depth-specific toxicity tests and were unsure what protocols were in place for determining how long dispersants persist in

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[1] Supposedly, dispersant dispersal only legal in offshore waters, contrary to what the shrimpers etc say they witnessed in Mississippi Sound.

[2] But see NRC. 2003. Oil in the Sea III - Inputs, Fates, and Effects. The National Academies Press, Washington, DC.

[3] Camilli, R. C., C. M. Reddy, D. R. Yoerger, B. A. S. Van Mooy, M. V. Jakuba, J. C. Kinsey, C. P. McIntyre, S. P. Sylva, and J. V. Maloney. 2010. Tracking Hydrocarbon Plume Transport and Biodegradation at Deepwater Horizon. Science Express 10.1126/science.1195223; Hazen, T. C., E. A. Dubinsky, T. Z. DeSantis, G. L. Andersen, Y. M. Piceno, N. Singh, J. K. Jansson, A. (cont.) Probst, S. E. Borglin, J. L. Fortney, W. T. Stringfellow, M. Bill, M. S. Conrad, L. M. Tom, K. L. Chavarria, T. R. Alusi, R. Lamendella, D. C. Joyner, C. Spier, J. Baelum, M. Auer, M. L. Zemla, R. Chakrabory, E. L. Sonnenhal, P. D'haeseleer, H.-Y. N. Holman, S. Osman, Z. Lu, J. D. Van Nostrand, Y. Deng, J. Zhou, and O. U. Mason. 2010. Deep-Sea Oil Plume Enriches Indigenous Oil-Degrading Bacteria. Science Express 24 August 2010 4 pp.

[4] Valentine, D. L., J. D. Kessler, M. C. Redmond, S. D. Mendes, M. B. Heintz, C. Farwell, L. Hu, and F. S. Kinna. 2010. Propane Respiration Jump-Starts Microbial Response to a Deep Oil Spill. Science Express 16 September 2010 10.1126/science.1196830

animal tissues or what their ultimate impact might be on a species-by-species basis (e. g., shrimp and oyster versus crab and fish). There was some concern that the dose-response analyses might not be consistent with NRDA protocols.

- **Importance of building more comprehensive trophic mass-balance models**.–Researchers in this breakout group felt that the development of comprehensive mass-balance models was very important, recognizing that it is also a demanding undertaking that needs thorough parameterization. Relative to SEAMAP, developing these models would require more frequent plankton surveys on a large scale to make sure that bottom-up drivers are effectively and realistically identified and quantified.

  The Exxon Valdez oils spill and subsequent monitoring reinforces the importance of examining trophic structure coupled with large scale physical models. There are still lessons to be learned from that event, even though the affected environments and the spills themselves were quite different. The utility of the GEM report was also raised. What relevant pieces might it provide that will allow us to take the research to the next level? It was recognized that the research community needs to pay attention to the evolution of the thought process applied to the Exxon Valdez spill, and then consider how lessons from the Exxon Valdez spill can be applied to the Deepwater Horizon oil spill.

- **Need for 3D biophysical models** – Researchers felt that models that include the behaviors of living organisms as well as the changing characteristics of the oil itself are critical to understanding food-chain dynamics and the biophysical mechanisms that could be impacted by oil spills, notably mechanisms affecting plankton aggregation and larval transport. Linking physical oceanography and zooplankton surveys was considered a top priority. Despite what we thought we knew about circulation in the GOM, the oil itself did not behave in predictable ways. The development of the subsurface "plumes" and the behavior of the Eddy Franklin are good illustrations. Oil reaching west to Texas was also not predicted by existing hydrodynamic models. Nor was the deposition of oil on the seafloor.

- **Adoption of ecosystem-level approach** - Implementing an ecosystem-based management approach and putting it into practice in a larger, integrated perspective on how to collect baseline information and assess impacts is critical at this point. Doing so will require greater interaction at the project-design phase of scientists from different disciplines. More attention should be paid to gap analyses of the geographic distributions of studies and the types of data being collected. From this point forward, developing a comprehensive understanding of gulf-wide processes and long-term changes should be adopted not only in consideration of oil spills, but rather as part of the regular cost of doing business in the Gulf of Mexico.

(2) <u>What worked well</u>

- **Academic Collaboration** - Interactions among scientists who do not normally collaborate was coordinated at some institutions, but not at others (the latter causing significant frustration among researchers). At some institutions, a mechanism existed that allowed individuals within or among departments to interact on a regular basis to define what kind of research they might do. In Florida, the Sea Grant Website and the Florida Oil Spill Academic Task Force (OSATF) provided some guidance. OSATF also provided a vehicle for interaction between academic scientists and government agencies. While a number of researchers signed up, few felt that they received significant feedback from the OSATF website; although requests coming to the OSATF from DEP and FWC were always sent to the designated lead at each institution on a regular basis, these messages were not always relayed to individuals at the respective institutions.

- **NSF Rapid Response Program** - The immediate primary funding vehicle for research was NSF's Rapid Response Program[5]. NSF diligently facilitated academic research by providing funds as rapidly as possible in a focused manner. While the rapid response process differed from NSF's regular routine in that the proposals were not peer reviewed, NSF did not coordinate or define collaborations. Researchers in the breakout session recommended that NSF institute a process for potential collaboration and prevention of effort duplication during future emergency responses.

- **Informal Collaboration occurred** - During the Florida Institute of Oceanography's (FIO) Granting Cycle, efforts were made both during the review process and during a meeting of PIs funded by BP through FIO to identify and encourage potential collaborations. The Northern Gulf Institute encouraged both vertical (within institutions) and horizontal (among institutions) collaborations in the initial round of funding. At FSU, for instance, the NGI-funded research included collaborations among physical oceanographers, biogeochemists, and marine ecologists.

(3) <u>What do we need to know and what would you do differently?</u>

The response was restricted by insufficiencies in the pre-existing infrastructure - One thing learned during this response is that there were abundant limitations. Instrumentation infrastructure and access to research vessels were limited. Data access and data syntheses were limited. Finally, coordinated guidance coupled with corresponding funding from federal agencies were limited (except when the effort involved applying standardized NRDA protocols to this exceptional situation).

- **Data limitations** - Data limitations are profound because the intensity of coastal research has declined significantly within the past 10-15 years due to lack of funding and subsequent loss of capabilities and disappearance of infrastructure, including loss of availability of research vessels in the GOM (see UNOLS assessment). The need to at least catch up to where we were decades ago is extremely important.

[5] NSF may want to determine what lessons were learned from the rapid response proposal process.

- **Comprehensive observation system needed** – Researchers agreed that there is a clear need for a comprehensive observational system (e.g., a much enhanced and expanded IOOS) in the Gulf of Mexico. Such a system already exists along the Atlantic and Pacific coasts. Costs of building and maintaining the GOM system should be shared by industry (e.g., oil and gas, transportation) and the federal government. The GOM is in a risk-prone setting due to hurricanes, offshore oil and gas development, shipping of dangerous cargos, etc. being juxtaposed against population centers, sensitive ecosystems, valuable fishing grounds, tourist destinations and valued cultural resources. The region lacks the required level of observational infrastructure that would allow monitoring of these interactions, whether potential or realized, while using newly gained observational datasets to build a better understanding of ecosystem-level processes throughout the GOM region.

  This could be augmented by fitting existing oil rigs, military towers, and wind platforms with acoustic receivers and sensor packages to collect biotic (e.g., distribution and movement of organisms ranging from red tides to fish, marine mammals, and sea turtles) and abiotic (e.g., water quality, current profiles) data that can be uploaded to and retrieved from satellites[6]. As technology costs decline, more investigators are using acoustic tracking methods for determining the spatial distributions of species of concern. New acoustic arrays would provide data useful for integrated ecosystem assessments and marine spatial planning.

- **Assessing impact of oil on productivity** – it will take years to assess the oil spill's impacts on long-lived species that have complex life cycles or lag times between their reproductive events and the addition of new adults to their populations. Gag grouper, for instance, have a pelagic larval stage (subject to oil on the surface), an estuary-dependent juvenile stage (subject to oil in seagrass beds), and a benthic offshore adult stage (subject to dispersed oil on the bottom, possibly picked up through trophic interactions). It will be difficult to show any kind of oil-related impact on recruitment in species such as this that already have large inter-annual recruitment variation. Impacts on long-lived species, like cetaceans, may take years to become evident. Impacts on the Gulf's pelagic fauna from 0 to 1000 m will also take time to understand. In the interim, researchers can evaluate sub-lethal effects on such things as growth and fecundity, as these methods can be put into action now. For shrimp, which are relatively short lived, the impact of oil on recruitment strength is easier to determine and could be incorporated into stock assessments in the near future. As more population-level impacts become known, trophic modeling can be used to identify likely responses at the ecosystem level. This ecosystem-based approach parallels the approach that was successfully undertaken after the Exxon Valdez spill.

- **Baseline information exists at institutions throughout the Gulf States**. Potential baseline data sources include:

[6] Note that a spatial bias is introduced based on the distribution of the infrastructure

a. SEAMAP, a NOAA-sponsored large-scale multivariate plankton-net and trawl survey that provides a tremendous resource for zooplankton, fishes, and invertebrates in the continental shelf waters affected by the spill. The SEAMAP program provides baseline information over a broad spatial and temporal scale, and employs statistically rigorous methods. A fundamental problem with SEAMAP's zooplankton component is the lag time between collection and sample processing, even to the alpha level of having species identifications, abundance, and distributions. Many of the zooplankton samples (which include fish eggs and larvae) have not been analyzed. Zooplankton data that are available could be evaluated to determine limitations on the use of future data; i.e., statistical power analyses could be performed to determine the levels at which changes can be detected. Fish and invertebrate data from trawl surveys are much more up-to-date than the zooplankton data. All SEAMAP samples have compromised utility in toxicology testing because they are preserved in formalin. Some archived (preserved in formalin) samples were destroyed by Hurricane Katrina.
b. Baselines exist for brown shrimp from Louisiana to west Florida that may be useful for evaluating the effect of oil/dispersants on growth, fecundity, and population size, and for determining the duration of these effects.
c. Baselines exist for bottlenose dolphins and their prey in Florida panhandle bays (Pensacola and Choctawhatchee Bays) and surrounding nearshore environs, but how far the data can be extrapolated to address population dynamics on a broader spatial scale is hard to determine. There may be no effect of the oil at this small scale. NMFS has some pre-spill data for dolphins from Mississippi to St. Joe Bay, Florida.
d. The Florida Fish and Wildlife Conservation Commission's (FWC) fishery-independent monitoring (FIM) program for young-of-the-year fish was discontinued in the Florida panhandle years prior to the spill. USF has some data from 90s on sampling stations.
e. Baseline data exists for individual movement patterns of sea turtles and other protected species.
f. Baseline data at FSU includes fishery species, many offshore reef habitats (HAPCs and Marine Reserves); oyster, saltmarsh, and seagrass communities throughout the Big Bend and exending west to Apalachicola and St. Joe Bay; studies on bioenergetics of fishes exposed to hypoxia throughout the northern gulf.
g. USF baseline on composition and abundance of eastern Gulf mesopelagic communities (primarily Dr. Tom Hopkins and students) from late 1970s through 1990s.
h. Zooplankton samples sent out for PAH analysis exhibited fractional PAH levels. There is no baseline data, though, so it can't be determined whether the detected PAH is from natural seeps, the Deepwater Horizon spill, or other sources. Some significance exists in the fact that the samples were collected from oiled areas.

(4) <u>What are the intersections/connections with other themes</u>

- **Should habitats be prioritized for research, monitoring, and modeling -** The question was asked as to how we would rank habitat in importance if we had to. But the growing knowledge among scientists and managers of the connectivity and linkages among habitats ultimately limits the value of this exercise. The coastal focus of the news media, the oil companies, and the citizens is easily explained by the fact that a coastal impact is more obvious and more easily inspected. This, in part, explains the use of dispersants, the primary purpose of which is to remove the oil from view. What researchers have learned in the last 15-20 years is the importance of the deep sea, where rich biological diversity rivals that of tropical rainforests, and where numerous ecosystem services are provided to neighboring ocean ecosystems. Sub-surface hydrocarbon plumes, though hidden from view, can be transferred to the continental shelf by upwelling and into coastal habitats by coastal currents. It is important that we focus on patterns and processes at the larger, more holistic spatial scale of the spill's impact, rather than limiting our attention to highly visible coastal habitats. The public's lack of understanding of ecosystem interconnectivities and the importance of offshore ecosystems should not be allowed to bias the research effort.

- **The relationship of sub-surface oil to living marine resources** - The subsurface oil plume at ~1,000-1,400 m is a feature that has never been encountered before, although similar plumes were observed during an experimental deep-sea oil spill created and monitored by Norwegian researchers. Other plumes associated with the Deepwater Horizon spill occurred at much shallower depths (e.g., 400 m and shallower). These plumes consist of oil microdroplets created by the dispersant that are so small (<100 µm) that their buoyancies cannot overcome the friction of the water around them, so they remain at depth (re. Stokes Law). Clouds of these microdroplets were transported many tens of miles away from the wellhead by slow-moving deepwater currents. The plumes did not appear to form at density discontinuities[7].

  Oil contact with the benthos can occur wherever the plume depth coincides with the corresponding seafloor isobath, and also wherever surface or subsurface oil becomes heavy enough to settle to the bottom, which is most likely in quiescent areas with pre-existing depositional tendencies. Normoxic depositional habitats support high concentrations of benthic invertebrates that are important to the Gulf's food chain. Ordinarily, depositional habitats collect natural organic matter (rather than oil) that can be used as food, enriching the benthic biomass. These same productive areas are more prone to oil sedimentation, which may accumulate to form a layer over the benthos, isolating the benthos from the oxygen supply in the overlying water. Direct toxic effects and physical obstructions to feeding after contact with oil are also highly likely to occur in these situations. In some areas, the benthos contains the resting-stage eggs (diapause eggs) of copepods that would ordinarily help repopulate the next year's spring zooplankton bloom, assuming survival of the eggs resting in seafloor sediments.

[7] Poster at PI Conference by Claire Paris-Limouzy (RSMAS) presented a biophysical model that predicted where microdroplets of different size go, matching independent observations in the field and predicting occasional upwelling.

Many of mid-water organisms (i.e., the deep-scattering layer, or mesopelagic organisms) travel through plume depths. If negatively impacted, these communities could fail to support trophic interactions with tunas, whales, swordfish, and other deep-diving animals that feed on this community. Some mesopelagic animals could actively transport oil from depth to the shallow surface waters of the open Gulf. Researchers in the session indicated more effort needs to be spent on the biological implications of these subsurface interactions.

- **Education sorely needed** – The public clearly does not make the connection between different Gulf habitats and has little knowledge of the deep sea or anything beyond the coastal zone. Scientists must connect to the public to educate them. Film, printed and web-based products from NGOs such as National Geographic and similar entities may be the most useful means of achieving effective public education regarding connectivity among Gulf habitats.

- **Technological Problems** - Overall, the impression is that most of the scientific community was unprepared to sample at the depths at which the leak occurred because the available technology for sampling at these depths was not available to them. Off-the-shelf instrumentation was untested in such applications, despite the claims of the instruments' manufacturers.

  Off-the-shelf CDOM sensors, with the exception of those adjusted to the proper excitation/emission wavelengths, were largely unreliable, providing a false impression that there was no oil in the water. USF deployed off-the-shelf CDOM sensors through oil at depth and near the surface in blue water, and the CDOM sensors failed to detect the oil, whereas backscatter devices were more reliable in identifying particles that were later confirmed to be oil by USF and NOAA . Backscatter, however, also detects terriginous materials and phytoplankton, making interpretations in green and brown waters more complicated. Concern was expressed that DO anomalies within vertical profiles (CTD casts) are also not reliable, as these are determined by hydrodynamic oxygen supplies and complex secondary biological responses to the oil, rather than the oil itself. Sonar worked well down to about 1,000 m, and it was agreed that newer acoustic technologies will likely improve the detection of subsurface oil in the future. There appear to be no commercially available pH meters that are full-ocean-depth rated.

Full Report: Oil and dispersant impacts and mitigation-human health and soci()-economic systems (eKposure, community vulnerability and resilience)

11/13/2010

Human Health and
Socioeconomic Breakout Group

Maureen lichtveld, MD, MPH
Steve sempier, MS

Dialogue topics

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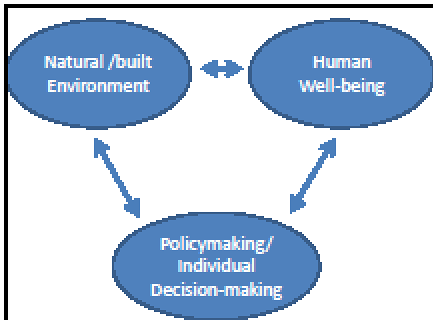

Trans-disciplinary research opportunities

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Full Report: Use of in situ and remote sensors, sampling, and systems for assessing extent, fate, impacts, and mitigation of oil/dispersant

Panel Members: Vernon Asper (Facilitator, USM), Gustavo Goni (plenary speaker, reporter, NOAA/AOML), Mitchell Roffer (ROFFS), D. Rudnick (SIO), A. Merten (NOAA/ORR), M. Howard (IOOS/GCOOS and TAMU), Ira Leifer (UCSB).

Additional input by Breakout session participants: Paula Coble, Ira Leiffer, Casey Moore, Corey Koch, Frank Muller-Karger, and others.

On day 1, panel members made presentations on the different interdisciplinary observations done in support of the Deepwater Horizon (DWH) incident, with each talk followed by questions and answers. On day 2, the panel members and group participants discussed gaps, provided recommendations based on these gaps, and discussed future work.

Several common themes recurred in the presentations and ensuing discussions: 1) General considerations on in-situ and remote sensing observations in support of monitoring, assessments, and restoration, 2) Role of satellite observations, 3) In-situ measurements of oil, dispersants, and tar balls at the surface and subsurface, 4) Observing network with sustained observations, and 5) Data accessibility and distribution.

The panel provided recommendations to these five themes. The group emphasized that the list of gaps identified is not comprehensive or conclusive, but it represents an important starting point.

1) General considerations on in-situ and remote sensing observations in support of monitoring, assessments, and restoration.

Given the nature of the DWH incident, an extraordinarily large suite of interdisciplinary observations was necessary to monitor the ocean conditions and assess the impact of oil on the diverse ecosystems present in the Gulf of Mexico. These observations could be categorized according to:

- *Sensor*: in-situ and remote sensing;
- *Location*: near-field (within a few km of the spill site) and far-field (Gulf wide);
- *Mode*: sustained and targeted;
- *Type*: atmospheric, sea surface, subsurface, and sediments;

Of great importance will be the establishment of a mechanism to rapidly and effectively coordinate and fund the academic, government and private research communities to make full use of human capacity and infrastructure available to be deployed in the region affected by the spill; the philosophy and strategy for coordinating these assets should be formalized as soon as possible to enable proper and effective responses to future disasters both in the US and abroad.

Gaps:

- There is no appropriate baseline information for several key parameters;
- There were very limited real-time observations to allow generation of daily, weekly, or even monthly maps of surface and subsurface oceanographic conditions;
- There were very limited maps of tar ball location ;
- There was lack of coordinate effort between various communities, including government, academic and private to carry observations – the result is that human capacity and research infrastructure available was not effectively utilized;
- Lack of a mechanism to coordinate with international partners (e.g. Cuba, Mexico, Bahamas)
- There were few, unclear and awkward processes for funding projects;

Recommendations:

- In preparation for possible future emergencies:
    - Improve the mechanisms that facilitate, fund and coordinate collaboration among government, academia, and private industry scientists to carry out observations and to distribute data, analyses, data products, impact assessments, and projections.
    - Establish a "rolodex" that identifies particular groups with specific research capabilities.
- Carry out a retrospective assessment of the DWH incident to assess:
    - What key parameters were measured, and what should have been measured
    - If these parameters were measured using the correct methodology/sensor,
    - If the parameters were measured at the right location and time,
    - What fraction of the collected data were used and how they were used in analysis,
    - When used in model initializations, was model performance improved,
    - If baseline data available for key parameters were adequate,
    - If observations were made in response to a recognized need of the operational and scientific communities;
- Post ship locations and planned tracks and operations in a site accessible to all scientists working on the incident.
- Evaluate the communication mechanisms to determine what did and did not function effectively
- While it is important that parameters are measured at the appropriate spatial and temporal scales, and have a clear scientific and operational justification, it is important that a basic set of physical and biogeochemical observations be collected continuously, in real-time, and observations broadcast broadly, as soon as a disaster is foreseen or immediately as it occurs;
- Make observations in the far field.
- Offer rapid funding of proposals through the various agencies (NSF, NOAA) involved in the managing of the monitoring of the incidents;
- Fund data quality-control efforts during the incident period.
- Continue to fund ship time of the academic and government fleet
- Update and cross-reference calibration equipment and technology on UNOLS and NOAA fleet as well as non-UNOLS or NOAA vessels;

- Foster stronger collaboration between oil companies, fisheries, and other industry stakeholders that deploy infrastructure in the region to install oceanographic equipment to carry out sustained observations.

2) Role of Satellite Observations.

The DWH incident reaffirmed that satellite remote sensing plays a critical role in the response to disasters that affect large areas over an extended period of time. Satellite imagery covering different parts of the electromagnetic spectrum over a range of spatial and temporal resolutions were used effectively on a daily basis by operational and research responders and by educational and public stakeholders. Satellite remote sensing will continue to play a key role in future studies related to oil spill, severe storms, and other extreme events.

In the DWH event, satellite observations were used to detect oil and ocean features that could potentially modify the oil pathways. Visible, infrared, and microwave satellite observations from various sensors (e.g. MODIS, and NOAA geostationary and polar-orbiting, and SAR, satellite altimeter) already in place were useful for the detection of surface oil and defining the limits of its extension and dispersal patterns. When combined with aerial observations, the data were used to estimate volume and discharge rates. Dynamic features, such as convergence and divergence zones as well as eddies were detected from satellite-derived currents, sea surface temperature, and ocean color and were validated by sparse in situ observations. In some cases, satellite altimeters provided the only source of continuous information on ocean surface currents, all of which is of interest to stakeholders and the public. There were limitations such as spatial resolution and cloud coverage. Critical to overcoming some of these limitations is the joint analysis of different data sets and blending of data to create fused products. More work needs to be done concerning false positives, assessing thickness of the surface oil layer, and merging data with different spatial and spectral resolutions.

The response and research efforts during and after the DWH event was facilitated through the study of currents, sea surface temperature, and ocean color from satellites. Yet the lack of coordination with onsite collection efforts offered few to no opportunities for extensive ground-truthing or validation. The few observations available from onsite responders, stakeholders, and researchers proved to be critical for oil identification.

Satellite scatterometers, which provide synoptic wind fields that include direction, are useful to monitor wind effect on surface oil extensions. At the moment, there are no scatterometers available. Satellite altimeters provided the only source of continuous information on surface ocean currents. MODIS and the European MERIS sensor provided extensive coverage of the water quality parameters, including sea surface temperature, oil spill extent and dispersal patterns, as well as data on water clarity, sediment concentration, phytoplankton concentration, frontal areas and the location of eddies and the Loop Current.

Gaps:

- The number of concurrent U.S. and international ocean observing satellites available in the past few years is now in steep decline – some satellites have stopped working, and there is continuing impeded access to data from foreign satellites
  - The U.S. is losing its ability to study and monitor the ocean synoptically, with periodicity, frequently, and especially over the long-term
  - There is an insufficient number of researchers familiar with sensor design, applicability and knowledge of use of multiple datasets
  - There is a loss of technical (science, engineering) know-how among U.S. students relating to space-based ocean observing infrastructure
- Strong coordination of all satellite monitoring efforts.
- Merge of satellite with other remote sensing and in situ data.
- Concise methods to determine thickness of oil surface layer.

Recommendations:

- The US needs to revisit the strategic plan and priorities established by the NAS Decadal Survey. Continuous review of strategic plans is recommended. NASA, NOAA, the USGS and other U.S. agencies need to establish a series of concurrent satellite missions spanning a range of spatial, temporal, and spectral scales.
- The US needs to integrate space-based remote sensing planning and implementation in the strategic planning and implementation of the US Integrated Ocean Observing System (IOOS). To date, this planning has not occurred. This was pointed out and highlighted by the U.S. Commission on Ocean Policy in its final report to the Nation. An important consequence of this failure is that the Nation is losing is space-based ocean observing capability and the know-how of building and maintaining such a system.
- Continue strong support of satellite missions to measure sea height, sea surface temperature, and multi-spectral ocean color able to resolve mesoscale and small scale features in the near shore and offshore regions; as well as scatterometer missions and SAR;
- Establish optimal techniques for blending data from surface drifters, HF radar, current profilers, T/S observations, gliders and other underwater autonomous vessels with satellite observations and airborne measurements to better resolve ocean dynamics.
- Improvement of oil/dispersant detection by funding studies of how parameters measured by satellites and airborne sensors may be affected by oil/dispersant extension and thickness;
- Support calibration studies of different remote sensors;
- Create new products using traditional and non-traditional visible and infrared spectra,
- Develop automated feature detections and automated tracking of oil

3) In situ Measurements of Oil, Dispersants, and Tar Balls at the Surface and Subsurface.

There were extensive discussions on how well various sensors and platforms are expected to perform at detecting subsurface oil based on their sensor characteristics. The participants discussed how well fluorometers detected oil, and the relative value of the different types of fluorometers used to attempt to map oil distribution. Fluorometers designed to detect CDOM (colored dissolved organic matter) and fluorometers designed to detect hydrocarbons (and especially the Chelsea Aquatracka) were used to identify water masses containing oil from the spill. These are sensitive to different combinations of fluorophores in the oil/dispersant mixture and can lead to very different results, depending on the precise composition of the hydrocarbons in the water, droplet size, and concentration. Both can detect hydrocarbons, but evidence also indicates that a negative CDOM fluorometer response does not necessarily equate to the absence of oil due to detection limits. Other techniques, such as Parallel Factor Analysis and time-resolved fluorescence were discussed. In addition, the role of oxygen on indirect oil detection was also discussed, along with different sensors used in the direct and/or indirect detection of oil at the subsurface. The value of video/picture observations of oil on and below the surface was discussed, indicating that they contributed to identification of layers within the plumes. However, it was stressed that their use is still not evident.

Gaps:

- Multiparametric sonde that includes a number of fluorescence excitation/emission wavelengths, backscattering, and absorption observations
- Sensors that can be deployed in environments containing oil contaminants and provide accurate observations
- Multiparameter (and multi-wavelength) sensors that can be incorporated and deployed across a range of delivery platforms, from CTD's and buoys to aircraft and ship-deployed XCTDs, XBTs, and other dropsondes.
- Appropriate protocols for field observations (radiometry, inherent and apparent optical properties) to provide satellite/airborne ground-truthing and validation data

Recommendations:

- Support the JAG recommendations on oxygen measurements;
- Distribute complete metadata with data from fluorometers, including light source and excitation and emission wavelengths, so that inter-comparability of data is more straightforward.
- Explore the possibility of reanalyzing some of the water samples already taken with more appropriate instrumentation;
- Conduct validation/calibration experiments to interpret fluorometer data obtained during response period;
- Fluorometers of the most appropriate wavelength should be used when possible, preferably with three separate channels, and these should be deployed throughout the water column, including depths deeper than 2,000-4,000 m;
- Carry additional studies to evaluate different sensors and platforms that provide data for oil detection and recommend if more appropriate sensors (e.g. hydrocarbon-specific fluorometers) should be installed in research and operational platforms, including ships, CTDs, gliders, sonobouys and dropsondes, etc.;
- Investigate the potential of having equipping autonomous vehicles (such as a gliders) with a suite of the most appropriate sensors;
- Investigate any potential interference effects of oil on different physical and chemical measurements (e.g. oxygen, salinity, etc);

- Obtain water samples for oil detection and, when possible, carry preliminary analysis of some of these samples on board of the research ship in order to guide subsequent measurements;
- Conduct additional research on the use of optical and multi-frequency acoustic backscatter to determine location and extension of the oil plume;
- Carry out assessment of degradation of oil by bacteria, evaporation; etc.;
- Carry out evaluation and validations of modeling efforts;
- Develop methods specifically for low-level hydrocarbon detection with other proxies;
- Support technology development for measuring these and other oil-detecting parameters, for example mobile platforms or moorings;
- Support enhancement of shipboard measurements, including observations from ships, AUVs, etc.

4) Observing Network with Sustained Observations.

Long-term, near real-time monitoring of the whole water column, with a dedicated suite of sensors on fixed and mobile platforms should be continued at the oil spill site. The US should make an explicit and immediate effort to integrate satellite remote sensing planning and deployment of appropriate satellite sensors as an integrated element of the U.S. Integrated Ocean Observing System (IOOS). These assets would augment the existing assets of the Gulf of Mexico Coastal Ocean Observing System (GCOOS) which is part of the IOOS. The networked system would not only allow DWH researchers to monitor conditions and impacts but would provide additional information in the event of other spills, extreme weather, search and rescue etc.

Gaps:

- Recurring extreme weather events, extensive offshore oil and gas activity, and strong unpredictable currents are all reasons for enhancing and maintaining a sustained ocean observing system in the Gulf of Mexico. The Gulf is historically underfunded relative to other coasts.
- It was noted that gaps exist in current observing networks (e.g. HF radar), in several geographical regions (e.g. no sustained observations in the Florida Keys, Florida Bay, Florida Straits, and west Florida Shelf).
- Lack of a mechanism to coordinate with international partners (e.g. Cuba, Mexico, Bahamas)

Recommendations:

- Create and sustain a robust ocean observing system for monitoring gradual changes and to respond to extreme events in the ocean ecosystem;
- Use of current capabilities as a start point for the development of one single plan;
- Carry out Observing System Simulation Experiments (OSSE) to design the observing network and to provide scientific and operational justifications for its design
- Observations must be interdisciplinary, including biological, physical, chemical, in the atmosphere, whole water column, and sediments;
- Observations need to be carried in a cost-effective manner, perhaps utilizing existing assets to the greatest extent possible;

- Given the extension of their Exclusive Economic Zones, consider inclusion of Mexico and Cuba as scientific partners in planning day-to-day research on the region;
- Implementation of a fixed sea floor observatory near the oil spill with cable connection for power and high bandwidth data, acquiring both seafloor and water column data.

5) Data Accessibility and Distribution.

Observations, distribution of data, analysis, assessments of impact, and projections need to be done in collaboration among scientists of different institutions that include government, academia, and private industry. Rapid data submission to data centers (e.g. NOAA/NODC), easy access to databases, and free distribution of data and products proved to enhance collaboration work and fast communication of results. Rapid distribution of data and analysis will also allow better planning of follow on cruises and studies. For example, a map with delayed-time and real-time distribution of oil/dispersant/tar balls extension, and location of findings of dead or alive animals, will serve to better plan cruises. It was discussed that some observations may be still missing from databases, as for example from powered AUVs.

Gaps:

- A unified operational system for data acquisition and open data distribution.
- A proper mechanism to include metadata describing origin and calibration of the data collected from autonomous and other platforms (e.g. gliders)

Recommendations:

- Fast distribution of real-time data and quality control data;
- Immediate development of a mechanism to credit and recognize data providers, and tag data posted on government websites with appropriate metadata;
- Secure distribution of all data and metadata;
- Fast distribution of these data to data centers;
- Centralized data distribution in an operational mode;
- Continue collaborative approach to include government, academia, and private industry.