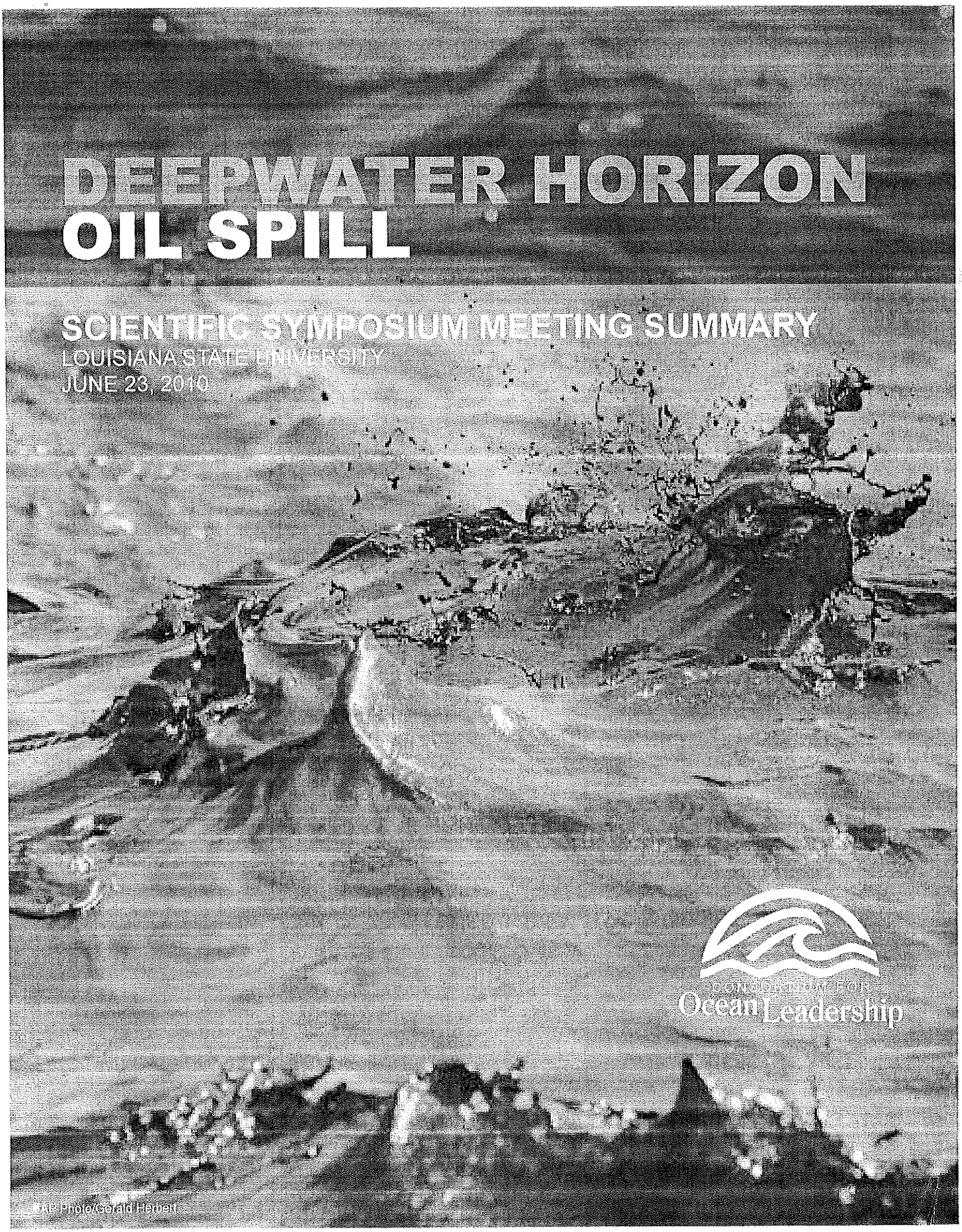
DEEPWATER HORIZON OIL SPILL

SCIENTIFIC SYMPOSIUM MEETING SUMMARY

LOUISIANA STATE UNIVERSITY
JUNE 23, 2010



CONSORTIUM FOR Ocean Leadership

AP Photo/Gerald Herbert

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Executive Summary

On June 3, 2010 more than 200 scientists convened on the campus of Louisiana State University (LSU) to discuss the urgent issues regarding the *Deepwater Horizon* oil spill that has been releasing large quantities of oil into the Gulf of Mexico since the end of April. The participants were briefed by federal agency officials about the government's response to date and research activities underway. The key component of the meeting was breakout sessions focused on estimating the flow rate of the spill, projecting its fate and determining the effects of the oil and the dispersants on the environment and human health.

RECOMMENDATIONS FOR MEETING THE MAJOR SCIENCE CHALLENGES OF THE SPILL

- To better understand and determine the magnitude of the spill, three dimensional assessments of the extent and characteristics of the oil are essential, including thickness of surface oil, extent of subsurface plumes, and the mixture of gas, oil, gas hydrate and water. These parameters can be construed by using high resolution video, acoustic Doppler current profilers (ADCPs), gas tight samples and temperature measurements.

- To track the fate and transport of the oil, the group recommended using biomarkers and chemical compound tracers; deploying smart autonomous underwater vehicles (AUVs) and towed vertical arrays with current profilers, mass spectrometers and fluorometers; and acquiring new remote sensing capabilities such as synthetic aperture radar. There was also concurrence for the need for a comprehensive Gulf of Mexico ocean observing system that includes a rigorous data management system.

- To ascertain the ecological and human impacts of the spill, there is crucial need for baseline ecological and sociological data. The toxicity and bioaccumulation of the oil, dispersants, drilling mud and volatile organic compounds must be understood in order to communicate risks to the public.

CROSS-CUTTING CHALLENGES

- Workshop participants universally concurred on the need for central coordination to better deploy scientific assets and avoid duplication of efforts. While the Coast Guard is in charge of the first response, there is no national lead entity coordinating the mobilization of science assets across federal agencies and within the broader ocean science community. At a minimum, there needs to be a central, comprehensive description of science activities underway to avoid duplication of effort, establish sampling protocols, and promote better coordination of shared research platforms and facilities (vessels, ROVs, etc).

- Attendees identified the need for a central data management center to coordinate the collection, storage and sharing of data and metadata that is being collected by academic researchers, industry and federal agencies working in the Gulf.

- There is a critical need for expedited rapid response funding for research and monitoring by the federal and private sector. NSF's RAPID grants have been one of the few expedited funding mechanisms available to the external research community.

DEEPWATER HORIZON OIL SPILL SCIENCE SYMPOSIUM

Agenda

Wednesday, June 2nd

5:00 - 7:00 Evening Reception

Thursday, June 3rd

7:00 - 8:00 Registration

8:00 - 10:00 Welcoming Remarks
Dr. Robert Gagosian, President, Consortium for Ocean Leadership
Dr. Chris D'Elia, Dean School of the Coast & Environment LSU
Dr. Nancy Targett, Board Chair, Consortium for Ocean Leadership

Federal Activities to Date / Scientific Research, Challenges and Priorities
Dr. Jane Lubchenco, Administrator NOAA
Dr. Marcia McNutt, Director USGS
Dr. Tim Killeen, Assistant Director NSF

10:00 - 10:45 Roundtable Discussion on Academic Research Activities

10:45 - 12:15 Breakout Working Group Sessions

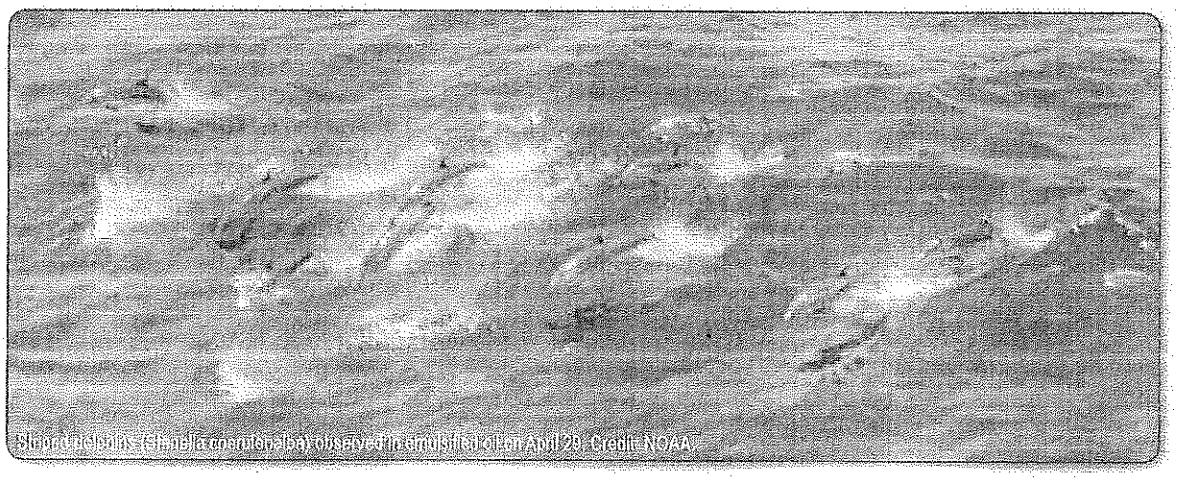
12:15 - 1:15 Working Lunch – Conducting Oil Spill Research in a Regulatory Framework
Dr. John Farrington, SMAST UMass-Dartmouth

1:15 - 3:15 Breakout Working Group Sessions (*continued*)

3:15 - 3:45 Break

3:45 - 4:45 Reports from Working Groups

4:45 - 5:15 Next Steps and Wrap-up



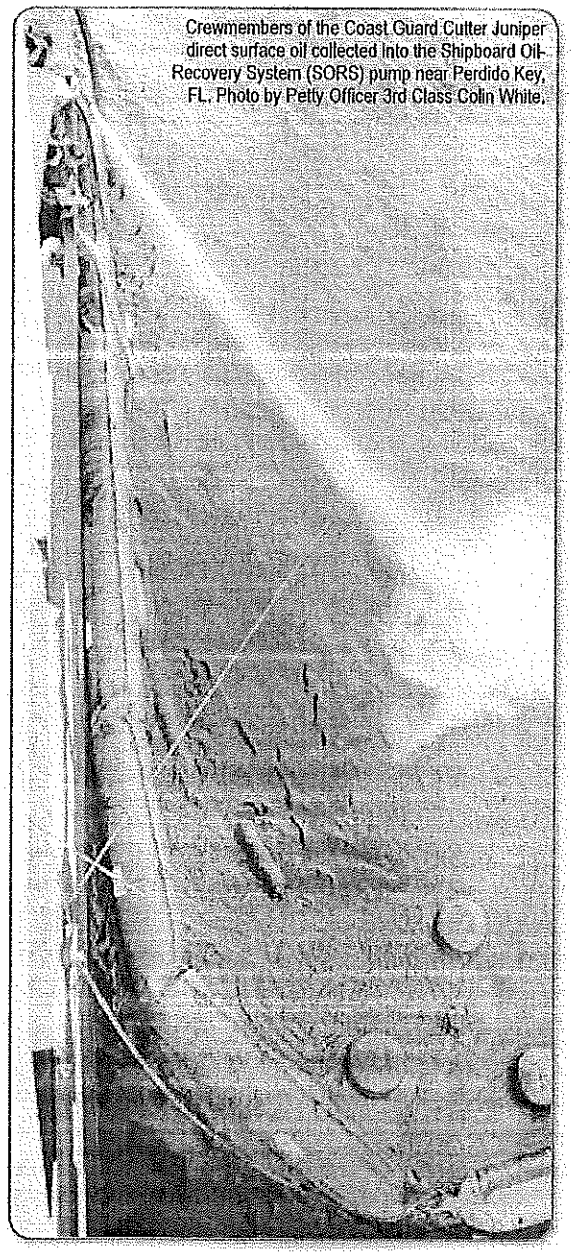
Spotted dolphins (Stenella coeruleoalba) observed in emulsified oil on April 29. Credit: NOAA

Background

On April 20, 2010, the *Deepwater Horizon* offshore drilling rig situated about 41 miles (66 km) southeast of the Louisiana coast experienced a catastrophic explosion and fire while drilling an exploratory well, killing 11 workers and causing the rig to sink to the seafloor. Two days after the incident, the U.S. Coast Guard announced the leaking of oil from the broken pipe on the seafloor approximately 5,000 feet (~1500 m) below the surface of the Gulf of Mexico. Additional leaks, coming from kinks in the broken pipe, were observed over the next several days by industry-grade remotely operated vehicles (ROVs) and oil sheen was observed at the sea surface. In the ensuing months, the leak has continued, making the *Deepwater Horizon* oil spill the largest in U.S. history.

On June 3, 2010 the Consortium for Ocean Leadership convened a federally-sponsored scientific symposium on the Louisiana State University (LSU) campus to discuss the urgent science issues related to the oil spill. Over 200 participants attended the event in Baton Rouge, including scientists from approximately 50 academic institutions, 10 non-profit organizations, and representatives from a dozen federal agencies. The Symposium was also broadcast live via the Ocean Leadership and CNN websites.

Building on a May 19th White House briefing, the Symposium provided an opportunity for the federal agencies to update the research community on their response to date as well as their research priorities. The primary focus of the meeting was to provide a forum for the external research community to identify for the federal agencies existing gaps in scientific knowledge surrounding the spill; opportunities to fill those gaps; and recommendations for both short- and long-term research needs to understand the impact of the spill on Gulf ecosystems and surrounding human communities.



Crewmembers of the Coast Guard Cutter Juniper direct surface oil collected into the Shipboard Oil-Recovery System (SORS) pump near Perdido Key, FL. Photo by Petty Officer 3rd Class Colin White.

Welcoming Remarks

In his welcoming remarks, **Dr. Chris D'Elia**, LSU's Dean of the School of the Coast and Environment, noted the importance of Louisiana to the United States. The state plays an essential role in the economy of the nation: its seafood production is second only to Alaska; it is a major shipping avenue for the country; and it is a fundamentally important and strategic source of the Nation's oil and gas reserves. Louisiana coasts comprise 40% of the nation's most fragile coastal wetland areas, and it is home to some of the nation's leading researchers with expertise in all issues related to the Gulf, including its environmental processes, resources, and its people. D'Elia implored the federal government, BP and the academic community to not forget the Gulf Coast research community and its vast resources as science plans and remediation and recovery efforts are developed and implemented.

Dr. Nancy Targett, Dean of the College of Earth, Ocean and Environment at the University of Delaware and Chair of the Ocean Leadership Board of Trustees, welcomed participants on behalf of Ocean Leadership's 96 Member Institutions, with special acknowledgement to Dr. D'Elia and LSU for hosting the Symposium on such short notice. In her overview of the agenda, she underscored the importance of having highly-respected earth scientists leading the three federal agencies [National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), and the National Science Foundation (NSF)] directly involved in monitoring and responding to the incident in the Gulf. She thanked Drs. Jane Lubchenco, Marcia McNutt, and Tim Killeen for their willingness to be active participants in the Symposium's day-long discussions and noted that the oceanographic research community was standing alongside the Gulf Coast institutions, ready to assist them in responding quickly and effectively to the oil spill.

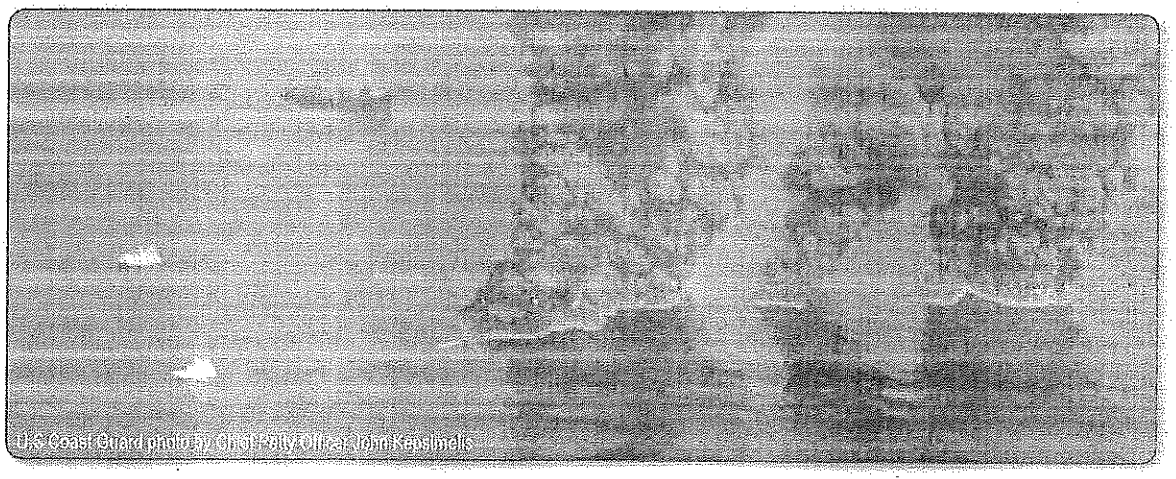
Dr. Robert B. Gagosian, President of the Consortium for Ocean Leadership, challenged the group to think ahead to the year 2025 and consider what information we will wish we had in hand today to tackle the science challenges facing this tragedy. Gagosian said the goal of the meeting was to identify existing gaps in both current scientific knowledge and short- and long-term needs. He described the Symposium as an important beginning towards mobilizing the research community-at-large around a set of community-based topics and priorities. He underscored Ocean Leadership's commitment to developing a follow-on series of theme-based scientific workshops to define what is known, what is not known, and what must be known in both the short- and long-term understanding and responses to this oil spill.

NOAA's current efforts towards creating a publicly-accessible database of research data collected in response to the spill.

Dr. McNutt described the strengths the Interior Department has for handling the science of an oil spill, including expertise in oil characterization, hydrodynamics, geo-spatial analysis, wildlife health, and risk assessment studies. Dr. McNutt stated that the goal of the Department's science response was to document, understand and predict short and long-term effects of the oil on species, ecosystems, services, cultural resources and coastal communities. McNutt commented on the lessons learned from the 1989 Exxon Valdez oil spill including the need for having baseline information before the spill, looking at ecosystem impacts over decades, and considering both offshore marine and coastal ecosystems.

McNutt reported the initial findings of the Flow Rate Technical Group (FRTG), which is comprised of federal scientists, independent experts, and academic researchers. Within the FRTG, four independent teams (mass balance, plume, riser insertion tube tool assessment, and nodal & reservoir teams) provided similar preliminary assessments ranging in the 12,000 to 19,000 barrels of oil being released into the Gulf each day. This range is considered the "lower bounds" estimate of the flow rate and continued efforts are underway towards establishing an "upper bounds" estimate. [N.B., more recent "upper bound" estimates have been in the 50,000 to 60,000 barrels per day range].

McNutt also updated the participants on the May 19th White House Science Summit that was convened by the Office of Science, Technology, and Policy (OSTP) and hosted by the Environmental Protection Agency (EPA). Approximately 30-40 deans, directors, presidents and scientists of major research institutions participated and identified the science that needs to be addressed, including the toxicity of dispersants and subsurface oil; the volume and fate of the oil; seafood safety; photochemical effects on the oil; petrochemical interference with chemical signaling within marine organisms; limiting factors in microbial metabolism; long-term effects of oil in the environment including air quality; re-suspension of toxins from storms; ecosystem tipping points; remediation; and human dimensions, including communicating real vs. perceived risk and economic analysis. McNutt outlined the approaches to these research efforts that were identified at the May 19th science summit,


U.S. Coast Guard photo by Chief Petty Officer John Kepsilnelis

Federal Activities to Date/Scientific Research Challenges and Priorities

Dr. Jane Lubchenco
Administrator NOAA

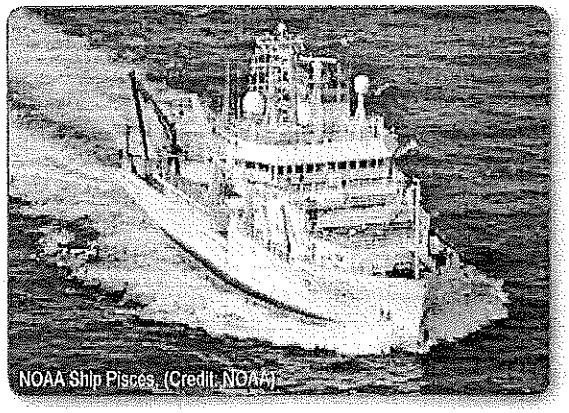
Dr. Marcia McNutt
Director USGS

Dr. Tim Killeen
Assistant Director NSF

Dr. Jane Lubchenco, NOAA Administrator, Dr. Marcia McNutt, USGS Director, and Dr. Tim Killeen, NSF Assistant Director each provided overviews of their respective agency's spill-related efforts. They each addressed the issues and themes that have played a critical role in decision making in the aftermath of the *Deepwater Horizon* rig explosion.

Dr. Lubchenco addressed NOAA's response to date in the Gulf, including collecting samples and baseline environmental data, assessing seafood safety, calculating the flow of oil, tracking surface oil, studying effects of dispersants on marine organisms, conducting aerial surveys of protected species, and analyzing Loop Current hydrodynamics. Lubchenco provided some preliminary results demonstrating a significant increase in sea turtle strandings since the start of the event, compared to prior spring stranding data. She explained that NOAA currently has at least seven research vessels involved in collecting data throughout the water column and sediments and she noted that the various federal sampling assets that were currently being deployed had collected over 2,000 baseline samples in the Gulf.

Lubchenco indicated that there was significant sub-surface water sampling underway and discussed the difficulties of fingerprinting the oil and the importance of using proper collection and storage protocols. She suggested an immediate follow-up workshop to review results and harmonize approaches to date before any additional research expeditions are planned, except for required monitoring activities. Lubchenco highlighted other near-term science actions, including mass balance calculations to understand surface and sub-surface fractions of total oil released and continued assessment of shoreline oil impacts and clean-up actions. She noted that NOAA is also interested in understanding the impacts of the dispersants, and is conducting surveys to assess the fate, transport and near-term effects of subsurface dispersed oil. In addition, she explained that NOAA is working to set up longitudinal surveys of potential oil and dispersants in seafood and studies to understand the impact of the event on coastal communities. Finally, Lubchenco highlighted the need for a more holistic ecosystem approach to understand the long-term impacts of the spill and briefly described


NOAA Ship Pisces. (Credit: NOAA)

including mobilizing the University-National Oceanographic Laboratory System (UNOLS) ships to use sonar to remotely sense oil in the water column, followed by gliders equipped with fluorometers to map subsurface oil. She explained that the group also suggested the use of autonomous underwater vehicles (AUVs) and gliders to collect water samples to quantify concentrations of dispersed oil as well as identify microbes to ascertain impacts on respiration. There was extensive discussion of a wide range of space-based assets, including ocean color and airborne observations, infrared, and other approaches as having been absolutely key to helping map the conditions in the Gulf before and since the *Deepwater Horizon* incident. McNutt concluded by highlighting the importance of a wide range of medium- to high-resolution remote sensing technologies, including both civilian and classified sources, for continuing to characterize the areas that may be affected by the incident.

Dr. Killeen gave an overview of the response to date of the National Science Foundation, including immediate actions taken by NOAA and NSF-supported scientists aboard the *R/V Pelican* and the *R/V Cape Hatteras*. Killeen spoke about the use of NSF's RAPID grants and the deployment of the academic fleet to support immediate science needs. NSF RAPID grants currently support research in biological oceanography, ecosystem science, engineering solutions, high-performance computing simulations and societal factors. NSF is specifically supporting high resolution 3D forecasts of oil movement in the Gulf. Killeen explained that NSF also wants to help determine the magnitude of methane gas released from the spill and model its impact on gas hydrate formation, seafloor structures, marine food webs and carbon cycling. Furthermore, bioaccumulation of carcinogens and metals in the environment and seafood are of interest to the Foundation. NSF is also interested in researching the human dimension of the spill, including collecting data on the status and impacts to social, cultural and economic assets of the Gulf communities.

Killeen emphasized the importance of investigating the role of hurricanes in re-suspending and re-distributing oil on the seafloor and in the water column. NSF is also interested in developing new biological and/or nanotechnologies to concentrate or disperse the oil. Killeen mentioned that the Foundation wants to incorporate environmental disasters into response and socioeconomic models to increase resiliency in individuals and communities. Finally, Killeen identified the need to use this tragedy as a teachable moment, including filming science operations and embedding reporters on expeditions, developing better public outreach, and including undergraduates in research activities.

Roundtable Discussion on Academic Research Activities

Dr. Chris D'Elia
Louisiana State University (moderator)

Dr. Nancy Rabalais
Louisiana Universities Marine Consortium

Stephen Sempier
Mississippi-Alabama Sea Grant Consortium

Dr. Edward Overton
Louisiana State University

Dr. Steven Lohrenz
University of Southern Mississippi

Several scientists from the Gulf summarized research efforts underway in their regions.

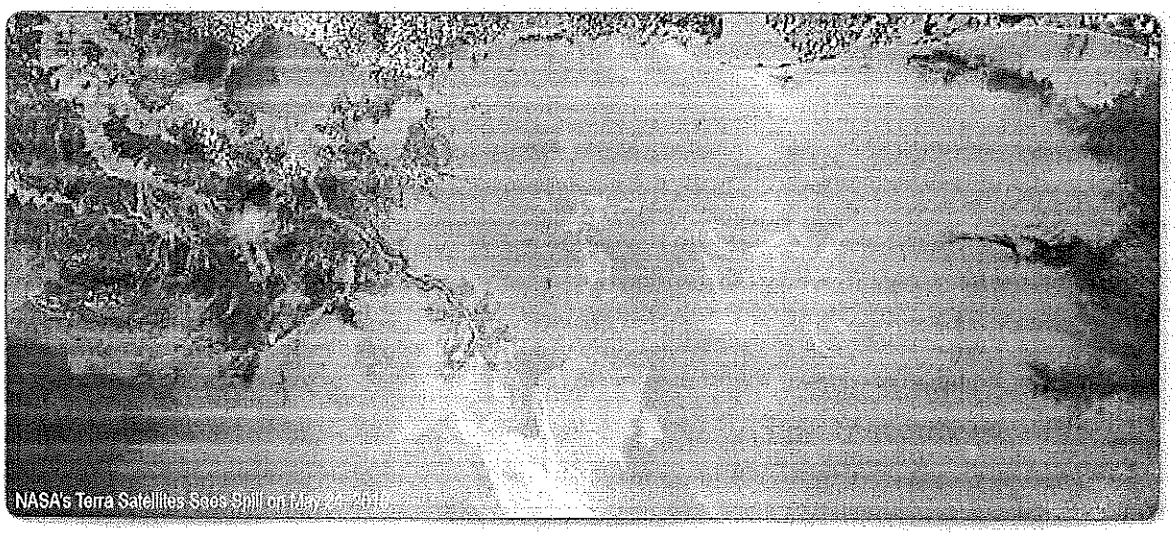
Dr. Steven Lohrenz presented activities at the University of Southern Mississippi (USM) and other Mississippi institutions in three major areas. First, he described the immediate response to the spill that involved mobilizing a team to establish high frequency radar sites to provide high resolution surface currents. These data are online as part of the Integrated Ocean Observing System (IOOS). NOAA is currently using data to simulate models for forecast trajectories. Lohrenz said that USM also plans to deploy a glider for mapping physical and optical properties off the Mississippi or Alabama coast to add to the fleet that is already at sea. Second, Mississippi is developing an environmental and ecological baseline as the oil slick moves, which involves a broad suite of samples (biota, nutrients, water quality, sediments, etc.). Finally, Lohrenz highlighted offshore work underway to assess the distribution of oil that was initially associated with the *R/V Pelican* cruise.

Dr. Nancy Rabalais spoke on behalf of the Louisiana Universities Marine Consortium (LUMCON) concerning their research and response efforts and noted that the *R/V Pelican* was one of the first research vessels on the scene. She indicated that there were many scientists at sea conducting various studies, including baseline data and ecosystem-level processes, such as formation of hypoxia and biogeochemical cycling of nutrients and carbon. Rabalais' research lab is one quarter of a mile from a BP Command Center in Cocodrie at the upper end of Terrebonne Bay; in a village of 100 people that has grown to over 3,000 in the past month. They are

doing their best to remain open to agencies, researchers and educators. One focus of her group is ecosystem-level research that serves management. LUMCON is also involved in marine education and public outreach and Rabalais described the oil spill as a science learning experience "even for us."

Dr. Edward Overton, an LSU hydrocarbon chemist, is focused on the chemistry of the oil from the *Deepwater Horizon* well. He described the oil as a light Louisiana crude which has some unusual characteristics, one of which is the fraction of "unstable asphaltene." The first sample taken was thick (high asphaltene), so he concludes that there are two types of oil in the water (typical Louisiana crude oil and the very high density oil). Overall, the high density oil appears in small proportions compared to the large proportions of Louisiana crude oil, which he stated was "good," from an evaporative point of view. He explained that some oils are rising to the surface in large globs, while others appear in microscopic globules, but by the time the oil reaches the shore, it's heavily weathered. The oil is not very water soluble and remains a surface feature. Overton considered the remaining high amounts of skimmable (not soluble) oil at the surface an indication of the lack of commitment to skimming the oil. He stated that the first priority should be stopping the flow and then capturing the oil before it reaches shore.

Stephen Sempier shared activities that are underway within Sea Grant, including the Gulf of Mexico Research Plan (GMRP). The plan was completed in September 2009, with over 1,500 participants in its development. Now, Sea Grant is developing an addendum to the plan focusing on oil spill research priorities and is conducting a preliminary survey of oil spill research priorities in preparation for a more formal survey. They are also developing a database of what oil spill research is currently underway in the Gulf of Mexico. They have also partnered on regional research initiatives with EPA to address regional needs. Finally they have been holding community forums to inform and educate the public and give residents the chance to have their questions answered.



NASA's Terra Satellites Sees Spill on May 27, 2010

Conducting Oil Spill Research in a Regulatory Framework

Dr. John Farrington
University of Massachusetts, Dartmouth
School for Marine Science and Technology; and Scientist Emeritus, Woods Hole Oceanographic Institution

Dr. John Farrington led a working lunch discussion where he shared his experiences in oil spill research. He noted that 11 individuals lost their lives in this mishap and that first and foremost we need to prevent future human causalities from similar accidents. He commended federal scientists for their tremendous response in terms of gathering baseline data, containment, cleanup, damage assessment, remediation, input, fates and effects, and added that the academic community can provide valuable contributions to these efforts. He noted that industry (BP) is doing the same thing, and that we are all constrained by the same legal/regulatory framework (e.g., Natural Resource Damage Assessment (NRDA)). However, he recommended that this should not deter scientists from pursuing the highest quality scientific research because it remains in the public interest.

Farrington asked Dr. Robert Haddad from NOAA to briefly speak about websites and the future public release of data. Haddad noted that the constraints are different from what happened in the *Exxon Valdez* spill and that NOAA is seeking to make all of the data they collect publicly available. He explained that the Natural Resource Damage Assessment (NRDA) has been a "black box" because of the litigation issues surrounding the government's case. Consequently, everyone has to agree (state trustees, NOAA, DOI) to make the data public.

Farrington described the need and urgency for responsible science in a crisis mode: he imparted the need to bring the best science, engineering and research to serve present needs and expand the knowledge base for the future. He cautioned the community to be mindful that research surrounding the spill is being conducted within an environment that is subject to regulatory and legal actions and encouraged scientists to pay special attention to scientific record keeping (i.e. sampling, shipboard notebooks, electronic data, correspondence) as all records can be subpoenaed. He explained that this type of research activity is part of a scientist's public service and academicians should not avoid this research because of the legal environment.

Farrington implored scientists to choose their words with care and to be clear when speaking to the media. He emphasized the fact that it is acceptable to say "I don't know" in response to a question as there will be varying opinions among scientists, and this accurately reflects the uncertainty of knowledge that scientists seek to address through research.

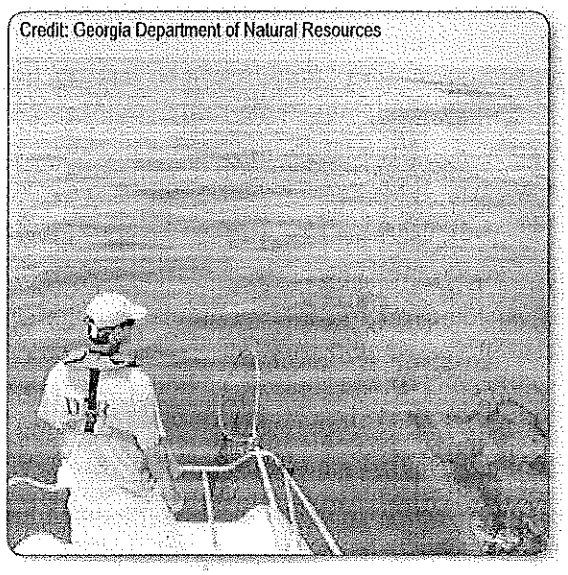
Farrington summarized his presentation by explaining that the best science will be required to comprehend this event and to establish a better understanding of the fate and effects of the oil spill. He asked what lessons will we learn from this experience that will help us prevent future tragedies. He questioned if there will be adequate science funding after the well-head is capped and if there will be adequate preparation before we continue to drill in deeper waters in the future. He concluded by stating that hindsight is 20/20 and reminded the audience that "chance favors a prepared mind."

Breakout Group Reports

Gulf residents are primarily concerned with the location of the spilled oil and learning how it will affect their lives in terms of their health, welfare, jobs and their environment. To address these concerns, Symposium participants attended afternoon breakout group discussions focused on three themes: ***1) determining the extent and magnitude of the spill; 2) tracking the fate and transport of the spill; and 3) evaluating the ecological and socio-economic impacts of the oil spill.*** Each group was charged with defining "what we know, what we don't know, and what we need to know" in each of these areas of scientific research.

DETERMINING THE MAGNITUDE OF THE SPILL

Determining the extent and magnitude of the spill is essential to assessing the environmental impact of the spill and tracking the spill over space and time. This information is also critical for informing decisions on spill mitigation and response. Preliminary estimates (as of May 27, 2010) of the flow of oil and gas from the broken riser pipe of the *Deepwater Horizon* rig were estimated at 12,000 to 19,000 barrels of oil per day. These estimates come from the Flow Rate Technical Group (FRTG) of the U.S. Geological Survey, which used three methods including video analysis, mass balance calculations, and remote sensing data to assess the rate of flow of oil and gas from the broken pipe at the riser. The 12,000-19,000 range is considered the "lower bounds" estimate and continued efforts are underway towards establishing an "upper bounds" estimate. Since a cap and siphon system was effectively employed during the week of June 14, new flow estimates of approximately 50,000 barrels per day have been reported.


Credit: Georgia Department of Natural Resources

Breakout group participants postulated that flow from the broken pipe is changing over time but reported that they have little sense of the variability of this flow. In addition, very little information is known about flow temperature and the proportions of methane gas, oil, gas hydrate, dispersant, and water in the flow (BP has said that about 40% of what is being released is methane by weight). Because of the different physical and chemical properties of oil, gas, gas hydrate, and water, this information is fundamental to better quantifying the volume of oil released from the broken pipe.

Little is known about the thickness of oil at the surface. Participants agreed this is variable, but it is important for mass balance equations used to assess the magnitude of the spill. Photography and remote sensing devices mounted on aircraft can only examine the two-dimensional extent of oil at the surface; new tools and investigations are needed to better determine the thickness of this surface layer. Other unknowns are the volumes and composition of subsurface plumes, at depth and below the water surface.

The physical and chemical characteristics of oil within the water column remain poorly understood. Working group members agreed that the "plume" of oil probably does not behave like a traditional, continuous, bulbous-shaped plume but instead it is composed of spatially-variable dispersed oil and neutrally-buoyant layers at different depths where direction and the speed of currents vary vertically. Researchers also agreed that acoustic measurements (28-38 kHz sonar) have provided valuable early assessments of subsurface oil and have revealed multiple layers (including a scattering layer at 400 m that persists for tens of kilometers) but agreed that the composition of these layers is not well constrained. Layers may be composed of oil, chemical dispersants, biota, gas hydrate flakes, and/or any combination of these elements. The group discussed previous studies describing the behavior of oil in seawater. These studies have shown that when oil is released at pressure, it can essentially create its own density. This dynamic can be compounded by ascending gas hydrate, which dissociates into water and gas at approximately 500 m and can ultimately saturate surrounding seawater with gaseous methane. These reactions can change some of the physical and chemical properties of the water column, affecting observations. *In situ* samples are essential for better quantifying the amount of oil dispersed throughout the water column and predicting the fate of this oil over time.

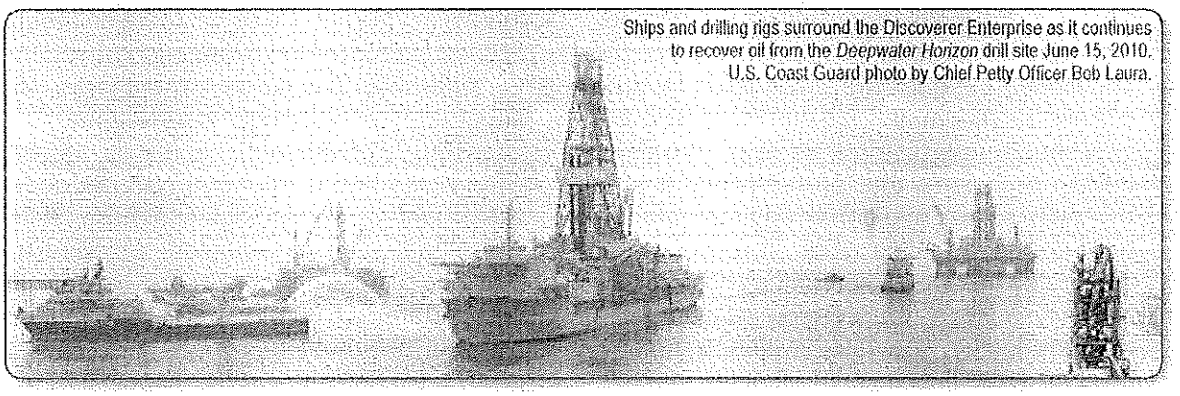
RESEARCH PRIORITIES

In order to better determine the extent and magnitude of the spill over spatial and temporal scales, it is essential to collect additional data to assess the rate and volume of flow from the pipe, the composition of petroleum constituents, the extent of oil suspended in the water column and the distribution and volume of oil at the ocean's surface. These measurements require the use of existing technology (e.g., tools similar to those used at hydrothermal vents) and creative use of existing data (e.g., exploring the potential of water column seismic data to examine layers of oil and/or gas hydrate below the sea surface). All efforts demand central coordination of data, metadata, and research tools such as ships and ROVs and AUVs. Were such an event to happen again, new tools such as satellites capable of sensing oil at the surface and profiling technology to analyze hydrocarbons throughout the water column on a continuous basis, are recommended investments in future research and development.

The group made the following lists of needs: first, high resolution video data of the leak is needed by researchers who are trying to assess fluid flow rate and volume using optical image analyses. Second, *in situ* measurements are needed to better quantify the rate and volume of the leak at the broken riser pipe. To make these measurements, the group suggested the installation of instrumentation such as acoustic Doppler current profilers (ADCPs). The group also recommended the collection of gas tight samples to determine the mix of oil and gas effusing from the pipe (gas tight samplers are routinely used in hydrothermal systems to collect pressurized samples of water and gas). Finally, there was consensus for the need to collect temperature measurements (many devices can be used for this, including "hobo" temperature probes which are routinely used to determine hydrothermal vent temperatures).

TRACKING THE FATE AND TRANSPORT OF THE OIL

Building on the information about the size of the spill, workshop participants discussed the fate and transport of the oil and other constituents that have been released or added to mitigate the spill. The first goal is to produce definitive multi-scale maps of the concentration of oil and dispersant throughout the water column. These maps



Ships and drilling rigs surround the Discoverer Enterprise as it continues to recover oil from the *Deepwater Horizon* drill site June 15, 2010. U.S. Coast Guard photo by Chief Petty Officer Bob Laura.

must be repeated to establish the evolution of the distributions.

RESEARCH PRIORITIES

There were two approaches recommended to develop these maps: the first approach uses coordinated multi-ship surveys with conventional sampling gear to ascertain the large- and small-scale structure of the effluent from the damaged well. Since shear stress can stretch and bend patches of oil and dispersant into narrow streamers and thin layers, sampling should be guided by model predictions and velocity profile observations collected by acoustic Doppler current profilers (ADCPs) lowered into the water column. Since water samplers have limited spatial scale, it is important that fluorometers are used to select depths for sampling. Selecting the horizontal position for profiles and discrete samples will allow chemical fingerprinting, using mass spectrometers and 3D fluorometery, droplet size analysis and oxidation and fractionation rate estimates. These are essential to discriminate sources and modeling the fate of the oil.

A second recommended approach was the deployment of a "smart" autonomous underwater vehicle (AUV) to collect *in situ* measurements in the water column to better determine the extent and nature of the spill. This AUV should be equipped with a) a fluorometer capable of multiple excitations and wavelengths to determine chemical compositions; b) a standard conductivity-temperature-depth (CTD) sensor package; c) a water sampling manifold capable of collecting oil samples and that minimizes sample contamination from the water column (traditional Niskin bottles are not recommended sampling tools because of sample contamination concerns); d) a mass spectrometer; and e) an acoustic scattering sensor for density measurements, such as an ADCP. One participant stated that all of these tools can be readily available within about one month and need to be optimized with field testing. The "smart" AUV would be programmed to follow oil layers within the water column and collect appropriate samples during its dives.

Instrumentation mounted on commercial vessels (e.g., cargo ships) was also suggested to provide additional data concerning the extent of the spill. Researchers in Bermuda are employing cargo vessels traveling between Bermuda and Jacksonville to collect real time measurements of hydrocarbons to anticipate the arrival of the oil along this transect.

Exploring new avenues of research to identify the use of tracers, including chemical compounds and biomarkers to track oil in the water column was another priority. In the aftermath of other major spills, chemical tracers such as sulfur hexafluoride (SF6), rhodamine dye, and microspheres were employed to track the spill's extent and fate.

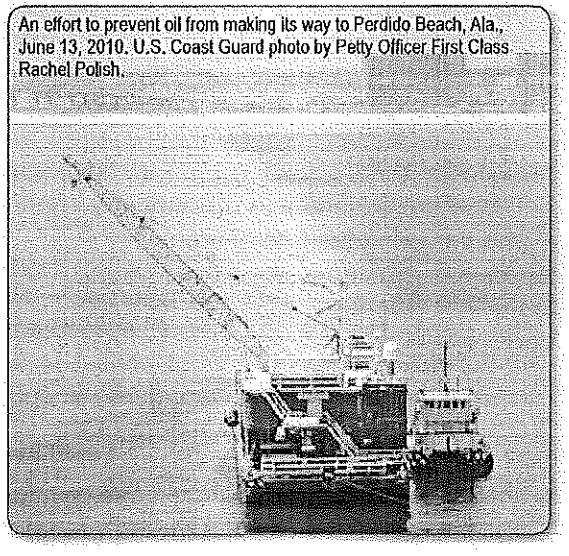
The results of those programs and the efficacy of the markers need to become part of the knowledge base for the *Deepwater Horizon* oil spill. It is recommended that the U.S. invest in research into biomarkers (e.g., are there certain organisms that preferentially absorb the oil?) as an additional environmentally-neutral tracer for this work. The group also suggested that we explore differences in heat capacity of oil at the surface as compared to surrounding seawater which may help determine the thickness of oil at the surface.

Workshop participants also suggested a variety of remote sensing tools to help track the oil, including active utilization of the current constellation of satellite sensors and the accelerated development of U.S. satellites equipped with sensors to detect oil at high spatial and spectral resolution. Currently, the U.S. does not have a system of satellite sensors with the capability of sustained, high frequency and high spatial resolution (< 0.5 km) observations of coastal processes. An extended suite of satellite sensors in both polar and geostationary orbits would provide complementary high spatial and spectral resolution as well as high temporal resolution observations with bands in the visible, near-infrared (IR) and short-wave IR wavelengths to improve the quantification of the extent of oil at the surface. The group also recommended that the U.S. acquire its own civilian Synthetic Aperture Radar (SAR)-capable satellite system with bands capable of detecting oil. Currently, the U.S. does not own such a tool and researchers rely on the use of SAR data collected by international colleagues. SAR is an effective tool in the arsenal of techniques for determining the extent of oil at the surface. Finally, it was recognized that new remote sensing technology and algorithms should be developed to determine the thickness of oil at the surface. Currently, capabilities for remote determination of oil thickness are very limited.

Considering that volatile organic compounds pose considerable health threats through inhalation, the need to observe the distribution of chemicals in the lower atmosphere received considerable discussion. There was clear support for more extensive deployment of air chemistry instruments, especially in areas where clean-up is underway, and at coastal areas where oil has come ashore. It was noted that passive samplers are available that could be dispersed more broadly and that federal aircraft (P3) are available for near-surface profiling.

There was widespread agreement on the need for a comprehensive ocean observing system for the Gulf of Mexico, including a rigorous data management infrastructure that would be integrated across communities and includes a grid repository and ensemble models that synthesize current or yet-to-be-developed ocean, coastline, hurricane and ecological models. The workgroup was very supportive of the HF RADAR observation system, which has major gaps in the Gulf.

The breakout group also noted that future grants and cooperative agreements ought to require a written plan for long-term data management that adheres to a standard protocol. Both the magnitude and fate and tracking breakout groups agreed that it is imperative to create a central database for



An effort to prevent oil from making its way to Perdido Beach, Ala., June 13, 2010. U.S. Coast Guard photo by Petty Officer First Class Rachel Polish.

collecting, storing, and sharing all data and meta information that is being collected by researchers, industry, and federal agencies working in the site of the spill. The preservation of these data should be enforced by a federal agency. They recommended that at a minimum, there needs to be a clearinghouse of information about observation and modeling activities. A central, publicly-accessible description of "who is doing what, where, an when" would be useful in the immediate aftermath of the spill to improve communication about spill research and mitigation. This information should also be used to more quickly leverage facilities and plan the use of existing tools (e.g., ships, autonomous underwater vehicles, etc.) to better coordinate data collection across academia and federal agencies.

EVALUATING THE ECOLOGICAL AND HUMAN EFFECTS

The volumes of oil, dispersant, gas hydrates and drilling fluid released from this incident have had significant environmental and economic impacts and will have destructive effects on the Gulf region for several decades. Consequently, the impact of the oil on ecological, sociological, and economic systems was of concern to the Symposium participants. While the bulk of the scientific expertise at the Symposium was comprised of ocean scientists, there were also social scientists who were concerned with the impact of the oil spill on local communities. Both groups of experts agreed that there is a critical need to develop infrastructure to create linkages between basic and applied researchers and social scientists to develop a broader understanding of the oil spill.

Two major themes persisted throughout the discussion. First was the lack of baseline data – both ecological and socio-economic. However, there have been many datasets that have been collected along the northern Gulf of Mexico after the hurricanes of 2005 and 2008, including those from the NOAA Mussel Watch program, the EPA Environmental Monitoring and Assessment Program, the USGS National Wetlands Center and the Louisiana Department of Natural Resources coastal restoration program. There is less data on the coastal ocean, but the NOAA Center for Sponsored Coastal Ocean Research (CSCOR) program and Northern Gulf of Mexico Institute have conducted many studies and the Minerals Management Service has conducted many surveys of the northern continental shelf and the deeper waters of the adjacent slope and rise. These data and syntheses are available through their Environmental Studies Reports and more recently as data submitted to the National Oceanographic Data Center (NODC). The socio-economic data are the least complete, but several available studies that resulted from post-hurricane conditions as part of the NOAA Coastal Research through Enhanced Science and Technology (CREST) program are accessible. Ultimately, the lack of baseline data may be a perception problem, where the underlying issue is the need to better identify and provide access to existing coastal and ocean data, which would facilitate the process of identifying and filling gaps.

The second major theme was the problem of risk assessment and communication. The public wants to know about threats to their health, the well-being of responders, how the environment will be affected, the safety of seafood, and the impacts on their jobs. The lack of information about the subsurface location and the composition of the oil and the dispersants hinders the ability to forecast ecological and human effects. From a toxicological perspective, it will be very difficult to make dose-response correlations because there is inadequate information to model the dose.

Beyond the need for information about the fate and transport of the oil (addressed

above) as it relates to environmental and human research, participants identified the lack of information about the toxicity of the drilling mud, the dispersants, the oil and combinations of these constituents. Without this information, it will be exceedingly difficult to understand and predict impacts on the environment and human health, which is important for those affected by this event and for improving policy for mitigating future scenarios. There is also a significant lack of information about the coupled and cascading ecological effects of the oil on ecosystems and local commerce. For instance, there is little known about the impact of oil and its degradation products on populations and community structures at multiple trophic levels from microbes to marine mammals. In terms of human behavior, there is very little known about the resiliency of human communities, so there is a huge information gap on the attitudes, behaviors and well-being of coastal residents responding to multiple stressful incidents. A final information gap identified by the participants involves the unintended consequences of damage containment, cleanup methods, and mitigation and restoration activities.

RESEARCH PRIORITIES

All participants identified the need for databases available to researchers and acknowledged the need for rapid analysis of samples. The group identified the need for long-term follow up of habitat and human effects, as the impacts of the spill are expected to last several decades. While a consensus was not reached on priority species to be studied, the group did agree that it was essential to investigate at the ecosystem-level and identify existing sentinel habitat sites and create new sites to provide for a wide array of ecosystems to monitor and compare effects and response. They also identified the need for molecular markers of exposure and endocrine disruption – which could affect immuno-, neuro- and reproductive pathways in animals and humans. Furthermore, risk assessments of marine species and human health are critical and the group noted that research on commercial species will yield both environmental and socioeconomic information. The group also highlighted the need to research the fate and effects of excess carbon and dispersants on benthic communities, which will be uniquely affected by this spill given their location on the sea floor. Ecological and psychological tipping points were other areas where there is limited data and which this information would be critical for policy makers. The need for studying future negative impacts to the system which are expected to occur when tropical storms re-suspend and redistribute toxicants along the seafloor and throughout the water columns was also considered important.

The group indicated that a top research priority was a catalog of existing research activities and long-term monitoring and modeling programs for ecosystems, human health and other socioeconomic factors. The lack of information about existing activities could likely result in an unnecessary duplication of effort, so there is a critical need for an inventory of baseline data as well as efforts to fill gaps in data sets. The need to establish and follow standardized sample collection and research protocols to ensure scientific integrity was also highlighted. The lack of ship time and vessel coordination was cited by several participants, particularly those from smaller institutions who felt they didn't have adequate access to vessels. Finally, there was strong encouragement for the development of expedited federal funding mechanisms for rapid responses to research and monitoring by the external research community. The group noted that to date, NSF's RAPID grants appeared to be the only mechanism currently available.

Call to Action

We are still in the midst of an emergency response and the pressures of the crisis are making it increasingly difficult to effectively coordinate multiple layers of activity, keep all parties and the public informed, and determine effective courses of action. Yet despite this difficult environment, it is incumbent upon the entire scientific community to work together to answer the immediate questions of concern to the public, put in place the necessary science plans to meet near- and long-term information needs, and develop the technology necessary to prevent future tragedies.

Ocean Leadership intends to follow up on this Symposium with a series of focused scientific workshops to further investigate the issues and priorities described above including ocean observations and models, effects on ecosystems, and human impacts including public health and socioeconomic factors.

Represented Organizations

Applied Marine Sciences Inc.
Battelle Memorial Institute
Bermuda Institute of Ocean Sciences
Bigelow Laboratory for Ocean Sciences
BP
CeNCOOS/MBARI
City College of New York
COAS/Oregon State University
Coast Guard Research & Development Center
Consortium for Ocean Leadership
Coastal Restoration and Enhancement Science and Technology
Department of Commerce
DoI Strategic Sciences Working Group
Ducks Unlimited
Ecology & Environment Inc.
Environmental Protection Agency
Florida A&M University - ECSC
Florida International University
Georgia Institute of Technology
Gulf Coast Research Laboratory
Harbor Branch Oceanographic Institution
Jackson State University
Johns Hopkins University - APL
Lamar University
Lamont-Doherty Earth Observatory
LDNR/Office of Coastal Management
Lower Mississippi Valley Joint Venture
Louisiana Sea Grant Law & Policy Program
Louisiana Sea Grant
Louisiana State University
Louisiana Universities Marine Consortium
LSU Center for GeoInformatics
LSU Health Sciences Center
Marine Biological Laboratory
MBARI
Minerals Management Service
Mississippi-Alabama Sea Grant Consortium
MMS Advisory OCS Scientific Committee
Mote Marine Laboratory
Museum of Natural Science, LSU
Mystic Aquarium
National Federation of Regional Associations
National Audubon Society
National Science Foundation
National Wildlife Federation
Naval Meteorology & Oceanography Command
Naval Oceanographic Office
Naval Research Laboratory
National Institute of Environmental Health Sciences, NIH
NIUST University of Mississippi
NOAA
NOAA OAR
NOAA/IOOS
NOAA-CREST Center
Northern Gulf Institute
Oberlin College
Ocean Conservancy
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Science and Engineering Alliance
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