Oil Spill Research and Development

Chairman Oberstar, Ranking Member Mica, and distinguished members of the Transportation and Infrastructure Committee, thank you for the opportunity to appear before you today on behalf of the University of New Hampshire and the Coastal Response Research Center.

Despite the significant advances in spill response made since the 1989 Exxon Valdez spill in Alaska, there are still significant gaps in knowledge about many aspects of oil spill response and restoration. Significant knowledge gaps exist with respect to the long-term fate and behavior and three dimensional (3D) predictive modeling of oil, especially if it is dispersed, submerged or emulsified. This lack of knowledge limits our ability to respond efficiently to spills, and increases the risk of damage to natural resources and the environment.

It is well documented that throughout history, accidents and failures lead to significant changes in engineering design and public policy (Petroski, 1992 and 2008). The 11 million gallon Exxon Valdez oil spill is no exception. It resulted in some of the toughest requirements and restrictions aimed at reducing the frequency and impact of future oil releases (e.g., double hull requirements for all tankers entering U.S. waters). The U.S. congress passed the landmark Oil Pollution Act of 1990 (OPA 90) in direct response to the Exxon Valdez incident. This legislation fundamentally changed oil spill prevention, preparedness, response and restoration in the United States. The requirements set forth by OPA 90 are divided into five categories: (1) Prevention; (2) Preparedness; (3) Response; (4) Liability and Compensation; and (5) Research and Development (R&D). The Minerals Management Services (MMS), U.S. Coast Guard (USCG), and the National Oceanic and Atmospheric Administration (NOAA) were designated as the three key federal agencies responsible for overseeing and conducting R&D associated with preventing and responding to oil spills, and the restoration of damaged natural resources as a result of spills. These three agencies have different R&D initiatives, each focusing on different aspects of the requirements under OPA 90.

MMS developed the Technology Assessment and Research Program (TA&R) to ensure that oil and gas exploration and production operations on the Outer Continental Shelf incorporated the use of the Best Available and Safest Technologies (BAST). This
program has two categories of research activities which fall under prevention, preparedness and response: Operational Safety and Engineering Research, and Oil Spill Response Research. The Technology Assessment and Research Program, within MMS, conducts R&D on all operations associated with offshore drilling. Some examples of R&D initiatives investigating prevention include blowout preventer procedures, deepwater drilling, deepwater structure assessment, strumming of risers and subsea inspection. Response and cleanup R&D initiatives within TA&R include remote sensing and detection, physical and chemical properties of crude oil, mechanical containment and recovery, chemical treating agents and dispersants, and *in situ* burning.

Funding for MMS’s R&D program is provided through the Oil Spill Liability Trust Fund (OSLTF) tax on imported and domestic oil, as stipulated in OPA 90. While MMS studies prevention of oil spills from a drilling, deepwater, and pipeline perspective, USCG looks at vessel design, regulations and operations. For example, by 2015 all tank vessels must be double hulled. The USCG is the lead for all tactical operations during oil spill response; therefore their R&D initiatives have included improving Area Contingency Plans, resource allocation (e.g., boom, vessels, aircraft), oil spill drills and exercises, and response and cleanup tactics (e.g., dispersant efficacy and application, skimming technology).

The Office of Response and Restoration (OR&R) within NOAA oversees scientific activities associated with oil spills. There are two divisions within OR&R, Emergency Response Division (ERD) and Assessment and Restoration Division (ARD). ERD focuses on spill response and cleanup R&D, while ARD focuses on natural resource damage assessment (NRDA) and restoration R&D. OR&R focuses on the fate, behavior and effects of oil in the environment. Some examples of specific studies include: Dispersant toxicity, biodegradation of oil in marshes and other sensitive habitats, impacts to fisheries, characteristics of submerged oil, and human dimensions relating to oil spills. OPA90 does not authorize R&D funding for NOAA, and all research must be funded by specific congressional appropriations.

The three major roadblocks that impede progress on oil spill research needs are: (1) lack of funding from the federal government and/or industry; (2) Insufficient agency and stakeholder cooperation from the oil spill community; and (3) lack of robust peer-review requirements for oil spill research.

In response to these roadblocks, The Coastal Response Research Center (CRRC) (http://www.crrc.unh.edu), a partnership between NOAA OR&R and the University of New Hampshire, was formed in 2004 to address the need for improved spill response and restoration. The center oversees and conducts independent research, hosts workshops, and leads working groups that address gaps in oil spill research in order to improve response, speed environmental recovery, and reduce the societal consequences of spills. Created by a memorandum of agreement between the University of New Hampshire and NOAA in 2004, CRRC acts as an independent, non-partisan entity to bring together members of the oil spill community, as well as those in relevant fields outside the spill community, including local stakeholders, and state, federal and international agencies to
address the many technical, economic, social, and environmental issues associated with oil spills in marine environments.

The Center is served by a multi-agency Advisory Board, comprised of members from U.S. EPA, NOAA, USCG, state-based R&D programs, and industry, that provides guidance on program direction. The board, in conjunction with the UNH and NOAA co-directors, developed five objectives for CRRC: (1) funding and oversight of relevant, peer-reviewed research that is able to be developed into practical improvements in oil spill response; (2) hosting topical workshops and working groups that include representatives of all spill community stakeholders to focus research efforts, and ensure that crucial real-world experience from oil spill practitioners is considered; (3) educating the next generation of spill responders through outreach and support of undergraduate and graduate student projects; (4) involving members of the international oil spill community to tap into expertise from around the world; and (5) developing response tools to aid responders.

Funding of relevant, peer-reviewed research is accomplished through a periodic request for proposal (RFP) process. Proposals are reviewed by three to four experts in the area of the proposed research. They are ranked by their scientific validity and how well they address key research needs related to the fate, behavior and effects of oil in the environment, and are likely to lead to practical improvements in oil spill response and restoration. A panel of leading scientists and practitioners then review the peer-reviewed and ranked proposals and recommend which should be funded. Each funded research project is assigned a NOAA liaison to ensure the research can be transformed into practice, and in addition, the CRRC’s Science Advisory Panel meets annually to review progress of the research and provide feedback to improve the quality and efficacy of the research.

Since its inception in 2004, CRRC has hosted over 20 workshops on a wide variety of topics across the spectrum of oil spill R&D needs, and led working groups on: Oil Dispersants; Modeling of oil in the environment; submerged oil; toxicity of oil; and ephemeral data needs. The workshops (Table 1) have identified deficiencies in response and restoration, while the working groups (Table 2) help coordinate which agency funds specific R&D projects to avoid duplication of effort.

CRRC has provided funding for four masters students and two Ph.D. students who have conducted research topics as diverse as movement of submerged oil, human dimensions of oil spills, and biodegradation potential of oil in Arctic environments. CRRC has also helped to educate numerous undergraduate students who participated in workshops as recorders, and assisted with graduate student research projects.
Despite the large volume of oil spill research conducted internationally, there has been a reluctance to incorporate this information in U.S. spill response. CRRC, as an independent academic institute, has brought together spill responders and researchers from the U.S., Canada, Norway, Russia, Finland, Sweden, and Denmark and other countries to discuss oil spill response issues, and has funded several proposals that include international research partners.

In keeping with its mission to ensure that research is transformed into practice, CRRC has created several spill response tools that are in use today, including the Environmental Response Management Application (ERMA®), the Oil Spill Toxicity Field Guide, and the link between Clarkson Deepwater Oil and Gas Blowout Model (CDOG) and NOAA’s GNOME model. These response tools were created to address deficiencies identified at CRRC workshops, and are currently being used in the response to the Deepwater Horizon incident in the Gulf of Mexico.

Long term fate and effects of dispersed oil, submerged oil, and accurate 3D predictive modeling of spills are three areas consistently identified by practitioners that
are in need of additional research, especially because they are issues at the heart of the Deepwater Horizon spill. With the unprecedented use of dispersants (590,000+ gallons as of May 18th, 2010) and the discovery of a 10 mile long submerged oil plume, these issues are key to the response to the Deepwater Horizon incident in the Gulf of Mexico.

**Long Term Fate and Effects of Dispersants and Dispersed Oil**

The Gulf of Mexico Contingency Plan allows dispersant use, without preauthorization, a minimum distance of 3 nautical miles from the shore and a water depth of at least 33 feet. As of May 18th, 2010 an unprecedented 590,000 gallons of chemical dispersant have been applied to the oil on the surface of the Gulf. Responders are also experimenting with injecting dispersants into the oil as it is being released from the damaged riser pipe ~5,000 feet below the surface. Beginning on May 3rd, a series of trial injections began and 3,000 gallons of dispersant were injected into the oil plume at a depth of approximately 5,000 feet. Visual observations indicate this was successful in reducing the volume of oil reaching the surface. US EPA and USCG recently approved the use of dispersants in the subsurface by the damaged riser pipe. The Deepwater Horizon blowout marks the largest volume of dispersants ever used, domestically and internationally. [N.B., 124,000 gallons of dispersant were used in the waters off the coast of Wales during the *Sea Empress* accident in 1996, making it the 2nd highest volume used]. While dispersants have proven to be successful at reducing oiling of shorelines, numerous questions remain regarding the fate of the dispersed oil and the chemical dispersant. Application of dispersants at this depth is unprecedented, and the fate and potential effects have never been investigated.

A large body of literature exists on dispersants dating back to the late 1960s. In 2008, as part of a CRRC-led Dispersants Working Group, the Louisiana University’s Marine Consortium (LUMCON) created a complete bibliography of the dispersant literature. This bibliography contains hundreds of references, however, it is significant to note the majority of them were not in peer-reviewed sources. More recently, peer-reviewed research has determined that the impacts of dispersed oil and dispersants on marine organisms a function of: (1) The length of exposure (most experiments are short duration, one time laboratory tests; (2) the life stage of the organism; (3) the type of oil; and (4) the degree of weathering of the oil and the *in situ* conditions (e.g., temperature).

When chemical dispersants are applied to oil slicks, the immediate goal is to disperse the oil into the water column. The dispersant molecules reduce the oil-water interfacial tension, and allow oil droplets to break away from slicks or sheens and move into the water. In order for dispersants to be effective, the water must be turbulent. The mixing energy provided by waves allows the oil droplets to break into a smaller size. Katz (2009) used holographic imagery to show how this occurs (Figure 1). The stretching of the droplet into a curved “dumbbell” shape is caused by turbulence and the lowered interfacial tension of the oil due to the dispersant. It is important to note that the end product is two or more droplets smaller than the original. This process generates a size distribution of droplets which is a function of the degree of turbulence, and the type and amount of dispersant applied.
Dispersants are typically applied at a dispersant-to-oil ratio between 1:10 and 1:60, and require a significant amount of mixing energy, supplied in large spills by wave energy, in order to be successful (Lee et al., 2009). Dispersants are not 100% effective because of a variety of biological, chemical and physical factors; the most common of which is inadequate wave and/or current energy. Low dispersion efficiency not only results in wasted effort and money, but can also leave significant amounts of dispersant and bulk oil in the environment.

Droplet size is a major factor dictating the fate of the dispersed oil. For example, if a dispersant is added at depth, larger droplets are more buoyant and will rise to the upper layers of the water faster than smaller droplets. Assuming the droplet size distribution reported in Lee et al., (2009), the time for droplets to rise from 5,000 feet (i.e., depth of Deepwater Horizon blowout) to the surface will range from 3,400 years to 1 – 2 days, and will be a function of droplet size. Other factors affecting the oil’s fate include: current direction and velocity, wind and wave direction and magnitude, and ambient water conditions (e.g., temperature, salinity). The National Oil Spill Response and Renewable Energy Facility (Ohmsett), operated by Minerals Management Services (MMS), in Leonardo, NJ, has conducted numerous studies in its wave tank on the application of dispersants.

Little is known about the long-term fate of dispersed oil. The National Research Council (NRC) published two studies in 1989 and 2005 reviewing the state of dispersant use and knowledge in the United States. Both reports indicated there was a lack of understanding on the fate and potential impacts of large quantities of dispersed oil. CRRC
established a Dispersant Working Group (DWG) in 2005 in response to the NRC’s recommendation for more robust and relevant dispersants research. The goal of this working group is to facilitate an integrated approach to dispersant research and coordinate funding among the DWG members. In February 2007, the CRRC hosted a Dispersants Forum to present the results of research funded by DWG members. DWG funded research has continued since then and addressed more gaps in our knowledge of dispersed oil and dispersants.

The ultimate goal of dispersants is to dilute the oil to an extent that it represents a low risk to the environment. This is accomplished through dispersing oil droplets into the water column, where they enter the mixed layer (ML) and disperse via currents and natural diffusion. Dispersants do not decrease the quantity of oil; they force dilution of the oil droplets into a large volume of water. Once dispersed, these oil droplets can have many potential fates including: sedimentation; dissolution; biodegradation; re-coalescence; and uptake by biota, either through ingestion or absorption (i.e., via direct contact on membranes or body surfaces) (Figure 2).

Sedimentation, where the oil becomes denser than the water and sinks to the bottom, is most likely to happen if the oil droplets adsorb (adhere) to suspended particulates such as sand, silt or clay. Adsorption is a physical process by which oil droplets attach to particulates.

Dissolution occurs when one or more of the many compounds in oil become dissolved into the ambient water. The solubility of the oil constituents in water varies greatly and can range from insoluble to concentrations in milligrams per liter. Temperature and pressure play a significant role in the amount and extent of dissolution that occurs.

Biodegradation is often cited as the most likely fate of dispersed oil, however, little research has been done on the likelihood of this scenario. Biodegradation, while potentially able to completely degrade the oil, is a complex and often misunderstood process. The majority of the studies that have examined biodegradation of dispersed oil have focused on droplets in the mixed layer, and found that biodegradation was often incomplete (i.e., some compounds remained), and significant degradation took weeks to months to occur (Harayama, 2004; Stewart et al., 1993; Lindstrom et al., 1999). No research has been done on the potential for biodegradation of dispersed oil at depths approaching those of the Deepwater Horizon, and the high pressures and different microbial communities at this depth may severely restrict or prevent any biodegradation from occurring. The surface area to volume ratio of the oil droplets will likely be key to successful biodegradation, as a large surface to volume ratio (i.e., smaller droplets) allows bacteria better access to the oil. Microbial biodegradation can also strip oxygen from the water, creating zones where many organisms cannot survive. When oxygen is no longer available, some microbes can use sulfate or carbonate from seawater to degrade the oil, releasing hydrogen sulfide or methane.
While unlikely if adequate dispersion occurs, the oil droplets may re-coalesce, increasing droplet size and possibly forming a slick. Re-coalescence can only occur if two or more oil droplets come into contact, and the dispersant has degraded and is no longer effective. While in the mixed layer this is unlikely due to relatively rapid biodegradation and dispersion, the uncertainty of the fate of dispersed oil in deeper water makes re-coalescence a possibility.

Many marine biota, including copepods, shrimp, and oysters, feed on microplankton and other very small organisms that are similar in size to some dispersed oil droplets (0.1 to 1 mm), and it is possible that these organisms may consume smaller dispersed oil droplets (Gyllenberg, 1981; Andrews and Floodgate, 1974). These smaller organisms are the foundation of the marine food web, and reduced body weight, population, or mortality may occur. In addition, the oil can bioaccumulate, impacting larger species, including commercially important species such as shellfish, tuna, and shrimp.

Many organisms in aquatic environments transfer dissolved gasses via special organs (i.e., gills) that can lead to increased exposure to dissolved chemicals through absorption (Barnett and Toews, 1978). While difficult to quantify, the large surface area to volume ratio of oil droplets will result in rapid dissolution of soluble chemicals, and potential exposure to biota.
The toxicity of oil is not well understood for many organisms because of its chemical variability and the lack of robust analytical methods, especially for off-shore organisms. Direct pathways of dispersed oil to marine organisms include: respiration, dermal contact, and ingestion. Oil can have chronic and acute effects on biota. Acute effects are typically indicated by mortality. Chronic effects are more difficult to monitor and include: reduced fecundity, smaller size, shorter lifespan, and decreased diversity.

These potential chronic and indirect effects can have significant implications for biological communities and at the ecological level (Figure 3). If the population of an economically significant species, such as shrimp, is impaired, it can have serious socio-economic consequences. This must be a consideration when prioritizing research on dispersant use.

![Figure 3: Potential biological effects of dispersed oil.](image)

The major gaps in dispersant knowledge arise in the link between the fate of dispersed oil and the biological endpoints. The key question that remains unanswered is: What is the most likely fate of the dispersed oil and dispersant in the marine environment? In 2009, CRRC held an R&D needs workshop that brought together members of the oil spill community and stakeholders to identify the top research needs to enhance spill response. Not surprisingly, understanding long-term fate of chemically dispersed oil was a top research priority. The Deepwater Horizon incident response has used significantly more dispersants than any other spill in U.S. history. The endpoint and effects from this huge quantity of dispersed oil cannot be confidently predicted because of lack of understanding of the potential pathways and effects. Additional peer-reviewed
research is needed to gain a better understanding of the ultimate fate of dispersed oil in the Deepwater Horizon blowout.

Long Term Fate and Effects of Submerged Oil

With increased reliance on heavier crude oils and refined products to fill the current energy demands, the likelihood of spills involving subsurface oil is on the rise. Submerged (non-floating) oil provides unique incident response challenges for detection, tracking, remobilization, fate and behavior modeling, containment and recovery. A 1999 National Research Council report for the U.S. Coast Guard “Spills of Non-floating Oils: Risk and Response” provided a list of research needs relevant to subsurface oil spills. Factors as simple as the salinity of the water will impact whether a given type of oil will sink or float. Strong currents in the water can keep heavier oil submerged whereas weaker currents will allow it to settle. Even if the oil sinks to the bottom, it may become re-suspended if the bottom current energy becomes strong enough. Submerged oil has been observed at a range of depths in the Gulf of Mexico in and around the Deepwater Horizon spill site.

Unfortunately, little advancement has been made in addressing these needs. Two recent oil spills resulting in submerged oil include: the 2004 Athos I accident in the Delaware River (submerged oil resulting from mixing of crude oil leaking out of the bottom of the ship and mixing with bottom sediment) and the 2005 DBL152 barge accident releasing a sinking heavy fuel in Texas coastal waters. These incidents raised awareness of the lack of knowledge and experience with detection, tracking, response, and restoration of submerged oil spills. In December 2006, CRRC hosted a workshop entitled, “Submerged Oil – State of the Practice” to delineate a set of research needs and study plans for possible funding for submerged oil. Topics of discussion included detecting and monitoring submerged oil, fate and transport, containment and recovery including protection of water intakes, and biological effects and restoration.

Subsequent to the workshop, a Submerged Oil Working Group (SOWG) was formed consisting of stakeholders from federal and state agencies, industry, NGO’s, international research agencies, and responder organizations. The CRRC-sponsored SOWG has coordinated research funding efforts, with the largest expenditure of research dollars by the U.S. Coast Guard (2008) focused on submerged oil detection. CRRC has funded two projects on submerged oil bioavailability and predicting where and how it moves. A workshop in October 2009 targeted liquid asphalt releases and the enormous amount of unanswered questions also associated with this product.

Modeling of Spills

One of the most important components of an oil spill response is the modeling that occurs to predict the fate and behavior of the oil, as well as the risks it poses to individual resources and the ecosystem. At the root of all spill models is a set of algorithms, step-by-step mathematical equations predicting how the oil will behave and.
affect natural resources. At its simplest, oil spill models are loaded with data about the spill scenario (e.g., release and type of oil) and environmental conditions (e.g., weather, bathymetry, habitat and species distributions). These data are then used in sub-models that address the physical transport of the oil, the physical fate of the oil, and the impact of specific response methods being used to cleanup the spill (Figure 4). The interactions among these sub-models result in a model that predicts the oil’s trajectory (where the oil will go); (Figure 5) and ideally the concentrations of individual compounds in the environment (e.g., phenanthrene). These estimates can then be used in biological effects models to predict impacts on natural resources (e.g., number of shrimp killed, loss of biomass, decrease in productivity).

Figure 4: Spill model data (McCay et al., 2009).
There are no comprehensive oil spill models that have algorithms to address the full spectrum of inputs and outputs required (Figure 6), especially because the amount of input data has greatly increased with the advent of NOAA’s Integrated Ocean Observing Systems (IOOS).

Further complicating the modeling is the reality that few oil spills behave two dimensionally (2D), and float exclusively on the surface of the water. More commonly, as in the Deepwater Horizon incident, the oil: (1) mixes into the water below the slick; (2) interacts with suspended sediment which causes it so submerge; and (3) dissolves into the water (i.e., particularly the lighter compounds in the oil). Only a few oil spill models are three-dimensional (3D) so that they can predict the mixing of the oil not only horizontally but also down into the water column.

In September 2006, CRRC and NOAA hosted a workshop entitled “Innovative Coastal Modeling for Decision Support: Integrating Physical, Biological and Toxicological Models.” The workshop brought together experts from diverse fields with NOAA OR&R scientists and oil spill responders, to discuss how to improve and integrate fate and effects modeling capabilities. Discussions centered on predicting risk, forecasting environmental effects, integrating transport models with environmental and toxicological data, communicating complex modeling to decision makers, and developing response time scale estimates that reflect uncertainties in the predictions and are useful to decision makers. The latter part is very important because complex models that require very long run times to obtain answers and require data not available during a spill response are not practical. The direct result of the 2006 workshop was a June 2007 CRRC summit of the leading oil spill modelers from around the world to discuss the state-of-the-art spill modeling, future oil spill models, and research questions that needed to be addressed to build future models.
The research needs identified included developing algorithms for: (1) vertical and horizontal dispersion coefficients; (2) drift and mixed layer impacts, and oil-sediment interactions as well as emulsification; (2) short and long-term toxicity impacts from oil and chemically-dispersed oil; (4) avoidance and attraction of birds; (5) uncertainty protocols for monitoring during spills to provide real-time reports to models; and (6) visualization tools to communicate 3D concentrations and uncertainties to decision makers and the public. Other needs included methods to seamlessly integrate IOOS data into the models and algorithms to address interactions of spills with shorelines.
The direct result of the summit was a commitment between the major spill modelers representing NOAA, industry, the private sector and spill responders to form a modeling working group (MWG) under the aegis of CRRC. The MWG brings modelers together to discuss common algorithms, state-of-the-art models, and ways to improve oil spill response modeling. The MWG does not write computer code, but rather is working within four subgroups: Physical Transport Modeling, Physical Fate and Behavior, Spill Response, and Biological Effects. The goal of the MWG is to develop a conceptual outline of the potential algorithms for the next generation of 3D spill models and to identify specific research needed to improve existing models. The MWG has made excellent progress, but has been hampered by the fact that there is not funding to support the work done by its members. This “volunteer” approach means that for most members, R&D must be done during their free time. To move this effort forward, support for participants is essential. In addition, funding for students to do literature searches and obtain the relevant peer-reviewed literature from related fields (e.g., physical oceanography, toxicology) is essential as the MWG members do not have time to do this.

Impacts of the Deepwater Horizon Spill on Natural Resources

The overarching goal of any oil spill response is to protect natural resources, protect flora and fauna, and to minimize damage to habitats and the human activities associated with them. In fact, oil spills far offshore usually only consist of search and rescue operations because the damage to natural resources and habitats is considered to be minimal, and extensive cleanup is considered impractical. The Deepwater Horizon oil spill is just the opposite; It is located in a productive region of the Gulf of Mexico with major shrimp, crab, oyster and pelagic fisheries, and contains up to 40% of the most important and productive salt marshes in the United States. All of this is further magnified by the number of important bird nesting habitats and recreational beaches along the eastern Gulf. Clearly, the impacts of the Deepwater Horizon oil spill could have devastating impacts on natural resources.

When oil began appearing on the surface after the Deepwater Horizon blowout, many experts predicted that oil reaching the salt marshes and beaches would create an environmental disaster of unprecedented proportion. The goal of the response became keeping the oil off the shoreline and out of the marshes. This was accomplished on the surface through the use of skimmers, \textit{in situ} burning, and protective booming of shorelines when fairly calm conditions prevailed. However, when winds and storms created waves and currents preventing booming, skimming and burning, the method of choice became application of chemical dispersants. With more than 590,000 gallons delivered by aircraft and now with approved injection at 5,000 feet, the oil is not reaching shorelines, but is submerged in the water. The concerted effort by responders to prevent oil from reaching the marshes and beaches has to date prevented some of the images many associate with the \textit{Exxon Valdez}, including oiled birds, sea otters, as well as blackened shorelines and huge floating oil slicks. Questions abound as to whether the worst is yet to come, and if there will there be long term effects of dispersing millions of gallons of oil, and if so, how fast will the natural resources rebound.
Unfortunately, I do not believe that anyone knows the answers to these questions. As data is collected by scientists to determine the amount of oil contamination in the water at various depths, we can begin to predict what the potential impacts may be. The basic risk equation is: Chemical Exposure $\rightarrow$ Toxicological Response. Exposure is a function of the rate of uptake by the organism, the concentration of the contaminant, the duration of the exposure, and the bioavailability, absorption and metabolic reaction related to the contaminant. The toxicity can be acute (lethal) or chronic (affecting growth, reproduction, behavior or population level parameters).

There have been scientific studies done that examine some constituents of oil and mimic certain environmental exposures, but there is a relatively limited database and some of it does not withstand the rigors of peer-review. None of it addresses the magnitude and extent of exposure that the Deepwater Horizon spill represents. Further compounding this is a lack of data and the incomplete knowledge of the deepwater ecosystem of the Gulf of Mexico. If we cannot answer the questions of exposure and the organisms present and their role in the ecosystem, nor the toxicological response, it is impossible at this time to predict recovery, or how to conduct adequate restoration. Only time and research will tell what the impacts to the natural resources will be and how long it will take for the Gulf to recover.

**Conclusions**

The Deepwater Horizon spill has again shown us that, when an oil spill occurs, we must be able to make difficult decisions, risk assessments and tradeoffs in a timely fashion to minimize the impact. Whether the spill involves floating, emulsified, dispersed and/or submerged oil, we must be able to make these decisions based on: (1) valid, detailed environmental information; (2) a fundamental understanding of the fate and behavior of the oil; (3) peer-reviewed data on the acute and chronic effects of the oil and response tools on individuals, populations, habitats and ecosystems; and (4) the best predictive oil spill models. My fear is that, as in the wake of the Exxon Valdez, the Deepwater Horizon spill will prompt a flurry of Federal authorizations of research activities, oversight committees, and even some increase in industrial research allocations, but that little actual federal funding will be appropriated for research needed to answer fundamental questions associated with response to and restoration of oil releases. We must take the lessons we have learned from this spill and apply them to ensure that, in the future, we have better tools to address such spills and minimize the impact.

To accomplish this, I recommend, first, that we not neglect the funding of fundamental scientific research. It is tempting to direct funds toward offshore drilling regulation, safety, operation, blowout prevention, and improved oil spill cleanup techniques, or even on the “nuts and bolts” engineering questions, such as how to improve the distribution of dispersants into a plume or better detect submerged oil. However, we must ensure that funding also is directed toward research that helps us
understand the fate, behavior and effects of emulsified, dispersed and submerged oil and create better 3D predictive spill models with well defined bounds of uncertainty and clear biological endpoints.

Second, we must fund scientific research that is peer-reviewed and transparent, and it should be carried out in consultation with responders to ensure that it fits their needs. Independent, academic research centers are the vehicles that can best serve as hubs for the oil spill community so that results will be respected by all stakeholders, since we know that studies carried out by industry or environmental NGOs will always be questioned by the other side. NOAA should be credited for seeing the importance of independent research around these issues when it formed its partnership with the University of New Hampshire that created the Coastal Response Research Center, an example of the type of independent, academic center needed to address these questions. Additional funding for such independent centers is essential.

Only by continuing to expand NOAA’s vision of making independent, science-based, oil spill response and restoration research a priority, will we have a better understanding of emulsified, dispersed and submerged oil and their fate, behavior and effects, and how and where to respond and restore the environment to minimize the damage when – not if – the next oil spill occurs.


Lee, K. Li1, Z. Venosa, A. Boufade, M. Miles, M. Wave Tank Studies on Dispersant Effectiveness as a Function of Energy Dissipation Rate and Particle Size Distribution. Final Report Submitted to the Coastal Response Research Center. Project Number: 06-085

