WRITTEN STATEMENT OF
Albert D. Venosa, Ph.D.
Director, Land Remediation and Pollution Control Division
National Risk Management Research Laboratory
Office of Research and Development (ORD)
U.S. Environmental Protection Agency (EPA)
Cincinnati, OH 45268

HEARING ON
Deluge of Oil Highlights Research and Technology Needs
for Effective Cleanup of Oil Spills

Before the

THE COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY AND THE ENVIRONMENT
U.S. HOUSE OF REPRESENTATIVES

June 9, 2010, 10:00 a.m.

Good morning. I am Dr. Albert D. Venosa, Director of the Environmental Protection Agency's (EPA) Land Remediation and Pollution Control Division in EPA's National Risk Management Research Laboratory, Cincinnati, Ohio. It is a pleasure to be here today to discuss EPA's oil spill research program.

For the past 21 years, I have led EPA's oil spill research and development program. The objective of this program is to conduct basic and applied research in both the laboratory and the field in the area of spill response technology development.

Section 7001 of the Oil Pollution Act of 1990 (33 USC 2761) established an Interagency Coordinating Committee on Oil Pollution Research (ICCOPR), chaired by the USCG, to coordinate a comprehensive program of oil pollution research and development among 13 federal agencies in cooperation and coordination with industry, academia, research institutions, state governments, and other nations. The ICCOPR was mandated to coordinate research and development in innovative oil pollution technology, oil pollution technology evaluation, oil pollution effects research, demonstration projects, simulated environmental testing, and a regional research program. This was accomplished effectively both in-house in each agency as well as through coordinated research grants to non-federal institutions mentioned above. The program has been successful, but much more still needs to be done to improve our response capabilities to national disasters such as the current Deepwater Horizon tragedy that has impacted the rich ecosystem of the Gulf of Mexico.

Why does oil spill research need to be continued?

The answer to this question has been made clear by the recent, devastating, and continuing oil spill in the Gulf of Mexico. Numerous questions have been raised on the effectiveness of dispersants, their inherent toxicity, the toxicity of dispersed oil, and how to deal with the shoreline and wetlands that are now being impacted as the spill moves to shore.

A 2006 study presented at the Freshwater Spills Symposium reported that, from 1980 to 2003, more than 280 million gallons of oil of all types (about 12 million gallons/year) were discharged to the inland waters of the U.S. or its adjoining shorelines in about 52,000 spill incidents. Little is known about the effect of spills of biodiesel, emerging biofuels, or by-products from their manufacture on watersheds. Waterborne transportation of oil in the U.S. continues to increase, and the volume of oil spilled from tank barges has remained constant at approximately 200,000 gallons spilled each year. EPA is also concerned about spills from pipelines and above ground storage tanks that could contaminate surface waters. These are the major sources of inland oil spills nationwide.

An oil discharge to the waters of the U.S. could affect drinking water supplies; sicken and/or kill fish, animals, and birds; foul beaches and recreational areas; and persist in the environment, harming sensitive ecosystems. Consequently, research is necessary not only to continue to find effective ways to mitigate and respond to petroleum spills but also to understand the potential adverse human health and ecological consequences of spills of alternative fuels and non-petroleum oils and to develop effective clean-up tools to mitigate these adverse consequences. Recent research on vegetable oils and biodiesel blends suggests that the biodegradability and environmental persistence of these oils is very complex[2]. Developing an understanding of the potential environmental impacts associated with spills of these oils requires fundamental research. Such fundamental research is critical in providing sound science to inform decision-making and field applications.

EPA's Role in Spill Response

The National Oil and Hazardous Substance Pollution Contingency Plan (NCP), which has been in effect for 41 years, established a successful oil spill response framework defining the roles of federal agencies. Under the NCP, the EPA or USCG provide federal On-Scene Coordinators (FOSCs) for the inland and coastal zones, respectively, to direct or oversee responses to oil spills. Other federal agencies with related authorities and expertise may be called upon to support the FOSC. At the national level, these federal agencies coordinate their activities through the National Response Team (NRT). The NRT is comprised of 15 federal departments and agencies and is chaired by EPA and vice-chaired by the USCG. The NRT coordinates emergency preparedness and response activities for oil and hazardous substance pollution incidents and provides federal resources, technical assistance, and policy guidance as defined in the NCP. The Science and Technology Committee, which is the NRT's science arm and of which I am a participating member, provides a forum for the NRT to fulfill its delegated responsibilities in research and development. Users of and sometimes collaborators in our research include multi-agency regional response teams, EPA's environmental response team, EPA and USCG FOSCs, and other government agencies such as NOAA, Fish and Wildlife Service, and states. Not only do these U.S. organizations rely significantly on EPA's research results, the international community does as well.

Past and Current Research

EPA's research includes development of practical solutions to mitigate spill impacts on freshwater and marine environments; development of remedial guidelines that address the environment, type of oil (petroleum and non-petroleum oils), and agents for remediation; and modeling fate and effects in the environment. Spill mitigation research includes bioremediation, chemical and physical countermeasures, and human and ecotoxicity effects. Fate and effects research focuses on modeling the transport of oil in a variety of settings with application to field situations.

The work described above has resulted in new protocols for testing the effectiveness of commercial oil spill treating agents; guidance documents[3] for implementing bioremediation in different environments such as wetlands, salt marshes, and sandy shorelines; a clearer understanding of the impact and persistence of non-petroleum oil spills in the environment (i.e., vegetable oils, animal fats, and biofuel blends); and development of new treatment approaches. Important on-going research is helping to understand oil persistence long after the initial spill incident, such as the Exxon Valdez oil that still lingers in certain areas of Prince William Sound, Alaska. We need to understand if the lingering oil still poses an environmental threat to the habitat and the resources at risk. If it does, we must learn why it still lingers and develop means to remove this lingering oil to safeguard the ecosystem.

Ten years ago, EPA began conducting research on non-petroleum oil such as vegetable oils and animal fats. This anticipatory research investment will be invaluable as the national emphasis on biofuels development takes hold because vegetable oils are the primary feedstocks for biodiesel production. Contrary to some claims, we have found that these oils are not readily biodegradable in the environment because of the complexity of chemical interactions among saturated and unsaturated fatty acids.

The Deepwater Horizon spill is raising questions about the inherent problems associated with current spill mitigation technologies. One approach to addressing these questions is to encourage such innovative approaches as green chemistry in the development of new, less toxic dispersants and other physical-chemical techniques for treating oil spills.

Future Research

Future research will necessarily involve some major refocusing of effort and coordination with other agencies that have leading roles in some of the following areas of research. Some key issues as a result of the Deepwater Horizon incident have raised new concerns about the effectiveness and toxicity of dispersant use, especially in the deep sea, so the following examples involving dispersants highlight needs in this area. The needs are not listed in any priority order.

- *Defining factors of spilled oil that control dispersibility*. Oil type is a key factor that needs to be studied in greater depth. We know less about the dispersibility of heavy refined products such as the IFO 180 and 380 fuel oils, bunker C, No. 6 fuel oil, and even No. 2 fuel oil compared to crude oils. We need to understand mechanistically the differences among the various types of oil in terms of their dispersible properties. We also need to understand how water-soluble dispersants differ from oil-soluble ones. We know very little about the biodegradability of dispersants and their constituents in saltwater, which is supposed to be their ultimate fate in the environment. We must increase our understanding of oil properties as they affect dispersibility (weight; viscosity; pour point; percentage of asphaltenes, polar compounds, and toxic components such as aromatics (PAHs), etc.).

- *Understanding the natural conditions under which spilled oil is dispersible*. These factors include temperature (dispersion may be less effective at low temperatures), mixing energy (wave energy on the water surface is needed for effective dispersion of oil into the water column, but little is known about deep sea injection into rapidly moving oil from a blowout); salinity; sub-sea conditions (dissolved oxygen; hydrostatic pressure; water solubility and composition of dispersants and their constituents; and toxicity to water column species both at the surface, within the water column above and below the pycnocline, and at extreme depths).

- *Effectiveness of dispersants on weathered emulsions*. If a water-in-oil emulsion ("mousse") occurs as a result of high-energy mixing, the resulting mousse has properties that prevent dispersion into the water column. We need to understand those properties and develop methods to mitigate them to make the mousse more dispersible. Very little research has been conducted in this area. Research is needed to determine if it is possible for a dispersant to be developed that will disperse oil trapped in water-in-oil emulsions.

- *Coalescence and resurfacing of dispersed oil droplets*. We know that the smaller the dispersed oil droplets, the less inclined they will be to re-coalesce. However, we still do not know exactly how large they must be for re-coalescence to take place. This would be an important property to know and understand as it might affect our ability to improve dispersant treatment. Study of this property would be best done in a wave tank that produces reproducible conditions between experiments. Alternating high energy and quiescent conditions to allow re-coalescence to occur would provide invaluable evidence on conditions for re-coalescence.

- *Quantification of horizontal and vertical diffusion of treated oil*. We know that vertical diffusion transports droplets deeper into the water column, while buoyancy makes them return to the surface. Wave energy decreases with depth of the water. Diffusion also decreases under the influence of vertical density stratification. Our knowledge of vertical and horizontal diffusion of dispersed oil in water is still very limited. We need better understanding of dispersed oil diffusion in seawater below and above the pycnocline to enable better model development of dispersed oil plumes in deep sea.

- *Research on the ecotoxicological effects of underwater injection of dispersants.* This is a new area that developed directly as a result of the Deepwater Horizon spill in the Gulf. Additional research is needed to determine the ecotoxicological effects of dispersants and dispersed oil in the deep sea.

- *Environmental fate, effects, and transport of released crude oil, dispersed oil, and dispersants on human health and the environment.* Spills, explosions, fires, and blowouts can have multiple environmental and public health impacts. Operational discharges of produced water, drill cuttings, and mud have chronic effects on benthic (bottom-dwelling) marine communities, mammals, birds, and humans. Humans can be affected by occupational exposure to oil and other chemicals while participating in response and cleanup operations, or by environmental exposure such as ingesting oil-contaminated seafood. Marine mammals are affected by the oiling of their fur and skin, and through consumption of oil-contaminated foods (e.g., mussels), or via inhalation of fumes that have liver, kidney, and central nervous system toxicity. The marine mammals most commonly affected include seals, sea otters, walruses, sea lions and whales, manatees and dugongs (in tropical waters), and polar bears in the Arctic. Sea otters are particularly vulnerable as they feed near the surface, have little blubber, and depend upon an intact fur coat to maintain their body temperature. Research is needed to better understand these impacts and how to mitigate the effects of an oil spill before it has affected the species at risk, including humans. Ecotoxicity research is needed in areas beyond human health effects, including research about effects on animals and other aspects of the environment.

- *Short and long term benefits and impacts of various spill management strategies, practices, and technologies.* The various spill management strategies in use today include mechanical removal techniques (use of sorbents, booming and skimming operations), *in-situ* burning, dispersants, and bioremediation. Mechanical removal techniques are the first line of defense used in response. However, such methods are highly variable in terms of effectiveness, and they depend on where the spill occurred. *In-situ* burning can be more effective, especially in wetlands where the oil can be concentrated and more easily burned. Dispersants can be effective on open water and used over large areas because of the way they are applied conventionally (overflights by fixed wing aircraft). One major requirement is the need for good mixing (wave energy). Dispersants are much less effective under quiescent conditions. Bioremediation can be very effective on sandy marine shorelines, wetlands, and salt marshes, but it is much slower (weeks to months or more), and bioremediation is not usually considered a first response. All these techniques could be improved with better research and more scientific understanding.

Finally, EPA's Environmental Response Team (ERT) plays a key role in testing and validating monitoring equipment in collaboration with the MMS at the Oil and Hazardous Materials Simulated Environmental Test Tank (OHMSETT) Facility in New Jersey to understand oil monitoring systems under the Special Monitoring and Response Technologies (SMART) protocol. This interaction allows ERT and the Coast Guard to be trained on oil spill monitoring equipment for detecting oil in the water column.

Summary and Conclusions

In conclusion, I want to emphasize that EPA's oil spill research program is an applied, practical program that is designed to address real and important emergency spill response and environmental protection challenges based on high quality, sound science. Our research informs EPA's regulatory decision-making and policy development for oil spill prevention, preparedness, and response programs and the National Response Team. EPA's oil spill research is important to the protection of the environment from oil spills. The research has been timely as we have developed a better understanding of how dispersants work (quantification of mixing energy needed for optimum dispersion and biodegradability of dispersed oil at several temperatures)[4-12], how to protect wetlands and marshes with innovative sorbent technology, and how best to implement bioremediation technology in a variety of environments. All of this research is useful for the current Gulf spill in terms of providing answers to many questions raised by EPA decision-makers, the Regional Response Teams (RRTs), the public, and the news media. It is imperative that EPA's Research and Development program continue to support oil spill response and prevention through its expertise and the knowledge gained through its research. It is critically important that EPA's research program in this area continues and evolves to address the needs identified to protect our natural resources and cleanup the environment following such disasters.

Thank you for the opportunity to testify today. I am happy to answer your questions.

References

1. Etkin, D.S. 2006. Risk assessment of oil spills to US inland waterways. Proc. 2006 Freshwater Spills Symposium (Download PDF).

2. Campo-Moreno, P, Y. Zhao, M.T. Suidan, and A.D. Venosa. 2007. “Biodegradation kinetics and toxicity of vegetable oil triacylglycerols under aerobic conditions,” Chemosphere, 68(11): 2054-2062.

3. http://www.epa.gov/emergencies/publications.htm#bio

4. Boufadel, M.C., H.L. Li, M.T. Suidan, and A.D. Venosa. 2007. “Tracer studies in a laboratory beach subjected to waves,” Journal of Environmental Engineering-ASCE, 133(7): 722-732.

5. Li, Z., P. Kepkay, K. Lee, T. King, M.C. Boufadel, and A.D. Venosa. 2007. “Effects of chemical dispersants and mineral fines on crude oil dispersion in a wave tank under breaking waves.” Marine Poll. Bulletin, 54: 983-993.

6. Li, Z., K. Lee, T. King, M.C. Boufadel, and A.D. Venosa. 2008. “Assessment of chemical dispersant effectiveness in a wave tank under regular non-breaking and breaking wave conditions,” Marine Poll. Bulletin, 56: 903-912.

7. Li, Z., K. Lee, T. King, M.C. Boufadel, and A.D. Venosa. 2009. “Evaluating crude oil chemical dispersion efficacy in a flow-through wave tank under regular non-breaking wave and breaking wave conditions.” Mar. Pollut. Bull. (2009), 58(5): 735-744.

8. Wrenn, B.A., Virkus, A., Mukherjee, and A.D. Venosa. 2009. “Dispersibility of crude oil in fresh water.” Environmental Pollut., 157: 1807-1814.

9. Li, Z., K. Lee, T. King, P. Kepkay, M.C. Boufadel, and A.D. Venosa. 2009. “Evaluating oil spill chemical dispersion efficacy in an experimental wave tank: 1. Dispersant effectiveness as a function of energy dissipation rate.” Environmental Eng. Sci., 26:1139-1148.

10. Li, Z., K. Lee, T. King, M.C. Boufadel, and A.D. Venosa. 2009. “Evaluating oil spill chemical dispersion efficacy in an experimental wave tank: 2. Significant factors determining *in-situ* oil droplet size distributions.” Environmental Eng. Sci., 26:1407-1418.

11. Li, Z., K. Lee, T. King, M.C. Boufadel, and A.D. Venosa. 2009. “Evaluating crude oil chemical dispersion efficacy in a flow-through wave tank under regular non-breaking and breaking wave conditions.” Marine Pollution Bulletin, 58:735-744.

12. Venosa, A.D. and E.L. Holder. 2007. “Biodegradability of dispersed crude oil at two different temperatures.” Marine Poll. Bulletin 54: 545-553.