"Oversight Hearing on the Use of Oil Dispersants in the Deepwater Horizon Oil Spill"
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Chairman Boxer and members of the Committee: I am Ronald J. Kendall, Director of The Institute of Environmental and Human Health (TIEHH), and Professor and Chairman of the Department of Environmental Toxicology at Texas Tech University. I have been engaged in research, along with my colleagues, on the science of the Deepwater Horizon Oil Spill (DHOS).

I appreciate the opportunity to appear before the Committee today to testify on the use of oil dispersants in the Gulf. Before I begin my remarks, I would like to extend my most sincere condolences to the families of those individuals who lost their lives at the outset of the Deepwater Horizon incident, and to all Americans whose lives have, or will be negatively impacted by this event.

As of early August 2010, the DHOS has resulted in the release of an estimated high end volume of over 180 million gallons of crude oil into the Gulf of Mexico. A total volume of 1,843,786 gallons of dispersant has been used in the Gulf since the oil leak began on April 20, 2010 (http://www.deepwaterhorizonresponse.com/go/doctype/2931/53339/). Approximately 42% of that total has been applied at the leaking wellhead located between 4,000-5,000 feet below the surface. Application of dispersant at these depths is unprecedented. Corexit 9500 has been the predominant dispersant used. Though application of dispersant at the wellhead may indeed have limited damage to some components of the Gulf of Mexico ecosystem (beaches, wetlands, etc.), it is unknown how, where, or to what extent the oil-dispersant mixtures will alter overall ecosystem structure and/or function. I will testify before you today as to why my colleagues and I believe that the DHOS represents an ongoing ecotoxicological experiment that is being conducted on a massive scale. These reasons are as follows:

1. We have very limited information on the environmental fate and transport of the mixture of dispersant and oil, particularly in the deep ocean.

2. We have very little information on the ecological effects of this particular oil and dispersant mixture in terms of acute, chronic, and indirect effects on marine and coastal organisms.

3. Given the volume of oil and dispersant that has been released into the Gulf of Mexico, we have a very poor understanding of ultimate ecosystem level effects which may occur in the weeks to months to years ahead.

These issues warrant serious concern among environmental toxicologists such as myself and many of my colleagues across the nation that are considering this event from an ecotoxicological perspective (Kendall *et al*., 2010). Perhaps most disconcerting is the uncertainty of how dispersant-oil mixtures may influence the ecology of the Gulf. When considered holistically, the Gulf ecosystem spanning the deep ocean, continental shelf, bays, estuaries, and marshlands is extraordinarily interconnected and complex. It is too soon, and there are insufficient data available to begin to predict outcomes. There is an urgent need for independent, peer-reviewed research that will help us understand the ramifications of using dispersants en masse, and at the bottom of the Gulf. The scientific community must engage this issue with an unbiased, science-based approach.

My testimony today, August 4, 2010, will draw upon current research efforts conducted by myself and colleagues at TIEHH in both the field and laboratory to evaluate the response of wildlife to oil, dispersant, and mixtures wherein dispersant is applied to the oil. I will also draw upon 40 years of experience in conducting field and laboratory research on the effects of environmental contaminants on wildlife resources, and our most recent book "Wildlife Toxicology: Emerging Contaminant and Biodiversity Issues" published May, 2010, by CRC Press.

Environmental Chemistry of the Mixture of Deepwater Horizon Oil and Dispersant

Oil spill dispersants are used to facilitate the physical mixing of crude oil with water. The interaction of dispersants with crude oil alters the chemical and physical properties of the oil and thus changes how the oil behaves in the environment. Such changes can determine the likelihood that marine organisms will be exposed to the various components of crude oil. The use of dispersants in no way reduces the amount of oil entering the environment, but does reduce the potential for slicks of oil to wash ashore and contaminate shoreline and coastal wetland habitats. Thus in theory, dispersant use limits the exposure of animals such as birds and marine mammals that may exist near the water surface or shoreline to the components of crude oil. However, it is recognized (and accepted once the decision is made) that dispersant use increases exposure potential for water-column and benthic organisms.

Crude oil is a complex mixture of thousands of chemical compounds; however, the aromatic hydrocarbons (both simple and polycyclic) are considered the most toxicologically important. Simple aromatics (benzene, toluene, xylenes) are volatile and are rapidly lost from the oil in most instances. It is not clear what impact the depth of the well and the use of dispersants at depth might have on the fate of the volatile components in the oil. Although oil from the DHOS is reported to have lower concentrations of petrogenic polycyclic aromatic hydrocarbons (PAHs) compared to crude oil from other sources (NOAA, 2010), burning of the oil is likely to produce significant concentrations of pyrogenic PAHs. It is well established that multi-ring PAHs are carcinogenic and important toxicologically from a chronic exposure standpoint.

There are uncertainties with regard to the environmental fate and transport of oil to which dispersant has been applied at depth. What happens to the volatile components in crude oil when dispersants are applied at such depths? What is the impact of dispersant on the mobility of oil? How is the mobility of dispersed oil affected by weather events such as tropical storms? Does dispersed oil biodegrade faster or slower than non-dispersed oil at these depths? Is there a greater oxygen demand created by the degradation of dispersed oil? Is dispersed oil more susceptible to abiotic process such as photodegradation or photoactivation?

Toxic Effects of Deepwater Horizon Oil and Dispersant

Crude oil can have physical, toxic, and indirect (e.g. food web-related) effects on fish and wildlife. The physical effects of crude oil exposure most often result in the loss of thermoregulation from the oiling of feathers or fur, but may also result in suffocation, and starvation. Toxic effects from crude oil exposure can arise from direct ingestion of the oil, inhalation of volatile components of the crude, or uptake of the water accommodated (soluble) fraction (WAF) of crude oil across exposed membranes. The use of oil dispersants enhances the likelihood of exposure and subsequent effects by producing smaller droplets of oil that could be mistaken as food, by increasing the amount of the water accommodated fraction (CEWAF, or chemically enhanced WAF) of crude oil, and by exposing aquatic organisms to the dispersant itself.

As previously stated, Corexit 9500 has been the dispersant most widely used in response to the DHOS. The U.S. EPA's National Health and Environmental Effects Laboratory recently reported that Corexit 9500 could be characterized as "slightly toxic" to Mysid shrimp (*Americamysis bahia*: 48hr LC50 of 42 ppm), and "practically non-toxic" to the inland silverside (*Menidia beryllina*: 96hr LC50 of 130 ppm; Hemmer *et al*., 2010). Among eight different dispersant formulations evaluated, four were less toxic to shrimp, but only one other dispersant was less toxic to the silverside. Though other National Contingency Plan-listed dispersant formulations may be less toxic than Corexit 9500, none are dramatically safer according to limited research directly comparing dispersants under similar protocols and conditions. EPA has concluded that "all of the dispersants are roughly equal in toxicity and generally less toxic than oil."

Recent efforts by EPA to characterize dispersant toxicity to marine organisms represent a step in the right direction in the development of a weight-of-evidence approach to assessing the impact of dispersant use. However, critical data gaps exist with respect to the potential impacts of dispersant use and the fate, transport, and effects of dispersed oil. The data gaps exist partially because of a lack of information on the toxicological interactions of crude oil and dispersants in general, and partially because of the unprecedented use of dispersants at depth in the DHOS specifically. While some aquatic toxicity data are available for various crude oil and dispersant combinations (NRC, 2005), additional data are needed from site-specific toxicity tests on crude oil emanating from the DHOS.

The combination of dispersant and oil in aqueous mixtures appears to be of greater risk to aquatic organisms than dispersant or oil alone. Dispersants enhance the availability of the crude oil and therefore potentially increase uptake of crude oil components into marine organisms. Dispersants also promote formation of micelles or oil droplets within aqueous matrices. A large majority of studies that seek to compare toxicity of oil alone versus dispersed oil demonstrate that dispersant-aided changes in crude oil solubility enhance exposure and toxicity among aquatic organisms.

It should be noted that nearly all research conducted on the chemical fate, transport, and toxicity of dispersants and dispersant-oil mixtures has been performed in settings and under conditions vastly different than those that exist deep in the Gulf where much of the dispersants have been applied. Extreme pressure, low temperatures and light, and reduced oxygen concentrations can dramatically alter physical, chemical, and biological processes. Further, extrapolation of toxicity data from a limited number of species indigenous to the Gulf may not provide sufficient information on the sensitivity of a broad array of ocean-dwelling organisms, particularly those that occupy deepwater niches.

Potential Gulf of Mexico Ecosystem Effects from Deepwater Horizon Oil Release and Use of Dispersants

All of us recognize that the Gulf of Mexico is an extremely important resource for the United States of America for many reasons including its natural beauty and wildlife, seafood and commercial fishing industry, tourism, and energy production, particularly oil. Although natural disturbances such as hurricanes can have substantial impact on the Gulf environment, these natural events come and go and are part of the way of life in the Gulf of Mexico. However, the DHOS is now the largest oil spill in American history, and the decision was made to add to that enormous volume of oil an unprecedented volume of dispersant. In toxicology, it is broadly accepted that “the dose makes the poison”. Therefore, we have significant potential for toxicity among Gulf organisms which may manifest as ecosystem level impacts as we move into the future. Why consider this at the ecosystem level? Take for instance the Kemp’s ridley sea turtle (*Lepidochelys kempii*), an endangered species for which extensive recovery efforts have been made. Many female Kemp’s ridleys nest along the coast of Texas before returning to the Gulf (Seney and Landry, 2008). They then head to feeding grounds, often off Louisiana or the west coast of Florida. The Kemp’s ridley sea turtle utilizes the Gulf of Mexico ecosystem throughout its life cycle (Shaver *et al*., 2005). To date, we have seen hundreds of dead turtles reported in the last several months (since April 2010). Kemp’s ridley sea turtles are highly susceptible to anthropogenic stressors like oil spills which may cause mortality or disrupt normal behaviors. When Kemp’s ridley eggs hatch, the young, which may be only about 1.5 inches long, return to the ocean where they will leave the near shore environment and enter an open ocean developmental stage; moving with Gulf currents, feeding predominantly on jellyfish, fish and crabs (Schmid and Witzell, 1997). It is thought that young turtles at sea may associate with *Sargassum* (floating seaweed) for refuge, rest and/or food. Oil-dispersant impacts on seaweed could result in serious negative impacts among young turtles. If oil affects the food supply of the Kemp’s ridley or disturbs critical stages of its life cycle, we may not see oiled, dead Kemp’s ridleys, but their population abundance could be imperiled by subtle indirect effects of dispersed oil on the environment.

Another example is the sperm whale (*Physeter macrocephalus*), also an endangered species. Sperm whales are the largest of the toothed whales, and they hunt relatively larger bodied prey (e.g. squid) in deep water. Dispersant-oil mixtures suspended in the water column, particularly in deep water, could be toxic to both adult and juvenile sperm whales, (Knap *et al*., 2002). Sperm whales are in the Gulf of Mexico during the summer which is also an important calving period (Blaylock *et al*., 1995). Young animals are often more susceptible to environmental contaminants than adults. This increases concern for juvenile sperm whales. In an ecosystem context, these whales feed heavily on cephalopods (particularly squid) and disruption of the food chain could be of considerable detriment to adults caring for young. Moreover, whales may be forced to abandon critical calving or feeding grounds due to the presence of suspended oil-dispersant mixtures. Therefore, we could potentially see both direct and indirect effects from the DHOS as a result of dispersed oil and associated toxic constituents in areas where sperm whales are known to occur in the Gulf of Mexico (Godard *et al*., 2004).

As a final example, the western Atlantic population of bluefin tuna (*Thunnus thynnus*) has experienced a tremendous decline over the last few decades. The DHOS may present additional negative impacts to this marine resource because primary spawning areas are located within the Gulf. The eastern Gulf spawning area is within the general vicinity of the well and potential plumes of dispersed oil (Teo and Brock, 2010). In the Gulf of Mexico, bluefin tuna catch per unit effort peaks in April, suggesting that the majority of spawning occurs during the March to May time frame. Thus, larval bluefin most likely occupy Gulf waters from the peak spawning times onward through the summer, suggesting a temporal overlap with the presence of dispersed oil, oil plumes, and oil sheen in the Gulf of Mexico. Bluefin tuna spawn in the open waters of the Gulf of Mexico, and larval tuna generally utilize surface layers of the Gulf. Larvae are carried by currents and accumulate in convergence zones. Pelagic *Sargassum* seaweed also accumulates in these zones and provides important habitat for larval fish (Comyns *et al*., 2002). It is likely that oil on the surface of the Gulf also accumulates in these areas and the potential exists for interactions between oil and *Sargassum* habitat that may ultimately influence larval bluefin tuna. One current unanswered question is whether oil (tar balls and/or dispersed) may bind or physically associate with *Sargassum*, increasing the risk of toxicity to larval bluefin tuna and other pelagic species.

In other habitats, the diet of larval tuna includes crustaceans prior to shifting to a fish based diet (Llopiz *et al*., 2010). Potential toxicity due to Corexit 9500 and dispersant-oil mixtures in the Gulf of Mexico may influence zooplankton and other crustaceans. The LC50 of Corexit 9500 has been reported to be 21 and 5.2 ppm for brine shrimp (*Artemia salina*) and copepods (*Eurytemora affinis*), respectively (George-Ares and Clark, 2000). Thus a potential for indirect effects of dispersants on bluefin tuna include reduced abundance of food resources. In addition, toxicity resulting from dispersed oil well below the surface could feasibly impact zooplankton and other crustaceans important to larval bluefin tuna due to their vertical water column migrations. Further, the direct toxic effects of Corexit 9500 on larval pelagic fish species such as bluefin tuna are relatively unknown.

Like everyone else, I received news that the well has been capped with great relief and guarded optimism. In the days since the flow of oil into the Gulf has stopped, many have begun to ask the question, "Where is the balance of the oil that leaked out?" I believe that the extensive use of dispersant has resulted in much of the oil released from the Deepwater Horizon site to remain suspended in the Gulf, dispersed in the water column.

A simple estimate drawn on experience gained during the Exxon Valdez oil spill of 1989 can be used to illustrate. There, approximately 11 million gallons of oil was released into Prince William Sound resulting in oiling of over 1,000 miles of shoreline. In the present oil spill, which is upwards of 20 times greater in volume than the Exxon Valdez spill, we have only seen 600 miles of oiled shoreline. Therefore, it may be surmised that, aside from volatilization, burning, and other remedial efforts, much of the oil remains at sea.

I appreciate the opportunity to testify today. This hearing will encourage the scientific community to generate much needed data related to use of dispersants in response to the DHOS. Again, I believe there is an urgent need for independent, applied research to fill data gaps on the potential impacts of dispersed oil on gulf wildlife. Hopefully, information generated in future studies will aid in the assessment of effects, identification of effective remedial strategies, and with the restoration and preservation of the Gulf Coast ecosystem.

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