SOT Society of Toxicology
Creating a Safer and Healthier World by Advancing the Science and Increasing the Impact of Toxicology

ISSUE STATEMENT

The Deepwater Horizon Oil Spill

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Introduction

The Deepwater Horizon (DWH) oil spill was the largest accidental release of crude oil in modern history. Announcements of major legal settlements continue to be released concerning the damage claims. Since the event, hundreds of research studies have been published on the economic and human and ecological health impacts. There continues to be attention on what happened to the oil and chemicals used in the cleanup and assessing their long-term effects on the environment and human health. Members of the Society of Toxicology (SOT) are specifically trained to study these important questions and interpret the findings. Their continuing efforts will help ensure that the ongoing scientific, risk management, and policy decisions regarding the DWH spill and future oil spills are based on sound science.

The Chemistry and Toxicology of Oil and Dispersants

The first step in assessing the impact of any release of chemicals into the environment is to identify the chemicals involved, their environmental fate (what happens to them after release), and their potential impact on ecosystems and human health. In the case of the DWH incident, scientists were initially concerned with the crude oil and natural gas released from the well and dispersants applied to help mitigate the spill. An additional concern is exposure to chemicals formed when the oil burned. Crude oil and natural gas are complex, naturally occurring mixtures that together comprise thousands of different chemicals. Dispersants also are complex mixtures. Each component of these mixtures has its own physical, chemical, and toxicological properties, which can combine in unpredictable ways. The DWH incident not only released much more oil than previous spills such as the Ixtoc I blowout in the Gulf of Mexico (1979) and the Exxon Valdez tanker accident (1989), but the oil was released at a much greater depth (1,544 meters vs. 50 meters). The greater depth of the DWH spill means that additional factors such as temperature, pressure, and salinity may have affected the physical and chemical behavior and transport of the oil, complicating the assessment of dispersant effects.

The DWH release added a substantial new source of oil to the ongoing natural and human-induced releases that routinely occur in the Gulf of Mexico. The DWH spill released about 4.9 million barrels (795 million liters) of crude oil, accompanied by a similar volume of natural gas.

Added to this was approximately seven million liters of dispersants that were applied either at the surface (two-thirds) or at the wellhead (one-third). Crude oil contains hundreds of hydrocarbons of various types, as well as chemicals containing sulfur, nitrogen, or oxygen. The toxicity of oil has been studied extensively. Some of the most toxic components of oil include benzene, toluene, ethylbenzene, xylene, and polycyclic aromatic hydrocarbons.

Once released, the oil was subjected to a variety of physical, chemical, and biological processes, including dissolution in seawater and evaporation (collectively called "weathering"), dispersion as small droplets into seawater (natural and facilitated by dispersants), sedimentation, transport, photodegradation, biodegradation, emulsification, and intentional combustion. Research by several groups and calculations made by federal agencies have provided a tentative approximation of the initial fate of the escaped oil. Although there is substantial uncertainty in some of the estimates, large fractions of the oil appear to have dispersed into small droplets, dissolved in seawater, or evaporated upon reaching the surface. In addition, some of the dispersed and dissolved oil remained initially as "plumes" at a depth of about 1,100 meters; much of this later sank like fallout to the sea floor. Some of the oil that made it to the surface, which was not burned or evaporated, migrated to coastal habitats. The use of dispersants likely increased the bioavailability of the oil (its ability to be taken up or acted upon by organisms) and enhanced the opportunities for biodegradation. However, it also may have increased the potential exposure of sensitive organisms. Debate continues regarding whether the use of dispersants at the source of the wellhead was effective, and this continues to be an active area of research.

Dispersants are used to enhance the mixing of oil with water, reducing exposure of organisms on the ocean surface and coastline. The trade-off with their use is that chemical dispersion of oil can increase the exposure of organisms below the surface in the water column and at the seafloor to oil, dispersants, and oil-dispersant mixtures. The dispersants used in the DWH incident (Corexit 9527 and Corexit 9500A) contain several surfactants (surface-active agents), solvents, and other chemicals. The application of Corexit 9527 and Corexit 9500A in the deep ocean (1,500 meters) was unprecedented. An important question is how the impact of the dispersed oil differs from that of undispersed oil, and for the DWH spill, this is not yet fully known. Certainly, the use of dispersants on the surface reduced the exposure of the coastline to oil and application of dispersants at the wellhead reduced the amount of oil reaching the surface. However, dispersant use in the deep ocean most likely increased the exposure of organisms in the water column and on the seafloor to dispersant and dispersed oil, and the potential effects of these chemicals in deep-water organisms are not well understood. Although most dispersants are thought to degrade rapidly in the environment, they have not been used previously in the deep ocean (1,500 meters) and persistence under these conditions is not known. Research on the DWH incident suggests that at least some components of the dispersants applied at the well in deep water were more resistant to biodegradation than expected, persisting up to 64 days after application was stopped. Dispersants are generally acknowledged to be less acutely toxic than the oil to which they are applied. However, application of dispersants increases the aqueous concentrations of petroleum hydrocarbons and distributes the oil over a larger volume, potentially increasing the exposure of benthic and mid-water organisms to oil. Understanding the fate and effects of dispersant applied in the deep ocean during the DWH incident continues to be an important need.

Environmental Effects

Toxicologists continue to be involved in laboratory and field studies to measure the impacts of the spill and to assess the long-term effects. Understanding these impacts is complicated by the occurrence of a diverse array of large-scale ecosystems within the Gulf where the oil and dispersants migrated, including deep-water bottom sediments and reefs, bays, estuaries, coastlands, bayous, and open water (surface and mid-water). It has been difficult to track the extent of contamination and persistence of the contaminants in each of these areas and, in turn, potential exposures to organisms. In addition, a large portion of the Gulf, including the area impacted by the DWH spill, is subject to hypoxia associated with nutrient inputs from the Mississippi River. Hypoxia in the Gulf is seasonal, occurring during warm weather months — when the spill occurred — and has been shown to adversely impact fish reproduction. Potential interactions between hypoxia and the spill are currently a subject of inquiry. These environmental concerns are compounded by the fact that the Gulf also is home to both protected and commercially valuable species. When evaluating different ecosystems, the ranges and life stages of species that passed through the affected areas immediately following the DWH incident must be considered. The species that are most sensitive to oil-related compounds, dispersants, or the complex mixture of the two are unknown, but are likely to include immature organisms, sessile organisms, and/or top predators. In addition to differences in species susceptibility, the potential for delayed or multigenerational impacts also must be considered. Distinguishing among the effects of this massive spill, the cleanup efforts, and the effects of natural releases of oil in the Gulf creates an additional complication.

Human Exposure and Health Effects

People can be exposed to chemicals in crude oil or dispersants through air, skin contact, or eating contaminated seafood from fisheries in the Gulf of Mexico. Because each source of crude oil has unique characteristics based on location, to understand the potential for short- and long-term health effects, the specific toxicity of the source must be identified. Once we understand the toxicity related to human health effects, scientists will need to document the levels of exposure from combinations of breathing contaminated air, skin contact, and consumption of contaminated seafood. Fortunately, testing by state departments of health, the US Food and Drug Administration (US FDA) and US National Oceanic and Atmospheric Administration (NOAA) has found primarily non-detectable or background concentrations of dispersants and PAHs in seafood and no increased health risks to humans consuming Gulf seafood (see Resources). Together the characterization of the component materials, research on their toxicity, and measures of the amount of exposure will allow for the assessment of potential toxic effects resulting from the DWH incident. Scientists and policymakers can use the data collected on human exposure and toxicity information to describe potential short- and long-term health effects. This analysis should cover all potentially affected people, including those who have worked on the cleanup of the DWH spill and members of the communities impacted along the shoreline.

Summary and Future Directions

Ongoing toxicological research continues to provide important information about the human and environmental health consequences of the DWH incident. However, many areas of uncertainty and gaps in our knowledge remain. Each spill has specific characteristics; although previous oil spills have been studied extensively, the information learned is not fully transferrable. The DWH spill was unique in the sheer volume of the spill, geographic area involved, and combination of oil and chemical dispersant release in deep water. Ongoing research will build on the results from current studies and define more completely the toxicity of the crude oil and dispersants released during the DWH incident and cleanup. Toxicologists are trained to investigate the human health, environmental, and ecological effects of the DWH incident. The research conducted by toxicologists and their objective assessments of the data are critically important to the development of sound, science-based public policy regarding the DWH incident.

Suggested Resources

http://www.laed.uscourts.gov/OilSpill/OilSpill.htm
http://www.epa.gov/risk/
http://www.gulfspillrestoration.noaa.gov/
http://www.eoearth.org/oceanoil
http://www.restorethegulf.gov/
http://www.fda.gov/food/ucm210970.htm
http://www.whoi.edu/oceanus/series/deepwater-horizon
http://www.whoi.edu/deepwaterhorizon/index.html

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