

NATIONAL RESEARCH COUNCIL REPORT

KEY FINDINGS

Oil Spill Dispersants: Efficacy and Effects

Oil dispersants are chemicals that change the chemical and physical properties of oil to enable it to mix with water more easily, in a similar manner to the way that dish detergents break up cooking oil on a skillet. By increasing the amount of oil that mixes into sea water, dispersants can reduce the potential contamination of shoreline habitats – but at the same time, a larger volume of water at varying depths becomes exposed to spilled oil. This report reviews ongoing research on the use of dispersants as an oil spill response technique and the impact of dispersed oil on marine and coastal ecosystems. The report concludes that more information on the potential benefits or adverse impacts of dispersant use is needed to make effective, timely decisions on using dispersants in response to an oil spill.

1. **Decisions to use dispersants involve trade-offs.** Oil dispersants break up slicks, enhancing the amount of oil that physically mixes into the water column and reducing the potential that oil will contaminate shoreline habitats or come into contact with birds, marine mammals, or other organisms in coastal ecosystems. At the same time, using dispersants increases the exposure of water column and sea floor life to spilled oil.
2. **The window of opportunity for using dispersants is early, typically within hours to 1 or 2 days after an oil spill.** After that, natural “weathering” of an oil slick on the surface of the sea, caused by impacts such as the heat from the sun or buffeting by waves, makes oil more difficult to disperse. Therefore, failure to make a timely decision regarding dispersant use can be a decision not to use dispersants.
3. **Better information is needed to determine the length of the window of opportunity and the effectiveness of dispersant application for different oil types and environmental conditions.** Given the potential impacts that dispersed oil may have on water-column and sea floor biota and habitats, thoughtful analyses are required so that decision makers can understand the potential impacts of a spill with and without dispersant application. A focused series of studies is needed to provide the information needed for an effective response to oil spills of all types and in various environments, using both laboratory research and, in the event of a spill, field research in areas treated with dispersants.
4. **More accurate methods of predicting the behavior of dispersed oil are needed to better predict the amount of oil that will mix into the water column.** Limitations of current methods for predicting concentrations of dispersed oil in the water column include inaccurate representation of the natural physical processes involved in dispersal. Improved representations will allow decision makers to better understand the consequences of using a dispersant in a particular set of circumstances.
5. **Exposure to the air, the heat of the sun, and the turbulence of the waves can “weather” oil on the surface of the water, creating an emulsion; but no wave-tank or laboratory studies have investigated how dispersants would work on an oil and water emulsion.** Studies are needed to investigate the chemical treatment of weathered oil emulsions.
6. **The recent introduction of safer chemical dispersants means that the toxicity of dispersed oil now typically results primarily from compounds within the oil itself.** It is known that



breaking up oil slicks into smaller droplets exposes more of the toxic compounds in oil, such as polynuclear aromatic hydrocarbons (PAH), but in general the mechanisms of toxicity are poorly understood. With a better understanding of the toxicity of dispersed oil to marine organisms, data can be generated on toxic levels and thresholds for use by decision makers.

7. **The factors controlling the biological and physical processes which determine the ultimate fate of dispersed oil are poorly understood.** Dispersed oil could accumulate in more stagnant areas, or could be consumed by plankton in the water column and enter the food chain. More detailed information on weathering rates and on the ultimate fate of dispersed oil are needed.
8. **Data from field studies on the concentration and behavior of dispersed oil are needed to validate models and provide real-world data to improve knowledge of oil fate and effects.** Detailed plans should be developed, including the pre-positioning of equipment and human resources, for rapid deployment of a monitoring effort for dispersant applications in the event of a spill so that the consequences can be recorded.

Box 1. *What happens when oil is released deep underwater?*

Based on the 2003 National Research Council report *Oil in the Sea III: Inputs, Fates, and Effects*

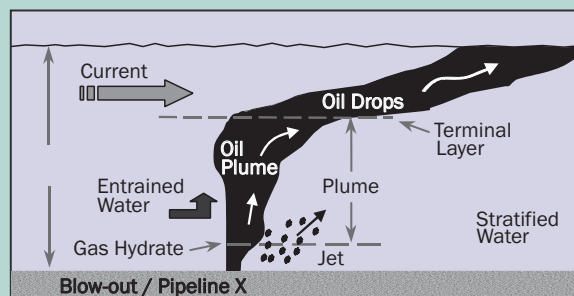
Accidental spills can also occur beneath the surface, for example blowouts of exploration wells such as the BP Gulf of Mexico disaster, pipeline ruptures, and shipwrecks. Oil leaking from a pressurized underwater spill doesn't simply rise to the surface—it forms underwater plumes of oil and natural gas that billow and drift beneath the oceans surface. Water temperature and salinity, the depth of the leak, and the density of the gas and oil all impact the physics of plume formation, but there are three distinct phases of any pressurized, underwater spill:

Jet Phase: The speed of the oil and natural gas being expelled from the pressurized, confined space of the well into the water makes the oil form droplets and the gas form bubbles.

Plume Phase: The momentum of these tiny droplets and bubbles drags significant volumes of sea water upward into the water column, forming a plume. In deeper water, so much water is incorporated into the plume that eventually, the oil–natural gas–water mix is no longer buoyant, and the plume will become suspended at what is called the terminal layer. If heavier components sink out of the suspension, the plume may reform and begin to rise again.

Post-terminal Phase: Once the plume reaches the final terminal layer, the rise of the oil and gas to the surface is driven purely by the buoyancy of the individual droplets and bubbles.

At the surface, the oil forms a slick thinner than those seen during typical shallow-water releases, in part due to the diffusion and dispersal of oil droplets as they rise and in part due to the layers of oil arriving at the surface at different stages. Natural gas released at depths below 300 meters can form hydrates, a mix of natural gas and water similar to ice. Because hydrates are dense, their formation can reduce the buoyancy of the plume, increasing the time that it takes for the oil and gas to reach the surface.



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The National Academies appointed the above committee of experts to address the specific task requested by the United States Congress. The members volunteered their time for this activity; their report is peer-reviewed and the final product approved by both the committee members and the National Academies. This report derivative was prepared by the National Research Council based on the committee's report. For more information, contact the Ocean Studies Board at (202) 334-2714 or <http://dels.nas.edu/osb>. Copies of the summary of *Oil Spill Dispersants: Efficacy and Effects* are available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu.



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