The Deepwater Horizon Oil Spill: Environmental Fate of the Oil and the Toxicological Effects on Marine Organisms

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ABSTRACT

The Deepwater Horizon spill was one of the largest oil spills in recorded history, depositing more than 2.6 million gallons of oil a day over the course of 84 days into the Gulf of Mexico, and with it considerable unprecedented problems and concerns. With an eventual total of 172 million gallons leaked into the Gulf, the Deepwater Horizon spill disrupted the ecology and deeply affected wildlife populations along 690 miles of U.S. coastline. The Exxon Valdez oil spill of 1989 resulted in the release of 10.8 million gallons of oil in Alaska. Comparatively speaking, however, the quantity of oil released from Deepwater Horizon was the equivalent of an Exxon Valdez spill happening every four days for three straight months. Although the volume of oil spilled from the Exxon Valdez tanker represents only a small fraction of that from Deepwater Horizon, Exxon Valdez cleanup efforts took decades and the effects of the spill on wildlife are still being observed today. While both disasters involved crude unprocessed oil, there are many factors that distinguish these two events. Oil spills, though generally involving similar compounds, often have unique characteristics and consequences, each depending on its environment, the nature of the spill, and many other natural factors. This review surveys the general environmental and toxicological effects and implications of oil spills, with particular emphasis on the unique aspects of the Deepwater Horizon spill.

THE SPILL EVENT

Deepwater Horizon was a semi-submersible Mobile Offshore Drilling Unit that controlled a two-mile long oil drill, with a mile of the drill suspended vertically underwater from the platform to the ocean floor (within a drill riser tube) and another mile of the drill in bedrock of the ocean floor (2). At the intersection of the drill and the bedrock was a wellhead unit with a shutdown mechanism that would prevent any free-flow (i.e. release) of oil from the well in the event of a well blowout. At the time of the explosion, however, the blowout preventer failed to contain any oil (3).

At 9:45pm on April 20, 2010, an abnormal amount of pressure built up in the drill column, with large methane gas bubbles travelling up the drill riser to the drilling platform (3). Ignition of these bubbles resulted in a sudden explosion that set fire to the platform, killing eleven workers. The fire continued to burn on the platform for a day, until the platform collapsed, and with it the mile-long drill riser, thereby initiating oil free-flow into the Gulf. Response teams were unable to immediately stop the flow of oil due to the conditions of the spill and failure of the safety systems. Over the course of three months, engineers from BP, the corporation overseeing the drilling, attempted several times to close the wellhead unsuccessfully. With the breach not mended, oil escaped at a rate of 2 million gallons a day over a course of 84 days. The magnitude of the blowout proved too much for traditional repair and containment techniques. To understand the methods of oil spill cleanup and remediation, we must review the properties and characteristics of oil and the fate of oil in the environment.

WHAT IS PETROLEUM?

Petroleum is a natural occurring carbon "soup" consisting of a mixture of alkenes, alkynes, and various hydrocarbons that are the products of decaying organic matter, which has been compressed by pressure for millions of years underground (4). In these petroleum pockets, more commonly known as oil reserves, hydrocarbons exist in gaseous, liquid, and/or solid form and can vary significantly in their carbon chain lengths (4). Light hydrocarbons (1-9 carbon chains) often comprise about 50% of the carbon present in crude oil, and often exist in a gaseous state (4). Large hydrocarbons (5-12 carbons in length) are typically present as liquids and are the hydrocarbons typically used for fuels and solvents. Even larger hydrocarbons (13-17 carbons in length) are used as fuels and lubricants. In addition to differences in molecular weight, each hydrocarbon molecule has a unique collection of chemical bonds and structure that can make it unique despite similarities in molecular weight. Such differences in physiochemical properties are responsible for the different environmental fates and toxicities associated with different hydrocarbons and hydrocarbon mixtures.

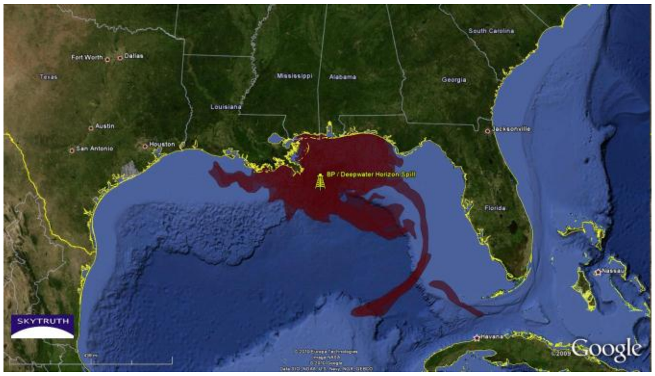

Figure 1. Map of cumulative oil slick from Deepwater Horizon (indicated in red), April 25 – July 16, 2011. Courtesy of Google and SkyTruth.

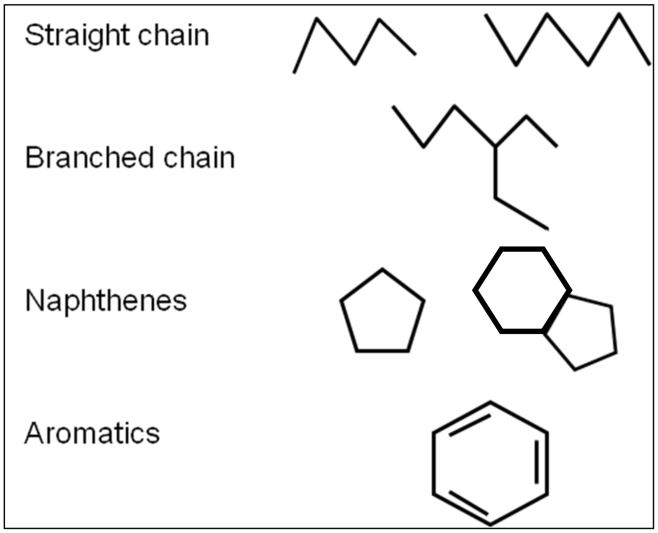

Figure 2. The hydrocarbon soup. Differences in lengths of carbon chains, branches, rings, and aromatic rings account for the countless variations of hydrocarbons in oil.

In the Deepwater Horizon spill, the contaminating hydrocarbons were untreated crude oil released directly from a deep hydrocarbon pocket and contained a wide variety of hydrocarbons with different physical states. In particular, the crude oil released from the Deepwater Horizon well-contained hydrocarbons with a relatively lighter molecular weight than that typically found in other crude oils (6).

ENVIRONMENTAL FATE OF OIL IN THE GULF SPILL

Hydrocarbons are naturally leaked into the environment, and it has been reported that 47% of crude oil found in the marine environment is from natural seepage, while the remaining 53% of oil in the marine environment results from anthropogenic sources (5). In fact, it has been estimated that 600,000 metric tons of oil are released worldwide each year from natural seepage, 140,000 metric tons of which are released into the Gulf of Mexico alone (5, 25). Since it is common for some areas in the ocean to seep oil from natural deposits, especially in oil rich environments like the Gulf, there are many natural, physical and biological processes that can facilitate the degradation of hydrocarbons, including UV rays from sunlight, water, wind, and microbial processes.

Oil dispersion and evaporation

Weathering, the process whereby natural environmental conditions induce oil degradation, is often the quickest immediate oil degradation process. Volatilization is one of the more rapid oil weathering processes that depend on the properties of the hydrocarbon. Lighter hydrocarbons evaporate more readily, particularly when environmental conditions such as temperature, wind speed, and sea conditions are especially favorable (5). Typically 30% of crude oil by volume evaporates in one to two days under average conditions (7). The evaporation of hydrocarbons of lower molecular weight (i.e. 2-3 carbon ring polycyclic aromatic hydrocarbons and monocyclic aromatic hydrocarbons)—which are known to have carcinogenic and toxic effects on organisms—can drastically decrease the overall toxicity of the crude oil (4). Once the lighter hydrocarbons evaporate, however, the heavier hydrocarbons precipitate into the water column, forming an emulsion below the surface (4). Since the BP oil spilled had a higher concentration of light molecular weight hydrocarbons, there was a slight increase in the percentage of evaporation when compared to that from spills of other crude oil mixtures. In particular, 24% of the total oil spilled from the Deepwater Horizon event (50 million gallons) was dispersed by evaporation and volatilization.

Photolysis

Photons—light energy from sunlight—in the form of UV rays can react with and break down hydrocarbons and thus create new byproducts. Absorption of photons by hydrocarbons results in their oxidation, a process by which carbon bonds of the hydrocarbon become reactive and physically/chemically react and bond with

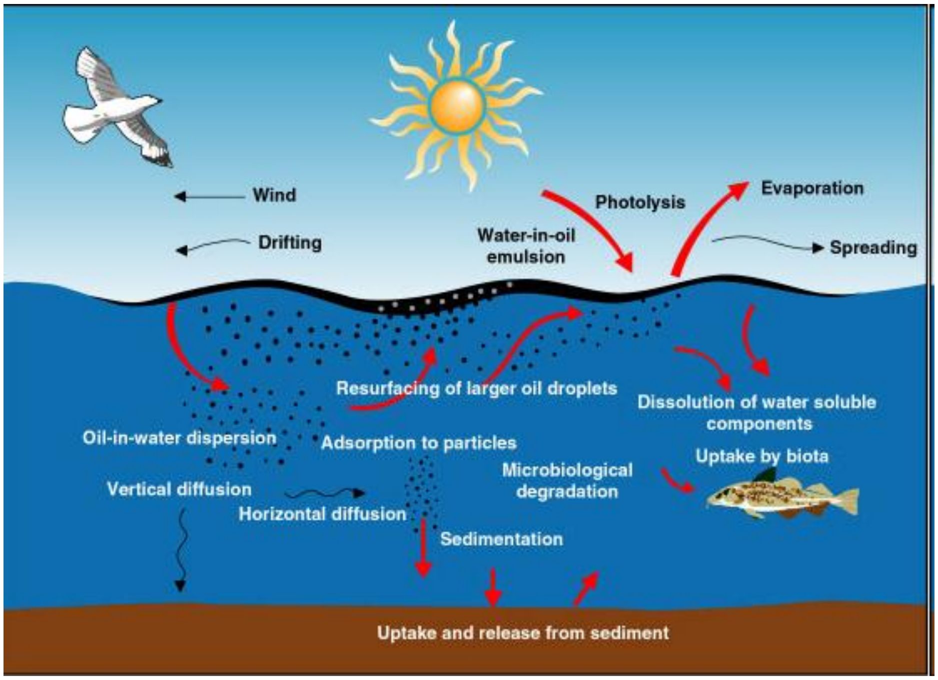

Figure 3. Schematic of the various processes oil can undergo once introduced to the environment. Adapted from: Daling, P.S., Aamo, O.M., Lewis, A., Strùm-Kristiansen, T., 1997. SINTEF/IKU oil-weathering model: predicting oil properties at sea. In: Proceedings1997 Oil Spill Conference. API Publication No. 4651, Washington DC, pp. 297±307.

oxygen. While such reactions generate more polar (water soluble) compounds, some of the resulting products are significantly more toxic and bioactive than the original oil hydrocarbons (4). Sunlight-dependent photo-oxidation reactions can be relatively slow and these reactions are often hampered by the absence of sunlight (7). Furthermore, the toxic products of photo-oxidation reactions are typically diluted into the large volumes of water in which they are generated, so the concentrations of these compounds necessary to produce toxicity or other biological effects are not commonly encountered (7). While there are as yet no published studies on the amount of Deepwater Horizon crude oil that has undergone photolysis, previous studies suggest that minimal amounts of oil were photo-oxidized (27).

Biodegradation

In many environments containing hydrocarbons, native microbes can often utilize hydrocarbons as an energy source. Microbial degradation of hydrocarbons is the ultimate fate of much of the dispersed oil in these situations, though the process is not instantaneous (7). Microbe-mediated hydrocarbon degradation requires that microbes come into contact with the oil, which is only possible when the crude oil is emulsified and suspended in the water column. The rate of biodegradation is dependent upon environmental conditions such as temperature, nutrition content, oxygen availability, and the chemical properties of the hydrocarbons (7). While these rates are often difficult to measure in the field because of high hydrocarbon dilution, variations in hydrocarbon degradability due to variation in microbe species, different oxygen content, and nutrient content have been reported (7). Dispersants and surfactants used to enhance oil emulsification have also been found to have a range of effects on biodegradation rate, depending on the properties of the specific dispersant or surfactant (8). The Gulf of Mexico's natural seepage of large amounts of hydrocarbons over long periods of time, coupled with warm temperature, has provided a favorable environment for the development and growth of hydrocarbon-degrading microbes. The presence of such microbial communities has likely resulted in an increase in the biodegradation capacity of oil released by Deepwater Horizon. In fact, recent studies have found different species of hydrocarbon-degrading microbes near the deep-sea oil plume that have appeared to have adapted to the increase in oil concentrations (9).

Settling

Although most of the oil rises to the surface and is degraded over time, oil can also sink when attached to suspended solids in the water column (6). A case study based on the 1979 Ixtoc I oil spill in the Gulf of Mexico, which is very similar to the Deepwater Horizon spill, indicated that 25% of the oil settled onto the Gulf of Mexico sea floor (26). Regarding the Deepwater Horizon Spill, however, some have reported that a layer of oil on top of the sea floor sediment did not resemble oil from natural seeps, indicating possible settling of oil from the Deepwater Horizon Spill. Ongoing sampling programs have yet to confirm the presence of oil on the bottom of the Gulf for the recent Deepwater Horizon spill (6, 27).

SPILL RESPONSE

Though natural methods can degrade crude oil, such processes are only effective when there is a slow and steady release of oil that does not overwhelm the capacity of these processes to operate. When a large oil spill occurs, it is almost impossible to rely on natural methods to eliminate the oil quickly enough, and human intervention is necessary to effectively remove large amounts of spilled oil. Often times, responders have a multitude of remediation techniques effective in removing oil from the environment from which to choose. The efficacy of each method, however, is dependent upon the environmental situation surrounding the spill site and the specific approach the response requires.

MECHANISMS OF RECOVERY

Booms

At the onset of a spill, the characteristics and properties of oil are what facilitate the spread of the oil slick and what contribute to its difficulties in collection and recovery. To contain the oil, many responders often deploy oil containment booms as the first equipment onsite and continue to use booms to collect oil (8). A boom is a floating physical barrier segregated in many sections of 15-30 meters long designed to separate surface oils (12). The segregations give the booms flexibility and prevent oil escape during strong wave movement (13). Booms are often used to contain a small area leaking oil such as that from a leaking oil tanker or used to prevent an important ecological area from oil contamination. These booms are typically more effective in preventing the spread of oil that is being released from a surface source (i.e. tanker) and are less effective when the leak is from the ocean floor. Booms have also been attached to boats to trawl the water and collect oil. A boom's performance, however, is affected by water currents, waves, and winds and often times one of these forces pushes oil over or under these booms.

Skimmers

Once oil is concentrated in a smaller area with the use of booms or other containment methods, skimmers are often used to collect the oil. Skimmers are vessels containing mechanical devices with various collection methods. The majority of skimmers either utilize vacuums—where the top layer of the oil is drawn out—or an alternate method relying on oil's propensity to adhere to surfaces. Most skimmers used in large oil spills often have a large surface area like a conveyer belt or brush to collect oil into collection wells within the vessel (14). Efficiency, however, is a concern, as most skimmers leave much of the oil uncollected. Some skimmers are more efficient for collecting only light hydrocarbons while others will only recover heavy hydrocarbons (14). Often, skimmers collect water in addition to the oil, using up necessary collection space (14).

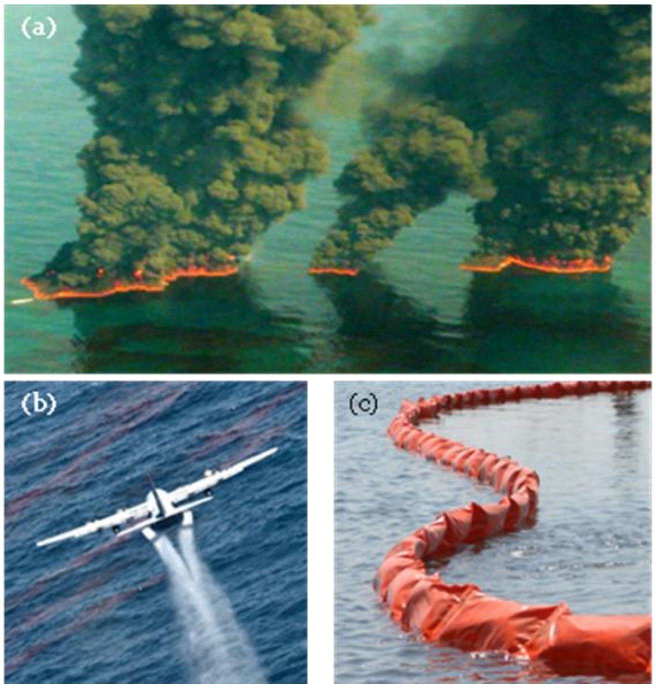

Figure 4. **(a) *In situ* burning**. Courtesy of John Kepsimelis, U.S. Coast Guard defenseimagery.mil **(b) Aerial dispersants.** Courtesy of David Biello (18 June 2010) scientificamerican.com. **(c) Boom/skimmer**. Courtesy of U.S. Coast Guard Eighth District External Affairs.

Sorbents

Sorbents, materials that recover oil through their ability to absorb or adsorb onto their surfaces, have often been used to recover oil. Sorbents are made up of either synthetic materials like plastic or organic materials like hay and clay, and can be highly efficient in retrieving oil in small areas. But they can also have an adverse effect in the environment (12). In cases where sorbents in granular or particulate form are used excessively, sorbents can clog pumps and jam mechanical skimmers, exacerbating the extent of damage (12). In addition, sinking sorbents can further damage the environment, as oil-soaked sorbents on the sea floor may release oil directly on to benthic organisms (15). Sorbents are rarely used in large spills, since tremendous amounts of sorbents would be needed, and disposing of large quantities of contaminated sorbents would be problematic.

In situ burning

In situ burning—the ignition of oil in a controlled area—is often used to clear vast areas of oil in a short amount of time. As compared to other methods of oil removal, burning is particularly advantageous, because it is a one-step solution that does not require transportation, storage, or disposal of the collected oil (12). *In situ* burning is often significantly more efficient than other common response mechanisms such as skimming and dispersants (12). However, burn efficiency can vary dramatically depending on the properties of the oil. For example, oil will not ignite if it is not thick enough or if the oil has been weathered. Additionally, when oil is burned, hydrocarbons present in the oil can be converted to toxic compounds (such as PAHs which are known carcinogens) and released in emissions from the burning process.

RECOVERY TECHNIQUES IN THE DEEPWATER HORIZON SPILL

Many of the recovery techniques described above could not be implemented in the Deepwater Horizon Spill due to the magnitude of the oil release and the relative unpreparedness of the response teams. Shortly after the well blowout, officials began utilizing booms to contain the oil and after a few days, weather and sea conditions hampered the success of the skimmers, at which point cleanup crews began to burn the oil. *In situ* burning, however, was not a feasible approach due to the inflammability of the weathered and aged oil, accompanied by concerns that the resulting toxic fumes would be hazardous to responders and the nearby coastal environment. As the blowout continued to leak even more oil, the sheer logistics of controlling such a magnitude of oil release using traditional methods became impossible. A few weeks later, the damaged wellhead was contained by a large dome fitted with a pipeline that allowed the oil to travel to the surface where it was collected by a storage vessel (10). However, frozen methane that formed on the dome of the transfer cap rendered the containment, transfer, and collection ineffective, and the cap was replaced by a temporary cap to stop the majority of the oil flow (10, 11). But with the new cap, a substantial amount of oil continued to flow from the well. As a result, a panel of scientists evaluating the problem recommended dispersant application, which became one of the most effective techniques used in containing the spill.

Dispersal

Over the past decade, dispersants have been increasingly used in oil spill responses. Designed to enhance the natural emulsification of oil, dispersants do not remove the oil from the environment. Rather, they minimize environmental damage by accelerating the natural relocation of surface oil slicks into the water column. The removal of oil from the surface prevents contamination of surrounding shores, and its presence in the water column enhances biodegradation by increasing hydrocarbon availability to microbes. Dispersants are composed of surfactants—active components containing both hydrophilic and hydrophobic characteristics that stabilize oil molecules and disperse into the water column—and solvents, which keep the surfactants in a soluble form. Dispersant efficacy depends on a multitude of factors, including the physical and chemical properties of the oil being dispersed, composition of the dispersants, mixing energy of the system, and ratio of dispersants to oil (16). Dispersants allow rapid treatment of large areas—even during harsh weather condition—and are often the only practical response technique in large-spill situations (16). The main reason for dispersant application is to prevent shore contamination of oil, which often is more disastrous than channeling the oil into the water column, where it can be degraded. Dispersants are almost always applied to the surface of the oil in an aerosol form from large aircraft or vessels.

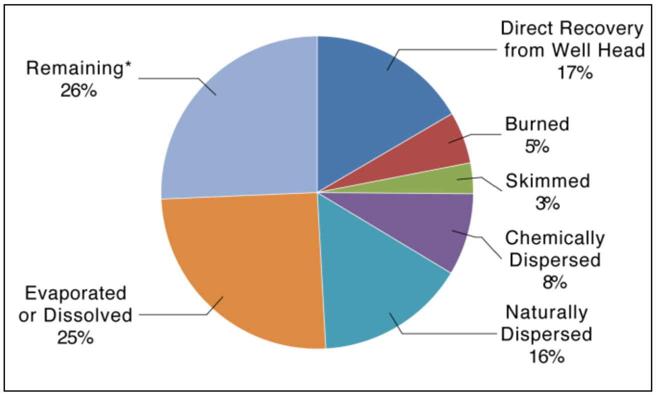

Figure 5. Fate of oil from Deepwater Horizon as of 14 July 2010. Adapted from: The Federal Interagency Solution Group, Oil Budget Calculator Science and Engineering Team (2010). Oil Budget Calculator. *Review Literature and Arts of the Americas*, (November).

The toxicity of oil dispersants is often of great concern to many. In the past decade, dispersants have been developed that are increasingly less toxic, and today's dispersants are less toxic than the oil they act on (12). Additionally, toxicity is not increased when the dispersants break up the oil into the water column since the dispersant mixture is often only present in the water column at very low concentrations (17). Dispersant toxicity has been observed when dispersants are used with oil present in shallow areas, where oil concentration is significantly higher than the concentration of water (12). When oil is dispersed, marine organisms often can detect the oil and swim away, but organisms like plankton and aquatic larvae, which do not have the ability to escape quickly, are often subjected to the toxicity of the dispersed oil. Because of the consequences associated with undispersed oil as well as dispersed oil, dispersant usage is often a trade-off between effects on marine organisms and shoreline species.

After the Deepwater Horizon blowout, 1.4 million gallons of dispersants were applied to the surface and 0.77 million gallons were applied directly to the wellhead (18). Deepwater dispersant application was unprecedented, and there were no studies on the fate of deepwater dispersants that could provide insights into the potential effects of this process (18). However, both cases hypothetically should disperse oil in the same method. Recent preliminary studies have suggested that deepwater dispersant application resulted in small liquid oil droplets that were retained in the deepwater column, with a smaller percentage of oil rising onto the surface. Any residual oil that was not dispersed by the deepwater dispersants was treated by dispersants applied aerially. A total estimate of 32 million gallons of oil was dispersed, with approximately 16% of the oil released (6). Effects of the dispersants were clearly noticeable, as shoreline damages from the oil appeared to be effectively minimized.

Bioremediation

Biodegradation of oil happens naturally, though the process is often too slow to have any effects over a short period of time. Bioremediation, on the other hand, is the process whereby selected high performance hydrocarbon degrading microbes, oxygen, or growth enhancers are added to polluted areas to promote biodegradation (19). The addition of bacteria, however, is oftentimes fruitless, as it is difficult to obtain higher-than-normal levels of degradation, and because these bacteria are often outcompeted by natural bacterial populations—and thus cannot be established at high enough concentrations to be efficient (20, 21). The introduction of growth enhancers (nutrients) or oxygen has the potential to cause more environmental damage due to eutrophication and is often unfeasible for open ocean bioremediation as large quantities of growth enhancers are needed (19). Due to such limitations, as well as the favorable microbial growth conditions, bioremediation was not a feasible option in the Deepwater Horizon spill recovery effort.

OIL TOXICITY

The impact of oil on marine organisms ultimately depends on the fate of the oil. As described previously, when oil is present in the environment, it is either dispersed in the top layer of the ocean (littoral zone) or remains on the surface and consequently on the coastal areas. If the oil is not dispersed, the oil will remain on the surface, and currents bringing oil towards coastal areas will harm coastal organisms like invertebrates, mammals, and birds. However, if it is dispersed, organisms such as fish, plankton, and larvae are immediately subjected to oil toxicity.

General effects

Oil toxicity depends on a multitude of factors, including the oil composition and characteristics (physical and chemical), condition (i.e. weathered or not), exposure routes and regimen, and bioavailability of the oil (4). Hydrocarbon toxicity is additive, and if levels are over threshold concentration, mortality can occur (4). One major effect of oil is narcosis, a reversible anesthetic effect caused by the oil partitioning into cell membrane and nervous tissue, causing central nervous system dysfunction (8). If oil hydrocarbons enter the body, they will travel to the liver where resident metabolic activity can activate components of the oil, increasing their toxic potency. Metabolites of polycyclic aromatic hydrocarbons (PAHs) and aliphatic hydrocarbons, both of which are often present in crude oil, can be highly toxic and carcinogenic (24). In particular, PAHs are the major contributors to toxicity, with different metabolic pathways producing metabolites, which have oxidative and carcinogenic properties due to their ability to attack and bind to DNA and proteins (4).

Toxicity in organisms

Oil enters an organism by two main routes of exposure: through direct contact with the skin or by ingestion and/or inhalation (4). One of the major routes of exposure, physical contact, usually affects birds and furred mammals. Because these animals rely on their outer coats for buoyancy and warmth, these organisms often succumb to hypothermia, drowning, and smothering when oil flattens and adheres to the outer layer (4). A second general exposure route is through ingestion or inhalation of the hydrocarbon by organisms that reside on the surface (4). Exposure by these routes leads to absorption into the bloodstream via the gastrointestinal or respiratory tracts. Due to the volatile nature of hydrocarbons, inhalation of hydrocarbons results in respiratory tract irritation and narcosis of mammals and birds. Toxicity resulting from oil/PAH ingestion occurs in all organisms and results from the action of liver enzymes attempting to degrade the oil PAHs. In addition to detoxification of oil PAHs, liver enzymes also activate PAHs to more toxic and reactive products, many of which are carcinogenic. In smaller organisms, such as plankton and larvae, ingestion of oil often causes mortality, while surviving organisms often show developmental and reproductive abnormalities.

ECOLOGICAL EFFECTS

The long- and short-term effects of oil often depend on the type of spill, the environmental conditions, and methods used to disperse or remove the oil. Differences in such conditions often result in significant differences in ecological and environmental effects. Although current ongoing research is examining the long-term effects of the Deepwater Horizon Spill, studies from a similar oil spill in the same region can provide insight on the long-term ecological effects of the Deepwater Horizon Spill.

Ixtoc I

The Deepwater Horizon spill closely resembled a 1978 Gulf Coast well blowout of the oil platform Ixtoc I, where oil flowed freely for 10 months with a total of 2.2165 million gallons of oil released (22). Numerous attempts to stem the flow failed, and as a result, oil flowed freely at an average of 930,000 gallons per day (22). Ixtoc I responders contained the oil utilizing similar methods as in the Deepwater Horizon spill: mechanical activity removed 4-5% of the oil, and dispersants were used to eliminate the remaining contents (22). Oil further away from the wellhead, however, was found to be weathered, rendering the dispersants ineffective. As a result, oil that coated beaches on the Mexican and Texas coasts wiped out local coastal fauna such as crabs and mollusks (22). Unusually large plankton blooms were observed in oil-contaminated areas, which indicated possible eutrophication or a decrease in zooplankton (their primary predator) caused by oil toxicity (22). In addition, fish and octopi populations dropped by 50-70% after the Ixtoc I spill, and years passed before the populations rebounded (22). Although drastic effects on marine life and ecosystems were observed, the effects of the spill eventually disappeared.

Though very similar to the Ixtoc I, the Deepwater Horizon spill was different mainly due to the dispersant effectiveness. Dispersant injection in the deepwater as well as aerial application over the rig was extremely effective as the oil was fresh and warm. Due to the dispersant effectiveness, coastal regions were not impacted as they were after the Ixtoc I spill. Without any coastal area contamination, populations of mollusks and invertebrates residing on the coastal areas and marshes were not affected to the same degree as in the Ixtoc I spill. However, since the oil was dispersed, there has been early indication that littoral communities were more adversely affected as greater concentrations of oil-derived PAHs and hydrocarbons were bioavailable to these species. In particular, preliminary reports indicate that oil and dispersant mix was found in blue crab larvae, suggesting that small droplets of oil-dispersants could have entered the food chain (28). PAHs from dispersed oil have been observed in contaminated regions and may point to potential long-term adverse effects such as carcinogenesis in littoral organisms. PAH and hydrocarbon toxicity can cause mortality in plankton, zooplankton, and larvae, though their effects are not observed until much later and typically appear as drastic decreases in populations. If no mortality is seen in such microorganisms by oil-derived chemicals, bioaccumulation via diet could occur and possibly cause toxicity higher up in the food chain. When the dispersed oil settles onto sediments on the sea floor, it remains persistent and can be long-lasting in anoxic sediments, which may cause toxicity in benthos-dwelling organisms (12). Until further studies eliminate or confirm such possibilities, many of the above scenarios remain highly likely, and ecosystem recovery may take years.

CONCLUSION

The Deepwater Horizon Spill has no doubt dramatically affected the Gulf of Mexico environment, as oil toxicity has adversely affected many marine organisms and will continue to have long-term effects. As witnessed in the Ixtoc I blowout, toxicity will continue to impact marine populations, with ecological restoration and population recovery taking years. When comparing between different oil spills such as the Exxon Valdez spill, it is important to understand that differences in the environment will play a crucial role in oil degradation.

The instant oil is released into the environment, many natural oil degradation processes change the properties of oil and ultimately degrade the hydrocarbons. Oil can evaporate off of the surface, undergo photodegradation, and most importantly, it can be dispersed into the littoral region where it is ultimately degraded by microbes. The combination of a microbe-favorable environment and the presence of established oil degrading microbes contribute to the main differences when comparing the slow recovery of the Exxon Valdez spill to the major spills that have occurred in the Gulf of Mexico.

The use of dispersants has been harshly criticized, as many fear for the environmental and toxicological impacts of the dispersants. In reality, the dispersants themselves—which mostly comprise of material similar to soap—are not extremely toxic. The resulting toxicity derives from the bioavailability of the oil after dispersal, as it becomes suspended in the littoral region where organisms can be directly exposed to the oil-derived hydrocarbons. Due to limited resources in physical containment and collection of oil, responders had few options. They were faced with the choice of either doing nothing—allowing the oil on the surface to travel and coat marshes and other economical valuable coastal regions—or dispersing the oil, where the oil will remain in the littoral zone. Both options could cause harm to organisms dwelling between both regions, and responders needed to choose the option that would most minimize environmental impact. The actual long-term impact on the Gulf will be unknown for years to come, though we know for certain that the current environmental state of the Gulf Coast and the coastal regions resulted from dispersant application.

The media dubbed the Deepwater Horizon spill to be one of the largest spills in history, though the reality is that a Deepwater Horizon-like spill (Ixtoc I) had previously occurred in the Gulf of Mexico. Both the Ixtoc I Spill and the Deepwater Horizon Spill presented similar problems, primarily the inability to fully respond to the spill with tools that would minimize environmental impact. Measures must be taken to ensure that response teams will have the tools necessary to respond quickly and effectively to spills of this nature in the future.

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