The Potential Impacts of the Gulf of Mexico's 2010 *Deepwater Horizon* Oil Spill

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Abstract

This essay attempts to answer the question "How might the repercussions of the BP Oil Spill on marine organisms in the ocean's deep scattering layer affect Gulf ecosystems such as Barataria Bay in Louisiana?". The essay begins by describing the *Deepwater Horizon* oil well blowout and giving background on the location and composition of Barataria Bay. It then recounts the visible damage of the spill to Gulf shorelines and marine mammals and describes the composition and importance of the ocean's deep scattering layer. After discussing serious environmental effects potentially brought about by the oil and possible repercussions of the spill on the marine food chain, the essay relates these impacts back to human society in terms of the U.S. economy, the Gulf's fishing industry, and the overall world energy crisis.

Although no definitive conclusion is reached in the essay, as the oil spill happened recently and it will likely be decades before the true effects can be determined, the arguments point to many possible, detrimental repercussions on the marine food chain. The effects of such an enormous oil spill, the delayed response of both BP and the U.S. government, and the irresponsible cleanup techniques that were used could have potentially caused significant environmental effects that would be extremely difficult, if not impossible, to reverse. The environmental effects examined in this essay would have serious impacts on the deep scattering layer, which serves as the base of the marine food chain; any changes to this community would impact the entire marine ecosystem in the Gulf of Mexico.

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I. Background on the *Deepwater Horizon* oil spill

On April 20, 2010, flammable methane gas shot out of a broken seal on an oil rig drilled 5,000 feet below sea level and 50 miles offshore in the Gulf of Mexico. The *Deepwater Horizon* oil well, leased to British Petroleum (BP), contained a blowout preventer that malfunctioned and did not cap the well when the gas was released. Instead, oil gushed out of the shaft, reaching an estimated 2.6 million gallons per day (Juhasz 7). The explosion not only killed eleven workers on the spot (Juhasz 238); it also caused "the largest unintentional oil spill in world history" (Juhasz 57). The oil reached the shores of four states and entered the Gulf of Mexico's Loop Current, which transports waters into the Atlantic Ocean (Juhasz 83). The spill littered beaches with tar balls and coated native wildlife with slime, and footage of the physical impact shocked the world (Haugen 8).

One area that was deeply affected by the disaster is Barataria Bay in Louisiana. It is the secluded home of many non-migratory species, such as the dolphins that reside there, as well as the breeding ground for many migratory, deep-sea creatures whose larvae grow and mature in the calm waters of the bay (Skloot, Skloot, and Cohen 88-89). Lousiana's marshes are described as a "unique confluence of saltwater, fresh water and brackish marshes" which provides an ideal environment for breeding. The mangroves and marsh grasses provide an excellent buffer to frequent hurricanes from the Gulf and provide "a bounty of crabs, shrimp and other crustaceans and additional life forms that keep the Gulf fed". This annual influx and outflow of species in Barataria Bay has fueled the survival and biological success of this ecosystem for thousands of years, and the single catastrophe of the BP Oil Spill could change its course permanently (Jervis).

The survival of species that reside near the surface of the Gulf in areas like Barataria Bay are not just in danger because of the direct effects of the oil spill; even if these effects were discounted, the crucial relationship of these surface species to the organisms of the suffering "deep scattering layer" could be enough to permanently impact this ecosystem. Most common marine organisms live in the upper, epipelagic zone of the ocean, but feed at night on organisms that are part of the deep scattering layer, or the DSL (Skloot, Skloot, and Cohen 84). This investigation is important because the effects of the oil spill on DSL organisms could have a significant impact on the survival of marine organisms in the Gulf, which is one of the world's most biologically diverse and fragile ecosystems. Due to the nature of marine food chains and the tendencies of the fishing industry, eventual impacts on areas like Barataria Bay as well as on human society in the Gulf may be very detrimental.

II. *Deepwater Horizon*'s Physical Damage

The immediate effects of the blowout were obvious, and very similar to those in the 1989 *Exxon Valdez* spill in Alaska's Prince William Sound, which up until 2010 had been the largest oil spill in U.S. history (NOAA). On March 24, 1989, the *Exxon Valdez* ship hit a rock reef and spilled 258,000 barrels of oil into Prince William Sound over the course of just five hours (Loughlin 1-2). As a result of the spill, sea otters, birds, and other animals were coated with oil, and many of these organisms eventually died from stress, heat loss, and poisoning (Markle 7-8).

Pelicans, dolphins, and other marine mammals were also covered with oil on the Gulf's shores after the *Deepwater Horizon* blowout, and large quantities of oil are still washing up on beaches. Exposure to oil is killing organisms at all stages of life, and is affecting breeding prospects, offspring mortality, and the future survival of certain species (Skloot, Skloot and Cohen, 89-90). There will likely be significantly fewer 2010 offspring that are able to "return as adults" after this disaster; this could have huge effects on the numbers of each species, success in reproduction, and health of the entire marine food chain (Haugen, 86). Endangered and threatened Gulf species such as brown pelicans and Kemp's Ridley turtles are already under stress from environmental issues like dead zones and overfishing, and are now facing added pressure from this spill (Skloot, Skloot and Cohen 94-95).

The physical impact on the Gulf's marshlands may also have detrimental effects on the health of the entire ecosystem. Marsh grasses that have been soaked in oil become "anaerobic at the roots", increasing vulnerability to weather and the likelihood that the next time a major tropical storm comes through the Gulf, "marshy islands" that serve as breeding grounds and nurseries for young marine organisms will disappear (Skloot, Skloot and Cohen 96). Additionally, oil is now buried in sediments on the floor of the ocean and the Gulf's marshes and waterways (Haugen 35). When organisms dig for prey in future years, they will likely dig up buried oil from the spill and in this way will be continually exposed to the oil (Haugen 39). However, the effects of the spill cannot be accurately represented by visual damage on shores miles away from the blowout site (Haugen 9). Perhaps the real damage lies below the surface in the deep scattering layer.

III. The Deep Scattering Layer

When the ocean was first being mapped out by scientists in the 1920s, the "daytime" seafloor appeared to be at 3, 300 feet below the ocean's surface; however, at night it appeared to rise "perplexingly towards the surface" (Skloot, Skloot and Cohen 84). In 1942, Navy scientists testing sonar systems "regularly encountered an echo from around 900 feet where no bottom existed", and named it the "deep scattering layer". Organisms such as hatchet fish, lantern fish, crustaceans, krill, jellyfish and phytoplankton can be found in the DSL. Many organisms in this layer have gas swim bladders that allow them to be sensitive to pressure differences and remain still at any depth; these bladders are also "excellent sound scatterers" and are likely responsible for the acoustic properties of the deep scattering layer (Ellis 261-262).

The marine organisms that live and breed closer to the surface could not survive without the creatures of the DSL, which form the foundation of the marine food chain. The organisms in the deep scattering layer "believed to account for 80 percent of all the biomass in the mesopelagic zone…perhaps the greatest distribution, population, and species diversity of all ocean fish on the planet" (Skloot, Skloot, and Cohen 85). DSL organisms have evolved photophores, or large eyes and organs, that can produce light for communication and camouflage ("counterillumination") that matches the amount of light filtered from the ocean's surface and helps to conceal these organisms from predators as they migrate up towards the surface at night (Skloot, Skloot, and Cohen 84). The DSL is a fundamental element of marine ecosystems around the world that brings together "layers of life gathering in extremely high densities to feed or to avoid being eaten" (Skloot, Skloot, and Cohen 101). This layer acts as both a crucial food source for surface organisms such as dolphins and fish in higher trophic levels as well as a predator for organisms in lower trophic levels such as plankton (Ellis 263-264).

Now that the oil has contaminated Gulf waters, especially in the mesopelagic and bathypelagic regions, the DSL will continue to rise at night to surface species waiting to feed above; only this time these organisms will be "ascending an ocean fouled with a toxic broth of oil, methane, chemical dispersants, and drilling mud" (Skloot, Skloot, and Cohen 87). The DSL is constantly moving up and down the vertical water column as well as inshore and offshore; this movement increases the likelihood that not only the organisms of the DSL, but the organisms that feed on it and the organisms which it feeds on, "will be exposed to the pollutants at some point in the course of their travels" (Skloot, Skloot, and Cohen 101). These pollutants brought on by the spill are bringing many environmental issues such as oil plumes, dead zones, and mucus layers into effect.

IV. Environmental Effects

Cleanup techniques for the spill, which were used to try to lessen the environmental impacts of the oil, were not implemented in a timely manner by the U.S. government or BP, nor were they very effective in cleaning up the spill. Booming and skimming surface material accounted for only 4% of the spilled oil (Juhasz 96-97). BP spread containment and absorbent boom around damaged shorelines to collect the oil, yet dispersants were also used to spread out the oil. Carl Safina, cofounder of the Blue Ocean Institute, expressed his frustration at the contradictory clean-up techniques: " 'Do you want to contain it or disperse it? It makes absolutely no sense to be doing both. Let's face it, with pollution, you count your lucky stars if you have what's called point-source pollution, that is, a single identifiable localized source of pollution, like the *Deepwater Horizon*. So what's BP doing with that? They're turning it into the worst pollution nightmare of them all: non-point-source pollution' " (Skloot, Skloot and Cohen 91). While the dispersants did their job of breaking up the oil and lessening its concentration in a given amount of water, they also spread it much farther than it might have travelled on its own (Juhasz 98). Common household chemicals like soaps and dishwashing liquids, as well as industrial and agricultural waste, also act as oil dispersants and are funneled down the Mississippi River straight into the Gulf of Mexico (Safina 102).

As the Gulf is also home to natural oil reservoirs below the ocean floor, natural seepages and oil leaks occur occasionally. Although slightly detrimental to an ocean ecosystem, marine organisms have adapted over time to survive these occasional oil leakages. Especially helpful in this process are microbes, which naturally break down oil. The "BP blowout [was] an intense, localized input" of oil, however, and this incident likely had very detrimental effects in the ocean depths of the Gulf. When microbes ingest oil particles, they consume oxygen – the more oil they need to break down, the more oxygen they use up. When large quantities of oil need to be broken down, these microbes produce dead zones, areas with little to no oxygen (Juhasz 92). The Gulf of Mexico, as the dumpsite for chemicals and excess nutrients from much of the United States, including agricultural material such as fertilizer and animal waste from the Midwest, already contains the second largest dead zone in the world (Skloot, Skloot, and Cohen 93). Nutrients such as nitrogen and phosphorus that pour out of the Mississippi River and into the Gulf of Mexico first create algal blooms as algae thrives on the nutrients. Eventual death of this algae leads to rapid depletion of oxygen in the area as aerobic bacteria consume oxygen to break down the organic material; the result is a dead zone, an area that is unable to support most life forms (Bruckner). Every year, the Gulf's dead zone grows larger, and it is currently about 8,000 square miles large – the size of Massachusetts (Safina, 102). Along with dead zone, dispersants also create conditions that are inhospitable to marine life.

Both oil and Corexit (a dispersant used by BP to clean up the spill), when applied alone to marine ecosystems, prove toxic to most organisms. But dispersed oil that has been treated with Corexit is the most toxic of all. The EPA has not studied Corexit's effects on wildlife very closely; there is a possibility that dispersants could kill the ocean's natural microbes that break down oil (Skloot, Skloot, and Cohen 91-92). The dispersants not only break down the oil in the hope that these natural microbes will take advantage of the bite-sized fragments; they also break down the oil into bite-sized pieces for other marine organisms (Juhasz 105). "'Dispersants increase the time period in which aquatic life is exposed as well as the area extent of exposure in the water column […] this increases the number of aquatic animals that are subjected to toxic conditions as well as the degree of toxicity'" reported Jacqueline Savitz, a director of Oceana (Juhasz 101). In this oil spill, the unique application of the dispersants ensured that both surface organisms and deep-sea organisms were directly exposed to the chemicals.

Corexit 9527 and Corexit 9500, both banned in the UK, were applied to the spill not only on the ocean's surface, but near the sea floor as well. When applied to a surface spill, dispersants break up oil to be biodegraded, but when applied deep underwater, oil fragments can be more easily incorporated into the water column, attaching to plankton and other marine organisms, and can take longer to biodegrade (Cavnar 172-173).

Corexit had been approved by the EPA for application on the ocean's surface, but not for application below the surface (Juhasz 100). Dispersants had never actually been used or tested "for subsea application" before BP's response to the *Deepwater Horizon* oil spill (Juhasz 99). The EPA issued a statement to BP on May 26, 2010 demanding that no more dispersant be used on the spill "except 'in rare cases'", but BP continued to apply large amounts of Corexit to the oil (Juhasz 107-108). BP is "financially liable for each barrel of oil and gas spilled" as well as "for all of the harm caused by their release". However, dispersants can "make it more difficult to measure exactly how much oil is escaping from a well"; essentially, BP's financial responsibility could be greatly lessened due to use of dispersants (Juhasz 106). In total, BP used almost 2 million gallons of dispersants and around 40% were applied underwater (Juhasz 98).

Dispersants don't remove the oil - they just dilute it and spread it out over a greater area (Juhasz 98). Since the oil did not remain concentrated around the wellhead for long, where did all of this oil go? On May 15, *The New York Times* announced that scientists had discovered giant plumes of oil in the depths of the Gulf of Mexico (Juhasz 79). The existence of oil plumes from the well blowout could also have detrimental effects on deep-sea organisms. The plumes indicate that a lot more oil was released from the wellhead than previously thought (Juhasz 79). These great oil monsters are completely submerged underwater and are invisible from the ocean's surface, potentially affecting deep-sea marine ecosystems but not the Gulf's shores (Haugen 9). After the appearance of the *Times* article, BP refused to acknowledge that these plumes did in fact exist (Juhasz 79). In June 2010, a team of scientists from the Woods Hole Oceanographic Institution documented an oil plume from the spill that was 22 miles long, 656 feet high, 1.24 miles wide, and located at a depth of 3,600 feet (Juhasz 81). According to Dr. Joye, there is a "shocking amount of oil in the deep water […] in multiple layers, three or four or five layers deep in the water column" (Juhasz 79). The plumes could help to explain why estimates of the flow rate from the wellhead vary so much; a lot of the oil that was released from the *Deepwater Horizon* oil well could be hidden in the deep ocean (Juhasz 80).

When released oil in the form of ashes from controlled surface burns, traces from underwater plumes, and chemically dispersed oil find their way to the ocean's depths, natural microbes start to break these remnants down and release a mucus-like substance. The mucus then sinks down to the very bottom of the ocean, where it covers the ocean floor, making it harder for organisms like worms that live in the ocean bed to come up out of the sand and feed (Juhasz 113).

Other environmental effects of the spill include exposure of other chemicals and toxins to marine life. Approximately 40% of emissions from the *Deepwater Horizon* oil well were methane, a greenhouse gas that is lethal to most organisms (Skloot, Skloot, and Cohen 92). Added methane may also be fueling "blooms" of microbes that thrive on methane but use oxygen and create dead zones in the process. "Muds", or drilling fluids from the wellhead, are "pumped into wells to keep the highly pressurized oil and gas from exploding upward". These fluids were also released from the wellhead, along with the oil and methane, and the fluids added heavy metals such as lead, mercury, arsenic, and cadmium to the marine ecosystem. In addition, oil in the ocean "prevents seafloor sediments from bonding with and burying arsenic that naturally occurs in the ocean", which allows arsenic levels to rise throughout the ocean. Unnaturally high arsenic exposure disturbs phytoplankton photosynthesis, causes unnatural behavior and birth defects in marine organisms, and kills predators that consume prey poisoned with arsenic (Skloot, Skloot, and Cohen 93). Perhaps these hidden effects of the oil in the Gulf encompass the true environmental cost of the spill and point to the possible impacts on the marine food chain.

V. The Gulf's Food Chain

The survival and reproduction of DSL organisms is crucial for the entire marine food chain in the Gulf, as these organisms serve as both predators for smaller organisms such as plankton and prey for larger marine mammals closer to the ocean's surface. A change in the population of any organism in the marine food chain is detrimental to the entire ecosystem, and the pressures placed on the DSL after this oil spill are likely to have serious effects on the entire marine food chain.

According to Dr. Samantha Joye, a marine science professor at the University of Georgia (Haugen 44) that testified to Congress in June 2010 about the effects of the oil spill on the Gulf's marine ecosystem, "Everything from the base of the food web […] to the higher order consumers […] will suffer direct consequences of the BP blowout as long as there is oil in the system, due to the inherent toxicity of crude oil components". Oil is a very toxic substance, containing high amounts of volatile organic compounds (VOCs) such as benzene, a human carcinogen. It also contains heavy metals, which can be ingested along with oil by organisms at the bottom of the food web and magnified up through successive trophic levels to fish and other marine organisms that we as humans consume (Juhasz 90). In biological magnification, organisms at higher trophic levels, such as humans, have higher concentrations of chemicals in their tissues than the organisms they consume because tissues from many organisms in one trophic level are needed to nourish one organism in the trophic level above (USGS).

As a marsh ecosystem, Barataria Bay is part of Louisiana's crucial "coastal water system that regularly flushes with tides that mix salt water and fresh water". These ecosystems are home to an array of organisms that is "more biologically diverse than the Everglades" and that includes mostly organisms that are not directly part of the DSL, such as dolphins and seabirds (Cart). However, these organisms feed on and are wholly dependent on the survival of organisms in the ocean's depths, and trophic cascade, the "collapse of an ecosystem starting at the bottom of the food chain", could be part of the Gulf's future if organisms of the deep scattering layer are truly harmed by the effects of the oil spill (Cavnar 108). This has very important implications for human society in the Gulf.

VI. The Impact on Human Society

The Gulf's economy is heavily invested in two industries: drilling and fishing. After the Obama administration's moratorium on new deepwater drilling operations, workers and families were impacted negatively and the region went through enormous economic losses. The fishing industry was also affected due to the timing of the oil spill: its April blowout date coincided with the very beginning of the summer fishing season (Haugen 9). After the oil spill, food safety regulations and government water closures temporarily prevented most fisheries from selling the majority of their catches, which had been contaminated by oil exposure (Haugen 39). Around 70% all oysters and 80% of all shrimp produced in the U.S. comes from the Gulf (Juhasz 104). If a dollar value was assigned to the Mississippi River Delta, it would represent a U.S. economic asset of $330 billion to $1.3 trillion (Cart). The Gulf fishing industry is completely dependent on the health and regularity of the deep scattering layer, which sustains the fish and seafood that their boats catch to sell.

Today, the Gulf region is still hurting badly due to lost jobs, income, resources, and economic profit. The Gulf region depends so heavily on the survival of its rich marshes and marine ecosystems; yet it is invested so heavily in deepwater drilling, which caused what could become the largest and most destructive oil spill in history.

VII. Our Oil Addiction

In my essay, I attempted to tie together information about a similar oil spill (the *Exxon Valdez* spill), known environmental effects of oil, the nature of marine organisms, and the economic impact of the BP spill to make a tentative statement about the likely effects of the *Deepwater Horizon* blowout on the Gulf's ecosystem and human society. As this oil spill has recently happened, it is impossible at this point to know what the eventual, long-term effects of this disaster will be. However, my research may indicate that the incident will have significant implications for the marine food chain and the fishing industry. The whole incident was one big, unintentional science experiment, and just as traces of the *Exxon Valdez* spill are still being found in Alaska, this spill will likely have repercussions for decades to come.

Although the impacts of the *Deepwater Horizon* blowout on the Gulf economy and fishing industry may be detrimental in the long term, many consequences of the spill as related to human society were instead almost immediate. Many fisheries were closed down within a short time after the spill, and fishermen had to scramble to find a source of income, in many cases from new jobs created by BP to clean up the spill (Cavnar, 175). However, the potential long-term environmental effects of the oil and dispersants on the deep ocean are even more concerning. We as humans almost have an unofficial "don't ask don't tell" policy about environmental impacts on the deep ocean (Skloot, Skloot, and Cohen 98). There is still so much more to learn about deep-sea marine life, but human impacts such as overfishing and oil pollution may be destroying these organisms before we even discover them (Skloot, Skloot, and Cohen 96). These deep-sea organisms play a crucial role in the survival and health of the entire Gulf marine ecosystem, and like the aftermath of the *Exxon Valdez* spill, it will likely take us decades to figure out exactly what impact the spill has had on the marine environment and the creatures that reside within it.

Oil dependency in our modern world is a huge problem, but until we come up with a highly dependable source of cheap, renewable energy, oil and gas will remain our main energy sources. Until we find better, more sustainable solutions to this worldwide energy crisis, we must make systematic changes to use oil more responsibly and to prevent future oil spills. If a spill does occur, governments, scientists, environmental groups, and oil companies need to come together and respond quickly and effectively using responsible cleanup techniques and other preventative measures. The *Deepwater Horizon* blowout demonstrated to the world that our oil addiction is compromising the planet we live on and fully depend on for our own survival and livelihood, and that unless we take action and change our behavior, some of the world's most beautiful and crucial ecosystems may be destroyed before we ever get a chance to explore them.

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