Summary of Information concerning the Ecological and Economic Impacts of the BP Deepwater Horizon Oil Spill Disaster

On April 20, 2010, the BP oil company's Macondo well blew out in mile-deep water in the Gulf of Mexico, causing the Deepwater Horizon drill rig to explode, killing 11 workers, injuring 17 others, and initiating one of the worst environmental disasters in American history. Over the course of 87 days, the nation watched in horror as numerous attempts to cap the gushing Macondo well failed. When the flow finally stopped on July 15, 2010, an estimated 171 million gallons of oil had leaked into the highly productive and biodiverse Gulf of Mexico.[1] Furthermore, 1.8 million gallons of toxic chemical dispersants were used in response efforts.[2]

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The fallout of this catastrophe included the tragic loss of the workers' lives, harm to the health of many Gulf coast residents, and an ecological and economic disaster that is still unfolding. We are still learning the full extent of the environmental damage, but federal agencies have estimated that the harm will last for generations.[3] The federal government is still in the process of conducting its Natural Resource Damage Assessment, which will document the damage to the Gulf's natural environment and identify the restoration work that the responsible parties will be required to complete; many of these studies are not yet publicly available. Furthermore, some of the businesses and individuals who fell victim to the Gulf oil disaster are still seeking compensation for their losses. The total price tag has yet to be determined. However, nearly five years later, we are starting to better understand some of the ecological and economic impacts. This white paper summarizes a range of published peer-reviewed studies and economic analyses publicly available as of May 2015.

SUMMARY OF INFORMATION REGARDING KEY IMPACTS:

- The oil spill contaminated more than 1,100 miles of coastline, at least 1,200 square miles of the deep ocean floor, and 68,000 square miles of surface water.
- To date, more than $11.6 billion has been paid to Gulf-area individuals and businesses who have suffered economic damages or medical issues as a result of the oil spill. Many claims are still pending. To date, $1.4 billion has been paid to governments for spill-related costs.
- The Gulf of Mexico commercial fishing industry was estimated to have lost $247 million as a result of post-spill fisheries closures. One study projects that the overall impact of lost or degraded commercial, recreational, and mariculture fisheries in the Gulf could be $8.7 billion by 2020, with a potential loss of 22,000 jobs over the same timeframe.
- In 2010, as a result of post-spill fishing closures, shrimp landings decreased by 32 percent in Louisiana, 60 percent in Mississippi, 56 percent in Alabama, while menhaden landings in Louisiana decreased by 17 percent.
- Estimates of lost tourism dollars were projected to cost the Gulf coastal economy up to $22.7 billion through 2013.
- Oyster harvests in Louisiana are at one-third of pre-spill levels due in part to releases of fresh water to protect the coast from oil.
- Marine mammal deaths could be as high as 5,000 individuals.
- A record high number of dolphin deaths and illnesses in the northern Gulf of Mexico have been shown to be caused primarily by oil contamination, coincident with the Gulf oil disaster.
- More than 1,000 sea turtles were found dead following the spill and surveys indicate that tens of thousands of turtles were exposed to oil. Since 2010, more than 2,000 sea turtles have stranded in the Gulf of Mexico. Typical stranding levels are 240 sea turtles per year.
- Nearly 1 million coastal and offshore seabirds are estimated to have died as a result of the oil spill.
- Scientists calculate that 12 percent of bluefin tuna larvae were contaminated by oil during the 2010 spawning season. Lab studies demonstrate that oil contamination leads to heart defects and death of bluefin tuna, as well as other large fish like amberjack, swordfish, and billfish.
- Fish caught in the aftermath of the oil spill were reported to have lesions, which scientists linked to oil spill exposure.
- Three deep-sea coral communities, containing corals hundreds of years old, were extensively damaged as a result of the spill. Moderate to severe reductions in the abundance and diversity of other bottom-dwelling organisms were recorded up to 57 square miles away from the wellhead.
- Unique and highly diverse seaweed habitats harboring deep-sea shrimp, crab, and lobsters suffered a dramatic die-off, reducing diversity by more than 85 percent.

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Deepwater Horizon Oil Spill - MODIS/Aqua and Advanced Land Imager, April 25, 2010. NASA / MODIS image taken from the Aqua satellite on April 25, 2010, showing oil slicks and sheen resulting from the Deepwater Horizon drill rig blowout in the Gulf of Mexico. On this day, the oil slick and sheen covers approximately 817 square miles, and reaches 50 miles from the point of origin.

OVERALL AREA OF IMPACT

Oil spill cleanup operations are rarely capable of recovering or treating more than a small portion of the oil spilled. The Gulf oil spill released approximately 171 million gallons of oil. We don't know the full fate of the oil, but we have some insights. Scientists estimate that approximately half of all the oil and nearly 100 percent of the methane gas released from the well stayed within the deep ocean.[4] The oil that rose to the ocean surface extended over an estimated cumulative 68,000 square miles—roughly the size of Oklahoma.[5] Additionally, as the surface oil weathered, was chemically dispersed, or burned, additional oil descended into the water column or sunk to the ocean bottom.[6] Scientists studying the fate of the oil in the deep ocean estimate the oil that remained in the deep sea contaminated the ocean floor over a minimum area of 3,200 km^2 (>1,200 mi^2), an area equivalent the size of Rhode Island. However, this footprint likely represents only between 4 and 31 percent of the total oil remaining in the deep ocean. For this reason, scientists suggest that area of contaminated seafloor is much larger, but has so far evaded detection due to the patchy nature of the oil settling onto the seafloor.[7,8] The amount of oil and its entrainment in the water column and deep-ocean environment is unprecedented. Numerous efforts are underway to understand the implications of this deep-water disaster.

Researchers calculate that some 22,000 tons of oil washed up on the shores of the Gulf Coast.[9] In total, studies report that 1,773 km (1,100 mi) of coastline were oiled across the Gulf of Mexico (ranging from heavy to trace amounts)[10]; of this, around 500 km were considered heavy to moderately oiled.[11] Estimates are that Louisiana sustained 60.6 percent of total impact, followed by Florida with 16.1 percent, Mississippi at 14.6 percent, and Alabama at 8.7 percent. Within habitat types, beaches made up 50.8 percent of oiled coastline, 44.9 percent was marsh habitat, and 4.3 percent was classified as other shorelines types. Of all marsh oiling, 94.8 percent occurred in Louisiana, while beach oiling was spread across Louisiana (32.9 percent), Florida (31.3 percent), Mississippi (21.1 percent) and Alabama (14.7 percent).[12] Additionally, scientists demonstrated that the capped well continued to leak hydrocarbons into the Gulf of Mexico until at least May 2012, perhaps as a result of a rupture in the well casing.[13]

IMPACTS TO THE DEEP-SEA ECOSYSTEM

Cognizant of the potential impacts to the deep-sea ecosystem, scientists began surveying known deep-sea coral communities shortly after the spill occurred. They found evidence of widespread damage at a coral community located 11 km southwest of the Macondo well, known to be in the path of a documented deep-water oil plume. Within this coral community, nearly half of the coral colonies showed damage on half or more of the colony.[14] Scientists then searched for new, previously unknown coral sites, and found two additional coral communities that sustained damage. One of these newly found sites was twice as far from the wellhead and in water 50 percent deeper than the first documented site, thus greatly expanding the known area of impact.[15] Scientists have shown that the impacted coral communities include corals that are more than 600 hundred years old, and that these coral's slow growth rates and longevity make them extremely vulnerable and slow to recover from disturbances.[16]

Another study examined impacts to bottom-dwelling (or benthic) organisms and found a "severe" reduction of their abundance and diversity in an area of 9 square miles surrounding the wellhead, with moderate effects extending

57 square miles around the wellhead.[17] Scientists report that the deep-sea soft-sediment ecosystem in the immediate wellhead area will likely take decades to recover from the spill's impacts, and that the loss of benthic biodiversity is correlated to an "exponential decline" in deep-sea ecosystem functioning due to the suppression of various populations and associated ripple effects.[18]

In the deep waters of the northern Gulf of Mexico, unique bank habitats (or salt domes) harbor the highest known levels of seaweed diversity in the region. Prior to the spill, scientists had documented rich seaweed assemblages attached to hard coral-like algae called rhodoliths, which provided habitat for deep-sea shrimps, crabs, and lobsters. After the spill, scientists re-surveyed these known salt domes and documented a dramatic die-off of seaweeds—from 60 species to about 10 species. The associated crustacean communities also declined in both abundance and diversity.[19]

Scientists also caution that the studies to date "only characterize the visually obvious and acute impacts on the corals and changes in infaunal communities are likely, including long-term, sublethal impacts to fauna" as laboratory experiments have confirmed the toxicity of oil and dispersant on these communities.[20]

IMPACTS TO MARINE MAMMALS

It is not yet clear how exactly the oil spill has affected the Gulf's 21 different marine mammal species. As of April 2011, officially 170 marine mammals were injured or killed as a direct result of the BP oil disaster (this number reflects the found animals that can be accounted for).[21] However, scientists surmise that the carcasses recovered after the Deepwater Horizon disaster represent only 2 percent of spill-related marine mammal deaths, and have suggested that given no additional information, the true death toll could be 50 times higher, putting the death toll of marine mammals closer to 5,000.[22]

Beyond the immediate death toll, impacts of the BP oil disaster on marine mammal populations continue to play out in an extended Unusual Mortality Event (UME). The BP disaster is acknowledged as the likely cause of a UME for dolphins and whales in the northern Gulf of Mexico. Since February 2010, nearly 1,400 dolphin and whale strandings have occurred (94 percent stranded dead), the longest and largest UME in the history of the region.[23] For perspective, the historical average in the affected region is six strandings per year.[24] There is strong evidence that the primary cause of these strandings is exposure to oil leading to life-threatening diseases and death (and not other potential causes, which were investigated and rejected).[25] This study supported previous research on bottlenose dolphins in Barataria Bay, which was heavily oiled by the Deepwater Horizon blowout, which confirmed that dolphins exposed to oil were afflicted with moderate to severe lung disease at five times the normal rate. Of the 29 dolphins evaluated in this study, half were given a "guarded or worse prognosis." Another 17 percent were considered in grave condition, indicating the likelihood that they would soon die.[26] These studies in combination led scientists to state that "the evidence to date indicates that the Deepwater Horizon oil spill caused the [illnesses] that contributed to the deaths of this unusual mortality event."[27]

In the case of manatees—which are found along the Florida Panhandle, Alabama, and Mississippi—scientists estimate that approximately 74 (ranging from 46 to 107) were exposed to the oil spill, with undetermined lethal or sublethal effects.[28]

Skin tissue collected from Gulf whales following the spill showed elevated concentrations of genotoxic metals (such as chromium and nickel, which are found in the Macondo well oil) in their skin. Scientists suggest that metal exposure is an "understudied concern" to whales swimming through oil-slicked waters.[29] Another study found that the chemical dispersants used during the oil spill can both kill cells and damage cell DNA of sperm whale skin cells at relatively low exposure, leading to sublethal but perhaps long-term harmful effects to whales.[30] (It is unknown, whether sperm whales actually came into contact with chemical dispersants at the concentration tested in the lab.) Endangered sperm whales were also observed to relocate away from the spill, with unknown implications to fitness and reproduction.[31]

IMPACTS TO SEA TURTLES

More than 1,000 sea turtles were found dead following the oil spill, hundreds of which were found with oil in their mouths, pharynges, and esophagi. Surveys conducted in 2010 indicate that tens of thousands of turtles that inhabit coastal waters during their lifetime were exposed to surface oil.[32]

Like whales and dolphins, sea turtles experienced an elevated number of strandings following the oil spill. Since 2010, more than 2,000 sea turtles, mainly endangered Kemp's ridleys, loggerhead, and green turtles, have stranded in the north-central Gulf of Mexico (data as of August 25, 2013).[33] For comparison, on average about 240 sea turtles strand annually.[34] Possible impacts from the Deepwater Horizon oil spill are being investigated, but no determinations have yet been made.

According to the National Oceanic and Atmospheric Administration (NOAA), "Sea turtles live for many years (decades) and the full extent of impacts to the five affected species of sea turtles may not be apparent for many years. The evaluation of impacts to nesting, oceanic, and neritic turtles is ongoing."[35] (Neritic turtles spend some portion of their life cycles in coastal waters).

IMPACTS TO SEABIRDS

Like marine mammals, calculating the true extent of seabird mortality requires accounting for birds killed but never recovered. Two recent studies—one focused on coastal bird mortality and the other focused on offshore bird mortality—indicate that approximately 1 million seabirds were likely killed as a result of the oil spill. Coastal bird mortality (those killed within 25 miles of shore) was estimated by two separate models to be between 600,000 and 800,000 birds. Scientists estimated that 32 percent of the northern Gulf population of laughing gull was killed along with 13 percent of the royal tern population, 8 percent of the northern gannet, and 12 percent of the brown pelican population.[36] Offshore bird mortality was harder to establish, given the historically sparse data on birds living offshore, but scientists estimated between 36,000 and 670,000 birds died offshore as a result of the spill, with the most likely number near 200,000.[37]

Scientists have also begun looking at birds that overwinter in the Gulf of Mexico, but reside elsewhere during the year. Common loons captured in the winter off the coast of Louisiana were found to have low but increasing concentrations of polycyclic aromatic hydrocarbons (PAHs) present in their bodies from 2011 to 2012. Scientists are still working to determine if the current concentration levels adversely impact Common loon health.[38]

IMPACTS TO OCEAN AND ESTUARINE FISH SPECIES

Assessing the impact of the oil spill on marine and estuarine fish species is difficult. Because in-situ testing is so difficult, toxicity testing in the lab is used to determine the levels that oil and dispersant concentrations can either kill or harm aquatic organisms. According to NOAA, scientists have demonstrated, through both field and laboratory studies, a number of sub-lethal impacts of oil exposure, including:

- Disrupted growth, development, and reproduction;
- Tissue damage;
- Altered cardiac development and function;
- Disrupted immune system;
- Biochemical and cellular alterations; and
- Changes in swimming ability and other behaviors that can adversely affect an organism's viability in the natural environment.[39]

Researchers have assessed which fish species were potentially in the region of the spill, and their likelihood of harmful exposure. They found that more than 60 different species were likely to have been in the spill region. Of these species, 40 are endemic, or found only in the Gulf of Mexico.[40]

The Gulf of Mexico is the only confirmed spawning ground of the western population of Atlantic bluefin tuna, and the oil spill coincided with the tuna's peak spawning season. Scientists calculate that approximately 12 percent of bluefin tuna larvae were caught in contaminated waters during the six-week peak spawning period.[41] Subsequent laboratory studies found that bluefin tuna embryos exposed to oil suffered serious defects in heart development. Scientists conclude that these defects led to the deaths of young bluefin tuna, as well as other Gulf populations of tunas, amberjack, swordfish, billfish, and other large predators that spawned in surface habitats covered with oil.[42] Scientists also state that the longer-term effects of the oil spill on bluefin tuna are still unknown and may not be known for decades.[43]

Despite documented evidence of negative impacts to certain fish species at the organismal (individual) level following the oil spill, there has been no measurable documented impact of the oil spill at the population level of any fish species in the Gulf of Mexico. In light of this apparent contradiction, scientists have identified a number of potential mechanisms to explain it, ranging from the spatial and temporal variability of impacts to the benefits to populations as a result of fishing closures due to the oil spill. But research is needed to test these hypotheses.[44]

IMPACTS TO OYSTERS

Oysters, which are an important component of healthy coastal ecosystems, have long been a mainstay of local Gulf economies, particularly in Alabama and Louisiana. However, oyster populations have been plummeting since 2010. According to the Louisiana Department of Wildlife and Fisheries, "Extensive reductions in oyster recruitment have occurred since 2010, and the dramatic results observed in recent years coincide with the occurrence of the 2010 Deepwater Horizon oil spill and response efforts. Research is ongoing into the possible impacts of oil, dispersant, and freshwater releases to Louisiana's near shore environment, including to oysters and oyster habitat."[45]

In 2010, the state of Louisiana released large volumes of freshwater from the Mississippi River in order to reduce the movement of spilled oil into sensitive marsh areas. However, freshwater decreased salinity in the oyster grounds below that which oysters can tolerate and resulted in substantial mortality of oysters.[46] Samples taken across the northern Gulf of Mexico in 2010 found that oyster larvae were rare or absent, and oyster recruitment in 2011 and 2012 was very low. Oyster harvests have subsequently collapsed. For example, in 2010 and 2011, Louisiana oyster production dropped to roughly half of historical harvest. It then plunged to a small fraction of historical harvest in 2012 before slightly rebounding in 2013 to less than a third of historical harvest.[47]

Booms laid to protect the coastline

OTHER IMPACTS TO MARINE AND ESTUARINE HABITATS

Preliminary analyses released by NOAA document a number of additional impacts to marine and estuarine habitats of the Gulf of Mexico, although studies are still ongoing to determine what degree of injury this caused to organisms associated with these habitats. For example, the analyses show:

- Shallow water sediments (those within 1 km of shore) were contaminated with oil at a level sufficient to adversely affect the health of organisms and overall ecosystem productivity;
- At least 10 square miles of seagrasses that provide food and shelter for a wide variety of organisms were oiled and/or adversely affected by response activities;
- At least 600 miles of sand beach habitat was oiled, and at least 400 miles of oiled beaches also experienced some level of impairment due to response activities; and
- Marsh and mangrove habitats that were oiled experienced loss of vegetative cover and condition, and researchers have also documented a lower abundance of snails—an important prey source for birds—in oiled areas.[48]

Researchers have also documented evidence that oil contaminated a "large portion" of the Gulf of Mexico's floating *Sargassum* mats. These mats are considered an oasis of biodiversity and provide important ecosystem services to marine animals.[49] Another study found an area of upper water column waters to have harmful oil agents 1.5 years after the Macondo well was capped, and that organisms in contact with those upper waters might experience DNA damage, some of which might not be apparent for years.[50] (Note: the linkage of harmful oil agents to Deepwater Horizon oil in this case is speculative.)

Researchers monitoring heavily oiled Louisiana coastal wetlands found PAH levels in wetland sediment samples remained 33 times higher than pre-spill levels, and expect that it will take decades for the PAH concentrations to return to baseline levels.[51] A separate study found that the PAH concentrations of oil trapped in sand along Alabama's beaches has remained constant for four years, suggesting the PAH weathering ceases when oil is submerged, which will prolong the exposure risk of organisms living in the affected beach environments.[52]

ECONOMIC IMPACTS

The economic damages to the communities, businesses, and individuals affected by the spill can be at least partially quantified by examining the damage claims BP has paid to date. As of December 2014, BP has paid more than $13 billion in damage claims, including $1.4 billion to governments for economic damages, and $11.6 billion in economic damages and medical claims to individuals and businesses.[53] The latter number is likely to rise, as the relevant court settlement agreement does not include a cap on paying for legitimate claims, and many claims are outstanding. In 2013, the claims center overseeing claim compensation projected that total claim costs could rise to $19.5 billion.[54]

BP also set up a fund of $2.3 billion for the seafood industry, of which $1 billion had been paid out as of December, 2013.[55] Separately, Halliburton has set up a $1.1 billion settlement fund to compensate businesses and property owners affected by the spill.[56] The affected states have not yet been compensated for economic damages.

Economic Impacts Related to Fisheries

Days after the wellhead explosion, federal and state governments began closing fishing grounds, including some of the Gulf's richest fishing grounds for species such as shrimp, menhaden and oysters.[57] At the height of the spill, 37 percent of federal waters in the Gulf of Mexico were closed to fishing. The State of Louisiana also closed a number of state waters to fishing. As of December 2014, some of those closures were still in effect due to ongoing oiling.[58] In 2010, shrimp landings in state waters decreased by 32 percent in Louisiana, 60 percent in Mississippi, and 56 percent in Alabama (while increasing 15 percent in Florida), while menhaden landings in Louisiana decreased by 17 percent.[59]

In total, the Gulf of Mexico commercial fishing industry was estimated to have lost $247 million due to the post-spill fishing closures.[60] A separate study estimated that

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Buras fishing community listen to Billy Nungesser, Plaquemines Parish president and U.S. Surgeon General Regina Benjamin on 7-20-10.

compensation due to recreational anglers—in the form of restoration investments—as a result of lost fishing opportunities is $585 million.[61]

Additionally, projections of the longer-term economic impacts are troubling. For instance, one study projects the potential overall economic impact of lost or degraded commercial, recreational, and mariculture fisheries in the Gulf of Mexico to be $8.7 billion by 2020.[62] The same study projects a loss of more than 22,000 jobs in the same timeframe as a result of the impacts to businesses that rely on healthy fisheries.

Economic Impacts Related to Tourism

The tourism industry was also impacted heavily by the spill. A study by the Knowland Group in August 2010 found that by June of 2010, 60 percent of hotels surveyed in Louisiana, Alabama, Mississippi, and Florida had experienced cancellations, and 42 percent of these hotels were having difficulty booking future events.[63] Louisiana reported that lost visitor spending through the end of 2010 totaled $32 million, and losses through 2013 were expected to total $153 million in this state alone.[64] Estimates of lost tourism and "brand damage" due to the oil spill were projected to cost the Gulf coastal economy up to $22.7 billion through 2013.[65]

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Shrimping boats in Venice, Louisiana.

Endnotes

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