2. Incident Overview

What Is in This Chapter?

- **Executive Summary**
- **Introduction (Section 2.1):** In brief, what happened after the *Deepwater Horizon* explosion and how did agencies respond?
- **Explosion, Well Blowout, and Containment (Section 2.2):** What happened in the immediate aftermath of the explosion on the *Deepwater Horizon* mobile drilling unit?
- **Consequences of the Blowout (Section 2.3):** How much oil and what other spill materials were released into the Gulf? What response actions were taken to reduce harm to people and the environment from the *Deepwater Horizon* incident?
- **References (Section 2.4)**

Executive Summary

On April 20, 2010, the *Deepwater Horizon* mobile drilling unit exploded, caught fire, and eventually sank, resulting in a massive release of oil and other substances from BP's Macondo well. Initial efforts to cap the well following the explosion were unsuccessful, and for 87 days after the explosion, the well blasted oil and natural gas continuously and uncontrollably into the northern Gulf of Mexico. According to the (U.S. v. BP et al. 2015), approximately 3.19 million barrels (134 million gallons) of oil were released into the ocean, by far the largest offshore marine oil spill in U.S. history. The total volume of oil released is about 12 times more than the 1989 *Exxon Valdez* spill; given the continuous release for nearly three months, the *Deepwater Horizon* spill was equivalent to the *Exxon Valdez* spill re-occurring in the same location every week for 12 weeks.

Oil under pressure gushed into the deep ocean from BP's Macondo well, located about 1 mile (1.6 kilometers) below the ocean surface and about 50 miles (80 kilometers) offshore. Subsea videos captured dramatic images of oil spewing unchecked from the well's broken riser pipe into the deep ocean. Oil moved with deep-sea currents, creating a plume of oil within the deep sea; oil and associated "marine oil snow" also settled on the sea floor. More buoyant oil traveled up through about a mile (1.6 kilometers) of water column and formed large surface slicks; at its maximum extent on June 19, 2010, oil covered over 15,300 square miles (40,000 square kilometers) of the ocean, an area 10 times the size of Rhode Island. Cumulatively over the course of the spill, oil was detected on over 43,300 square miles (112,100 square kilometers) of the ocean, an area about the size of Virginia. Currents, winds, and tides carried these surface oil slicks to the Gulf states, fouling more than 1,300 miles (2,100 kilometers) of shoreline, including beaches, bays, estuaries, and marshes from eastern Texas to the Florida Panhandle. In addition, some lighter oil compounds evaporated from the slicks, exposing air-breathing organisms like marine mammals and sea turtles to noxious fumes at the sea surface.

A wide variety of response actions were undertaken to try to collect and disperse the oil and reduce human and wildlife exposure. A total of 1.84 million gallons (almost 7 million liters) of chemical dispersant were used during the spill (USCG 2011), with the objective of breaking the oil into small droplets. Other response actions included physical removal and burning of oil floating on the water surface, nearshore oil collection, removal of oil and oiled materials along shorelines, major releases of fresh water to keep the oil offshore, beach and fishery closures, construction of berms, and wildlife rehabilitation and relocation.

2.1 Introduction

Source: *U.S. Coast Guard.*

Figure 2.1-1. Explosion of the *Deepwater Horizon* mobile drilling rig.

The April 20, 2010, explosion, subsequent fire, and sinking of the *Deepwater Horizon* mobile drilling unit (Figure 2.1-1) triggered a massive release of oil and other substances from BP's Macondo well.[1] Initial efforts to cap the well following the explosion were unsuccessful and, for 87 days after the explosion, the well blasted oil and natural gas continuously and uncontrollably into the northern Gulf of Mexico.

Oil under pressure gushed into the deep ocean from the BP's Macondo well, located about 1 mile below the ocean surface and about 50 miles offshore. Subsea videos captured dramatic images of oil spewing unchecked from the well's broken riser pipe into the deep ocean. Oil moved with deep-sea currents, creating a plume of oil within the deep sea; oil and associated "marine oil snow" also settled on the sea floor. More buoyant oil traveled up through about a mile of water column and formed large surface slicks; at its maximum extent on June 19, 2010, oil covered over 15,300 mi^2 of the ocean, an area 10 times the size of Rhode Island. Cumulatively over the course of the spill, oil was detected on over 43,300 mi^2 of the ocean, an area about the size of Virginia.

Currents, winds, and tides carried these surface oil slicks to the Gulf states, fouling 1,300 miles of shoreline, including beaches, bays, estuaries, and marshes from eastern Texas to the Florida Panhandle. In addition, some lighter oil compounds evaporated from the slicks, exposing air-breathing organisms like marine mammals and sea turtles to noxious fumes at the sea surface. Air pollution resulted from compounds in the oil that evaporated into the air and from fires purposely started to burn off oil at the ocean surface.

A wide variety of response actions were attempted to contain, redirect, disperse, and remove the oil in order to minimize or mitigate damage to public health, public welfare, and natural resources. Chemical dispersants were applied both on the ocean surface and in the deep sea at BP's Macondo well, with the objective of breaking the oil into small droplets and creating an oil/water mixture that remained suspended in water. Other response actions included attempts to physically remove and collect oil, and to keep oil away from sensitive habitats.

This chapter describes the *Deepwater Horizon* oil spill incident, including a timeline of events and a summary of response actions, in order to provide the context for discussion of environmental harm and restoration in Chapters 4 (Injury to Natural Resources) and 5 (Restoring Natural Resources) of this Draft PDARP/PEIS.

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[1] Three companies owned the Macondo well. BP had a 65 percent share, Anadarko Petroleum Corporation had a 25 percent share, and MOEX Offshore had a 10 percent share (National Commission 2011). If the proposed consent decree is entered by the Court, the United States will not be pursuing natural resource damages against the other responsible parties who are indemnified by BP. See Consent Decree Section XIII (Covenants Not to Sue and Reservations).

2.2 Explosion, Well Blowout, and Containment

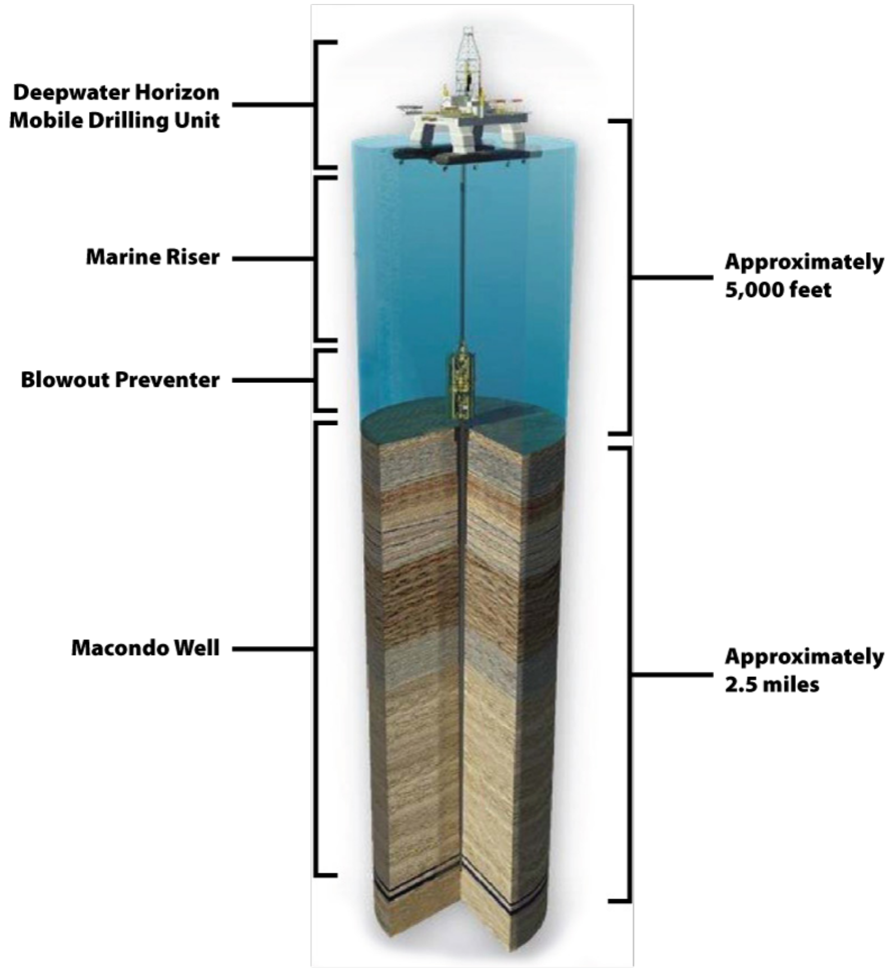
On the evening of April 20, 2010, a blowout, explosions, and fire occurred on the *Deepwater Horizon* drilling rig. The crew members on the rig were engaged in a planned temporary abandonment procedure for BP's exploratory Macondo well, which had been dug to a depth of about 2.5 miles (13,000 feet) below the ocean floor. A series of human errors and mechanical failures resulted in explosions and fire that tragically killed 11 crew members and injured 17 (National Commission 2010). The rig sank two days later, rupturing the marine riser—the almost mile-long pipe that connected the rig at the sea surface to the blowout preventer on the sea floor on top of the Macondo well (Figure 2.2-1).

The explosions should have automatically triggered the blowout preventer, but due to improper maintenance, the automatic function failed to activate. Subsequent attempts to operate the blowout preventer with remotely operated vehicles on the ocean floor also failed to stop the blowout (U.S. v. BP et al. 2014, 2015).

Relevant Terms in This Section

- ***Deepwater Horizon* (DWH):** The mobile drilling rig that exploded. The subsequent oil spill was named after the *Deepwater Horizon* rig.
- **Macondo:** BP's well that the *Deepwater Horizon* was drilling. The top of the Macondo well was on the seafloor, about 5,000 feet below the sea surface. The well extended about 13,000 feet below the sea floor.
- **Mississippi Canyon 252 (MC252):** The lease block where Macondo was located. The U.S. government leases mineral rights in the Gulf of Mexico using a grid pattern, where each cell (lease block) has a unique identifier. The oil that spilled was South Louisiana sweet (low sulfur) crude from MC252.

Within a week after the explosion, BP embarked on an effort to develop containment options for a deep water blowout. Several intervention techniques were attempted, including a cofferdam, a riser insertion tube tool (RITT), an operation to force mud into the well from the top (referred to as "top kill"), a "top hat," and a capping stack. The cofferdam was a large containment dome placed over the leak with a pipe that would channel hydrocarbons from the cofferdam to a collection ship on the ocean surface. This effort failed because the cofferdam became clogged with hydrates that formed when the methane gas escaping from the well came into contact with cold sea water. A smaller tube was then installed into the end of the broken riser (the RITT) to carry oil and gas to the ocean surface. The RITT was in place from May 15 to May 25, 2010, and successfully collected some of the discharged oil (U.S. v. BP et al. 2015).



Source: U.S. v. BP et al. (2014)

Figure 2.2-1. Connection of the *Deepwater Horizon* drilling rig to BP's Macondo well.

The RITT was removed on May 25, 2010, to prepare for an attempt at the top kill operation, which involved trying to stop the discharge by pumping in synthetic-based drilling mud and firing "junk shots" of bridging materials. Unsuccessful attempts were made on May 26, 27, and 28, 2010 (U.S. v. BP et al. 2015).

A "top hat" was then deployed, which was a containment dome smaller than the cofferdam. A top hat was in place from June 3 to July 10, 2010, directing hydrocarbons to the ocean surface for capture or flaring. By June 8, the *Discoverer Enterprise* (a drillship) was collecting nearly 15,000 barrels per day through the top hat. Subsequently, additional steps were taken to increase the collection capacity (National Commission 2010; U.S. v. BP et al. 2015).

From July 10 to 12, 2010, a "capping stack" was installed, which was essentially a smaller version of a blowout preventer. The capping stack was closed off on July 15, 2010, which marked the end of the release, 87 days after the blowout began on April 20 (National Commission 2010; U.S. v. BP et al. 2015).

As all of these spill containment measures were being put into place, two rigs were also mobilized to drill both a primary and backup relief well (National Commission 2010). The relief wells ultimately intercepted the Macondo well and permanently sealed it with cement in mid-September 2010, after the flow of oil had already ceased (U.S. v. BP et al. 2014). Figure 2.2-2 provides a timeline of the key containment attempt events.

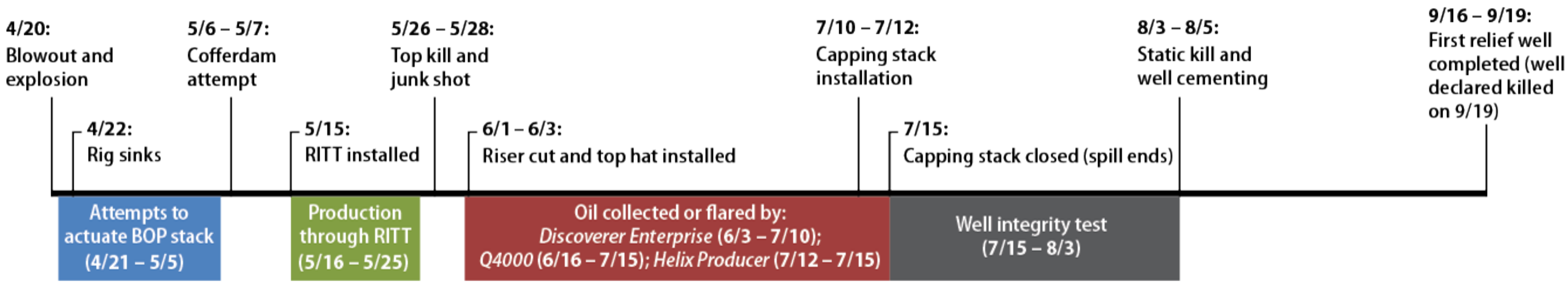


Figure 2.2-2. Timeline of key events of the *Deepwater Horizon* incident in 2010, according to the U.S. District Court (U.S. v. BP et al. 2015).

April 21–May 5:	**Valve attempts:** Attempts to deploy blowout preventer (BOP) valves on the wellhead fail.
May 2:	**Relief wells:** Drilling the first of two relief wells begins. These wells will later be used to inject mud and cement to seal the leaking well.
May 6–7:	**Cofferdam:** A cofferdam (i.e., containment dome) lowered over the leaking Macondo well fails to capture oil when the opening becomes clogged with hydrates.
May 15:	**RITT:** A mile-long tube inserted into the broken pipe begins to siphon off a small fraction of the leaking oil to a ship on the surface for nine days.
May 16:	**Relief wells:** Drilling of the second relief well begins (the spill will be stopped before this well is completed or used).
May 26–28:	**Top kill:** Attempt made to stop the leak by pumping mud and bridging material into the well. The top kill effort consisted of two elements: (1) injecting various bridging materials (such as golf balls, rubber balls, shredded tires, and other materials) into the well to restrict flow (“junk shot”), and (2) pumping mud into the well to overcome the momentum of the flow. These attempts fail.
June 1–3:	**Top hat:** Installation of a new cap/collection system that eventually siphons approximately 15,000 barrels per day to the *Discover Enterprise* on the surface.
June 16 to July 15:	**Q4000:** A second collection system, the Q4000, begins to capture and burn up to 10,000 barrels per day.
July 10–12:	**Capping stack:** A new cap assembly is installed.
July 12–15:	**Helix producer:** A third collection ship, the *Helix Producer*, operates for only three days before the well is capped.
July 15:	**Capping stack:** The capping stack is closed and oil stops leaking into the Gulf.
August 3–5:	**Static kill:** With the capping stack stopping the flow of oil, drilling mud and cement are pumped into the well.
September 16–19:	**Bottom kill:** The first relief well is completed; cement is injected to form a final seal on the well. Well is declared killed on September 19, 2010.

2.3 Consequences of the Blowout

The failure of BP's Macondo well led to 87 days of continuous uncontrolled oil and natural gas discharge into the northern Gulf of Mexico. Oil covered a broad swath of the sea floor, traveled hundreds of miles in deep-sea plumes, rose to the surface through about a mile of water column, and created large slicks at the sea surface. Some of the surface oil subsequently rained back down to the sea floor as oily marine snow.

> **Response to the Spill**
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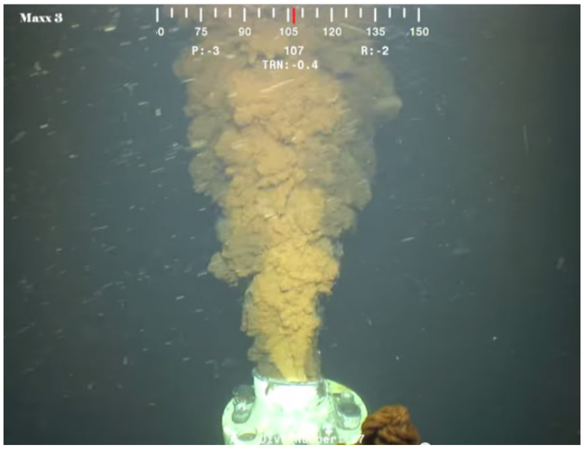
> - Agencies undertook extensive efforts to respond to the *Deepwater Horizon* incident. Response actions included efforts to contain and remove the oil (e.g., burning of surface oil, shoreline cleanup) and efforts to minimize or mitigate damage from the oil (e.g., dispersant application, freshwater releases, and wildlife rehabilitation).
> - Response actions resulted in additional environmental consequences, described in Chapter 4, Injury to Natural Resources.

In addition, the response to this uncontrolled oil discharge resulted in additional environmental consequences, including an unprecedented use of chemical dispersants both at the wellhead and the sea surface, hundreds of oil patches burned at the sea surface, synthetic-based drilling muds released on the sea floor, deployment of boom and construction of berms to prevent oil reaching the shore, and disruptive mechanical collection and removal of oil that reached the shore. Each of these consequences is summarized below.

2.3.1 Release of Oil and Natural Gas

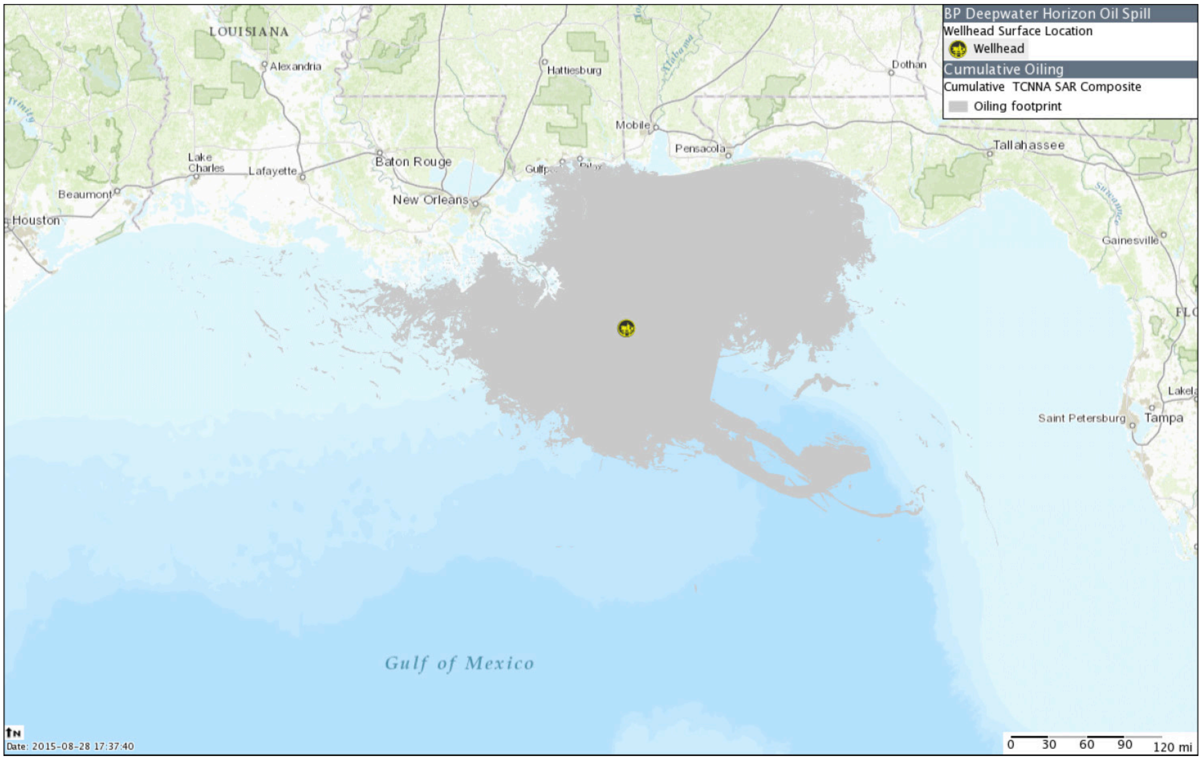
The volume of oil released during the *Deepwater Horizon* incident was unprecedented for an oceanic spill. The release of 3.19 million barrels (134 million gallons) of oil is about 12 times more than the 1989 *Exxon Valdez* spill[2]; given the continuous release for nearly three months, the *Deepwater Horizon* spill was equivalent to the *Exxon Valdez* spill re-occurring in the same location every week for 12 weeks. In addition, it has been estimated that the reservoir contains 2,400 standard cubic feet of natural gas (primarily methane) for every barrel of oil (U.S. v. BP et al. 2015; Zick 2013). At that ratio, at least 7.7 billion standard cubic feet of natural gas was released from the well. Dramatic videos showed the escape of a large plume of oil and natural gas after the riser pipe was cut (Figure 2.3-1).



Source: *DOE (2010).*

Figure 2.3-1. Oil and hydrocarbons escaping from BP's Macondo well on June 3, 2010, during the *Deepwater Horizon* oil spill.

[2] The Trustees for the *Exxon Valdez* oil spill estimated a spill volume of 257,000 barrels for that spill (*Exxon Valdez* Oil Spill Trustee Council, Undated).



Source: *ERMA (2015).*

Figure 2.3-2. Cumulative area of detectable oil slick during the *Deepwater Horizon* spill. As discussed in Chapter 4, Injury to Natural Resources, these oil slicks were detected using synthetic aperture radar from satellites.

The scale of oil released during the *Deepwater Horizon* spill was enormous. Below the surface, a deep-sea plume ultimately extended more than 250 miles southwest of the well (Boesch 2014). Most of the natural gas released was likely consumed by microbes in the deep sea; the footprint of petroleum and brown flocculent material from particulates and microbes falling onto the sea floor covered hundreds of square miles (Kessler et al. 2011; Reddy & Valentine 2014; Stout et al. 2015). The discharged oil rose through the water column to the sea surface, creating widespread oil slicks across the northern Gulf of Mexico (Figure 2.3-2). Cumulatively, oil slicks covered over 43,300 square miles of the ocean surface (ERMA 2015), an area about the size of Virginia. At its maximum extent on June 19, 2010, oil covered 15,300 square miles, an area about 10 times larger than Rhode Island.

The oil on the sea surface mixed with water to form vivid emulsions (Figure 2.3-3) and generally formed narrow strands of thick oil with more widespread areas of oil sheen. Currents, tides, and winds transported the oil to the Gulf Coast, contaminating over 1,300 miles of shorelines from Texas to the Florida Panhandle (Nixon et al. 2015).

The chemical characteristics of oil, the exposure of resources to oil and other spill materials, and the harm caused by this exposure are discussed throughout Chapter 4, Injury to Natural Resources.

Source: *NOAA.*

Figure 2.3-3. Emulsified oil on the sea surface as seen from an airplane on May 18, 2010. When the oil mixed with water, it changed from black to reddish-brown to orange. The oil typically sorted into long but relatively narrow strands of thicker oil, with broad areas of sheen.

In addition, results of air monitoring and sampling showed that volatilization of *Deepwater Horizon* oil released oil constituents into the air. Hydrocarbons evaporating from oil at the sea surface may have formed organic aerosols, ozone, and nitrogen oxidation products, which can impact the lung and heart function of humans and animals (Mauderly & Chow 2008; McDonald et al. 2010).

The chemical properties and behavior of dispersants in the environment are discussed further in Section 4.2, Natural Resource Exposure.

2.3.2 Dispersants

Dispersants are chemicals that reduce the tension between oil and water, leading to the formation of oil droplets that are more readily dispersed within the water column (Waring et al. 2015). A main purpose of using dispersants is to enhance the rate at which bacteria degrade the oil in order to prevent oil slicks from fouling sensitive shoreline habitats.

In response to the *Deepwater Horizon* incident, 1.84 million gallons of two dispersants—Corexit 9500A and Corexit 9527A—were applied: 1.07 million gallons of the two dispersants were applied to surface waters, and 0.77 million gallons of Corexit 9500A were injected directly into the gushing oil at the Macondo wellhead on the sea floor (USCG 2011). The large-scale use of dispersants raised concerns about the potential for toxic effects of dispersed oil in the water column, as well as the potential for hypoxia due to bacterial consumption of dispersed oil.

Response personnel coordinated aerial dispersant operations from Houma, Louisiana, for 90 days from April 21 to July 19, 2010. Aircraft applied dispersant (Figure 2.3-4) over 305 square miles within an 18,000 square mile operating area (Houma 2010).

Source: *U.S. Coast Guard photo by Petty Officer 3rd Class Stephen Lehmann.*

Figure 2.3-4. Aircraft applying dispersant across the *Deepwater Horizon* surface oil slick.

Aerial dispersant applications to surface oil were applied more than 3 nautical miles offshore, with 98 percent of the dispersant applied more than 10 nautical miles offshore (Houma 2010). However, on April 29, 2010, a plane with an engine failure conducted an emergency discharge of about 1,000 gallons of dispersant near the shoreline in western Barataria Bay, Louisiana. Samples collected in the area on June 22, 2010, had no detectable dispersant constituents (Houma 2010).

In addition to aerial application, dispersant was injected directly into the oil plume at the wellhead. *Deepwater Horizon* was the first oil spill where subsea dispersant injection occurred as a response action. Prior to the *Deepwater Horizon* spill, the concept of subsea application had only been tested experimentally a few times in shallow water areas (USCG 2011).

BP requested the use of subsea applications of dispersant in late April 2010 because of greater efficiency and an ability to inject dispersants continually without daylight restrictions on surface spraying. The Coast Guard approved this request on May 15, 2010, after two operational tests were completed (USCG 2011). A total of 770,000 gallons of Corexit 9500A was injected subsea during response activities (USCG 2011).

2.3.3 Drilling Mud

Synthetic-based drilling mud was used in the original drilling of the Macondo well and in the failed top kill response operation conducted May 26 to 28, 2010. These muds include petroleum-based chemicals and barium sulfate, which can smother biota on the sea floor when released in sufficient quantity. During the top kill attempt, mud was pumped into the failed well in the attempt to stop or reduce the flow of oil and gas (USCG 2011). The mud was disgorged and subsequently found on the sea floor near the well (see Section 4.5, Benthic Resources).

2.3.4 In Situ Burning

Between April 28 and July 19, 2010, response personnel conducted 411 controlled, in situ burns of the oil (Mabile & Allen 2010). Aerial spotters directed fire teams to areas of dark oil. Crews contained a sufficient amount of oil using fire boom and then ignited the oil. The largest number of burns occurred on June 18, 2010, when 16 different burns were conducted, consuming an estimated 50,000 to 70,000 barrels of oil (Figure 2.3-5; Mabile and Allen (2010)). The burns conducted during the *Deepwater Horizon* response were unprecedented in U.S. history, exceeding any previous in situ burns in both duration and magnitude (USCG 2011).

Source: *Mabile and Allen (2010).*

Figure 2.3-5. Plumes of smoke rising from in situ oil burns conducted on June 18, 2010.

Aerial spotters directed the controlled in situ burn response personnel to areas that potentially contained burnable quantities of surface oil (Mabile & Allen 2010). When possible, Trustee response personnel attempted to capture and relocate sea turtles and other potentially affected wildlife before burn operations commenced (USCG 2011).

Plumes of smoke from burning oil primarily consisted of aerosolized black carbon soot. These organic particles were measured at high concentrations within the smoke plumes. Organic particles in these plumes were lofted high into the atmosphere by the intense heat generated by the burning oil, increasing atmospheric pollution (Middlebrook et al. 2012).

2.3.5 Skimming

During the *Deepwater Horizon* response, mechanical surface skimmers removed oil and oil-water mixtures from surface waters in the Gulf. Skimming operations covered a wide geographic area and were employed in offshore and nearshore waters and in beaches, bays, and marshes (USCG 2011).

By the end of April 2010, offshore skimming operations included 26 vessels capable of working in deep water, seven dedicated tugboats, and three offshore oil storage barges to support and sustain skimming operations near the well. From early June through mid-July 2010, the number of offshore skimmers increased to a staggering 593 different vessels (USCG 2011). Many of these vessels were commercial fishing vessels reconfigured to serve as skimmers (Figure 2.3-6). The tremendous increase in vessel activity near the well may have impacted marine mammals and other wildlife.

Source: *NOAA.*

Figure 2.3-6. Commercial fishing boat, modified to serve as an oil skimmer, collecting oil from the *Deepwater Horizon* spill in April 2010.

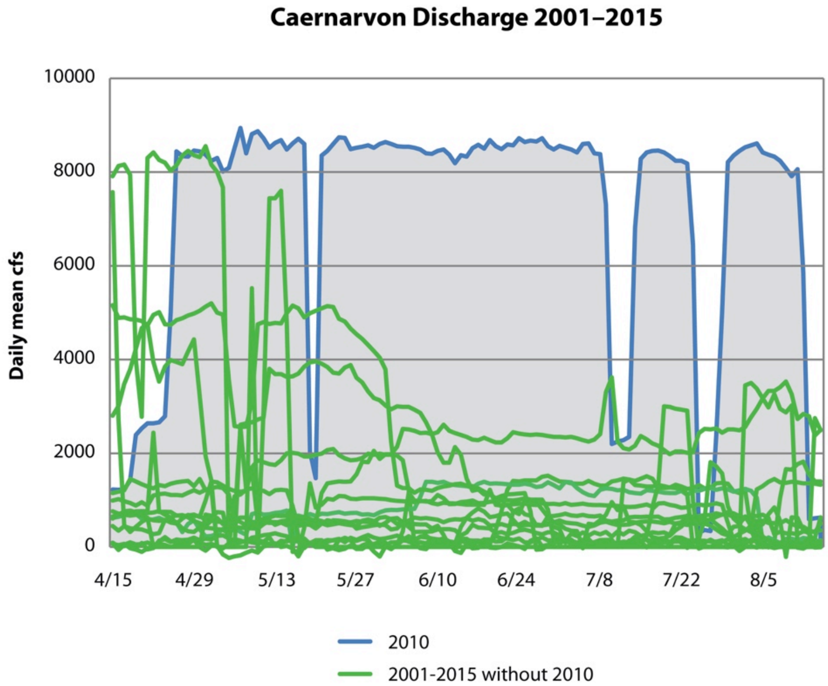
Skimming efficiency varied with environmental conditions. Favorable skimming conditions generally included swells under 2 feet and choppy waves under 2 feet. In the nearshore environment, smaller skimming vessels were used so they could move more quickly between oil patches. The Coast Guard stationed surface skimmers in gaps between barrier islands in an attempt to skim oil before it entered the bays protected by barrier islands. However, much of the emulsified oil that reached the nearshore environment was co-mingled with debris or was tar-like, making it difficult or impossible to skim. In beaches, bays, and marshes, a diverse array of skimming equipment was deployed in an attempt to recover different forms of oil (discussed in more detail in Chapter 4, Injury to Natural Resources), including the vividly colored oil-in- water emulsions (“mousse”), pockets of black oil, tar balls, mats of weathered oil, and sheens (USCG 2011).

2.3.6 Freshwater Releases

With oil approaching the shoreline in April 2010, water from the Mississippi River was released as part of a series of response actions intended to reduce the movement of oil into sensitive marsh and shoreline areas. These actions were taken when efforts to control oil discharge from the Macondo well had been unsuccessful, the amount of oil escaping from the well had been underestimated, and accurate information about the amount was not available. Recognizing the critical importance of Louisiana’s estuarine habitat over the long-term to diverse floral and faunal species, salinity control structures at nine separate locations in Louisiana were opened (Davis Pond, Caernarvon, Bayou Lamoque, West Pointe a la Hache, Violet Siphon, White Ditch, Naomi Siphon, Ostrica Lock, and Bohemia).

The impacts of the atypical release of fresh water on oysters and other nearshore aquatic species are discussed further in Section 4.6, Nearshore Marine Ecosystem.

Unlike the sediment diversions utilized by the State of Louisiana as part of its coastal restoration efforts, the structures opened in response to the *Deepwater Horizon* oil spill have been historically used to manipulate salinity levels and to maintain salinity gradients in the estuaries. As shown in Figure 2.3-7 by the green lines, which depict historical flow rates for the Caernarvon structure, these salinity control structures are typically opened during specific times of the year, for limited durations, and with controlled flow rates intended to make targeted impacts to salinity levels in Louisiana's coastal waters. In contrast, as shown by the blue lines, when used as a *Deepwater Horizon* oil spill response action, these structures were opened at or near maximum capacity for extended periods of time to repel the approaching *Deepwater Horizon* oil. By the time BP's Macondo well was shut down and the salinity control structures were closed in late 2010, the highly atypical flow of fresh water over a sustained period had greatly reduced salinity levels in Louisiana coastal areas.



***Data source:** USGS (2015).*

Figure 2.3-7. Highly atypical flow of fresh water discharged from the Caernarvon salinity control structure during the 2010 spill response (blue line), compared to daily water flow during the summer of years 2001–2015 (green lines).

2.3.7 Shoreline Protection Actions

Response actions designed for shoreline protection included placement of boom, construction of berms, and deployment of Hesco baskets (i.e., wire-mesh baskets filled with sand). Because boom was identified as a critical limited resource, planning strategies were used to prioritize available boom for areas identified as environmentally sensitive (USCG 2011).

Shoreline protection techniques and their impact on natural resources are discussed further in Section 4.6, Nearshore Marine Ecosystem.

2.3.7.1 Boom Placement

Boom was placed and anchored with the intention of protecting shoreline or corralling oil on the water surface to enhance the effectiveness of skimmers or other response techniques (Figure 2.3-8). Boom was deployed and, in some cases, recovered using boats, airboats (in marsh areas), and by hand (on shorelines). Hard boom was used to contain, deflect, or exclude oil from shorelines. Sorbent boom was used to soak up oil and needed to be removed once saturated (NOAA 2010b).

The amount of boom deployed in the northern Gulf of Mexico was extraordinary. By the end of August 2010, some 3.7 million feet (over 700 miles) of hard boom and over 9 million feet (1,700 miles) of sorbent boom had been deployed (USCG 2011). The total length of deployed boom (over 12.7 million feet) is approximately the distance from New York City to Los Angeles.

Source: *U.S. Coast Guard*

Figure 2.3-8. A vessel places containment boom along Barataria Bay to prevent oil from coming ashore.

The Coast Guard's retrospective review of response operations noted that the response effort's booming operations were generally ineffective. Tide, current, and sea conditions made it difficult for the large expanses of containment boom to be tended properly. Environmentally sensitive areas were not identified clearly in existing plans. The booming strategy could be counterproductive, for example, when oil would get on the wrong side of the boom and then be held in place against environmentally sensitive areas. Boom also became "stranded" (i.e., pushed onto land) by tides, currents, and "lost" anchors. A stranded boom removal response team worked to identify and remove stranded boom (USCG 2011). Both boom deployment and the subsequent deployment of boom removal teams greatly increased nearshore boat traffic; stranded boom smothered vegetation and disturbed birds, with additional foot and boat traffic impacts when response crews removed the boom; and countless anchors remain in the bottom waters.

2.3.7.2 Berms

The State of Louisiana requested that BP fund the construction of over 100 miles of sand berms, which were intended to prevent oil from entering estuaries and marshes. Dredging and construction began in mid-June 2010, though little progress had been made by July 15, 2010, when the well was capped.

Personnel at the Bon Secour National Wildlife Refuge constructed a smaller berm to protect Little Lagoon, an environmentally sensitive estuary at the refuge, from oil intrusion. Personnel also constructed berms in front of storm blowout areas to protect the dune ecosystem on the refuge (USCG 2011).

2.3.8 Shoreline Response Activities

The Shoreline Cleanup and Assessment Technique (SCAT) program directed shoreline treatments across the northern Gulf of Mexico for beaches and marshes. The SCAT program was already in place by the time oil first made landfall during the second week of May 2010. The SCAT program was conducted in four stages (Michel et al. 2015):

Shoreline cleanup techniques are discussed further in Section 4.6, Nearshore Marine Ecosystem.

- **Stage I/II (May to September 2010).** Focus on removal of floating oil adjacent to the shoreline and bulk oil removal from the shoreline.

- **Stage III (September 2010 to March 2011).** Ongoing cleanup activities on beaches, marshes, and man-made shoreline structures.

- **Stage IV (March to November 2011).** Resurvey of affected areas; determination of “No Further Treatment” status.

Following Stage IV, the Shoreline Cleanup Completion Plan was implemented from November 2011 to April 2014 to complete the removal actions to the point where they were no longer part of active response.

In general, the goal of shoreline treatment activities was to meet the No Further Treatment guidelines developed at each stage of the spill by the responsible party and agency representatives. The general objective was to proceed with shoreline treatment until the actions were either no longer effective or determined to no longer provide a net environmental benefit (Michel et al. 2015).

Cleanup crews engaged in a wide variety of activities that varied by location. On beaches, crews used manual and mechanical removal methods, including both onsite treatment and sediment relocation (Owens et al. 2011). Manual techniques in supratidal (above the tide line), intertidal, and subtidal (below the tide line) habitats involved crews removing oil, tar balls, and tar mats by placing sorbent pads and digging and raking with shovels and other hand-held tools (USCG 2011). In addition, heavy mechanical equipment, including excavators, augers, and modified commercial beach-cleaning machines, was used extensively to clean up the oil (USCG 2011).

One measure of the level of the cleanup effort is the total amount of oil waste material generated during response activities. EPA reported that, as of June 19, 2011, over 626 million pounds of oiled waste material had been collected and transported to disposal facilities, and shoreline cleanup continued well after that date. Through February 2014, that total had increased to over 642 million pounds of oiled waste material (Michel et al. 2015). Oiled waste includes oil and water mixtures, tar balls, oiled vegetation and debris, and oiled response equipment such as boom and safety gear used by response workers (EPA 2011). The cleanup goals for high-use, amenity beaches were more stringent than for non-amenity beaches, to minimize treatment disturbance impacts on environmental resources of non-amenity beaches (Michel et al. 2015; Michel et al. 2013). As detailed in Section 4.6, Nearshore Marine Ecosystem, over 12,500 acres of sand beach habitat were affected by response activities undertaken to clean up the oil. These response activities on oiled sand beaches resulted in approximately 100 million pounds of oil waste materials removed from sand beaches (Michel et al. 2015).

The methods most used for marsh cleanup were vacuuming the oil, placing sorbent boom, and placing absorbent peat (USCG 2011). Where oiling was light, natural recovery was typically the preferred technique to minimize disturbance to the area. Floating mechanical flushing machines were also used on a limited scale (Owens et al. 2011). For more than six miles of the most heavily oiled marshes in northern Barataria Bay in Louisiana, crews used intensive raking and cutting methods to remove oiled vegetation mats, wrack (decomposing vegetation washed up on the shore by the surf), and thick oil layers on the marsh substrate (Michel et al. 2013).

Source: *NOAA.*

Figure 2.3-9. Striped dolphins (*Stenella coeruleoalba*) swimming through emulsified oil.

2.3.9 Wildlife Response Activities

Wildlife capture, transportation, rehabilitation, and relocation efforts focused primarily on marine mammals, sea turtles, and birds during the response to the spill (Figure 2.3-9, Figure 2.3-10, and Figure 2.3-11, respectively) (USCG 2011). The management of wildlife response operations was led by the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS).

Source: *NOAA and Georgia Department of Natural Resources.*

Figure 2.3-10. A NOAA veterinarian prepares to clean an oiled Kemp's ridley turtle.

Agencies initially deployed their own personnel and resources to address wildlife response, and followed existing oil spill response protocols. However, the magnitude of the spill and impacts to animals required rapid expansion of their efforts to include contract wildlife responder personnel, procurement of additional equipment, and the development and use of site-specific protocols (USCG 2011). While marine mammal and sea turtle response operations were directly managed by authorized government agencies, because of the threatened or endangered species status of many of these animals, wildlife response operations were primarily staffed by state and federal resource agency personnel, and rehabilitation was conducted by professional wildlife rehabilitation organizations. Wildlife response and rehabilitation were operating within the incident command structure of the spill.

Source: *USFWS.*

Figure 2.3-11. USFWS wildlife biologist holds an oiled brown pelican captured off the coast of Louisiana.

As response to the spill progressed, wildlife teams were positioned across the northern Gulf of Mexico to assist with various wildlife response-related activities. The Trustees undertook substantial capture, transportation, rehabilitation, and relocation efforts for marine mammals, sea turtles, and birds. These activities included responding to mammal and sea turtle strandings and reports of oiled birds; documenting, inventorying, and storing dead animals; serving as wildlife observers; identifying sensitive and fragile habitats; providing guidance; and taking measures to reduce impacts to wildlife from cleanup activities.

Further discussion of wildlife response efforts is provided in the marine mammals, sea turtle, and birds sections of Chapter 4, Injury to Natural Resources.

Rehabilitation teams worked with many nonprofit organizations, wildlife care centers, and aquariums across the country on capturing, transporting, and caring for animals during these recovery efforts. A wildlife hotline was also created to process and respond to reports of dead or oiled wildlife from responders and members of the public (USCG 2011).

These tremendous response actions were necessitated because of the large number of animals that were directly exposed to *Deepwater Horizon* oil. Some animals were not only exposed to oil, but also handled by humans, and kept in captivity during recovery efforts, which added to the stress caused by the spill. Some animals were captured and relocated, which prevented exposure to oil but disrupted their natural habitat. Any animals that needed to be handled because of the oil spill may have been adversely affected regardless of the extent of oil exposure. Chapter 4, Injury to Natural Resources, discusses the impacts to wildlife in more detail.

2.3.10 Lost Human Use: Closures

During the oil spill response, agencies closed beaches and fisheries and restricted vessel traffic around the Macondo well area to protect human health and enable response activities to proceed safely. The closures resulted in lost use of recreational areas and fisheries. The Trustees can claim for damages to compensate for these lost uses.

2.3.10.1 Beaches

Authorities closed beaches in 2010 and 2011 in Alabama, Florida, Louisiana, and Mississippi, affecting tourism and recreation. Beach closings can be quantified in units of "oil spill advisory days," where one beach closed for one day equals one "oil spill advisory day."

More information on beach closures is provided in Section 4.10, Lost Recreational Use.

Through June 15, 2011, the numbers of oil spill advisory days in each state were as follows (NRDC 2011):[3]

- **Alabama:** 1,661 oil spill advisory days at 30 beaches from June 1 to July 30, 2010.
- **Florida:** 2,245 oil spill advisory days at 30 beaches from June 8, 2010 to June 15, 2011.
- **Louisiana:** 3,420 oil spill closure days at 11 beaches from May 7, 2010 to June 15, 2011.
- **Mississippi:** 2,148 oil spill advisory days at 17 beaches from June 28 to November 30, 2010.

[3] Source only goes through June 15, 2011, for Florida and Louisiana.

2.3.10.2 Fisheries

Authorities closed fisheries for public-safety reasons, to protect fishermen from injuries, and to protect the public from potentially eating contaminated or tainted seafood. These closures resulted in substantial lost use of recreational fisheries during the spill. NOAA Fisheries first issued an emergency rule to close a portion of the Gulf of Mexico exclusive economic zone to all fishing in response to the *Deepwater Horizon* oil spill on May 2, 2010. This action closed off 6,817 square miles from fishing for public safety reasons (NOAA 2010b). NOAA Fisheries then published additional rules expanding the closure areas based on the location of the oil slick. Closures reached a peak of 88,522 square miles (nearly 37 percent of federal waters in the Gulf of Mexico) on June 2, 2010 (NOAA 2010a). NOAA Fisheries reopened the last remaining closed area in federal waters on April 19, 2011 (NOAA 2011).

The following closures occurred across the different states:

- **Louisiana:** Louisiana issued its first fishery closure in state waters on April 30, 2010. Closure areas expanded during the spill in response to reports of oil. Louisiana announced a reopening of some areas to commercial fishing on May 10, 2010. Reopening of areas has continued over time, with the most recent opening of waters to commercial and recreational fishing in portions of Barataria Bay occurring on June 9, 2015 (LDWF 2015).
- **Mississippi:** Mississippi issued its first fishery closure in state waters on June 1, 2010. Closure areas expanded during the spill in response to reports to oil. Mississippi announced a reopening of some areas of commercial and recreational fishing starting on July 19, 2010. All Mississippi territorial waters were re-opened completely for commercial and recreational fishing activities on August 21, 2010 (Jewell 2015).
- **Alabama:** Alabama issued its first closure for state waters for commercial and recreational fishing on June 1, 2010. Closures of different areas were in place until September 6, 2010, when all waters were reopened to all valid fisheries (Outdoor Alabama 2015).
- **Florida:** Florida issued its first fishery closure for a portion of its state waters on June 14, 2010. All Florida fishery closures were lifted on August 17, 2010 (FWC 2010a, 2010b).

By September 2010, commercial and recreational fishing reopened to the harvest of fish, crabs, and shrimp in all state waters east of the Mississippi River and north of the northern shore of Pass a Loutre (USCG 2011).

2.3.11 Boat Response Activity

As mentioned previously, motorized boat activity increased dramatically in response to the spill. Hundreds of vessels responded to the spill in the open waters of the northern Gulf of Mexico, attempting to corral, disperse, and burn as much surface oil as possible. Hundreds more responded to oil in nearshore environments, placing boom, assessing shoreline oiling, transporting response workers, and transporting elected officials, agency staff, and journalists. In the nearshore environment, these unprecedented levels of boat activity (Figure 2.3-12) affected nearshore and submerged aquatic vegetation, disturbed wildlife, accelerated erosion with increased boat wakes, disturbed shoreline vegetation and fringing oyster habitat as boats parked on marsh, and scarred habitat through use of airboats to deploy boom and retrieve stranded boom.

Source: *Weston Solutions.*

Figure 2.3-12. Boat response activity tracklines, May 2010 to March 2014 in Barataria Bay, Louisiana.

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