



# The Deepwater Horizon Oil Spill: Coastal Wetland and Wildlife Impacts and Response

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## Summary

The explosion of the Deepwater Horizon drilling rig in the Gulf of Mexico on April 20, 2010, and the resulting oil spill began a cascade of effects on the coastal areas of the Gulf and on the wealth of species that inhabit those areas, effects that continue even though oil stopped flowing in July and the well was sealed in September. Gulf coast wetlands, like those elsewhere, have value for water quality, flood control, shoreline protection, and recreation. They serve as nurseries for many species, including fish and shellfish of commercial significance, waterfowl, and a host of resident and migratory species. They also have cultural importance to the people of the Gulf. The effects of the spill come on top of historic wetland losses due to subsidence, drainage, and saltwater intrusion, along with rising sea levels, coastal erosion, and global climate change.

Impacts of oil spills on wetland ecosystems depend on multiple factors, including the type of oil, exposure of the oil to weathering factors before it reaches the shore, the season in which the spill occurs, etc. Mitigation and cleanup of damage to wetlands is far from an exact science and involves many tradeoffs; there is no single, best solution. A number of options exist, ranging from mechanical recovery and use of dispersants to doing nothing. Estimating wildlife impacts is particularly difficult in this case because the spill occurred far offshore, and the initial wildlife mortality came far out in the Gulf, where animals sank without reaching the shore. When oil arrived at the shore, more animals began to be counted. Moreover, because the Gulf wetlands host many species of birds during seasonal migrations, impacts of the spill could be felt in areas well away from the Gulf.

Among other issues is a seemingly simple question: who decides what to do when such an event occurs? But the answer is complex. The organizational structure for deciding how to respond to oil spills is specified in the National Contingency Plan (NCP), which was created administratively and has been broadened by the Clean Water Act, the Superfund law, and the Oil Pollution Act. Under the NCP structure, the Coast Guard is the lead federal agency for overseeing response and cleanup. Until oil from the well stopped flowing, very little cleanup of wetlands was occurring, because of both the ongoing risk of greater harm from cleanup and the potential for re-oiling. As cleanup proceeds, a number of questions arise. To cite only two, what factors will determine cleanup strategies, and how are needs to improve scientific understanding of the impacts of oil spills being considered?

Decisions about cleanup of wildlife are no easier. Cleanup of individual animals is labor-intensive, and some scientists argue that the survival of an animal that has been cleaned is so uncertain as to call into question whether treatment is, in fact, humane. Rescue groups are dedicated to salvaging those that can still be saved. The effects on a species as a whole vary markedly from one species to another, depending on that species' abundance and ecological needs; appropriate responses at the species level are unclear.

History, particularly from the relatively well-studied *Exxon Valdez* spill of 1989, offers insight into the future of Gulf resources as well. First, some cleanup efforts might do more harm than good in the long run. Second, it is not possible to predict all of the ramifications for the complex Gulf ecosystem in the decades to come, but history suggests that at least some effects will continue for decades. Finally, litigation could play a major role in disseminating—or not disseminating—scientific information about the spill and its effects.

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## Introduction

Since the April 20, 2010, explosion on the mobile offshore drilling unit Deepwater Horizon in the Gulf of Mexico, public and private efforts have focused on containing, capturing, cutting off, and capping the oil. These collective efforts under water and on the surface of the Gulf are intended in large part to keep the oil from reaching coastal marshes and wetlands—what Coast Guard Admiral Thad Allen, the National Incident Commander for responding to the spill, termed the “worst case scenario for us to deal with.”<sup>1</sup> Nevertheless, within a few weeks of the explosion there were reports that oil had reached coastal areas and had begun to affect land and wildlife.<sup>2</sup>

Uncontrolled leaking from the MC252 Macondo well site continued for three months after the explosion. In mid-July, the flow of oil from the well was stopped with a temporary cap on the gushing wellhead, but oiling of the Gulf’s shorelines continued even after oil was no longer flowing from the well. On September 17, more than 35% of Gulf Coast shoreline miles were oiled to some degree, but less than 7% was oiled to a moderate or heavy extent, according to the federal government.<sup>3</sup> On September 19, the government reported that the ruptured well was “effectively dead” and posed no continuing threat to the Gulf because of the completion of a relief well that successfully sealed off the last path for oil to escape.<sup>4</sup> Despite that good news, scientists and public officials recognize that damage to marine and wildlife habitats has occurred (although immediate impacts were less severe than anticipated), not all of the 4.9 million barrels of oil estimated to have been released from the well is gone from the Gulf, and concern remains about lingering effects that may occur for some time to come.

The risk posed by the wellhead has ended, as has the emergency phase of response. But the oil spill response is ongoing and day-to-day cleanup operations continue—cleaning shoreline, sampling Gulf waters, and responding to any recoverable oil that is found.<sup>5</sup> The extent of oiled vegetation on shore, resulting damages, and how quickly plants will regenerate are largely unknown. Biological effects on wildlife won’t be known for at least a full breeding/spawning season. Additional impacts may occur as a result of oil that remains in the Gulf—oil that has not been recovered, burned, skimmed, evaporated, or degraded naturally. Beyond such generalizations, the history of prior spills does show that damages are likely to be unknown or poorly understood for some time, probably years. And whether science will be available to answer important questions is uncertain (see discussion of “Science and Litigation,” below).

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<sup>1</sup> Adm. Thad Allen press conference call, May 21, 2010, p. 7, [http://www.deepwaterhorizonresponse.com/posted/2931/Teleconference\\_Allen\\_May\\_21.562827.pdf](http://www.deepwaterhorizonresponse.com/posted/2931/Teleconference_Allen_May_21.562827.pdf). Adm. Allen retired from the U.S. Coast Guard in early 2010, but continued to serve as National Incident Commander until Oct. 1, 2010.

<sup>2</sup> See <http://www.restorethegulf.gov/release/2010/05/07/breton-national-wildlife-refuge-closed-public-entry>, reporting closure of Breton National Wildlife Refuge (LA), reporting shoreline contamination on May 5, 2010. For frequently updated maps of the spill, response, fishery closures, and other geospatial features, see <http://gomex.erma.noaa.gov/erma.html>.

<sup>3</sup> Unified Command for the BP Oil Spill, “The Ongoing Administration-Wide Response to the Deepwater BP Oil Spill,” September 17, 2010, <http://app.restorethegulf.gov/go/doc/2931/900375/>. These numbers reflect a daily snapshot, not cumulative impacts.

<sup>4</sup> Unified Command for the BP Oil Spill, “Statement from Admiral Allen on the Successful Completion of the Relief Well,” September 19, 2010, <http://app.restorethegulf.gov/go/doc/2931/900707/>.

<sup>5</sup> Unified Command for the BP Oil Spill, “Gulf Coast Incident Management Team Established in New Orleans,” September 20, 2010, <http://app.restorethegulf.gov/go/doc/2931/901235/>.

This report addresses the importance of wetlands in general, the ecology of the coastal wetlands in the Gulf, impacts of oil spills on wetland habitats, response options, the implications of hurricane season for the spill's impacts, and cleanup and recovery issues.<sup>6</sup> The emphasis is on the nearshore environment, although a few species found in deeper waters will be mentioned. In addition, some lessons from past spills such as the *Exxon Valdez* in Alaska will be discussed, along with issues that may arise as response and recovery transition to restoration of the Gulf.

## Why Are Wetlands Important?

Wetlands are sometimes referred to as “in-between” areas that consist of both dry uplands and open water environments—they are transition zones that are neither “land” nor “water.” More commonly, wetlands are known as marshes, bogs, and swamps. Because they have both upland and aquatic characteristics, they often have a richer flora and fauna than other environments. In practice, wetlands may be hard to define, but scientists generally agree that the presence of a wetland can be determined by a combination of certain distinctive soils, plants, and hydrology. In different regions, some wetland areas may be continuously inundated by water, while other areas may not be flooded at all, or only at certain times of the year. In coastal areas, flooding may occur daily as tides rise and fall.

Functional values, both ecological and economic, at each wetland depend on its location, size, and relationship to adjacent land and water areas. Many of these values have been recognized only recently. Historically, many federal programs encouraged wetlands to be drained or altered, because they were seen as having little intrinsic value. Today, scientists and policymakers recognize many valuable functions, including flood control and shoreline protection, as well as nurseries and protection for fish, shellfish, and wildlife, as described in the box below.

### Functions and Values of Wetlands

**Water Quality.** Wetlands are efficient water filters, because wetland plants and soils clean fresh water of contaminants before it moves into surface waters or groundwater. Wetlands filter runoff and remove sediment, nutrients, pesticides, metals, and other pollutants.

**Flood Buffers and Erosion Control.** Wetlands reduce the severity of floods by acting as natural retention areas; consequently, destruction or loss of wetlands makes downstream flooding worse. Similarly, nearshore wetlands act as buffers to reduce shoreline erosion and stabilize land.

**Shoreline Protection.** Coastal wetlands are particularly important in the Gulf region, because they can help reduce coastal flooding by absorbing the energy, wind, and water from incoming hurricane storm surges. Many of the coastal areas in the Gulf are in flat or low-lying areas, which are particularly vulnerable to tropical storms and hurricanes. It is estimated that for every 3.4 miles of healthy coastal wetlands that a given storm surge must travel over, the height of the surge is diminished by one foot.

**Nurseries for Fish and Shellfish.** Coastal wetlands serve as important nurseries for numerous fish and shellfish, as many species depend on wetlands for some or all of their life cycle, where they feed, take refuge, or reproduce. Approximately 75% of the nation's commercial fish and shellfish depend on estuaries at some stage in their life cycle, and estuaries depend on the adjacent wetlands to maintain water quality and provide the basis for food chains. About

<sup>6</sup> This report will not address questions of liability or compensation. These areas are addressed in other CRS reports, including CRS Report R41262, *Deepwater Horizon Oil Spill: Selected Issues for Congress*, coordinated by Curry L. Hagerty and Jonathan L. Ramseur; also see CRS Report R41308, *The 2010 Oil Spill: Criminal Liability Under Wildlife Laws*, by Kristina Alexander.

97% of the commercial fishery landings from the Gulf are species that depend on estuaries for reproduction, nursery areas, food production, migrations, or shelter. Commercial fishing in the Gulf coastal region contributed more than \$680 million to the nation's economy in 2007.

**Wildlife Habitat.** Coastal wetlands are home to many different animals and, importantly, are stopover or winter habitat for many migrating birds. In the Gulf region, birds that live in wetlands include many species of egrets, shorebirds, ibises, pelicans, herons, and others. Gulf wetlands also are home to many threatened or endangered species such as piping plovers, and several species of sea turtles and sturgeon. Marine mammals are also found in wetlands and along the Gulf coast; species include manatees, three species of whales, and seals. Some of the marine mammals are also protected as endangered or threatened. (See "Coastal Habitat as Home," below.)

**Recreation.** Many recreational activities depend on wetlands, including fishing, hunting, bird-watching, boating, and wildlife photography. In 2004, tourism and recreation employment in the five Gulf coast states totaled more than 416,000 jobs.

**Cultural Importance.** Many cultures, such as the Cajun culture in the Gulf, have been heavily influenced by or rely upon wetlands. Some Cajuns who live along bayous and wetlands rely upon those wetlands for fishing, hunting, and trapping. Similarly, wetlands are important to several indigenous tribes in the Gulf region. The Seminole tribe of Florida, for example, depends on healthy natural resources of the South Everglades and Big Cypress regions for fishing, hunting, and economic support (conducting tours).

**Sources:** Gulf Restoration Network, *Wetland Importance*, <http://www.healthygulf.org/our-work/wetlands/wetland-importance>; National Oceanic and Atmospheric Administration, National Marine Fisheries Service, *Wetlands, Fisheries, & Economics in the Gulf of Mexico*, <http://www.nmfs.noaa.gov/habitat/habitatconservation/publications/habitatconnections/num4.htm>; National Ocean Economics Program. *Coastal and Ocean Economic Summaries of the Coastal States, 2009*. <http://www.oceaneconomics.org/NationalReport>. For information on disaster assistance for commercial fisheries in light of the spill, see CRS Report RL34209, *Commercial Fishery Disaster Assistance*, by Harold F. Upton.

## Coastal Wetlands and Assets in the Gulf of Mexico

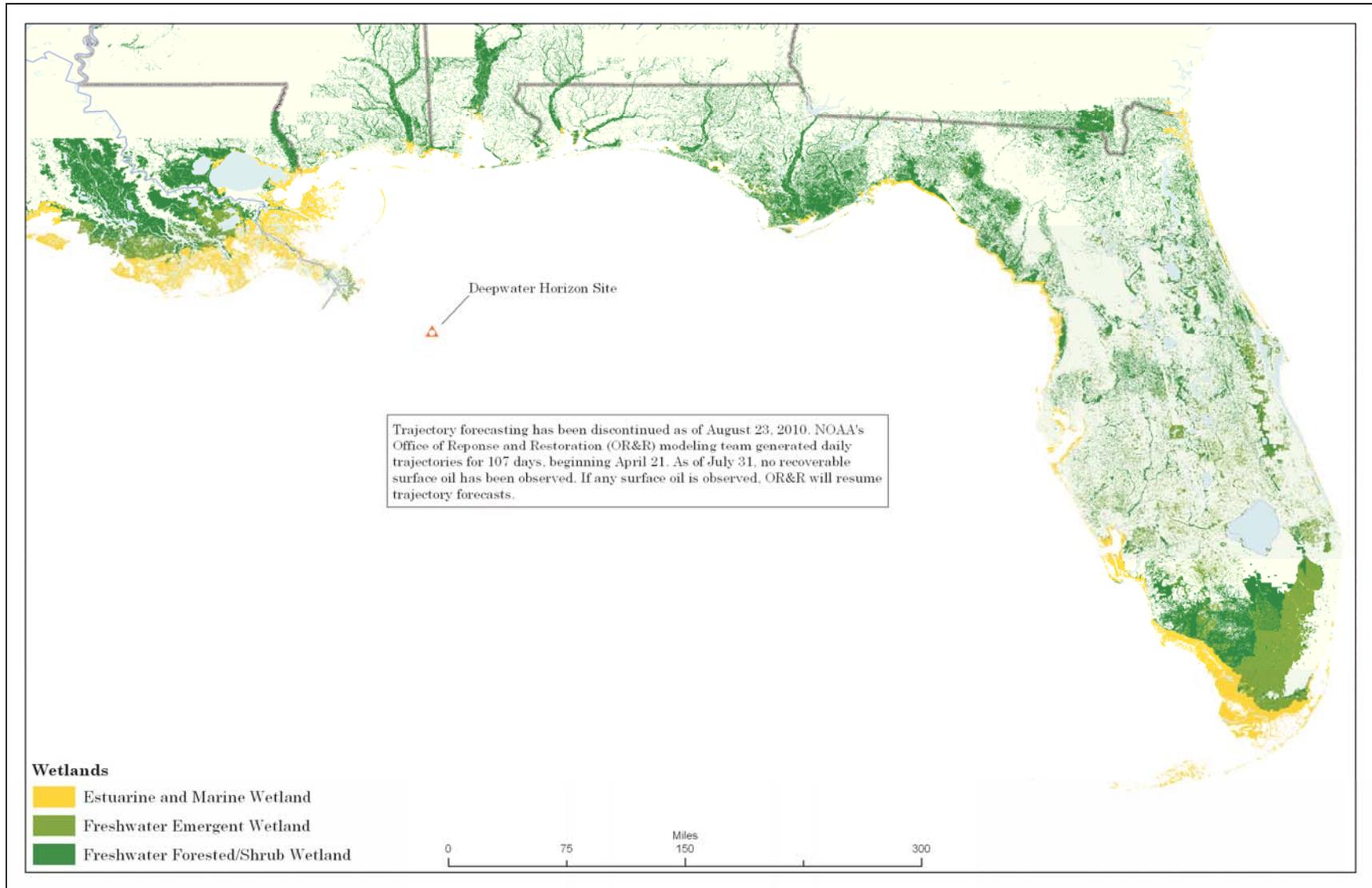
The U.S. portion of the Gulf of Mexico has 1,631 miles of coastline.<sup>7</sup> There are an estimated 15.6 million acres of wetlands in both saltwater and freshwater habitats in the coastal watersheds of the five U.S. states around the Gulf. (See **Figure 1**, which identifies wetlands in Louisiana, Mississippi, Alabama, and Florida.) Saltwater habitat wetlands, which occur in tidal areas where saltwater and freshwater mix, total 3.5 million acres and are of three types: estuarine intertidal emergent wetlands (salt and brackish water marshes), estuarine shrub wetlands (mangrove swamps and other salt-tolerant woody species), and estuarine and marine intertidal non-vegetated wetlands (such as sand bars, shoals, and sand spits). Freshwater habitat wetlands total 12.1 million acres and include forested and shrub wetlands, and emergent wetlands.<sup>8</sup> These types of wetlands generally contain shallow water and are dominated by herbaceous plants. Areas directly adjacent to the Gulf shoreline that are potentially exposed to oil from the Deepwater Horizon spill contain both saline and brackish tidal wetlands and tidal freshwater wetlands.

Environmental Sensitivity Index (ESI) maps prepared by the National Oceanic and Atmospheric Administration (NOAA) provide a concise summary of coastal resources that are at risk if an oil

<sup>7</sup> The U.S. Gulf coastline consists of the following: Florida (Gulf portion), 770 miles; Alabama, 53 miles; Mississippi, 44 miles; Louisiana, 397 miles; and Texas, 367 miles. See "Coastline of the United States," <http://www.infoplease.com/ipa/A0001801.html>.

<sup>8</sup> An emergent wetland is one that has plants, such as cattails and bullrushes, whose roots and part of the stem are below water level with the rest of the plant above water.

Figure I. Gulf of Mexico Coastal Wetlands



Source: Prepared by CRS based on U.S. Fish and Wildlife Service National Wetlands Inventory; ESRI Data and Maps 9.3.1.

spill occurs nearby. In these maps, areas are scored from 1 to 10, and under this system most Gulf coast wetlands are ranked at 10, the most sensitive, or at risk.<sup>9</sup>

## **Gulf Coast Protected Lands**

The Gulf coast is the site of a number of national wildlife refuges, national parks, and national seashores that are home to numerous birds and other wildlife. Four national wildlife refuges were in the path of oil as it spread to shore: Breton and Delta, both in Louisiana, and Grand Bay and Bon Secour, in Alabama; Gulf Islands National Seashore (Florida and Mississippi) also was affected.<sup>10</sup> Although oil has stopped flowing and the well has been capped and sealed, other refuges and National Park units could be at risk depending on fate of oil that remains in Gulf waters, and on impacts from future hurricanes and other storms. In addition to federally protected lands, many state parks and public beaches are located along the Gulf coast, as are several Department of Defense installations throughout the region that provide wildlife habitat.

## **Historic Loss of Gulf Coast Wetlands**

Coastal wetlands are subjected to stressors from land-based activities, including dredging and filling, and from seaward events, such as coastal storms, tidal surges that cause erosion, saltwater intrusion, and inundation. In recent years, Gulf coast wetlands have experienced acreage losses from these multiple stressors. Between 1998 and 2004, coastal wetlands in the five Gulf states declined by an estimated 371,000 acres (2.3% total); although there were small wetlands gains in portions of the region, losses far outweighed the gains. Saltwater wetlands declined overall by nearly 45,000 acres (about 1.2%) during that period, while freshwater wetlands declined by 329,000 acres (2.7%). The changes in wetland acreage were much greater for Gulf coastal wetlands than for coastal wetlands in other regions, such as the Atlantic coast, which experienced a 0.1% overall decline, or the Great Lakes, which had a 0.3% increase between 1998 and 2004. The losses of wetland acreage in the Gulf coast are attributed to a number of factors. Most saltwater wetland losses in the Gulf resulted from inundation or flooding from storms or sea level rise and subsidence. Losses of freshwater wetlands have resulted from development in rural and urban areas, timber harvesting activities, drainage, and filling for extensive residential and commercial development activities.<sup>11</sup>

## **Wetland Loss in Louisiana**

In Louisiana specifically, wetland change and loss have been especially severe for decades, even before the Deepwater Horizon oil spill. Wetlands are vital to many parts of the state's economy, yet they have been converting from land to water more rapidly than elsewhere. Louisiana's wetlands today represent about 40% of the wetlands of the lower 48 United States, but about 80% of historic losses. Louisiana lost about 1,900 square miles of coastal lands, primarily marshes,

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<sup>9</sup> See [http://response.restoration.noaa.gov/book\\_shelf/827\\_ERD\\_ESI.pdf](http://response.restoration.noaa.gov/book_shelf/827_ERD_ESI.pdf).

<sup>10</sup> Spill data as of Aug. 3, 2010, based on maps from National Oceanic and Atmospheric Administration, available at <http://gomex.erma.noaa.gov/erma.html#x=-90.42000&y=28.03000&z=6&layers=3796+8440+7303+5723>.

<sup>11</sup> Susan-Marie Stedman and Thomas E. Dahl, *Status and Trends of Wetlands in the Coastal Watersheds of the Eastern United States, 1998 to 2004*, National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Department of the Interior, Fish and Wildlife Service, 2008.

from 1932 to 2000, plus 200 square miles or more from hurricanes in 2005.<sup>12</sup> While the rate of wetlands loss has decreased, it is estimated that Louisiana loses about 25 square miles (16,000 acres) of wetlands annually, and the state experiences about 90% of the total coastal marsh loss in the lower 48 United States each year.<sup>13</sup>

Changes to the state's coastal area result from a combination of natural environmental processes (erosion, saltwater intrusion into fresh systems, sea level rise) and human-related activities, according to the U.S. Geological Survey. Wetland loss has occurred naturally for centuries, but until recently, land losses have been counterbalanced by various natural wetland-building processes.

The seasonal flooding that previously provided sediments critical to the healthy growth of wetlands has been virtually eliminated by construction of massive levees that channel the river for nearly 2,000 kilometers; sediment carried by the river is now discharged far from the coast, thereby depriving wetlands of vital sediment. In addition, throughout the wetlands, an extensive system of dredged canals and flood-control structures, constructed to facilitate hydrocarbon exploration and production as well as commercial and recreational boat traffic, has enabled salt water from the Gulf of Mexico to intrude brackish and freshwater wetlands. Moreover, forced drainage of the wetlands to accommodate development and agriculture also contribute to wetlands deterioration and loss.<sup>14</sup>

Also important to the entire coastal ecosystem of the Gulf are barrier islands that are a first line of defense acting as a buffer to reduce the effects of ocean waves and currents on estuaries and wetlands. Barrier islands result from the accumulation of sediments deposited at the mouths of rivers such as the Mississippi in Louisiana and the Apalachicola in Florida. Over thousands of years, sediments accumulate as unconsolidated sands and muds and gradually become compact. At the same time, marine coastal processes of erosion and degradation work at the margins of the land, eventually resulting in formation of low-relief islands that are separated from the mainland by shallow bays and lagoons. Plants often get established on barrier islands, especially on the leeward side, and help to provide stability.

But in these low-lying areas, even a moderate wind can raise water levels at the shoreline. Today, barrier islands, like wetlands, are eroding as a result of storms, sea level rise, and human development. As they disintegrate, they expose the system of sheltered onshore wetlands to additional wave action, saltwater intrusion, storm surge, sediment transport, and contamination by oil that is now circulating in the waters of the Gulf. According to the USGS, the potential exists for water to move across the full width of the islands in locations that are both low and narrow, possibly transporting oil inland into back bays and marshes.<sup>15</sup>

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<sup>12</sup> Hurricanes Katrina and Rita produced both gains and losses of wetland acreage. In October 2006, it was estimated that the net effect of the 2005 hurricanes was a loss of nearly 217 square miles (139,000 acres) of land just in Louisiana. This estimate was considered preliminary, because some transformations of land to water are permanent, and others are transitory or temporary. Confirmation of permanent losses from the hurricanes' storm surges is unlikely before several growing seasons have passed. John A. Barras, *Land Area Changes in Coastal Louisiana After the 2005 Hurricanes: A Series of Three Maps*, U.S. Geological Survey, Open-File Report 2006-1274, October 2006.

<sup>13</sup> U.S. Geological Survey, National Wetlands Research Center, U.S. Department of the Interior, "Without Restoration, Coastal Land Loss to Continue," May 21, 2003, [http://www.nwrc.usgs.gov/releases/pr03\\_004.htm](http://www.nwrc.usgs.gov/releases/pr03_004.htm).

<sup>14</sup> U.S. Geological Survey, Marine and Coastal Geology Program, "Louisiana Coastal Wetlands: A Resource At Risk," November 3, 1995, <http://marine.usgs.gov/fact-sheets/LAwetlands/lawetlands.html>.

<sup>15</sup> U.S. Geological Survey, "Barrier-Island Inundation and Overwash: Application to the Deepwater Horizon Oil Spill," June 15, 2010, [http://www.usgs.gov/deepwater\\_horizon/scenario/](http://www.usgs.gov/deepwater_horizon/scenario/).

## **Coastal Habitat as Home**

The coastal estuaries, marshes, and beaches of the Gulf also serve as habitat for a wealth of plants and animals.<sup>16</sup> They are among the most productive of all ecological communities. The plant life consists of plankton, algae, and larger plants, including grasses and some salt-tolerant trees such as bald cypress and tupelo gum trees. Water in such habitats is full of silt, and easily stirred by minor wave action. The turbid waters are full of microscopic single-celled algae, and other small photosynthetic microorganisms. These plants in turn feed zooplankton—microscopic animals that are food for fish larvae, juvenile crabs and shrimp, and on up the food chain. The high productivity of coastal wetlands leads to enormous species diversity, with species adapted to their own niches varying in salinity, turbidity, light penetration, wave action, and other factors that may or may not be well understood. Not surprisingly, the rich marshes and, to a lesser extent, beaches of the Gulf provide breeding grounds, nurseries, stopover points, and homes for many species, including many that are threatened, endangered, or economically important.

## **Breeding Grounds and Nurseries**

While many commercial species are caught in deeper water, many commercial fish and shellfish depend on marshes and estuaries of the Gulf for some part of their life cycle: blue crab, shrimp, oyster, menhaden, black and red drum, flounder, striped mullet, and others. Adults of these species generally move into the marshes and estuaries, spawn, and leave eggs to hatch and develop. The eggs and juveniles are eaten by crabs, minnows, gobies, and other small predators. In turn, small alligators, herons, egrets, turtles, and other species feed on these animals, particularly where a low tide may concentrate available food resources. Insects of the marshes and estuaries feed—and many feed on—a host of young birds. Smaller birds nest in grasses, on floating vegetation, or on beaches. Larger species nest in trees, often in huge colonies. Greatest biodiversity is typically found in marshes, whether freshwater, brackish, or saline. Somewhat lower diversity occurs in open bays of fresh or saltwater, and in mudflats or marginal beaches.

The key feature of coastal ecology is that damage to the coast, and particularly to biologically rich marshes, will have effects on many species that spend the bulk of their life cycles many miles distant on land, and in oceans, lakes, and rivers. Among the most transitory of species are the migrants that use the coast as a stopover for resting and feeding during their spring or fall migrations.

## **Stopover Areas for Migrants**

Shorebirds (plovers, gulls, terns) and wading birds (egrets, herons, ibises, bitterns), pelicans, and various species of hawks and other birds are present in the spring and fall in coast marshes. In the winter, waterfowl such as Canada, snow, and blue geese are abundant, along with dozens of species of ducks. Birds using the coast during migration may summer and breed in any part of the continental United States and Canada. Some will return to the Gulf for overwintering habitat. Others will stop in the Gulf coast area for the fall migration. These migrating birds will encounter the spill and its remaining effects just before they begin their journeys across the Gulf to winter

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<sup>16</sup> An overview of coastal ecology, particularly in the upper Gulf of Mexico and coastal Louisiana, can be found in Michael J. Mac, Paul A. Opler, and Catherine D. Pucket, et al., *Status and Trends of the Nation's Biological Resources, Vol. 1*, U.S. Geological Survey, Reston, VA, 1998, pp. 384-430.

homes in the Caribbean or Latin America.<sup>17</sup> In both directions, a meal immediately before or after their flight across the Gulf may be critical to reaching their destinations. Moreover, the specialized feeding behavior and anatomy of many of these species may limit their feeding sites to a narrow band of wetlands and shallow water, where oil impacts may interfere with access to foods. Consequently, depending on their migration patterns, bird populations as far away as Alaska and northern Canada or central and South America or the Caribbean may be affected by the Gulf spill.

The diversity makes Gulf coast refuges hot spots for bird watchers at all seasons, and especially in the spring migration. Of the Delta and Breton National Wildlife Refuges, which lie at the mouth of the Mississippi River, one author writes:

Some of the most impressive sights are in the spring migration, when great numbers of small birds come in from across the Gulf, sometimes to their first landfall in hundreds of miles, weary and highly visible—rose-breasted and blue grosbeaks, indigo and painted buntings, scarlet and summer tanagers. There are as many as twenty-five warbler species, along with tremendous flights of tree swallows—sometimes sixty thousand, skimming over the inland ponds or just stopping to rest a little while before moving on north.<sup>18</sup>

To address the problems faced by the fall migrants, U.S. Fish and Wildlife Service (FWS, Department of the Interior) “biologists are working to restore and bolster wetland habitats and food sources in nearby, uncontaminated areas in Louisiana, the Chenier Plain of east Texas, and the lower portion of the Mississippi Alluvial Valley.”<sup>19</sup> The effort is being carried out in cooperation with the Natural Resources Conservation Service (NRCS, Department of Agriculture), which “will be working in cooperation with private landowners and other partners to establish habitat and food sources as well as improve the overall habitat management on participating lands.”<sup>20</sup> For the species that must feed in the immediate area of the coast, these efforts may not be fruitful, but for those birds able to feed farther inland, the additional food may be able to replace the reduced food sources at the contaminated coastline.

## Threatened and Endangered Species

The Gulf coast is home to a wealth of species listed under the Endangered Species Act (ESA).<sup>21</sup> **Table 1** shows the total number of listed animal species in each of the five Gulf coast states, as well as the number of animal species living in that state’s coastal or marine environment that could be affected by oil contamination. As the table shows, the bulk of the listed species in each state are not likely to be affected by the spill because their habitats do not occur along the coast. In a few cases, the threat to a species is conjectural, because its habitat may be fairly near the

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<sup>17</sup> Most bird species use the same routes going north or south. Of those that stop for feeding, the location of the stop would likely be similar in spring and fall. A few species use one route in the spring and a somewhat different route in the fall.

<sup>18</sup> Laura Riley and William Riley, *Guide to the National Wildlife Refuges: How to Get There and What to See and Do* (Garden City, NY: Anchor Press, 1981), p. 238.

<sup>19</sup> See FWS press release of July 8, 2010, “Using Sound Science, Fish and Wildlife Service Addresses Urgent Habitat Needs for Birds and Other Wildlife Along the Gulf Coast,” available at <http://www.fws.gov/news/NewsReleases/showNews.cfm?newsId=33448A43-ECBE-6890-C4B5296DBEDF3EAC>.

<sup>20</sup> More information about the NRCS program may be found at [http://www.nrcs.usda.gov/news/nrcs\\_migratory\\_birds.html](http://www.nrcs.usda.gov/news/nrcs_migratory_birds.html).

<sup>21</sup> 16 U.S.C.A. § 1531.

coast, but not likely to become oiled unless storms blow contamination inland. (Note that where species are at risk primarily in the event of major storms, the entry in the table adds them in by showing a range of potentially affected species.)

Listed species that are likely to have direct mortality or to suffer loss of food, nesting habitat, and the like include least terns, piping plovers, five species of sea turtles, the American crocodile, three species of whales, manatees, and three species of sturgeon. Sea turtle nests along the Gulf coast have been the focus of a special effort. As of October 12, 2010, teams of professionals and volunteers have collected 278 nests for transport to Florida’s east coast where the eggs are held until the 14,676 hatching and young turtles are released, away from the spill.<sup>22</sup> Eventually, surviving females from these transported nests will return either to their original nest sites or to Florida’s coast to lay their eggs.

In addition to the species currently listed, two species that were once listed but have recovered have also experienced effects of the spill: the American alligator, as well as the brown pelican, which has become iconic in the current case because it is designated as the Louisiana state bird. The American alligator is found fairly commonly farther inland now, but it may occur in brackish water; in the absence to date of serious Gulf coast hurricanes that can push oil inland, risk to this species has been slight.

Pelicans, on the other hand, are found almost exclusively in marine and coastal environments. Because pelicans nest in great rookeries, returning birds can contaminate their own nests as well as those of other birds. Eggs of any species that have been fouled are nearly certain to die, even with minor contamination. Chicks may be abandoned when parent birds die or become too debilitated to feed their young. Fish fed to the young may be contaminated and have uncertain effects on the birds’ development.

**Table 1. Endangered and Threatened Animal Species in the Gulf of Mexico**  
(coastal species in habitats that may become oiled)

State	Total Endangered Animal Species	Endangered Animals: Possibly Oiled Habitat	Total Threatened Animal Species	Threatened Animals: Possibly Oiled Habitat
Texas	49	8	9	3
Louisiana	10	8	8	4-5
Mississippi	20	10	11	4
Alabama	58	10-11	21	4
Florida	35	23-24	19	9-10

**Source:** Compiled by CRS from FWS Endangered Species Program Data, Species Profiles. Available at <http://www.fws.gov/endangered/>.

**Notes:** All listed coastal and marine species in a state are considered as being in potentially oiled habitat, except certain species occurring only on the east coast of Florida. A range of figures indicates that the exact location of some coastal species is not known, or that effects on the listed species might depend on the occurrence of severe storms washing contaminated oil well into coastal marshlands. Columns should not be summed, since

<sup>22</sup> See <http://www.deepwaterhorizonresponse.com/external/content/document/2931/895663/1/Consolidated%20Wildlife%20Table%20091010.pdf>.

many coastal species occur in multiple states. An FWS website list shows fewer animals, but excludes species under the jurisdiction of NMFS; see <http://www.fws.gov/home/dhoilspill/pdfs/FedListedBirdsGulf.pdf>.

## **Oil Spills: Impacts on Wetland Habitats and Animals**

Habitats such as salt marshes and mangrove forests and the biota that reside in them are subject to destruction or alteration by oiling events.<sup>23</sup> The degrees of impacts of oil on wetland vegetation are variable and complex and can be both acute and chronic, ranging from short-term disruption of plant functioning to mortality. The primary acute damage to the marshes is that plants, which hold the soil in place and stabilize shoreline, will suffocate and die, especially if multiple coatings of oil occur. Once vegetation dies, the soil collapses. Then the soil becomes flooded, and plants cannot re-grow. If plants cannot re-establish, soil erosion is accelerated, giving rise to even more flooding and further wetland loss. If oil penetrates into the sediments, roots are continuously exposed to oil, with chronic toxicity making production of new shoots problematic. Consequently, plant recovery is diminished, and eventually land loss occurs. In addition to direct impacts on plants, oil that reaches wetlands also affects animals that utilize wetlands during their life cycle, especially benthic organisms that reside in the sediments and are a foundation of the food chain.<sup>24</sup>

In the Gulf, coastal saltwater wetlands and tidal freshwater wetlands are sensitive to oil, both immediately and in the long term. The severity of immediate and longer-term impacts and damages depend on a number of factors, including—

- the type and quantity of oil spilled (low-sulfur light crude such as that associated with the Macondo well is considered less toxic than denser heavy crude or refined fuel oils involved in other spills. Still, the quantity of oil from the Deepwater Horizon spill is the largest that has ever occurred in U.S. waters);
- the condition of the oil on and below the surface, including the length of time it is in the water before it hits land (oil weathers over time, through the natural actions of evaporation, photodegradation, and microbial degradation, which all reduce acute toxicity);
- season and prevailing weather (both the natural degradation processes and ecosystem recovery occur more rapidly in warmer climates than colder regions, but a spill that occurs during the growing season of plants will have more severe impact than one in the fall or winter when plants are dormant);
- type of shoreline and composition of vegetation (wetlands and similar fragile environments are more at risk and more difficult to clean than harder surfaces such as sandy beaches);

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<sup>23</sup> National Research Council of the National Academies, *Oil in the Sea III, Inputs, Fates, and Effects* (Washington, D.C.: The National Academies Press, 2005), p. 157.

<sup>24</sup> Dennis F. Whigham, Stephen W. Broome, and Curtis J. Richardson, et al., Statement of the Environmental Concerns Committee, Society of Wetland Scientists, "The Deepwater Horizon Disaster and Wetlands," [http://www.sws.org/docs/SWS\\_OilEffectsOnWetlands.pdf](http://www.sws.org/docs/SWS_OilEffectsOnWetlands.pdf).

- type of waves and tidal energy in the area of the spill (wave energy is necessary to help move oil away from land and to enhance the effects of chemical dispersants); and
- presence of dispersants (chemical dispersants are used to enhance breakdown of the oil, but the long-term ecosystem effects of chemically dispersed oil and the dispersants themselves are uncertain).<sup>25</sup>

## Estimating Mortality

The effects on wetland habitats lead directly to effects on the animals and plants in those habitats. The federal government has the lead in managing some categories of species, while states take the lead in the rest. Comprehensive data are more readily available for the former, which are called federal “trust species.” The trust species consist of birds, marine mammals, and threatened and endangered species. The principal federal agencies involved in managing these species are the FWS and the National Marine Fisheries Service (NMFS, Department of Commerce).

### Birds

Oil contamination of birds can have acute effects:

Birds are primarily affected through thermoregulatory challenges caused by oiling of plumage and through ingestion. Oil reduces the ability of bird feathers to provide insulation, which increases their risk of hypothermia. Rate of heat loss is much higher in the water than in air, so oiled plumage is particularly problematic for birds that must find food in the water, such as seabirds, cormorants, and grebes. Oil is most commonly ingested by birds while preening their contaminated feathers or while feeding on contaminated prey.<sup>26</sup>

The President of the American Bird Conservancy stated that “rescue groups are prepared to do everything humanly possible to capture and save as many oiled birds as they can find, but there are problems well beyond our abilities to mitigate or even count. In addition to the potential catastrophic losses to shorebirds that we know to be at risk on their breeding grounds and in the wetlands around the Gulf, the oil spill poses a serious threat to seabirds.”<sup>27</sup>

The coating of feathers also results in loss of buoyancy, and, if severe, can cause the bird to drown and then sink. It is this phenomenon that makes an accurate estimate of bird deaths extremely difficult. Based on past spills, many argue that mortality analyses based on counts of carcasses and on estimates of the ultimate survival of oiled birds that have been cleaned and released produce a marked undercount of actual deaths, particularly for species that forage farther offshore. According to the Exxon Valdez Oil Spill Trustee Council, after the 1989 Alaska spill, the number of recovered carcasses of birds was only a fraction of the estimated deaths:

The carcasses of more than 35,000 birds and 1,000 sea otters were found after the spill, but since most carcasses sink, this is considered to be a small fraction of the actual death toll. The best

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<sup>25</sup> Testimony of Jane Lyder, Deputy Assistant Secretary for Fish and Wildlife and Parks, Department of the Interior, before the House Natural Resources Subcommittee on Insular Affairs, Oceans and Wildlife, June 10, 2010.

<sup>26</sup> Holly K. Ober, *Effects of Oil Spills on Marine and Coastal Wildlife*, Dept. of Wildlife Ecology and Conservation, Univ. of Florida, 2010, <http://www.wec.ufl.edu/Effects%20of%20oil%20spills%20on%20wildlife.pdf>.

<sup>27</sup> See <http://www.abcbirds.org/newsandreports/releases/100504.html>.

estimates are: 250,000 seabirds, 2,800 sea otters, 300 harbor seals, 250 bald eagles, up to 22 killer whales, and billions of salmon and herring eggs.<sup>28</sup>

The number of live but contaminated birds found in the Gulf as of October 12, 2010, was 2,080, along with 6,104 carcasses, for a total of 8,184.<sup>29</sup> Of the birds collected alive, 1,243 were released after examination, cleaning, and recovery. Carcasses are stored, and will be used as evidence in litigation concerning damage to natural resources. If no more carcasses were found, and if the same ratio were to apply to the BP spill as in the *Exxon Valdez* spill, then about 43,600 bird deaths would be expected.<sup>30</sup> However, not only does this calculation assume (improbably) that no more carcasses will be found, but also that the diligence and thoroughness in collecting carcasses in the Gulf is similar to the diligence and thoroughness in Prince William Sound.

## Marine Mammals

Marine mammals inhabiting the Gulf include manatees, several species of whales, dolphins, and seals. These species do not have significant hair that can become oiled, but rely on a layer of fatty tissue for warmth. However, contact with oil can cause skin irritations, perhaps leading to infections. A more significant threat is inhalation of fumes when they surface to breathe. Moreover, their prey may be contaminated with hydrocarbons, or the prey populations may be reduced or absent. Some of the Gulf's whales feed by sifting large amounts of water through plates called baleen. These plates may become clogged with oil.<sup>31</sup> As of October, 12, 2010, there were 9 marine mammals collected alive, and 97 dead; of the carcasses collected, 91 did not have visible oil, and a necropsy will be needed to determine the cause of death.<sup>32</sup> While marine mammals may be physically capable of avoiding oil slicks, according to the National Oceanic and Atmospheric Agency, "[r]esearch on dolphins in human care has shown that the animals avoid oil on the surface of the water, however observations of wild dolphins have documented the animals swimming in, feeding in and socializing in oiled water during previous oil spills in the Gulf of Mexico."<sup>33</sup> Where a spill covers a very large area and volume of water as it does in the Gulf, the animal may have to avoid much of its previous range.

## Endangered Species

Threatened and endangered species living in the wetlands and coastal areas face varying degrees of risk. Moreover, the threats to a given individual may be different from those to a species: a breeding bird that is unable to find sufficient food to feed its young may abandon its attempt to breed for the year, and the young will die without the care of the parent bird. Or the eggs may become oiled, fail to hatch, and be abandoned. But the adult can survive itself. In either case, if

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<sup>28</sup> See <http://www.evostc.state.ak.us/facts/qanda.cfm>.

<sup>29</sup> See FWS Consolidated Fish and Wildlife Collection Report at [http://www.fws.gov/home/dhoilspill/pdfs/collection\\_06182010.pdf](http://www.fws.gov/home/dhoilspill/pdfs/collection_06182010.pdf).

<sup>30</sup> Data on bird deaths from oil spills are scarce. The ratio of carcasses to actual deaths could be higher or lower than those in Prince William Sound. In addition, this figure assumes that all birds captured alive survived. To the extent that they did not, the estimates of actual deaths would be increased.

<sup>31</sup> Holly K. Ober, *Effects of Oil Spills on Marine and Coastal Wildlife*, Dept. of Wildlife Ecology and Conservation, Univ. of Florida, 2010, <http://www.wec.ufl.edu/Effects%20of%20oil%20spills%20on%20wildlife.pdf>.

<sup>32</sup> <http://www.fws.gov/home/dhoilspill/collectionreports.html>.

<sup>33</sup> See [http://gulfseagrant.tamu.edu/oilspill/facts\\_impacts.htm](http://gulfseagrant.tamu.edu/oilspill/facts_impacts.htm).

abandonment is widespread, the damage to the species could be severe even if all adult birds were to survive.

## Weather and Storms

The effectiveness of offshore measures in capturing or breaking up oil in open waters of the Gulf in part determines whether oil reaches coastal areas. One factor that can influence the success of such measures is storms and weather events, since high winds and strong tides can push oil further inland from shoreline areas.

The official hurricane season in the Atlantic Ocean begins June 1 and ends November 30. On August 5, 2010, the National Hurricane Center (NHC) issued its updated outlook for 2010 hurricanes in the Atlantic and Gulf of Mexico, predicting an “active” season with “8 to 12 Hurricanes (top winds of 74 mph or higher), of which ... 4 to 6 could be Major Hurricanes (Category 3, 4 or 5; winds of at least 111 mph).”<sup>34</sup> If hurricanes occur while large amounts of oil are present in Gulf waters and at shorelines, several concerns emerge. First, barrier islands that normally protect coastal wetlands from oil may be overtopped or destroyed by winds and water. Second, heavy winds and storm surges could push oil further inland into areas that would not normally become oiled. Third, even though the oil stopped flowing from the Deepwater Horizon site in July, hurricane-strength winds could stir up oil that has penetrated sediments, thus releasing oil and causing renewed impacts on plants and wildlife. Fourth, tropical storms and hurricanes can disrupt or delay ongoing oil spill response and cleanup activities: this has been the case resulting from several storms in June and August that affected Gulf waters and shores.

According to the NHC, the presence of oil is not expected to affect either the intensity or the track of a fully developed tropical storm or hurricane appreciably, and an oil slick in and of itself would have little effect on a hurricane, a storm surge, or nearshore wave heights. In addition, high winds and seas generally mix and weather the oil, which actually can help accelerate biodegradation processes and disperse the oil further. Movement of oil would depend greatly on the track, wind speed, and size of a hurricane, and other factors in the evolution of the storm.<sup>35</sup>

## Mitigation and Cleanup of Wetlands

Much of the response effort in the Gulf has focused on capturing, or otherwise addressing, oil in open waters or setting barriers to deflect it from reaching land. Protective booms placed offshore were intended to prevent oil from reaching shore (most were removed after oil stopped flowing from the well). There is evidence that these and other measures have been at least partially successful in reducing the volume of oil and preventing oil in very large amounts from contacting marshes and beaches, as had been anticipated and feared initially. Another defensive measure, a project to build sand berms to provide additional physical protection for Louisiana’s barrier islands, is being constructed, despite controversies about the effectiveness of the approach.<sup>36</sup>

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<sup>34</sup> See [http://www.noaanews.noaa.gov/stories2010/20100805\\_hurricaneupdate.html](http://www.noaanews.noaa.gov/stories2010/20100805_hurricaneupdate.html).

<sup>35</sup> National Oceanic and Atmospheric Administration, U.S. Department of Commerce, “NOAA’s Oil Spill Response, Hurricanes and the Oil Spill,” May 27, 2010, [http://www.nhc.noaa.gov/pdf/hurricanes\\_oil\\_factsheet.pdf](http://www.nhc.noaa.gov/pdf/hurricanes_oil_factsheet.pdf).

<sup>36</sup> For discussion of the Louisiana protective berm project, see CRS Report R41262, *Deepwater Horizon Oil Spill*: (continued...)

But, inevitably, some oil escapes capture and is pushed by wind and tides toward land. Wetland plants can be affected both by oil that floats over the surface of the marsh and by oil that has been incorporated into sediment. There are several possible approaches to cleaning up oil that reaches coastal wetlands and competing theories of different approaches in different places. Moreover, experts acknowledge tradeoffs for each approach. Each has limitations—some of which are serious—and none is effective in all cases. As Admiral Allen said, “The problem is, the hardest place to pick up oil is in a marsh or a wetland.”<sup>37</sup> There is no silver bullet and no single best solution, and often the response can be more destructive than the spill itself. Some studies even suggest that a certain level of oil in the soil of wetlands may stimulate plant growth, although the mechanisms by which this occurs are not clearly understood.<sup>38</sup>

## **Mechanical Recovery**

Mechanical removal techniques are often used first, once oil reaches land. It is possible in some cases to physically remove oil by hand, with shovels or rakes, vacuums, or other equipment, or to skim and mop it with absorbent materials. However, these methods are difficult, and their effectiveness is highly variable. This technique works best on sandy beaches or rocky shores but is difficult in marshy areas, because damage from heavy equipment and human trampling of sensitive plants and soils can equal or exceed damage from the oil. Recovery of wetland vegetation from the mechanical cleanup can take considerable time. Further, oil sitting on the surface of shallow waters can get pushed into soft ground where, in the absence of oxygen, it contaminates sediments or biodegrades very slowly.

## **Flushing**

In some cases low-pressure flushing can be used to push oil into areas where it can be vacuumed or absorbed. Seawater is pumped through the marsh to dilute the oil that sticks to grasses, thus enhancing tidal movement to promote natural recovery. High-pressure spraying can be effective. It was used to clean the rocky shore of Prince William Sound in Alaska, although with some negative effects on shoreline invertebrates, but the Gulf coastal wetland environment is very different from that in Alaska, and high-pressure spraying likely would erode soils and destroy wetland vegetation. Even low-pressure spraying only works when oil is floating on the surface.

## **Applying Chemical Dispersants**

A related technique is to spray dispersants—a mixture of surfactants, solvents, and other chemicals—onto the oil. Like dish soap, dispersants break the oil into smaller droplets that fall from the surface into the water column, where microbes degrade them or currents move them away. This technique is primarily used in open waters: chemical dispersants have been used in the

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(...continued)

*Selected Issues for Congress*, coordinated by Curry L. Hagerty and Jonathan L. Ramseur.

<sup>37</sup> Adm. Thad Allen Press Conference, June 5, 2010, <http://www.deepwaterhorizonresponse.com/go/doc/2931/620563/>.

<sup>38</sup> Qianxin Lin, Irving A. Mendelssohn, and Charles B. Henry, Jr., et al., “Effect of Oil Cleanup Methods on Ecological Recovery and Oil Degradation of *Phragmites* Marshes,” *1999 International Oil Spill Conference, Paper ID #250*, 1999, <http://www.iosc.org/papers/00598.pdf>.

Gulf spill to break up oil before it reaches shorelines.<sup>39</sup> However, there is some evidence that when dispersants are added to water during flushing of marsh vegetation, oil removal is slightly enhanced.<sup>40</sup>

But there are many questions about environmental effects of chemically dispersed oil and the dispersants themselves in wetlands. Many scientists contend that adding dispersants enhances removal and that on balance the use of dispersants is less harmful than letting oil get into marshes. However, other scientists are concerned about harmful effects of dispersants on aquatic plant and animal life in both open waters and coastal areas. If dispersants are used, there are environmental tradeoffs: (1) greater concentrations of chemically dispersed oil in the water column, (2) a potential reduction in persistent stranded oil, and (3) unknowns in terms of long-term toxicity.<sup>41</sup> Long-term effects of applying dispersants to oil in coastal wetlands are not well known, because research has focused more on acute toxicity than chronic effects. If dispersant chemicals penetrate sediments, the toxic effects might be long-lasting.<sup>42</sup>

## **Burning**

Burning is considered one of the most effective techniques for responding to spilled oil. It was used successfully to clean up several oil spills following Hurricane Katrina, and, when wind conditions permit, it has been used *in situ* in the Gulf to prevent oil from reaching shore.<sup>43</sup> However, there are limits to how and when burning can be used. Burning coastal plants may kill them and result in further coastal erosion. It can be difficult to control the burn and confine it to small areas, thus threatening other plant material not affected by oil. Burning removes oil's more toxic components, such as volatile aromatic compounds, but it does not destroy stickier, heavier (high molecular weight) compounds that can sink into wetland soil. There is evidence that the concentration of oil in sediments is greater in areas that have been burned than in unburned areas.<sup>44</sup> Marshes with low water levels cannot be burned without killing the plant roots. But research has shown that the presence of just a few inches of water above the roots when a burn occurs can be sufficient to provide sufficient protection, thus allowing subsequent regeneration of the plants.

Also, oil that is weathered, or degraded (that is, petroleum that has been on the surface and exposed to air for several days), does not burn well, because flammable hydrocarbons have volatilized. That has likely been the case with oil from the Deepwater Horizon spill, as it typically took more than a week for tides and winds to move oil from the rig site to shore.

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<sup>39</sup> As of September 17, approximately 1.84 million gallons of total dispersant have been applied—1.07 million on the surface and 771,000 sub-sea. See: <http://app.restorethegulf.gov/go/doc/2931/900375/>.

<sup>40</sup> National Research Council of the National Academies, *Oil in the Sea III, Inputs, Fates, and Effects* (Washington, D.C.: The National Academies Press, 2005), p. 144.

<sup>41</sup> Testimony of Aaron Viles, Gulf Restoration Network, before the House Natural Resources Subcommittee on Insular Affairs, Oceans and Wildlife, June 10, 2010.

<sup>42</sup> S.R. Pezeshki, R.D. DeLaune, and A. Jugsujinda, et al., "Major Field Test Evaluates a Shoreline Cleaner to Save Oiled Marsh Grass," *1997 International Oil Spill Conference*, 1997. <http://www.iosc.org/papers/01172.pdf>.

<sup>43</sup> According to the government, as of mid-September, 411 controlled burns have been conducted and have removed more than 11 million gallons of oil from open waters. See: <http://app.restorethegulf.gov/go/doc/2931/900375/>.

<sup>44</sup> National Research Council of the National Academies, *Oil in the Sea III, Inputs, Fates, and Effects* (Washington, D.C.: The National Academies Press, 2005), p. 144.

## **Cutting Back Vegetation**

In small heavily oiled areas, vegetation can be cut back to leave plants intact and prevent oiling of birds that come in contact with the vegetation. This technique is moderately effective at cleaning up oil, and it has been successfully used in the past for smaller spills and plant regeneration has followed (including spills affecting Gulf coast marshes in the past). But it does not work well in large areas. One of the risks is physical damage from human contact and trampling. Some experts believe that areas where grasses are cut take much longer to recover than oiled areas that are not cut.

## **Bioremediation**

Biodegradation is the process in which oil molecules are broken down by bacteria, which occurs naturally. However, to make oil biodegrade faster, bioremediation agents or techniques are sometimes applied. Bioremediation involves either introducing nutrients in the form of fertilizer into the marsh (i.e., biostimulation) or adding bacterial microbes designed to be especially effective at degrading oil (i.e., bioaugmentation). EPA has made information available about dispersants and bioremediation agents that are authorized for use on oil discharges in the United States.<sup>45</sup>

This technique can be effective in some places, but where it has been used on spills in wetland areas, results have been mixed. Experts believe that it probably has limited potential in coastal marshes such as those in Louisiana, because oxygen levels in wetland soils often are so low that microbial activity is limited, whether nourishment is added or not. That is, oxygen is the factor limiting degradation of oil, not nutrients, and there are no proven methods of adding oxygen to muddy, water-saturated marsh soils. It is likely to be more effective in wetlands at a higher elevation than coastal Louisiana, or areas that are infrequently flooded, because more oxygen is present. Bioremediation is not usually considered as a first response but is more often a secondary treatment after removal of bulk oil.

Nutrient addition may enhance the growth and productivity of dominant plant species within an oiled area, but it also may reduce species diversity or composition among remaining wetland plants. It may even be toxic to some organisms. Bioremediation in combination with detergents was used during cleanup of the *Exxon Valdez* spill. In that instance, treated areas were significantly cleaner after the first year, but scientists later determined that the addition of large amounts of fertilizer or nutrients disturbed the ecological balance of the overall system, thus altering the course of long-term recovery.<sup>46</sup>

## **Doing Nothing**

It may seem counterintuitive, but many scientists believe that doing nothing is sometimes the best option, contending that aggressive cleanup or remediation can have serious harmful effects and may delay the eventual recovery that might naturally occur. According to the National Research

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<sup>45</sup> U.S. Environmental Protection Agency, "National Contingency Plan Product Schedule," [http://www.epa.gov/emergencies/content/ncp/product\\_schedule.htm](http://www.epa.gov/emergencies/content/ncp/product_schedule.htm).

<sup>46</sup> *ScienceDaily*, "Caution Required for Gulf Oil Spill Clean-Up, Bioremediation Expert Says," May 4, 2010, <http://www.sciencedaily.com/releases/2010/05/100504142110.htm>.

Council, there is no consensus on whether it is better to immediately clean up an oiled area that may then take many years to re-establish, or leave it alone to weather naturally and risk uncertain effects over long periods. In many instances, cleanup techniques delay recovery time, due to physical disruption of roots, flushing of soils, lowering the soil surface below levels where aquatic vegetation can re-establish, and activities that mix oil deeper into wetland and marsh soils.<sup>47</sup>

On the other hand, if oil is allowed to persist around plants, it kills the existing vegetation and can prevent new shoots from growing when they contact floating oil, which could lead to more wetland erosion. By deciding to do nothing, there are essentially no direct environmental side effects, and it may still be possible to explore alternatives later. But several considerations do apply: when the oil is especially heavy (although that is not the case in the Gulf spill), or if tides are insufficient to move the oil, unassisted or natural recovery may not be completely effective. Also, doing nothing may be more appropriate for a one-time event (such as the *Exxon Valdez* incident) than for a spill in which oil continued to flow for weeks or months, as with the Deepwater Horizon spill. Further, because effectiveness may not be known for months or years, it can be difficult to persuade the public that doing nothing is best.

## **Oil Spill Response: Who Decides What to Do?<sup>48</sup>**

Several options, including technologies, exist for responding to oil that reaches coastal wetlands, but all have apparent advantages and disadvantages, as previously described. Once the oil moved from the open Gulf waters to shoreline areas, decisions about how to actually respond were made within the overall complex organizational structure that exists in the United States for responding to oil spills.

The federal government's oil spill response framework is found in the National Contingency Plan, which contains the government's procedures for responding to oil spills and hazardous substance releases. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) was established administratively in 1968, after U.S. policymakers observed the response to a 37-million-gallon oil tanker spill (*Torrey Canyon*) off the coast of England and saw the need for a coordinated approach to cope with potential spills in U.S. waters.<sup>49</sup> Subsequent laws have broadened the NCP, including the Clean Water Act in 1972 (33 U.S.C. 1251 et seq.); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund, 42 U.S.C. 9601 et seq.) in 1980; and the Oil Pollution Act (OPA, 33 U.S.C. 2701 note) in 1990.

The NCP establishes the National Response System (NRS), which is intended to be a multitiered and coordinated national response strategy. Key components of the NRS include:

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<sup>47</sup> National Research Council of the National Academies, *Oil in the Sea III, Inputs, Fates, and Effects* (Washington, D.C.: The National Academies Press, 2005), pp. 142, 145.

<sup>48</sup> The following section of this report is based in part on CRS Report R41262, *Deepwater Horizon Oil Spill: Selected Issues for Congress*, coordinated by Curry L. Hagerty and Jonathan L. Ramseur.

<sup>49</sup> See EPA "National Contingency Plan Overview" at <http://www.epa.gov/emergencies/content/lawsregs/ncpover.htm>.

- a National Response Team (NRT), composed of representatives from the 15 federal departments and agencies assigned roles in responding to oil spills.<sup>50</sup> The U.S. Coast Guard chairs the NRT when a response is being mounted to a spill in a coastal region.
- Regional Response Teams (RRTs), composed of regional representatives of each NRT member agency, state governments, and local governments. The Coast Guard leads the relevant RRT during responses to oil spills in coastal waters.
- Area Committees (ACs), composed of qualified personnel from federal, state, and local agencies. The primary function of each AC is to prepare an Area Contingency Plan (ACP) for its designated area.
- an On-Scene Coordinator (OSC), who directs the response efforts and coordinates all other efforts at the scene. In general, in coastal areas Coast Guard Captains of the Port serve as OSCs for their particular area, but in the current case, the federal OSC is Rear Adm. Paul Zukunft, who is the Coast Guard's assistant commandant for marine safety, security, and stewardship.

The NCP provisions specific to oil spill response are found in 40 CFR Part 300, Subpart D. As the primary response authority in coastal waters, the Coast Guard OSC has the ultimate authority to ensure that an oil spill is effectively removed and actions are taken to prevent further discharge from the source. The OSC is broadly empowered to direct and coordinate all response and recovery activities of federal, state, local, and private entities (including the responsible party), drawing on resources available through the appropriate ACPs and RRTs.

To manage response operations for the Deepwater Horizon spill, the federal government established a Unified Command structure, led by a National Incident Commander (Coast Guard Admiral Thad Allen in the current case), to link the organizations responding to the incident and provide a forum for those organizations to make consensus decisions.

Although the OSC must consult with designated trustees of natural resources regarding damages<sup>51</sup> and with the governor(s) of the state(s) affected by the spill, the OSC has the authority and responsibility to determine when removal (i.e., cleanup) is complete.

As oil from the Deepwater Horizon spill reached the shores of several Gulf coast states, the entities charged with responding to the spill began to focus on cleanup of coastal marshes and wetlands, particularly on considerations related to the several possible cleanup techniques discussed in this report. In early June, representatives of several federal agencies that are part of the NRT, plus emergency response and local technical experts, held a workshop to develop a response plan for marshes and other nearshore and shoreline areas affected by the oil spill. The

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<sup>50</sup> For a list of member agencies, see <http://www.nrt.org/production/NRT/NRTWeb.nsf/MADispForm?Openform>.

<sup>51</sup> Natural resource damages refer to the environmental impacts caused by an oil spill that result in an actual adverse effect on the resource (e.g., animals, plants, and their habitats) or on the services provided by that resource to the public (e.g., drinking water, recreation). When a spill occurs, natural resource trustees conduct a natural resource damage assessment to determine the extent of injury, and the party responsible for the spill is liable for the damages. In the Deepwater Horizon case, the natural resource trustees include NOAA, FWS, the National Park Service, state trustees from Louisiana, Mississippi, Alabama and Florida, tribal trustees, and BP. See [http://www.response.restoration.noaa.gov/book\\_shelf/1959\\_deepwater-Horizon-NRDA-ORR-web-5-7-10.pdf](http://www.response.restoration.noaa.gov/book_shelf/1959_deepwater-Horizon-NRDA-ORR-web-5-7-10.pdf). For more on the Natural Resource Damage Assessment process, see CRS Report R41396, *The 2010 Oil Spill: Natural Resource Damage Assessment Under the Oil Pollution Act*, by Kristina Alexander.

resulting plan identified current cleanup methods and strategies along with their advantages and disadvantages, depending on the level of oiling of marshes, and included a table showing potential activities that could be considered by the Incident Commander (Admiral Allen).

As to which methods are actually to be utilized, the response plan stated, “The selection of any cleanup strategy will be determined on a case-by-case basis in consultation with appropriate natural resource experts and trustees. Clean up operations will be conducted by the responsible party and overseen by the Federal, State and Tribal Agencies with authority.”<sup>52</sup>

However, while the oil was still flowing, very little cleanup actually was occurring, at least near or on the shore, since recontamination could occur readily. Rather, under the National Incident Command structure, Shoreline Cleanup Assessment Teams (SCATs) undertook comprehensive surveys and collected information on oil once it reached shore.<sup>53</sup> Information that the assessment teams reported daily—and continue to report even after oil from the well stopped flowing—is processed by the Incident Command Center as part of broader planning and priority-setting to guide operations. Shorelines have been resurveyed multiple times, as oiling conditions changed, and some cleanup recommendations likely changed as a result. Until oil stopped flowing in mid-July, shoreline cleanup was limited to triage—removing bulk amounts of oil from beaches and, in some cases, heavily oiled marshes—but even these areas were not being thoroughly cleaned. Methods being used in the marshes were primarily flushing and sorbents (i.e., absorbent booms). Given the high environmental sensitivity of marshes and wetlands and the potential for re-oiling until the leaking undersea well was capped, the initial choice was to do as little as possible that could be more harmful to the ecosystem.<sup>54</sup>

With the flow of oil from the well apparently stopped, and the emergency phase of the spill response over, more comprehensive cleanup continues. The biology of an area or type of use will determine the desired cleanup endpoint. That could mean, for example, zero tolerance for oil on a high-amenity recreational beach and nearly the same for a marsh. A number of questions can be anticipated to arise during this process.

- What is meant by “case-by-case” determination of cleanup strategy, in the NRT response plan? That is, what factors (physical, biological, legal), would result in different methods being used at some sites? Would this decision include scientific controls to decide what methods are most effective?
- What kind of training is being provided to persons who are actually involved in cleanup? While many persons are reportedly being trained and used for cleanup of less complex areas, such as beaches, different preparation may be required for those who will perform cleanup work in sensitive marshes and wetlands.

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<sup>52</sup> U.S. National Response Team, “Oil Spill Response Strategies for Coastal Marshes during the Deepwater Horizon MC252 Spill,” June 15, 2010, [http://www.nrt.org/Production/NRT/NRTWeb.nsf/AllAttachmentsByTitle/SA-1061NRT\\_Marsh\\_Cleanup\\_Options\\_DWH.06032010.pdf/\\$File/NRT\\_marsh\\_cleanup\\_overview\\_6-15.pdf?OpenElement](http://www.nrt.org/Production/NRT/NRTWeb.nsf/AllAttachmentsByTitle/SA-1061NRT_Marsh_Cleanup_Options_DWH.06032010.pdf/$File/NRT_marsh_cleanup_overview_6-15.pdf?OpenElement).

<sup>53</sup> The teams generally consisted of four persons, representing the federal government (usually NOAA, sometimes FWS), the affected state, and the responsible party. They often were accompanied by a contract archaeologist who could identify historic sites or structures to be avoided during cleanup, such as civil war artifacts or Indian mounds. The responsible party provided logistics (e.g., helicopters and boats).

<sup>54</sup> Douglas Helton, Incident Operations Coordinator, Office of Response and Restoration, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, personal communication, June 24, 2010.

- The NRT response plan necessarily is focused on removal of oil, which likely will continue for some time. But even in the early stages, there have been opportunities for scientific evaluation arising from these events. How are the needs to improve scientific understanding of the impacts of the oil spill and response activities being considered during cleanup?

## Who Decides About Wildlife?

The process of cleaning an individual animal may take a week or more: collecting and transporting the animal; rest and/or feeding and hydration to allow the animal to withstand the stress of the cleaning or rehabilitation process; cleaning and treatment; drying; further feeding and blood tests, and rest; transport to a release site; and release, often at a very distant location.<sup>55</sup> As with many wildlife questions, data are better for birds than for many other species.

Cleanup of wildlife is controversial, in terms of both the benefits to individual animals and the question of the cleanup's relevance to the status of the species. The issue is, if only a small fraction can be saved, and if the food sources, breeding sites, and resting places are damaged or destroyed, how useful is it to clean a small fraction and release the animals to an environment where they may become recontaminated? Even if one focuses on the individual birds rather than the species, some scientists argue that the life expectancy of a bird that has been cleaned and released remains low, and its chances of breeding are poor, although some groups, such as gulls, fare better than other groups.<sup>56</sup>

There may be no definitive answer to such questions, other than the human need to do something that might help, plus the expectation that at least some fraction of the cleaned animals will survive at least somewhat longer. To those who hold this view, the rescue of oiled animals is not amenable to a simple cost-benefit analysis. It may be no coincidence that much of the rescue of oiled animals is done by dedicated corps of volunteers.

## Cleanup and Recovery Issues: The Long Term

Once the oil is removed or cleaned up to the extent possible, recovery of the ecosystem can begin. Recovery can occur within a growing season or require years to decades, based on factors such as those listed previously that influence the severity of impacts (e.g., the type and quantity of oil, and season and prevailing weather). Documented recovery of oiled marshes is more rapid in the warmer environment of the Gulf than in colder climates, but it still ranges from weeks to decades.<sup>57</sup> Lessons from the *Exxon Valdez* spill may be useful in the BP oil spill for both the biological response and for management of scientific information.

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<sup>55</sup> For a graphic description of this process, see <http://www.washingtonpost.com/wp-srv/special/nation/one-birds-odyssey/?sid=ST2010061502171>.

<sup>56</sup> "Should Oiled Birds Be Cleaned?" by Nell Greenfieldboyce, National Public Radio, June 14, 2010. Available at <http://www.npr.org/templates/story/story.php?storyId=127749940>.

<sup>57</sup> National Research Council of the National Academies, *Oil in the Sea III, Inputs, Fates, and Effects* (Washington, D.C.: The National Academies Press, 2005), pp. 145-146.

## Lessons from the *Exxon Valdez*

The *Exxon Valdez* spill in 1989 had well-known short-term effects, but its long-term effects are less well known. While the markedly different conditions (a single event with short-term oil release; much colder climate; preponderance of rocky shores over marshes, beaches, and mudflats; lower human population; fewer long-established natural oil seeps and therefore fewer native microbes capable of digesting oil; less disturbed baseline ecosystem, etc.) mean that many lessons do not transfer well, there are two lessons particularly worth noting as Gulf onshore cleanup plans develop.

First, short-term remediation actually delayed recovery in some habitats. For example, while rocky shores cleaned with high-pressure hoses or hot water became suitable for the hauling out of seals or sea otters, other aspects of recovery were negatively affected: microbial populations that might have digested oil were destroyed.<sup>58</sup> At these sites, the recovery process for intertidal species (barnacles, crabs, limpets, etc.) proceeded more slowly than in untreated areas in which some oil weathered and some sank into the rocks, sand, or gravel.<sup>59</sup>

Second, before the spill in Prince William Sound (PWS), the paradigm for oil spills had been that a spill's effects were primarily acute, rather than long-term. But in the intervening 21 years, studies have shown that some effects can endure for decades, and that some species recover much more slowly than others. Research did not continue indefinitely after the spill, though some responses were studied for longer than others. The following list gives a sample of the conclusions of a scientific review of the published information on ecosystem responses in the years after the spill:

- While about 2% of the oil mass remained on PWS intertidal beaches after 3.5 years, the rate of decay of this oil dropped markedly in subsequent years because it became sequestered from wave action, sunlight, and oxygen—all of which tend to promote degradation of the oil, as previously described. About 14% of the oil that contaminated PWS tidal areas in 1992 was still present in 2001.
- Where mussels anchored themselves to these rocky shorelines, the subsurface oil contaminated the mussels and provided a route into the food chain.
- In the mouths of rivers, oil in the substrate killed pink salmon embryos at least as late as 1993 (the most recent year available to the reviewers).
- Sea otter populations recovered at the rate of 4% per year, short of the expected 10% per year. By 2000, sea otter populations remained at about half the estimated pre-spill population in one heavily contaminated area. Effects included an abnormally high mortality in animals born after the spill.
- Some birds, such as harlequin ducks, showed higher mortality rates than normal for more than a decade. This species feeds heavily on invertebrates in lower tidal areas. Another sea duck, Barrow's goldeneye, also showed chronic exposure for at least a decade. This species also forages in the nearshore environment.

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<sup>58</sup> Katherine Unger, "Comparing Deepwater Horizon to Exxon Valdez," The Wildlife Society. Available at [http://joomla.wildlife.org/index.php?option=com\\_content&task=view&id=689&Itemid=321](http://joomla.wildlife.org/index.php?option=com_content&task=view&id=689&Itemid=321).

<sup>59</sup> For example, see effects of such cleaning at Kenai Fjords National Park, available at [http://www.nps.gov/kefj/naturescience/upload/KEFJ\\_EVOS\\_1989-2009\\_qa.pdf](http://www.nps.gov/kefj/naturescience/upload/KEFJ_EVOS_1989-2009_qa.pdf).

- Sublethal effects occurred in other species. For example, black oystercatchers (a bird that forages on rocky shores) had less breeding and smaller eggs for at least three years.
- Among social species, such as killer whales, loss of key individuals can affect large numbers of animals: when adult females in this matriarchal species died after the *Exxon Valdez* spill, the social disruption apparently led to suppressed reproduction, and likely to the later disintegration of a pod of whales.<sup>60</sup>

While most of the species mentioned above are not found in the Gulf, in both the Gulf and PWS, there exists the opportunity for hydrocarbons to become lodged in various substrates, to be absorbed by various species that are eaten by other species, and to inhibit the growth or reproduction of still others. It remains to be seen how different the biological response in the Gulf will be, but the *Exxon Valdez* spill suggests that long-term impacts are highly likely, even if their specific nature will be difficult to predict.

Moreover, the resulting effects of the *Exxon Valdez* spill could be compared scientifically to the effects of the BP spill in new research. The diverse habitats, wildlife, microbes, shoreline structures, etc., could provide insight on how to handle future spills in still more environments, as oil development moves into more challenging areas.

## Science and Litigation

Free and open access to scientific information concerning oil spills is not a given. In the Gulf, many lawsuits have been filed already and more can be expected. In the past, litigation strategies have driven parties in lawsuits to direct government or corporate scientists to withhold data in order to prevent opponents in court from having an advantage as litigation progressed. After the *Exxon Valdez* spill, the Alaska attorney general:

issued a series of memos to state scientists ordering them to keep their data on the spill under wraps. His motivation, [he] said, was to prevent Exxon from gaining the upper hand in the litigation that was shaping up from the moment the *Valdez* ran aground.... The gag has been particularly effective in muzzling the most contentious data—that relating to environmental damage....

Indeed, far too little data has been made public for the response experts to come to a unanimous opinion of the best strategies for cleanup. In some cases, the response specialists have not been allowed to see the state's damage assessment results....<sup>61</sup>

In the wake of that spill, contractors working for Exxon were allowed to release results of studies that concluded that the spill had not had, and would not have, adverse effects on plants and animals in PWS. Alaska's scientists could not provide timely contrary information.<sup>62</sup> At the same time, other Exxon researchers were not allowed to present their research on the spill's effects, due to the possibility of harming Exxon's defense.<sup>63</sup>

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<sup>60</sup> Charles H. Peterson, Stanley D. Rice, and Jeffrey W. Short, et al., "Long-term Ecosystem Response to the Exxon Valdez Oil Spill," *Science*, vol. 302 (December 19, 2003), pp. 2082-2086.

<sup>61</sup> Lisa Busch, "Science Under Wraps in Prince William Sound," *Science*, vol. 252 (May 10, 1991), pp. 272-273.

<sup>62</sup> Ibid.

<sup>63</sup> Stephanie Pain, "Exxon Gags Sound Researchers," *New Scientist*, no. 1860 (February 13, 1993).

The tension between disclosure of scientific research and litigation strategy has already begun in the Gulf, with independent scientists complaining that, unless they are employed by BP, or by the federal or state governments, they are not allowed access to coastal areas in a manner that would permit independent research.<sup>64</sup> In addition, various organizations, including the National Wildlife Federation and the American Association of University Professors, voiced concern that BP asked a number of scientists in the region to do research on the spill, and to sign confidentiality agreements lasting three or more years as a condition of doing so.<sup>65</sup>

Confidentiality agreements have been signed by many federal employees, contractors, subcontractors, or other persons hired in connection with the employee's work on the spill. The terms of the Department of the Interior (DOI) version of these two-page agreements include these provisions:

All documents, information or other work developed by me in connection with this matter are privileged and confidential. I shall not reveal any of these documents, information or other work to any person, other than employees, subcontractors, or persons that I hire to assist me in connection with my work on this matter, without prior written approval of the office of the Solicitor, United States Department of the Interior....

Unless prior written approval of the Office of the Solicitor, United States Department of the Interior is obtained, the undersigned shall not engage in publication or public discussion of confidential material, information, documents, or work product in any forum, scientific, technical or otherwise, prior to the completion of a natural resource damages assessment and final resolution of any and all administrative or judicial actions related to this matter.<sup>66</sup>

In one respect, the agreement differs from the agreements reportedly signed by BP contractors: federal agreements have (or had) no specific time limits. Release is contingent upon final resolution of relevant administrative and judicial actions. If another spill were to occur in the Gulf or elsewhere, parties to a later spill would have no clear way of knowing whether research on the effects of the BP spill would be useful in forming a response, unless a federal employee were aware of the research and attempted to clear it with the DOI Solicitor for use in responding to the later spill. At the same time, high ranking federal officials claim to be unaware of restrictions on independent researchers or on their access to study sites, unless the researcher wishes to participate in NRDA formally.<sup>67</sup>

When the scientific community voiced its concerns about such requirements, BP reportedly changed its policies.<sup>68</sup> In addition, it committed \$500 million for a fund (Gulf Research Initiative,

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<sup>64</sup> For example, see Linda Hooper-Bui, "Opinion: The oil's stain on science," *The Scientist*, vol. On-line edition (August 5, 2010). Available at <http://www.the-scientist.com/news/print/57610/>. Hereafter referred to as "Opinion: the oil's stain on science."

<sup>65</sup> Mark Tran, "BP denies 'buying silence' of oil spill scientists," *The Guardian*, July 23, 2010, <http://www.guardian.co.uk/environment/2010/jul/23/bp-oil-spill-scientists-silence/print>. For text of letter to Attorney General Eric Holder from the National Wildlife Federation and others, see <http://www.nwf.org/News-and-Magazines/Media-Center/Resources-for-the-Press/~media/PDFs/Wildlife/Oil-Spill-Transparency-Letter.ashx>.

<sup>66</sup> Dept. of the Interior. *Confidentiality Agreement, Mississippi Canyon 252 Oil Spill*. Undated. Copy available from author.

<sup>67</sup> See "Opinion: the oil's stain on science" (cited above), Editor's note, citing Pete Tuttle, FWS environmental contaminant specialist, and Dept. of the Interior NRDA coordinator.

<sup>68</sup> Lauren Schenkman, "After Outcry, Oil Data Inches Into the Open," *Science*, vol. 329 (August 20, 2010), pp. 888-889. Available at <http://www.sciencemag.org/cgi/reprint/329/5994/888-a.pdf>. (Hereafter cited as "After Outcry.")

or GRI) for competitive grants for scientific research. According to a BP press release “All GRI-funded research will be independent of BP, and the results will be published in peer-reviewed scientific journals with no requirement for BP approval.”<sup>69</sup> NOAA is also reported to have relaxed its restrictions on scientific publication.<sup>70</sup>

It appears that the state of scientific research, access to study sites, and rules for publication are in flux. There was clearly no default setting for science research among federal agencies or independent scientists at the start of the oil spill, although there is some indication of greater freedom to do independent research. A general policy for determining what science can be done, and what access researchers may have, particularly during the critical immediate response to crisis, may benefit responders to future crises. The Gulf oil spill might also produce broader agreement on when and how research resulting from a disaster may become generally available.

## Conclusion

The long-term impacts from the Deepwater Horizon release on the environment will be investigated for some time, probably many years. There are unanswered questions about the amount of oil still remaining in the Gulf, how the oil will degrade in the environment, what mitigation actions will be taken, and what immediate and long-term damaging effects might result from those actions.

Oil has the potential to endure in the environment long after a spill. In coastal marshes, oil may be pushed or may seep into bottom sediments and may persist for a long period of time, having potential to be re-suspended by waves or storm events, and remaining a threat to wetlands and wildlife.

The costs of the oil spill in damages to wildlife and wetland resources—killed or injured animals, contaminated or destroyed vegetation and habitat—cannot be measured at this point. Likewise, the financial costs of response and recovery will be unknown for years. Those financial costs will include public and private response activities, fines and penalties, and third party claims. They also will include natural resource damage settlements. In the current case, natural resource damages and assessment costs—including those for determining the extent of impacts, restoring injured resources to baseline, and compensating for interim losses—are likely to be substantial in absolute terms, but still could be small compared with response costs and third party claims.<sup>71</sup>

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<sup>69</sup> See <http://www.bp.com/genericarticle.do?categoryId=2012968&contentId=7065262>, viewed Sept. 30, 2010. Access to BP research funded outside of GRI was not covered in the press release.

<sup>70</sup> See “After Outcry,” cited above. CRS was able to find no indications that standards for disclosure of scientific information have been modified for employees in DOI agencies.

<sup>71</sup> Douglas Helton and Tony Penn, “Putting Response and Natural Resource Damage Costs in Perspective,” 1999 *International Oil Spill Conference*, no. #114, <http://www.iosc.org/papers/01767.pdf>. The authors examined cost data on 48 U.S. spill incidents between 1984 and 1997 and found that, overall, response costs were the largest category. However, in the case of the *Exxon Valdez* spill, approximately 30% of the total known costs (which exceed \$9 billion, according to the authors) were response costs, and 60% were third party claims. Natural resource damage and assessment costs comprised 10% of the known costs. For an overview of natural resource damage assessment laws and policies, see CRS Report R41262, *Deepwater Horizon Oil Spill: Selected Issues for Congress*, coordinated by Curry L. Hagerty and Jonathan L. Ramseur.

Although events are still at a relatively early stage, a number of questions arise. When will recovery be complete, and how do we define success, or completion? What is an acceptable level of habitat recovery? NOAA regulations (15 C.F.R. § 990.30) state that recovery “means the return of injured natural resources and services to baseline”—in other words, a return to conditions as they would have been had the spill not occurred. But what this means in actual terms is open to considerable debate. A conventional definition of recovery is probably “return to the way things were before the spill.” Unfortunately, this benchmark is vague and hard to quantify. Change is particularly characteristic of coastal areas, which are already subject to significant annual losses in the Gulf coast area. In the case of Prince William Sound, for example, it is difficult to apply this standard of recovery because there is little information about “the way things were” before that spill. Multiple variables affect local species and ecosystem services. Similarly, one species at a spill site could have been on the decline at the time of an incident, because of changing water temperatures or other factors. Even in the absence of a major disturbance like an oil spill and cleanup, ecosystems are constantly in transition, and the physical and biological conditions that once characterized any given site are likely to shift considerably over time.<sup>72</sup>

With so many unknowns, predicting the long-term future of the wealth of natural resources in the Gulf could be foolhardy. Even so, observations from the *Exxon Valdez* spill and other spills offer some insight. First, there will likely be significant long-term effects, and the impacts will not be evenly distributed. Some areas and species will require more time than others. Moreover, the stresses of these effects are an add-on to wetlands that are already disappearing due to subsidence, global sea level rise, and other factors. If a wetland area simply disappears as a result of some combination of these factors, no recovery can occur, regardless of remediation. The Gulf’s wildlife was already under stress from these same factors. The spill seems likely to exacerbate existing trends, although in ways that are hard to predict.

Second, litigation has been a driver of post-spill action in the past, and multiple lawsuits have already been filed in response to the Deepwater Horizon event. If the *Exxon Valdez* experience is an indicator, the timely sharing of data among scientists appears likely to suffer. Some information could be temporarily or indefinitely concealed, possibly to the detriment of recovery of various resources. Since much is unknown about coastal wetlands and their inhabitants, the withholding of data could be a handicap to recovery.

Third, the spill did provide at least one benefit that might not have occurred otherwise. Federal employees from many agencies have reported for weeks of duty, sometimes as volunteers, to use their expertise in responding to the spill.<sup>73</sup> They, and a large number of state and local employees, as well as volunteers, now have experience in responding to a disaster of this magnitude. As a result, a large number of government employees and others have had training in the Incident Command system; this training could be useful in future disasters of any nature.<sup>74</sup>

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<sup>72</sup> U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Response and Restoration, “Has Prince William Sound Recovered From the Spill?,” June 2, 2005, [http://response.restoration.noaa.gov/topic\\_subtopic\\_entry.php?RECORD\\_KEY%28entry\\_subtopic\\_topic%29=entry\\_id,subtopic\\_id,topic\\_id&entry\\_id%28entry\\_subtopic\\_topic%29=258&subtopic\\_id%28entry\\_subtopic\\_topic%29=13&topic\\_id%28entry\\_subtopic\\_topic%29=1](http://response.restoration.noaa.gov/topic_subtopic_entry.php?RECORD_KEY%28entry_subtopic_topic%29=entry_id,subtopic_id,topic_id&entry_id%28entry_subtopic_topic%29=258&subtopic_id%28entry_subtopic_topic%29=13&topic_id%28entry_subtopic_topic%29=1).

<sup>73</sup> For FWS employees, for example, see “Service Stories: Tight quarters and a 4:30 a.m. wakeup call on a ‘flotel’ for oil spill responders,” available at <http://www.fws.gov/home/dhoilspill/index.html>.

<sup>74</sup> See “Oil Spill Response: Who Decides What to Do?,” above.

When immediate response to the spill and recovery (however it is defined) are complete, attention will likely turn to restoration. At that point, another question that will arise is, what does restoration mean? In June, President Obama committed the federal government to a long-term plan of Gulf coast environmental restoration. The White House said that a federal interagency task force, led by Navy Secretary Ray Mabus, will develop a plan with the goal of making the Gulf better than it was before April 20 (or, better than the baseline condition called for in NOAA's regulations that define recovery). When that plan emerges, it will represent the most recent such proposal, adding to numerous other plans and projects that have been proposed to rebuild coastal areas that have experienced decades of adverse effects from erosion, storms, and development, especially in Louisiana's wetlands. Some of those earlier plans were endorsed by Congress,<sup>75</sup> and some of them are underway now, but critics observe that there has been little action to date for reasons that include costs, complexity, and ecological and institutional challenges. Of great interest will be how existing and new plans and proposals will be coordinated, how current short-term responses to the oil spill may affect long-term restoration,<sup>76</sup> and how barriers that have stalled previous efforts can be overcome.

During the immediate response to the spill, Congress has provided substantial oversight of efforts to contain and mitigate the oil and its impacts. Congress also is considering policy and legislative changes to prevent such events in the future.<sup>77</sup> In the longer term, Congress is likely to be influential in guiding the environmental restoration plan for the Gulf coast that the President has pledged to pursue. During the immediate response to the oil spill, two key questions have been, who is responsible for cleanup, and who pays.<sup>78</sup> Similar questions will arise in relation to longer-term restoration, especially questions of who will pay for restoration and what the federal role will be.

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<sup>75</sup> For example, the Coastal Wetlands Planning, Protection and Restoration Act of 1990, also known as the Breaux Act, provided funding to carry out coastal wetland restoration projects in Louisiana and other states. Similarly, the 2006 Gulf of Mexico Energy Security Act provided revenues from offshore oil and gas activities for wetland restoration and other activities in states bordering the Gulf.

<sup>76</sup> For example, in May the federal government granted a portion of Louisiana's request to dredge sand and other material to build berm structures offshore of existing barrier islands in order to reduce inland movement of oil. The state had sought permission to build 128 miles of barrier berms; the government authorized 45 miles of structures. As described in CRS Report R41262, *Deepwater Horizon Oil Spill: Selected Issues for Congress*, coordinated by Curry L. Hagerty and Jonathan L. Ramseur, this proposal has been controversial. For example, in commenting on the state's request, NOAA, EPA and other federal agencies raised a number of concerns, including that the project could deplete finite Louisiana sand resources, thus affecting future high-priority barrier island restoration projects and largely negating two decades' of planning efforts. See "NOAA Considerations on Louisiana Proposal for Barrier Island Restoration Plan" in U.S. Army Corps of Engineers, "Corps decision on state's emergency permit request," May 27, 2010, <http://155.76.147.200/news/Emergency%20Permit%20Documents%20Compressed%20FINAL.pdf>, p. 11.

<sup>77</sup> For information on congressional and legislative activity, see CRS Report R41407, *Deepwater Horizon Oil Spill: Highlighted Actions and Issues*, by Curry L. Hagerty and Jonathan L. Ramseur.

<sup>78</sup> For general discussion of these questions, see CRS Report R41262, *Deepwater Horizon Oil Spill: Selected Issues for Congress*, coordinated by Curry L. Hagerty and Jonathan L. Ramseur.

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