# Plan for *Deepwater Horizon* Oil Spill Natural Resource Injury Restoration: An Overview

**OCTOBER 2015**

# Find Us Online

Please visit the Trustees' website at www.gulfspillrestoration.noaa.gov. There you can:

- Download this overview document.
- Learn more about the injuries to natural resources from the *Deepwater Horizon* incident and the proposed plans to restore these natural resources.
- Read the complete Deepwater Horizon *Oil Spill Draft Programmatic Damage Assessment and Restoration Plan and Draft Programmatic Environmental Impact Statement* (Draft PDARP/PEIS).
- Learn how to participate in the public review process and submit comments.

This document is intended to provide an easy-to-read overview of key components of the Draft PDARP/PEIS, not a full summary. All public comments should be made on the Draft PDARP/PEIS and not on this overview document.

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# Introduction

## The *Deepwater Horizon* Incident

**An unprecedented event:** On April 20, 2010, the *Deepwater Horizon* mobile drilling unit exploded, caught fire, and eventually sank in the Gulf of Mexico. Tragically, 11 workers were killed and 17 were injured by the explosion and fire. The event also resulted in a massive release of oil and other substances from BP's Macondo well. Initial efforts to cap the well following the explosion were unsuccessful, and for 87 days after the explosion, the well continuously and uncontrollably discharged oil and natural gas into the northern Gulf of Mexico. Approximately 3.19 million barrels (134 million gallons) of oil were released into the Gulf of Mexico, by far the largest offshore oil spill in United States history.

**Widespread effects to a diverse and productive ecosystem:** The northern Gulf of Mexico comprises a vast, interconnected ecosystem containing some of the nation's most diverse and productive natural resources. Oil spread from the deep ocean to the surface and nearshore environment, from Texas to Florida. The oil came into contact with and injured natural resources as diverse as deep-sea coral, fish and shellfish, productive wetland habitats, sand beaches, birds, endangered and threatened sea turtles, and protected marine mammals. Additionally, the oil spill prevented people from fishing, going to the beach, and enjoying their typical recreational activities along the Gulf of Mexico. Extensive response actions, including cleanup activities and actions to try to prevent the oil from reaching sensitive resources near the shore, were undertaken to try to reduce harm to people and the environment. However, response actions also had their own impacts on the environment.

## Assessing and Restoring Injuries

**A comprehensive assessment:** Under the Oil Pollution Act (OPA), a council of federal and state "trustees" was established soon after the spill to assess the natural resource injuries resulting from the *Deepwater Horizon* incident, develop a restoration plan to compensate for those injuries, and acquire funding to make restoration possible. The Trustees act on behalf of the public, and they comprise a group of federal agencies along with designated agencies representing each of the five Gulf states (see box on the next page).

**Explosion of the *Deepwater Horizon* mobile drilling rig.**

The injuries from the *Deepwater Horizon* incident affected a wide array of integrated and linked resources over an enormous area for a long time. The effects constitute an ecosystem-level injury.

**Broad, interconnected impacts require a comprehensive restoration plan:** The impacts caused by the *Deepwater Horizon* spill cannot be fully described at the level of a single species, a single habitat type, or a single region. Rather, the oil released into the environment was toxic to a wide range of organisms, and it resulted in injuries to multiple habitats, species, and

## The *Deepwater Horizon* Natural Resource Trustees

Natural resource trustees act on behalf of the public to assess injuries and recover damages (funds) to develop and implement plans for restoring, rehabilitating, replacing, or acquiring the equivalent of the natural resources that have been damaged. Trustees fulfill these responsibilities by assessing the nature and extent of the injury, developing restoration plans, providing the public with meaningful opportunity to review and comment on proposed plans, and documenting their decisions through a public Administrative Record.

A group of federal agencies and state agencies from all five Gulf states serve as Trustees for the *Deepwater Horizon* incident:

- **Federal:***
  - U.S. Department of the Interior, as represented by the United States Fish and Wildlife Service (USFWS), National Park Service (NPS), and Bureau of Land Management (BLM)
  - National Oceanic and Atmospheric Administration (NOAA), on behalf of the U.S. Department of Commerce
  - U.S. Department of Agriculture (USDA)
  - U.S. Environmental Protection Agency (EPA)
- **Texas:** Parks and Wildlife Department (TPWD), General Land Office (TGLO), and Commission on Environmental Quality (TCEQ)
- **Louisiana:** Coastal Protection and Restoration Authority (CPRA), Oil Spill Coordinator's Office (LOSCO), Department of Environmental Quality (LDEQ), Department of Wildlife and Fisheries (LDWF), and Department of Natural Resources (LDNR)
- **Mississippi:** Department of Environmental Quality (MDEQ)
- **Alabama:** Department of Conservation and Natural Resources (ADCNR) and Geological Survey of Alabama (GSA)
- **Florida:** Department of Environmental Protection (FDEP) and Fish and Wildlife Conservation Commission (FWC)

* Although a trustee under OPA by virtue of the proximity of its facilities to the *Deepwater Horizon* oil spill, the U.S. Department of Defense (DOD) is not a member of the Trustee Council and did not participate in development of this Draft PDARP/PEIS.

ecological functions. These injuries affected such a broad array of linked resources and ecological services over such a large area that they can best be described as an injury to the entire ecosystem of the northern Gulf of Mexico. Consequently, the Trustees have proposed a restoration plan that uses a comprehensive and integrated ecosystem approach to appropriately address these ecosystem-level injuries.

**Funding for restoration:** OPA makes parties responsible for an oil spill liable for the costs of responding to and cleaning up the spill, as well as the costs of assessment and restoration needed to compensate for injuries to natural resources and the services they provide. The Department of Justice has lodged for public comment a settlement in a proposed Consent Decree with BP. Under this settlement, BP would

pay a total of $8.1 billion for use by the Trustees—which includes $1 billion already committed for Early Restoration—plus up to an additional $700 million to respond to natural resource conditions unknown at the time of the proposed settlement. As documented in the *Draft Programmatic Damage Assessment and Restoration Plan*, based on the assessment of injuries and on the restoration required to compensate for these injuries, the amounts allocated in the proposed settlement are adequate, they provide a reasonable and fair means to achieve the goals of OPA to make the public and the environment whole, and they advance the public interest. Settlement also avoids the uncertainties and delays of litigation, thus recovering money for restoration sooner.

The proposed Consent Decree is subject to its own public comment process regarding the sufficiency of the settlement. Comments on the settlement should be addressed to the Department of Justice. A link to the proposed Consent Decree and directions for commenting to the Department of Justice are available at www.gulfspillrestoration.noaa.gov.

## About This Document

The Trustees have developed a document entitled *Draft Programmatic Damage Assessment and Restoration Plan and Draft Programmatic Environmental Impact Statement* (Draft PDARP/PEIS). The draft document fulfills two purposes:

- It provides a natural resource damage assessment and proposed restoration plan, under OPA.
- It presents an examination of the environmental impacts of various restoration alternatives, under the National Environmental Policy Act (NEPA).

Given the ecosystem-level nature of the injuries, the Trustees prepared the Draft PDARP/PEIS document in a *programmatic* manner. Instead of identifying and analyzing specific restoration projects, the Draft PDARP/PEIS provides higher-level guidance for identifying, evaluating, and selecting future restoration projects. The Draft PDARP/PEIS also describes how the Trustees propose to allocate restoration funding across geographic areas and various types of restoration activities.

This document provides an overview of the Draft PDARP/PEIS, including key findings. For a more complete discussion with technical details and citations, please refer to the full Draft PDARP/PEIS. The Draft PDARP/PEIS is the official statement describing the Trustees' determinations and proposed decisions, and its text will control in case there are any differences between the Draft PDARP/PEIS and this document.

## Public Input

Public input is an important part of restoration planning. The Trustees involved the public soon after the spill, including a formal scoping process early in 2011. These initial efforts helped to inform the Trustees on types of restoration and environmental impacts important to consider in the Draft PDARP/PEIS. Through websites and public meetings, the Trustees have kept the public informed about the progress of restoration and sought continued input on restoration projects. The Trustees considered this input from the public in the development of the Draft PDARP/PEIS.

The public is now encouraged to review and comment on the Draft PDARP/PEIS, available at www.gulfspillrestoration.noaa.gov. The Trustees will hold a series of public meetings to facilitate review and comment. Meeting locations, dates, and times are specified in the *Federal Register* notice announcing release of the Draft PDARP/PEIS and in additional announcements made by the states. They are also listed on the Web at www.gulfspillrestoration.noaa.gov. After the close of the public comment period, the Trustees will consider all relevant comments received during that time and revise the PDARP/PEIS as may be appropriate. A summary of comments received and the Trustees' responses will be included in the Final PDARP/PEIS.

# Incident and Ecosystem Setting

Oiled marsh in Louisiana.

## Key Points

- The *Deepwater Horizon* spill resulted in a surface oil slick that, over time, covered a cumulative area of 43,300 square miles, an area approximately the size of the state of Virginia.
- Oil surged upward from the deep ocean floor and was pushed toward the shorelines of the Gulf states by currents, winds, and wave action. The extent of shoreline oiling exceeded the distance by road from New Orleans to New York City. At least 1,300 miles (2,100 kilometers) of shoreline were exposed to oil from the spill.
- The northern Gulf of Mexico comprises a vast regional ecosystem—an interactive, interdependent network of organisms (from microbes to plants to animals) and their chemical, biological, and physical environments. This ecosystem contains some of the nation's most diverse and productive natural resources, and it provides critical services to humans, including fisheries, recreation, and protection from storms.
- All of the natural resources of the northern Gulf of Mexico ecosystem were threatened and many were injured, some severely, as a result of the *Deepwater Horizon* incident. These injuries caused significant adverse effects to the environment—including resources managed by the Trustees—and to the economy of the region.

# The *Deepwater Horizon* Incident

## Explosion and Oil Spill

On April 20, 2010, the *Deepwater Horizon* mobile drilling unit, located about 50 miles offshore from Louisiana, exploded, caught fire, and eventually sank. This resulted in a massive release of oil and other substances from BP's Macondo well, which was located beneath the *Deepwater Horizon* unit, about 1 mile below the ocean surface.

Initial efforts to cap the well following the explosion were unsuccessful, and for 87 days after the explosion, the well blasted oil and natural gas continuously and uncontrollably into the northern Gulf of Mexico. It was by far the **largest offshore oil spill in the history of the United States**. The total volume of oil released is about 12 times more than the 1989 *Exxon Valdez* spill that took place in Alaska.

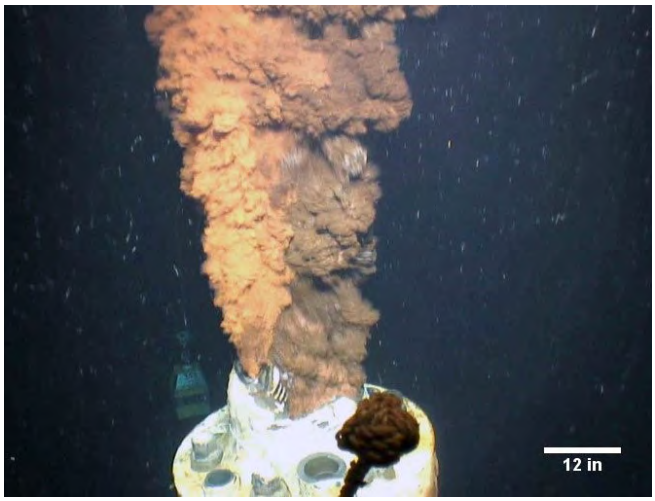
Oil under pressure gushed into the deep ocean from BP's Macondo well. Oil moved with currents, creating a contaminated plume within the deep sea. Oil and associated "marine oil snow" (solid particles, including

### *Deepwater Horizon* by the Numbers

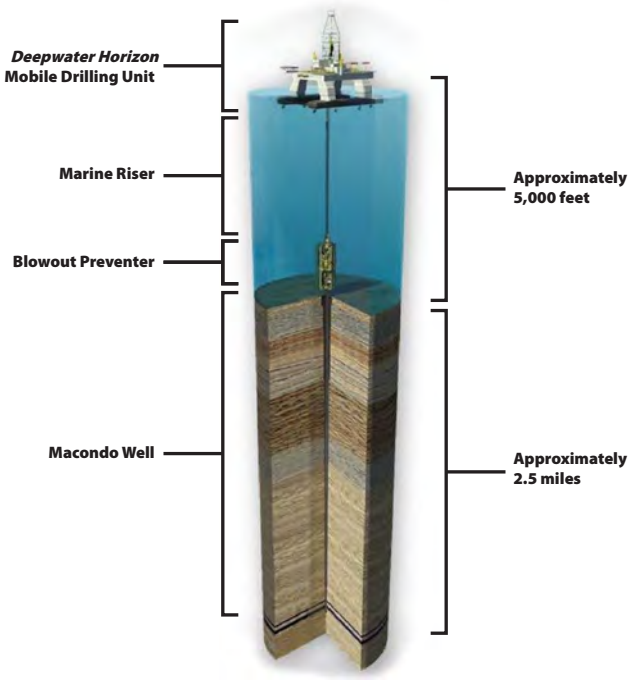
- **3.19 million barrels (134 million gallons)** of oil released into the ocean.
- **15,300 square miles:** the maximum extent of the oil slick on a single day (June 19, 2010)—an area 10 times the size of Rhode Island.
- **43,300 square miles:** cumulative extent of the surface slick during the course of the spill—an area approximately equal to the size of Virginia.
- **At least 1,300 miles** of shoreline fouled by oil—more than the distance by road from New Orleans to New York City.
- **1.84 million gallons** of chemical dispersant used.

**43,300-square-mile cumulative area of detectable oil slick during the *Deepwater Horizon* spill, based on satellite images.**

naturally occurring particles containing oil droplets) also settled on the sea floor. More buoyant oil traveled up through the water column and formed large surface slicks. Currents, winds, and tides carried these surface oil slicks to the Gulf states, fouling beaches, bays, estuaries, and marshes from eastern Texas to the Florida Panhandle. In addition, some lighter oil compounds evaporated from the sea surface, which exposed marine mammals and sea turtles to noxious fumes when they surfaced to breathe.




Underwater videos captured dramatic images of oil spewing unchecked from the well's broken riser pipe into the deep ocean.

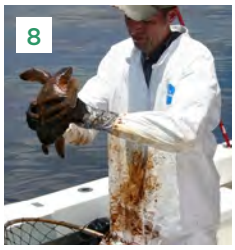



**An illustration of the *Deepwater Horizon* drilling unit and BP's Macondo well. The top of the Macondo well was on the sea floor, about 5,000 feet below the sea surface. The well was dug to a depth of about 13,000 feet below the sea floor.**

**Location of BP's Macondo well on the continental slope.**

## Response Activities

A wide variety of response actions were undertaken to try to collect the oil, disperse it, and attempt to reduce human exposure and injuries to natural resources. Some of these response actions are pictured below.



**1.** Deploying booms to keep oil away from the shoreline. **2.** Applying dispersant chemicals to break the oil into small droplets. **3.** Burning floating oil. **4.** Closing beaches and fisheries. **5.** Physically removing oil floating on the water surface (skimming). **6.** Releasing fresh water into the Gulf of Mexico to keep the oil offshore. **7.** Constructing berms. **8.** Rescuing, rehabilitating, and relocating wildlife. **9.** Removing oil and oiled materials along and near the shoreline.

Response actions were intended to reduce the impact of the oil spill, and they were often successful. However, some of these response activities also affected the environment in negative ways. For example, burning oil produced air pollution, increased boat traffic and shoreline activity disturbed habitats, and the release of unusually large amounts of river water into estuaries changed the salinity of the water, which affected oysters and other creatures. Beach and fishery closures also prevented people from enjoying recreational activities.

# The Northern Gulf of Mexico Ecosystem

The northern Gulf of Mexico comprises a vast regional ecosystem—an interactive, interdependent network of organisms (from microbes to plants to animals) and their chemical, biological, and physical environments. Ranging from the coastline itself, to its bays and estuaries, to the expansive continental shelf, to the vast open ocean and deep sea, the northern Gulf of Mexico ecosystem contains some of the nation's most diverse and productive natural resources. All these resources were threatened and many were injured, some severely, as a result of the *Deepwater Horizon* incident.

## A Diverse Array of Life

The northern Gulf of Mexico hosts a diverse array of fish, shellfish, and bird species, as well as many species of federally protected whales, dolphins, and sea turtles. Larger organisms such as mahi-mahi and dolphins are supported by smaller organisms in the water column and within the sediments on the ocean floor, which play an integral role in the food web.

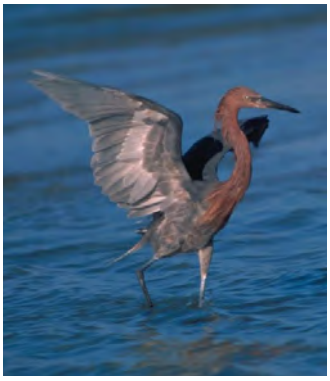
**Sea turtles**

**Phytoplankton and zooplankton**

**Benthic organisms** (e.g., corals, mollusks, sponges, and marine worms)

**Marine mammals**
(e.g., dolphins and whales)

**Birds**



**Crustaceans**
(e.g., shrimp)

**Fish**

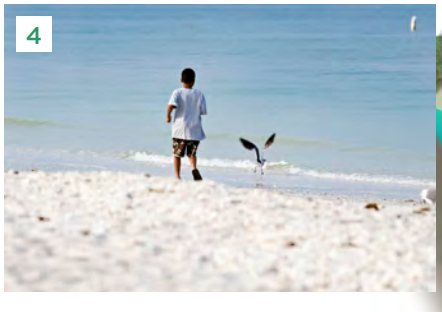
## Habitats of the Northern Gulf of Mexico

The animals, plants, and other living organisms of the northern Gulf of Mexico reside in an interconnected fabric of linked habitats.

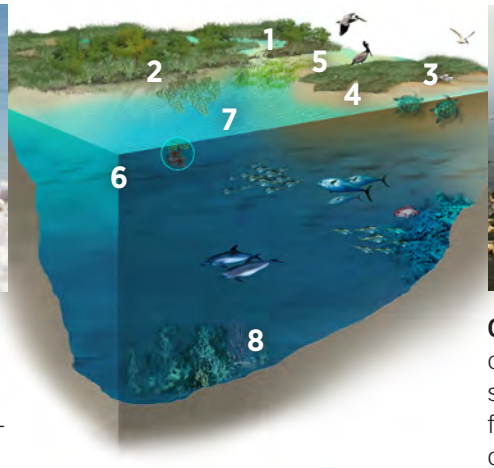
**Marshes** are a critical and highly productive transition zone between land and water, providing habitat for many species of fish, shellfish, and birds.

**Black mangroves** help stabilize and protect shorelines and provide essential feeding and nursery habitat for young fish such as red snapper, and birds such as pelicans.

**Barrier islands** protect the coastline against storms and provide important habitats for a diverse array of birds, sea turtles, and other wildlife.




**Sand beaches and dunes** provide important habitats for shorebirds, nesting sea turtles, and beach mice, and they provide recreational opportunities for people.



**Oyster habitat** is found throughout the coastal ecosystem. Oysters stabilize shorelines, provide habitat for fish, and filter the water, which improves water quality.

**The water column** supports aquatic life at all depths. At the surface, large floating mats of algae (seaweed) called *Sargassum* provide essential shelter and food for young fish and sea turtles.

**Submerged aquatic vegetation**, such as seagrass, stabilizes coastal habitats and provides refuge, food, and shelter for fish, shellfish, invertebrates, sea turtles, and other species.

**The ocean floor** comprises several diverse habitats, including soft-bottom areas, deepwater corals, and mesophotic reefs (reefs that are deep enough to get only a small amount of sunlight). It is home to deep-sea organisms such as red crabs and urchins.

## Connectivity

The northern Gulf of Mexico ecosystem is a complex web, in which certain physical processes and biological interactions in one location have important impacts on organisms in other locations. For example, nearshore habitats provide food, shelter, and nursery grounds for many animals that use the open waters of the Gulf, including fish, shrimp, shellfish, sea turtles, birds, and mammals. In this way, the nearshore ecosystem fundamentally supports the entire Gulf of Mexico ecosystem, including offshore habitats. The Trustees' injury assessment and restoration alternatives are based on an understanding of the nature, extent, connectivity, and importance of the northern Gulf of Mexico ecosystem resources.

## A Vital Resource

The northern Gulf of Mexico provides many important **ecosystem services** that directly or indirectly benefit society. The region's extensive network of coastal wetlands, estuaries, and barrier islands support important populations of fish and wildlife; help maintain water quality; protect shorelines from storm surge and wave action; and provide enormous enjoyment for the American people. The northern Gulf ecosystem supports economically valuable recreation and tourism industries, as well as many of the nation's most commercially and recreationally important fish and shellfish species, such as oysters, shrimp, red snapper, and tuna.

## Environmental Stressors

The northern Gulf of Mexico is affected by a wide variety of natural stressors, such as drought, fluctuating temperatures, hurricanes, and land subsidence. It is also affected by human stressors such as development, channelization of rivers and alteration of natural flooding and sedimentation patterns, climate change and accelerated sea-level rise, agricultural and wastewater discharges, fishing pressure, and invasive species.

# Injury

## Key Points

- The oil released into the environment by the *Deepwater Horizon* incident was toxic to a wide range of organisms, including fish, invertebrates, plankton, birds, sea turtles, and marine mammals. It caused an array of toxic effects, including death, disease, reduced growth, impaired reproduction, and physiological impairments that made it more difficult for organisms to survive and reproduce.
- The water, sediments, and marsh habitats in many locations in the northern Gulf of Mexico had concentrations of oil that were high enough to cause toxic effects. The degree and extent of these toxic concentrations varied by location and time. The extent and degree of toxic levels of oil has declined substantially from 2010 to the present.
- Exposure to oil and response activities resulted in extensive injuries to multiple habitats, species, and ecological functions, across broad geographic regions.
- The *Deepwater Horizon* spill resulted in injuries to marsh habitats, including marsh plants and associated organisms; to shoreline beaches and sediments, and organisms that live on and in the sand and sediment; to fish and invertebrates that live in the water; to a large number of bird species commonly associated with marsh, beach, and open ocean habitats; to floating *Sargassum* habitats offshore and submerged aquatic vegetation; to deep-sea and nearshore ocean-bottom habitats, including to rare, deepwater corals and bottom-dwelling organisms such as red crabs; to all five species of threatened or endangered sea turtles that live in the Gulf of Mexico; and to marine mammals, including dolphins and whales, associated with estuarine, coastal, and open ocean habitats.
- The injuries caused by the *Deepwater Horizon* spill affected such a broad array of integrated and linked resources and ecological services over such a large area that they cannot be adequately described at the level of a single species, a single habitat type, a single set of services, or even a single region. Rather, the effects of the *Deepwater Horizon* spill constitute an injury to the entire northern Gulf of Mexico ecosystem.

**Stenellid dolphins swimming in oil.**

# How the Trustees Assessed Injury

The Trustees conducted a detailed assessment to determine the nature, degree, geographic extent, and duration of injuries from the *Deepwater Horizon* incident to both natural resources and the services they provide to the public. This assessment was then used in the restoration planning process to inform the type and amount of restoration appropriate to address the injuries.

The Trustees began to assess injuries as soon as news of the spill was received, and they continued with a multi-phased iterative approach, in which planning and design decisions were informed by the data that had already been collected and evaluated. The Trustees used a variety of methods, including field and laboratory studies and models. They used scientific inference to make informed conclusions about injuries that they were not able to study directly. The Trustees assessed injuries to natural resources such as water column organisms, benthic (bottom-dwelling) organisms, nearshore ecosystems, birds, sea turtles, and marine mammals, and to the services provided by those resources, such as recreational beach use and fishing.

The injury assessment involved two main steps: **injury determination** and **injury quantification**.

## Step 1: Injury Determination

In this step, the Trustees evaluated whether the *Deepwater Horizon* incident injured natural resources or impaired their ability to provide services. This part of the assessment basically involved answering the following questions:

1. Can a **pathway** be established from the discharge to the exposed resource? This step involved confirming the sequence of events that resulted in oil being transported from BP's Macondo well to the locations where injuries occurred.
2. Did **exposure** take place? This step involved confirming that the injured resources were indeed exposed to *Deepwater Horizon* oil.
3. What **injuries** occurred as a result of the exposure and/or response activities?

## Step 2: Injury Quantification

In this step, the Trustees determined the degree (severity), geographic extent, and temporal extent (duration) of the injuries and service losses that occurred. To do this, the Trustees compared the injured resources and services with baseline conditions—that is, the condition that would have existed

## What Is Injury?

According to the regulations associated with the Oil Pollution Act, injury is: **"An observable or measurable adverse change in a natural resource or impairment of a natural resource service. Injury may occur directly or indirectly to a natural resource and/or service."**

Types of injuries can include (but are not limited to) adverse changes in survival, growth, and reproduction; health, physiology, and biological condition; behavior; community composition; ecological processes and functions; physical and chemical habitat quality or structure; and public services.

All of these types of injury occurred as a result of the *Deepwater Horizon* incident.

## Collecting Data in the Field

Field data collection involved roughly 20,000 trips, which generated more than 100,000 samples of water, tissue, oil, and sediment and more than 1 million field data forms and related electronic files. Testing of samples generated millions of additional records. The Trustees developed rigorous protocols and systems to manage sample collection, handling, and data storage. To store data, the Trustees developed a "data warehouse," referred to as the Data Integration, Visualization, and Reporting system (DIVER), which is publicly accessible at https://dwhdiver.orr.noaa.gov.

**Sediment samples collected in the Gulf.**

if the *Deepwater Horizon* incident had not occurred. Due to the geographic magnitude of the *Deepwater Horizon* incident, the Trustees could not quantify every injury that occurred. Instead, they focused on where injury quantification could provide the most useful information for estimating overall ecosystem impacts, and where it could be most helpful for Gulf-wide restoration planning.

Because of the vast scale of the incident and potentially affected resources, the Trustees evaluated injuries to a set of representative habitats, communities, species, and ecological processes. Studies were conducted at many scales, including the cellular, individual, species, community, and habitat levels. The Trustees evaluated many endpoints, including mortality, immune system suppression, reproductive impairment, growth inhibition, behavioral impairment, lesions, developmental defects, and others. The Trustees generally did not quantify changes in the population size or status of specific plants and animals, because natural variability from year to year can make it difficult to detect oil spill impacts at the population level. They used more than just counts of animals killed by the spill, because so many of the animals killed were not visible.

# Exposure

## Natural resources were exposed to oil and other contaminants released from the *Deepwater Horizon* incident over a vast area.

- The *Deepwater Horizon* disaster released approximately 134 million gallons (3.19 million barrels) of oil and 1.84 million gallons of dispersant chemicals into the environment.
- Every day for 87 days, BP's Macondo well released an average of more than 1.5 million gallons of fresh oil into the ocean—the equivalent of a large oil spill occurring every day for nearly 3 months.
- Combining direct observations, remote sensing data, field sampling data, and other lines of evidence, the Trustees documented that oil:
  - Was transported within deep-sea currents hundreds of miles away from the failed well.
  - Rose to the sea surface and created slicks that cumulatively covered a total area of 43,300 square miles—an area approximately the size of the state of Virginia.
  - Sank onto the sea floor over hundreds of square miles.
  - Was spread by wind and currents and washed onto at least 1,300 miles of shoreline.
- Natural resources were exposed to oil and/or dispersants across a broad range of habitats, including the deep sea; over 5,000 vertical feet of water column; the sea surface; and nearshore habitats such as beach, marsh, mangrove, and submerged aquatic vegetation.
- A wide variety of living organisms, including fish, shellfish, sea turtles, marine mammals, and birds, were exposed to oil and/or dispersant chemicals throughout the northern Gulf of Mexico. Natural resources were exposed through various pathways, including direct exposure and contact with contaminated water, air, sediments, and habitats (for example, oiled marsh).

**A sea turtle surfaces to feed on a Portuguese man of war in an area contaminated with oil from the *Deepwater Horizon* spill.**

- Despite natural weathering processes over the past 5 years, oil remains in some habitats, where natural resources continue to be exposed to it.

### How the Trustees Confirmed Exposure

The Trustees examined many lines of evidence, including:

- Photographs and other direct observations of oil from airplanes, helicopters, boats, and shorelines.
- Data from satellite- and airplane-mounted sensors.
- Data collected from remotely operated vehicles underwater.
- Data from thousands of samples of water, sediment, soil, and other media, confirming both the presence of oil and the specific "fingerprint" of *Deepwater Horizon* oil. That is, the samples contained oil that matched the chemical makeup of the oil from the *Deepwater Horizon* spill, which helped to confirm the source of the oil.
- Examinations and observations of birds, dolphins, turtles, and other organisms that were captured or died during the spill.

# Toxicity

The nature, extent, and severity of injuries from the *Deepwater Horizon* incident depended not only on exposure to oil, but also on how toxic the oil was.

The Trustees used a variety of field observations and controlled laboratory tests to determine how exposure to *Deepwater Horizon* oil would affect various organisms. Major findings included:

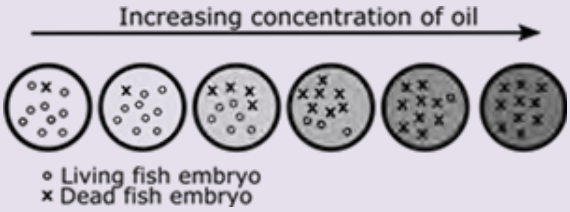
- Exposure to *Deepwater Horizon* oil caused a range of toxic effects in animals, including death, impaired reproduction, disease, and other physiological malfunctions that made it more difficult for organisms to survive and thrive.
- Fish embryos and larvae were particularly vulnerable to the toxic effects of *Deepwater Horizon* oil in the water. Fish species that develop quickly, such as tuna, mahi-mahi, and speckled sea trout, were more sensitive to oil toxicity than other species like minnows that take more time to develop.
- *Deepwater Horizon* oil was 10 to 100 times more toxic to developing invertebrates and fish in the presence of certain wavelengths of ultraviolet light found in sunlight. This effect would have been enough to cause many organisms at the ocean surface and in the water column to die.
- Exposure to *Deepwater Horizon* oil in the water also caused developmental abnormalities in early life stage organisms. These included heart and spinal defects that result in death.
- When juvenile and adult aquatic organisms were exposed to *Deepwater Horizon* oil, toxic effects included (but were not limited to) inhibited growth, suppressed immune systems, decreased swimming ability, and an abnormal response to stress. The adverse effects of oil still had serious detrimental effects even if they did not result in immediate death.
- Other environmental stressors added to the problems caused by exposure to *Deepwater Horizon* oil. For example, animals exposed to *Deepwater Horizon* oil were less likely to survive exposure to certain bacteria.

**Bird carcasses catalogued as part of the *Deepwater Horizon* injury assessment.**

- In laboratory tests, juvenile and adult animals exposed to *Deepwater Horizon*–oiled sediment suffered from a variety of injuries, including death, decreased growth, impaired reproduction, low hatching success, impaired embryonic development, and other abnormalities.
- When marsh periwinkle snails were exposed to oiled marsh grass (*Spartina*) in the laboratory, most of the snails were not able to move out of the oiled area to their preferred habitat (standing grass). The longer the snails were exposed to oil, the more snails died.
- *Deepwater Horizon* oil exposure caused adverse effects in all oyster life stages that the Trustees tested. Similar to other organisms, early life-stage oysters were the most sensitive. *Deepwater Horizon* oil caused reduced egg fertilization success (especially with additional ultraviolet light exposure), increased death, abnormal development, reduced growth, and reduced ability of young oysters to settle and grow.
- Turtles used as surrogates for sea turtles that ingested *Deepwater Horizon* oil in the laboratory suffered multiple effects, including evidence of dehydration, decreased digestive ability, and DNA damage. Some animals demonstrated an abnormal stress response.

## How Toxicity Is Tested in the Laboratory

One way to test toxicity is by adding the same number of organisms into exposure chambers (often beakers) with different levels of oil, along with a "control" chamber that contains no oil (see example figure below). After exposure to oil for a specific amount of time, the scientists count the living and dead organisms in each exposure chamber. Scientists repeat each experiment multiple times to account for variation.




To describe and compare toxicity tests, scientists determine what concentrations of oil kill 20 percent or 50 percent of test organisms (after considering the number of deaths in the control samples). For adverse effects other than death (for example, reduced growth), scientists report the concentrations of oil that cause a 20 percent or 50 percent difference from the typical control measurement. These standard measures allow comparison of toxicity across different tests.

The Trustees used these methods with dozens of different species at various life stages, including gametes (eggs and sperm), embryos, developing larvae, young/juveniles, and adults.

- Birds that ingested *Deepwater Horizon* oil by eating contaminated prey in the laboratory experienced a wide variety of toxic effects, including hypothermia, weight loss, lethargy, anemia, liver and kidney dysfunction, and heart abnormalities. Birds that ingested *Deepwater Horizon* oil by preening oiled feathers also experienced negative effects, including reduced body temperatures, poor body condition, lethargy, feather damage, increased feather plucking, anemia, and abnormal heart function. In addition, laboratory studies demonstrated that birds with oil on their feathers require more energy to take off and fly, compared with unoiled birds. This higher energy demand for flight can lead to lower survival due to increased risk of being eaten, increased need to feed along migratory flyways, and disruption of migration patterns (which may lead to a delayed arrival at breeding grounds and a subsequent reduction in breeding success). The Trustees documented many birds in the field with oiled feathers. Therefore, birds in the field likely suffered similar adverse effects, which would impact their fitness and survival.

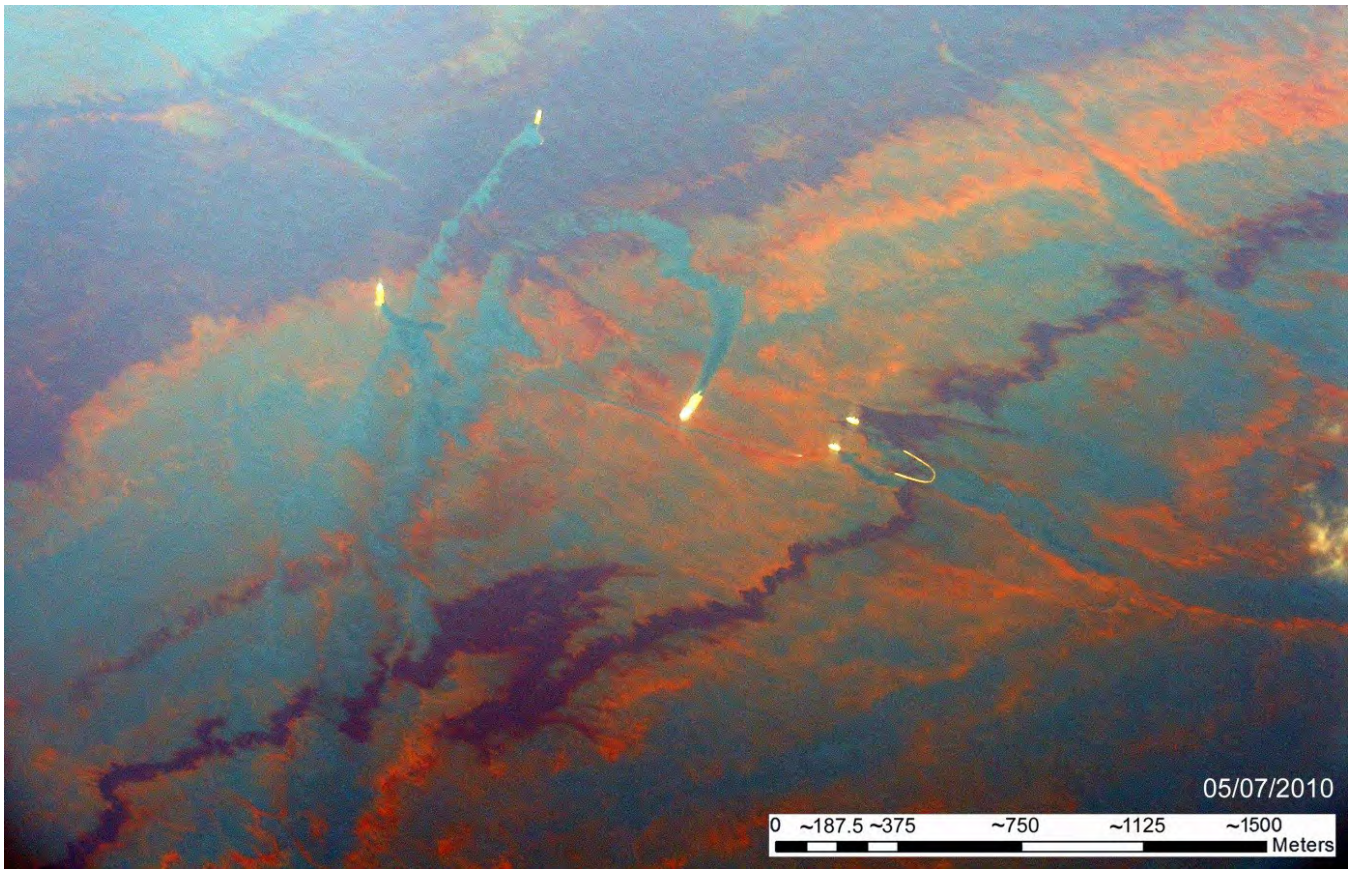
When organisms are exposed to chemical contaminants such as oil, the resulting toxic effects can occur in a variety of ways, depending on the species, individual life history, nature of the exposure, and other factors. However, there is remarkable consistency in observed toxic effects of oil among the *Deepwater Horizon* toxicity testing results discussed here, data from other *Deepwater Horizon* laboratory and field studies, and information from other oil studies.

## Effects of Dispersant Chemicals

The Trustees also examined how dispersant chemicals affected organisms. By themselves, the chemical dispersants used during the *Deepwater Horizon* response are considerably less toxic to fish than the oil itself. However, when dispersants are added to waterborne oil, they allow more of the toxic components of oil to mix into the water.

# The Water Column

Water column resources, including fish, invertebrates, and *Sargassum* habitat, were injured as a result of exposure to oil floating on the ocean surface, oil mixed into the upper water column by wind and wave action and the addition of chemical dispersants, oil as it moved from the wellhead to the surface, and oil mixed into the deep sea.




**Oil on the sea surface, May 7, 2010. When the oil mixed with water, it changed from black to reddish-brown to orange.**

The Gulf of Mexico waters from the shoreline to the deep sea support a wide variety of organisms, including plankton, numerous fish species at different life stages, mobile invertebrates (such as shrimp, crabs, and squid), sea turtles, seabirds, and marine mammals. These organisms, among others, play important ecological roles. For instance, they serve as prey or predators in the food web, and they cycle and transport nutrients between nearshore and offshore areas and between the surface and deep water. Many fish and crustaceans support robust commercial and recreational fisheries. Floating mats of seaweed called *Sargassum* create essential offshore habitat for invertebrates, fish, birds, and sea turtles. *Sargassum* provides both shelter and food, and it serves as the only naturally occurring structure on the surface of an otherwise featureless open ocean.

## Assessment Approach

Prior to the *Deepwater Horizon* incident, many of the aquatic species in the northern Gulf of Mexico, especially those in the deep ocean, had not been well studied. After the spill began, the Trustees conducted a large, sustained, and multifaceted oceanographic field program, including more than 40 cooperative studies with BP that involved multiple research vessels, remotely operated underwater vehicles, aircraft, satellite resources, and other specialized equipment. These efforts produced a large inventory of physical, biological, and chemical data.

Due to the vast size of the impacted area and the complexity of the water column, the Trustees combined field and remote sensing observations with laboratory studies and numerical modeling approaches.

## Exposure

The estimated average daily volume of contaminated water under the surface oil slick was 15 trillion gallons. As a comparison, this volume is approximately 40 times the average daily discharge of the Mississippi River at New Orleans. The *Deepwater Horizon* spill exposed many different types of organisms throughout the water column to oil. Following the blowout, *Deepwater Horizon* oil spread throughout the Gulf of Mexico water column, resulting in a deep-sea oil plume, rising oil plume, surface slick, and consequent subsurface oil. *Sargassum* and surface oil are subject to the same physical processes and both accumulate in convergence zones (i.e., where surface waters come together). Thus, *Sargassum* was observed in the same places as surface oil. An understanding of the distributions and life history patterns of other organisms allowed the Trustees to determine that exposure occurred to different species and life stages over time and space.

## Injury Determination

Concentrations of oil measured in the Gulf of Mexico following the *Deepwater Horizon* spill exceeded levels that the Trustees' toxicity testing showed could cause death or other harmful effects to water column organisms. Field studies documented community-level and physiological injuries to water column organisms, including reduced survival, food web shifts, community structure shifts, reduced growth, impaired reproduction, and adverse health effects.

## Injury Quantification

To estimate the number of organisms killed as a direct result of oil exposure, the Trustees used predicted death rates (from laboratory toxicity studies) of early life stages of fish and invertebrates exposed to oil in the surface slick, the subsurface mixing zone, the rising cone, and the deep plume of oil. The total number of larval (newly hatched) fish and planktonic invertebrates killed was approximately 2 to 5 trillion and 37 to 68 trillion, respectively. Of these totals, 0.4 to 1 billion fish larvae and 2 to 6 trillion invertebrates were killed in estuarine surface waters. This represents a large loss of a source of food for larger organisms, as well as a loss of the adult fish the larvae would have produced. The Trustees estimated that the lost larvae from nine fish species due to the *Deepwater Horizon* spill would have produced thousands of tons of adult fish—and that number just represents nine species out of more than 1,000 known fish species in the Gulf of Mexico.

The Trustees analyzed long-term datasets and did not detect widespread changes to fisheries populations as a result of the *Deepwater Horizon* oil spill. However, due to the inherent variability in fisheries datasets, the Trustees cannot rule out the possibility of population-level effects. Analysis of *Sargassum* found that exposure to oil may have caused the loss of up to 23 percent of this habitat within the area affected by the cumulative footprint of the *Deepwater Horizon* oil slick. The total loss of *Sargassum*, including areas where additional growth was unable to occur, was about 4,300 square miles.

# Benthic Resources

Benthic resources were injured over a variety of habitats and depths from the deep sea to the coastline.

**Progression of injury to a coral colony that was covered by spill residue in 2010. Opportunistic organisms called hydroids colonized the injured coral in 2011, and the coral began to lose branches in 2012.**

Benthic resources comprise rare corals, fish, crabs, and a myriad of small animals and microbes that live in a variety of habitats on the sea bottom and are part of the foundation of life and food webs in the northern Gulf of Mexico. Soft-bottom sediment is by far the dominant type of benthic environment in the northern Gulf of Mexico. Hard substrate (surfaces)—including natural reef or rock substrates, artificial reefs, and oil and gas platforms—accounts for the remaining 4 percent. Both hard and soft substrates support a wide variety of marine life, and many mobile animals move back and forth between the soft- and hard-bottom habitats.

## Assessment Approach

The Trustees evaluated benthic injuries ranging from nearshore environments to the deep sea. Assessment activities focused on benthic areas near the wellhead and where surface oil may have sunk to the sea floor through a combination of physical and chemical factors. The Trustees considered and accounted for minor amounts of oil that come from naturally occurring hydrocarbon seeps. They focused assessment activities on both the predominant soft sediment environment and the rarer hardground habitats. A variety of sampling techniques were used, including photography, videography, and collection of sediment and biological samples.

## Exposure

Benthic resources were exposed to oil and other spill-related constituents through four main pathways:

- Underwater plumes of oil.
- Contaminated marine snow (solid particles settling to the sea floor).
- Direct contact with contaminated sediments.
- Uptake of contaminated food.

Benthic resources were exposed across a large swath of the northern Gulf of Mexico, though exposure decreased and became patchy with increasing distance from the wellhead. Benthic sediments were

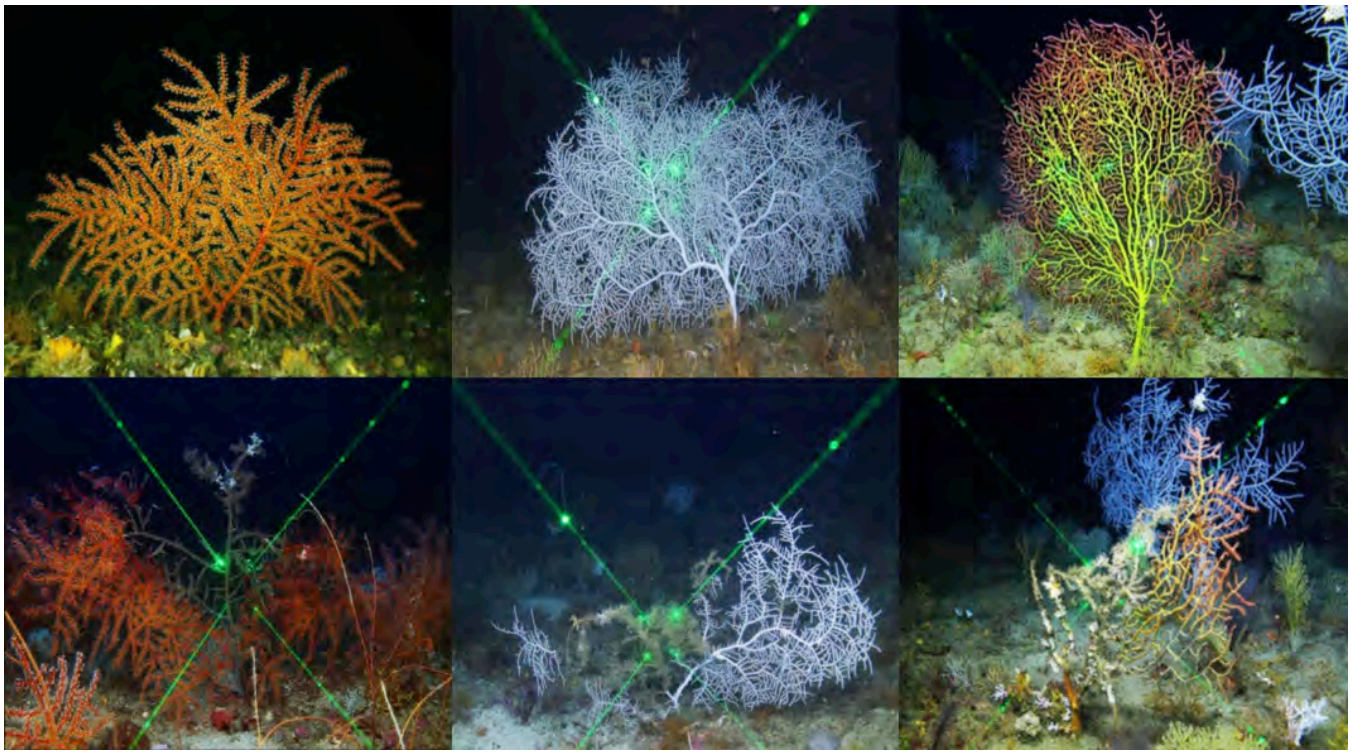
confirmed to be contaminated with *Deepwater Horizon* oil more than 31 miles from the wellhead. Patchy exposure potentially occurred below where the oil spread across the sea surface or in the deep plume.

## Injury Determination

Effects of the *Deepwater Horizon* oil spill were documented across a wide variety of benthic habitats and communities. The Trustees documented a variety of injuries in two particular areas: a large area of deep-sea benthic habitat surrounding the wellhead, and along the edge of the continental shelf at the mesophotic (deep, low-light) reef area known as the Pinnacles reefs. The types of natural resource injuries documented in the deep-sea benthos included smothering by debris and drilling mud, toxicity of sediment, adverse effects to the structure of animal communities, injuries to red crabs and deep-sea hardground coral colonies, changes in microbial communities, and degradation of the physical and chemical quality of the sediment. Some reports of injuries to natural resources along the continental slope and shelf were identified in other studies, but these injuries were not reported to be widespread. The exception was mesophotic reef habitat, which experienced widespread injury to corals and a severe reduction in the abundance of certain fish.

## Injury Quantification

The Trustees quantified injuries to resources in two general areas: the deep-sea habitats around the wellhead and the mesophotic Pinnacles reefs. The injured zone around the wellhead was confirmed to encompass more than 770 square miles. The area of injury to mesophotic reefs was identified as encompassing just over 4 square miles. An additional 97 square miles around the reef had uncertain exposure and injury. In general, resource recovery is expected to vary across benthic resources, and may be on the order of decades to hundreds of years for some resources such as hard corals, based on the slow progression of change in deep-sea environments and the fact that deep-sea corals killed by the spill were hundreds of years old.



**Examples of healthy (top) and injured (bottom) colonies of sea fans observed at mesophotic reefs in the Gulf of Mexico.**

# Nearshore Marine Ecosystem

A wide variety of nearshore and shoreline resources were injured over hundreds of miles of coastline of the northern Gulf of Mexico.

**1.** An oiled beach on the Chandeleur Islands, Louisiana. **2.** Oiled marsh habitat. **3.** A healthy penaeid shrimp. **4.** Healthy oysters.

The nearshore marine ecosystem of the northern Gulf of Mexico is a vast, biologically diverse collection of interrelated habitats that stretch from Texas to Florida. These habitats include marshes, mangroves, sand beaches and dunes, barrier islands, submerged aquatic vegetation, oyster reefs, and shallow unvegetated areas.

Nearshore habitats in the northern Gulf are among the most biologically productive coastal waters in the United States. They provide food, shelter, and nursery grounds for many animals that use the open waters of the Gulf, including fish, shrimp, shellfish, sea turtles, birds, and mammals. In this way, the nearshore system fundamentally supports the entire Gulf of Mexico ecosystem, including offshore habitats.

Nearshore habitats also provide many services that humans value. Marshes protect the shoreline from erosion and storm surge; provide feeding and nesting habitat for important fish and wildlife species; and provide nutrient cycling, water quality improvement, and carbon sequestration. Many of the region's most important commercial and recreational fisheries

include species that spend all or part of their lives in the nearshore environment. Sand beaches also support important recreational activities in the Gulf states.

## Assessment Approach

The Trustees selected a few key species in the nearshore marine ecosystem to serve as indicators to evaluate effects due to oiling. The studies considered various mechanisms of injury to plants and animals from oiling, including physical smothering, toxicity from ingestion, and dermal (skin) exposure. Coastal wetland soils, nearshore ocean sediments, and tissues of submerged aquatic vegetation and nearshore animals were evaluated for oil concentrations. The assessments also considered ways in which nearshore resources could have been injured by response efforts, including intolerance of low-salinity (river) water, physical destruction and removal of natural habitat features, and crushing or smothering.

## Exposure

Almost all of the types of nearshore ecosystem habitats found in the northern Gulf of Mexico were oiled and injured as a result of the *Deepwater Horizon* oil spill. Oil was observed on **more than 1,300 miles** of shoreline from Texas to Florida. *Deepwater Horizon* oil was found in soil and sediment samples and other environmental media, in some cases persisting for several years after the spill (for example, soil samples collected in Louisiana salt marshes in fall 2013, and buried oil excavated from sand beaches as late as March 2015).

## Estuarine Coastal Wetlands

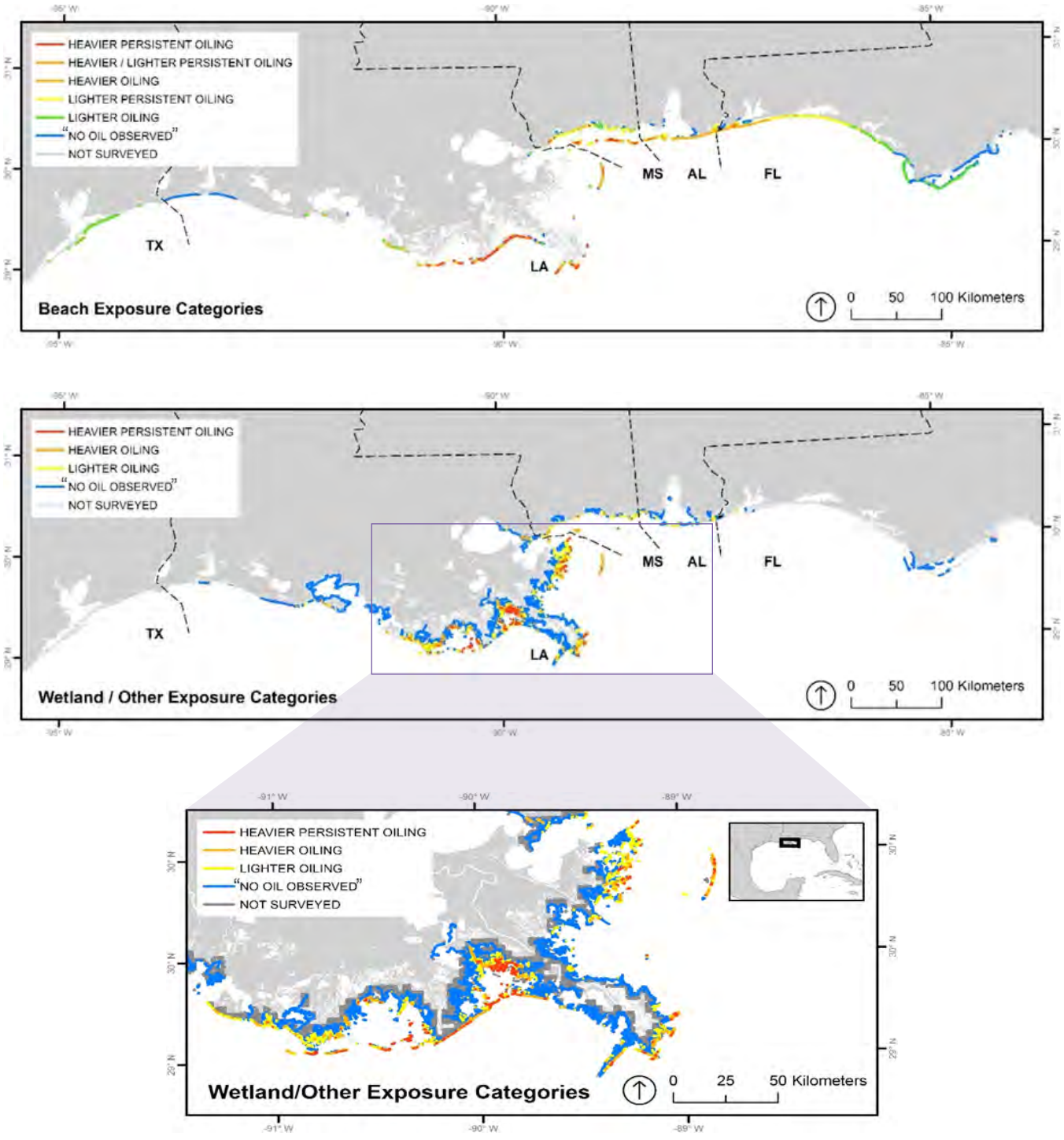
The Trustees conducted an extensive assessment of injury to coastal wetlands and associated animals. Injury to coastal wetlands was observed across wide swaths of the northern Gulf of Mexico. Most severe injuries, including fewer snails and nearshore oysters, and reduced growth of shrimp and fish, were observed along more heavily oiled shorelines, particularly at the edges of marshes. Salt marsh plant cover and vegetation mass was reduced along 350 to 721 miles of shoreline, which degraded its value as habitat. Response activities such as washing, cutting, and raking of oiled shoreline vegetation, and inadvertent stranding of oil booms, also impacted marsh animals and coastal wetland habitat. The yearly rate of erosion of marsh edge was doubled as a result of oiling and response actions in the most heavily oiled areas. Injuries to estuarine wetlands affect other resources; for example, nearshore oysters serve as an important source of larvae for subtidal oysters.

## Subtidal Oysters

Oysters living away from the edge of the marsh (subtidal oysters) support a robust commercial fishery, improve water quality, and provide habitat for economically and ecologically important fish. The number of oysters in coastal Louisiana was reduced by summer river-water releases intended to keep oil from entering the marshes. Due to direct death and subsequent reproductive loss from a combination of the effects of oil and river-water releases, an estimated 4 to 8.3 billion oysters (adult equivalents) were lost Gulf-wide over three generations of oysters (7 years). Based on the average weight of a harvested adult oyster (and how much survivors would have continued to grow if they had not been harvested or killed), this represents the equivalent of 240 to 508 million pounds of fresh oyster meat.

## Beaches

Sand beaches and dunes are ecologically important in the northern Gulf of Mexico. They provide habitat to crabs, snails, worms, beach mice, and other small organisms, which in turn are food for larger animals such as birds and fish. Sand beaches and dunes across the northern Gulf of Mexico were oiled extensively as a result of the *Deepwater Horizon* spill. Response activities also occurred extensively and repeatedly at sand beaches across the northern Gulf to clean up and remove the oil, causing additional injuries to the habitat. The severity of the injury varied




These maps show where oil was observed at beaches (top) and wetlands (middle and bottom) along the Gulf coast after the *Deepwater Horizon* spill. The categories are based on shoreline surveys conducted during response activities and as part of the natural resource damage assessment during 2010 and 2011. Oil was later found in some areas described as "no oil observed," so it either came ashore after the surveys were conducted or it was not detected by the original surveys.

with the degree of oiling and the type and frequency of response activity. The Trustees concluded that at least 600 miles of sand beaches were oiled to some degree and 436 miles of sand beach habitat were injured by response activities, stretching from Texas to Florida.

## Shallow Unvegetated Habitats and Gulf Sturgeon

The U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NOAA Fisheries) designated the Gulf sturgeon as a threatened species in 1991 under the Endangered Species Act. This species uses nearshore unvegetated habitats as well as some rivers that drain into the Gulf. The Trustees conducted an assessment and estimated that between 1,100 and 3,600 Gulf sturgeon were potentially exposed to *Deepwater Horizon* oil in the northern Gulf of Mexico. Although a direct kill of Gulf sturgeon from the oil was not observed, field observations and laboratory studies revealed evidence of physiological injury.

## Submerged Aquatic Vegetation

Submerged aquatic vegetation serves as important habitat for fish, birds, and sea turtles. The Trustees conducted a series of field studies to evaluate injuries due to oil exposure, physical response activities, and freshwater releases. A total of 271 acres of seagrass were lost in the Chandeleur Islands due to oil-related injury. The Trustees documented about 9,400 square feet of scars and blowholes in Florida seagrass beds due to impacts from boats involved in response activities, and smaller-scale injuries occurred in other locations in the northern Gulf. A total of 50 acres of submerged aquatic vegetation was lost along the Lake Cataouatche shoreline in Jean Lafitte National Historical Park and Preserve in Louisiana due to the summer river-water releases during response.

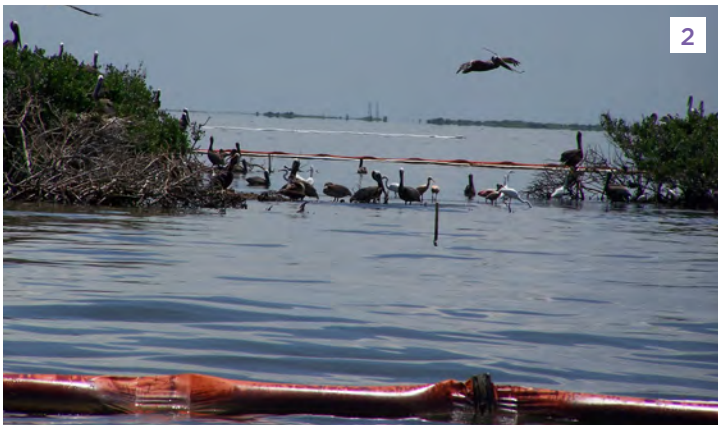
## Conclusions and Ecosystem Implications

Injuries were detected over a range of species, communities, and habitats, affecting a wide variety of ecosystem components over many hundreds of miles of the northern Gulf of Mexico coastline. Some of these losses, such as increased erosion of the marsh edge, are permanent. Other injuries may take many years or decades to recover. Because of the importance of marshes and other nearshore habitats in sustaining commercial fisheries, birds, marine mammals, and other important species, these injuries have cascading impacts that influence the overall health and productivity of the northern Gulf ecosystem.

# Birds

Exposure to oil and response actions injured a large number of bird species occupying different habitats, from offshore to nearshore, including open water, beaches, island waterbird colonies, bays, and coastal marshes.

**1.** An oiled bird attempts to fly. **2.** Birds near a containment boom in Barataria Bay, Louisiana. **3.** An oiled pelican captured for cleaning.



Birds are highly valued and ecologically important components of the northern Gulf of Mexico ecosystem, providing recreational, aesthetic, and economic value and playing vital roles in ecosystems by serving as both predators and prey in many food webs. More than 150 species of birds occur in waters and wetlands of the northern Gulf of Mexico for at least a portion of their lives. Nearly 300 species use either the coast itself or coastal upland habitats directly adjacent to the Gulf. The region supports a variety of birds throughout the year, as nesting grounds during the summer for resident species, as a stop-over for migrating species in the spring and fall, and as wintering grounds for numerous species that breed elsewhere. Among wildlife, marine and coastal birds are particularly susceptible to oil spill effects because they use the water surface, where oil tends to concentrate.

## Assessment Approach

The Trustees focused on estimating numbers of dead birds and loss of reproduction. They conducted field studies to document the number and distribution of bird carcasses and live birds impaired by oil. They also conducted laboratory studies of birds exposed to *Deepwater Horizon* oil, and they used models to estimate additional bird deaths and injuries that were not observed directly in the field. Specifically, the Trustees:

- Used a "Shoreline Deposition Model" to estimate the number of nearshore birds that died from April 20 to September 30, 2010—roughly when widespread wildlife rescue and recovery operations ended. Because most dead or dying birds are never found, the model uses correction factors to account for several sources of loss of dead or impaired birds.

- Used a "Live Oiled Bird Model," which combined observations of rates and degrees of bird oiling with predictions of likelihood of death, to estimate nearshore bird deaths that occurred from October 1, 2010, through March 31, 2011.
- Estimated deaths in offshore habitat using an "Offshore Exposure Model," which determined the overlap between the distribution of oil and offshore birds, and then estimated mortality during summer 2010.
- Qualitatively assessed mortality in areas that were not fully captured by quantitative methods, including, but not limited to, interior marsh and breeding colonies where access was greatly restricted during the spill.
- Estimated the loss of reproduction based on the estimated number of adult birds that died and their expected reproduction if they had lived.

## Exposure

The *Deepwater Horizon* oil spill affected four broad bird habitat types in the northern Gulf of Mexico:

- Nearshore habitats (including nearshore waters, beaches, and marsh edge), which support a diversity of resident and migratory birds—including the endangered piping plover and the threatened red knot—for nesting, feeding, and resting.
- Offshore habitats, which are used by birds feeding on fish and zooplankton and as bird resting spots on *Sargassum* mats. Offshore birds include boobies, shearwaters, storm petrels, and several species of terns.
- Coastal islands, which are used by waterbirds as nesting areas. During the breeding season, a substantial proportion of birds in the northern Gulf of Mexico occur in coastal island colonies.
- Interior marshes, which serve as nursery habitats for many species of fish, shrimp, and invertebrates that are food for many bird species.

Birds were exposed to oil in several ways, including physical contact with oil in the environment; subsequent ingestion of external oil during preening; and ingestion of oil while foraging for food and by consuming contaminated prey, water, or sediment.

## Injury Determination

The Trustees used field observations of oil distribution, dead birds, and live oiled birds to quantitatively and qualitatively assess bird mortality. Given the array of habitats and associated bird species affected, a variety of methods were applied to document the scope of bird injury.

The Trustees also conducted laboratory studies that demonstrated a wide range of negative physiological effects on birds exposed to *Deepwater Horizon* oil. Effects of ingesting *Deepwater Horizon* oil included disruption of reproduction; anemia; changes in immune function; reduced kidney, liver, and gastrointestinal function; and heart abnormalities. Physical effects of plumage oiling included structural damage to feathers, leading to impaired flight capability and behavioral alterations. The impairments observed during controlled studies undoubtedly occurred in wild, oil-exposed birds and resulted in increased rates of death.

## Injury Quantification

The Trustees estimated that between 51,600 and 84,500 birds of at least 93 species died as a direct result of the spill. Species with high death estimates included brown pelicans, laughing gulls, terns, skimmers, and northern gannets. The Trustees estimated that an additional 4,600 to 17,900 chicks died before they could fledge (that is, before they were developed enough to fly) because their parents perished and did not return to the nest. These are underestimates of overall injury, as qualitative assessments indicated that bird deaths occurred in areas where deaths were not fully quantified, particularly coastal marshes and island waterbird colonies.

# Sea Turtles

Five species of sea turtles and their vital offshore, continental shelf, nearshore, and beach habitats were injured by the *Deepwater Horizon* oil spill and by related response activities. Long-term, sustained restoration approaches are necessary to address injuries across life stages and geographic areas.

Five species of sea turtles live in the Gulf of Mexico: loggerhead, Kemp's ridley, green turtle, hawksbill, and leatherback. All of these species are listed under the Endangered Species Act. The Gulf of Mexico provides critically important habitats for sea turtle reproduction, feeding, migration, and refuge, including extensive *Sargassum* habitat in the open ocean that small juvenile turtles depend on for survival. Sea turtles occupy unique ecological roles as long-lived, late-maturing animals that rely on both marine and terrestrial ecosystems to support their life history.

## Assessment Approach

The Trustees assessed oil exposure and injury to sea turtles through boat-based rescues and veterinary assessments, aerial surveys, satellite tracking of live sea turtles, recovery of stranded sea turtles, and monitoring of nesting sea turtles and their nests. Specifically, the Trustees:

- Observed nearly 1,800 turtles through boat- and plane-based surveys.
- Confirmed turtle exposure to *Deepwater Horizon* oil based on direct observation, analytical chemistry, and surface oiling data obtained by satellites.
- Assessed the degree of external oiling of turtles and developed categories for the degree of oiling for use in injury assessment and quantification.

**A heavily oiled, small juvenile Kemp's ridley turtle rescued by response workers.**

- Observed that externally oiled turtles generally had also ingested oil, which demonstrated exposure via multiple pathways.

Overall, the Trustees estimated the total number of turtles exposed, the total number injured by oil exposure, and the total number injured by response activities. Given the extensive nature of the *Deepwater Horizon* oil spill, and the fact that the different sea turtle life stages require vast areas of different types of marine habitats, the Trustees considered how different life stages are distributed and how different species of sea turtles use habitats in different parts of the Gulf. Thus, the Trustees assessed injury to sea turtles by species and life stage.

## Exposure

The Trustees determined that four species of sea turtles (Kemp's ridley, loggerhead, green turtle, and hawksbill) and their habitats were exposed to *Deepwater Horizon* oil in the open ocean, across the continental shelf, and into nearshore and coastal areas, including beaches. A fifth species, the leatherback, was likely exposed to *Deepwater Horizon* oil, and some exposed leatherbacks likely died. However, leatherback injuries were not quantified due to data limitations and logistical constraints.

The *Deepwater Horizon* oil spill contaminated critical turtle habitats throughout the northern Gulf of Mexico, especially the sea surface, for extended periods of time. Sea turtles likely were exposed to oil through a variety of pathways:

- Direct contact with oil when swimming at or near the surface, and on nesting beaches.
- Inhaling oil, oil vapors, and smoke.
- Ingesting oil-contaminated water and prey.
- Transfer of oil compounds from adult females to their developing embryos.
- Oil contamination of essential turtle habitats.

## Injury Determination

The Trustees concluded that sea turtles throughout the northern Gulf of Mexico suffered adverse effects, including death, from *Deepwater Horizon* oil exposure and response activities. Miring in oil and exposure to oiled surface habitat caused significant harm to sea turtles, including decreased mobility, exhaustion, dehydration, overheating, likely decreased ability to feed and evade predators, and death. The Trustees determined that chronic toxic effects of oil and indirect sub-lethal effects on reproduction and health likely resulted in injury, though these effects are less well understood. Response actions undertaken to remove oil from the beaches and the ocean resulted in direct injuries to turtles in all areas of the northern Gulf of Mexico. Relocation of eggs from the Gulf of Mexico to the Atlantic coast of Florida resulted in the loss of sea turtle hatchlings. Other response activities, including vessel strikes and dredging, also resulted in turtle deaths.

## Injury Quantification

The Trustees estimated that between 4,900 and 7,600 large juvenile and adult sea turtles, and between 56,000 and 166,000 small juvenile sea turtles, were killed by the *Deepwater Horizon* oil spill. Nearly 35,000 hatchling sea turtles were also injured by response activities. Some other types of injuries were included in the assessment, but could not be formally quantified due to data limitations and logistical constraints (for example, boat strike injuries).

**Loggerhead sea turtle hatchlings.**

# Marine Mammals

Marine mammals along the Gulf coast and in offshore waters were injured by exposure to oil from the *Deepwater Horizon* spill. Injuries included elevated death rates, reduced reproduction, and disease. Without active restoration, these populations will require decades to recover from these injuries.

**A female bottlenose dolphin in Barataria Bay, Louisiana, in 2013, supporting her dead calf, her second failed pregnancy in two years.**

The northern Gulf of Mexico is home to 22 species of marine mammals, including manatees in coastal seagrasses and dolphins and whales in estuarine, nearshore, and offshore habitats. Marine mammal species vary in size and physiology, feeding habits, and life histories. Manatees graze in seagrass habitats, baleen whales strain plankton out of the water as they swim, and other species are predators that rely on a wide variety of resources in the marine ecosystem.

Marine mammal populations have been severely impacted by human activities, including commercial and recreational fishing, pollution, industrial activities, vessel strikes, and intentional harm. To address declining populations, all marine mammals are now protected under the Marine Mammal Protection Act, which prohibits individuals from harassing, harming, or disturbing marine mammals. Manatees and sperm whales are also protected under the Endangered Species Act. Other endangered or threatened whale species can occasionally be found in the Gulf of Mexico, though they are less common. The distribution of manatees overlaps with the *Deepwater Horizon* oil footprint, but none were sighted in oil, so they were not considered further in the assessment.

## Assessment Approach

To determine the exposure and injury to whales and dolphins due to the *Deepwater Horizon* oil spill, the Trustees compiled a variety of information, including field studies, stranded carcasses, historical data on marine mammal populations, and toxicity testing studies. For example:

- Researchers used historical sightings and conducted surveys in the *Deepwater Horizon* oil spill-affected area to determine the number of animals exposed to *Deepwater Horizon* oil.
- Biologists and veterinarians determined the potential routes of exposure of *Deepwater Horizon* oil to the tissues and organ systems of marine mammals.
- Scientists reviewed the number of dead, stranded animals over time to determine the effect of the *Deepwater Horizon* incident.
- Researchers temporarily captured dolphins living in Barataria Bay, Louisiana, and Mississippi Sound in Mississippi and Alabama to collect health data on dolphins in *Deepwater Horizon* oil-contaminated habitat. They compared their findings with data from dolphins living in areas that were not affected by the spill, as well as pathology data from dead, stranded dolphins.
- Scientists conducted surveys to determine survival and reproductive success in dolphin populations living within the spill area and compared them with survival and reproductive success rates found outside of *Deepwater Horizon*-oil contaminated habitat.

## Exposure

The *Deepwater Horizon* oil spill contaminated prime marine mammal habitat in the estuarine, nearshore, and offshore waters of the northern Gulf of Mexico. *Deepwater Horizon* oil contaminated every type of habitat that northern Gulf of Mexico marine mammals occupy. During response activities and surveys, scientists observed more than 1,100 marine mammals in the *Deepwater Horizon* surface slick. The Trustees estimate that tens of thousands of dolphins and whales were exposed to *Deepwater Horizon* oil, based on population abundances and the size of the contaminated area.

Dolphins and whales were likely exposed to *Deepwater Horizon* oil by inhaling contaminated air or aspirating liquid oil. These routes of exposure are consistent with the types of health effects documented in living dolphins and dead, stranded dolphins (e.g., effects on the lungs). Chemists found chemicals in the lung tissue of one dead, stranded dolphin that were consistent with what would have been found in vapor above the oil slick. Marine mammals may also have been exposed to *Deepwater Horizon* oil by ingesting contaminated sediment, water, or prey, or by absorbing contaminants through their skin. Chemists identified *Deepwater Horizon* oil on the skin of dead, stranded dolphins.

## Injury Determination

The Trustees determined that exposure to *Deepwater Horizon* chemical contaminants resulted in death, reproductive failure, and adverse health effects in northern Gulf of Mexico marine mammal populations. The most significant adverse health effects included lung disease, adrenal disease, and poor body condition. Exposure to *Deepwater Horizon* oil contributed to the largest and longest-lasting marine mammal unusual mortality event on record in the northern Gulf of Mexico. More than 1,000 dolphins and whales were found stranded in Alabama, Mississippi, and Louisiana from 2010 to 2014 (an average of more than 200 per year), compared with an average of 54 per year prior to 2010 for the same region.

In addition to injuries from direct exposure to *Deepwater Horizon* oil, marine mammal habitat was degraded and marine mammals were affected by response activities. The Trustees have ruled out other potential causes of the observed injuries and concluded that the impacts from the *Deepwater Horizon* oil spill are the only reasonable cause for the patterns of observed deaths, reproductive failures, and other health effects.

## Injury Quantification

The Trustees quantified injuries to bottlenose dolphins in four bay, sound, and estuary areas: Barataria Bay, the Mississippi River Delta, Mississippi Sound, and Mobile Bay. The Barataria Bay bottlenose dolphin stock was one of the most severely injured populations: the *Deepwater Horizon* oil spill caused a 35 percent increase in death, a 46 percent increase in failed reproduction, and a 37 percent increase in adverse health effects to Barataria Bay bottlenose dolphins, compared with a healthy population. These injuries are estimated to result in up to a 51 percent decrease in the Barataria Bay dolphin population, which will require approximately 39 years to recover from the effects of the *Deepwater Horizon* oil spill without any active restoration.

Dolphin and whale populations living farther offshore were generally less affected than bay, sound, and estuary dolphins. However, many of these species are highly susceptible to population changes because of their low initial population numbers. Thus, it is unclear how effectively these populations can recover from lower estimated injuries. For example, *Deepwater Horizon* oil exposure resulted in up to an estimated 7 percent decline in the population of endangered sperm whales, which will require 21 years to recover. For Bryde's whales, 48 percent of the population was impacted by *Deepwater Horizon* oil, resulting in up to an estimated 22 percent decline in population that will require 69 years to recover. For both nearshore and offshore populations, injuries were most severe in the years immediately following the spill and have improved slightly over time, but not completely disappeared.

# Lost Recreational Use

The oil spill reduced human uses of shoreline and coastal resources, resulting in lost use valued at hundreds of millions of dollars.

**Beach closures are one example of how the *Deepwater Horizon* spill affected recreational use of the northern Gulf of Mexico.**

The Gulf of Mexico is a popular destination for many types of recreation. The *Deepwater Horizon* oil spill resulted in losses to the public's use of natural resources for outdoor recreation, such as boating, fishing, going to the beach, and generally using and enjoying the Gulf's environment. The spill affected these activities through people canceling trips, choosing alternate recreational sites, or having less enjoyable recreational experiences. These spill impacts started in May 2010 and lasted through November 2011, and they affected activities in all five Gulf states.

When an oil spill impacts natural resources, it diminishes the value of the recreational services they provide. The reduction in the number of people using the affected resources is an important determinant of that lost value. Another important indicator of lost value is the distance people travel and the expenses

The *Deepwater Horizon* spill caused the public to lose more than **16 million user days** of boating, fishing, and beach-going experiences. **Total recreational use damages due to the spill are estimated at $693.2 million.**

they incur to reach the resources under normal (un-oiled) conditions. The Trustees fed this information into economic models to estimate the lost recreational value attributable to the spill.

A spill can also cause other types of economic losses, both public and private, which are outside the scope of the Trustees' assessment. Private losses are generally associated with declines in business profits, lost wages, or costs of repairing property damage caused by the spill. Public economic losses that are outside the scope of the Trustees' assessment include losses in revenue from taxes or fees collected by local municipalities. These public losses are subject to a separate legal action brought by the Gulf states and local governments and compensated for under a separate settlement agreement.

## Characterization of Injury

Recreational activities affected by the spill included water contact activities (swimming, snorkeling, SCUBA diving, and surfing), boating (motorboating, sailing, and personal watercraft), fishing, and wildlife viewing. Direct effects on recreation included the closing of some beaches and recreational fisheries due to oiling and cleanup activities. Due to widespread press coverage, the public was highly aware of the spill, which contributed to further declines in recreational use.

## Measurement of Lost Recreational User Days

The Trustees defined a "user day" as any time an individual visits a beach, goes fishing, or goes boating for the purpose of recreation for at least part of the day. To measure lost recreational user days, the Trustees compared the number of user days during the spill versus the number of user days that would have occurred without the spill (the baseline). While several data collection efforts on recreational use in the northern Gulf of Mexico exist, they were not comprehensive enough over time and space to estimate the baseline level of recreational use. Thus, the Trustees determined the best way to measure lost user days was to collect data until well after losses from the spill were no longer evident.

The Trustees conducted three primary studies to estimate the value of lost recreation use: the Shoreline Study, the Inland Fishing Study, and the Boating Study. Data collected through aerial photography, in-person surveys, and on-the-ground counts at recreational sites provided estimates of lost recreational use for the majority of times and geographical areas where spill impacts occurred. The geographical and time coverage of these data collection activities, however, did not include all relevant months, places, and times of day impacted by the spill. To address missing coverage, the Trustees also performed several targeted supplemental data collection activities and analyses.

## Measurement of Value

The Trustees estimated the value of lost recreational use by employing the "travel cost method," a technique that is frequently used in natural resource damage assessments. The model accounts for lost trips, substitute trips, and diminished-value trips. Multiplying the number of lost recreational user days by the value of a lost user day provides an estimate of the value of the recreational losses (damages).

## Estimate of Damages

The Trustees estimated that more than 16 million user days were lost, and these trips would have occurred to sites along the coasts of Texas, Louisiana, Alabama, Mississippi, and Florida. The effects of the spill impacted recreation in the Gulf of Mexico as late as November 2011. Total recreational use damages due to the spill are estimated at $693.2 million, with uncertainty ranging from $527.6 million to $858.9 million.

# Restoration

## Key Points

- The extensive injuries to multiple habitats, species, ecological functions, and geographic regions clearly establish the need for comprehensive restoration planning on an ecosystem scale that recognizes and strengthens existing connectivity between habitats, resources, and services in the Gulf of Mexico.

Restoration workers plant grass on the Chandeleur Islands, Louisiana.

- The magnitude of the restoration is large, and the timeframe to accomplish restoration is long. For this reason, the Trustees are undertaking restoration planning at a program level. The Draft PDARP/PEIS provides a framework for restoring injured resources and services, and gives the Trustees flexibility to accommodate changes (for example, changes in technology or scientific understanding) over the lifetime of the restoration process.

- The Trustees evaluated programmatic restoration alternatives and have proposed a comprehensive, integrated ecosystem restoration plan based on five goals:
  - Restore and conserve habitat.
  - Restore water quality.
  - Replenish and protect living coastal and marine resources.
  - Provide and enhance recreational opportunities.
  - Provide for monitoring, adaptive management, and administrative oversight to support restoration implementation.

- The Trustees have allocated funding for specific restoration types and restoration areas, based on their understanding and evaluation of exposure and injury, as well as their analysis of where restoration spending for the various restoration types would be most appropriate and effective.

- The Draft PDARP/PEIS identifies a restoration portfolio including 13 restoration types, and allocates funding to these restoration types in specified restoration areas.

- The programmatic restoration plan will direct and guide many years of ongoing restoration needed to address the injuries to natural resources and services from the *Deepwater Horizon* incident. This programmatic plan is the foundation for the Trustees' development of multiple subsequent restoration plans and environmental reviews that will propose and select specific projects for implementation.

- The Trustees' proposed restoration plan does not identify specific restoration projects. Subsequent phases of restoration will identify, evaluate, and select specific restoration projects for implementation that are consistent with the restoration framework laid out by the Draft PDARP/PEIS. They will also include opportunities for public input.

# A Comprehensive and Integrated Ecosystem Restoration Plan

Restoration activities under the Oil Pollution Act are intended to restore or replace habitats, species, and services to their baseline conditions and to compensate the public for interim losses from the time natural resources are injured until they recover to baseline conditions.

The Trustees examined alternative ways to address the injuries caused by the *Deepwater Horizon* incident. OPA and NEPA require Trustees to follow a specific process to develop and evaluate these alternatives. Chapters 5 and 6 of the Draft PDARP/PEIS describe this process and the alternatives that the Trustees considered.

Restoration planning for large marine oil spills has been conducted in the past, but the duration, longevity, and pervasive impact of the *Deepwater Horizon* oil spill on resources throughout the northern Gulf of Mexico calls for a restoration effort of unprecedented magnitude. The extensive injuries to multiple habitats, species, ecological functions, and geographic regions clearly establish the need for comprehensive restoration planning on an ecosystem scale that recognizes and strengthens existing connectivity between habitats, resources, and services in the northern Gulf of Mexico.

Thus, the Trustees are proposing a **comprehensive, integrated ecosystem restoration plan** with a portfolio of restoration types that address the diverse suite of injuries that occurred at both regional and local scales. The Trustees developed this plan after carefully reviewing the available scientific data, making reasonable scientific inferences, and considering ecological linkages (interactions between habitats and species), resiliency, and sustainability.

## Restoration Terms Defined

**Restoration:** Any action that restores, rehabilitates, replaces, or acquires the equivalent of the injured natural resources.

**Baseline:** The condition of the natural resources and services that would have existed had the incident not occurred.

**Early Restoration:** For *Deepwater Horizon*, restoration projects funded under the Framework Agreement between the Trustees and BP, allowing projects proposed by the Trustees to move forward in advance of reaching full resolution of the case.

**Natural resource services:** The functions performed by a natural resource for the benefit of another natural resource and/or the public. For example, a beach provides nesting habitat for sea turtles and recreational opportunities for people. Other ecological examples include nutrient cycling, water purification, food production for other species, and habitat provision. Other recreational services include wildlife viewing, fishing, boating, nature photography, education, and hiking.

The Trustees have determined that natural resource damage settlement funds in the amount of $8.1 billion (plus up to $700 million for adaptive management for unknown conditions) are appropriate and sufficient to address injuries caused by this spill. This includes up to $1 billion already committed for Early Restoration. For the *Deepwater Horizon* spill, Early Restoration was intended to accelerate restoration of injured natural resources and their services, but not to fully compensate the public for all resulting injuries and losses. The Draft PDARP/PEIS builds upon the Early Restoration progress made by the Trustees to set the path forward for fully compensating the public for the magnitude and extent of injuries resulting from the *Deepwater Horizon* spill.

To address the diverse suite of injuries that occurred at both regional and local scales, the Trustees' preferred alternative allocates these funds in two ways:

- **Restoration types.** The proposed plan allocates specific amounts of money to 13 restoration types. The portfolio includes restoration approaches focused on specific resource types such as marine mammals, restoration of supporting habitats such as coastal wetlands, and monitoring and adaptive management.
- **Restoration areas.** The proposed funding for each restoration type is specifically allocated to eight areas. Seven of these areas are geographically defined: Alabama, Florida, Louisiana, Mississippi, Texas, regionwide projects, and projects in the open ocean. The eighth "area" refers to additional funds that will be reserved for currently unknown conditions and adaptive management.

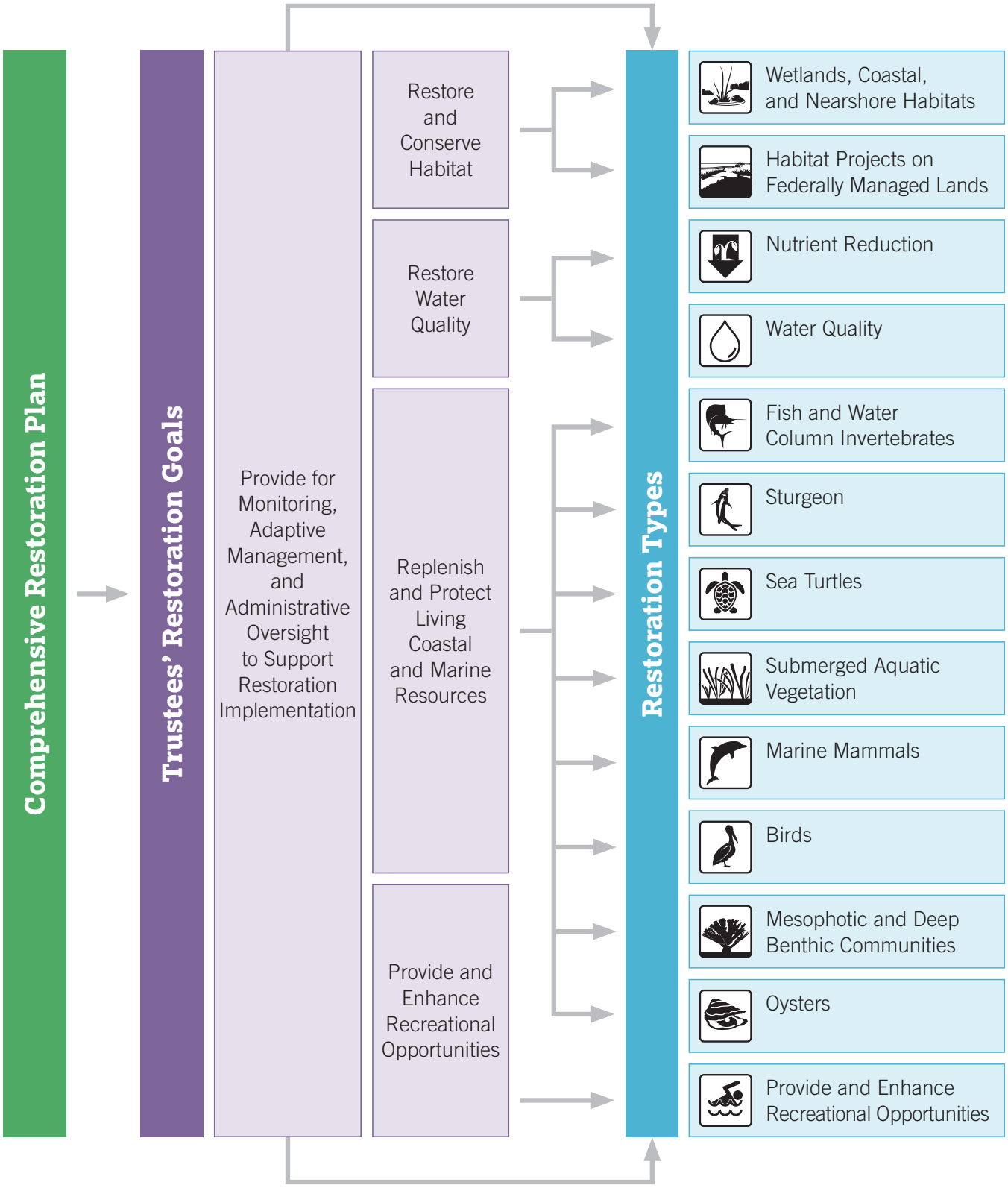
## What Is a Restoration Portfolio?

A **portfolio** approach to restoration involves distributing restoration "investments" across a range of different restoration types and locations. This is similar to the idea of a financial investment portfolio in which financial assets are diversified in order to maximize returns and reduce risks. Portfolio theory has a long history in financial management, but also has been used in natural resource management to balance ecological benefits against risks.

The Trustees propose to allocate funds based on their understanding and evaluation of exposure and injury to natural resources and services, as well as their analysis of where restoration spending for the various restoration types would be most appropriate. By investing in a wide range of resources and habitats throughout the region, the Trustees' portfolio approach will provide benefits to a large variety of species and ecological services. It will also maximize the likelihood of appropriately compensating the public for all the resources and services injured by the spill.

## Goals and Restoration Types

The proposed restoration plan focuses on five goals and 13 restoration types, as illustrated by the diagram below.



The five goals work both independently and together to restore injured resources and services. For example:

- The goal of restoring and conserving habitats addresses the fact that wetlands, barrier islands, and submerged aquatic vegetation beds are highly productive and serve as important nursery and foraging habitat for many species of birds, turtles, marine mammals, finfish, shellfish, and invertebrates.
- The goal of restoring water quality recognizes the intricate linkages between improving water quality, the health and resilience of coastal and marine habitats and resources, and the public's use of those resources.
- Specific groups of living coastal and marine resources (for example, birds, sea turtles, and marine mammals) will be helped both by actions that directly benefit the animal groups and by restoration actions that restore their habitats.
- The goal of providing and enhancing recreational opportunities takes into account the myriad ways that the human community interacts with the natural environment. This goal involves improving on those experiences by maintaining healthy coastal and marine habitats and resources, increasing public access, and enhancing the quality of recreational activities.

The Trustees have also included monitoring and adaptive management as one of their goals. This goal encompasses a flexible, science-based approach to ensure that the restoration portfolio being implemented over the coming decades provides long-term benefits to the resources and services injured by the spill in the effective and efficient manner envisioned in this plan.

## Allocating Restoration Funds

The table on the next page shows how the Trustees have proposed to allocate funds by goal and restoration type (rows) and restoration area (columns). This table also highlights where investments have already been made through the Trustees' Early Restoration efforts.

This investment of funds focuses on restoring coastal and nearshore habitats throughout the northern Gulf of Mexico, with a particular emphasis on restoring Louisiana coastal marshes. Given the critical role that these habitats play for many injured resources and for the overall productivity of the northern Gulf region, coastal and nearshore habitat restoration is the most appropriate and practical mechanism for restoring the ecosystem-level linkages disrupted by the *Deepwater Horizon* spill. As ecologically significant as these coastal and nearshore habitats are, however, aspects of this vast and diverse injury will require additional restoration, especially for resources that spend some or all of their lives in the open waters of the Gulf of Mexico. Therefore, this plan also calls for restoration focused on specific resource groups, water quality improvements, and recreational use opportunities, which will directly support the recovery of these vital resources.

## Restoration Funding in Dollars

| Major Restoration Categories | Unknown Conditions | Regionwide | Open Ocean | Alabama | Florida | Louisiana | Mississippi | Texas | Total Restoration Funding* |
|---|---|---|---|---|---|---|---|---|---|
| **1. Restore and Conserve Habitat** | | | | | | | | | |
| **Wetlands, Coastal, and Nearshore Habitats** | | | | **65,000,000** | **5,000,000** | **4,009,062,700** | **55,500,000** | **100,000,000** | **4,234,562,700** |
| **Habitat Projects on Federally Managed Lands** | | | | **3,000,000** | **17,500,000** | **50,000,000** | **5,000,000** | | **75,500,000** |
| Early Restoration (through Phase IV) | | | | 28,110,000 | 15,629,367 | 259,625,700 | 80,000,000 | | 383,365,067 |
| **2. Restore Water Quality** | | | | | | | | | |
| **Nutrient Reduction (Nonpoint Source)** | | | | **5,000,000** | **35,000,000** | **20,000,000** | **27,500,000** | **22,500,000** | **110,000,000** |
| **Water Quality (e.g., Stormwater Treatments, Hydrologic Restoration, Reduction of Sedimentation, etc.)** | | | | | **300,000,000** | | | | **300,000,000** |
| **3. Replenish and Protect Living Coastal and Marine Resources** | | | | | | | | | |
| **Fish and Water Column Invertebrates** | | | **380,000,000** | | | | | | **380,000,000** |
| Early Restoration Fish and Water Column Invertebrates | | | 20,000,000 | | | | | | 20,000,000 |
| **Sturgeon** | | | **15,000,000** | | | | | | **15,000,000** |
| **Sea Turtles** | | **60,000,000** | **55,000,000** | **5,500,000** | **20,000,000** | **10,000,000** | **5,000,000** | **7,500,000** | **163,000,000** |
| Early Restoration Turtles | | 29,256,165 | | | | | | 19,965,000 | 49,221,165 |
| **Submerged Aquatic Vegetation** | | | | | | **22,000,000** | | | **22,000,000** |
| **Marine Mammals** | | **19,000,000** | **55,000,000** | **5,000,000** | **5,000,000** | **50,000,000** | **10,000,000** | | **144,000,000** |
| **Birds** | | **70,400,000** | **70,000,000** | **30,000,000** | **40,000,000** | **148,500,000** | **25,000,000** | **20,000,000** | **403,900,000** |
| Early Restoration Birds | | 1,823,100 | | 145,000 | 2,835,000 | 71,937,300 | | 20,603,770 | 97,344,170 |
| **Mesophotic and Deep Benthic Communities** | | | **273,300,000** | | | | | | **273,300,000** |
| **Oysters** | | **64,372,413** | | **10,000,000** | **20,000,000** | **26,000,000** | **20,000,000** | **22,500,000** | **162,872,413** |
| Early Restoration Oysters | | | | 3,329,000 | 5,370,596 | 14,874,300 | 13,600,000 | | 37,173,896 |
| **4. Provide and Enhance Recreational Opportunities** | | | | | | | | | |
| **Provide and Enhance Recreational Opportunities** | | | | **25,000,000** | **63,274,513** | **38,000,000** | **5,000,000** | | **131,274,513** |
| Early Restoration Recreational Opportunities | | | 22,397,916 | 85,505,305 | 120,543,167 | 22,000,000 | 18,957,000 | 18,582,688 | 287,986,076 |
| **5. Monitoring, Adaptive Management, and Administrative Oversight** | | | | | | | | | |
| **Monitoring and Adaptive Management** | | **65,000,000** | **200,000,000** | **10,000,000** | **10,000,000** | **225,000,000** | **7,500,000** | **2,500,000** | **520,000,000** |
| **Administrative Oversight and Comprehensive Planning** | | **40,000,000** | **150,000,000** | **20,000,000** | **20,000,000** | **33,000,000** | **22,500,000** | **4,000,000** | **289,500,000** |
| **Adaptive Management NRD Payment for Unknown Conditions** | **700,000,000** | | | | | | | | **700,000,000** |
| **Total NRD Funding** | **$700,000,000** | **$349,851,678** | **$1,240,697,916** | **$295,589,305** | **$680,152,643** | **$5,000,000,000** | **$295,557,000** | **$238,151,458** | |

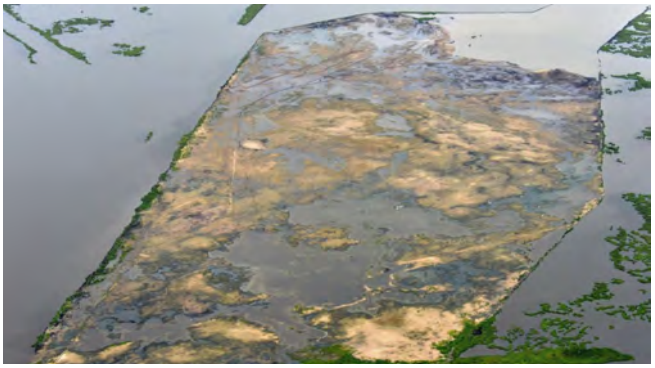
* The total restoration funding allocation for the Early Restoration work; each restoration type; and monitoring, adaptive management, and administrative oversight is $8.1 billion (plus up to an additional $700 million for adaptive management and unknown conditions).

# Goal: Restore and Conserve Habitat

The Trustees are allocating the greatest amount of funds to the goal of "Restore and Conserve Habitat," given the critical role that coastal and nearshore habitats play in the overall productivity of the Gulf of Mexico. This goal addresses the fact that wetlands, barrier islands, and submerged aquatic vegetation beds are highly productive and serve as important nursery and foraging habitat for many species of birds, turtles, marine mammals, finfish, shellfish, and invertebrates.

## Wetlands, Coastal, and Nearshore Habitats

The Trustees are allocating funds throughout all five Gulf states to restore coastal and nearshore habitats—such as wetlands, oysters, submerged aquatic vegetation, beaches, islands, and barrier headlands—either individually or in combination with one another. The Trustees are making this allocation as part of the strategy to develop a diversified portfolio that supports Gulf-wide recovery of injured resources that rely on these habitats.



**This aerial view shows the Lake Hermitage Marsh Creation project in Plaquemines Parish, Louisiana.**

## Habitat Projects on Federally Managed Lands

The Trustees are allocating funds to Florida, Alabama, Mississippi, and Louisiana to address injuries that occurred on specific federally managed lands. Restoration in these diverse lands will include a portfolio of approaches that support a wide array of plants, fish, and wildlife in areas including, but not limited to, coastal wetlands, marsh, submerged aquatic vegetation, sand beaches, and dunes. Although public visitation is encouraged on lands managed by federal agencies, the Trustees will pursue projects that help to minimize the impacts created by this visitation.

**Protective sand fencing was added to Bureau of Land Management property at Fort Morgan as part of the Alabama Dune Restoration Cooperative Project.**

# Goal: Restore Water Quality

The Trustees are allocating funds to improve water quality in coastal watersheds as part of the strategy to address ecosystem-level injuries as well as lost recreational use. This goal recognizes the intricate linkages between improving water quality and the health and resilience of coastal and marine habitats and resources.

## Nutrient Reduction

The Trustees are allocating funds throughout all five Gulf states to reduce excessive nutrient loading to coastal watersheds, which in turn will reduce threats such as hypoxia, harmful algal blooms, and habitat losses, thereby compensating for injuries to multiple resources. A suite of agricultural conservation practices, forestry practices, and measures to reduce pollution and hydrologic impairments will be used to reduce nutrient loadings, depending on watershed and site characteristics. Restoration also could include stormwater management practices, creating and enhancing wetlands, and coastal and riparian (stream- or riverbank) conservation.

## Water Quality

The Trustees are allocating additional funds to Florida to address water quality degradation that will compensate not only for injured resources, but also for recreational losses caused by the spill, which were greatest in Florida. This restoration type is similar to the Nutrient Reduction restoration type, but focusing this effort within the state of Florida will address specific water quality issues that adversely affect the overall health and quality of this state's beaches, bays, and nearshore habitats that have high recreational value. Specific project examples could include stormwater control measures, agricultural conservation practices, erosion control practices (such as living shorelines, vegetated buffers, and unpaved road stabilization), and restoring natural hydrologic flows.

**The Apalachicola River meets the Gulf of Mexico at Apalachicola Bay in Florida.**

# Goal: Replenish and Protect Living Coastal and Marine Resources

The Trustees are allocating funding to resource-specific restoration actions as part of the integrated restoration portfolio. The goal to replenish and protect living coastal and marine resources acknowledges that resources such as fish, sea turtles, and deep coral communities make up an interconnected food web of the Gulf of Mexico. They provide many important ecosystem services such as contributing to a resilient, biologically diverse, and productive system better capable of rebounding from both natural and anthropogenic events and pressures.

## Fish and Water Column Invertebrates

The Trustees are allocating funds to address direct sources of mortality to fish and water column invertebrates. The Trustees are making all of this allocation within the open ocean restoration area, because of the need to address specific species and life stages that may not sufficiently benefit from coastal and nearshore habitat restoration. Strategies will focus on reducing bycatch (unintentional capture) and reducing other causes of death—for example, by incentivizing the use of fishing equipment that reduces bycatch, bycatch mortality, or death from catch-and-release fishing.

**This "Seaquilizer" fish descender device allows fish to be released gently at a specific depth, which reduces harm from catch-and-release fishing. Restoration activities could include promoting the use of such equipment.**

## Sturgeon

The Trustees are allocating funds to address the specific recovery needs of this protected species. The funds are allocated to the open ocean restoration area and will target sturgeon recovery in priority rivers. Projects will focus on restoring conditions that allow sturgeon to access spawning habitat and spawn successfully in rivers that are part of this species' natural range.

**Biologists weigh a Gulf sturgeon. Restoration activities will help improve access to critical habitat in rivers that flow into the Gulf.**

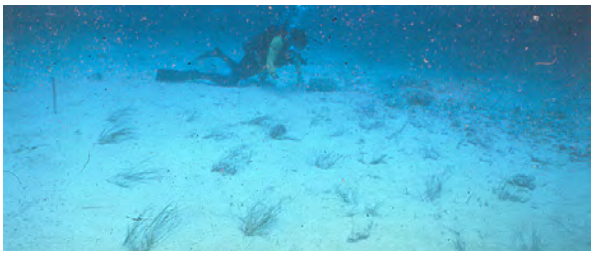
## Sea Turtles

The Trustees are allocating funds across all seven geographically defined restoration areas, with particular emphasis on open ocean and regionwide restoration activities, because of the diversity of species and life stages that were injured. Because some sea turtles migrate over long distances, the Trustees may use regionwide or open ocean funds for restoration outside the Gulf of Mexico as ecologically appropriate, and these funds may be used for resource-level planning, prioritization, implementation, and monitoring for resource recovery, among other uses. Specific activities could include reducing bycatch, enhancing sea turtle stranding response and mortality investigation, and improving nesting habitat by protecting nests and reducing artificial sources of light that can disorient hatchlings at night.

**Turtle excluder devices on nets allow sea turtles to escape unharmed. Restoration activities could include promoting the use of such devices.**

## Submerged Aquatic Vegetation

The Trustees are allocating funds to Louisiana to restore the Chandeleur Islands submerged aquatic vegetation beds. This allocation of funds will ensure that restoration can be targeted to the unique ecosystem that was affected in this area. Activities could involve protecting remaining vegetation, stabilizing sediment, and selecting suitable areas to regrow vegetation.



**A diver installs seagrass transplanting units at a restoration site in the Florida Keys National Marine Sanctuary.**

## Marine Mammals

The Trustees are allocating funds to Louisiana, Mississippi, Alabama, Florida, the open ocean, and regionwide activities. These funds may be used for resource-level planning, prioritization, implementation, and monitoring for resource recovery, among other uses. Because marine mammals face a wide range of threats, the Trustees will implement a portfolio of restoration approaches that could include decreasing and mitigating interactions with commercial and recreational fishing gear, characterizing and reducing impacts from noise, reducing illegal feeding and harassment, and increasing understanding of causes of marine mammal illness and death.

**This sign at a pier is an example of how restoration funds can help protect marine mammals and other animals by educating anglers.**

## Birds

The Trustees are allocating funds for birds across all seven geographically defined restoration areas because of the diverse array of species and geographic areas that these species inhabit. Because some birds migrate over long distances, the Trustees may also use regionwide and open ocean funds for restoration outside coastal Gulf of Mexico habitats. Specific approaches could include conserving, creating, or enhancing nesting and foraging habitat; reestablishing breeding colonies; managing bird predators; and addressing direct human threats to certain bird species.

**The brown pelican (adult with young shown here) is one of many bird species that could benefit from restoration activities.**

## Mesophotic Reefs and Deep Benthic Habitats

The Trustees are allocating substantial funds for this restoration type, all allocated to the open ocean restoration area. This allocation reflects the Trustees' conclusions about the large injury to these rare and long-lived resources, as well as an understanding of the expense of working in these remote regions of the Gulf of Mexico. Specific activities could include reducing the impacts of oil and gas development, fishing, recreational activities, and marine debris on these sensitive habitats.

**Protecting mesophotic and deep benthic communities can help restore corals and associated communities such as fish and invertebrates.**

## Oysters

The Trustees are allocating funds to specifically address unique aspects of injury to oysters that may not be fully addressed by restoration conducted within the goal of "Restore and Conserve Habitat." Funds will be distributed to all five Gulf states, as well as regionwide initiatives, to address injuries to specific oyster beds as well as population stability and broader ecological functions that need to be restored. Specific approaches could include restoring reef habitat, enhancing oyster reef productivity, and increasing oyster spawning stock populations.

**A barge deploys oyster shells to restore subtidal oyster reefs in St. Louis Bay, Mississippi.**

# Goal: Provide and Enhance Recreational Opportunities

The Trustees are allocating funds to restore aspects of lost recreational opportunities not fully addressed by activities conducted under the other restoration goals. This goal acknowledges the many ways in which people interact with the natural environment, from fishing to sunbathing to bird watching and countless other recreational activities. Therefore, this goal seeks to improve those experiences by maintaining healthy coastal and marine habitats and resources, enhancing public access to these coastal resources, and enhancing the quality of these recreational activities.

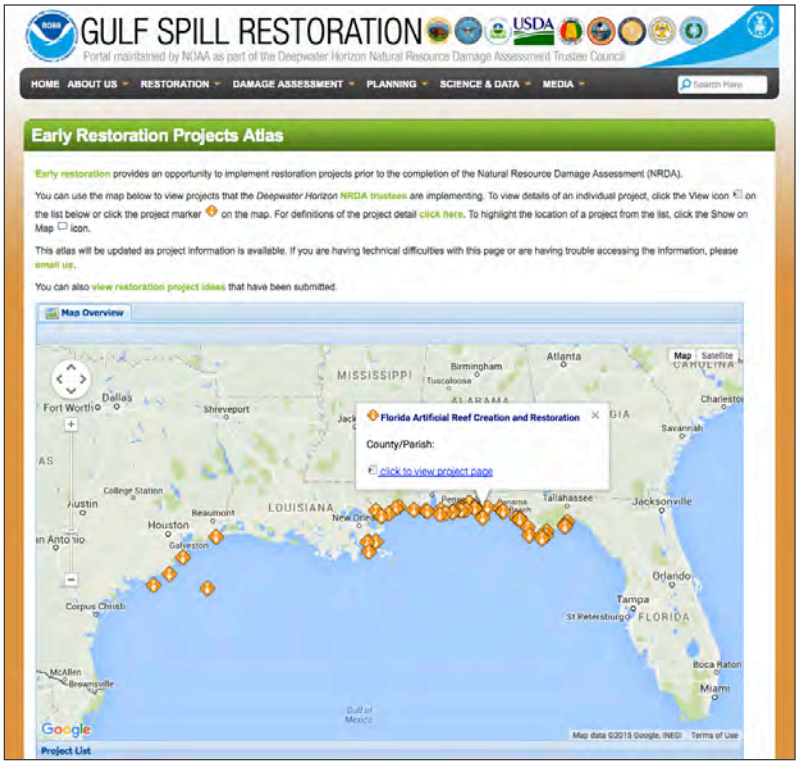
## Provide and Enhance Recreational Opportunities

The Trustees are allocating funds to Florida, Alabama, Mississippi, and Louisiana to address specific components of recreational use injuries. These funds are in addition to any recreational use benefits that may result from other ecological restoration projects. This restoration type will enhance recreational opportunities such as fishing, beach-going, and boating by improving infrastructure, access, and education. Education and outreach can also be used to engage people in restoring and caring for natural resources. Activities could include acquiring land along the coast, building improved or new infrastructure, implementing new or improved on-water recreation opportunities, and providing new educational opportunities.

**This marsh boardwalk and fish cleaning station are similar to structures in the Sea Rim State Park Improvements project in Texas.**

# Goal: Provide for Monitoring, Adaptive Management, and Administrative Oversight

The Trustees are allocating funds to provide for monitoring, adaptive management, and administrative oversight. These efforts will apply to all of the restoration activities conducted under the other four goals. Monitoring, management, and oversight are particularly important because the implementation of this restoration plan will occur over many years.




**Websites help to keep the public informed about restoration activities.**

Specific activities will include:

- **Monitoring and adaptive management.** The Trustees are allocating funds for the broader monitoring and adaptive management activities of the restoration plan. Adaptive management involves fine-tuning the restoration program over time, based on monitoring data and evolving scientific understanding. The Trustees' commitment to monitoring and adaptive management will allow for restoration to proceed now without waiting to resolve every scientific question first.

  In addition, some of this funding will support activities such as the development and maintenance of a Web-based public portal to provide access to monitoring data and other important information related to restoration activities.

- **Administrative oversight and comprehensive planning.** Restoration will require administrative oversight to guide project selection, implementation, and adaptive management. The Trustees are allocating additional funds for this oversight. The largest amounts of administrative funding will go to the areas with the largest restoration fund allocations.

- **Natural resource damage payment for unknown conditions.** The Trustees have also set aside funds to address currently unknown conditions that may be uncovered in the future. The Trustees are making this allocation because conditions will change over the course of the many years it will take to fully implement the restoration proposed in this plan. Setting aside funds to address future unknown conditions reduces the risk of proceeding with restoration in light of those uncertainties.

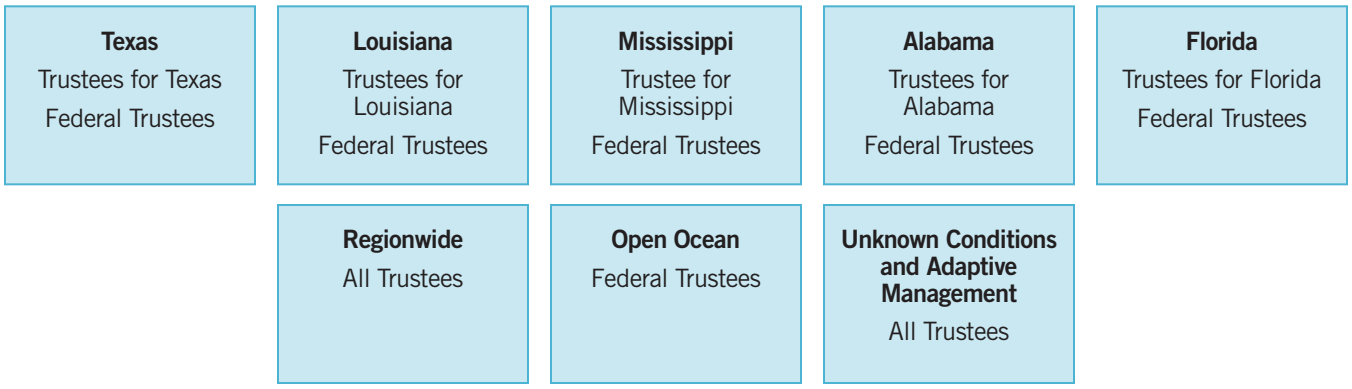
# Governance

The magnitude and geographic scale of the restoration in the Draft PDARP/PEIS is far greater than in any other prior undertaking by natural resource trustees. The Trustees need an effective way to meet their responsibilities, which include the following: restoration planning, restoration implementation, monitoring and adaptive management, financial management, public engagement, and tracking and reporting to the public on restoration progress. In keeping with these responsibilities, and in the context of the comprehensive, integrated ecosystem restoration plan, the Draft PDARP/PEIS describes the Trustees' governance structure to implement restoration, as follows:

- The Trustees will continue to work together as a Trustee Council with overall responsibility for assuring that restoration is achieved with financial accountability, and that obligations set forth in OPA, the Consent Decree, the PDARP/PEIS, and future restoration plans are met.
- The Trustees additionally propose a distributed governance structure that assigns a Trustee Implementation Group (TIG) for each of the eight restoration areas (restoration in each of the five Gulf states, open ocean, regionwide, and a TIG for unknown conditions and adaptive management). The composition of each TIG varies, depending on the geographic area and restoration types to be performed in each restoration area, as shown in the figure below.

Each TIG will generate future restoration plans that identify specific restoration projects, consistent with the funding allocated to restoration types within each TIG. These restoration plans will be consistent with the PDARP/PEIS, and each plan will be integrated with the appropriate analysis of tiered environmental impacts. TIG decisions will be made by consensus and documented through a public Administrative Record. The Trustees will ensure that the public is involved through public notice of proposed restoration plans, opportunities for public comment, and consideration of all comments received.

## Trustee Implementation Groups (TIGs)



# Conclusion

The *Deepwater Horizon* oil spill was an unprecedented event—by far the largest offshore oil spill in the history of the United States. The oil released into the environment was toxic to a wide range of organisms, and it resulted in injuries to multiple habitats, species, and ecological functions. These injuries affected such a broad array of linked resources and ecological services over such a large area that they can best be described as an injury to the entire ecosystem of the northern Gulf of Mexico.

To address these injuries, the United States and the five Gulf states filed suit against BP, the major party responsible for the *Deepwater Horizon* spill. The federal and state agencies responsible for overseeing restoration—known as the Trustees—are proposing to accept a settlement from BP that will provide funding for a comprehensive portfolio of restoration activities. That settlement is subject to a separate public review and comment process conducted by the Department of Justice.

Just as the injuries did not happen in isolation, restoration efforts require a broader ecosystem perspective when deciding how best to restore the resources and services injured by the *Deepwater Horizon* incident. Thus, the Trustees are proposing a comprehensive, integrated ecosystem restoration plan with five complementary goals and a portfolio of restoration types that address the diverse suite of injuries that occurred at both regional and local scales. The proposed restoration plan describes how funding will be allocated across eight restoration areas and 13 restoration types, but it does not prescribe specific projects or activities. State and federal agencies will subsequently identify, plan, evaluate, implement, and monitor specific restoration projects.

The proposed plan prescribes a governance structure through which the Trustees will work together to oversee restoration planning and implementation, and it allocates funding for administrative oversight, monitoring, and adaptive management. These administrative functions will be critically important in ensuring that restoration funds are used in a coordinated manner and that the Trustees keep the public engaged and informed. Given the length of time needed for restoration implementation, adaptive management and monitoring provide the flexibility to adjust the program in the future to respond to changes or to new information.

Altogether, the Trustees have determined that the proposed comprehensive, integrated ecosystem restoration plan is the best approach to address the ecosystem-level injuries that resulted from the *Deepwater Horizon* spill. By investing in a wide range of resources and habitats, the Trustees' portfolio approach will provide benefits to a large variety of species and ecological services and will maximize the likelihood of appropriately compensating the public for all the resources and services injured by the spill.

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- Sea fans (p. 20): Etnoyer, P.J., MacDonald, I.R., Wickes, L.N., Dubick, J.D., Salgado, E., and Balthis, L. 2015. Decline in condition of sea fans on mesophotic reefs in the northern Gulf of Mexico before and after *Deepwater Horizon* oil spill. Paper presented at the 2015 Gulf of Mexico Oil Spill and Ecosystem Science Conference, Houston, TX. Photos by Ian MacDonald (top left) and Peter Etnoyer (all others).
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