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# Oil in the Ocean: FAQs



## How much oil has spilled in the Gulf of Mexico?

That is not an easy question to answer because the material flowing out of the Deepwater Horizon wellhead is a mix of substances other than oil and oil itself if a complex mix of chemicals that react with the environment differently under different conditions. The spill also presents some particularly difficult problems, not the least of which is the fact that it happened so deep—more than a mile beneath the surface—making it difficult to measure and monitor.

The material entering the Gulf almost certainly contains a mixture of oil, gas and sediment that may change over time. In addition, the actual flow rate may vary over time. The only volume we will know with certainty is the amount of oil captured by ships on the surface. The volume of oil that makes it to the surface forms a slick that can be photographed from airplanes and satellites to provide another rough estimate of volume. However, a large portion of the oil released never reaches the surface and has been found to form constantly changing “plumes” that stretch for miles underwater.

In addition, many chemicals found in oil either evaporate into the atmosphere or dissolve into the seawater, making it difficult to estimate the total volume of material released. Moreover, the volume of oil spilled is not always the most effective measure of how damaging a particular spill will prove to be.

## What happens to oil when it enters the ocean?

Oil chemicals entering the ocean have many fates. Volatile chemicals are lost by evaporation to the atmosphere. Other chemicals are broken up by photochemical reactions (catalyzed by sunlight). Bacteria can also degrade certain oil components.

The combination of biological, physical, and chemical processes is usually referred to as weathering. These weathering reactions have different rates depending on the chemical structure of the oil, habitat conditions (such as water temperature or oxygen and nutrient supply), and mixing of the water by wind, waves, and currents. In some spills, oil does not last much beyond weeks to months.

But when oil pours into shallow waters with muddy sediments—such as marshes or lagoons—and conditions allow the oil to become mixed into the mud, it may persist for a long time. This is a result of the fundamental chemistry of oil compounds. Since they don’t dissolve in water, oil compounds tend to adhere to particles in the water or get incorporated into biological debris, such as fecal matter or dead organisms. These oiled particles and debris settle from the water column and become part of the sediments on the bottom.

Once mired in the sediment, some oil chemicals can persist for years or decades, depending on the environment. In areas swept by high-energy currents, the material may be dispersed. In areas where sediments accumulate (such as ship channels through urban harbors), the contaminated sediments become an environmental concern—both when simply lying on the bottom and when channels are dredged and the mud must be disposed.

A large portion of the oil in the Gulf appears to be rising to the surface and has been spreading outward from the site of the Deepwater Horizon platform. Satellite photos and surface observations show that currents and winds initially moved the surface oil mostly north and east of the drill site, toward the northern Gulf coast, with another large slick extending southwest of the site. Periodic changes in surface winds have also moved a portion of the oil westward.

Not all of the oil comes to the surface right away—or ever. Much of the oil stays beneath the surface and gets caught in deep currents that move it independently of the surface oil and in complex, constantly changing plumes. As of June 21, researchers had found multiple plumes of oil as deep as 3,300 feet down and more than 140 miles from the drill site. Some of the plumes are more than ten miles long.

Some of the oil may stay very deep for a long time. How long is not known, because we have very little experience with the movement of oil so deep underwater. We do know that a number of factors can influence the oil’s behavior, including the intense pressure and low temperatures at depth, the size of droplets it forms, and the specific chemical composition of the oil.

Small droplets (less than 0.5mm or 0.02 inches in diameter) can remain suspended in the water, trapped by layers of seawater. Chemical dispersants that have been injected near the drill site break up the oil into even smaller droplets, making it more likely that the oil will remain submerged. The dispersants are another variable that make it difficult to predict exactly where the oil will end up and in what form

it will be once it is there.

As oil continues to gush out of the well, new slicks and plumes will form and perhaps move in new directions, depending on the changing currents and winds they encounter. One concern is that a large hurricane or tropical storm will move large amounts of surface and sub-surface oil in new directions or towards the Gulf coast.

Researchers from WHOI and elsewhere are deploying instruments to identify, characterize, and track plumes of oil deep below the surface of the Gulf. Learn more about their work.

What are some of the ways oil gets into the ocean?

Scientists have known since the 1970s that accidents account for only a small percentage of the oil entering our waters. In fact, accidental spills of all types—from ships, shore facilities, pipelines, and offshore platforms—contributed just 9.8 percent of the oil entering the marine environment on an annual, worldwide basis between 1990 and 1999 (but just 3 to 4 percent in U.S. waters).

That doesn't mean we should dismiss the importance of spills. Accidents such as the 1989 *Exxon Valdez* incident off Alaska or the 2002 *Prestige* spill off Spain can have devastating effects on marine life and on people's ability to use the ocean. The impact of a spill depends on the type of oil, the amount spilled, the ocean and weather conditions, and the dynamics of the area or ecosystem where it takes place.

Progress in prevention—through more stringent laws, rules, and guidelines, and increased vigilance by industry and regulators—has reduced accidental spills, at least in developed countries. For instance, studies of tanker spills have prompted regulations for the steady, ongoing replacement of single-hulled tankers in the world fleet with double-hulled tankers.

But spills are just one small way, albeit dramatic, for oil to mix with our waters. So where is the rest of it coming from?

- Seeps: Between one-third and one-half of the oil in the ocean comes from naturally occurring seeps. These are discrete areas of seafloor springs where oil and natural gas leak and rise buoyantly from oil-laden, sub-seafloor sediments that have been lifted close to the earth's surface by natural processes.

If oil is natural to the oceans and if it is the biggest source of input, what is the fuss about oil as a pollutant? The answer lies in the locations and rates of oil inputs. Oil seeps are generally old, sometimes ancient, so the marine plants and animals in these ecosystems have had hundreds to thousands of years to adjust and acclimate to the exposure to petroleum chemicals. On the other hand, the production, transportation, and consumption of oil by humans often results in the input of oil to often-pristine environments and ecosystems that have not experienced significant direct inputs and have not become acclimated.

- Extraction: Accidental and normal operation of oil drilling and production platforms puts some oil into the sea, including oil mixed into the briny waters that escape from the oil reservoirs. But this spillage and waste, and the atmospheric releases from platform equipment, is one of the smallest sources of oil in the sea.

- Transportation: In the 1960s and 1970s, scientists studied tar balls collected along major tanker routes and the beaches downstream. They revealed that large amounts of oil were entering the marine environment as a result of ballast water (bilge) discharges and other aspects of "normal" tanker operations. As a result of that research, international conventions and national laws and regulations have led oil shippers to minimize their discharges, particularly in harbors. Today, in spite of increasing numbers of tankers plying the seas, the amount of oil spewed has stabilized or decreased in many places.

- Consumption: The everyday use of oil in cars, trucks, industrial and manufacturing plants, and other machinery of the modern economy is the most egregious and insidious source of oil pollution. The drippings and emissions from millions of machines accumulate on land and eventually run into our waterways.

From the 1950s through the 1970s, one of the most common sources was the indiscriminate disposal of used automobile crankcase oil down sewer systems. Since that time, scientific findings have prompted regulations and public awareness campaigns that promote the recycling and proper disposal of used oil.

But we still have a problem. Look underneath your parked car and notice the patch of oil. This happens day and night for millions of automobiles, trucks, and buses, creating a chronic, significant source of oil to the sea. Rainstorms wash these oil patches into streams or storm sewers that discharge into harbors and rivers. It is terribly hard to measure these types of inputs.

Fossil fuel hydrocarbons from engine exhaust also accumulate in the atmosphere. Sometimes the soot is deposited into our waters; otherwise it is washed out of the atmosphere and into the oceans by rain or snow.

On a smaller scale, new research has shown that outboard engines of small boats and pleasure craft are a significant source of oil pollution—up to 2.2 percent of all inputs in U.S. waters (worldwide data are not available). Engine manufacturers are responding with new models of engines that release much less oil and gasoline, but it may take some time for these changes to propagate through the boating

community.

How long will it take for coastal areas to recover from being oiled?

This is a complicated question because each oil spill is different, and it's not certain what recovery means. Even if a marsh or beach looks as if it has returned to normal, full restoration may take a very long time. Some of the issues that determine how fast recovery can happen are:

- Composition of oil that reaches shore
- Type of sediments along the shore
- Amount and kinds of vegetation present
- Nature of winds, wave action, tides, and flushing currents in the area
- Average air and water temperature
- Types of bacteria found at different depths in a beach or marsh
- Response once oil is released into an area and the methods used to clean or contain a spill

Oil coming ashore in different places may also have markedly different chemical compositions because of evaporation on the ocean surface and the presence or lack of dispersants. Thin, thick, or sludgy oil may come ashore in some places, and tar balls in others; and the methods used to remove each type of contamination is different. Different compounds will also persist for different lengths of time in the sediment, depending on how quickly bacteria break down each.

The sediment itself is also an important factor in determining how far oil penetrates and how long it persists. Sand, soil and clay provide different locations for the oil to reside and different habitats for bacteria that can consume oil compounds. Certain bacteria also require specific temperatures, so seasonal cycles can affect the rate of breakdown of petroleum compounds in marsh soil.

Scientists studying large oil spills on many coasts have found that oil remains in sediments below the surface, where it can't be seen. Near WHOI, an oil spill 41 years ago still affects the marshes there and also affects where and how deep crabs burrow. Although the surface appears pristine, researchers can still detect oil several centimeters down by analyzing sediments and still observe effects in plants and animals in the marshes.

Learn more about what WHOI has learned about the impact of oil spills over the years.

Are there predictable currents and circulation patterns in the waters of the Gulf?

Yes. Much of the Gulf circulation is influenced by the Loop Current, a warm ocean current that flows northward between Cuba and the Yucatán peninsula and then swings eastward, creating an open loop in the Gulf of Mexico that eventually exits southeast through the Florida Straits and feeds into the Gulf Stream. The Loop Current travels at about 3.3 feet per second and is one of the fastest currents in the Atlantic Ocean—though not as fast as the Gulf Stream. It is between 125 and 190 miles wide and 2,600 feet deep and is present in the Gulf of Mexico most of the year.

Periodically, the Loop Current spawns a closed loop, or eddy, as it appears to have done in the Gulf now. Such eddies can divert water from the Loop Current and carry it west toward the coastlines of Mexico and Texas through the deep waters of the Gulf. In addition to transporting water and marine life, both the Loop Current and eddy can affect where spilled oil and other material will end up. Under certain conditions, the loop could carry oil southeast, around the Florida peninsula and up the east coast of the United States. Both the Loop Current and eddy can also influence the intensity of an approaching storm or hurricane, and a hurricane entering the Gulf of Mexico could strengthen significantly as it crosses over warm water. This could drastically change the distribution of oil on the surface and at depth.

Learn more about WHOI's efforts to study the Loop Current.

How long does it take oil from the leaking pipe to rise to the surface?

Like many questions about the action of oil in the environment, this is difficult to answer. In most cases, large droplets take about three to four hours to rise to the surface and small ones (those below 0.2 to 0.3mm in diameter) can take 24 to 48 hours to rise to the surface, if they do at all. WHOI scientists working in the Gulf are finding small droplets attached to marine snow—particles of organic matter that constantly rain down from the surface to the deep ocean—which cause them to sink to the bottom or to remain suspended in the water.

What is WHOI doing to help in the Gulf?

In response to numerous requests from government, industry, and academic research organizations WHOI has already provided scientific and technical guidance and assistance related to measuring the flow of oil into the water, to understanding the spread of the oil on the surface and at depth, and to predicting the physical, chemical and biological impacts of the oil in the environment. A current list of WHOI research projects and technologies deployed to the Gulf is available here.

This expertise is based on four decades of experience researching oil spills and their short- and long-term effect on the environment and in designing, building, and maintaining vehicles and sensors for use in the deep ocean. The Institution also stands ready to respond to requests for greater involvement, if needed.

How does oil affect marine life?

From experiments and field measurements, we know that certain types and concentrations of petroleum chemicals can harm marine life. Long-term effects of oil exposure can alter the physiology and ecology of populations of marine organisms, especially those found in sensitive habitats.

Biological and physical processes can reduce the concentration of oil chemicals in an ecosystem, especially if the source of pollution is cut off. As concentrations decline and chemical compositions change, plant and animal communities usually rebound. But the recovery can range from months to decades depending on the chemistry, the conditions, and the organisms and ecosystems affected.

One of the significant advances in the 1970s and 1980s was the development of guides to the sensitivity of various types of coastal ecosystems to oil pollution. Maps of sensitive ecosystems are now used during responses to accidental oil spills, improving the ability of resource managers and engineers to assess where containment booms and other prevention and cleanup measures should be deployed.

There have been few studies, however, on the cumulative effect of chronic inputs of oil to the marine environment, including the many sources associated with oil consumption on land. Assessing these impacts is complicated because oil runoff is often accompanied by other polluting chemicals, making it difficult to tease out which ones have which deleterious effects. Limited experiments have taught us that the interactive effects among chemicals can either increase or decrease each chemical's long-term effects, depending on the organisms and chemicals.

Much of our knowledge about the effects of oil is still limited. It has focused on biochemical and physiological effects on a few individual organisms and on the degradation of a few particular habitats. But we need a better understanding of the large-scale effects of oil on entire communities and populations, rather than individual organisms. The complexity of how species interact within ecosystems—such as how damage to one species can affect the other species that feed on it—leads to contentious debate whenever regulators start to weigh long-term impacts on marine life.

NOTE: If you find an oiled, injured, or dead marine mammal, sea turtle, or bird, you should contact the NOAA Wildlife Hotline: 1-866-557-1401

I have an idea for how to fix the broken pipe. How can I get it to the people in charge?

BP has established a process to receive and review suggestions on how to stop the flow of oil, contain the spill or apply commercially available technology, products and services. Proposals are reviewed for their technical feasibility and proof of application. Given the large number of proposals offered by industry professionals and the general public, it may take some time to technically review each one. For more information, visit their website http://www.horizonedocs.com/index.html

In addition, the Department of Homeland Security is soliciting white papers through the Federal Business Opportunities.

You can also get involved by volunteering in many places around the Gulf.

*Last updated: July 28, 2014*


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