Under Siege: Marine Life vs. the Gulf Oil Spill

Status of the Oil Spill and Cleanup

Last updated February 5, 2013

At 10 pm on April 20, 2010, an explosion on the Deepwater Horizon oil drilling rig southeast of the Louisiana coast killed eleven crewmembers and caused the largest marine oil spill in United States' history. On Thursday, July 15 the ruptured oil well was capped, and on Day 109, August 6, authorities announced that the well had been successfully plugged with mud and cement, finally stopping the leak. Nevertheless, by the latest estimate, 205.8 million gallons (4.9 million barrels, at 42 gallons per barrel) of crude from the undersea reservoir was leaked into the ocean nearly a mile below sea level. Economically, the spill has severely impacted the lifestyle of innumerable Gulf Coast inhabitants – from fishermen, to oil rig operators, to restauranteurs and others dependent upon the tourist industry. Ecologically, the Gulf's marine life continues to be under threat from the environmental impacts caused by the oil and, of increasing concern, the millions of gallons of detergent-like dispersants intended to assist the clean-up. Although these dispersants removed the visible oil from the water surface, a load of toxic heavy metals (including arsenic) did not magically disappear — it sank into the sediment at the ocean floor.

Clean-up efforts for the affected areas included one of the largest groups of people to ever face such a task. Over 17,500 National Guard troops were deployed from Gulf Coast states and more than 48,200 personnel and 9,700 vessels worked to protect the nearby shorelines. People who customarily fished and shrimped the area used their ships to assist clean-up efforts on the water. Floating containment boom lined the beaches to try to keep the oil offshore.

Of the many problems resulting from the oil spill, few are more obvious than the health of the native wildlife in the Gulf. At this point, how much wildlife has been affected, and to what degree, are uncertain. Efforts to assist the larger species included capturing and cleaning the birds and turtles found in the oil slick. Many others of these animals died from the toxic effects of the oil and still more perished in controlled burns.

According to *The Times-Picayune* (New Orleans) on December 30, 2010, 113 miles of Louisiana coastline were still under active cleanup, with another 55 miles awaiting approval to start the cleanup process. Seventy-two miles of coastline are now considered "cleaned." Most of the marshes still have a "bathtub ring" of oil, but officials decided that cleanup activities would do more damage than the oil itself, so further cleanup has been suspended. As of December 23, there were still 6,170 workers and 260 vessels participating in the cleanup with key target dates of February when migratory birds return and of course the local tourist season. Said one official, "We know we're not done. We're still working."

In January 2012, preparations for the federal court proceedings revealed emailed conversations just before the disaster suggesting that BP knew that the potential for a catastrophic oil spill was high, and that they took steps to prevent sharing predicted flow rates with outsiders. "Difficult discussions" were apparently also ongoing with the U.S. Coast Guard. In March 2012, BP agreed to settle lawsuits, totalling an estimated $7.8 billion, brought by more than 100,000 Gulf Coast fishermen, sickened cleanup workers, and others harmed by the disaster. [The Exxon Valdez disaster in 1989 resulted in a similar settlement totalling only $1 billion, equivalent to $1.8 billion in today's dollars.] BP has already paid out billions in cleanup costs and compensation to victims, and U.S. government claims were not included in the totals. In May 2012, a former BP engineer was indicted on charges of obstruction of justice by deleting hundreds of text messages from his phone related to the flow rate; his case is still pending. In November 2012, BP announced that it would plead guilty to manslaughter, obstruction of Congress and other charges, and pay a record $4.5 billion in penalties to resolve the case. In January 2013, the U.S. Department of Justice announced that Transocean Deepwater Inc., the company that

operated the Deepwater Horizon drilling rig for BP, agreed to pay $1.4 billion in civil and criminal penalties for the spill, much of which for violations of the Clean Water Act. Both BP and Transocean are still facing further financial liability for the spill.In March 2012, the U.S. Congress passed the RESTORE (Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States) Act, diverting much of the fines and penalties associated with the oil spill to restoration activities in the Gulf states, including scientific research. The National Academy of Sciences received $150 million from the payout to help fund an independent, 30-year Gulf Coast research program.

Although the oil-covered birds and turtles received most of the attention in the media, far more species of marine invertebrates and marine plants also faced the disaster. These organisms play vital roles in the marine food web and ecological stability of the area. Among those particularly vulnerable to the oil spill are clams and oysters that filter seawater for food, coral colonies that require clean, clear water to survive, and the various plants (algae and seagrasses) that provide a foundation for the many levels of the food web. None of these organisms, and most of the other 15,000 species of animals and plants now living in the Gulf of Mexico,[1] can be cleaned in the ways applied to the Brown Pelicans on the Gulf Coast. Even before the Deepwater Horizon disaster, these organisms faced many human-caused problems, including run-off fertilizer from farming and golf courses, pollution, and human waste, and other damages caused by the infrastructure of the energy industry (read more...).

In April 2012, a panel of experts convened at the 17th Annual Tulane Environmental Law Summmit presented the continuing impacts of the Deepwater Horizon Oil Spill. Shrimp with no eyes and fish with cancerous tumors were documented — animals born long after the Gulf was declared “safe” for fishing. Declines in stock of many commercial species are expected, as occurred following the Exxon Valdez oil spill in 1989. The chronic effects of the disaster are yet to be fully determined.

For more updates on the Deepwater Horizon oil spill, visit the following news websites:

- National Oceanographic and Atmospheric Administration's National Ocean Service Office of Response and Restoration
- CNN’s Deepwater Horizon update
- New Orleans Oil Spill Gulf of Mexico 2010
- New York Times Oil Spill Resources
- Restore the Gulf.gov
- General Facts About the Gulf of Mexico
- IOOS: Deepwater Horizon Oil Spill
- H-Energy Roundtables: The Gulf of Mexico Disaster
- Encyclopedia of Earth: Ocean Oil and Deepwater Horizon Oil Spill
- The Final Hours of the Deepwater Horizon (NY Times)
- Tracking the Oil Spill in the Gulf (NY Times)
- GulfBase: Resource Database for Gulf of Mexico Research
- The Big Picture: One Year Later
- Scientific American: Lasting Menace
- Congressional Research Service Report for Congress (August 2010)
- Gulf's Complexity and Resilience Seen in Studies of Oil Spill (NY Times, April 2011)
- Opinion: How Science Failed During the Gulf Oil Disaster, by Christopher Reddy (Wired.com, April 2012)

[1] “Gulf of Mexico: Origin, Waters, and Biota, Volume 1 – Biodiversity, edited by D. L. Felder and D. K. Camp, Texas A&M Press, 2009

This website made possible by donations from Dr. Harry Lee and Mr. Philip Bartels.

Issues

Many factors play a role in the effects of the Deepwater Horizon oil spill. Pre-oil stresses on ecosystems are problems that could become much worse if and when oil enters the equation. Ocean tides and currents play a role in where the oil spreads from the source. These and other factors must be considered when assessing the damage done to the marine life by the oil spill.

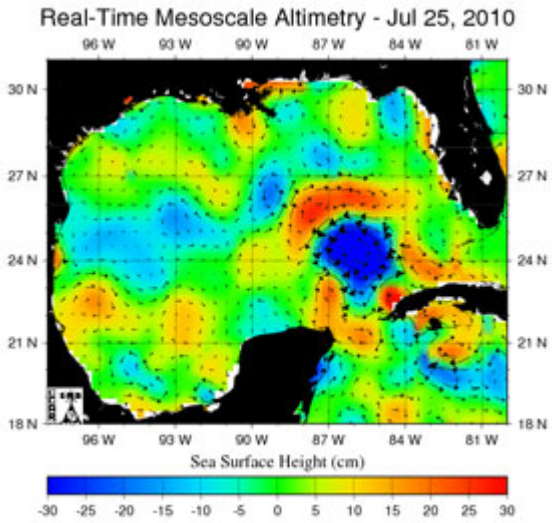
Learn more about:

- Loop Current
- Pre-oil spill stresses on the Louisiana Wetlands
- Pre-Oil Spill Stresses on the Coral Reefs of Florida
- Red Tide and Dead Zones along the Gulf Coast

Loop Current

The Gulf of Mexico has several oceanographic phenomena that are important to interpreting effects of the oil spill. One of these is the Gulf Loop Current. This warm-water current runs north through the Yucatan Channel between Mexico and Cuba into the Gulf of Mexico then exits the Gulf as part of the Florida Current just south of the Florida Keys and north of Cuba into the Atlantic Ocean as the Gulf Stream. What's more, there are cycles that this Loop Current goes through at random intervals – it varies in speed, depth, and extent into the Gulf. The waters carried by the Current are much warmer than the waters in the Gulf and can affect (or be affected by) hurricanes as they enter. These cycles cause the current to vary in size and reach at any given time of the year.

The cycle of the Gulf Loop Current includes four phases. The **first phase** of the cycle starts with the Current shallowly entering the Gulf of Mexico from the Caribbean Sea, wrapping around Cuba and immediately heading out to the Atlantic. Over time, the Loop grows in size, reaching farther into the Gulf more and more in the **second phase** of the cycle. After reaching into the Gulf, a portion of the Loop detaches to create an eddy vortex that circles south of the U.S. Gulf Coast. This is the **third phase** of the cycle. This eddy starts to slowly drift toward Texas and Mexico, gradually decreasing in size and intensity. The Loop recedes back toward the western tip of Cuba during this stage. In the final **fourth phase,** the Loop retreats back to its original position and the eddy diminishes as it drifts west.



Loop Current and Eddies as of June 27, 2010[1]

Loop Current Effects on Hurricanes

The Loop Current and its eddies are believed to boost the strength of hurricanes entering the Gulf. This was the case for hurricanes Katrina and Rita in 2005. Both hurricanes passed over the warm waters of the Gulf Loop Current and an eddy created by the Loop, enabling each to grow to category five hurricanes. Some residents fear that a hurricane passing over the oil spill might draw in the oil and then spread it over land.

Loop Current Effects on Oil Spill

The Loop Current and its eddies could interact with the oil spill in two ways. First, the oil could enter the Loop Current (already detected in small amounts in May 2010) and enter the Atlantic Ocean traveling toward Europe and Greenland via the Gulf Stream. If the oil were to become trapped in an eddy, this could drift the oil toward Mexico and Texas. However, oil trapped within an eddy, circling within the Gulf of Mexico, will do less damage to the coastline and the marine life that currently flourishes there. If this were to happen, the damaging effects of the oil toxins might be reduced and the toxins would disperse becoming "relatively inert and not nearly as toxic as liquid crude."[2] The plants and animals in the Loop Current will not be so lucky.

Oil from the Deepwater Horizon accident was reported in small amounts in the Loop Current in May 2010 by University of South Florida scientists. Communities along West Florida and the Florida Keys continue to monitor reports for signs of approaching danger. One such effort includes the use of a robot named Waldo to detect oil in the current. The Loop Current, the eddies, and the surrounding sea temperatures

are all being monitored by the National Data Buoy Center, part of the National Oceanic and Atmospheric Administration (NOAA).

Resources on the Loop Current

- Gulf of Mexico Loop Current : Weather Underground
- National Data Buoy Center
- Global NearReal-Time Altimeter Geostrophic Velocity Viewer

[1] Colorado Center for Astrodynamics Research (CCAR) generated by: Global NearReal-Time Altimeter Geostrophic Velocity Viewer.

[2] How bad could BP oil spill get for the Gulf and the nation? - USATODAY.com

Pre-oil spill stresses on the Louisiana Wetlands

The Louisiana Wetlands serve as a nursery for much of the wildlife that flourishes in the Gulf of Mexico. Species of marine invertebrates such as shrimp, crabs, oysters, and many fish all spawn in these areas. As wetlands vanish so too will the marine life. As wildlife dwindles, the shrimping and fishing industry will of course feel the full effect. One fisherman stated that without these "invertebrates that [wildlife] feed on, Louisiana, and our way of life, will be changed forever. All life starts at the bottom of the food chain ... this is where the most damage will occur when the oil and dispersants cover our waters."[1]

Flooded Davis Pond in the Louisiana Wetland

Even before the Deepwater Horizon tragedy, there were several factors known to threaten the wildlife and habitats of the Mississippi Delta. The wetlands of Louisiana have taken a beating from levees and oil pipeline canals that send the Gulf's harvested oil inland. These wetlands protect the area from natural storms and disasters and without them there is nothing standing in the way of nature's violent outbursts.

Resources on Louisiana's Wetlands

- IU wetlands expert: It's too early to assess effects of Gulf oil spill
- Louisiana's Wetlands @ National Geographic Magazine
- Regaining Ground: In aftermath of Katrina and Rita, scientists make case for coastal recovery balancing ecology with economy
- H-Energy Roundtables: Louisiana's Wetlands: A Battered and Bruised Energy Landscape

[1] A fisherman's plea to preserve the Louisiana bayou

Pre-Oil Spill Stresses on the Coral Reefs of Florida

The coral reefs in southern Florida are the only coral reefs found in the lower 48 United States, the only barrier coral reef in North America[1], and the third largest barrier coral reef in the world. These fragile ecosystems support a large range of marine life. The effects of pollution, tourism, boat groundings, and other human activities put stress on these ecosystems, causing severe long-term damage before the Deepwater Horizon oil spill ever happened.

Crushed Coral

Several factors play a role in the success of a thriving coral reef ecosystem. Growth is a slow process for coral with an estimated rate of “one to sixteen feet every 1,000 years.”[2] Most coral found in Florida requires shallow, warm, clear water, good water circulation, and a very specific, narrow temperature range. These conditions can are often disrupted by human activities. When human interaction causes destruction, recovery is a very long process for the affected coral reef and the marine life that depends upon it.

The most common damage from human activity is from recreational activities like boat anchoring or grounding that physically damages the coral. Irresponsible divers collecting the coral or associated marine life, as well as marine debris (little), also pose periodic threats. But the most constant damage is caused by run-off from South Florida farms, groves, golf courses, and lawns that contaminates the water and reduces the amount of sunlight that reaches the reefs. Most coral reefs develop in the photic zone of the ocean, that is, where sunlight can reach. Sunlight is vital to coral that live symbiotically with tiny algae (called *zooxanthellae*) that live in coral tissue producing food from sunlight and also giving the coral their vibrant colors. "Bleached" coral is the result of lost zoozanthellae, either through death of the algal cells or when the algae actually leave the coral as a result of poor conditions. Bleached corals can recover, but often do not. [Other species of coral that do not share a symbiotic relationship with algae — called *azooxanthellate corals* — are also found in the region; there are 94 verified species of azooxanthellate corals in the Gulf.[3]]

On November 16, 1990, the Florida Keys National Marine Sanctuary and Protection Act was passed by the U.S. Congress to “protect the resources of the [2,800 square nautical mile] area” that includes the Florida Keys, areas in the Atlantic Ocean, Florida Bay, and the Gulf of Mexico. This act enables the National Oceanic and Atmospheric Administration (NOAA), and other organizations to protect the area and educate the public about its fragile ecosystem. Recreational activities such as removing portions of the reef have been outlawed by this act. When damage to the reef occurs, this act also outlines the penalties for those who are responsible. There are several scientists who work for NOAA to serve and protect the area. Dr. Billy Causey, Southeast Regional Director for the National Marine Sanctuary Program, is one of those staff members who develops policies to protect the Sanctuary. In an interview with Dr. Causey regarding the Deepwater Horizon oil spill and protection of the Sanctuary, he stated, “we have been ready since April 20,” (read the interview with Dr. Causey).

The oil spill in the Gulf of Mexico is about 450 miles away from the Sanctuary. However, several environmental factors — such as the Gulf Loop Current and hurricanes — could cause the spill to enter the Sanctuary and impact its coral reefs. If the oil spill reaches the coral reefs in Florida in any form, whether it be tar balls or the fine dispersed part carrying heavy metals, the additional stress will only amplify the existing issues that threaten the only barrier reef in North America.

Resources for Pre-oil Stresses on Coral Reefs in Florida

- Threats to Southeast Florida Coral Reefs
- Florida's Coral Reefs
- Azooxanthellate corals
- Protecting Coral from Oil Spills and Other Hazards

[1] Coral Reef Evaluation & Monitoring

[2] Florida's Coral Reefs

[3] "Gulf of Mexico: Origin, Waters, and Biota, Volume 1 — Biodiversity, edited by D. L. Felder and D. K. Camp, Texas A&M Press, 2009, pg 335

Red Tide and Dead Zones along the Gulf Coast

Fertilizer runoff from the Mississippi River and in the Florida Everglades causes large plumes of red algae to flourish. The overgrowth of these plants reduce the amount of sun to other plants which then die and decompose. The decomposition of these plants creates a greater demand for oxygen, thus depleting the area and creating dead zones. Harmful algal blooms also produce toxins that are dangerous to marine life and humans. Animals such as bivalves can accumulate these toxins and if eaten can cause serious health problems for the consumer. Wildlife cannot flourish here because the oxygen levels are too low to support them.

Red Tide

Dead zones are often caused by red tides. Dr. José Leal, Director of The Bailey-Matthews Shell Museum, described red tide as follows: “Red tides are caused by large blooms of a marine microorganism called *Karenia brevis*. Those single-celled organisms release a toxic gas that causes the death of marine invertebrates and vertebrates such as fish and dolphins. Sometimes, during prolonged periods of red tide, the levels of oxygen dissolved in seawater severely decrease, as a result of the deaths of millions and millions of animals in the area.” To read the entire interview, click here.

Resources on Dead Zones

- Dead Zone Is Price Gulf Coast Pays as Farms Cash In on Ethanol
- Connections - NASA Science

Places and Habitats

Several places in the Gulf of Mexico have already been affected by the Deepwater Horizon oil spill. The most obvious is the Louisiana coastal area. Other locations have not been impacted but are on the alert, watching for oil or its after-effects entering their marine environments.

Learn more about:

- Sanibel Island
- Florida Keys
- Louisiana Wetlands

Sanibel Island

Sanibel Island is a barrier island located off of the southwestern coast of Florida. This island is only 12 miles long and 4 miles wide. One of the main attractions to this island is the sea shells that wash up on the shores in large quantities. Similar to the Florida Keys, Sanibel Island is situated on the large, underwater plateau of the Florida peninsula where many bivalves and other sea shells thrive. The unique “shrimp-like” shape of the island catches shells as they move with the tide onto the shore. Sanibel Island is also home of The Bailey-Matthews Shell Museum, one of the world’s few museums dedicated solely to the study of seashells. More than half of the island is composed of wildlife refuges. For this reason, the island is popular for tourists who visit the sanctuaries to explore Florida's unique wildlife.

Sanibel Island

Much of Sanibel Island is dedicated to wildlife refuges protecting creatures such as scallops and other mollusks, native and migratory birds, American alligators, and many native plants such as Mangroves. In fact, mangroves are very prevalent on Sanibel Island and play a major role in keeping the islands natural habitats intact. The largest wildlife refuge is the J.N. Ding Darling National Wildlife Refuge. The refuge “consists of over 6,400 acres of mangrove forest, submerged seagrass beds, cordgrass marshes, and West Indian hardwood hammocks.”[1] Fishing is also a main attraction to the island, with many species found in the bay areas between Sanibel and the mainland as well as in the Gulf of Mexico. Common game fish species include sea trout, redfish, tarpon, and others that make this area a very popular fishing destination.

The surrounding waters near Sanibel Island are susceptible to harmful algal blooms, known as red tides because of their orange-red appearance. According to Dr. José Leal, Director of The Bailey-Matthews Shell Museum, “red tides are caused by large blooms of a marine microorganism called *Karenia brevis*.” *Karenia brevis* is a member of the phytoplankton and naturally produces neurotoxins. These large blooms produce high levels of the toxins released into the water and over extended periods of time, can kill many marine animals and plants. When marine organisms die and decompose, large amounts of oxygen are used up, causing the area to become anoxic.

As of mid-July 2010, no oil from the Deepwater Horizon disaster has reached the Sanibel Island and is not expected to reach the shorelines of western Florida, with the exception of the Florida Panhandle. However, the oil spill has greatly diminished the level of tourism that this area economically relies on. Dr. Kumar Mahadevan, President of Mote Marine Laboratory in Sarasota, Florida, said that “People are going elsewhere. It’s not even the oil that is the problem, it’s the perception. The media gives the sense that all the areas are affected.” Although the oil might never reach the white sandy beaches of Sanibel Island and the surrounding areas, the oil spill is taking its toll on the local economy.

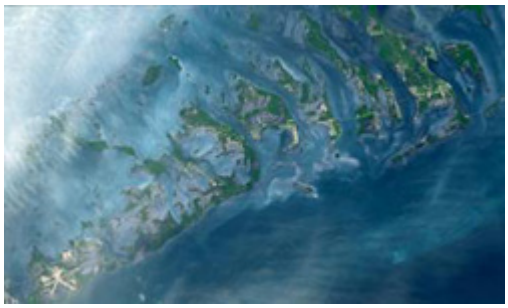
Resources for Sanibel Island

- Sanibel-Captiva Land and Wildlife Conservation
- J.N. Ding Darling National Wildlife Refuge
- Sanibel Island Florida. A complete insiders guide Sanibel and Captiva island

[1] Sanibel Island

Florida Keys

The Florida Keys consist of nearly 1,700 islands and 140 square miles of dry land off of the southern tip of Florida on the edge of the Florida Plateau. The island farthest to the southwest is actually a group of islands, the Dry Tortugas Archipelago, uninhabited but the location of the Civil-War-era Fort Jefferson. Key West is the westernmost island with a dense human population, and is home of Mote Marine Laboratory's Living Reef Exhibit. Summerland Key, approximately 30 miles east of Key West, is the location of Mote Marine Laboratory's Tropical Research Laboratory.



Lower Florida Keys from Space

The Florida Keys were actually created by plants and animals. Coral and marine algae that once thrived there created large reefs that became exposed and fossilized when sea levels fell more than 300 feet approximately 15,000 years ago. The limestone sand grains eroded from the remains of the plants, corals, and other marine animals are now the foundation of the Florida Keys, giving them their shape today.

Today's living coral reefs came into existence 5,000 to 7,000 years ago and include almost 6,000 coral reefs between Key Biscayne and the Dry Tortugas.[1] These reefs are the only reefs in the continental United States and contribute to the local Florida economy by attracting both tourists and researchers. They form the third largest coral reef system in the world (following Australia's Great Barrier Reef and the reefs off of Belize, Central America).

The Deepwater Horizon oil spill causes great concern for the fate of the coral reefs of Florida. In May 2010, oil was detected in the Loop Current, which passes from the Caribbean, into the Gulf, then over the Keys reefs. If the amount of oil in the Loop increases, serious damage could occur to the fragile coral reef ecosystem. There is some speculation whether the oil will reach the reefs. On June 20, 2010, Dr. Billy Causey, Southeast Regional Director of the National Marine Sanctuary Program, said that "it is highly unlikely that the Keys will see a sheen or liquid form of any oil."[2]

Currently, there is an underwater robot traveling along the edges of the Loop Current near Key West monitoring the water for signs of oil. The Mote Marine Laboratory in Sarasota[3] developed the robot, nicknamed Waldo, which is watching for any detectable oil that might enter the rotating eddy and direct oil into the Loop Current. As of July 2010, there was no immediate threat to the Keys, but the concern of oil reaching the reefs will continue until the spill has been stopped and the affected areas recover.

Resources for the Florida Keys

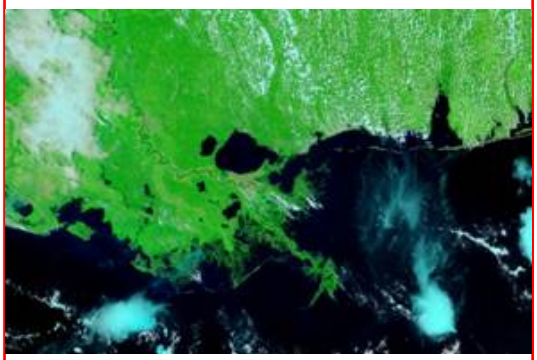
- Florida Keys Information – How the keys were formed
- Waldo robot monitoring the Loop Current
- Florida Coral Reefs
- Anxious monitoring near Florida coral reefs for oil spill

[1] Florida's Coral Reefs

[2] Anxious monitoring near Florida coral reefs for oil spill

[3] Robot checks Florida Keys water for signs of oil spill

Louisiana Wetlands



Louisiana Wetlands and the Mississippi Delta

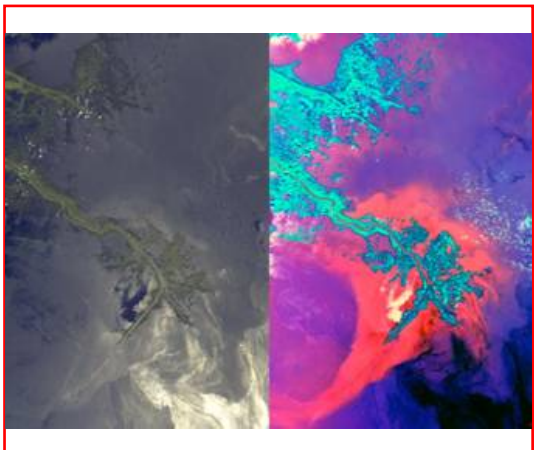
The Mississippi River drains over 24 million acres of watershed into the Gulf of Mexico through the state of Louisiana. The marshes, bayous, and wetlands created by this massive flow of freshwater form the basis of the Louisiana Wetlands and account for over 40% of the wetlands in the lower 48 United States. The entire area consists of nearly 7,000 square miles of wetlands composed of freshwater, saltwater, and in some areas a mixture of both. These wetlands have slight variations that make them unique with different wildlife. There are natural levees, bottom-land hardwoods, swamps, freshwater marshes, intermediate marshes, brackish marshes, and salt marshes.[1]

Ribbed Mussel

The wetlands of Louisiana are both valuable wildlife habitat and storm buffers against hurricanes. The plants and animals that live and migrate here are diverse. Marine life in the salt marshes include the Ribbed Mussel (*Geukensia granosissima*), Periwinkles (snails of the family Littorinidae), the Black Mangrove (*Avicennia germinans*), and Cord Grass (*Spartina alterniflora*).

Brackish marshes are salty, but have a lower salt concentration than the salt marshes. Seagrasses are common in these areas along with speckled trout, fiddler crabs, and blue crabs. Invertebrates, like crabs, living in these brackish marshes attract birds through out the year. Migratory birds from all over North America visit the wetlands to rest, feed, and gain energy for their long journeys. Wetlands play a vital role for these birds. This is why the health of the animals living here is so important. The damaging effects of oil and dispersants on the native animals will then affect the health of the birds. This impact will then continue through the food web both locally and wherever the affected birds migrate.

Birds that reach the Gulf of Mexico could face the dangers of the oil spill from direct contact with the oil or from eating contaminated animals in the area. Cornell University Lab of Ornithology has asked birdwatchers to report any evidence of these effects via their website, NestWatch.org. Data collected here is used to monitor the success rates of nesting birds and any affects that the oil spill might have on bird populations.



Oil has already encroached on Louisiana's wetlands.[2] For these areas, there are three factors that determine how damaging the affects will be on the inhabitants. According to Dr. James Cowan, Jr., Professor of Oceanography and Coastal Sciences at Louisiana State University, these three factors are: an animal's mobility, their life cycle, and the effects of the oil spill on their habitat.[3] Animals such as oysters and mussels that attach to surfaces are effectively immobile, meaning that they cannot escape any oil entering their environment. Animals with short life cycles, such as some shrimp and crabs that only live for one year,

are more vulnerable and could be wiped out if spawning levels are diminished even for a short time. Animals that live longer have greater potential to survive, even if one year of reproduction is unsuccessful. Finally, the effects of oil on habitats play an important role in survival rates. In the case of the Deepwater Horizon oil spill, both nursery habitats in the wetlands and adult habitats offshore have been affected. For this reason, this oil spill could be devastating for the marine life of the Louisiana wetlands. This is also bad news for the fishing and shrimping industries that rely on these creatures. Dr. Kumar Mahadevan, President of Mote Marine Laboratory in Sarasota, Florida, points out that everyone "will be paying more for sea food and getting less."

Oil Spill Encroaching on the Mississippi Delta

Resources for Louisiana Wetlands

- Coastal Wetlands Planning, Protection and Restoration Act
- Louisiana Coastal Area
- Coastal Protection and Restoration Authority of Louisiana
- Types of Wetlands

[1] Types of Wetlands

[2] NASA Images Show Oil's Invasion Along Louisiana Coast

[3] Scientific Research into Gulf Seafood Survival

Species - Marine Life of the Gulf Coast

Of the more than 15,000 species of marine wildlife in the Gulf of Mexico, only a handful – birds, turtles and fish seen wallowing in oily water and near oily beaches – have received serious media attention. But what other species are being affected? And what does all of this mean for the overall ecology of the Gulf of Mexico? These questions are explored in the following sections.

Most of marine life is comprised of small animals and plants that nourish the ocean's fish, birds, and larger wildlife. Marine invertebrates (animals without backbones) make up the majority of marine animals. These animals include clams, oysters, mussels, crabs, shrimp, snails, squid, octopus, corals, sea fans, starfish, sea urchins, sea lilies, sea cucumbers, sponges, and many others.

An all-species inventory of the marine biodiversity of the Gulf of Mexico, sponsored by the Harte Research Institute for Gulf of Mexico Studies (Texas A&M University-Corpus Christi) was researched in 2009 (fortuitously just before the Gulf oil spill) by more than 140 taxonomic experts from 15 countries. A total of 15,419 species are documented and are now available as an online searchable database, BioGoMx (see Gulfbase.org).

Additional news about marine life since the oil spill:

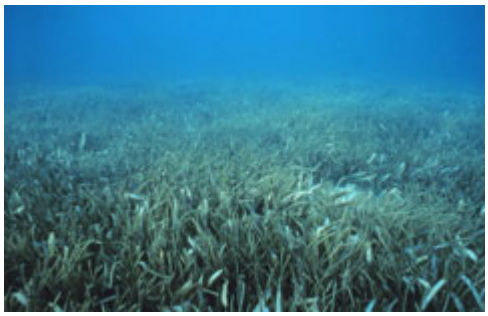
- In April 2012, scientists at a Tulane University conference reported Gulf fish with cancerous tumors and shrimp without eyes, deformities blamed on the long-term effects of the oil spill (read more).
- In May 2012, Alabama Department of Conservation and Natural Resources closed its waters to shrimping. Part of this decision was based on increasing concern over deformities, lesions, and tumors reported in Gulf coast seafood catches. The closure was lifted in August 2012.
- In July 2012, scientists definitively blamed the oil spill for the slow death of a Gulf of Mexico deep-sea coral community. Read the article in Proceedings of the National Academy of Sciences. Dr. Erik Cordes, Temple University, participated in these investigations and, with his students and colleagues, continues to study the effects on the deep-sea communities of the Gulf.

Explore the Species of the Gulf

- Sea Plants
- Bivalves
- Corals
- Plankton

Sea Plants

Sea plants like marine algae, seagrasses, marsh grass, and mangroves provide habitats for many marine creatures including shrimp, bivalves, fish, plankton, and other small organisms. In large concentrations, these plants stabilize the substrate that might otherwise be affected by erosion. From the human perspective, wetlands and mangrove stands offer a buffer against storms such as hurricanes, protecting the inland areas where people live – especially in places like the coastlines of Florida and Louisiana.



Seagrass

Mangroves, marine algae, seagrasses, and marsh grass play another vital role for many marine creatures – that of nursery. Many animals spawn in these areas because their young have a better chance of evading predators while hidden in the plants. Many animals rely on these plants as a main food source as well. Sea urchins are just one example of an invertebrate that eats marine algae, also keeping the algae in check against overgrowth.[1] Without these vital plants, marine animals would have little protection from the elements, predators, and human activities.

There are many pre-oil spill threats to marine plants in the Gulf of Mexico (read more...). Pollution and fertilizer runoff, damage from boat groundings, and human-caused stresses on natural water systems are just a few types of degradation that impact these fragile ecosystems. The effects of the oil spill in combination with these pre-existing conditions are difficult to predict. However, it is certain that the results will not be good for the already stressed environments that many species of marine life call home.

When exposed to oil and the dispersants used to clean up the spill, the sea plants themselves are directly affected. But in addition, the marine animals that depend on these plants – as food and shelter – are also impacted, and the rest of the food web will feel the effect.

[1] Sea Urchin

Bivalves

Clams, oysters, scallops, and mussels are familiar marine invertebrates that all belong to the bivalve class of mollusks. Many species are commonly found in fish markets as seafood, or are picked up on the beach as seashells. These animals usually have two symmetrical shells that house the animal's soft body. It might surprise you to learn that most of these animals do not have a head, and their brain consists only of a very small set of interconnected ganglia. That is not to say that these animals are not smart little creatures! They play an important role in the sea through their feeding technique known as filter feeding. To eat, these animals draw in water and filter out the suspended food particles as the water passes through the bivalve's gills. By doing this, they also help to keep the water clean. Their gills allow the animal to breathe as well, which is pretty clever for an animal without much of a brain!

Bay Scallops

The water-filtering abilities of bivalves are legendary. The average adult oyster can filter 25 gallons of water each day. Zebra mussels (an introduced freshwater species, but nevertheless playing this important ecological role) can filter all of the water in Saginaw Bay (the large bay between the "thumb" and "mitten" of the U.S. state of Michigan) 1.3 times every day. But during their filtering activities, bivalves also are known to concentrate contaminants in their bodies without harm to themselves – this is called *bioaccumulation*. Perhaps the best known example of this concerns red tide (a toxic condition of the water caused by blooms of microscopic plankton that turns the seawater orange-red), which often results in local bivalve harvesting bans. This is because the bivalves have concentrated too much of the red tide toxin as a result of filtering. While the concentration doesn't hurt the bivalve, eating that bivalve would make us very sick.

There is a large diversity of bivalves living in the Gulf. According to a 2009 checklist[1], 528 species of bivalves can be found in the Gulf of Mexico. These animals live along the coastline, in the wetlands, in the coral reefs, and in deep-water habitats in the Gulf of Mexico. Here is a list of just a few of the common bivalves found in the Gulf with their common and scientific names, from "A Picture Guide to Shelf Invertebrates from the Northern Gulf of Mexico" website:

Note: All links below are in PDF format.

- Red-ribbed Scallop, *Aequipecten glyptus*
- Texas Venus, *Agriopoma texasianum*
- Paper Scallop, *Amusium papyraceum*
- Baughman's Ark, *Anadara baughmani*
- Smooth Duckclam, *Anatina anatina*
- Common Jingle Shell, *Anomia simplex*
- Florida Spiny Jewelbox, *Arcinella cornuta*
- Stiff Pen Shell, *Atrina rigida*
- Corrugate Jewelbox, *Chama congregata*
- Empress Venus, *Circomphalus strigillinus*
- Beautiful Crassatella, *Eucrassatella speciosa*
- Round-rib Scallop, *Euvola raveneli*
- Ridged Venus, *Globivenus rigida*
- Dirt Hiatella, *Hiatella azaria*
- Common Eggcockle, *Laevicardium serratum*
- Rough Scallop, *Lindapecten muscosus*
- Clench's Venus, *Lirophora clenchi*
- Short Macoma, *Macoma brevifrons*
- American Horsemussel, *Modiolus americanus*
- Transverse Microcockle, *Nemocardium transversum*
- Ponderous Ark, *Noetia ponderosa*
- Crested Oyster, *Ostrea equestris*
- Fragile Spoonclam, *Periploma fragile*
- Schwengel's Venus, *Pitar cordatus*
- Glass Scallop, *Propeamussium dalli*
- Atlantic Winged Oyster, *Pteria colymbus*
- Corrugated Razor Clam, *Solecurtus cumingianus*

Resources on Bivalves

- Philadelphia shells help measure pollution from BP oil spill

[1] "Gulf of Mexico: Origin, Waters, and Biota, Volume 1 – Biodiversity, edited by D. L. Felder and D. K. Camp, Texas A&M Press, 2009

Corals

Corals are marine organisms that create the physical foundation for life in the ocean's reefs. A coral "head" might appear to be a single organism, but it is actually composed of many genetically identical individuals (called *polyps*) that work together to create the hard calcium carbonate skeleton that we call "coral." They extract "calcium from seawater and combine it with carbon dioxide to construct the elaborate limestone skeletons that form the reef backbone."[1] Coral colonies also include microscopic algae (called *zooxanthellae*) that live symbiotically in the tissues of the coral.[2] The coral polyps gain additional energy and color from the zooxanthellae that supplement what the coral eats from organic particles and plankton suspended in the water.

A Soft Coral, or Gorgonian

Coral species with zooxanthellae require sunlight to survive, which is why they live in the *photic zone* where sunlight can sufficiently reach plants for photosynthesis. Coral live in the photic zone because the zooxanthellae require sunlight to photosynthesize.[3] These tiny plant cells live in the coral tissues and turn sunlight into food for itself and the coral. Coral "bleaching," when coral loses its color, occurs when this symbiotic relationship is disrupted. Loss of sunlight or disease can cause the zooxanthellae to die and consequently the coral usually dies as well. Insufficient sunlight can be caused by algal blooms (caused by too much nutrients in the water, or twoo few algal grazers) that overgrow the reef, hinderin the zooxanthellae's ability to photosynthesize.

Brain Coral

"Coral" actually includes two kinds of colonies - hard corals and soft corals. Hard corals, like Brain Coral or Elkhorn Coral, form the typical hard skeletons best known as coral, hence the name "hard" corals. Soft corals are more commonly known as sea whips, gorgonians, or sea fans. These coral relatives grow more like plants, branching or growing bushy, sometimes in a flattened fan shape.

Resources on corals

- Florida Coral Reefs
- Threats to Florida's Coral Reefs
- Molasses Reef
- Looe Key
- Looe Key National Marine Sanctuary
- Looe Key
- Sea Fan from Looe Key

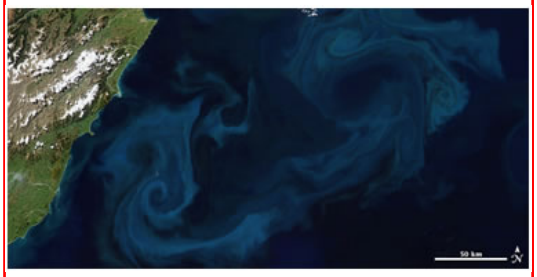
[1], [2] Florida's Coral Reefs

[3] Zooxanthellae… What's That?

Plankton

Plankton is the basic food source in the sea, and all marine life depends upon it. Many different kinds of animals feed directly on plankton, from corals and clams, to crinoids and whale sharks.

Plankton includes a variety of tiny plants (*phytoplankton*), animals (*zooplankton*), and marine bacteria (*bacterioplankton*). In their early stages of development, as larvae and eggs, many species of mollusks, crabs, fish, and other marine animals form part of the zooplankton. Many zooplankton species feed on other plankton; clam larvae (called *veligers*) feed on phytoplankton, and jellyfish feed on larval fish. As adults, filter-feeders like bivalves eat all types of plankton using their gills to separate the plankton from the water.



A Phytoplankton Bloom East of New Zealand

Because plankton are so small, they aren't very strong swimmers. They float in the ocean currents traveling where the wind takes them. Plankton is found in ocean waters all over the world, but is most abundant in coastal areas. In large quantities, plankton can turn water a cloudy grey-green color. These cloudy waters can be seen even in space as they swirl through the ocean.[1]

One interesting type of zooplankton is the arrow worm or chaetognath. This is a predatory marine worm that feeds on other zooplankton. In the Gulf of Mexico, there are 24 species of chaetognaths.[2] This common zooplankter is also an important food source for fish and squid.

Arrow Worm

Phytoplankton is responsible for "half of the oxygen generated by plants on Earth."[3] Oddly, one type of phytoplankton (called *dinoflagellates*) contributes to red tide, a phenomenon that turns the water orange-red and makes the water toxic to other marine life, causing them to die and decay which in turn deprives the area of oxygen.[4] Perhaps even more interesting, ancient phytoplankton played an important roll in the development of crude oil deposits. The by-products of photosynthesis helped to create the ingredients that formed the "underlying basis for petroleum or crude oil."[5] However, the process of creating naturally formed crude oil requires hundreds of years; the fact that crude oil is made of organic matter and waste does not mean that oil is safe for any plankton.

The effects of the oil spill in the Gulf of Mexico on plankton are difficult to determine. However, it is clear that marine life cannot thrive in oily environments. The toxic hydrocarbons and heavy metals found in oil are carcinogenic. As oil disrupts the environment of these small and vital plants and animals, the animals that depend upon plankton for food will be affected in turn. These effects will cascade throughout the food web and marine life of all sizes will be impacted.

[1] What are Phytoplankton?

[2] "Gulf of Mexico: Origin, Waters, and Biota, Volume 1 – Biodiversity, edited by D. L. Felder and D. K. Camp, Texas A&M Press, 2009, pg 1166

[3] Satellite Sees Ocean Plants Increase, Coasts Greening

[4] Phytoplankton Bloom in the Gulf of Mexico : Natural Hazards

[5] Perspectives on Phytoplankton

Lifestyles

Marine lifestyles are diverse and unique. Because marine plants and animals are surrounded by water, they perform basic functions in a much different manner than land plants and animals. These differences are perhaps most apparent in how they feed and breed.

Learn More About:

- Broadcast Spawning
- Filter Feeding

Broadcast Spawning

One of the most common methods of reproduction in the sea is broadcast spawning. Sometimes called mass spawning or synchronous spawning, broadcast spawning takes place when animals release their eggs and sperm into the water, where fertilization occurs externally.

Broadcast spawning is common in many mollusks and other invertebrates. Species like limpets, clams, sea anemones, fan worms, and jellyfish all reproduce externally by releasing their sperm and eggs to be fertilized by their neighbors. Some species like the Moon Jellyfish release only sperm by males, which is then collected by females to fertilize their eggs internally.

When broadcast spawning occurs the surrounding waters become cloudy with the tiny gametes. Broadcast spawning is often critically timed when conditions are ideal to increase the success rate of reproduction.

In the Gulf of Mexico, many coral species spawn a few days after the full moon in August during a time frame of 30 minutes to an hour.[1] During this time, thousands of gamete bundles containing either sperm or eggs are released. These bundles float to the surface of the water where they fertilize each other, creating larvae. These larvae then become part of the zooplankton as they float on the surface for a few days. Then they drift back down to new locations to form new colonies and eventually new reefs. According to Dr. David Vaughan, Director of the Center for Coral Reef Research at the Mote Marine Laboratory in the Florida Keys, “it’s kind of like upside-down snow.” The Deepwater Horizon oil spill is of great concern to coral biologists. If the oil spill enters an area where coral spawning is occuring, it could cause severe damage to the coral larvae that only are only produced once every year.

Coral Spawning

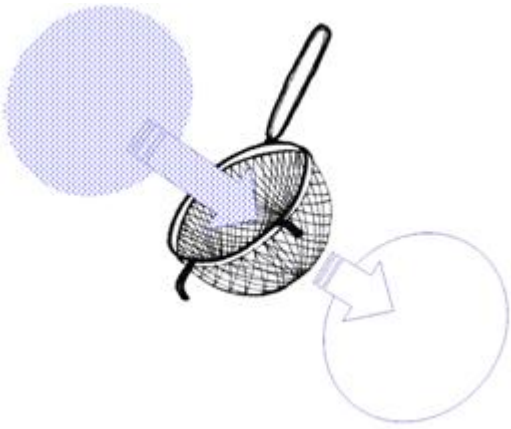
Resources for Broadcast Spawning

- Broadcast Spawning in Corals: What are the Odds of Success?
- Possible Moonlight Trigger Found for Annual Mass Spawning of Corals

[1] Deepwater broadcast spawning by Montastraea cavernosa, Montastraea franksi, and Diploria strigosa at the Flower Garden Banks, Gulf of Mexico

Filter Feeding

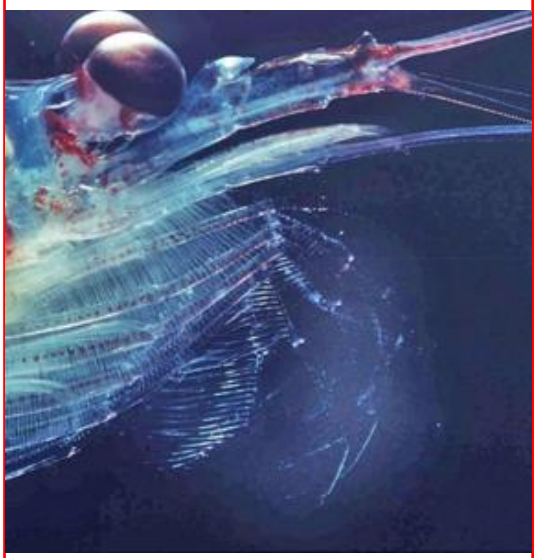
Many marine animals feed by separating food particles from water, known as *filter feeding*. This method of eating is similar to removing boiling water from cooked vegetables with a sieve or strainer. Filter feeders include a wide range of animals including bivalves, some snails, sponges, fan worms, barnacles, corals, sea lilies, some fish, and even some birds like Flamingos and baleen whales like the Blue Whale.



Filter Feeding is Like Using a Sieve

The many filter-feeding animals, sometimes called *suspension feeders*,[1] use various methods of filtering. Baleen whales and the Flamingo suck food-containing water into their mouths then press the water out past sieve-like mouthparts (baleen "teeth" of the whale), retaining the food in their mouths. The Whale Shark swims through the water with its mouth gaping, then closes its jaws and presses the water out its gills, retaining the food within. Depending on the animal, these larger filter feeders sometimes consume smaller filter feeders like the larvae of crustaceans and bivalves.

Krill, a shrimp-like crustacean, have long legs with “feeding baskets” that branch out to collect food particles and filter it from the water. The animal then draws the collected food into its mouth. Bivalves collect food as part of their respiratory activities. As water passes through the animal’s gills, food particles collect in the sticky mucus on the surface of their gills and are transported by cilia to the animal’s mouth.



Krill “Feeding Basket”

Filter feeding plays an important role in marine ecosystems. The water filtered by these animals is effectively being cleaned because particles are being removed. This clean water allows other marine life to thrive. The Gulf of Mexico is home to 15,000 diverse species of marine plants and animals. The clean water produced by these filter feeders allows sunlight to enter the water’s depths to reach plants and animals like coral that need sunlight to grow.

The Deepwater Horizon oil spill has caused great concern about filter-feeding animals. As the oil enters their habitats, animals like clams and oysters will undoubtedly filter oil-containing water. In small amounts, the oil might not kill these animals because of their well-documented abilities to tolerate low levels of toxin. However, when these animals are consumed by larger animals, they will also consume the oil that has accumulated in their prey. Bivalve filter feeders are well known to “bioaccumulate” toxins like the hydrocarbons found in oil, making them an especially dangerous part of the food web for predators, including human consumers. Dr. José Leal, Director of the Bailey-Matthews Shell Museum on Sanibel Island, stated that a main concern is the “hydrocarbons, which are very powerful carcinogens … if someone eats that then they will have a problem right away.”

[1] A Revised Classification of Suspension Feeders | NZETC

Interviews

The Museum of the Earth had the opportunity to speak with several scientists who have vast experience with the plants and animals affected by the oil spill. These individuals are professors at universities, directors of marine labs, or managers of museums. Click the links below to read their interviews.

Interviews:

- Interview with Dr. Jose Leal (The Bailey-Matthews Shell Museum)
- Interview with Dr. Kumar Mahadevan (Mote Marine Laboratory)
- Interview with Dr. Billy Causey (NOAA)
- Interview with Dr. David Vaughan (Mote Marine Laboratory)
- Interview with Dr. Drew Harvell (Cornell University)

Interview with Dr. Jose Leal

Dr. José Leal *(Director of The Bailey-Matthews Shell Museum)*

We're interested in learning about your perspective on the oil spill and its effects on marine life.
Dr. Leal: There is no question that this accident turned out to be a major threat to biodiversity in the Gulf of Mexico, a menace that we are not prepared to understand, because we do not fully know how many species are out there in the deep-sea to begin with, and how the oil could affect the way the organisms interact in the food web. Anyway you look at it, it is not pretty.

The west coast of Florida currently appears to be safe from the oil spill. Could it still enter the area?
Dr. Leal: The continental shelf in southwest Florida is relatively wide. The Loop Current, which flows from the northern Gulf in a clockwise direction to the south and out west of the Florida Keys, tends to stay away from the shallow shelf. This is what we believe will happen, preserving most of the coast of southwest Florida from the contaminated water. But elsewhere in the Gulf, the problem is very serious.

What concerns are there with the marine life, specifically the animals you study?
Dr. Leal: If you move away geographically from the areas where the animals are simply being smothered by crude oil, there remains the problem of bioaccumulation, which happens when animals or plants are capable of storing substances in their tissues, substances in this case that are detrimental to other organisms in the food web. Some bivalves such as clams, mussels, and oysters are capable of doing that, amplifying in their tissues the concentration of toxic compounds present in contaminated seawater. That is passed down the food web to anyone ingesting those bivalves, including humans.

Can you tell me a little more about the red tide and how it negatively impacts an area?
Dr. Leal: Red tides are caused by large blooms of a marine microorganism called *Karenia brevis*. Those single-celled organisms release a toxic gas that causes the death of marine invertebrates and vertebrates such as fish and dolphins. Sometimes, during prolonged periods of red tide, the levels of oxygen dissolved in seawater severely decrease, as a result of the deaths of millions and millions of animals in the area.

How might the oil affect the existing threats to the Florida coastal areas and their marine life?
Dr. Leal: Current oceanographic models locate the flow of oil-contaminated water away from the coastal areas of Southwest Florida (where the Shell Museum is located). However, there is a chance that water could reach the Florida Keys and the coast of South Florida. Again, the effects of the oil would be contingent on the amount and "thickness" of the oil fraction affecting these areas. The effects on the coast of West Florida (e.g., Pensacola and adjacent areas) are serious and one can expect molluscan populations to be affected as discussed above. Given the distance from Deep Horizon, it is unlikely that large amounts would be involved in the southernmost part of the state. In Southwest Florida, we suffer from releases of polluted water from Lake Okeechobee via the Caloosahatchee River, an abnormal set of

circumstances that, if combined with oil, could result in local environmental disaster. But now we realize that Southwest Florida should be safe from a "direct hit" by the oil spill.

What does the oil spill mean for the work you do? How has your work been impacted?
Dr. Leal: As a marine biologist and director of an educational institution based on biodiversity (mollusks being the second most diverse group of organisms in the planet), I worry immensely about the effects of the oil spill. My work is impacted to the extent that I seek, as part of my job, to learn more and get involved with the issues surrounding the spill. And, although the beaches in Southwest Florida are totally clean, there is the wrong perception elsewhere that our part of the coast has been impacted, which results in a momentary decrease in numbers of visitors to the Shell Museum and its general area.

From your experience, what marine mollusks do you think are at the greatest risk?
Dr. Leal: Mollusks in the deep sea are "invisible" to mostly everyone, but may represent the most affected by this huge volume of oil. In the deep sea, many mollusks and other marine invertebrates feed on organic remains and detritus that accumulate close to the bottom. If this layer is affected by oil, they will gobble up oil instead. I mentioned bioaccumulation earlier, a phenomenon more likely to occur far away from the immediate spill area. The heavy stuff stays near the spill, but the fine, light fraction – the more liquid part – is far-reaching. I don't think anything can survive for a mile around that spill. We may also be losing species that we don't even know about, even before we knew of them. And, again, marine food webs are very complex. If there is one element affected, that specific impact could affect many or all elements of the food web.

What are the most popular marine life attractions on and near Sanibel Island?
Dr. Leal: Mote Marine Lab, in Sarasota, for instance, and evidently all the attractions and research organizations in the Florida Keys.

Some of these creatures are edible and are commercially harvested. How severely has the oil impacted the industries that rely on these creatures?
Dr. Leal: From what I understand, I think they have been severely impacted. The oyster industry in the Florida Panhandle is most likely suffering from the spill. Oysters cannot run away from the oil. And, again, we face the issue of bioaccumulation. Some of the components of crude oil, called polycyclic aromatic hydrocarbons, are very powerful carcinogens and there is the possibility these animals could have been affected by them.

You mentioned the oil missing the southwest coast of Florida. What are some of the other predictions?
Dr. Leal: I'm not one to make any formal predictions, but I think that just common sense dictates that one has to be attentive for monitoring seafood that could be affected by the lighter fraction of oil. This lighter fraction, mixed in seawater, could be transported for long distances.

What about the dispersants? How are they affecting things?
Dr. Leal: Supposedly the dispersants could be as bad as the oil itself to sealife. I am sure scientists are analyzing the effects of the dispersants compared to the effects of oil itself.

For more information on Dr. José Leal and The Bailey-Matthews Shell Museum, visit http://shellmuseum.org/director.cfm

Interview with Dr. Kumar Mahadevan

Dr. Kumar Mahadevan *(Executive Director and Senior Scientist of Mote Marine Laboratory & President of the Mote Marine Foundation)*

What marine life is at greatest risk in the Gulf from the Deepwater Horizon oil spill?
Dr. Mahadevan: Well, obviously the greatest risk is for the primary producers in that area. Where the oil is there is a lot of phytoplankton. That loss of productivity is going to affect the other animals in the food chain. It starts at the base of the food chain. Other than that, the sea turtles because they migrate at this time, and they aren't as adept to avoid the oil as the larger animals. There is also concern because the oil sheen will look like a jelly fish and the turtles sometimes eat that.

What marine invertebrates are at greatest risk?
Dr. Mahadevan: The greatest risk is at the location of the rig itself, because oil came from the bottom, there is a lot of impact on the invertebrates there because of the actual oil spilling is right there. The area becomes anoxic, because the oil pushes out the oxygen and the bacteria that eat the dead animals cause more oxygen loss.
In the shallow areas, especially the shorelines, there is a lot of oil coming through, and that is going to affect the shrimp larvae. The oil that gets into the marshes will affect the life there, too. The oyster beds in that region are some of the most productive in the world and those are being affected as well. Anything that filter feeds, like oysters, they are in trouble. The oil and dispersants are going to enter the animal, affect them and will affect the animals that eat the oysters.
A bigger worry is the threat to the coral reefs of the [Florida] Keys. Many of them are filter feeders. If oil gets into the Loop Current and goes to the reef, we're going to see some major impact.

Can the coral survive?
Dr. Mahadevan: Some will get hit so much and die. But some will get affected where maybe just their reproduction will be affected. It depends on the how severe the impact is.

There has been report of oil in the Loop Current. Do you think the current will send the oil toward the Keys?
Dr. Mahadevan: I think that [at] some point it will. At this point, there isn't much in the [Loop] Current, so the concentration is low. But we are more interested in the long term. If they can stop the oil, then we might be okay.

What marine life is most threatened on the west coast of Florida?
Dr. Mahadevan: Well the way the Loop Current works, [the oil] is far from our coastline. The odds of us getting surface oil right now are pretty low. Scientists are having trouble determining how much is subsurface oil. I would be hesitant to say we are safe from that. The surface oil could become tar balls.

NOAA is predicting one of the worst hurricane seasons this year, so it depends on nature, and how soon they close [the well] and clean [the oil] up.
The bottom line is that the impact is going to stay with us for decades. Areas from Louisiana to the panhandle, they are going to face impacts for years to come. There will be reducing fisheries and harvesting of oysters.

What does the oil spill mean for the work you do? How has your work been impacted?
Dr. Mahadevan: We are a research, visitation, and public outreach location. [At] the aquarium, which is public outreach, we are concerned about the oil reaching our marine aquarium systems because we take water from the sea and recycle it. From a research point of view, some of the long-term data we have collected is now all not worth as much because the conditions have changed. Now we need new baselines.
In a way it's kind of good because people have taken the Gulf of Mexico for granted. And now with the spill, people start to realize how much these areas are worth. Whatever your career is, if you live in the Gulf you can see the impact. So that is good in a sense, I guess, because that will help people realize it. In all our education programs, we reach about 40,000 kids and now we have a heightened awareness with these kids. So those are maybe some of the positive things.

Are there plans underway for protecting the unaffected coastal sanctuaries from the oil?
Dr. Mahadevan: I think the plans vary along the coast depending on the counties, because, at least in Florida, all the emergency operations are organized county by county. The common denominator has been BP, the federal government, and state agencies working together. Some of that has been questioned on how that has been handled however. My worry is, are we relying on BP and the government too much? I think different counties will handle it differently.
But some counties are not just relying on the federal government. We are learning the lessons from Louisiana, those being that the booms are not really affective, and we are learning from that to see what else we can do. I'm optimistic and I see things are getting better.
A short answer is I think everyone has a plan. How well it's going to work, we know in some cases it will, but not in all places. Beaches are easy to clean up. Oyster reefs, mangroves, and marshes are tough to clean. You can't just clean them.

You studied the effects of oil refinery effluents in the Persian Gulf. Have you found parallels to the Gulf oil spill?
Dr. Mahadevan: All my knowledge on the Persian Gulf is based on what I read. They have a lot of coral and beautiful water, and that was the biggest challenge they had.
When I studied the effluents, they were very small. Periodically they had spills that went into the Persian Gulf that caused problems. The products they put in were all volatile and evaporated quickly, so that helped. But they were more toxic, and could have caused problems.
The volatile components are toxic but are not the issue. The main issues are that the oil separates into different components, and they use dispersants, which are like soap, and they are emulations and we don't know where these things are because much of it is underwater.
Scientist just don't know how much there is or where it is. If you don't know where it is, how will you suck it up or clean it?

What else about the Gulf oil spill is similar to your previous studies?
Dr. Mahadevan: The Ixtoc spill in the 1980s caused a lot of problems. They still go to coastlines and see tar balls and oil. For example, Exxon Valdez people can still go and turn rocks and find oil. It is very persistent for long periods of time. We are going to be dealing with this for a long time. At least a few decades.

Based on your prior experience, what effects do you think might happen in the Gulf as a result of the oil?
Dr. Mahadevan: The long-term effects are a reduction in fisheries. The Gulf is one of the most productive in the world, and we are going to have to import more seafood to offset our reduced production. I think that will be one effect that will be very obvious to these people. The fishers will feel the direct impact, but everyone else will be paying more for seafood and getting less.
Not much is cheerful, but if we can stop the spill, clean as much as we can, and work on long-term restoration and help, we could do well. Specifically, we have the technology now to help restore the

areas and some of the fisheries in the Gulf. Scientists have come a long way where they can stock the fisheries and the environments. We have high hopes for restocking the fisheries. Those are a couple of things we can be proactive about, and hopefully the federal government will help take the lead.

Which clean-up efforts do you think are working? Which are not?
Dr. Mahadevan: I think the efforts are working when it comes to BP. It looks like they are staying up with what is happening. As we move forward now, we need to think about restoration and restocking. It's going to be a long term commitment. I'm sure they are getting a lot of innovative ideas on how to clean up the oil from bacteria that eats oil and everything else. I'm hoping they are vetting these ideas for use.

How might the oil affect the existing threats to the Florida coastal areas and the wildlife?
Dr. Mahadevan: That's a classic ecosystem question because ecosystems are like rubber bands. They can stretch to a point but after that point they break. These problems affect the ecosystems but they keep lumbering on. One of the worries we have is that the oil spill comes in and does the last stretch and breaks the ecosystem. The red tide we get here, the oil spill won't relate to that *per se*. The oil spill will reduce productivity. It will be more severe because there will be less countering mechanisms, and scientists don't understand all of these issues as they come together. Over time, we will get a feel for it. It's going to be a long process though.

What is the greatest concern for the west coast of Florida if the oil enters that area? Do you think it will?
Dr. Mahadevan: The biggest concern obviously is our economy, which is heavily reliant on tourism, fishing, and boating, those activities. If oil gets here, it will really kill our economy. Whether people go fishing for a day offshore or they are lying on the beach, attracting tourism is the biggest challenge. The long-term concerns, like I said, are the fisheries and the sport fishing that will be affected.
We're hoping oil never shows its face here. We haven't had any oil, but our hotels here have had 30% cancelations. People are going elsewhere. It's not even the oil that is the problem, it's the perception. The media gives the sense that all the areas are affected.

What can be done to fix the media perception issue?
Dr. Mahadevan: The governors are trying to get BP to put money into marketing efforts to get people to come. We have a beach condition report on our [web]site. It was created to tell what beaches have red tide and which don't. We have about 33 beaches and we want to make it available to all those beaches. Those informational things that we can get on a webpage give people the chance to learn the truth and will be very helpful.

For more information about Dr. Kumar Mahadevan, visit www.nmsfocean.org/about-us/person/dr-kumar-mahadevan

Interview with Dr. Billy Causey

Dr. Billy Causey *(Southeast Regional Director for the National Marine Sanctuary Program of the National Oceanic and Atmospheric Administration)*

You were on an oil-related call recently. Can you share anything about that? What damage and losses are there?
Dr. Causey: Well. we really don't have any major assessment of what we lost. In the [Florida] Keys, we have not seen any loss as far as any invertebrates. I would have to rely on what the scientists have done with their assessments. It's too early in the Keys to say we have lost any marine life. That's yet to be determined.

Can the coral in the Florida Keys be protected? How?
Dr. Causey: We're talking about several different questions here. First, are we talking about the kind of threat from the Deepwater Horizon blowout? Or are we talking about ship grounding that could spill oil. In each case, we want to reduce the threat through various physical and chemical means, and reduce its interaction with the natural resources. In the case of the BP blowout, that is so far away and the oil would have to travel such a distance where weathering reduces it to 30-40% in volume. And microorganisms are reducing it as it flows. There are a number of things that naturally degrade it.
Should it be here, we'll probably see emulsified oil and tar balls. Those could be removed by skimmers, or if it was on beaches, it would be picked up. If it's something on the reef, we would have to rely on skimmers and booms. There are a number of mechanisms to reduce the threat to the natural resources.

After speaking with Dr. Mahadevan of the Mote Marine Laboratory, I understand the booms aren't working very well. Is that correct?
Dr. Causey: The booms do work, and Dr. Mahadevan's statement is accurate. But it depends on the conditions. Booms don't work well to contain oil when there are heavy waves. It depends on the currents and weather conditions. But the booms on calm days are working to corral the oil and burn it off. There has been a lot of that. There's a variety of mechanisms to remove the oil and handle the impact. It just depends on the conditions, and the conditions presented by the immediate threat of the conditions. The purpose is to remove it to reduce the threat and protect the marine life as much as you can.
We have not seen any oil in the Keys from the BP blowout, and at this point, we don't anticipate any. The Mote Marine Lab sent out some unmanned underwater vehicles to detect and sample any trace of oil, and they have not found anything at this point. We have no reason to believe that oil has reached this area.

Are there plans underway for protecting the Keys and the coastal sanctuaries from the oil?
Dr. Causey: Plans are totally underway. The entire area committee and Florida Peninsula Command are under a unified command to respond to any threats. Command has been keeping various groups ready to call in and deploy booms and skimmers to respond when necessary. We have had some tar balls show up a few weeks after the BP blowout and we sent them to Connecticut for analysis. We found out they aren't from the BP spill. But we have a lot of people ready to go, meeting on a regular basis, [and] continually

reviewing the status, so we are prepared.

You're a policy developer, what policies are being implemented concerning this spill?
Dr. Causey: The main thing is implementing the policies established for oil-spill response, and following the protocol. NOAA serves as a protocol with others trustees where we have policies in place. Are we developing new ones at this time? No. Will we in the future? Probably.
There is the Florida Keys National Marine Sanctuary and Protection Act of 1990 established by Congress, which is one that holds strong for the Keys area. It basically says there will be no hydrocarbon, oil, or gas explorations in this area and also outlines how the area will be protected.

How might the oil affect the existing threats to the Florida coastal areas and the wildlife (runoff, coral bleaching, red algal blooms, ship grounding damage)?
Well, any time you add a stress, you risk damaging the reef environments. The corals aren't bleaching this year. The water quality, which has affected the coral in various ways, has been very warm this year. Any time you add an additional stress, you run the risk of pushing corals to the limit. We're not there with this blowout and I don't think we'll see a major stress at this point.

What are the concerns with the Loop Current and how that might affect the spill?
Dr. Causey: Well, the Loop Current fluctuates between years. This year, the top of the Current pinched off and disconnected from the Loop as an eddy and is keeping the oil up there. The Current is mostly surface currents and we have been sampling for oil in the Current. We haven't found anything in this area though.
If anything should come our way, again, we have been ready since April 20.

For more information on Dr. Billy Causey, visit http://www.dep.state.fl.us/oceanscouncil/members/bios/causey.htm

Interview with Dr. David Vaughan

Dr. David Vaughan *(Executive Director of the Tropical Research Laboratory & Director of the Center for Coral Reef Research at the Mote Marine Laboratory in the Florida Keys)*

From your perspective, what marine life is at greatest risk in the Gulf of Mexico from the Deepwater Horizon oil spill?
Dr. Vaughan: That's a tough question, because it needs to be qualified by where. We work in the Florida Keys and our concern is the coral reefs. So far, they have not been affected. It seems like the biggest impact is for the animals at the upper Gulf coast. Those animals include sea turtles, marine mammals, many birds, as well as the fish and their eggs and larvae.

What about the mollusks?
Dr. Vaughan: Well, I usually tell people about the large biomass. The oil spill is just past the continental shelf. Probably some of the biggest damage is right near the blowout. Most people really have no clue of what effect the dispersants have on the animals. We have done tests on the dispersants here and found that some of the dispersants have worse affects on the animals than oil.

Do you think the Keys will see any oil?
Dr. Vaughan: Right now I do not. At the beginning I thought "absolutely." There is normally something called the Loop Current which runs through the Gulf and it sometimes goes past where the blowout was. It then passes south of the Keys, sometimes between Dry Tortugas and the other Keys. If that had happened, and the oil spill was inside that current, we would have had the oil coming into the Florida Keys, into the beaches of Miami, and eventually toward Jacksonville. The only reason it didn't happen is because the Loop Current changed directions. At the time of the BP blowout, the Current hadn't reached the blowout. The upper portion then pinched off into what is known as the Franklin Eddy and trapped any oil from the well that did enter the Current.
We have two Autonomous Underwater Vehicles (AUVs) out there testing the waters off of the Keys. One AUV, Waldo, has been deployed a second time with new batteries for another two to three week round. I'm predicting two weeks before we know if any residual is coming. There are about four more AUVs that are going deeper in the area of the spill. Then the data, and actually our data, goes to Rutgers University Coastal Ocean Observation Lab (RUCOOL) for analysis with [those from] the other autonomous vehicles. I didn't know how well they would work up until now. But now I would tell you they are very dependable submersibles, which are a lot cheaper than manned submersibles at about $120,000 to $130,000 and can go out for up to a month to collect data every three seconds and send it back for analysis 24 hours a day, 7 days a week, for a few weeks. These things use very little energy. They don't operate like a typical sub. These things look like torpedoes with no propeller system. They are naturally buoyant gliders, with two glider wings. When it gets the signal, it pumps air into a chamber to move the center battery forward which makes it sink as it moves forward. It then does the reverse to rise up as it glides forward. All this is done with several 12 volt batteries. They're very efficient.

Can you give me some additional coral-specific details concerning the spill?
Dr. Vaughan: One of the reasons we are concerned about the corals is that even though the oil is near the surface, and if it was fresh, it would go above the coral, a problem happens when they use dispersants which are vary lethal to coral larvae. And two times a year, the coral reproduce. Some brood and then some spawn a few days after the full moon of August. The first type brood and they develop eggs and release sperm. The sperm swim to the top for a few hours then go down to find eggs to fertilize. The second type is broadcast spawning, which takes place after the full moon in August where they release gamete bundles which are positively buoyant and they float to the surface. It's kind of like upside-down snow. As soon as they come to the surface, they burst and release their sperm and eggs. At that time, if there were oil and dispersants, it would go through the fertilized larvae which stay there for a week before they travel back to the bottom again to start growing.
We just did a biopsy on the brooding corals and found they were not very susceptible to oil, but very susceptible to dispersants and the combination of oil and dispersant. We've had a few, very difficult years for the coral. In the winter, we've had some cold spells where we had the shallow-water temperature drop about 30 degrees Fahrenheit and we lost several corals then.

Are there any other details you could share regarding the coral?
Dr. Vaughan: We're mainly concerned about the dispersants on the hard corals. Since the oil usually goes to the surface, it may not be a problem except when coral spawn. When the oil is treated with dispersant, it may cause a problem. Corals have the unique relationship with the algal zooxanthellae in their tissue. There's a film of mucus on the coral polyps where a layer of bacteria live and provide a natural antibiotic for the coral. If the algal component leaves the corals, they will bleach. They don't die from bleaching but die from disease that comes after. This is because, from what we have found, the algal component doesn't give all its energy to the coral but also gives some to the bacteria, which produces the naturally occurring antibacterial that protects the coral.

So it's almost like AIDS with humans?
Dr. Vaughan: Yes it really is. And a lot of people don't know what coral is. Whatever they think, we know they are very complicated organisms that depend on up to three different phyla. We're worried about the dispersants because it breaks up the oil so it won't float. And we are concerned it may have the same effect on the bacterial layer on the corals.
There is a little bit of good side to this. And it's good for some of the natural oils as opposed to the refined oil. In the Gulf, there are a number of locations where oil, methane, and hydrogen sulfide seep into the ocean. There are organisms that have adapted to live in these conditions. There are naturally occurring bacteria that attack the oil and use it as an energy source. A little less known is that some animals utilize the methane gas by utilizing the bacteria that use it for energy. These happen at the cold seeps in the deep ocean, which are similar to the hydro-thermal vents in the deep ocean. There are animals that are similar to those who live near hydrothermal vents, and there are some crustaceans and bivalves that can live there and make use of the naturally seeping gas.
I was very lucky to have a chance to go down in a submersible to visit one of these brine-pool cold seeps. It was reported by some of the people exploring for petroleum deposits when looking for salt domes that occur under the ocean where salt deposits and hydrocarbons collect. Those are the areas they like to find to drill a well for natural gas. In this area, we saw both methane and liquid crude coming out. This one had water flowing into the salt dome that caused the salinity to go up 3 times that of normal ocean water and made a pool of water almost separate from the ocean water. It looked like a black oasis ocean pond. Around that pond was covered with cold water, black methane mussels that lived near the brine just far [enough] away from the methane to get oxygen.

Have you seen a change in your work as a result of the spill?
Dr. Vaughan: Oh yes. Up until this time, I really didn't have much experience with the AUVs. I knew Mote [Marine Laboratory] had one to check for red tide toxins. But I never realized until the oil spill just how well these things work to detect and give us an early warning on what is coming. In the past few months, I've been working on deploying, retrieving, and going through the graphs and data from the AUVs to report to the public what to expect. I didn't know how much stress and fear people had before I was able to deliver this information. People in the Keys wanted to know how much is coming out, how bad is it and what to expect. Several organizations were slow to deliver information and people didn't know what to expect when they saw pictures of birds in Louisiana covered in the chocolate-looking mud. They didn't

know if it was hours or days away. And they didn't know what to do. But with the information from the AUVs, which go far past the Keys where we think the oil may travel, we are at least able to tell the public that things are okay for now. It's like a scout telling us a head of time.

I understand that tourism has been affected by the perception in the media. Is that true?
Dr. Vaughan: Yes, and people were afraid of the oil and wouldn't come and stay in hotels or even eat the Florida lobster because they thought they would be covered in oil. I had calls from people asking if we were evacuating. So the information we're getting from the AUVs is very helpful in getting information to the public. It would be wonderful if Florida had 25 of these things to look at the water near the beaches to show people that the water is okay in those areas.

Where can I find this information?
Go on our website http://mote.org/robot and that will bring up information from the robots. What I say about these things is that "this has changed my life in a good way. Here's technology that is being used for the good."

For more details on the data collected from the Autonomous Underwater Vehicles, visit:

- http://rucool.marine.rutgers.edu/deepwater/
- http://rucool.marine.rutgers.edu/deepwater/category/deepwater-blog/

For more information on Dr. David Vaughan visit http://isurus.mote.org/Keys/reef_restoration.phtml

Interview with Dr. Drew Harvell

Dr. Drew Harvell *(Professor of Ecology and Evolutionary Biology at Cornell University)*

What are your main concerns pertaining to marine life and the oil spill?
Dr. Harvell: I think it would be important to track the biodiversity impacts of this issue because they are huge. The water-column species, jellyfish, invertebrate larvae, fish larvae (spawning tuna) are directly in contact with the spill. I think that is really important. I would like to see a biodiversity calendar to document the losses.
Another thing we worked on for many years in the Florida Keys was studying the coral populations. We were interested in doing a rapid response after the oil spill because even if the oil doesn't hit, we expect there should be a lot of stress. I heard from some of the folks in the Florida sanctuaries that oil is expected to hit the Keys. And if they get hit, there are expected to be pretty big impacts.

What marine invertebrates and plants are at greatest risk?
Dr. Harvell: It's easy to say the coral is at risk. But there are also a lot of invertebrate larvae that are very fragile and summer is the spawning season [when] so many of them will be exposed. And one thing I would say, for a crab and coral – a crab has an exoskeleton, coral has nothing. Every bit of the surface area is exposed for these corals. And of course that's really disastrous because these corals make coral reef ecosystems that are home to many other plants and animals.

Could you provide a public-understandable description of how corals feed?
Dr. Harvell: Corals are basically solar powered. Most of their nutrition comes from the symbiotic relationship with the algae that live in their tissue. They need clean water for photosynthesis. There are some species that are carnivorous and capture zooplankton at night with their barbed tentacles. So not all are filter feeders, but it's the sunlight that's the most important part of their diet. The algae live in the tissues and create the food. But they are kind of like the "Achilles heal" of the coral because they are easily disrupted by temperature stress, and this summer has been hot. If there is an oil hit combined with the hot summer, the results will be disastrous. The symbiosis between the algae and coral can be disrupted very easily.
Corals are really complicated. It's not just the symbiotic algae but also the bacteria that live on the surface of the coral, and they are important to the health of the coral too. If there is oil and dispersants hitting them, that could really disrupt the coral. And I would suspect an increase in coral disease.

What effects would oil in the water have on how corals feed?
Dr. Harvell: What I think will happen is that it will disrupt the symbiosis. It would affect the way they feed, and if they bleach, then the coral is going to die. In terms of the carnivorous feeding, I don't know how the oil would affect that. But what coral tends to do when they are stressed, they tend to retract their tentacles and not feed. Even if they didn't lose the symbionts, the oil could cause a loss in sunlight and make it harder to produce their food.

How might the spill affect existing problems like pollution runoff, coral bleaching, red algal blooms, etc?
Dr. Harvell: I don't know. I don't know how those will interact with the oil spill. All I can hope is that this spill was so terrible that it will make it so this won't happen again. Hopefully we'll have policy changes in that way. This is a continuing conflict; we need to harvest energy while balancing our sustainability.

For more information on Dr. Drew Harvell, visit http://www.eeb.cornell.edu/harvell/harvell.html

How You Can Help

There are many organizations that are contributing to the recovery, clean up, and restoration of the Gulf of Mexico against the continuing damaging effects of the Deepwater Horizon oil spill. Here are some to which you can contribute aide and assistance. Please contact webmaster@museumoftheearth.org to suggest other worthy projects that are benefiting the marine plants and animals of the Gulf of Mexico.

- National Wildlife Federation Gulf Oil Spill Restoration Fund
- Save BioGems: NRDC's Gulf Coast Recovery Fund
- Gulf Restoration Network
- Mote Marine Laboratory - Deepwater Horizon Oil Spill: Mote's Response
- Gulf Savers - a Wetlands Restoration Solution by Restore the Earth Foundation, Inc.
- Coalition to Restore Coastal Louisiana
- ORCA - Ocean Research & Conservation Association

You can also take part in:

- NRDA for the Gulf: Improving Our Ability to Quantify Chronic Damages, November 2-4, 2011