OIL SPILL SCIENCE

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OYSTERS AND OIL SPILLS

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Oysters regularly cope with challenges like pollution, changing water temperatures, fluctuations in fresh and salt water, harvesting, and coastal development. Science shows that oysters can be resilient, but extreme natural and manmade events can degrade oyster reefs.

In order for oyster reefs to thrive, young oyster larvae prefer adult oyster shells to attach to, settle, and grow. To help oysters do this, many communities organize oyster restoration projects such as this one in Hernando County, Florida. (UF/IFAS/Camila Guillen)

OYSTERS 101

Oysters grow in clusters, forming reefs in nearshore areas, such as along salt marsh shorelines and on **intertidal** mudflats. Oysters also grow farther out from shorelines in shallow water known as the **subtidal** zone. When the conditions are right, oysters can spawn several times throughout the year, usually during the warmer months. Adult male and female oysters release sperm and eggs into the water simultaneously for successful reproduction.[1] Adult oysters in nearshore areas exchange sperm, eggs, and larvae with oysters in subtidal waters. This exchange between areas is important for

sustaining oyster populations (Figure 1).

Young oyster larvae float in the water until they settle on and attach to shells of older, well-established oysters. If oyster shells are unavailable, larvae will settle on other nearby things like rocks, boat docks, or marine debris. At this stage, the tiny oysters are known as **spat** and will stay attached to the mature oyster shells or other structures as they, too, grow into adults. Generations of oyster growth such as this creates oyster reefs. Similar to corals, oysters are commonly regarded as the 'engineers' of their ecosystem because of their reef-building abilities.[1,2]

These thick, strong mounds of shells are not only essential for the growth of oysters themselves; they are also a home or a source of food for other living marine resources. As a key species in their food web, oysters play a critical role in a healthy coastal wetland. Oyster reefs trap sediment and provide hard structure to help stabilize shorelines from the natural process of erosion and land loss. Additionally, oyster reefs protect against storm surge by buffering and spreading wave energy back out to sea.[1,2] Thus, oysters provide protection from strong storms to communities of people that live along the coast.

Brackish water is very important for oyster survival. Too much or too little salt can reduce their ability to live, grow, and reproduce. Oysters do well in an environment where the **salinity** ranges between 14 and 28 parts per thousand.[1] Oysters are famous for their ability to 'clean' the water they live in. They pull in water past their gills to capture and eat tiny food items and then expel that filtered water back out. In doing so, they also sift out natural and foreign materials, thereby maintaining higher water quality and clarity and cycling important nutrients in the ecosystem. By filtering water around them, oysters provide a valuable service to the animals and plants living in their area, promoting the growth of other important habitats such as seagrass beds (Figure 2).[1]

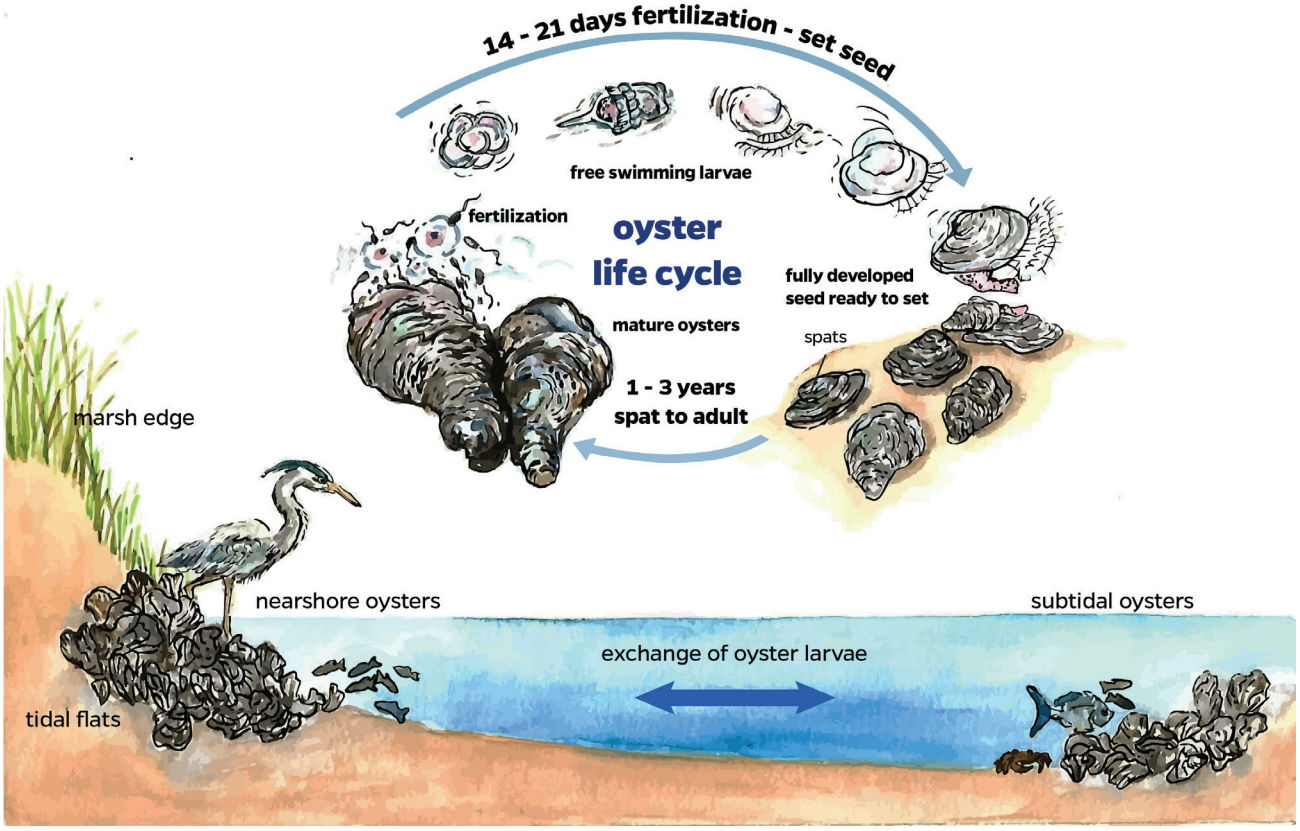

FIGURE 1. *Oysters need each other to survive. After fertilization occurs, their larvae float in the water until settling on and attaching to the shells of mature oysters, becoming spat. Here the spat will grow and become part of either the nearshore or subtidal oyster community. When they are old enough to reproduce, nearshore oyster beds exchange their sperm, eggs, and larvae with the subtidal oyster reefs, and the cycle continues. Healthy oyster reefs support a variety of wildlife in wetland ecosystems. (Anna Hinkeldey, adapted from* ***www.hook.life****)*

IF OYSTERS FILTER THE WATER, CAN THEY BECOME CONTAMINATED BY OIL SPILLS AND BE UNSAFE TO EAT?

Multiple studies revealed no evidence of oil-related chemical accumulation in shellfish after the Deepwater Horizon oil spill.

When a spill happens, slicks and mats of oil can drift over and settle onto oyster reefs. As oysters filter water through their bodies they can then encounter contaminants dissolved in the water. Oil compounds like **polycyclic aromatic hydrocarbons (PAHs)** and spill-related chemicals like **dispersants** cause concern because they can be harmful to humans and wildlife.[3]

Some contaminants, such as dispersant and PAHs, can build up, or **bioaccumulate**, once they enter an organism's body. Oysters cannot move away from oil and dispersants because they are cemented to their reefs. So if they are living and feeding in an area where a spill has occurred, they are more likely to bioaccumulate pollutants. Oysters are also less efficient at removing chemicals from their bodily tissues compared to other animals like fish or crabs.[4] These qualities may put oysters at risk, but those same qualities make them useful for monitoring changes in the environment and how oil and other chemical pollution might move through a food web.[5,6]

For example, scientists examined what oysters, mussels, and barnacles were eating in oiled and unoiled locations before, during, and after the Deepwater Horizon oil spill (DWH) of 2010. They sampled surrounding waters as well as shellfish tissues and shells and found no evidence of oil-related chemical accumulation in the shellfish.[6,7,8]

However, those results do not mean that oysters did not encounter oil. It could mean that the methods in these studies, the timing, and locations they studied were not capturing the full story. Perhaps the oysters did not eat oiled materials or they did not eat enough oiled materials to be able to detect it.[6] Oysters can slow or stop feeding when under stress, so they could have stopped feeding when exposed to oiled materials, which would make levels of oil in their bodies undetectable.[6]

Though studies are limited, some scientists think that oysters and other **bivalves** living in areas where **natural seeps** regularly release oil might be more tolerant of oil compared to bivalves living in non-seep locations.[9,10] The different types of bacteria living in and around oyster reefs may have evolved over time to help oysters rid themselves of oil and oil-related chemicals. These bacteria biodegrade oil, or break down and eat oil, and could be the reason why some scientists have seen little to no negative impact to oysters living in spill areas. Scientists need more baseline information about relationships between bacteria and oysters to be sure.[9,10] Read the publication ***Microbes and Oil: What's the Connection?*** for more information on this topic.

FIGURE 2. *Oysters filter water through their gills to feed on tiny particles in the water, and in doing so they pull pollutants and nutrients out of the water, expelling cleaner water back into the environment. (Anna Hinkeldey, adapted from* ***www.hook.life****)*

Even though oysters appeared to not have bioaccumulated spill-related chemicals, experts conducted a thorough Gulf-wide seafood testing program – including oysters – to ensure that seafood in the Gulf was safe to eat after the DWH oil spill. They concluded that Gulf seafood was safe to eat.[11,12] To learn more about seafood safety, read the publication ***The Deepwater Horizon Oil Spill's Impact on Gulf Seafood.***

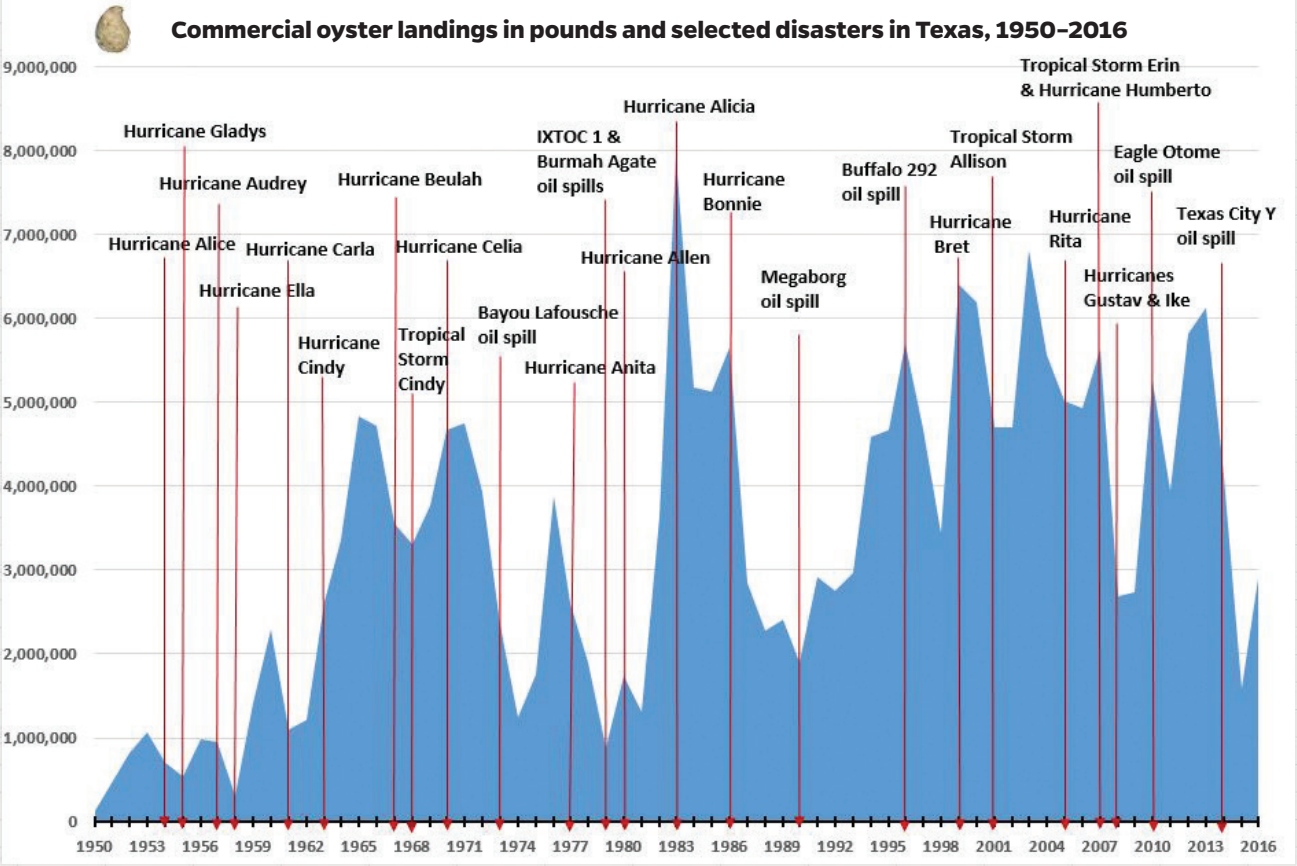

FIGURE 3. *Fisheries landings data can be used to gauge changes in populations over time, but cannot reveal the direct cause of those changes. Many factors must be considered when interpreting landings information, such as major weather events and manmade disasters.*[22,23]

HOW DO OIL SPILLS IMPACT YOUNG OYSTERS AND FUTURE OYSTER POPULATIONS?

Oyster larvae in the lab

If a spill happens during spawning season, oyster sperm, eggs, and larvae can be at risk of exposure to oil and dispersants. Emergency responders do not apply dispersants within 3.45 miles of shorelines or water less than 33 feet deep, where oysters usually live.[13] However, lab studies evaluating dispersed oil impacts to wildlife can reveal important information for future decision-making.

Scientists have conducted laboratory-based toxicity experiments to understand how water contaminated with various doses of oil and dispersants might affect growth and survival rates of oyster larvae. Conducting toxicity studies like these usually involves exposing test subjects to a wide range of doses. Concentrations of chemicals used in experiments could be higher than what is usually measured in the environment and higher than what is usually in the water after a spill.[14] This can sometimes yield results that may not reflect what happens in a real-life, constantly changing environment such as a wetland ecosystem. Additionally, changes in salinity, sunlight, and other factors can influence what happens in the field and cannot always be replicated in a lab.

Some scientists studying DWH impacts to oysters found that exposure to oil and dispersants at an early age can negatively impact fertilization, normal development, and behavior of free-swimming oyster larvae, and the survival rate of larval oysters.[14,15,16] Similar experiments conducted by other scientists concluded that the DWH oil spill likely did not negatively affect growth and settlement of oyster larvae. To fully understand oil and dispersant impacts on oyster populations, they stressed the importance of observing not only oyster larval growth, but also oyster spat settlement, when conducting toxicity studies in the lab.[17]

Keeping an eye on oyster populations

Fisheries **landings** data are used by natural resource managers, fishermen, and others to monitor changes in populations of fish and shellfish harvested by fishermen. During and after disasters like oil spills, people look to landings information to see if there are major fluctuations in landings that could signal a problem for both the fishing industry and the environment. For example, the National Marine Fisheries Service tracks the pounds of oysters commercially harvested throughout time, and their data show years with high

and low levels of harvest. Sometimes landings decrease in the years following events like hurricanes and oil spills, but that is not always the case (Figure 3).

It is important to note that landings data are limited in some ways when it comes to evaluating direct impacts from disasters. Disasters can alter animal populations, but many other factors – such as environmental conditions, interactions with other species, management decisions, fishing effort, and pollution – can influence populations, too. For example, a decision by the government to close an area to commercial fishing for a period of time can have a positive effect on marine populations that is difficult to quantify. For this reason, scientists study as many factors as they can to better understand the dynamics of oil spills and oysters, and other animals. To learn more about landings and disasters, read the publication ***Fisheries landings and disasters in the Gulf of Mexico***.

WHAT DOES RIVER WATER HAVE TO DO WITH OYSTERS AND OIL SPILLS?

Emergency responders work hard to employ the best available techniques to protect wildlife from spilled oil; however, there are trade-offs when making decisions. Some habitats can benefit from protection while others may not. For example, during the DWH incident, oil was quickly approaching shorelines. In an attempt to protect coastal areas that would be hard to clean, officials decided to release a large amount of fresh water from man-made reservoirs located along the Mississippi River. Under normal circumstances, natural resource managers routinely schedule fresh water releases from these reservoirs at specific times of the year in order to improve wetland health. Carefully controlled and brief releases of fresh water help maintain levels of salinity in wetlands where oysters, fish, and other organisms live and tolerate a range of salt levels in the water. However, if salinity drops too low for too long, oysters can have problems with growth and reproduction, and death can occur. Fresh water releases made in the past have been associated with lower oyster landings.[18]

During the DWH incident, fresh water releases occurred at very high flow rates for several weeks in hopes that it would push the spilled oil away from the coast. The release continued much longer and at much higher flow rates than in previous years, which created very low salinity levels in wetlands, particularly in Barataria Bay and Breton Sound, Louisiana (Figure 4).[2,19]

Scientists and resource managers working on behalf of the **Natural Resource Damage Assessment (NRDA)** estimated that between 4 and 8.3 billion subtidal oysters

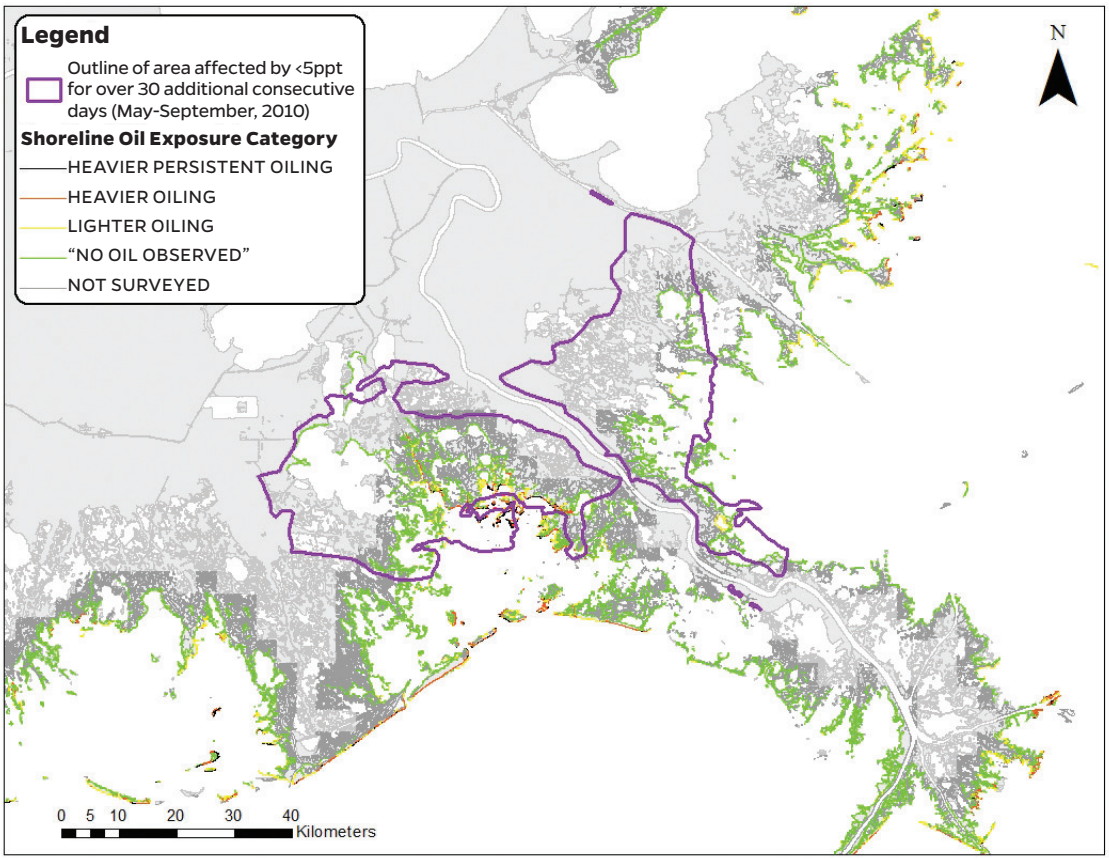

FIGURE 4. *In an attempt to push approaching Deepwater Horizon oil away from coastal marshes, officials released fresh water from reservoirs. Salinity levels (noted in the Legend as ppt, or parts per thousand) were very low for a long time, causing harm to oysters. The area outlined in purple is where scientists measured high levels of fresh water for more than a month, much longer than what is normally experienced in a year's time.[2] (Jacob Oehrig and Shahokh Rouhani)*

Emergency responders (foreground) were advised by local oystermen in identifying where – and where not – to anchor booms around oyster beds during the Deepwater Horizon oil spill. Here, U.S.C.G. Chief Petty Officer John Kapsimalis is using a pole to feel along the bottom of a bay in order to avoid anchoring on oysters. (John Kapsimalis)

were lost due to fresh water river releases, particularly in the Barataria Bay and Black Bay/Breton Sound areas. They found that numbers of oysters in oiled subtidal areas were very low in 2010 and, in many of these same areas, dropped to zero in 2011.[2] Scientists continued to monitor oysters through 2014 and determined that fresh water releases led to reduced oyster populations as well as smaller oyster size.[2,19] In addition to the river releases related to DWH emergency response, other fresh water events such as Louisiana's Bonnet Carre Spillway release in 2011 added to the loss of oysters, causing economic hardship to the oyster harvesters and broader seafood industry.[20]

Combined with the effects of direct oiling of oysters, some cleanup methods– such as raking – to physically remove oil from marsh plants and neighboring oysters increased the erosion of marsh shorelines between 2010 and 2013. These actions reduced oyster habitat within about 155 miles of shoreline, resulting in the loss of an estimated 8.3 million adult-equivalent oysters.[2] Additionally, experts predict that fewer mature adults means fewer potential offspring, so future generations of oysters could decline.[21] They calculated that 5.7 million future adult oysters per year will be unable to grow because the mature oyster shells they would need to adhere to for growth during their larval stage will not be available.[2] The emergency response community works with natural resource managers and scientists to use the best available information for decision-making and continue to improve cleanup methods to avoid damaging habitats when responding to spills.

OYSTER RESTORATION IN THE GULF

In the past, oysters have recovered from natural disturbances like floods, droughts, and hurricanes.[1] Oysters can replenish and sustain themselves even when conditions are not optimal. Environmental factors such as temperature, salinity, and food availability affect the success of oyster growth and reproduction. However, the DWH oil spill was a record-breaking manmade disaster with large-scale impacts that are still unclear. The combined impacts of reduced oysters and spawning stock, decreased larval production and settlement on new reefs, and loss of suitable settlement habitat has threatened the long-term sustainability of oysters in the northern central Gulf of Mexico.[2]

To help oysters and oyster communities recover, experts are conducting region-wide restoration projects. Natural resource managers will focus on improving oyster abundance and spawning stock to produce more larvae. Some states are integrating oyster aquaculture into their natural resource programs to enhance oyster larvae stock. Other projects will include building habitats with surfaces that are ideal for oyster larvae to settle on and grow. Some habitats, such as marsh edges and intertidal mud flats, will be managed so that the oyster reef ecosystem can continue to thrive and function for all of its inhabitants, including fish, crabs, birds, and other wildlife.[21] For more information about the impacts of oil spills on wildlife and other spill-related topics, visit ***gulfseagrant.org***.

Oysters filter materials from the water, and some of those materials can end up in the growth layers of their shells. Examining shell growth layers can tell scientists what and when the oysters were eating. (Ruth Carmichael)

GLOSSARY

Bioaccumulate — The accumulation or build-up of chemicals in the tissues of an organism. In the aquatic world, the bioaccumulated chemical can enter an organism via several methods, including their food, gills, and other tissue membranes.

Bivalve — An invertebrate with two shells hinged together, a soft body, and flattened gills. These animals are part of the class Bivalva, which includes oyster, clam, and scallop.

Brackish — The mixture of river water and seawater, which results in slightly salty water.

Dispersants — Chemicals that are used during oil spill response efforts to break up oil slicks and limit floating oil impacts to sensitive ecosystems such as coastal habitats.

Intertidal — An area of shoreline, such as sandy beach or rocky coast, that is covered by water at high tide and exposed to air and sun at low tide.

Landings — The quantities, in number or weight, of seafood unloaded at a dock by commercial fishermen or brought to shore by recreational fishermen, as reported to biologists, resource managers, or seafood dealers.

Natural Resource Damage Assessment (NRDA) — The legal process used to determine the impacts of oil spills, hazardous waste sites, and ship groundings on natural resources and humans.

Natural seeps — Occur in areas where oil flows slowly up through networks of cracks in the ocean floor, forming springs of oil. As much as one half of the oil that enters the coastal environment comes from natural seeps of oil and natural gas.

Polycyclic aromatic hydrocarbons (PAHs) — A chemical group found in many sources, including but not limited to oil, tar, ash, coal, car exhaust, chargrilled animal fats, and smoke from burning oil or wood.

Salinity — The average concentration of dissolved salts in a body of water.

Spat — An early life stage in the oyster life cycle, when oyster larvae attach to the shells of an established oyster reef or other hard surface to grow.

Subtidal — The area below the low tide water line that is submerged under water most of the time.

A Shoreline Cleanup Assessment Team (SCAT) discovered oil debris attached to an oyster shell on the shoreline of Raccoon Island, a protected bird breeding sanctuary in Louisiana. SCAT teams, including the U.S. Coast Guard, BP, and other agencies, worked together to prevent the spread of oil following the Deepwater Horizon oil spill. (U.S. Navy/ Petty Officer 2nd Class Jonathen E. Davis)

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