



OIL SPILL SCIENCE

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In the immediate aftermath of the Deepwater Horizon spill, BP committed \$500 million over a 10-year period to create the Gulf of Mexico Research Initiative, or GoMRI. It is an independent research program that studies the effect of hydrocarbon releases on the environment and public health, as well as develops improved spill mitigation, oil detection, characterization and remediation technologies. GoMRI is led by an independent and academic 20-member research board.

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SKIN LESIONS IN FISH: WAS THERE A CONNECTION TO THE DEEPWATER HORIZON OIL SPILL?

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In the winter following the Deepwater Horizon oil spill of 2010, numerous fishermen reported seeing skin lesions on offshore fish in the Gulf of Mexico. Skin lesions are a relatively rare occurrence in offshore fish populations. People had questions about what caused the lesions and concerns about fish health and seafood safety.



FIGURE 1. A red snapper caught in the Gulf of Mexico by scientists studying fish skin lesions. Inset: A close-up photograph shows a lesion on the skin of a red snapper caught in Gulf waters after the Deepwater Horizon oil spill. The cause of this lesion is unknown. (C-IMAGE/ Steven Murawski)

WHAT ARE FISH SKIN LESIONS?

A fish skin lesion is generally a change in color or an opening in the skin or fins of a fish (Figure 1). Lesions can occur on the surface of the skin, and they can go deeper into the muscle or organs of a fish.^{1,2} Other lesions originate beneath

the surface of a fish's skin and push outward, spreading through to the surface (Figure 2a).²

There are many causes of lesions. Skin lesions can develop when a fish is wounded by another animal or is injured from nets or traps. Contact with harmful

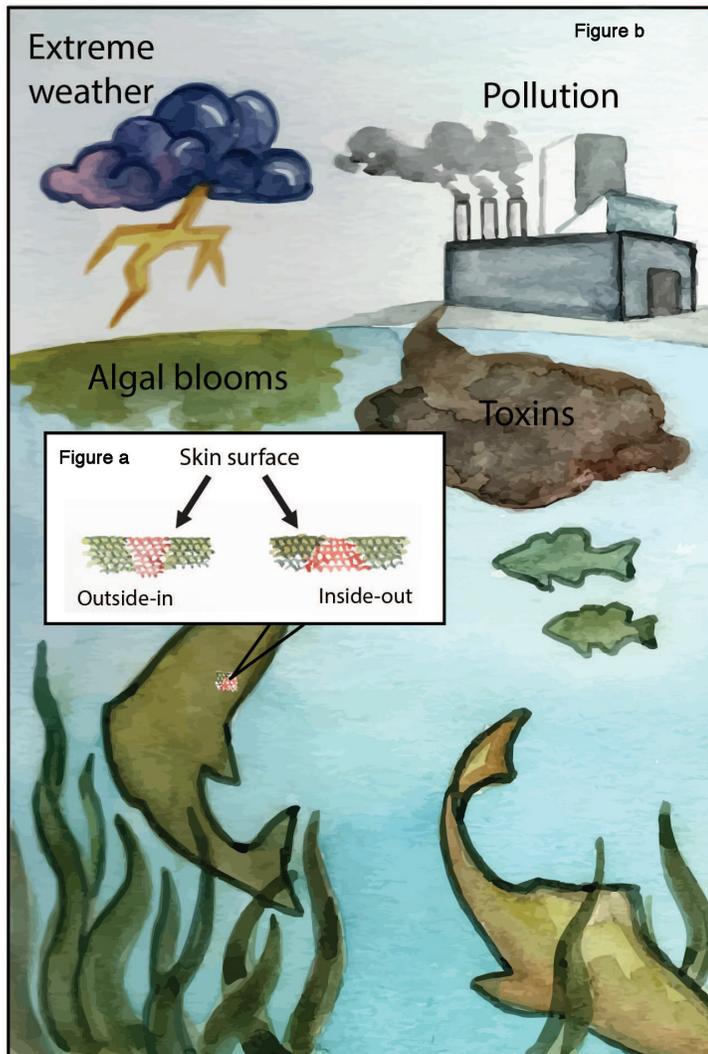


FIGURE 2. (a) A fish skin lesion is generally a change in color or an opening in the skin or fins of a fish. Lesions can occur on the surface of the skin and go deeper into the muscle or organs of a fish (outside-in). Other lesions originate beneath the surface of a fish's skin and push outward, spreading through to the surface (inside-out). The shape of a lesion can help scientists determine its cause. (Adapted from Law 2001) (b). Many different factors cause skin lesions, some of which occur at the same time. This can make it challenging for scientists and natural resource managers to identify what is behind an outbreak. (Florida Sea Grant/Anna Hinkeldey, adapted from Law 2001)

algae, fungi, bacteria, parasites, or toxins can also cause lesions. Poor nutrition, drastic changes in weather, environmental pollution, and other stressors can induce lesions (Figure 2b).^{1,2,3,4} Many of these factors can occur simultaneously, challenging scientists and natural

resource managers when they try to identify a root cause of fish skin lesions.^{1,2,3,5}

WHY DO FISH SKIN LESIONS CAUSE CONCERN?

If too many fish are unhealthy and become unable to reproduce, that population of fish may decrease in numbers. A dramatic change in population numbers of a fish species can cause an imbalance in an ecosystem. It can also negatively affect the fishing and seafood industries.⁵ Unhealthy fish can signal to people that the surrounding environment may be unsafe not only for aquatic creatures, but for humans as well.⁵ Fish lesions or sores are unattractive and worrisome to tourists and anglers, potentially resulting in negative impacts on tourism and recreational fishing industries.⁵

DID THE DEEPWATER HORIZON OIL SPILL CAUSE INCREASED FISH SKIN LESIONS?

Of particular concern about oil from the Deepwater Horizon (DWH) wellhead were the polycyclic aromatic hydrocarbons (PAHs). PAHs are a group of **hydrocarbons** commonly found not only in oil and tar, but also in smoke from burning wood or tobacco, in grilled meats, and emissions from vehicles and power plants. Although PAHs naturally occur, some can be harmful to living things. Certain PAHs are known to cause cancer, birth defects, mutations, or even death in animals.⁸ The public also had questions about the use of chemical **dispersants** that emergency responders sprayed onto the surface oil slicks and injected at the leaking wellhead during DWH. Dispersants are used in oil spills to help break up oil into smaller droplets and prevent it from reaching shorelines where clean-up is more challenging.

Fish and other aquatic creatures can be exposed to PAHs in a variety of ways, including eating contaminated prey, swimming through an oil slick, or dwelling on the ocean floor where oil has settled.⁹ While the immune systems of fish are very sensitive to PAH pollution, they are able to break down oil compounds in their bodies.¹⁰ Fish response to oil exposure varies depending on the composition and concentration of the PAHs, fish species and age, duration of exposure, how they were exposed to oil, and many other environmental factors.¹⁰

Scientists, natural resource managers, and emergency response managers have previously documented multiple types of PAH-related injuries to fish in other oil spills.^{10,11,12} For example, scientists found that exposure

Lacking pre-spill data, the results do not reveal a clear cause-and-effect relationship between Deepwater Horizon and fish skin lesions.

to PAHs and other chemicals in waters along the Pacific coast increased the risk for development of liver lesions in fish living there.¹² Following the DWH oil spill, there were mounting questions from the fishing community about a perceived increase in Gulf offshore fish with skin lesions. This public concern led teams of scientists to investigate whether there was an increase in skin lesions in offshore fish and if the DWH oil spill caused the lesions.

No baseline information about fish lesions and associated PAH levels existed before the DWH spill.⁴ Without pre-spill information, there was no way to determine if fish lesions noted afterwards were a result of the spill. Scientists attempted to determine if PAHs caused the lesions in 2011 and again in 2012 by studying thousands of deep-dwelling fish. These fish included red snapper, red grouper, Gulf smoothhound, Atlantic sharpnose shark, yellowedge grouper, king snake eel, and golden tilefish.⁴ They recorded the various types of wounds they found on the fish, differentiating between

lesions and mechanical damage (bite marks or injuries from fishing gear). After analysis in the lab, scientists confirmed the fishermen's observations that during and shortly after the DWH spill, offshore fish were experiencing skin lesions.⁴ A consistent and relatively high frequency of skin lesions took place in 2011, especially near the DWH well site.⁴ The scientists also determined it was an **episodic exposure**. This meant that fish were exposed to increased levels of PAHs for a period of time and then exposure decreased.⁴ The lesions occurred for a short time in the year following the spill and then frequency decreased. By 2012, there appeared to be fewer lesions.⁴ The PAH concentrations measured in the fish were all well below levels of concern for seafood consumption.^{4,13}

The next challenge scientists faced was to find the source of the PAHs they identified in the lesioned fish. More specifically, they wanted to know if PAHs from DWH oil caused the lesions on the fish they sampled. To determine the source of the PAHs, researchers considered oil from many sources. They studied PAHs from **natural seeps**, rivers flowing into the Gulf, land runoff, atmospheric fallout, and low-level inputs from oil and gas production structures in the Gulf. Scientists eliminated each potential PAH source as the cause for the lesions.



Scientists dissect fish samples during a research cruise in the Gulf of Mexico in order to understand the impact the Deepwater Horizon oil spill had on fish health. (C-IMAGE)

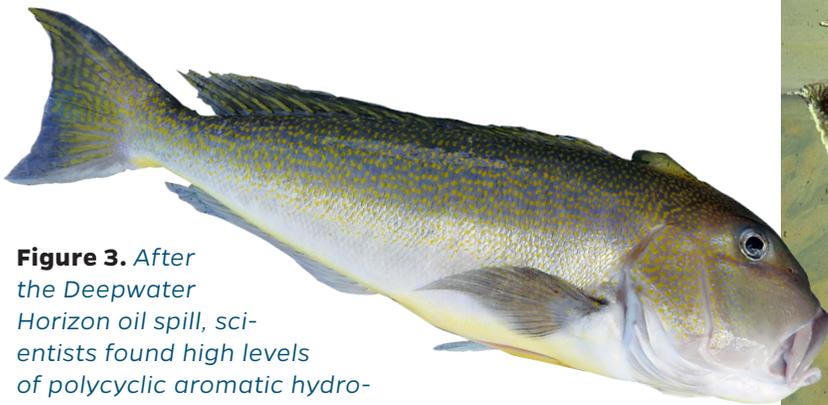


Figure 3. After the Deepwater Horizon oil spill, scientists found high levels of polycyclic aromatic hydrocarbons in golden tilefish and a high occurrence of skin lesions.¹⁴ (C-IMAGE/Susan Snyder)

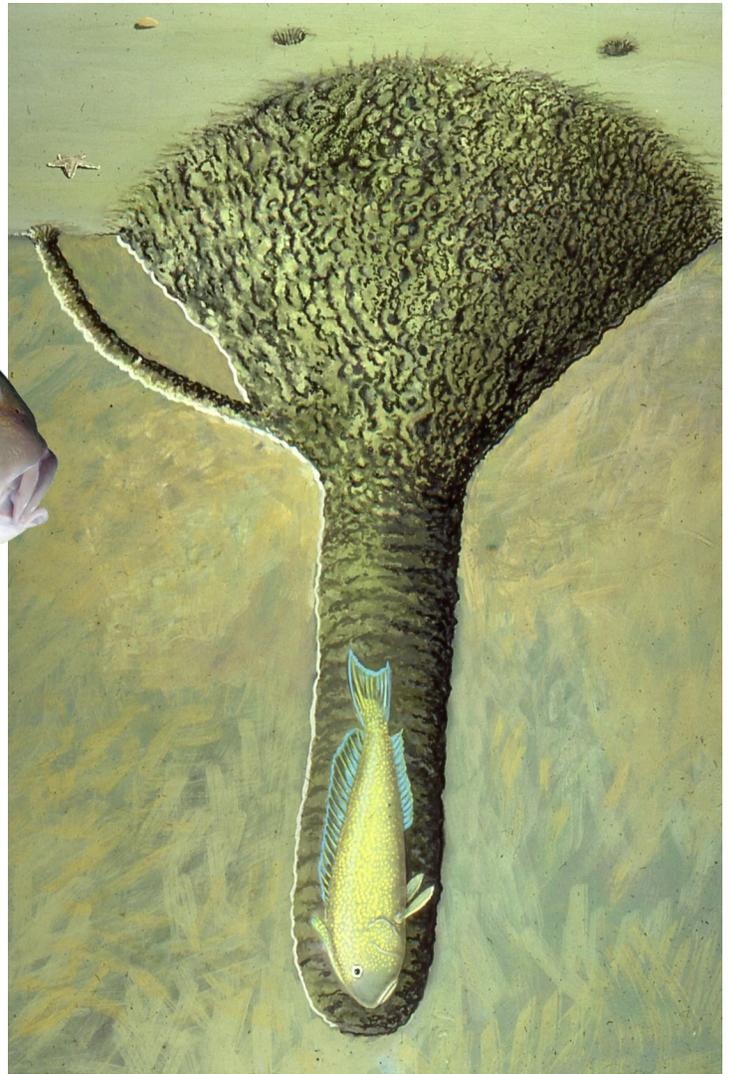
A fish's habitat and behavior may influence its health after a spill like Deepwater Horizon.

Chemical tests did show a strong similarity between the PAHs in lesioned fish and the PAH samples of the DWH oil. However, lacking pre-spill baseline data, the results do not reveal a clear cause-and-effect connection.⁴

Scientists considered other potential causes for the lesions. Reduced **salinity** and temperature changes are known causes of stress in fish, so scientists compared historical salinity and temperature levels in the northern Gulf of Mexico to levels in 2010. They found salinity and temperature to be consistent and rejected them as factors causing the lesions.⁴

For now, scientists recognize there is a **correlation** between the skin lesion event and the increased PAHs in the water following the DWH oil spill. Long term monitoring of PAHs in Gulf finfish may help determine if the lesions were caused by the DWH oil spill.⁴

In the skin lesion study, scientists found that golden tilefish had the highest occurrence of lesions compared to other fish sampled in 2011 and 2012.^{4,14} To better understand the many factors involved in oil contamination



Tilefish burrow deep into the ocean floor. Scientists think this behavior may have exposed them to Deepwater Horizon oil that had settled onto the bottom of the Gulf of Mexico.¹⁴ (Ken Able, Churchill Grimes, Bob Jones)

of Gulf of Mexico species like golden tilefish, scientists compared PAH levels of fish living within, on top of, and away from the ocean bottom. They wanted to determine how oil exposure impacted fish living in these areas after the oil settled on the ocean floor.¹⁴

The scientists chose three species for their study: red snapper, king snake eel, and golden tilefish. Red snapper spend most of their time in the water around reefs searching for food like squid, crabs, and other fish. Because of this, scientists considered the snapper to be at a lower risk of exposure to oiled sediments.¹⁴ King snake eel dwell on top of the sandy or muddy bottom, putting them at moderate to heavy risk of oiled sediment exposure. Golden tilefish burrow in the soft sandy

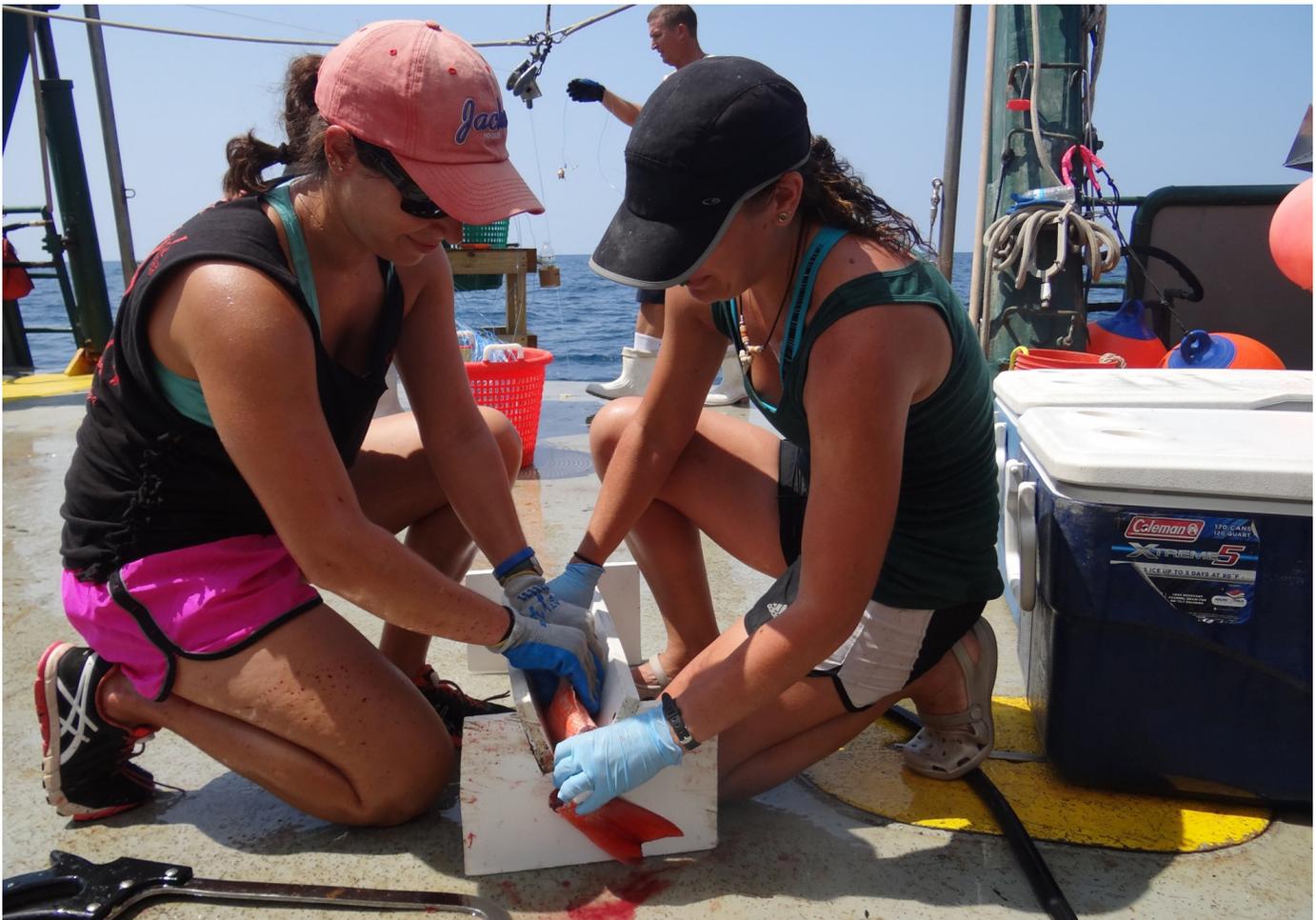
bottom, exposing them to sediments that could have relatively high contamination levels (Figure 3).¹⁴

In this study, scientists found that golden tilefish had persistent and significantly higher levels of PAHs compared to the other two species, though the PAHs' source was not identified.¹⁴ The golden tilefish PAH levels did not significantly decrease over the three-year sampling period, but the levels for red snapper and king snake eel returned to normal.¹⁴ Scientists think that the golden tilefish's burrowing behavior is a key factor in its high PAH exposure levels. Using their mouths and fins, golden tilefish constantly dig up the ocean floor to keep their burrows from filling in with sediment. This behavior could also repeatedly expose golden tilefish to buried oil, entering the golden tilefish through their skin or mouths.^{9,14} Clues about where fish spend their time, what they eat, and how they interact with their environment help scientists determine the role the DWH event and other sources of petroleum releases in the

Gulf had – and may continue to have – on fish and other aquatic wildlife.

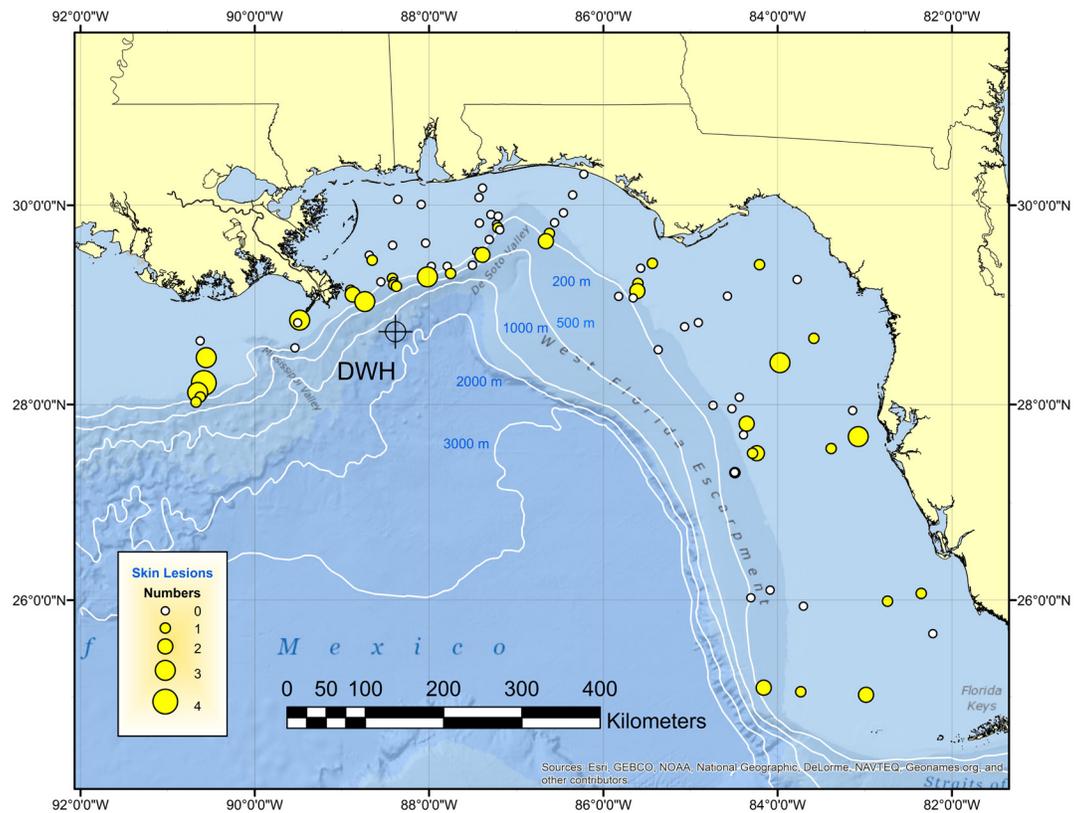
Scientists used fish lesion data as clues to help answer questions related to oil movement.

One team of scientists studying the movement of Deepwater Horizon oil in the Gulf utilized the fish skin lesion data to corroborate their conclusions about the path oil took in 2010.¹⁵ They created computer models incorporating different types of oceanographic information such as water circulation patterns, depth, and weather patterns to track oil movement.¹⁵ They concluded that oil from the DWH oil spill floated beneath the water's surface from the wellhead to the West Florida Shelf (Figure 4).¹⁵ The scientists noted the path of oil to the West Florida shelf corresponded with the locations of fish caught with lesions. They also found that chemical



Scientists measure fish in the Gulf of Mexico to better understand the impact of the Deepwater Horizon oil spill. (C-IMAGE)

FIGURE 4. Yellow dots indicate the locations of sampling stations and numbers of skin lesions per station in the Gulf of Mexico during research cruises made from June through August, 2011. Scientists caught a total of 3,952 fish at 84 stations. They used this information to confirm that oil from Deepwater Horizon traveled to the West Florida Shelf, noting that the transport of oil was consistent with the locations of lesioned fish and the chemical tests of livers of fish.¹⁵ (Reprinted from Murawski 2014 & Weisburg 2014)



tests of livers of fish in those locations supported their oil transport computer models.¹⁵ This type of transport information could be used in collaboration with emergency response managers to design sampling programs for damage assessment of future spills.¹⁵

weather or algal blooms (Figure 2a and 2b). Reporting sightings of unhealthy or dead fish helps managers and public health officers make these determinations and keep people and wildlife safe (see side bar on page 7).

Reporting sightings of sick fish can help scientists and natural resource managers.

Scientists, natural resource managers, and emergency response agencies regularly monitor aquatic ecosystems for sick or injured fish. Lesions on fish can indicate an unhealthy environment or other stress. Authorities can determine if sick fish are a result of an acute or chronic event. In other words, they try to determine if fish have been harmed from an abrupt and damaging event or if they have been exposed to injury over a longer time. For example, the Texas Parks and Wildlife Department's Kills and Spills Team investigates incidents of **fish kills** to determine the cause and protect the environment. Fish kills are mass die-offs in populations and communities of fish and other aquatic creatures. Common causes of fish kills include low dissolved oxygen, chemicals and toxins, disease, and extreme



Scientists process the fish they sampled during a research cruise in the Gulf of Mexico. The fish parts will be analyzed in a laboratory. (C-IMAGE)

FOUND A SICK FISH? WHAT NOW?

Bacteria that are also human **pathogens** can cause some fish lesions.^{1,6} If fish appear to be lesioned or are behaving strangely, use common sense and do not touch the fish.¹ However, if contact is necessary, always take proper safety precautions, including wearing gloves and thoroughly washing your hands.^{1,6,7} Usually, just a few sick fish are not cause for alarm, but many sick or dead fish can be concerning.¹ If you spot unhealthy or dead fish in the Gulf of Mexico, call one of these hotlines:

Texas Parks and Wildlife Kills & Spills Team
(512) 389-4848 or (281) 842-8100

Louisiana Department of Environmental Quality
(888) 763-5424

Mississippi Department of Natural Resources
(601) 961-5599

Alabama Marine Resources Division (AMRD)
(251) 861-2882 or (251) 968-7576

Florida Fish and Wildlife
Conservation Commission
(800) 636-0511



A king snake eel with a skin lesion is documented during a research cruise in the Gulf of Mexico. (C-IMAGE/Susan Snyder)

GLOSSARY

Correlation — The relationship or connection between things that happen or change together.

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

Episodic exposure — Refers to wildlife that are exposed to harmful levels of chemicals for a period of time, rather than continuously.

Fish kill — A population or community of fish that dies off in a localized area.

Hydrocarbon — A compound composed of carbon and hydrogen atoms. Most hydrocarbons naturally occur in crude oil and natural gas and are formed from decomposed organic matter.

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.

Pathogens — Disease- or illness-producing agents such as bacteria or viruses.

Polycyclic aromatic hydrocarbons (PAHs) — A group of hydrocarbons commonly found in oil, tar, burned wood, and animal fats.

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

Fishery scientists use the “long line” method of fishing to catch fish for their studies. (C-IMAGE)

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HAVE MORE QUESTIONS?

More information about the health of aquatic life during and after the Deepwater Horizon oil spill, including discussions of seafood safety, can be found on the Sea Grant Oil Spill Science website at gulfseagrant.org/oilspilloutreach.

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