OIL SPILL SCIENCE

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THE DEEPWATER HORIZON OIL SPILL'S IMPACT ON GULF SEAFOOD

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Even five years after the Deepwater Horizon oil spill, consumers have concerns about whether Gulf seafood is safe to eat. Federal and state scientists tested more than 22,000 seafood samples during the oil spill and did not find a single sample where levels of chemicals from oil or dispersants were unsafe. Scientists are still conducting studies to ensure that the seafood harvested from the Gulf is safe to eat.

Local seafood is an important part of the Gulf of Mexico community and livelihood. During the oil spill, there was much concern about whether local seafood was safe to eat. (UF/IFAS photo)

Scientists have found that eating seafood is good for people's health and recommend that most people eat two servings of seafood, about the size of the palm of your hand, each week.[1] However, experts encourage pregnant women, young children, elderly individuals, and those with certain health conditions to avoid eating some types of seafood. This includes seafood that is raw, partially cooked, or that which tends to be high in mercury concentrations. Fish with high mercury include tilefish, shark, swordfish, and king mackerel.[1]

If seafood is good for our health, then why are there recommended limits to the amount of some types of seafood we should eat? Seafood, like other foods that we eat, can be exposed to contamination through the natural environment, pollutants, oil and chemical spills, and processing and handling procedures. The U.S.

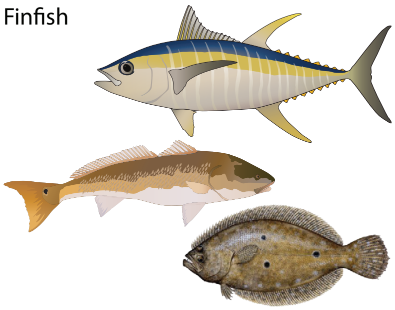
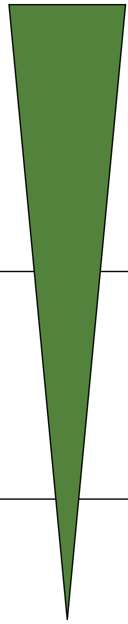
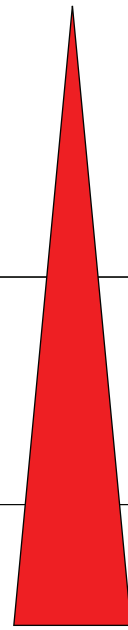
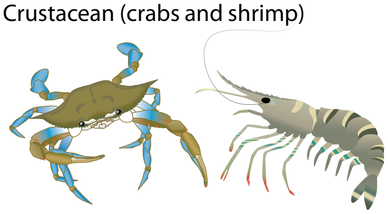
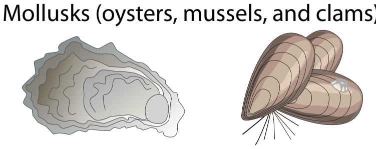
Type of seafood	Contact with chemicals	Build up/removal of chemicals
Finfish 	More mobile  • Are mobile and can swim away from contaminated areas. • Are less likely to come in contact with floating oil but can be exposed to dispersed oil or weathered oil that is mixed into the water column. • Can be exposed if the area where a fish lives, feeds, or breeds is contaminated.	Less build up  • Bioaccumulate smaller PAHs more readily than larger PAHs (larger PAHs are of greater concern to humans because these are the PAHs that can cause cancer). • Are relatively efficient at removing PAHs from muscle tissue (filets) but contaminant level can be higher in organs (liver and gall bladder).
Crustacean (crabs and shrimp) 	• Are somewhat mobile and can move away from oil. • May live or feed in areas with higher concentrations. For example, burrowers might be exposed to contaminated bottom sediments.	• Bioaccumulate smaller PAHs more than larger ones, compared to mollusks. • Not as efficient as removing PAHs as fish are but better at removing PAHs than mollusks are.
Mollusks (oysters, mussels, and clams) 	• Are less mobile and cannot move away from oil. • Are living and feeding where chemicals might accumulate. Less mobile	• Have a greater tendency to bioaccumulate PAHs. • Remove larger PAHs more slowly than smaller PAHs. More build up

FIGURE 1. *During an oil spill, different types of marine life that we eat as seafood will be exposed to varying levels of oil-derived chemicals based on where they live, feed, and breed and how mobile they are.[11] Some aquatic animals are better at breaking down chemicals such as polycyclic aromatic hydrocarbons (PAHs) than others.[11] Credit for images: ©1992, Diane Rome Peebles (flounder image) and Jane Hawkey, Chip Chenery, Tracey Saxby, and Dieter Tracey, IAN Image Library (all other images; ian.umces.edu/imagelibrary/).*

Food and Drug Administration (FDA) provides guidelines for the types and amount of seafood that we should eat. For most people, the risk of ingesting low levels of contaminants from food is not a concern because their body can break the chemicals down.[2,3]

CONCERNS AFTER THE DEEPWATER HORIZON OIL SPILL

During the Deepwater Horizon oil spill, about 172 million gallons of Louisiana sweet crude oil spilled into Gulf of Mexico waters. In addition, a total of 1.84 million gallons of Corexit, a **dispersant**, was used to break up oil at the sea surface and at the wellhead almost a mile below the water's surface.[4,5,6,7,8] The release of oil and use of dispersants raised public concern about eating seafood from the Gulf of Mexico despite federal and state reassurance that seafood was safe to eat. Federal and state agencies temporarily closed fishing waters in areas where oil was found or was predicted to travel based on currents and wind conditions.[9] At one point, 88,522 square miles or 36 percent of U.S. Gulf of Mexico waters were closed to fishing.[10]

Oil contains many chemicals, some that are harmful in small doses and some that are not. Certain **polycyclic aromatic hydrocarbons**, or PAHs, for example, can cause mutations, developmental defects, or cancer in wildlife and humans.[9] Crude oil and drilling fluids that are used to extract oil contain different types of metals, such as arsenic, mercury, copper, and lead, and scientists have found many of these metals at elevated levels in the sediments in oil spill zones.[11] These chemicals and metals can build up in marine organisms and reach levels of concern that make seafood unsafe to eat.[11]

According to the FDA, the dispersants that were used during the Deepwater Horizon oil spill have low potential to build up in seafood and are low in human toxicity, so there was likely little public health risk associated with eating seafood exposed to dispersants.[9] However, dispersants break up oil slicks into smaller droplets, which can cause an increase of oil in the water column. Wildlife can take up these smaller droplets, potentially increasing the exposure to PAHs.[12]

Federal and state agencies created a plan to ensure that seafood from the Gulf of Mexico was safe for consumption during and after the oil spill. (NOAA photo)

CRITIQUES TO THE FDA LEVEL OF CONCERN

Some groups of people are at higher risk to the effects of chemical exposure than others. For example, a healthy adult that eats fish twice a week will not have the same health risk as a young child with a lower body weight, an elderly adult with compromised health, or a person who eats fish for every meal. Due to these differences, risk assessments often err on the side of caution or scientists conduct additional assessments for these subpopulations. During the oil spill, some scientists had concerns about FDA's protocol for reopening fishing areas. They suggested that average consumer body weight and how much seafood Gulf coast residents eat daily were not accurate. They also suggested that more studies should be conducted to look at the health risks for children and pregnant women and that the levels of concern should be more conservative to protect people falling outside of the averages used in the FDA's protocol.[18, 19]

ROUTES OF EXPOSURE TO CHEMICALS

Chemicals from oil or dispersants can contaminate seafood in a variety of ways. An animal can eat oil droplets or eat other animals that have been exposed to chemicals. Chemicals can also be absorbed through the skin or gills or attach to the skin of an animal. The amount of a chemical that an animal comes in contact with depends on many things, such as how the organism feeds and where it lives (Figure 1).[13]

Once contaminants are in an organism's system, they can build up, or **bioaccumulate**, over time. An organism can reduce the amount of bioaccumulation by processing, breaking down, and removing the chemicals through their waste or, in some organisms, chemicals can leave the body through processes in their organs and tissues (Figure 1).[13]

Vertebrates, such as fish, and invertebrates, such as crabs, oysters, and shrimp, have the ability to break down the chemicals in oil, but some do it better than others. Invertebrates break down petroleum chemicals more slowly and not as well as other animals.[14, 15] This inefficiency can cause PAHs to accumulate in their tissues. Finfish, on the other hand, can rapidly break down and remove PAHs from their bodies. However, it is important to note that organs, such as the liver and gall bladder which help remove chemicals from a fish's body, may have higher levels of PAHs than muscle and other tissues (Figure 1).[13]

AGENCIES DEVELOP A PLAN TO ENSURE SEAFOOD SAFETY

During the Deepwater Horizon oil spill, federal agencies, such as the National Oceanic Atmospheric Administration (NOAA), FDA, and U.S. EPA, worked with the Gulf of Mexico states to develop and implement a program to ensure Gulf seafood safety.

First, the FDA set a **level of concern** for PAHs and **dioctyl sodium sulfosuccinate (DOSS)**, a chemical that is found in dispersants, for different types of seafood. The level of concern determines how much of a certain chemical will harm a human. By testing seafood samples and making sure the chemicals are below these levels of concern, the FDA can determine if Gulf seafood that might have been exposed to oil or dispersants is safe to eat. The levels of concern were calculated based on the average weight and age of consumers and amount of seafood people eat and how often they eat it.[16, 17]

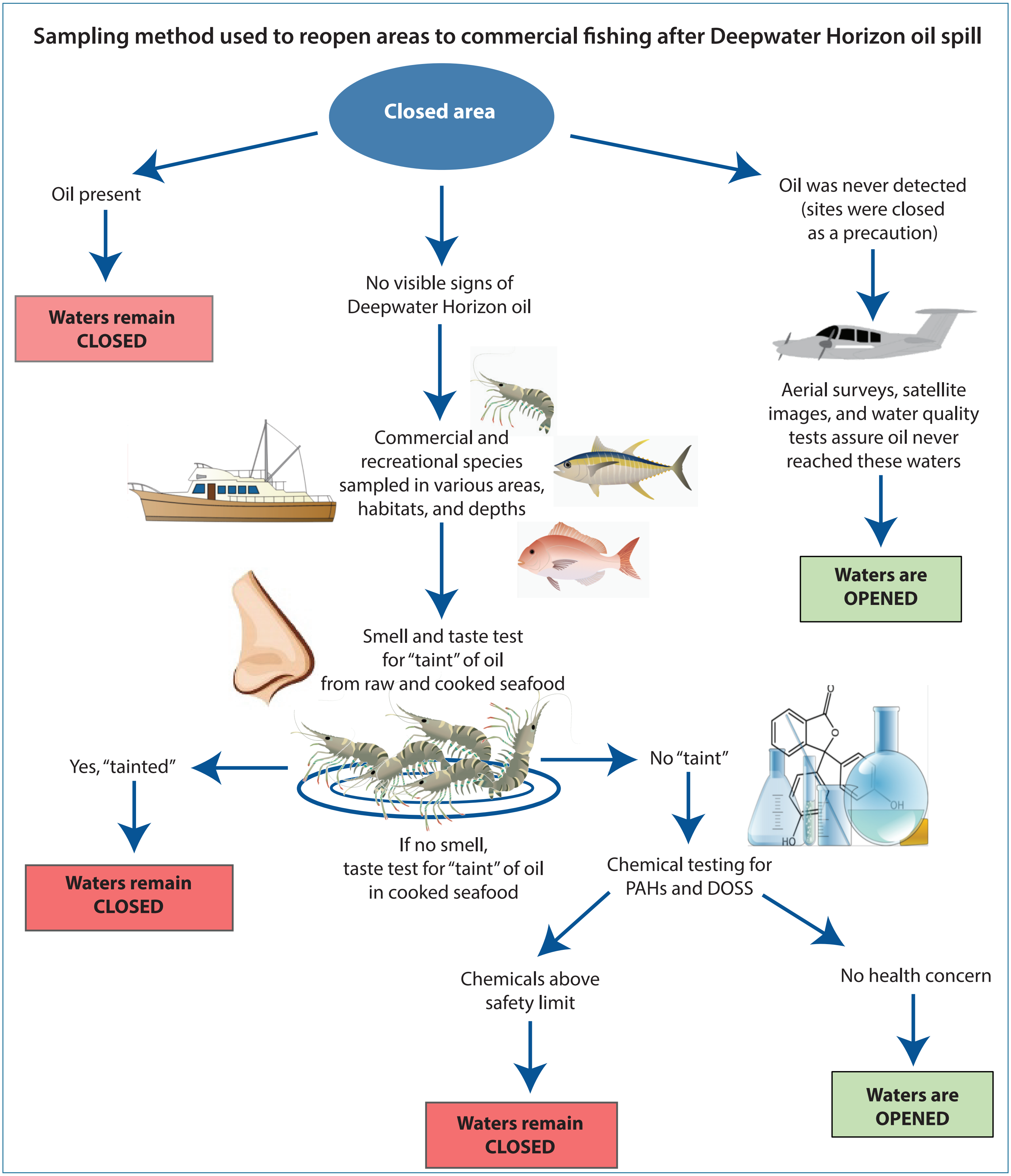


FIGURE 2. *Federal and state agencies set up a method for sampling, testing, and reopening closed harvest waters. Waters were reopened when they had no visible oil present and seafood samples that were collected passed sensory and chemical testing. Credit for images: Kim Kraeer, Lucy Van Essen-Fishman, Jane Hawkey, Tracey Saxby, Diana Kleine, and Jason C. Fisher, IAN Image Library (ian.umces.edu/imagelibrary/).*

In total, federal and state agencies tested 22,000 seafood samples during and after the oil spill. All samples showed that seafood was safe for consumption. (UF/IFAS photo)

Separate levels of concern were set for shrimp and crabs, oysters, and finfish because consumers eat varying amount of these types of seafood.[16, 17]

The federal and state agencies then developed a set of guidelines for sampling, testing, and reopening fishing grounds in both federal and state waters (Figure 2).[9, 16] Seafood was not tested from an area until signs of fresh oil from the Deepwater Horizon spill were no longer visible.[9] Filets of finfish, edible blue crab tissue, whole oysters, and the edible parts of shrimp were all tested. A sample could be made of one animal or multiple animals. A legal size fish, for example, could be tested alone or smaller fish from the same area could be combined to make a complete sample. Multiple oysters, shrimp, and blue crabs were also combined, by seafood type, to make a complete sample. The samples had to pass a smell and taste test and a chemical test to be sure that PAHs and DOSS were below the FDA's level of concern.[16] According to the guidelines, officials would reopen the sampled areas that passed all of the tests.[16]

Due to public concern, the FDA also tested crabs, oysters, and shrimp in some harvest waters for elevated levels of mercury, arsenic, cadmium, and lead.[20] The NOAA Mussel Watch program, a long-term program that monitors the amount of metals and other contaminants in seafood, also conducted two rounds of sampling in 2011. Scientists tested oysters for levels of arsenic, cadmium, lead, mercury, copper, nickel, selenium, and vanadium and then compared these levels to 30 years of data that had been collected previously through this program.[20] Officials reopened all federal waters by April 19, 2011, based on visual, sensory, and chemical testing of seafood samples.[21] Some areas in state waters remained closed after this date. Heavily oiled areas in Barataria Basin in Louisiana, for example, were not reopened to fishing until June 2015 because of oil contamination.

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Polycyclic aromatic hydrocarbon (PAH)		FDA Level of Concern (ppb)	Highest level of PAH (ppb)	
			Before Deepwater Horizon oil spill	After areas were reopened to fishing
Non-cancer-causing PAHs	Anthracene	1,846,000	0.4	Too low to be detected
	Phenanthrene	1,846,000	3.9	1.7
	Fluorene	246,000	1.7	0.3
	Fluoranthene	246,000	1.0	0.1
	Naphthalene	123,000	8.0	1.7
	Pyrene	123,000	1.1	0.3
	Chrysene	123,000	2.1	0.7
Cancer-causing PAHs	Benzo(k)fluoranthene	13,200	0.3	Too low to be detected
	Benzo(b)fluoranthene	1,320	0.2	Too low to be detected
	Benz(a)anthracene	1,320	Too low to be detected	Too low to be detected
	Indeno(1,2,3-cd)pyrene	1,320	Too low to be detected	Too low to be detected
	Dibenz(a,h)anthracene	132	Too low to be detected	Too low to be detected
	Benzo(a)pyrene	132	Too low to be detected	Too low to be detected

TABLE 1. *The amount of polycyclic aromatic hydrocarbons (PAHs) found in Gulf of Mexico shrimp during the federal-state testing program were all below the Levels of Concern (LOCs), or levels that are safe for consumption that are set by the Food and Drug Administration (FDA). All data used to create this table was provided by NOAA.*[25]

REGIONAL SAMPLING SHOWS SEAFOOD IS SAFE

Through the multi–agency program, more than 8,000 seafood samples were collected and tested. All chemical tests for PAHs and DOSS were much lower than the established level of concern that was set by FDA or not detected at all (Table 1).[16] The FDA's additional testing for metals showed that there were not elevated levels of metals in crabs, oysters, shrimp, or mussels.[20]

Four of the states in the Gulf of Mexico received funding to conduct their own sampling in state waters (Figure 3). The states tested finfish, shrimp, crabs, and oysters for PAHs and DOSS. Of the more than 13,500 samples tested, not a single sample contained PAHs or DOSS above the FDA's level of concern.[26, 27, 28, 29]

Independent scientific studies also indicated that seafood was safe to eat in addition to the state and federal seafood testing. One study collected reef fish from commercial sites that were open to fishing. Scientists tested the seafood samples for PAHs, DOSS, and metals (lead, cadmium, mercury, arsenic, and selenium). All PAH levels in the 96 samples were below the FDA's levels of concern. Dispersants were not detected in any samples, and metal levels were undetectable or similar to levels reported pre–DWH oil spill.[24]

Some scientists were concerned with the health risk to Vietnamese–American communities that may eat more seafood and were suspected to fall outside of the average body weight used to determine the level of concern for PAHs. Scientists contacted consumers to ask about their seafood consumption and potential health risks and also testing shrimp from reopened fishing grounds to measure levels of PAHs. The study determined that the Vietnamese–American consumers weighed less than the average body weight used in calculating the FDA's levels of concern. It also found that the consumers ate more than three times the amount of shrimp used in the FDA's risk assessment. Accounting

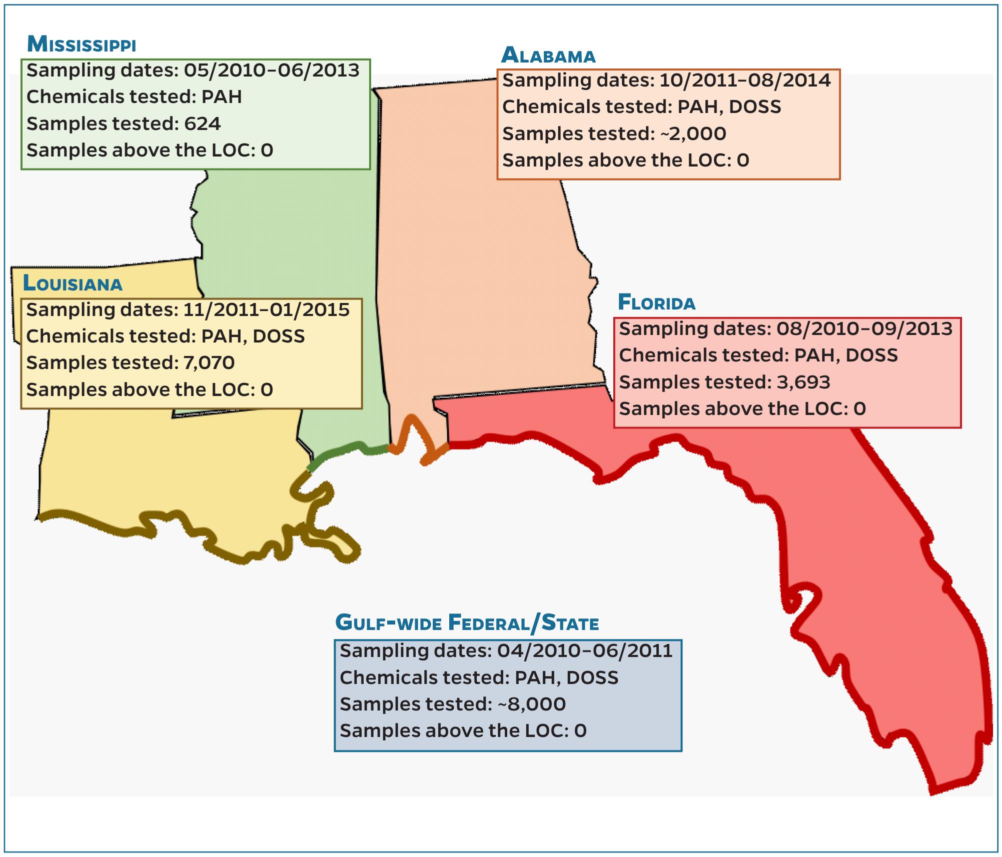

FIGURE 3. *Federal and state agencies tested seafood for polycyclic aromatic hydrocarbons (PAHs) and dioctyl sodium sulfosuccinate (DOSS), a chemical in dispersants after the Deepwater Horizon oil spill. Finfish, shrimp, oysters, and crabs were sampled in the federal program and by all state programs. Florida also tested clams and lobsters. Of the more than 22,000 seafood samples tested, none contained PAH or DOSS concentrations above the Food and Drug Administration Level of Concern (LOC).*[25, 26, 27, 28, 29]

for the underestimates in weight and level of seafood consumption, this study did not find any health risks based on the low levels of PAHs that were detected in the shrimp samples.[19]

Scientists are still studying Gulf coast residents and testing the seafood that they catch or buy at the market. These studies are looking at long-term health impacts so the results may not be out for some time.

ONGOING STUDIES CONTINUE TO MONITOR SEAFOOD

Federal and state monitoring and independent studies have shown low levels of PAHs, DOSS, and metals in seafood from the Gulf of Mexico. The Gulf of Mexico Research Initiative (GoMRI) has funded studies to look at the short-term and long-term impacts on fish populations and human health. Emerging information can be found on GoMRI's website, http://gulfresearchinitiative.org.

To learn more about how oil and dispersants impact aquatic life and how these organisms break down these chemicals, refer to our other publications, which can be found on the Oil Spill Science Outreach Program website at http://gulfseagrant.org/oilspilloutreach.

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.

Dioctyl sodium sulfosuccinate (DOSS)
A primary component of both dispersant formulas used in the Deepwater Horizon oil spill. It increases the attraction within oil and water molecules and hinders the formation of large oil slicks on the surface of the ocean. DOSS can also be found in consumer products such as detergents, cosmetics, and laxatives and, therefore, can be found in coastal waters.

Dispersant
Chemicals that are used during oil spill response efforts to break up oil slicks and prevent the oil from impacting of marine life and coastal habitats.

Level of Concern (LOC)
Values calculated to determine the concentration of a chemical that is in a product and that one can be exposed to before there is a health concern.

Polycyclic aromatic hydrocarbon (PAH)
A group of hydrocarbons commonly found in oil, tar, burned wood, and animal fats. More than 100 PAHs exist and some are known to cause cancer, birth defects, mutations, or death.

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