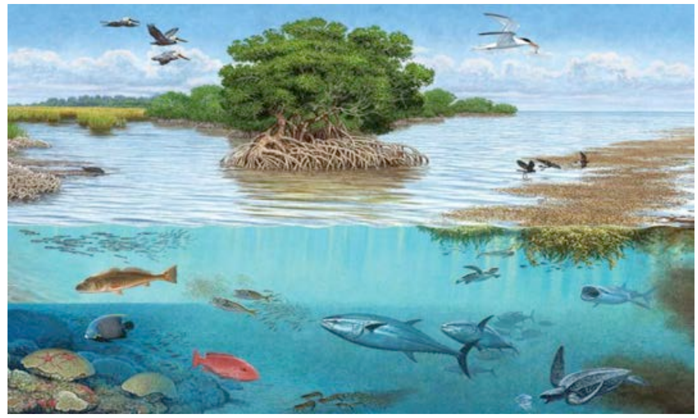
# Ecology
## *In the Gulf of Mexico*

## What is Ecology?

The study of the relationships between living organisms and their environment.



*"Layers of Life" from National Geographic (used with permission).*

### Ecological Connectivity in the Gulf of Mexico

The Gulf of Mexico is a productive, warm-water marine ecosystem. It is the ninth largest body of water in the world and supports high levels of biodiversity. The Gulf ecosystem has been altered by human activities such as nutrient loading, hypoxia, overfishing, and oil and gas drilling.

Understanding the relationships between the marine organisms and their environment is essential to their protection. The ecology of the slope and shelf edge in the eastern Gulf of Mexico is poorly known and woefully understudied compared to the central and western Gulf where oil and gas extraction predominates. When the Deepwater Horizon oil spill occurred in 2010, ecologists were concerned about the profound effects it might have on marine life from the coast to the deep sea and how those effects would ripple throughout the trophic system, from primary producers to apex predators. The magnitude of these effects and potential consequences for ecological processes needed to be studied.

### Deep-C Ecologist Tasks

The ecological component of Deep-C research focused on time series that define changes in community structure and function associated with the Deepwater Horizon blowout and its aftermath, while developing post-spill baselines of unstudied environments. Concentrating their efforts in the northeastern Gulf of Mexico, Deep-C scientists focused on biodiversity, species distribution, and the effect of exposure to oil. The ecology team was tasked with defining and quantifying the diversity of biological responses to the dynamic physical and chemical properties of the environment in order to understand the severity and longevity of the oil spill and demonstrate the cumulative effect on mid- to upper-trophic level responses and resiliency of the system. From the deep sea to the coast, studies were conducted across trophic levels to assess the sensitivity of marine organisms to specific compounds released during the oil spill.

### Deep-C Ecological Research

***Microbial responses to the Deepwater Horizon oil spill***

*Sediment core from October 2012 ecology cruise*

Microbes serve as a vehicle for transferring hydrocarbons (oil) into the food web. Within weeks of the Deepwater Horizon oil reaching, and subsequently penetrating beach sands, the proportion of hydrocarbon-degrading species increased by orders of magnitude reducing both the relative abundance of other microbial groups and their biological diversity. In response to this microbial bloom, rates of oil degradation increased. In deep sea sediments, the presence of protist grazers, other organisms that consume the oil-eating microbes, slowed the rate of degradation. As the oil degraded, the diversity and species composition of these sediments began to re-approach baseline conditions. This indicates that oil-degrading microbes are ever-present in the sediments, they bloomed in response to the presence of hydrocarbons, and that the overall community is resilient.

### *Warm temperatures accelerated the degradation of buried oil on the beach*

Deep-C researchers spent two years studying oil that had been buried in the sand in the days following the Deepwater Horizon spill. This research, conducted in Pensacola Beach, Florida, was conducted by digging trenches in the sand and analyzing the buried oil for evidence of microbial degradation. After one year, most of the buried oil had disappeared and it was determined that temperature was a pivotal factor: during warm summer temperatures oil degraded three times faster than during colder winter months. Buried oil layers consumed four to five times more oxygen and produced up to six times more carbon dioxide than the unpolluted beach sand, revealing strong aerobic microbial decomposition activities. Modeling of this data over time allows for the calculation of decomposition rates for specific oil components under in-situ conditions and predictions of the beach recovery period. The results of this research can be used for designing responses in future beach oil contamination events.

### *Dispersants mobilized Polycyclic Aromatic Hydrocarbons (PAHs) faster*

Studies have shown that crude oil attaches readily to sand grains and because of this typically oil cannot penetrate the surface of the seafloor by more than a few centimeters. Corexit (a dispersant used after the Deepwater Horizon oil spill) detaches the oil that is coating the sand grains and reduces adhesion of oil to sands, thereby enhancing mobility of oil components in submerged coastal sands. Through this mechanism, potentially harmful PAHs can penetrate tens of decimeters into the sediment, extending persistence, and may reach groundwater level in shore environments.

### *Benthic macrofauna*

Benthic macrofauna provide critical links between the microbial and planktonic communities on which they depend. In addition, they also facilitate the transfer of hydrocarbons throughout the trophic web via their role as prey in deep sea environments. Preliminary results from comparisons of recent (2012-2013) collections from sediments in the De Soto Canyon with existing pre-spill (2000-2002) data suggest that while the overall biodiversity changed little, macrofaunal density increased and community structure changed significantly perhaps as a result of organic enrichment provided by the increase in oil and subsequently microbes. If this turns out to be the case, then an important source of food for bottom dwelling species could have increased at least in the short term.

### *New plankton records set in the Gulf*

Researchers documented the abundance and variety of phytoplankton in the Gulf during several research cruises from 2011-2014. Species identified include 90+ species of coccolithophores, 123+ species of diatoms, and 29+ species of dinoflagellates. In addition, a new species, and several new subspecies were identified. Using Niskin bottles and .2 micron filters, the Deep-C team was able to analyze samples collected along West Florida Shelf transects that revealed dominance shifts from the diatom *Nanoneis cf. longta* in September to the coccolithophorid *Emiliania huxleyi* in December 2013.

*Navilithus altivelum, rare phytoplankton discovered in the Gulf of Mexico.*

### *Sampling fishes by region and depth*

Biological diversity declines with depth, as does basic knowledge of ecology and life histories, which makes characterizing the fishes in the northeastern Gulf a challenging task. Prey, predators, and scavengers all have their ecological niches within distinct depth ranges. To determine if and how the oil from Deepwater Horizon impacted these populations, intensive long-term surveys were initiated across geographic regions and depth strata. Surveys were undertaken at various depths along the continental shelf-edge (68 to 200m), upper slope (200-400m), mid-slope (400-900m), and deep slope (>900 m to 2,645m) of the De

Soto Canyon region Deep-C researchers conducted 10 research cruises (between 2011-2014), which resulted in sampling more than 4,000 fishes from 101 species (including 34 species of sharks and rays) making this the largest survey of deep-sea elasmobranch (sharks and relatives) fishes ever conducted in the Gulf of Mexico. More than 10,000 biological samples, from whole fish to whole organs and varied tissue samples, were distributed globally for analysis across 18 research institutions. These samples provided critical life history information and data on heavy metal contamination for a wide range of significantly understudied species.

***Elevated exposure to PAHs close to spill site***

To test whether Polycyclic Aromatic Hydrocarbons (PAHs), the most toxic substances in crude oil, are affecting deepwater Gulf fish, Deep-C scientists measured levels of commonly used fingerprints or "biomarkers" of PAH exposure in more than 1,000 deep sea fish, focusing on abundant sharks (gulper sharks, shortspine dogfish) and bony fish (tilefish, hakes) that were collected 12 to 42 months following the Deepwater Horizon blowout. The PAH biomarker used in this research included liver enzymes, which break down PAHs for excretion and tend to increase when animals are exposed to these pollutants, and the bile that collects in the gallbladder. Although findings vary by species, the results of this research suggest that fish collected closer to the oil spill are more likely to exhibit higher levels of PAH biomarkers, suggesting that they may be biologically affected by oil exposure. However, since the actual biomarker levels observed in deep sea fish were low in comparison with earlier studies on coastal fish (perhaps due to lower metabolism in deep sea fish), it is unclear whether these species will experience the types of health effects that can occur as a result of chronic PAH exposure, such as cancer or reproductive complications.

## Deep-C's Ecology Team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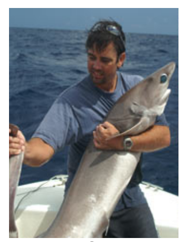
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## What Did We Learn?

- New fish and plankton species were discovered during the research cruise surveys.
- When researching fish species' ability to metabolize the oil, it was found that near the site of the spill that chemicals in species were continuing to increase after the well was capped. However, now that is starting to decline.
- When the dispersants were sprayed at the well, it may have contributed to the production of big plumes in the deep sea leading to a scientific theory that oil settled down there instead of coming up to the surface.
- Overall, the majority of species sampled were able to recuperate from the toxicity exposure that followed the Deepwater Horizon oil spill. However, researchers are still seeing elevated levels of PAHs in deepwater sharks, which suggests that time is still needed for a complete recovery.
- Microbes bloomed in response to the oil spill and are now returning to baseline conditions.
- Studies showed that warm temperatures accelerated the degradation of buried oil on Florida beaches.

# LESSON PLAN: Setting the Baseline

***It is difficult to assess the health of the Gulf of Mexico after the 2010 Deepwater Horizon oil spill due to lack of critical baseline data.***

## *Importance of collecting baseline data*

**Objective:** To understand what baseline data is and its importance.

**Standards:** OLP 6-7; SC.912.L.17.13, SC.912.L.17.16

**Time Required:** One 50-minute class period

**Keywords:** baseline data, monitoring

**Materials:** Copies of the *"Dealing with Disasters"* article (on page 68)

## Background

**Baseline data** is the initial data collection, which serves as a basis for comparison with the subsequently acquired data. In other words, baseline is information that is used as a starting point by which to compare other information. Establishing baseline ecological conditions allows scientists to understand existing environmental conditions and track changes over time, aka **monitoring**. Why collect baseline information?

- To provide a description of the status and trends of environmental factors against which predicted changes can be compared and evaluated.
- To provide a means of detecting change by monitoring.

"*Ask virtually any scientist working to understand the spill's ecological effects and they're likely to name one major obstacle: baseline data. Whether the focus is birds, whales, or other animals, scientists have only partial knowledge of what the Gulf was like before the spill. Like pencil marks on a door frame recording children's height as they grow, baseline data tell us where we were, so that we can understand what has happened since. They're a crucial piece of the scientific method, and they can only be collected ahead of time, through monitoring programs. Unfortunately, monitoring work is easy to undervalue, right up to the point where a major change such as an oil spill happens. Then the data become priceless—but only if we've collected them*" (Cornell University, 2015).

## Procedure

1. **Read the *"Dealing with Disasters"* article** and have a discussion in class.
2. **For Homework:** Write a 1-2 page paper focusing on how the article relates/parallels to the Deepwater Horizon oil spill disaster and what baseline data you think was needed to accurately assess the damages.

## Questions

1. What is baseline data? *The initial collection of data, which serves as a basis for comparison with the subsequently acquired data.*
2. Why is it important to collect? *Allows scientists to understand existing environmental conditions and track changes over time.*
3. How can baseline data be collected? *Answers will vary; it depends on what is being studied.*
4. How do scientists assess impacts? *Based on the comparison of pre-and post-data.*
5. If you were a scientist, what kind of data would you collect in order to monitor marine organisms? *Answers will vary.*

## Resources & References


**Dealing with Disasters** http://blog.disasterexpert.org/2011/08/importance-of-having-good-baseline-data.html

**Environmental Impact Assessment, Chapter 5: Baseline Information**
http://www.ku.edu.np/aec/envs402/eia%20chapter%205%20%20baseline%20information.pdf

**Oil Spill Recovery** http://www.birds.cornell.edu/page.aspx?pid=1855

ARTICLE REPRINT

## Dealing with Disasters

Posted online Wednesday, August 31, 2011 (Reprinted with approval.)
By Gisli Olafsson, Emergency Response Director for NetHope a consortium of 33 of the leading international NGOs in the world
*Source: http://blog.disasterexpert.org/2011/08/importance-of-having-good-baseline-data.html*

### The importance of having good baseline data

Information and communication is the lifeline of any disaster response. It is critical for people on the ground to convey the situation, as well as the urgent need for supplies and relief in specific locations. It helps organizations collaborate to avoid duplicative effort and gaps in assistance.

The crisis response community has long known that the use of information and communications technology (ICT) can quickly coordinate efforts, thereby making their work more targeted and effective. Recent improvements in ICT, such as availability of BGANs, WiMax and WiFi mesh networks, provide an opportunity to improve information sharing, not only within organizations but also between them.

This blog post illustrates the need for a coordinated collection of baseline data in disaster prone countries through a cross-organizational, multi-phased approach.

The humanitarian sector has the opportunity to harness technological advancements to improve information-sharing during a crisis. Technology is not the solution. But it is a significant tool that can enhance intelligent and immediate decision-making.

### The State of Crisis Information Management

Numerous challenges in information management arise when responding to a major disaster or conflict, such as:

- recording the damage to housing, infrastructure, and services
- tracking displaced populations
- distributing the massive influx of humanitarian supplies
- coordinating the work in and between clusters, as well as the work of dozens of agencies outside the cluster approach

A recent survey of organizations that responded to the devastating earthquake in Haiti pointed out that one of the key issues they faced was an overall lack of baseline information about the situation in the country. For many of the UN clusters operating, it took months to get a comprehensive overview of what the situation was like before the earthquake struck, and then to start understanding what effects it had.

In Haiti the situation was particularly devastating because almost all government offices and ministries had been destroyed in the earthquake, and most of their data systems were lost. This is a common issue faced by response organizations around the world.

Baseline and post-disaster information is collected and controlled by many autonomous parties, including national authorities, many of whom may be working together for the first time. Due to the lack of a common repository of baseline data, organizations spend considerable amount of time either recreating the data or searching for it. Therefore, it is important to improve access to, and interoperability of, data collected before, during, and after an emergency. This is essential to building better response capacity.

Humanitarian response to sudden onset disasters requires:

- rapid assessment of the spatial distribution of affected people and existing resources
- good geographical information to plan initial response actions
- shared knowledge of which organizations are working where (who-what-where or “3W data”) so that response can be coordinated to avoid gaps and overlaps in aid

This applies to any humanitarian response. But in a sudden onset disaster, the timeframes of information supply and demand are severely compressed. Pre-assembled information resources for the affected area may not exist. Even in areas where development projects have been present before the crisis occurred, data is often dispersed and unknown by the wider humanitarian community, or cannot be accessed and assimilated quickly enough.

Recurring data problems include:

- Discoverable data. Data is either not made available to, or is not discoverable by, relevant organizations.
- Available data. Data may not be immediately accessible, archived, or stored/backed up in a location outside of the devastated area.
- Released data. Data sets may be subject to legal restrictions. Even if these restrictions are waived for humanitarian use, there may be problems with immediate authorization and redistribution.
- Formatted data. Data may be unsuitable for direct import into a database or GIS system, and may require substantial processing.
- Conflicting data.

Emergencies create an ever increasing number of information web portals, which is in itself a good thing. However, it can be problematic when the data is rapidly evolving. The enthusiasm to (re)publish as much information as possible can lead to confusion and inefficiencies, as users search through multiple copies of similar looking data to extract what is new or different.

The above issues are widely recognized by practitioners in humanitarian information management. Still, these problems recur in almost every sudden onset disaster emergency, in both developed and developing countries.

Each emergency brings together a unique collection of local, national and international humanitarian players. Some are experienced emergency responders, and some are not. Some are government-endorsed, whilst others are simply concerned citizens. While there will be some common elements across every emergency (government, UN agencies, major INGOs), the varying roles played by each makes it impossible to predict a 'humanitarian blueprint' for each new emergency. This vast range of experience, resources, and mandates, can make sharing response best practices extremely difficult.

Common problems with baseline data can - and must - be resolved for each emergency. For example:

- During the initial days of an emergency, the main coordinating agencies agree at a national or local level which administration boundaries and P-code datasets should be used for coordination. It is critical that this decision is communicated to everyone involved in the disaster response.
- Humanitarian assessment templates and base map data should be standardized and made compatible.
- The supply of baseline data should be driven by the information needs of the humanitarian response. Priorities differ from emergency to emergency, and this presents a constant challenge in using limited resources to meet urgent information needs at each stage of the response.
- The information needed by the affected community is not necessarily the same as the information demanded by large humanitarian agencies.

A well-coordinated humanitarian response will use multiple datasets, created by different personnel in different agencies, describing a highly dynamic and multi-faceted situation. To make these datasets interoperable and manageable imposes a higher overhead cost. But to create a data model that is planned strategically versus reactively will minimize that cost.

**Moving forward**

A multi-agency effort is essential to improve the availability and accessibility to baseline and crisis information. This needs to be a collaborative effort of the entire humanitarian response community with support and involvement of the private and academic sectors. The now no longer existing IASC Task Force on Information Management did a good job by defining what the Core and Fundamental Operational Datasets (COD/FOD) are that we need to collect for each country, but the difficult part is to actually ensure they are available for each country and that those that have been collected are actually kept up to date.

# LESSON PLAN:
# Breaking it down

## *An experiment on how microbes affect oil degradation*

**Adapted from:** Slick Oil Lab, Science in the Real World: Microbes in Action

**Objectives:** To demonstrate methods of scientific inquiry and laboratory skills. To understand ecology concepts by identifying carbon compounds as a food source, discussing microbial degradation, and identifying a color change as indicative of a chemical reaction.

**Standards:** OLP 5-6; SC.912.L.17.16, SC.912.L.18.8, SC.912.P.8.12, SC.912.N.1.1

**Time Required:** Two 50-minute class periods, plus quick daily observations for a week

**Keywords:** microbes, oil degradation, bioremediation, tetrazolium indicator

**Materials:**

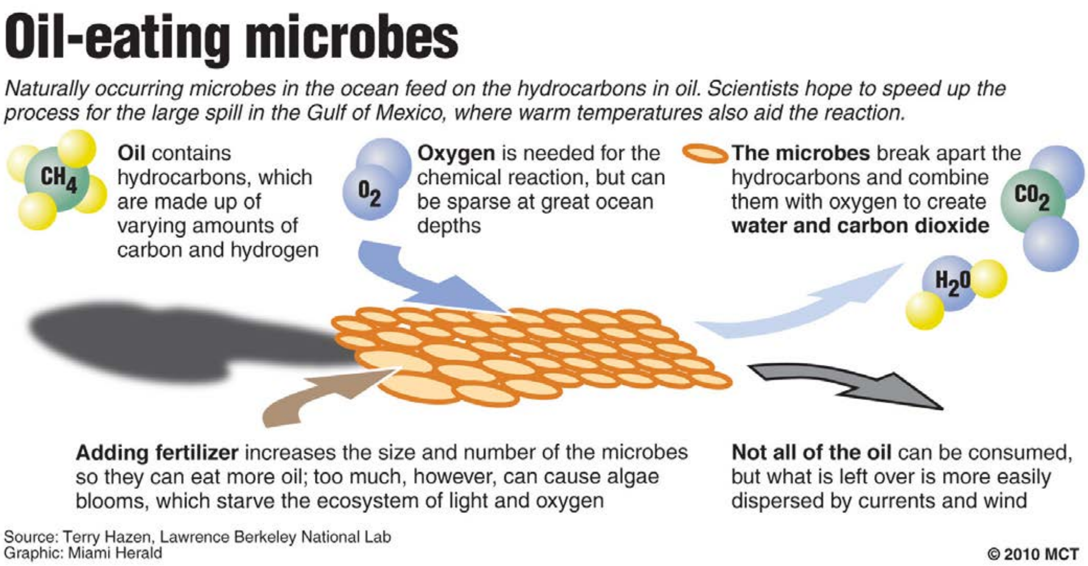
- Four culture tubes
- Four caps
- One test tube rack
- Marking pen
- Label tape
- 1ml plastic pipettes
- 3ml 0.02% tetrazolium indicator*
- 1ml of each drain cleaner (Rid-X Septic System Treatment, BioKleen Bac-Out Drain Care Gel, and Drain Care Build-Up Remover (powdered; mix 1tbsp w/ 500mL of water))
- 2-3ml of cooking oil (each group will test one kind – canola, peanut, vegetable, olive oil)
- Copies of the student worksheets (1 worksheet, print double-sided for each group)

**Note: Requires preparation of solutions before the lab; Takes 1-5 days for results*

## Background

### *What are microbes?*

**Microbes** are tiny, single-cell organisms too small to be seen with the naked eye. Since oil is a great food source for microbes, many different types (primarily bacteria and fungi) have evolved to break down oil into carbon dioxide and water. Oil seeps occur naturally at the seafloor, and thus hydrocarbon-degrading microbes are present everywhere in the marine environment, especially in the oil-rich Gulf of Mexico. The majority of microbial degradation occurs by aerobic respiration, which means the oil-degrading microbes "breathe" oxygen and burn or decompose oil hydrocarbons just as humans breathe oxygen and break down food for energy.



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***Why are microbes so important?***

**Biodegradation** mediated by native microbial communities is the ultimate fate of the majority of oil hydrocarbons that enter the marine environment. The Deepwater Horizon oil spill released light crude oil composed of a variety of compounds with varying degrees of biodegradability. Research has shown that microbes can biodegrade up to 90% of some light crude oils. Therefore during the oil spill, the microbe population bloomed and was instrumental in helping clean up the oil-contaminated environment in the Gulf.

## Oil Degradation Lab

Microorganisms can degrade toxic compounds in petroleum products. Scientists often select microbial strains for their unique ability to degrade various compounds. At sea and on shore, oil spills can be "seeded" with these oil-degrading organisms along with inorganic nutrients that enhance their growth on the oil. This technique is a type of **bioremediation**.

Think of a clogged drain…waste that contains oil is difficult to dissolve and causes other compounds to become stuck in the waste. Mixtures of bacteria can digest the oil and nutrients in the waste, allowing the remainder of the waste to dissolve. In this lab, you will visibly determine whether microorganisms in some brands of drain cleaners can metabolize cooking oil. The following ingredients will be mixed in test tubes and observed for one week: commercial drain cleaners that list bacteria as an ingredient, **tetrazolium indicator** solution that turns pink when oil-degrading bacteria are present, and cooking oil. Tetrazolium is an indicator dye that is colorless in its oxidized form, but pink when reduced. When microorganisms metabolize carbon compounds they make waste products that serve as reducing agents (aka reductants or electron donors) that will reduce tetrazolium, turning it pink. Therefore, when bacteria metabolize a particular carbon source, they make reducing agents and the tetrazolium turns pink. This is how you will measure microbial metabolism.

## Procedure

1. **Prepare tetrazolium stock solution (0.2%)**

   ***The day before the lab***…2,3,5 triphenyl tetrazolium chloride: Make a stock solution of 0.2% tetrazolium by adding 0.05 g tetrazolium powder to 25 ml distilled water. Mix thoroughly and store in refrigerator.

   ***The day of the lab***…Dilute the tetrazolium - Make a fresh 0.02% solution the day of the lab by mixing 1 part 0.2% tetrazolium with 9 parts distilled water. Put solution in a flask or bottle with a 1 ml dropping pipette. Caution: do NOT to use the pipette for any other solution.

2. **Set up group lab materials.** Each group should have:
   - One test tube rack
   - Four test tubes with caps
   - 1ml pipettes
   - Masking tape and a permanent marker
   - 3ml 0.02% tetrazolium indicator
   - 1ml of each drain cleaner (Rid-X Septic System Treatment, BioKleen Bac-Out Drain Care Gel, and Drain Care Build-Up Remover (powdered; mix 1tbsp w/ 500mL of water)
   - Five drops oil for each test tube (cooking oils: canola, peanut, vegetable, or olive oil. Assign one oil per group)

### *CLASS #1*

3. **Discuss the microbe background information with your students and then review the "Oil Degradation Lab" information.**

4. **Hand out the student worksheets (pages 74-75) for each group.** Have the students read over the procedures once, and then review the procedure step-by-step with the class.

   **Tips and Tricks**
   - Provide examples of controls in experiments and sample data tables for students to assist them with the process.
   - Caution students that if a reagent has a pipette—do not use that pipette in any other solution.
   - Results should take 1-5 days; if there is no change after five days, keep tubes a few days longer. If you have an incubator, set the temperature to 30-32°C.

   **Lab Procedure**

   i. Write down the names of the drain cleaners and cooking oil on the worksheet. Mark test tubes 1, 2, and 3.
   ii. Add 1 ml tetrazolium indicator to each test tube, followed by five drops of cooking oil. IMPORTANT: Use the same type of cooking oil for each test tube!
   iii. To test tube 1, add 1ml of drain cleaner 1.
   To test tube 2, add 1ml of drain cleaner 2.
   To test tube 3, add 1ml of drain cleaner 3.
   iv. Cap the tubes. Gently tap the tube with your index finger while holding it with your other hand to create a whirlpool to mix.
   v. Set up a control tube for this experiment.
   vi. Design a data table to record your observations for a week starting with today. Oil degradation will cause the tetrazolium indicator to turn pink.
   vii. Label your test tube rack and store in a safe place in order to make observations for the next week. Record any physical changes on your data table.

5. **Have students make observations and record them for a week starting today.**

### *CLASS #2*

6. **Once all the observations have been recorded for a week, have students work on analysis questions in their groups and review them as a class.**

## Questions

1. Did all drain cleaners react the same? Which ones showed the most evidence of microbial metabolism? *Answers will vary.*
2. Compare your results with classmates who used a different type of oil. Did all oils show evidence of microbial metabolism? Explain your answer. *Answers will vary.*
3. Why do you think some bacteria might grow better with certain oils as a food source compared to other oils? *Presence of different enzymes or metabolic pathways allow some bacteria to use one oil but not another.*
4. Do you think bacteria could degrade petroleum oil products? Would all bacteria be effective for treating oil spills? *Yes. Some bacteria would have metabolic pathways to degrade oil, but not all bacteria.*

## Resources & References

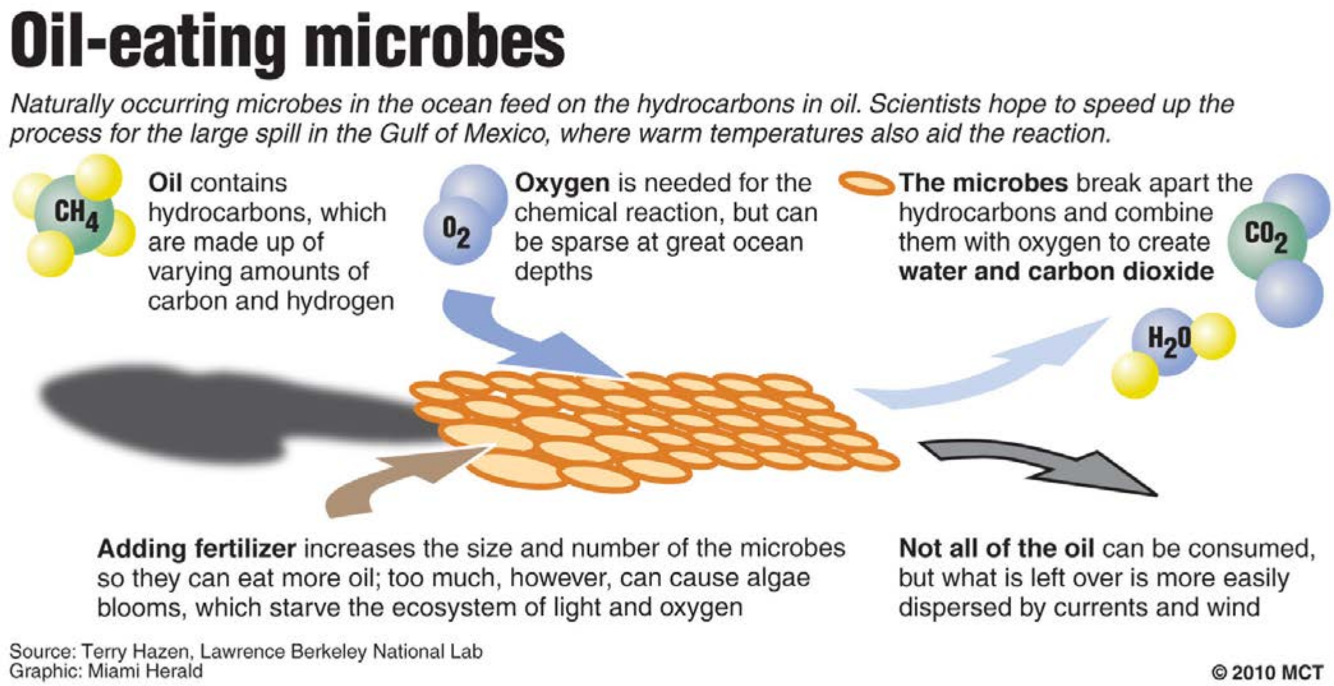
**Oil-eating Microbes Fact Sheet:** http://deep-c.org/images/documents/fact-sheets/Microbes_FactSheet-web.pdf

**Science in the Real World: Microbes in Action, Slick Oil Lab:**
http://www.umsl.edu/~microbes/pdf/A%20Slick%20Oil%20Lab.pdf

# STUDENT WORKSHEET

**Names of Group Members:** ______________________________________________

Over the last 3 ½ billion years, microorganisms have evolved that can use almost every carbon compound as a food and energy source. Oils are long chain hydrocarbon molecules with a variety of side branches. Specialized bacteria can break down all types of oils including those that are derived from mineral and petroleum products. In this experiment, you will determine whether microorganisms in some brands of drain cleaners can metabolize (break down) cooking oil.



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## Materials

- One test tube rack
- Four test tubes with caps
- 1ml pipettes
- Masking tape
- Permanent marker
- 3 ml 0.02% tetrazolium indicator
- 1 ml of each drain cleaner
- Five drops oil for each test tube

## Procedure

1. Write down the names of the drain cleaners and cooking oil. Mark 3 test tubes 1, 2, 3.
2. To each test tube add 1 ml tetrazolium indicator, followed by 5 drops of cooking oil. IMPORTANT: Use the same type of cooking oil for each test tube!
3. To test tube 1, add 1ml of drain cleaner 1. To test tube 2, add 1ml of drain cleaner 2. To test tube 3, add 1ml of drain cleaner 3.
4. Cap the tubes. Gently tap the tube with your index finger while holding it with your other hand to create a whirlpool to mix.
5. Set up a control tube for this experiment.
6. Design a data table in which to record your observations for a week starting with today. Oil degradation will cause the tetrazolium indicator to turn pink.
7. Label your test tube rack and store in a safe place in order to make observations for the next week. Record any physical changes on your data table.

## STUDENT WORKSHEET

**Name of Drain Cleaners:**

1.________________________ 2. ________________________ 3. _________________________

**Name of Cooking Oil:** ________________________

**Data Table**

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**Analysis**

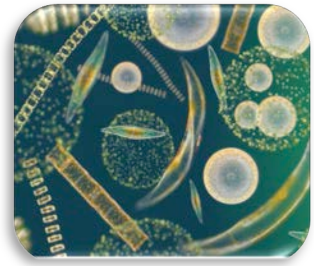
1. Did all drain cleaners react the same? Which ones showed the most evidence of microbial metabolism?

2. Compare your results with classmates who used a different type of oil. Did all oils show evidence of microbial metabolism? Explain your answer.

3. Why do you think some bacteria might grow better with certain oils as a food source compared to other oils?

4. Do you think bacteria could degrade petroleum oil products? Would all bacteria be effective for treating oil spills?

# LESSON PLAN:
# Go with the flow: the life of plankton



## *Use microscopes and illustrations to dive into the world of plankton*

**Objectives:** To understand the types of plankton and their importance. To use a microscope to identify and illustrate plankton.

**Standards:** OLP 5,6; SC. 912.L.17.2, SC.912.L.17.8, SC.912.L.17.9

**Time Required:** One 50-minute class period

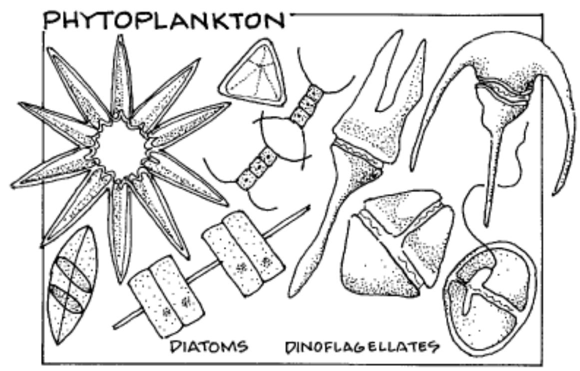
**Keywords:** phytoplankton, zooplankton, neutral buoyancy

**Materials:**
- Microscopes
- Live plankton or prepared slides
- For live plankton: dish with plankton sample and pipettes
- Drawing paper
- Plankton ID guides
- Copies of the *Images of Tiny Drifters*

## Background

**What are plankton?**

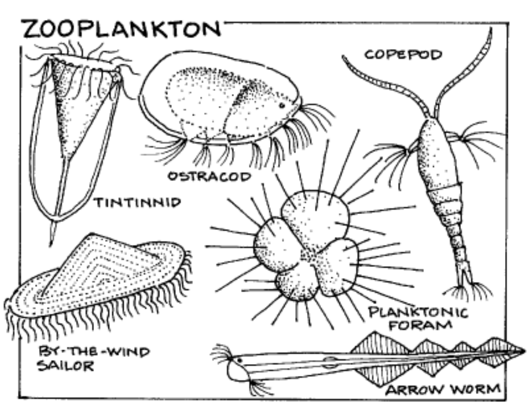
Plankton are primarily microscopic plants and animals that live in the water and cannot swim against major currents. These drifting creatures *go with the flow*. Most plankton can only control their movements vertically in the water column through the use of **neutral buoyancy**. That means it will neither float on the surface or sink to the bottom. This is done by controlling surface area and density. There are two major types of plankton: zooplankton and phytoplankton.




**Phytoplankton: primary producers**

Phytoplankton, or plant plankton, live near the surface of the ocean because they need sunlight to make food. As a plant, phytoplankton contains chlorophyll and thus makes its food through the process of photosynthesis. This process not only adds oxygen back into the water, but is also responsible for a high percentage (about 50 to 70%) of the atmospheric oxygen on Earth.

The two most common types of phytoplankton are **diatoms** and **dinoflagellates**. Diatoms are surrounded by a cell wall made of silica; these organisms actually live in a glass house. They can be found in diatomaceous earth, which is the source of abrasives in certain brands of toothpaste. Dinoflagellates have some characteristics of both plants and animals. They have a tail-like flagellum to move around. They are most commonly known as the source of a dangerous toxin, which is the cause of “red tide.” This, however, is only when certain species form an algal bloom. Red tides often result in fish kills, and have the capability of producing toxins that can accumulate in fish and shellfish.




**Zooplankton** or animal plankton are consumers that feed on phytoplankton or other zooplankton. They both are, however a food source for many other aquatic animals. Zooplankton can be separated into two categories. **Meroplankton** spend part of their lives as plankton (typically during its larval stage, such as crabs and fish). **Holoplankton** spends their whole lives as plankton (jellyfish, copepods, and amphipods).

***Why is plankton so important?***

Plankton is the base of the food chain. They are primary producers and important in nutrient cycling, which can tell us a lot about changes in our ocean. These organisms serve as indicator species and can demonstrate how marine environmental changes might affect larger organisms such as birds, fish, and sharks.

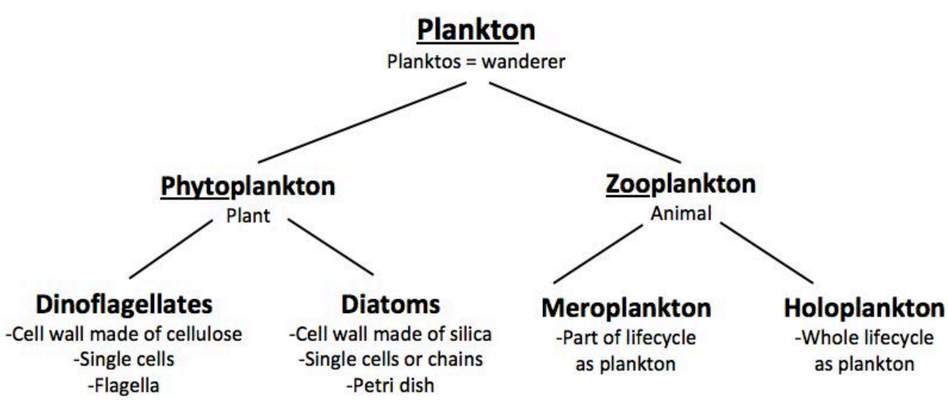
***Oil spill affect on plankton:***

The 2010 Deepwater Horizon oil spill exposed plants and animals to harmful crude oil. Though less visible, plankton were impacted as well. Oil and dispersants can dramatically shift the balance of energy flow in the microbial loop and fundamentally change basic trophic interactions among lower trophic levels, meaning a disruption such as the spill could have caused a major disruption in the pelagic food web. The extent of the disruption is not clear. However, dramatic fluctuations in the structure of the plankton association in northwestern Florida were observed as late as May 2011, eight months after the closure of the well. Additional analyses of the data are currently being conducted to determine whether the spill or other environmental factors were responsible for these fluctuations.

Sedimentation of oil and detritus from the water columns provides an archival record of chemical constituency, environmental conditions, and biological effects of pre-spill, spill, and post-spill conditions (including evidence of recovery), which appear in progressively shallower core-depth intervals. Important primary producers in the Gulf of Mexico are photosynthesizing protists, including pelagic diatoms and nanoplankton. Their presence in sediments are particularly useful because they leave sedimentary records that extend from the present to far back in geologic time, enabling us to identify abrupt, large-scale changes in living populations and extreme environmental events.

## Procedure

**1. Introduction to plankton: Define and discuss types and importance.**
The following diagram can be drawn on the board to allow students to follow along.




**Fun Facts:**
*Plankton produce about 50% of all the oxygen we breathe!*

*Did you know... that every time you swallow seawater, you could be consuming plankton?*

*There could be over a million phytoplankton in one teaspoon of seawater!*

*Plankton are most visible when certain conditions lead to a population explosion known as a bloom.*

**2. Use a microscope to view plankton**

- Plankton can be collected using a plankton tow. If you have live plankton, the wet-mount slides will need to be prepared OR prepared slides can be used (see Carolina Biological).
- Explain how to identify phytoplankton and zooplankton using the ID Guides (see resources).
- Demonstrate how to operate the microscopes properly.
- Have students illustrate the plankton being observed and use ID guides to label the type.

If using live plankton: Each workstation should have a microscope, a dish with a plankton sample, pipettes, slides, the drawing paper, and writing supplies. Using the pipette demonstrate how much water they should put on their slides. Show them how to use the slide covers (optional). Help them to properly focus their microscopes, as needed.

After observation questions: What kind of plankton did you find? How did they look different? Did they move different? Did you see holo- or meroplankton? Which was the most abundant? and Did you see any adaptations or special features on the plankton that help it to meet a survival need?

**3. Look at the attached images of phytoplankton and write a descriptive paragraph about their characteristics.**

- Phytoplankton shapes: spines, chains, hard shells, flagella (long tails) serve as adaptations.
- Move up and down in the water using neutral buoyancy and controlling their surface area and density.
- The formation of chains helps gain surface area to stay afloat. Others have vacuoles within their bodies to provide buoyancy.

## Questions

1. What is the definition of plankton? *Primarily microscopic plants and animals that live in the water and cannot swim against major currents.*
2. When looking under the microscope, how do phytoplankton and zooplankton differ? *Phytoplankton are typically smaller than zooplankton; zooplankton typically move around in your slide.*
3. What physical characteristics assist with neutral buoyancy? *Formation of chains and vacuoles.*
4. How do you think the Deepwater Horizon oil spill may have affected the plankton? *Answers will vary.*
5. How do you think plankton respond to varying environmental conditions? *Answers will vary.*

## Extensions

Have students classify plankton (kingdom, phylum, class, scientific name, and common name).

Activity to recognize larval and adult forms. Meroplankton Match-Up
www.nps.gov/cuis/learn/education/.../Meroplankton%20Match-up.doc

## Resources & References

**Carolina Biological** (prepared slides can be purchased here)
http://www.carolina.com/life-science/microscope-slides/10449.ct?mCat=10337&intid=srchredir_microscopeslide&_requestid=49937

**Lab#1: Microscopy & Plankton** (for directions on how to use a compound microscope, prepare a wet-mount slide, and how to find plankton in a slide)
http://www.biosbcc.net/fukui/labs/01.pdf

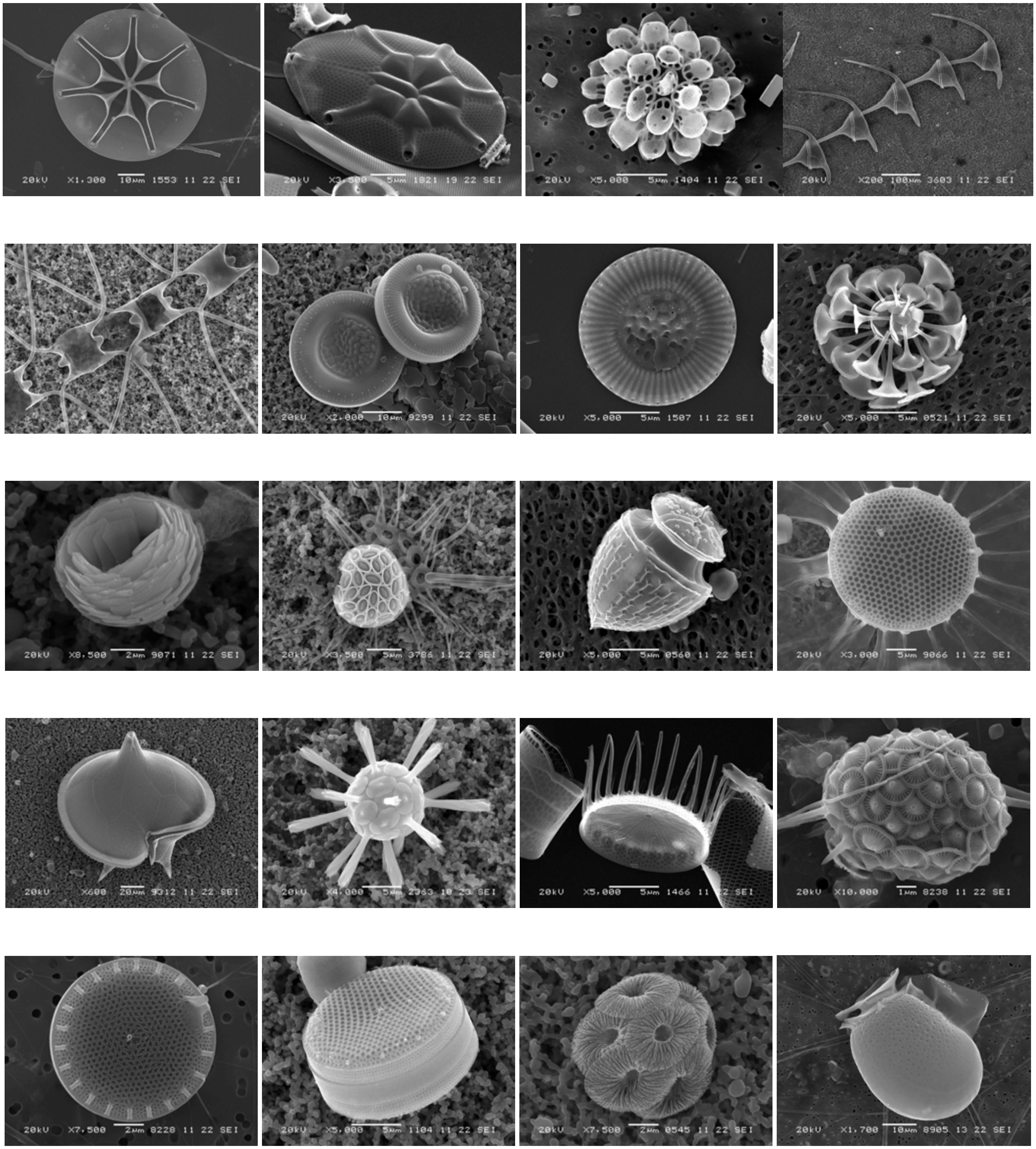
**Phytoplankton and the Oil Spill** – NGI Discovery Porthole
http://www.northerngulfinstitute.org/impact/resources/gulfResearchInitiative/phytoplanktonOilSpill.pdf

**Plankton Fact Sheet from Deep-C**
http://deep-c.org/images/documents/fact-sheets/Plankton_FactSheet-web.pdf

**Plankton ID Guides:**

- Plankton Identification (page 4 and 5) http://er.jsc.nasa.gov/seh/Ocean_Planet/activities/ts3ssac3.pdf
- Common Phytoplankton Key
  http://estuaries.noaa.gov/teachers/pdf/plankton/common_phytoplankton_key.pdf

## *Images of Tiny Drifters: Phytoplankton, Plant Plankton*



*Images provided by Dr. James Nienow, Professor of Biology at Valdosta State University*

*"Suppose you fill up a one-liter water bottle with seawater from just about anywhere along the coast. If you look at it, the water appears clear. However, when you look at it more closely, you find that it contains thousands of diatoms and other types of microalgae. These microorganisms, virtually invisible to the naked eye, in aggregate are responsible for about half of the world's oxygen production, roughly equivalent to all of the terrestrial forests and grasslands we are so familiar with." – Dr. James Nienow*

# LESSON PLAN:
# Research Cruises in the Gulf

## *Catching and sampling deep-sea fishes and sharks*

**Note:** This lesson plan works well in conjunction with the following lesson on *"Toxicity: Exposure to PAHs*" on page 83

**Objective:** To learn about what it is like to go on a scientific research cruise, and to develop a research question and sampling scheme.

**Standards:** OLP 5 & 7; SC.912.N.1.1, SC.912.N.4.1

**Time Required:** One 50-minute class period (can be expanded over two class periods, to allow additional discussion time)

**Keywords:** research cruise, sampling

**Materials:** Computer, projector, and student worksheets

### Background

Studying the ecological impacts of the 2010 Deepwater Horizon oil spill from the deep sea to coastal communities is a challenging undertaking. It involves a team of scientists working on various research projects taking multiple samples from a several locations to put the pieces of the puzzle together. **Sampling** many times is necessary in order to be able to draw well-supported conclusions. One sample can only tell you what was happening at that single place at that specific time. Therefore, a variety of techniques are used to conduct the research. In particular, the fieldwork under Deep-C Consortium projects required intensive use of the Research Vessels Apalachee and Weatherbird II.

Deep-C ecologists Dr. Dean Grubbs and Dr. Chip Cotton from the Florida State University Coastal & Marine Laboratory researched the bony fishes and sharks in the northeastern Gulf of Mexico. The research focused on learning what animals can be found in the region of the Deepwater Horizon oil spill in the deep sea; particularly the ones closest to the bottom that potentially could have been directly impacted by the spill. The ecology team concentrated their efforts in three regions: the Louisiana slope to the west side of De Soto Canyon (–direct exposure), the east side of De Soto Canyon and north Florida Slope (–less affected), and southwest of Tampa on west Florida Slope (–unaffected/lightly affected). Working with Dr. Jim Gelsleichter from the University of North Florida, they compared community abundances and used a toxicological approach, looking at their exposure to toxins that are associated with oil across those three regions. Most people think the deep sea is relatively homogeneous, but in fact it is not in terms of species found there. The community of animals on the west side of the canyon is completely different than that found on the west Florida Slope. Small regional differences translate to big differences in the community.

As part of the Deep-C Consortium, the ecology team went on 10 **research cruises** resulting in the sampling of more than 4,000 fishes from 101 species (including 34 species of sharks and rays), making this the largest survey of deep-sea elasmobranch fishes ever conducted in the Gulf of Mexico. Deep sea is considered deeper than 200m (600-700ft). Using sampling methods Dr. Grubbs developed, they caught a wide variety of sharks, from the lantern shark that is about 10 inches long (a bioluminescent shark that migrates vertically) to the six-gill shark that is 16-17ft long (likely the largest fish predator in the Gulf). Every cruise they caught some species that hadn't been caught previously. From their research they found a difference in exposure and metabolism of PAHs (polycyclic aromatic hydrocarbons) among regions and the time frames of exposure varied based on species. For some deep sea bony fishes, the peak exposure was one and a half years after the Deepwater Horizon oil spill and may be recovering. Deepwater sharks grow very slowly and for some species, their peak signals of oil exposure were two and a half years after the spill. The researchers are seeing signs of recovery in some species, while signals of oil exposure are persistent in others.

This research requires lethal sampling. To make the most out of sacrificing an animal, many tissue samples are collected for a variety of studies:

- Muscle (stable isotopes, mercury)
- Fin clips (genetics)
- Liver (toxicants, mercury, PCBs, condition)
- Bile (toxicants)
- Blood (toxicants, reproduction, stress physiology)
- Gills (stable isotopes)
- Reproductive tracts (life history)
- Aging structures (spines, vertebrae for life history)
- Stomachs (diet studies)
- Heads (biomechanics, brain studies)
- Jaws (tooth studies)
- Eyes (visual physiology)
- Hearts (cardiac function)
- Rectal glands (osmoregulation)
- Vouchers (taxonomic studies)

## Procedure

1. Ask students what they think it is like to go out on a scientific research cruise? (5 min)
2. Pass out Student Worksheets #1 and #2.
3. Separate them into small groups and have them discuss the following: If they were ecologists studying the impacts of the oil spill, how would they set up an experiment to figure out how the oil was affecting the fishes and sharks? (15 min)
4. Have student read *"A day out on the research vessel - Account from Dr. Dean Grubbs"* on page 82 (5 min)
5. Watch a portion of "Creatures of the Deep" (end at 11:45 min; 19:50-21min talks about teams and hauling gear) – the Toxicity lesson will pick up from there and run to the end of the video at 26:42 min. Answer the questions on Student Worksheet #2.
   https://www.youtube.com/watch?v=WEIqgFUxV2g&list=UU2L3PrUh7nWFA_Fva8RoGcA
   *In the cold, deep waters of the Gulf of Mexico, little-known animals spend their entire lives far removed from our human world. Until now, little research has been conducted on these creatures of the deep, keeping much of their lives a mystery.*
6. Discuss the video and ask the students what they thought…have their ideas of what it is like to go out on a research cruise changed? (10min)
7. Collect the Student Worksheets.

### Answers to Research Cruise Questions from Creatures of the Deep - Changing Seas TV

1. In the deep sea; of the 500 shark species, 55-60% of them live their whole lives deeper than 700ft
2. 10
3. Northern Gulf of Mexico
4. Expensive, far away in depth/ hard to access
5. To catch fishes in different habitats and depths
6. To look at different things to find information on age, genetics, diet, exposure to toxic chemicals
7. Isopods
8. True

## Resources & References

**Background Information on Sharks** http://ocean.si.edu/sharks

**Creatures of the Deep Video – Changing Seas TV** http://www.changingseas.tv/episode503.html
https://www.youtube.com/watch?v=WEIqgFUxV2g&list=UU2L3PrUh7nWFA_Fva8RoGcA

**Deep-C's *Voices from the Field* Blog: Fisheries/Ecology Cruise**
http://deepcconsortium.blogspot.com/search/label/Ecology%2FFisheries%20Cruise%20-%20October%202012

**Deep-C's Deepwater Sharks Fact Sheet**
http://deep-c.org/images/documents/fact-sheets/DeepwaterSharks_FactSheet-web.pdf

**Sampling the Ocean – Cal Echoes Lesson Plan** (extension questions utilized for student worksheet)
https://calechoes.wordpress.com/lesson-plans/

## Contributing Expert

Dr. Dean Grubbs, Marine Ecologist at the Florida State University Coastal and Marine Laboratory

## Student Worksheet #1

Group Work: You are an ecologist studying the impacts of the 2010 Deepwater Horizon oil spill. How would you set up an experiment to figure out how the oil was affecting the fishes and sharks in the northeastern Gulf of Mexico? With your team of researchers, come up with a sampling scheme.

1. What is your testable research question?

2. What is the time scale of your question (does it happen quickly or slowly)?

3. What is the spatial scale of your question (does it occur over a large area or a small area)?

4. What kind of equipment would you use? What are the advantages of using this equipment? What are the limitations?

5. Would it be useful to combine data from more than one type of equipment in order to address your question?

6. How often will you take samples? Why?

7. Where will you take samples? Why?

8. How many samples will you take? Why?

9. What is the time period over which sampling will occur (one day, ten years, etc.)?

10. What are the aspects of your sampling environment that you cannot control? Is it possible to account for those factors when analyzing your data?

# Student Worksheet #2

## Working around the clock: A day out on the research vessel - Account from Dr. Dean Grubbs

“A day out on the research vessel – we don’t ever stop, we work 24-hours-a-day. We carry a science crew that we can divide in half for setting our gear, then everyone is involved in hauling the gear.

So when we get on our first site for example, half of the team would set three of our deep-water sets that include a ‘short’ long-line (500m of line on the bottom, five different hook sizes, several different trap styles, temperature depth recorder, oxygen probe on the line). We will target very specific depths in specific habitats.

The team may set at 300, 500, and 700m deep. Only takes about 20 minutes to set the gear. Wake up the other half of the science crew and will haul all of those lines. When each line comes on board, each fish that comes up, it is quite a process to keep everything on track when sampling fishes.

The fish immediately gets a photograph and a specimen ID, so we can go back in the future because a lot of these are species that are poorly known to science and some are new species. We need photographic record so we can link the samples back to that original timestamp of when we collected the animal.

It then goes through a process of getting measured and weighed. There are about 20 different samples taken from each animal. Things for genetics, life history studies (such as reproduction and telling how old the animal is), muscles are taken for stable isotopes to look at the food web, muscles are taken for mercury bioaccumulation, blood is taken for stress physiology and reproductive parameters, and then we take liver, bile, and blood that’s also used for the toxicity study, biomarker studies where the look for exposure to and metabolism of any toxins that might be associated with the oil spill.

It is a long process to take the animals from capture to all the samples. Takes several hours. As soon as they are done processing all the animals from those three stations, then finally that first team gets to go to sleep for three hours while the other team sets the next set of gear. It is typically three or four hours of sleep for every 30 hours on the boat.”

## *“Creatures of the Deep”* Video from Changing Seas TV – Answer the following questions:

1. Where do most shark species live?

2. How many days was this particular research cruise?

3. Where are the scientists headed?

4. Why is it difficult to study the deep sea?

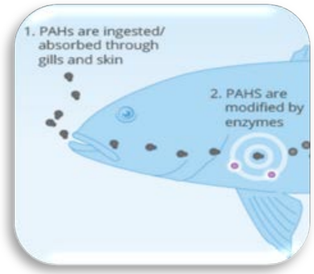
5. What is the reason for different traps and hooks?

6. Why do they need to take multiple samples from one specimen?

7. What is the name of the scavenger that eats the fish on the line?

8. True or false. The type of species found changes, as you get deeper in the ocean.

# LESSON PLAN:
# Toxicity: Exposure to PAHs




## *How do scientists sample marine organisms for PAHs*

**Note:** This lesson plan works well in conjunction with the *Research Cruise* lesson.

**Objective:** To become aware of how exposure to a pollutant such as Polycyclic Aromatic Hydrocarbons (PAHs) can be toxic to organisms and how marine scientists sample for PAHs.

**Standards:** OLP 5-7; SC.912.L.14.46, SC.912.L.17.16, SC.912.L.17.9, SC.912.N.1.7

**Time Required:** One 50-minute class period

**Keywords:** PAHs, toxicity, liver, gallbladder, food chain/web, biomarkers, enzymes

**Materials:** Computer, projector, copies of Student Worksheet

## Background

### *What are PAHs?*

**Polycyclic Aromatic Hydrocarbons (PAHs)** are organic compounds containing only carbon and hydrogen which are composed of multiple aromatic rings. They are a group of more than 100 chemicals that are formed by the partial burning of coal, oil and gas, garbage, or other organic substances (such as tobacco or charbroiled meat). Some PAHs are manufactured and may be found in coal tar, crude oil, creosote, and roofing tar. A few are used to manufacture medicines, dyes, plastics, and pesticides. Some PAHs have been shown to interfere with reproductive and immune systems in laboratory animals and may be carcinogenic to humans.

According to NOAA's *How Oil Affects Habitats and Species*, PAHs can:

- cause direct toxicity (mortality) to marine mammals, fish, and aquatic invertebrates through smothering and other physical and chemical mechanisms.
- also cause sublethal effects such as: DNA damage, liver disease, cancer, and reproductive, developmental, and immune system impairment in fish and other organisms.
- accumulate in invertebrates, which may be unable to efficiently metabolize the compounds.
- then be passed to higher trophic levels, such as fish and marine mammals, when they consume prey.

### *How did the Deep-C Consortium study PAHs in fish?*

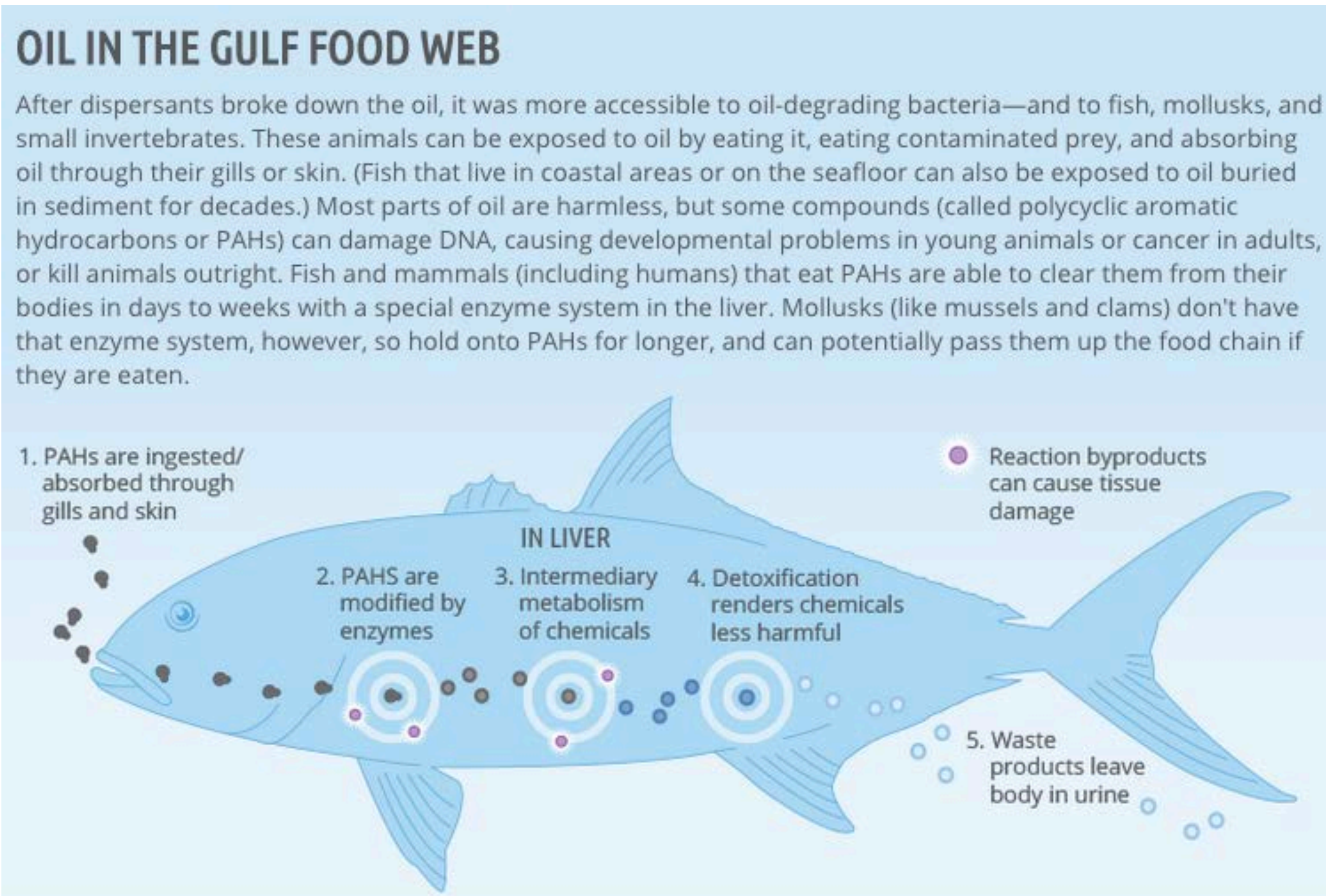
Deep-C studies of the trophic interactions of fish species in the northeastern Gulf of Mexico are motivated by evidence that Deepwater Horizon oil reached the continental shelf from the deep sea via the De Soto Canyon, and by anecdotal evidence from fishermen and scientists that this event had a significant effect on fish health and community composition. Given the strong linkages between large-scale oceanographic features such as the Loop Current, geomorphology (i.e. the De Soto Canyon and the Apalachicola River Delta), and fisheries productivity, Deep-C researchers evaluated post-spill impacts on the Gulf ecosystem that link results from the ecological research with those of the other Deep-C research areas. The goal was to survey fish assemblages to determine the level and effect of exposure to PAHs, the most toxic substances in crude oil, on fish health and characterize areas most likely affected by the spill.

To test whether PAHs are affecting deep water Gulf fish, Deep-C scientists measured levels of commonly used fingerprints or "**biomarkers**" of PAH exposure in more than 1,000 deep sea fish, focusing on abundant sharks (gulper sharks, shortspine dogfish) and bony fish (tilefish, hakes) that were collected 12 to 42 months following the Deepwater Horizon blowout. The PAH biomarker used in this research included **liver enzymes**, which break down PAHs for excretion and tend to increase when animals are exposed to these pollutants, and the bile that collects in the **gallbladder**. Although findings vary by species, the results of this research suggest that fish collected closer to the oil spill are more likely to exhibit higher levels of PAH biomarkers, suggesting that they may be biologically affected by oil exposure. However, since the actual biomarker levels observed in deep sea fish were low in comparison with earlier studies on coastal fish (perhaps due to lower metabolism in deep sea fish), it is unclear whether these species will experience the types of health effects that can occur as a result of chronic PAH exposure, such as cancer or reproductive complications. Further research is needed.

## Procedure

1. **Ask students what type of pollutants/chemicals they think went into the Gulf of Mexico when the oil spill occurred in 2010 and how do they think animals responded to those pollutants?** (Write answers on worksheet on page 86.)

2. **Project the "Oil in the Gulf Food Web" image below from** [http://ocean.si.edu/gulf-oil-spill-interactive.](http://ocean.si.edu/gulf-oil-spill-interactive)
   - Read the description aloud and discuss the process step-by-step from ingestion/absorption to waste.
   - Have students write and/or draw this process.




*Designed by: Lucy Reading-Ikkandal, Development by: Edward Wisniewski*
*Source: Gulf of Mexico Oil Spill Interactive,* [*http://ocean.si.edu/gulf-oil-spill-interactive*](http://ocean.si.edu/gulf-oil-spill-interactive)

3. **Watch eight minutes of "Creatures of the Deep" (start at 11:45min and stop at 19:45min) and have student answer eight questions on their worksheet.**
   [https://www.youtube.com/watch?v=WEIqgFUxV2g&list=UU2L3PrUh7nWFA_Fva8RoGcA](https://www.youtube.com/watch?v=WEIqgFUxV2g&list=UU2L3PrUh7nWFA_Fva8RoGcA)
   Notes from the video:
   - PAHs take a long time to break down.
   - Blood, liver, and bile samples were collected to assess exposure to and metabolism of PAHs.
   - Blood – looking at effects of oil spill or toxicity in general.
   - Liver (large pink), associated with the gallbladder, which contains bile (green/brown tint). It is time and light sensitive so they try to get the samples as quickly as possible. It goes into a light sensitive container and then immediately ice. The toxicity samples are worked up in the lab at UNF.

- Is there evidence that the PAHs have been taken up in the food chain? Are they getting sequestered in the liver and then disappearing or metabolizing? Chromosome damage?
- Closer to the oil site – higher rate of occurrence of PAHs.
- Deep sea fishes metabolism is slow.

**4. Wrap up with a summary of the video and have students turn in their worksheets.**

**Answers to Research Cruise Questions from Creatures of the Deep - Changing Seas TV**

1. Polycyclic Aromatic Hydrocarbon
2. Looking for metabolites of toxins
3. Gallbladder
4. Yes
5. Slow
6. Mercury
7. Yes
8. True

## Resources & References

**Creatures of the Deep Video – Changing Seas TV**
https://www.youtube.com/watch?v=WEIqgFUxV2g&list=UU2L3PrUh7nWFA_Fva8RoGcA OR
http://www.changingseas.tv/episode503.html

**Gulf of Mexico Oil Spill Interactive**
http://ocean.si.edu/gulf-oil-spill-interactive

**How oil affects habitats and species** – from NOAA shorelines coastal habitats fact sheet
http://www.noaa.gov/factsheets/new%20version/shorelines_coastalhabitat.pdf

## Contributing Expert

Dr. James “Jim” Gelsleichter, Associate Professor of Biology at the University of North Florida

## Student Worksheet for Lesson on Toxicity: Exposure to PAHs

**Name: ___________________________________**

*What type of pollutants or chemicals do you think went into the Gulf of Mexico when the oil spill occurred in 2010?*

*How do you think the animals responded to those pollutants?*

*"Oil in the Gulf Food Web" (see image)*
*Draw the exposure process and how PAHs enter and exit the fish:*

*Class discussion notes about this image:*

*"Creatures of the Deep"* Video from Changing Seas TV – Answer the following questions:

1. What does PAH stand for?
2. Why do the scientists sample the liver?
3. What organ is associated with the liver?
4. Is there a higher rate of occurrence of PAHs closer to the spill site?
5. Do deep sea animals have slow or high metabolism?
6. Muscle is taken for ___________ analysis.
7. Does mercury bioaccumulate through the food web?
8. True or False. Body size increases with depth.

## Ecology Quiz

1. What is baseline data?

2. Why is it important to collect baseline data?

3. From the oil degradation experiment, what indicated evidence of microbial metabolism?

4. Are microbes found naturally in the Gulf of Mexico ecosystem?

5. Why are phytoplankton known as primary producers?

6. What physical characteristics of plankton assist with neutral buoyancy?

7. From “Creatures of the Deep” video, name three samples that were collected from fish during the research cruise in the Gulf of Mexico.

8. When scientists are out at sea, what is the reason for different traps and hooks on the line?

9. What are PAHs?

10. What organs do scientists sample to measure exposure and metabolism of PAHs?

## Ecology Glossary

**Baseline Data**: is the initial collection of data, which serves as a basis for comparison with the subsequently acquired data

**Biomarkers:** biological marker, generally refers to a measurable indicator of some biological state or condition; occasionally used to refer to a substance the presence of which indicates the existence of a living organism; like fingerprints, used to measure PAHs (in the lesson's case)

**Bioremediation:** the use of either naturally occurring or deliberately introduced microorganisms or other forms of life to consume and break down environmental pollutants, in order to clean up a polluted site

**Consumer**: an organism that gets its energy from eating other organisms

**Food Web:** a system of interlocking and interdependent food chains

**Gallbladder:** an organ associated with the liver that collects bile

**Holoplankton:** organisms that are planktonic for their entire life cycle (i.e. jellyfish, copepods, and amphipods)

**Liver:** a large lobed glandular organ in the abdomen of vertebrates, involved in many metabolic processes

**Liver enzymes:** biological molecules (proteins) that act as catalysts and help complex reactions occur everywhere in life

**Meroplankton:** organisms that are only planktonic for part of their life cycle (i.e. larval stage, crabs, fish)

**Microbes:** tiny, single-cell organisms too small to be seen with the naked eye

**Monitoring**: tracking changes over time

**Neutral buoyancy**: neither floats or sinks

**Oil Degradation:** the break down or weathering of oil

**Photosynthesis**: the process of converting sunlight into food/energy

**Phytoplankton**: plant-like plankton, primary producers

**Plankton:** free-floating, microscopic organisms that move through the water column and with the currents

**Polycyclic Aromatic Hydrocarbons (PAHs):** organic compounds containing only carbon and hydrogen—that are composed of multiple aromatic rings; the most toxic substances in crude oil

**Producer**: an organism that produces its own energy, either from the sun or from chemicals

**Tetrazolium:** an indicator dye that is colorless in its oxidized form, but turns pink when it is reduced

**Toxicity:** the degree to which a substance can damage an organism; can refer to the effect on a whole organism, such as an animal, bacterium, or plant, as well as the effect on a substructure of the organism, such as a cell or an organ such as the liver

**Zooplankton**: animal-like plankton such as newly hatched crabs and other invertebrates