Unit III Red Tide and Harmful Algal Blooms

Researchers at the Florida Fish and Wildlife Conservation Commission's Florida Marine Research Institute (FMRI) are on the edge of scientific discovery. They are working to discover the mysteries of *Gymnodinium breve* (*G. breve*), the dinoflagellate responsible for Florida's red tide. Their work is focusing on the life cycle of this troublesome alga and better ways of tracking its blooms. They are also working in collaboration with a consortium of agencies to more quickly identify toxicity in shellfish and thus shorten the time that aquacultural businesses need to be closed for public health purposes.

Toxic Algae

Lesson Objectives: Students will be able to do the following:

- Identify and describe an organism that causes Red Tide
- Name three diseases caused by harmful algal blooms (HABs)
- Describe the ecological implications of HABs

Key concepts: plankton, phytoplankton, photosynthesis, dinoflagellate, diatom, HAB harmful algal bloom (HAB), toxin

Harmful Algal Blooms

Plankton are organisms that float near the top of the ocean. They cannot swim against a current but must float from place to place or use primitive means for motility. Some plankton are microscopic plant-like organisms called **phytoplankton** or microalgae. These organisms are the base of the ocean food chain. They produce their own food through the process of **photosynthesis**, much like their land plant counterparts. Some phytoplankton are further classified as either **dinoflagellates** or **diatoms**. Dinoflagellates can be distinguished by two dissimilar **flagella** or whiplike structures that are used to move them through the water column. Diatoms have a two-part cell wall made of silica, called a **frustule**.

Some of these microalgae produce **toxins**. Under favorable growth conditions, millions of cells become concentrated in the water, releasing their toxins and causing a **harmful algal bloom (HAB**). Most of these blooms are caused by dinoflagellates, but some are caused by diatoms. These blooms discolor the water changing it to yellow, orange, pink, brown, or red depending on the organism causing the bloom and the concentration of the organism. In the past, all HABs

were called red tides, no matter what the water color. Today scientists prefer to use the term harmful algal bloom, because it more accurately describes the phenomenon.

Harmful algal blooms have been reported worldwide for centuries. They are naturally occurring phenomena that in some places have been triggered by pollution. They affect marine organisms and can result in large fish kills. HABs are also associated with the five following illnesses: neurotoxic shellfish poisoning (NSP), paralytic shellfish poisoning (PSP), diarrheic shellfish poisoning (DSP), amnesic shellfish poisoning (ASP), and ciguatera.

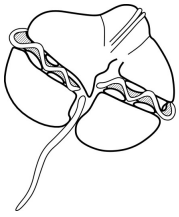
Neurotoxic shellfish poisoning (NSP) is caused by *G. breve.* This dinoflagellate which is responsible for Florida's red tide, is the only HAB organism known to trigger respiratory irritation in humans. Diarrheic shellfish poisoning (DSP) is caused by the dinoflagellate *Dinophysis.* This particular illness has never been verified in the United States. Paralytic shellfish poisoning, a life threatening syndrome, is caused by several dinoflagellates including *Alexandrium*, *Gymnodinium catenatum*, and *Pyrodinium bahamense*. These three illnesses (NSP, PSP, and DSP) are difficult to distinguish, because they have similar symptoms including diarrhea, numbness, dizziness, and disorientation. Humans normally contract these illnesses by eating bivalve shellfish, which as filter feeders concentrate the plankton in their digestive tract. The toxins are then passed on to the consumers. Amnesic shellfish poisoning (ASP) is caused by a diatom, *Pseudo-nitzschia*. Its symptoms include abdominal cramps, vomiting, and disorientation.

Ciguatera is a form of fish poisoning most commonly caused by the dinoflagellate *Gambierdiscus toxicus*. Humans become ill after eating fish that have concentrated algal "toxins" in their bodies. The symptoms include nausea, diarrhea, vomiting, and temperature reversal.

HAB caused illnesses are sometimes difficult to identify, because the symptoms are common and the identification methods are still being refined. Scientists are working today to produce faster more accurate assay techniques to identify the causes of these illnesses to better serve the public.

Florida Red Tide

In 1946 the organism causing Florida's red tide was identified as a dinoflagellate called *Gymnodinium breve*. This organism, measuring only one thousandth of an inch long, reproduces by splitting in two every 48 to 72 hours. It normally exists in concentrations up to 1000 cells per



liter in seawater with relatively few toxic effects. However, a reproductive explosion in response to environmental cues can cause the population to soar, creating a bloom that can turn the water red.

Scientists theorize that *G. breve* **cysts**, a resting stage in the *G. breve* life cycle, may be triggered by seasonal changes in environmental conditions. Cysts are most abundant in offshore sediments. As this cyst resting on the ocean floor is reawakened, thousands of new organisms are produced, flooding the water with more plankton. These organisms infiltrate the water column where they are driven by the winds and spread by the currents. The neurotoxin they produce effectively suffocates fish by inhibiting the respiratory response. Slow moving fish and bottom dwellers seem to be most affected, but the toxins can also kill horseshoe crabs and sea snails. Large fish kills are a public nuisance when they litter beaches and near shore waters.
Reports of manatee deaths have been confirmed as a result of concentrated levels of *G. breve*. This dinoflagellate also causes respiratory problems and neurotoxic shellfish poisoning in humans.

Implications of Harmful Algal Blooms

Since HABs are worldwide phenomena causing a variety of disturbances, scientists are trying to better understand their distribution and biology. Satellite remote sensing imagery is being used to follow HABs and record distribution data that is communicated to appropriate agencies. As this technology becomes more sophisticated, this information could be used to warn coastal communities so that the proper authorities could be prepared to clean up dead fish more efficiently or even intercept the fish at sea before they reach the beaches. Additionally this information can be used to identify shellfish beds that may be affected by the blooms, allowing for efficient purging times to reduce the economic impact on the shellfish industry.

Activity: Growing Algae

Adapted from WOW! The Wonder of Wetlands Environmental Concern Inc.
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Algae, found at the base of the food chain, are good indicators of environmental health. They grow and respond to changes in environmental factors such as sunlight amount, pollution level, or nutrient totals. These tiny plant plankton sometimes respond to environmental cues with population explosions that release toxins into the water. These harmful algal blooms affect the water environment and the organisms that live there. At other times algae respond to changes in nutrient levels with population growth that affects water quality even without the release of toxins.

Objectives: Students will be able to do the following:
1. Observe changes in algal growth in response to nutrient levels.
2. Explain changes in water quality due to algal growth.
3. Assess the potential affects of water quality on a water ecosystem.

Materials:
- Water samples containing algae
- Clear containers for holding samples (5 one quart jars)
- Plant fertilizer such as Peters or Rapid-Gro
- Measuring spoons in either metric or standard measure
- Spoon
- Paper for labels
- Markers for labeling

Procedure:
(This is a two-part observation experiment that takes place over several weeks.)

Prior Set-Up
Water containing algae must be obtained prior to the set-up day. Pond water or water from another natural source works best if it is available. Aged tap water (let it sit for about 48 hours) or tap water seeded with gravel from an aquarium will also work if pond water is not available.

Experiment Set-Up
1. Explain to students that they are setting up model water environments to be used in a later experiment.
2. Have students fill the jars with the water containing algae.
3. Have students add one teaspoon of plant fertilizer to each jar.
4. Have students stir the water thoroughly.
5. Have students put jars in an area with good indirect light. (Make sure that the area is not too cold.)

6. Explain that the plant food acting as a nutrient will help the algae to grow to a point where it can be seen.
7. Allow the algae to grow for about two weeks or until algal growth is evident.

Note: Duplicate jars could be set-up and a discussion of replicates and statistically valid data could be added.

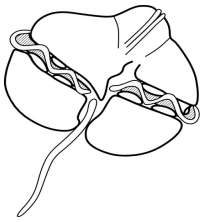
Experiment:

1. Discuss with students the various water parameters that affect algal growth rate such as temperature, sunlight, pH, and nutrient levels.
2. Discuss sources of nutrients and what type of activities would affect nutrient levels in water.
3. Explain that in this experiment only the affects of one variable, nutrient level, will be observed.
4. Have students observe the water in the jars that were previously set-up and record their findings.
5. Have students label one jar as a control. Explain that no additional nutrients will be added to this jar. It will be used for comparison purposes only.
6. Have students label each of the other four jars.
7. Have students add increasing amounts of plant fertilizer to each jar. For instance, jar one could have an additional teaspoon of fertilizer; jar two could have two additional teaspoons, etc. (Be sure labels include nutrient level amounts.)
8. Have students observe the jars over the next two weeks (or longer period) and record their observations.
9. Discuss how nutrient concentration affected growth rate.
   Was there a point at which the nutrient level did not seem to affect growth rate?
   How is this like what happens in nature?
   Where would those extra nutrients come from?
   At what point does a nutrient become a pollutant?

Possible Extensions:

1. In addition to observing algal growth, students record the temperature and pH of each sample.
2. Use another parameter such as temperature, pH or sunlight amount as the variable.
3. Design separate experiments to determine the best pH, temperature, or nutrient level for this particular water sample.

Activity: Algal Explosion



Algae sometimes respond to environmental cues with population explosions. These rapid increases in population can have far reaching affects. Some population increases are accompanied by toxin releases that affect the organisms in the water and the water quality. Fish are particularly susceptible to these harmful algal blooms, because they ingest the toxin as they swim through the water. This can cause an increase in fish deaths over a short period of time.

Objective: Students will be able to demonstrate the effects of harmful algal blooms on fish populations.

Materials:

- Poker chips-at least two different colors (Colored paper or other types of identifiers can also be used if poker chips aren't available.)
- Playing area (open area outside or inside suitable for a walking or running tag game)
- Boundary markers (cones, chalk line, rope, etc.)
- Gym vests or other identifiers for "fish"
- Chart to record data (easel with paper, dry erase board, chalkboard, clipboard, etc.)
- Pen, pencil, marker, etc.

Procedure:

1. Discuss the effects of harmful algal blooms on fish populations and how toxins released into the water may change fish numbers.
2. Explain that in this activity, students will be fish and algae interacting in the ocean (playing field). Remind students of physical safety issues, and let students know if this activity will involve running or only walking.
3. Explain the rules of the activity as follows:
   Algae are trying to get to the finish line without being eaten (tagged) by the fish.
   Tagged algae must show their poker chips to the fish that tagged them.
   If the chip is red, the alga released toxin into the water that killed the fish, so the fish and alga go to the finish line to become algae in round two.
   If the poker chip is not red, the alga was eaten by the fish. In round two the alga becomes a fish.
4. Randomly divide the class into fish and algae. For the first round, in a class of twenty-five students designate about four students as fish.
5. Have students designated as algae, stand along the end of the playing area identified as the starting line.
6. Have students designated as fish; enter the playing field at least halfway between the start and finish lines. Have fish turn their backs to the algae.

7. Have algae close their eyes and give each alga a poker chip. Algae should put the chip into a pocket without looking at it or keep it in a hand. After the chips are distributed, the algae may open their eyes.
8. Once chips are distributed the algae and fish may face each other.
9. On the start signal, algae try to get to the opposite end of the playing field.
10. After each round the number of fish and algae are recorded, and chips are redistributed. (If all fish or algae die, record the results, discuss it, and start again with a new population.)
11. Following the activity with a discussion of the change in population size for both organisms and relate this to what happens in nature. Additional discussions could focus on carrying capacity and how it is affected by environmental factors.

Note to Teachers: The percentage of red chips distributed in each round is up to your discretion. It is suggested that the first rounds have only a few red chips to simulate actual environmental conditions. In the following rounds, some environmental factor can set off an algal explosion.

Possible Extensions:

1. The ratio of algae to fish can be changed to represent various types of environments. For instance, a lone fish may be the only survivor in a sea of algae spreading toxin into the environment.
2. When algae get to the finish line, they choose a card to determine if they have been killed by another factor such as pollution entering the environment or freshwater influx. This would require the deceased to sit out for one round.

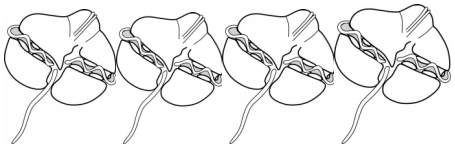
Student Information: Harmful Algal Blooms

Harmful algal blooms (HABs) occur naturally around the world. Microscopic plant-like organisms called algae are always present in seawater in low amounts. Some of these algae contain toxins. Sometimes, when conditions are right, they reproduce rapidly causing a population explosion or “bloom”. There can be millions of these organisms in just one liter of water during this time. These blooms may discolor the water. The water can become yellow, orange, pink, brown, or even red.

Scientists are studying HABs because they cause fish kills and illnesses in humans. Researchers follow a bloom using remote sensing and satellite pictures to determine how far the bloom travels and what area it affects. They also want to know more about the toxin that is released, so they can help people that may get sick after eating toxic seafood. Additionally they want to know how it affects other marine animals such as manatees.

Scientists have been trying to find ways of controlling or eliminating HABs. Right now it is too costly to remove a bloom that covers thousands of square miles. There also may be positive results following a bloom. Even though some fish are killed, other populations seem to increase. After a bloom, fishermen have reported higher catches of crabs and other animals. Scientists know that blooms add more food to the food chain and remove some weaker species. It seems that nature has a way of balancing itself when populations get too big. Scientists think that HABs may be one of nature’s control mechanisms in the ocean just as wild fires are control mechanisms on land.

We have a responsibility as a global community to be sure that whatever we do has positive effects on the environment.



Red Tide Vocabulary

Cyst-a capsule-like resting stage of some algae; seed

Diatom-microscopic plant-like organisms having cell walls made of silica

Dinoflagellate-microscopic plant-like organisms having two flagella

Flagella-whip like extensions of unicellular organisms used for locomotion

Frustule-a cell wall made of silica and composed of two parts

Harmful Algal Bloom (HAB)-the proliferation, as population explosion, of harmful or toxic nuisance algae

Photosynthesis-the chemical process by which plants make their own food; the process uses carbon dioxide, water, nutrients, and sunlight

Phytoplankton-minute, free-floating aquatic plants

Plankton-small or microscopic plants and animals that float in the water

Toxin-poison produced by an organism

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