Eyes on Harmful Algal Blooms

HAB Detectives

Goal

- For students to understand the effects of harmful algal blooms on the Chesapeake Bay.
- For students to use the Eyes on the Bay website to analyze information on harmful algal blooms.

Voluntary State Curriculum

6-8th Grade

Social Studies

2.0 Geography: A.1.a. Using geographic tools, describe distribution of natural resources & modifications to the environment; 4.a. How humans modify their natural environment (water use; economics of modified environment); and, b. (consequences of modifying the environment).

3.0 Economics: 6 (b) Public health issues.

Science

1.0 Skills & Processes (all)

3.0 Life Science: A. Diversity of Life (b) Plants make food; E. Flow of Matter & Energy. c. (photosynthesis); e. decomposition; f. (water cycle; nitrogen cycle); F. Ecology: a. (fluctuations in populations due to environmental conditions; b. (limiting factors of environment – including disease); c. (competition for resources).

[With Extension activity involving the use of microscopes, meets 3.0 Life Science B. Cells 1. a-e form & function of plant & animal cells].

6.0 Environmental Science: 1. A. Natural Resources & Human Needs 1. Impact of human population on environmental quality B. Environmental Issues - How humans accelerate changes (fertilizers & wastes).

Grades 9-12

Government/History

Government 1.3 (pollution issues; health care & disease); & 3.1 (environmental issues);

U.S. History 6.2.1 (impact of urban sprawl);

[Potential exists to meet U.S. History 5.2 (Clean Water Act; regulations by the Environmental Protection Agency.]

Science

Goal 1 Skills & Processes

Goal 2 Earth Science: 2.1.1 Current technology to study the atmosphere, land and oceans; 2.5 Connect prior understanding & new experiences to evaluate natural cycles (all).

Goal 3 Biology: 3.5 (interdependence); 3.6 (investigate a biological issue).

Student Learning Objectives

1. Students will be able to describe harmful algae and their relative distribution in the Chesapeake Bay and tributaries;
2. Students will be able to describe how algae are harmful to aquatic organisms and people;
3. Students will be able to identify and describe factors that contribute to algal blooms;
4. Students will apply what they have learned during the investigations to identify ways to lessen algal growth.

Time

- 3 50-minute period

Materials

- Internet access to the Eyes on the Bay website (www.eyesonthebay.net)

Overview

Students will begin this lesson by using the Eyes on the Bay website to learn about the causes and effects of harmful algal blooms (HABs). Once they have a general understanding, students will use an interactive movie to explore HABs that occurred in the Chesapeake Bay in 2003.

Once students have used the movie to learn about harmful algal blooms in 2003, they will apply what they have learned to the current year in the Chesapeake Bay. Using the Eyes on the Bay website, they will look for recent harmful algal blooms and examine the conditions of the bay prior to a bloom event.

Science Understanding for Teachers

Algae are an important part of the Chesapeake Bay ecosystem. Like land plants, algae photosynthesize and oxygenate the water during the daytime (at night algae consume oxygen through the process of respiration). Aquatic algae are the primary producers (photosynthesizers) of the estuarine environment. Aquatic algae are generally classified as either macroscopic (seen by the human eye) or microscopic. Macroscopic algae, commonly referred to as macroalgae or seaweeds, are large plant-like structures commonly found growing on bottom sediments. Microscopic algae are known as phytoplankton and are found floating in the water column. Macroalgae and phytoplankton can both bloom, but the term "algal bloom" typically refers to a rapid increase in the number of algal cells that dominate the planktonic community.

Water, sunlight carbon dioxide and nutrients are necessary for algae to grow and for the process of photosynthesis to occur. Carbon dioxide and water are plentiful in the aquatic environment, but the amounts of sunlight and nutrients can vary greatly. The amount of sunlight varies seasonally and regionally. Sunlight is only available near the water's surface (the photic zone), so algae only occur in surface waters. Nutrients in the aquatic environment can range from scarce to excessive. When nutrients are scarce algae growth is limited, but when nutrients are abundant algae can bloom to very high levels. Excess nutrients can enter the aquatic environment when storms wash fertilizer off farms and lawns, when wastewater systems overflow, when septic systems fail, or from other sources of runoff. The input of excessive nutrients, primarily nitrogen, into an estuary can lead to an overabundance of algae. This process is known as eutrophication and is a common problem in the Chesapeake Bay, which has lead to an increase in the number of harmful algal blooms (HABs) observed.

Naturally occurring algal blooms can become harmful if they reach exceedingly high levels, or if the algae produce a toxin. However, not all HABs are toxic. HABs can prevent sunlight from reaching underwater bay grasses and can interfere with the feeding of shellfish and other organisms that filter water to obtain their food. HABs can also cause nighttime oxygen levels to plummet (during respiration), potentially resulting in fish kills. Dying algae can also settle on bottom sediments and smother the organisms that live in and on those sediments. Some algal species can also produce chemicals that are toxic to humans and aquatic life. There are many algal species in the Chesapeake Bay that are considered harmful, particularly when they reach high levels. However, of the more than 700 species of algae in the Chesapeake

Vocabulary

Bioaccumulate -- storage of chemicals in an organism in higher concentrations than are normally found in the environment.

Consumer -- uses the producer for its food; it may in turn be used as food by a secondary consumer.

Food chain -- transfer of food energy from one organism to another as each consumes a lower member and in turn is preyed upon by a higher member.

Food web -- an interlocking pattern of food chains.

Harmful algal bloom (HAB)-- excess algae that makes the water turbid or blocks ultraviolet light. Some blooms produce toxins that are harmful to aquatic life and humans.

Non-point source pollutant -- comes from many diffuse sources. Runoff picks up and carries away pollutants, depositing them into water bodies.

Nutrients -- forms of Nitrogen and Phosphorous required for plants and animals to grow and survive.

Photosynthesizers -- an organism that uses light to generate the energy it needs to fix carbon dioxide.

Point source pollutant -- pollutants discharged from an identifiable point, including pipes and containers.

Producer -- green plant or bacterium that uses photosynthesis or chemosynthesis; first level in the food chain.

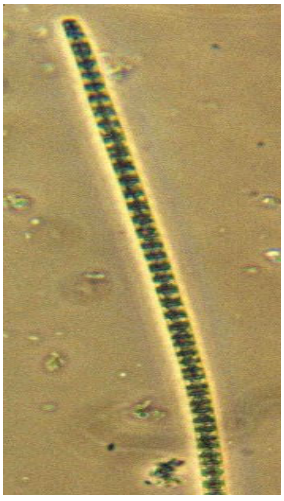
Septic system -- water and sewage that is disconnected from a municipal system. It is usually comprised of a tank that treats the sewage and, a leachfield for disposal.

Turbidity -- the amount of solid particles that are suspended in water and that cause light rays to scatter.

Before you Begin...

- *Visit the Eyes on the Bay website to see if there have been any recent algal blooms that you want to highlight for the students. Recent HABs will be represented by purple diamonds.*
- *Review the following concepts: algae, decomposers, food chain, food web.*
- *If you decide to do the extension activity at the end, check to see how long it will take to collect algae on your samples. Time will vary depending on location and season.*
- *To prepare your students, try these activities:*

- *Micro Odyssey (Project WILD Aquatic)*
- *Blue-Ribbon Niche (Project WILD Aquatic)*
- *Energy Pipeline (Project WILD)*
- *What's For Dinner (Project WILD)*



Bay, less than 3% of them have ever been considered harmful.

In toxic algae, it is common for the toxins to affect the functioning of nerve and muscle cells. These toxins may also cause skin and respiratory irritation, diarrhea, vomiting, numbness, dizziness, and paralysis. So, how can a tiny microscopic organism cause so much trouble for aquatic life and humans? The answer is bioaccumulation. Bioaccumulation is an increase in the concentration of chemicals in successively higher trophic levels of the food chain. These toxins accumulate faster than they can be broken down. A phytoplankton cell may contain only a tiny amount of toxin, but a copepod eats dozens of phytoplankton cells a day. A fish may eat hundreds of copepods in one day, and a larger fish may eat several fish in one day. Some of the organisms that ingest toxic algae may not be affected, but will retain the toxins in their bodies to be passed up the food chain.

Humans are affected by toxic algae through the consumption of contaminated fish and shellfish, or through direct contact with or ingestion of water containing toxic algae. Toxic algae can cause illnesses such as Ciguatera Fish Poisoning, Diarrhetic Shellfish Poisoning, Paralytic Shellfish Poisoning, and even death.

Engage

Part 1: What's that HAB?

1. Ask students if they have ever seen a cluster of dead fish in the Chesapeake Bay or in a stream. In what season did they see this? Have they ever been on the Bay or in one of the tributaries and seen a green or rusty hue to the water? Have they ever planned a trip to the beach only to discover signs posted warning of swimmer's itch? If so, they may have witnessed an algal bloom.
2. If you haven't already done so, review what algae is, how they are primary producers and how they serve as the base for the food chain in an estuarine environment. Tell students that they will be learning about algal blooms and their effects on the Chesapeake Bay.

Explore

Group Work or Pairs

3. In pairs or small groups, have students visit the Maryland DNR website Phytoplankton page. From the home page, they should click on:

- "Frequently Asked Questions" in the right side-bar.
- Have students read: "What are Harmful Algae?" and "How Have Harmful Algae Affected Maryland?"
- They can also visit some of the other page links to find out more about some of the more common types of algal blooms in the Chesapeake Bay watershed.

Reading for Understanding

Have students answer the following questions:

a. How does algae support aquatic life?
b. What makes algae harmful?
c. What types of aquatic life is harmed and how?
d. What causes algal blooms?
e. Provide some examples of economic impacts of HABs.
f. Choose one type of bloom described on the website. Describe it in detail. If you can find a picture of it, draw a sketch.

Did You Know...

Oceans are important sinks (storage deposits) of carbon? Calcium carbonate ($CaCO_3$) is used to make shells, which eventually fall to the ocean floor. After millennia, these deposits resurface through geologic processes as limestone deposits.

Explain

1. Discuss the questions and students' answers as a class. Students should add to their answers as class members provide new information. If you have time, have each pair of students present their sketch and describe the bloom to the rest of the class. Have students post their sketches around the classroom.

2. Start with a type of harmful algae (you might select one a student identified and described above). Have students identify different aquatic organisms (or even people) that are impacted by this algae. Take a ball of string, and pass it from student to student as they identify the connections (e.g., food web, economics, etc.) between harmful algae and other organisms. They should see that algal blooms have

an impact on a variety of living organisms as well as on people.

Explore

Part 2: 2003 HABs in Maryland

In this activity, students will use an interactive Flash movie on the Eyes on the Bay website to learn how HABs plagued the Chesapeake Bay in 2003.

1. As a class, review the following concepts with students:

- Algae
- Harmful algal bloom
- Water quality parameters
- Nitrogen
- Turbidity (for detailed information, see the Eyes on the Bay **Dissolved Oxygen** lesson)

Small Groups

2. Tell students that in this next activity they will work in small groups to explore the Eyes on the Bay website and an interactive movie reviewing the 2003 HABs in the Chesapeake Bay. From Eyes on the Bay (www.eyesonthebay.net) the movie can be found under **Lesson Plans**. The students will need to use the website and the movie to answer the following questions:

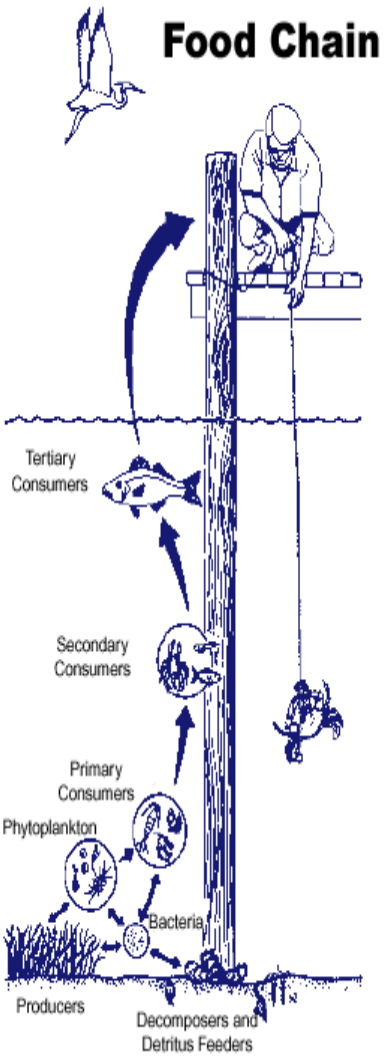
    1. Use the "Eyes on the Bay" website to determine the general range of salinities of where *Prorocentrum* occurred in 2003 and the general range of water temperatures when *Prorocentrum* disappeared from the Bay. (Hint: Use salinity data from the fixed monthly stations (red squares on the map).

    2. Search the Eyes on the Bay publications database to find when *Prorocentrum* first occurred in 2001 and 2002, versus 2003. Eyes on the Bay Publication Database (Hint: Search by each Year and 'Prorocentrum').

3. Find fixed monthly station TF2.4 on the Potomac, near the site of the 2003 *Microcystis* bloom. What was the salinity during the bloom in September?

4. On the "Late May" slide in the presentation, visit the link taking you to options to choose various maps. http://eyesonthebay.dnr.maryland.gov/sim/Dataflow.cfm

   Select the Lower Patuxent 5/27/03 map and note overall trends in dissolved oxygen and turbidity when algal blooms were in full progress.



Explain

3. Now students will be asked to think critically and identify trends in algae blooms. Facilitate a discussion to assist students in answering the following questions:

5. What was the yearly progression (time periods) of major blooms in Maryland's Chesapeake Bay?

6. What was the spatial distribution in the Bay of the three types of blooms?

7. What were the locations of the largest blooms for each three HAB species?

8. Describe several impacts harmful algal blooms had on aquatic organisms or people during the season (April – September) in 2003. Why do you think hurricane Isabel ended the algae bloom season in 2003?

Part 3 - HABs on the Bay

Re-Engage

Review some concepts with students:

- What is algae?
- How role does algae play in the aquatic ecosystem?
- What is bioaccumulation?
- What causes algal blooms? Are they always toxic?

Explore

Pairs or Small Groups

Have students visit the Eyes on the Bay website. A recent bloom will be indicated by a **purple diamond**. Algal blooms generally occur between April and September. If there are any recent algal blooms, have them visit that site(s) to find out more about it.

If there is a bloom, have them identify:

- Where is it?
- What kind of bloom is it?
- Under what conditions did it occur (i.e. what was the weather like the previous one or two weeks)? *Note: this is difficult even for scientists to determine at times!*

Important Note: ***Harmful algal blooms can be toxic to fish and humans. The State operates a 24-hour Hotline at (888) 584-3110, in order to receive reports from the public regarding algal blooms, fish kills, and sick fish. The public and physicians are also asked to call this number in the event of human illness believed to be associated with algal blooms and fish kills.***

Explain

1. Students should browse the site to read about HAB events throughout the Bay. If the information is available, they should pay particular attention to the **dissolved oxygen** and **chlorophyll** levels.

If they find information about dissolved oxygen and chlorophyll have them identify:

- Why might these parameters be indicators of algal blooms?

2. Also, have students look at some of the monitoring stories related to HABs, and answer the following questions: "How do algal blooms impact other plants and

animals in Maryland?" "How do algal blooms impact people and pets?" "What can be done to reduce algal blooms?"

- Visit: http://dnr.maryland.gov/waters/bay/Pages/cblife/algae.aspx ...and read about:
  - *Chattonella* under "Radiophytes"
  - *Microxystis aeruginosa* under "Cyanobacteria"
  - *Pfiesteria* under "Dinoflagellates"

Extend

We suggest using the following activities to extend this lesson:

Sum of the Parts (Project WET) - Students demonstrate how everyone contributes to the pollution of a river as it flows through a watershed and recognize that everyone's "contribution" can be reduced.

Water Quality Windows (Healthy Water, Healthy People) - Students explore the different water quality ranges required by organisms by interpreting data; sorting and classifying organisms according to their requirements; and applying their knowledge to determine how changes in water quality affect organisms.

Back to the Future (Project WET) - Students analyze streamflow monitoring data to determine the safest location for a future community.

Whose Problem Is It? (Project WET) – Students analyze the scope and duration of a variety of water-related issues to understand the relationship between local and global issues.

There Is No Point to This Pollution! (Healthy Water, Healthy People) - In this activity, students analyze data to solve a mystery, interpret a topographical map, and analyze and compare water quality data to learn about the cumulative impacts of nonpoint source pollution.

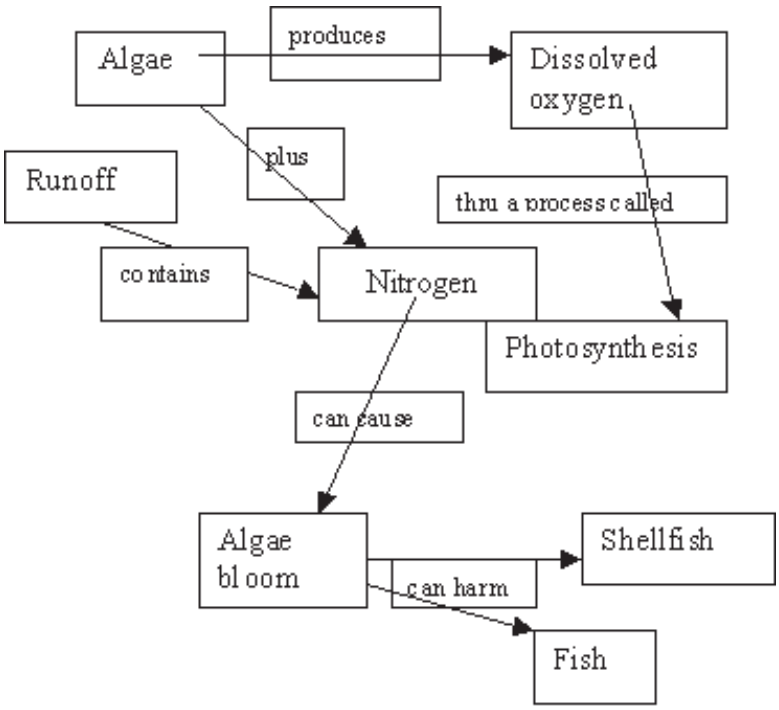
Evaluation

1. On a sheet of paper, have students construct a concept map using the following terms:

- algae
- nitrogen
- water
- water quality
- algae bloom
- harmful algae bloom
- toxic
- runoff
- dissolved oxygen
- photosynthesis
- human health
- shellfish
- fish

These words should be connected by phrases such as: caused by, relies on, forms, etc. In one or two paragraphs, have students explain their concept map. They may use examples of activities they've done or information they found on the Eyes on the Bay website.

2. An alternative assessment would be to have students draw a food chain in the Chesapeake Bay. Have them explain the role that algae plays and how a HAB effects the food chain. See the example of a HAB concept map below.



Extensions

All About Algae (Developed by ANSERC — see Resources section)

- Using half of a Styrofoam plate (grocery stores may donate some meat trays), insert two microscope slides, back to back through the plate.
- Using a string, attach a weight to the Styrofoam. Tie a string to the top of the plate and place in a secure area in a pond, stream, off a dock, or anywhere in the water. Tie it to a stationary object so it won't float away. Leave for at least two days.
- Place the slides under a microscope and have students look at all the phytoplankton and zooplankton. Have them compare slides that were in different places.
- Hint: use a small amount of club soda to slow down the specimens.

Resources

Introduction to an Ecosystem
Chesapeake Bay Program
http://www.chesapeakebay.net/ecointr6.htm

Project WET and Healthy Water, Healthy People
Cindy Etgen, Maryland State Coordinator
410-260-8716
cindy.etgen@maryland.gov
http://www.dnr.maryland.gov/education/projectWET.html

Academy of Natural Sciences Estuarine Research Center
Lloyd Jenkins, Outreach Coordinator
410-586-9717
jenkins@acnatsci.org
http://www.acnatsci.org/research/anserc

National Oceanic and Atmospheric Administration (NOAA)
1998 State of the Coast Report
http://oceanservice.noaa.gov/websites/retiredsites

Environmental Protection Agency
Nonpoint source pollution
http://www.epa.gov/owow/nps

Name _____

Part I – What's that HAB?

In this investigation, you will learn about algae and how it affects the Chesapeake Bay. You will learn different factors that cause algal blooms, and grow algae yourself!

To begin, you will visit the Eyes on the Bay website: www.eyesonthebay.net and do some background reading and watch a short movie about a past algal bloom event.

Directions: Visit the Eyes on the Bay website: www.eyesonthebay.net
Click on "Monitoring news and reports"
Click on "Harmful algal blooms"
Scroll down to the middle of the page and read:
(1) "*What are Harmful Algae?* and,
(2) "*How Have Harmful Algae Affected Maryland?*"

Answer the following questions:

1. How does algae support aquatic life?

2. What makes algae harmful?

3. What types of aquatic life is harmed and how?

4. What causes algal blooms?

5. Provide some examples of economic impacts of HABs.

6. Choose one type of bloom described on the website. Describe it in detail in the space below. If you can find a picture of it, draw a sketch.

Part 2: 2003 HABs in Maryland

2003 was the second wettest year on record in Maryland and we experienced colder than normal weather to start the year. As a result, water temperatures were at or near their historic lows during the spring.

During this exploration, you will work in small groups to explore the Eyes on the Bay website and an interactive movie reviewing the 2003 HABs in the Chesapeake Bay.

Directions: From Eyes on the Bay (www.eyesonthebay.net) the movie can be found under **Lesson Plans**. Use the website and the movie to answer the following questions:

1. Determine the general range of salinities of where *Prorocentrum* occurred in 2003 and the general range of water temperatures when *Prorocentrum* disappeared from the Bay. (Hint: Use salinity data from the fixed monthly stations (red squares on the map).

   Range of salinities: _____
   Range of water temperatures: _____

2. Search the HAB database to find when *Prorocentrum* first occurred in 2001 and 2002, versus 2003. http://eyesonthebay.dnr.maryland.gov/eyesonthebay/stories.cfm (Hint: Search by Year and Prorocentrum).
   2001 _____
   2002 _____
   2003 _____

3. Find fixed monthly station Quantico - TF2.4 on the **Potomac**, near the site of the 2003 *Microcystis* bloom. Use the Long Term Data Download page to determine: (http://eyesonthebay.dnr.maryland.gov/bay_cond/LongTermData.cfm)

What was the salinity during the Microcystis bloom on the Potomac, September, 2003?

Salinity:_____ _____

_____

4. On the "Late May" slide in the movie presentation, visit the link taking you to options to choose various maps.
   http://eyesonthebay.dnr.maryland.gov/sim/Dataflow.cfm
   Select the Lower Patuxent 5/27/03 map and note overall trends in dissolved oxygen and turbidity when algal blooms were in full progress.

   Dissolved oxygen:

   Turbidity: