Lesson #3: Phytoplankton and Ocean Color

Introduction/Rationale/Background

Satellites are able to collect four types of ocean data: sea surface temperature, sea surface height, ocean color, and ocean roughness. Ocean color is affected by the amount of phytoplankton (algae) present. The greener the ocean, the more phytoplankton present; the bluer the ocean, the less phytoplankton there are. (Therefore, the beautiful blue of tropical waters actually signifies low productivity.) Phytoplankton hold such significance because they are the beginning of the food chain and they are early indicators of climate change since they depend on specific conditions for growth.

Phytoplankton live in the surface, sunlit waters of the ocean. When they grow and reproduce, they absorb CO_2 and other chemicals from the water. When large phytoplankton blooms occur, the surface waters lose CO_2. This disturbs the previous equilibrium between ocean and atmosphere, and the ocean replenishes its CO_2 by absorbing more from the atmosphere. This process is one of many processes that affect the concentration of carbon in the atmosphere and indirectly may play a role in the greenhouse effect.

Lesson Concepts and Skills

Phytoplankton - microscopic green plant component of the plankton that is responsible for most of the photosynthetic activity in the ocean

Materials

Chart paper, one piece per group of four or five students
Markers for use on chart paper, one per group
Masking tape or magnets
Copies of the "Phytoplankton Farming" packet for each student
Wax pencils (or masking tape and a pen)
Two containers 250-500 mL, either clear glass or plastic
Eye droppers
Algae sample (from an aquarium, pond, or scientific supply company)
Liquid plant fertilizer
Water
Aluminum foil cut into 10 cm x 10 cm square pieces, two per group
Sunny classroom location

Green paint samples from a home improvement store's paint department, for each group
Copies of "Phytoplankton Facts" for each student
Computer with a projector
Beaker
Healthy potted plant with leaves
Petroleum jelly
The following are used in the "Extension" simulation "Blooming Algae." Decide whether it will be a teacher demonstration or group activity.

- 500 mL beaker or large glass vase
- Approximately 120 mL ($\frac{1}{2}$ c.) light brown sugar
- Approximately 60 mL ($\frac{1}{4}$ c.) light corn syrup
- Candy creatures (gummy worms, gummy fish, or gummy lobsters)
- Cold water
- Approximately 120 mL ($\frac{1}{2}$ c.) cooking oil
- Approximately 60 mL (4 Tbsp.) Green decorative sugar

Poster or color transparency of "Carbon Cycle" diagram
Copies of "Ocean Color Evaluation" for each group of four students

Management/Preparation
Consider having students set up the "Phytoplankton Farming" experiment two weeks before this lesson so that instruction may take place in one class period.

Algae must be disposed of responsibly. Do not allow students to pour the algae cultures down the drain once the exploration activity is complete. Microwave the cultures until they boil (no harm will be done to the microwave). Once cool, pour down the drain. An alternate method for disposal is to add bleach to the cultures to make a 1% solution. Let them sit overnight, then pour them down the drain with plenty of running water.

Teaching Strategies Employed
Cooperative learning
Guided discovery

Time Frame
Two weeks for the Exploration activity, one class period for the remainder of the lesson

Target Audience
Grade five

National Science Content Standards
As a result of activities in grades 5-8, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

As a result of activities in grades 5-8, all students should develop an understanding of populations and ecosystems.

Behavioral Objectives
Students will identify function of phytoplankton in the biosphere by conducting experiments and simulations and reading for information.

Students will detect the presence of phytoplankton in bodies of water by examining ocean color in satellite images and classroom models.

Engagement
Divide students into groups of four or five. Distribute chart paper and markers to groups. On the chalkboard, draw a web with the word "Plants" in the center and four branches sprouting from it. Label the different branches "Appearance," "Basic Needs," "Where They Grow," and "Size and Shape." Instruct students to copy the web onto their chart paper. Tell students to brainstorm facts they know about plants and fill in the appropriate part of the web. Allow ten minutes for this activity and circulate to assist students. (If necessary, jumpstart the activity by filling in one or two items on the chalkboard example web so that students understand what you are looking for.)

Stop the class after ten minutes, or when the bulk of their ideas are on paper. Provide masking tape or magnets to each group and have them secure their web to the chalkboard/wall. Next, tell the groups to select a spokesperson. One by one, have the spokespeople share their web while the rest of the class listens. At this point in the lesson, do not correct students' mistakes on the web. The focus of the lesson is to teach them about plants in an unfamiliar setting – the ocean.

Leave the webs on display. They will be used again later in the lesson.

Exploration

Distribute "Phytoplankton Farming" packet to students.
(This experiment takes place over the course of one to two weeks, so it might be beneficial to have students begin before the official phytoplankton lesson is taught.)

Once the students have completely carried out the experiment and have written conclusions, hold a class discussion to review results and observations. Do not correct any responses until students have read about phytoplankton in the "explanation" section of the lesson.

Explanation

Distribute copies of the "Phytoplankton Facts" sheet to all students. Read and discuss as a class.

Visit http://svs.gsfc.nasa.gov/vis/a010000/a010000/a010030/index.html to see an animation of upwelling.

Review the basic needs of plants (sunlight, nutrients, carbon dioxide) and reinforce the fact that phytoplankton share those needs. Refer back to the "Phytoplankton Farming" activity. Ask students what made the phytoplankton/algae grow so much in the one sample. (Nutrients, or fertilizer.)

To illustrate the fact that plants, and therefore phytoplankton, "breathe," carry out these simple demonstrations. (Try to conduct both demonstrations simultaneously, if possible, to save time.) About 45 minutes before class begins, fill a beaker with water and drop a healthy, freshly gathered leaf into it. Place it in a sunny location by a window. It should remain there until the container feels warm, about one hour. Allow students to observe using a hand lens. They should see small bubbles on the surface of the leaf and the inside of the beaker.

For the second demonstration, find a healthy potted plant. Select one leaf to cover with petroleum jelly. Be sure not to remove the leaf from the plant and to cover both sides of the leaf. It should eventually turn yellow and die.

Ask students how the bubbles got on the leaf and the beaker in the first demonstration. (Leaf released a gas while under water.) Tell students that the bubbles contained oxygen. Plants need carbon dioxide to live and they release oxygen into the atmosphere.

Ask students to explain what happened in the second demonstration. (The petroleum jelly suffocated the leaf so that it could not take in carbon dioxide or release oxygen. Chlorophyll makes food for the plant and gives leaves their green color. Since the leaf could not make its own food, it quit making new chlorophyll and turned yellow.)

Teach students that phytoplankton (along with grass and trees on land) play an important role in the carbon cycle by removing some of the excess carbon dioxide from the atmosphere. Display the carbon cycle diagram (below) and explain.

Extension

Conduct the "Blooming Algae" simulation. Decide whether to conduct this as a teacher demonstration or, if the materials are available, allow students to carry out the simulation in groups.

For extra credit, allow students to work in a group and visit the site http://earthobservatory.nasa.gov/Study/PrecisionFarming/. They should read about the way farmers are using satellites to aid in maintaining their farmland. Instruct groups to write a summary of the article once they have read and discussed it. (Caution: all but the first page is a bit technical. Be sure to preview so that you may decide its appropriateness for your students' abilities.)

(Gifted and talented extension: In the computer lab, direct students to visit http://www.bigelow.org/hab/color.html. They should read the information on the page, focusing in particular on the "ocean optics" and "scattering and absorption" sections rather than the "harmful algae blooms.")

Evaluation

Have students collect the web from the "Engagement" portion of the lesson. Distribute a contrasting color marker from what they used earlier. Tell them to read what they wrote on the webs and make corrections and additions to the content. If you wish, have the spokesperson share these corrections with the class, or simply have students hang the webs again so that all may see.

Ask students to brainstorm with a partner some negative outcomes of a phytoplankton bloom. (Blocking the sunlight from the bottom of shallow areas of the ocean which kills sea grasses - food for fish and other creatures. Decaying phytoplankton blooms eventually strip the water of oxygen.)

Have students work in groups to complete the Ocean Color Evaluation paper.

Assessment

Use the rubric below to evaluate students' progress throughout the lesson.

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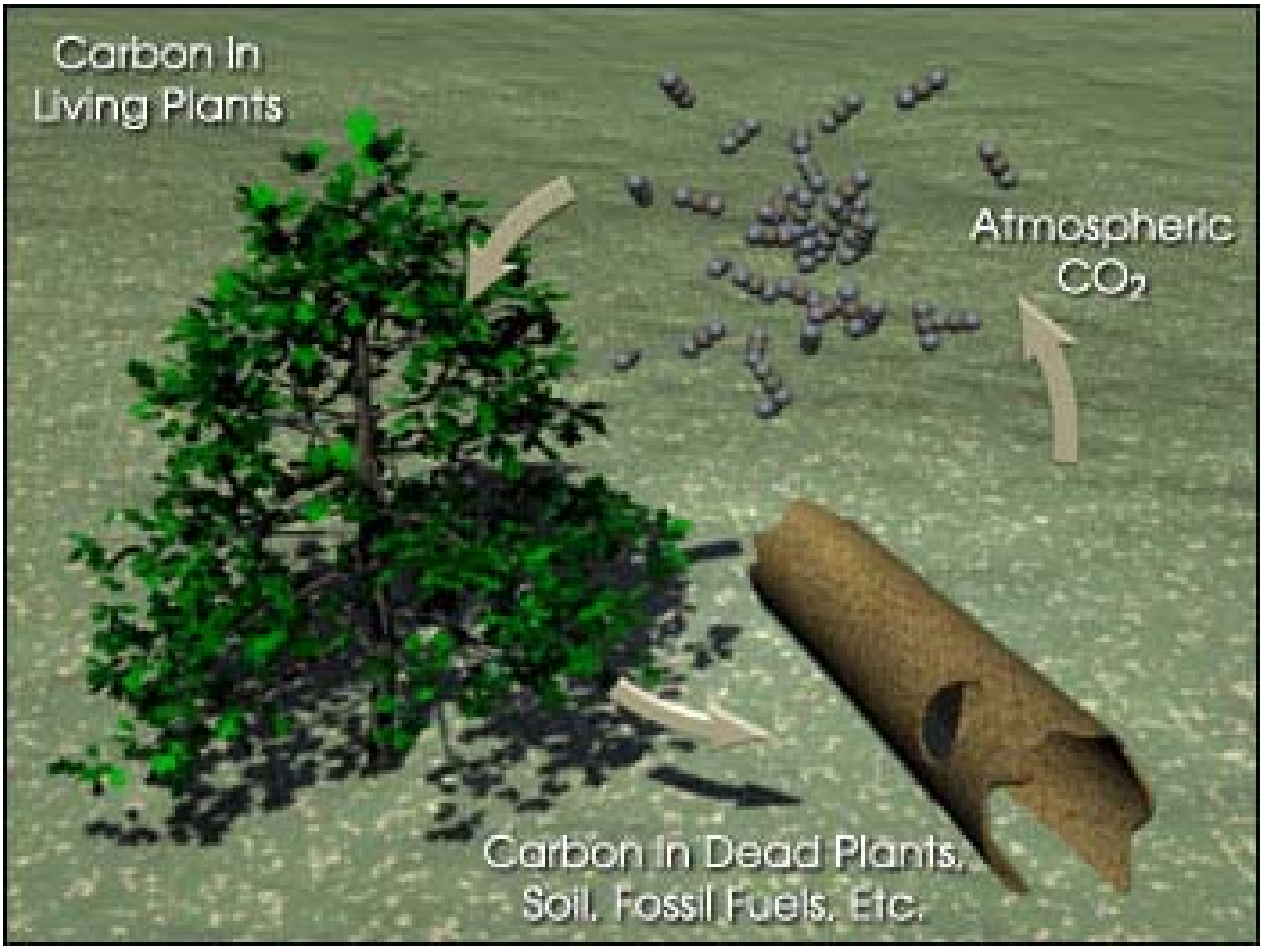
Phytoplankton and Ocean Color Rubric

Concentration	***Points Possible***	***Points Earned***
Student demonstrates a fundamental understanding about plants, namely: • Basic needs are carbon dioxide, sunlight, and nutrients (phosphorus, nitrogen, iron, etc.) • Can be microscopic, like phytoplankton, or enormous, like giant redwoods. • Oftentimes are green (because of chlorophyll) • Can grow in the ocean or on land, given the right conditions	8	
Students followed directions to correctly carry out the Phytoplankton Farming and Blooming Algae activities.	4	
Students worked cooperatively.	4	
TOTAL	16	

Carbon Cycle Diagram



Phytoplankton Farming activity

(Modified from "Building a Bloom" http://www.bigelow.org/edhab/building_bloom.html)

Question/Problem

Does adding nutrients to water affect living things, namely phytoplankton?

Hypothesis

After adding nutrients to water, I predict that _____ _____ because _____ _____.

Materials

Wax pencils (or masking tape and a pen)
Two containers 250-500 mL, either clear glass or plastic
Eye droppers
A few drops of the phytoplankton sample
Liquid plant fertilizer, "Nutrients"
Water
Aluminum foil
Sunny classroom location
Paint samples

Procedure

1. Write your group's name on the containers, either with the wax pencil or on masking tape. One should be labeled "Control," the other, "Nutrients."

2. Add an equal amount of water to both containers.

3. Add an equal number of drops (just a few) of the phytoplankton sample to both containers.

4. Cover the top of the "Control" container with a piece of aluminum foil.

5. Add a few drops of the liquid plant fertilizer to the "Nutrients" container.

6. Cover the top of the "Nutrients" container with a piece of foil.

7. Place the containers in a sunny window so that the light and temperature conditions are the same.

8. Every two to three days, make observations about the color and smell of the phytoplankton in the containers. Write your observations on the "Data" table on the next page.

DATA

	Date:	Date:	Date:	Date:	Date:	Date:
Control **General Observation** What do you see? What looks different?						
Nutrients **General Observation** What do you see? What looks different?						
Control **Smell** (Don't use opinions, be scientific and objective.)						
Nutrients **Smell** (Don't use opinions, be scientific and objective.)						
Control **Color** (Use paint sample cards.)						
Nutrients **Color** (Use paint sample cards.)						

Conclusions

Answer in complete sentences.

1. Was your hypothesis correct? Explain.

_____

_____

_____

2. What do you think phytoplankton is another name for?

_____

3. What had the biggest effect on the phytoplankton?

_____

_____

_____

Phytoplankton Facts

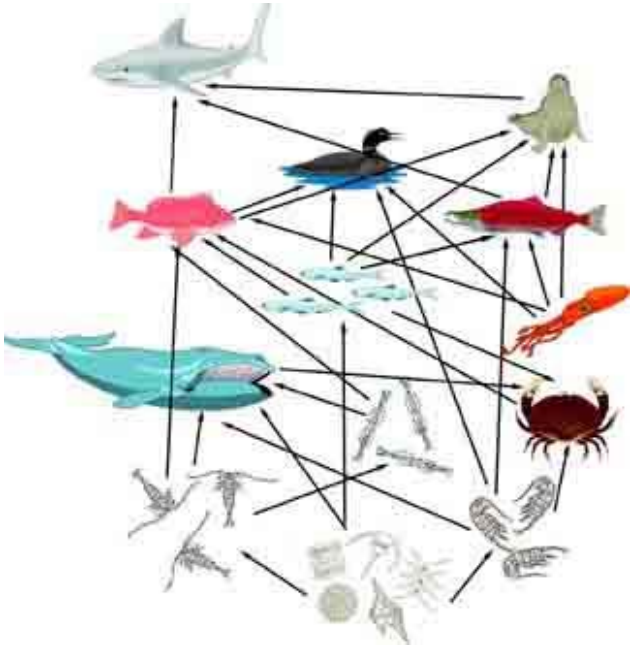
Phytoplankton are microscopic floating plants that live in the ocean all over the world. A teaspoon of sea water can contain as many as a million one-celled phytoplankton.

PLANKTON

http://www.bigelow.org/flowcam/flo_r2.html

They require sunlight, water, carbon dioxide, and nutrients for growth and are only found in the ocean's upper zones. Phytoplankton are the base of the ocean's food web, so they support almost all things that live there.

Marine Food Web



Phytoplankton are eaten by swarms of tiny, drifting animals, called zooplankton that, in turn, are eaten by small fish, such as herring. Herring are eaten by larger fish, such as dogfish, which are then eaten by even larger fish or dolphins. Whale sharks and blue whales feed directly on zooplankton.

Studying phytoplankton is important because the world's fish stocks are affected by how much plankton there is for young fish to eat. More importantly, some scientists believe that phytoplankton can have an effect on the gases trapped within our atmosphere that change Earth's climate. All of the world's phytoplankton create at least half of the oxygen that we breathe. Scientists who use satellites to study ocean color are really looking at phytoplankton. There can be so many phytoplankton in one area that they actually change the water to green! From outer space, satellite sensors can distinguish even slight variations in color to which our eyes are not sensitive. Different shades of ocean color reveal varying concentrations of phytoplankton.

Basically, there are five essential reasons why scientists monitor phytoplankton:

1. *They are the very beginning of the food chain in the ocean.* Microscopic animals (zooplankton) eat the phytoplankton; then they are eaten by larger zooplankton, which are eaten by fish, and by the blue whale.
2. *Their basic needs are the same as a plant on land: light, water, CO_2, and nutrients.*
3. *The places phytoplankton are sensed by satellites tell scientists where the ocean is full of nutrients.*
4. *Many animals depend on phytoplankton.* If they disappear, the entire food chain is affected.
5. *Phytoplankton are extremely important in converting carbon dioxide from the atmosphere into oxygen.*

Bloom off Newfoundland in the Western Atlantic on July 21, 1999

Many times, the nutrients that phytoplankton need come from upwelling, which is when water from the deeper parts of the ocean mixes with the surface water and brings with it nutrients that had sunk to the bottom. Other times, nutrients come from land sources, such as sewage runoff or farming fertilizers.

Blooming Algae activity

Materials

500 mL beaker or large glass vase
Approximately 120 mL (½ c.) light brown sugar
0.5 cm x 5cm strips of green "Fruit by the Foot" snack or "Fruit Roll-Up"
Approximately 60 mL (¼ c.) light corn syrup
Candy creatures (gummy worms, gummy fish, or gummy lobsters)
Cold water
Approximately 120 mL (½ c.) cooking oil
Approximately 60 mL (4 Tbsp.) Green decorative sugar

Procedure

1. Put a layer of brown sugar (about 1 cm thick) at the bottom of the beaker or vase. Place one end of the strips of the green fruit roll snack into the brown sugar. These represent sea grass.

2. Add the corn syrup until it covers the brown sugar. These two layers represent the bottom of the ocean.

3. Place a gummy creature on the brown sugar near the side of the container so that you can make observations.

4. Gently add the water until it is 6-8 cm deep. You should see some air bubbles rising from the bottom since it is a healthy environment.

5. Add a 2 cm layer of cooking oil so that it creates a top layer. This layer is called the ***photic zone*** because it receives the Sun's light.

6. The green sugar represents healthy phytoplankton that are getting enough sunlight, carbon dioxide, and nutrients. SLOWLY sprinkle a small amount of the phytoplankton onto the photic zone. Observe what it does.

7. Continue sprinkling the phytoplankton on the surface. What eventually happens to it? What does this suggest about its basic needs?

Adapted from http://www.bigelow.org/foodweb/bloom1.html

Names _____

_____

_____

_____

Date _____

Ocean Color Evaluation

1. Study the pictures below. Using what you know of ocean color and phytoplankton, explain what you observe in the "Mississippi River Delta Image."

_____

_____

_____

_____

_____

_____

_____

_____

2. Study the bottom two images. Do you think the cause of the water discoloration is the same in the Yangtze River and Pearl River images compared to the Mississippi image? Explain your reasoning.

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Mississippi River Delta
Yangtze River
Pearl River
Guangzhou
Hong Kong