Title: SeaWiFS – Studying the Ocean from Space

Lesson developed by Elizabeth Tobin*.
Information and lab modified from: http://oceancolor.gsfc.nasa.gov/SeaWiFS/
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Summary:
The purpose of this lesson is to teach students about a new approach taken by Oceanographers to study the world’s ocean from space and how ocean researchers use quantitative data collected from satellites to better understand the ocean as a system. Students will learn about NASA’s SeaWiFS Project, and how NASA scientists use satellites to look at changes in ocean color to monitor types and abundances of phytoplankton, which provide critical information about primary production in the ocean and the role of the ocean in the global carbon cycle. Students will then have the opportunity to simulate how NASA scientists use ocean color intensity to identify phytoplankton abundances on a global scale.

Grade levels: 8th - 12th grade marine science or oceanography class
In Class time required: 1 -110 minute period or 2 – 55 minute periods
Prep time: 20 min
Lesson Format: Introductory inquiry activity, lecture and follow-up lab.

Key Concepts:
1. Small changes in ocean color can signify different types and abundances or marine phytoplankton.
2. Oceanographers use satellite images to study both the behavior and evolution of marine systems.
3. Oceanographers can use ocean color data collected from space to study primary productivity and assess the ocean’s role in the global carbon cycle.

Materials required:
8.5 x 11 color copies of global SeaWIFS image** - 800px-Seawifs_global_biosphere.jpg
SeaWIFS Power Point presentation
Bio-optical Oceanography Lab – student hand out
10 mL test tubes**
Green food dye (or very dense phytoplankton culture)
1 mL plastic pasture pipettes**
100 mL beakers**

** See lab packet for total number needed
Background:
Students should have already learned about phytoplankton (microscopic plant-like protists) and have a general understanding about primary production and the global carbon cycle. A basic understanding about the electromagnetic spectrum (light and color) is also helpful.

Lab Preparation:
1. Set up enough lab stations for students to work in groups of 4 or less. Each lab station should include: small test tube rack, 5 x 10 mL test tubes, 2 x 1 mL pasture pipettes, 100 mL beaker of fresh water and 100 mL beaker of fresh water dyed with 1 mL of green food color stock plankton sample.

2. Prepare the samples of unknown chlorophyll a concentrations representing different parts of the ocean by adding the appropriate number of drops (below) of the stock plankton sample to 10mL of fresh water. Clearly label each test tube. Prepare at least 2 sets, but one for each station is best. The stock plankton sample represents 25 mg/m³ chlorophyll a.

- California Current (coastal ocean): 40 drops = 5 mg/m³
- Southern Pacific (open ocean): 1 drop = 0.1 mg/m³
- Equatorial Pacific: 5 drops = 0.6 mg/m³
- Northern Sargasso Sea (spring): 10 drops = 1 mg/m³
- Northern Sargasso Sea (winter): 1 drop = 0.1 mg/m³

Student Engagement: SeaWiFS Biosphere Image ~ 30 min
Start the lesson with “What do you notice, what do you wonder?” using the printed 8.5x11 color SeaWiFS global biosphere images. Working in groups of 3-4 have students look at the image and determine what kind of information/data it is providing. Have each group come up with at least two things that they noticed, and two things they wonder about the image to share with the class. Have each group share their observations/inquiries as the teacher writes them on the white board. You will refer these during the power point presentation.

* This image of the global biosphere is derived from near-daily surface ocean color and land vegetation data from SeaWiFS collected from Sept. 1997 – August 1998. The 1997-1998 El Nino even was the strongest recorded to date.

Content Introduction ~ 30 min.
Use the Power Point presentation to teach your students about the SeaWiFS project and bio-optical oceanography. The presentation includes slides that will aid in your explanation about why ocean scientists study the ocean from space (asses highly productive regions in the ocean, role of the ocean in the global carbon cycle and how these processes change over different
temporal and spatial scales), the SeaWiFS project and provides different case study examples of how the SeaWiFS data had been used by ocean scientists. You will also discuss the “What do you notice, what do you wonder” comments written on the board during this presentation (As indicated by the slide of the SeaWiFS biosphere image).

** More detailed background information on the SeaWiFS project and case study examples can be obtained from: http://oceancolor.gsfc.nasa.gov/SeaWiFS/

Application and Assessment: Bio-optical Oceanography Lab ~ 50 min.

Have your students work in groups of 4 or less to complete the lab. Make sure each student has a lab handout that includes all of the instructions and questions to be answered. If you would like, you can briefly go over the lab prior to having the students start. Finish the lesson with a wrap-up class discussion.

**Extra:** If you can obtain different types of phytoplankton cultures put them out on display so the students can see how different species of marine phytoplankton have different colored pigments that help in identification. You can also use this discussion how marine phytoplankton are classified by their pigments (e.g., green, brown and red algae)

Image of the stock plankton sample (right) and color reference tubes (left) made by a student group.
How Does Bio-optical Oceanography (Sea-WiFS) Work?

The Big Questions asked by ocean scientists when looking at bio-optical data:
How much phytoplankton is there?
How does the distribution and abundance of phytoplankton change in time and space?

Bio-optics Lab:

A. Preparing your reference optics (color intensity)

1. Fill each of the test tubes with 10 mL of fresh water.

2. Leave the first test tube as is, this will represent clear ocean water.

3. Add two drops of the “plankton sample” (e.g., green colored water) to the second test tube. Carefully shake the test tube to evenly distribute the color throughout the water. The water should have turned a very pale green color.

4. Add four drops in the third test tube and repeat the procedure. You will notice that the color is much darker than the second tube. That is because the concentration of "phytoplankton" in this test tube is twice as high as in the previous one.

5. Add about eight drops of the food coloring to the 4th and 16 drops to the 5th test tube.
B. Calibrating you reference optics
(Matching color intensity to cell concentrations)

To determine the actual concentration of chlorophyll a (a green pigment found in photosynthetic algae and plants) in each of the test tubes and match that concentration to the color that you see, complete the following calculations and fill the values into each column of the table as you complete each step.

Important info you’ll need to know:
There are about 20 drops to 1 mL
There are about 10 mL of water in each of the test tubes.
Chlorophyll a concentration in stock phytoplankton beaker = 25 mg/m³
1 mL is equal to 10⁻⁶ (0.000001) m³

1. Divide the number of drops you used by 20 to determine how many mL of “cells” you added:
   \[ \text{mL} = \frac{\text{# drops}}{20} \]

2. Convert mL to m³:
   \[ \text{m}^3 = \text{mL} \times \left( \frac{0.000001 \text{m}^3}{1 \text{ mL}} \right) \]

3. To find out the total weight of cells you added to the tube multiply the volume of cell culture used in m³ (found in step 2) by the concentration of the phytoplankton culture:
   \[ \text{Weight of cells (mg)} = (\text{m}^3 \text{ used}) \times (25 \text{ mg/m}^3) \]

4. The volume of water in the tube _________ mL = __________ m³

5. Now calculate your chlorophyll a concentration using this formula:

   \[ \text{Chlorophyll a concentration (mg/m}^3\text{)} = \frac{\text{mg}}{\text{Volume (m}^3\text{)}} \]

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<tr>
<th>Test Tube</th>
<th>mL added (step 1)</th>
<th>m³ added (step 2)</th>
<th>cell weight (step 3)</th>
<th>Vol. water (m³)</th>
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** The basic principle behind remote sensing of ocean color from space is this: the more phytoplankton in the water, the greener it is...the less phytoplankton, the bluer it is. Pretty simple really.

** C. Identifying the concentration of an unknown sample

Now you can compare your reference optics to the already prepared test tubes which represent Chlorophyll a intensities from different regions of the ocean. Using your calibrated reference tubes determine the Chlorophyll a concentrations for each region of the ocean and fill in the concentrations below.

California Current (coastal ocean): ____________
Southern Pacific (open ocean): ________________
Equatorial Pacific: ____________
Northern Sargasso Sea (spring): ____________
Northern Sargasso Sea (winter): ____________

Label each region on the map below and answer the following questions. *You can also refer to the SeaWiFS biosphere image to help answer some of the questions.
1. Define Primary Production.

2. What role does the ocean play in the global carbon cycle?

3. What regions of the ocean have the highest primary productivity? Provide two reasons why you think these areas of the ocean have the most productivity.

4. What region of the ocean has the least primary productivity? Provide two reasons why you think this area of the ocean has the lowest productivity.

5. How do ocean scientists use ocean color data collected from space to determine how productive different regions of the ocean are?

6. How might ocean scientists use ocean color data to detect changes in a marine system over time?