CoSEE
CENTERS FOR OCEAN SCIENCES EDUCATION EXCELLENCE
BEST OF COSEE HANDS-ON ACTIVITIES

Activity Title: Getting the Big Picture: Reading the Ocean Stories Satellites Tell

Learning Objectives

This activity is an introduction to satellite images and how they can be used to learn about ocean conditions and phytoplankton, and to generate questions about ocean conditions, processes, and life.

Objectives:

- Given a satellite image of sea surface temperature or chlorophyll a, students will be able to
- Describe what is being measured
- Explain the color coding used in the image, and tell what each color represents
- Identify the geographic area, ocean, and land area in the image
- Describe patterns in SST or chlorophyll based on satellite images
- Propose and communicate an explanation for the observed patterns
- Describe how these factors might relate to SST or chlorophyll observations: wind and wave conditions; seasonal patterns for air temperature; regional currents; bathymetry; stratification; and upwelling events
- Identify phytoplankton bloom events on a satellite image

Ocean Literacy Principles:

#3 -- The ocean is a major influence on weather and climate.

b. The ocean absorbs much of the solar radiation reaching Earth.

e. The ocean dominates the Earth's carbon cycle. Half the primary productivity on Earth takes place in the sunlit layers of the ocean

#5 -- The ocean supports a great diversity of life and ecosystems.

f. Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is "patchy".

#7 --The ocean is largely unexplored.

b. Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.

d. New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean

scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

Supplies and Materials

- Copies of the sea surface temperature and chlorophyll a satellite images for the Southern California Bight and the Gulf of Maine
- Copies of questions for students
- Bathymetry and circulation maps of Southern California Bight and Gulf of Maine for reference (included below)

Background

The oceans are vast, and for most of history, ocean research was based on data from a series of individual sampling stations, extrapolated to generalize about conditions between stations. Today, ocean observing satellites allow oceanographers to study a wide variety of factors at regional or global scales.

Many types of satellite data are rendered into color-coded images that are intrinsically interesting and intuitively readable. Two very useful parameters that can be studied via satellite images are sea surface temperature (SST) and surface chlorophyll-a (chl) levels. SST allows us to follow the movements and interactions of surface water masses, infer upwelling, and observe the effects of insolation, wind, and storm events. Chl images show us the levels of phytoplankton in the upper meter of the ocean, including high concentrations during bloom events. Although it is not possible at present to identify genera or species of phytoplankton from satellite images, chl images can be used to locate and track blooms, and are enormously helpful in guiding scientists in choosing sampling sites for harmful algae blooms.

Teachers can use satellite images to help students improve their spatial, map-reading, and observation skills, and to give them opportunities to practice using evidence as the basis of explanations. These activities will help students learn some important concepts related to oceans and will introduce them to the ways satellites can help us study enormous areas of ocean and integrate information from different areas and over long time periods.

Since literacy and communication skills are central to learning in all subjects, this exercise includes an opportunity for students to write, draw, act, or animate their explanations to communicate about the observations they make using the satellite images.

Many students are interested in careers related to technology, and this activity brings together information and materials generated by many different workers: electrical, mechanical, and aerospace engineers for designing and building the satellites; computer specialists for designing the software and hardware to capture ocean data, transmit it, translate it, and generate images; ocean scientists to design investigations and interpret the data; shipboard crew and scientists to collect ground-truth studies, and writers, artists, and publicity staff to communicate about the satellite missions and products.

In studying the satellite images, students can learn about the large scale of ocean processes, and because these examples are taken from near-shore locations, students can learn some ways humans and oceans are connected. One of the most dramatic topics to connect with these studies is harmful algal blooms, which occur regularly in both the areas highlighted here, and which can have serious impacts on humans. To avoid misconceptions, it should be made clear to students that only some algal blooms are composed of toxic phytoplankton species. Some links for teaching about

phytoplankton are given in the resource section.

Duration

This lesson will take 1 or 3 50 minute class periods.

Audience

This lesson is best for grades 6-12.

Procedure

1. Introduce the size and scale of the ocean using a globe, and point out that we know most about the areas of the ocean that are relatively close to coastlines. It is difficult and expensive to carry our research cruises to parts of the ocean that are far from coasts.

   Describe the usefulness of satellites, which can be equipped with sensors to observe wide areas of the ocean, and over several days can even observe the entire surface of earth.

   Introduce sea surface temperature and chlorophyll *a* as two very useful parameters.

2. Divide the class into pairs or groups of 3 and distribute copies of either the Gulf of Maine or the Southern California Bight images. Choose the guiding questions you want them to consider and post or distribute them to the students.

3. Ask students to observe the images and keep track of their observations and questions.

   To limit the time necessary and provide opportunities for comparisons, you may wish to have some students look at only temperature or only chlorophyll images, or compare the temp and chlorophyll from only one region.

4. After the class has had 15 – 20 minutes to study the images, discuss with the class some of their observations and questions.

   Describe the students' assignment: based on their study of the images, they will develop a story to explain what is happening in this part of the ocean. The story should use evidence and any background information they have learned, and should describe what factors may have influenced the water to cause the changes you observed. The story may be oral, written, drawn and illustrated as a poster or comic strip, presented as a powerpoint show, or acted out. You may decide what format will be most appropriate for their students. Bonus: challenge students to provide two different explanations for what might have caused the changes. Set a time limit for the presentations.

5. Provide access to additional information for students to use when they compose their explanations. See resources for some suggested web sites for students to visit.

6. Have a student "conference" where they describe or display their theories to their peers. To save time, you may wish to have students make a poster or visual display, and putting these up around the room, instead of having students present oral reports.

7. Evaluation: Students can be assessed on their effort in making observations and composing a story to explain their observations; the content and delivery of their presentation, and the questions they generate. Questions should be considered a valuable outcome for the activity.

Suggested guiding questions for observing and interpreting satellite images:

1. What information is displayed in the images?

Sea surface temperature (SST) or Chlorophyll *a* (chl)

2. What is sea surface temperature (SST) and why isn't it just called "sea temperature"?

   It is the temperature of the ocean at the surface only - these satellites cannot sense more than a few centimeters below the surface of the ocean.

3. What is chlorophyll *a* (Chl -a) and what does it indicate?

   It is a photosynthetic pigment, found in land plants and phytoplankton. It is used as a proxy for the concentration of phytoplankton in the water.

4. What region or part of the coastline is displayed in the images you are working with?

5. When was the data collected by the satellite? If it was collected over a time range, how long was the time period?

   Gulf of Maine images: monthly averages for each month, 2003

   Southern California Bight: one satellite image per day with A= March 9th and H= March 16th, 2002

6. What does the color scale bar in each image tell you? What are the units?

   Gulf of Maine images: Temperature: degrees Celsius from -2 to 30

   Gulf of Maine chlorophyll a: milligrams per cubic meter from 0.10 to 10.0

   Southern CA Bight: Temperature in degrees C from 11 – 15

   Southern CA Bight chlorophyll: milligrams per cubic meter from 0 to 5

   In the California Bight images, what could the white/blank areas represent?

   The white or blank areas represent clouds. The Gulf of Maine images are averages from a month of data, so clouds are not shown.

7. Look at the sea surface temperature graphs - is there change over time? Describe what you notice, and write down any questions you have about what you observe.

   Students may discuss with a partner, list, or write about what they notice. Questions are an important outcome for this activity, and they may be the basis for further investigation.

8. What factors or conditions might influence sea surface temperature?

   Strong winds or a storm event could bring up cold water from depth

Tides flowing over shallow underwater areas can bring cold water to the surface

Precipitation from a storm event could cool water in summer

Currents can bring warmer or cooler water from other areas

Seasonal sunlight levels can warm surface water or allow for cooling

The coriolis effect pulls water to the right in the northern hemisphere, so winds from the north in CA pull water away from shore, causing upwelling. In the Gulf of Maine, prevailing winds are from the southwest

9. Look at the chlorophyll a images - is there change over time? Describe what you notice, and write down any questions you have about what you observe.

   Students may discuss with a partner, list, or write about what they notice. Questions are an important outcome for this activity, and they may be the basis for further investigation.

10. What factors or conditions might influence chlorophyll levels?

    Seasonal light levels need to be high enough (enough daylight hours) to support photosynthesis

    General amount of sun or clouds

    Nutrient supply in surface waters – high levels promote blooms; low nutrient levels could inhibit growth of phytoplankton

    Stratification or layering in the water column could prevent phytoplankton from accessing nutrient supply; upwelling or mixing can bring nutrients to the surface

    Precipitation from a storm event can bring a supply of nutrient rich water from land and river runoff

11. Circulation patterns: Look at the maps of bathymetry (sea floor depths and features) and regional surface circulation for your region. How could these factors relate to the patterns you observed in the satellite images?

    Surface circulation patterns can bring warmer, cooler, nutrient- rich or poor water to an area. The coriolis effect tends to make surface water move to the right in the northern hemisphere, so currents from the north in California or from the south in the Gulf of Maine promote coastal upwelling.

12. Is there ever or always a relationship between sea surface temperature and chlorophyll a levels? Describe why you think this and indicate which images support your ideas.

    Based on the Gulf of Maine images, the warmest and coldest water temperatures are not associated with the biggest blooms or the highest levels of chlorophyll. However, in both sets of

    images phytoplankton blooms occur in relatively cold water. In the Southern California Bight images, there appears to be an upwelling event, which would bring cool, nutrient rich water to the surface, and that is associated with higher levels of phytoplankton.

13. What additional information, images, or data would be useful for you to support your explanation?

    See resources section for suggested resources

Assessment

None.

Additional Resources

Resources for sea surface temperature and chlorophyll

Follow these links to view recent images of SST and Chl in these areas. Are conditions similar to or different from what you observed in the first set of images?

- Southern California Coastal Ocean Observing System SCCOOS http://www.sccoos.org/
- Satellite images of Southern California coast, including sea surface temperature and chlorophyll
- http://www.sccoos.org/interactive-map/ click on "satellite imagery" in the list on the left
- Gulf of Maine Ocean Observing System GOMOOS http://www.gomoos.org/buoy/satellite.html

Additional Resources

Background on factors that cause phytoplankton to bloom

http://serc.carleton.edu/eet/phytoplankton/primer.html

http://www.bigelow.org/foodweb/

http://www.mbari.org/staff/conn/botany/phytoplankton/phytoplankton_blooms.htm

How physical ocean factors affect biological productivity

http://www.bigelow.org/shipmates/overview.html

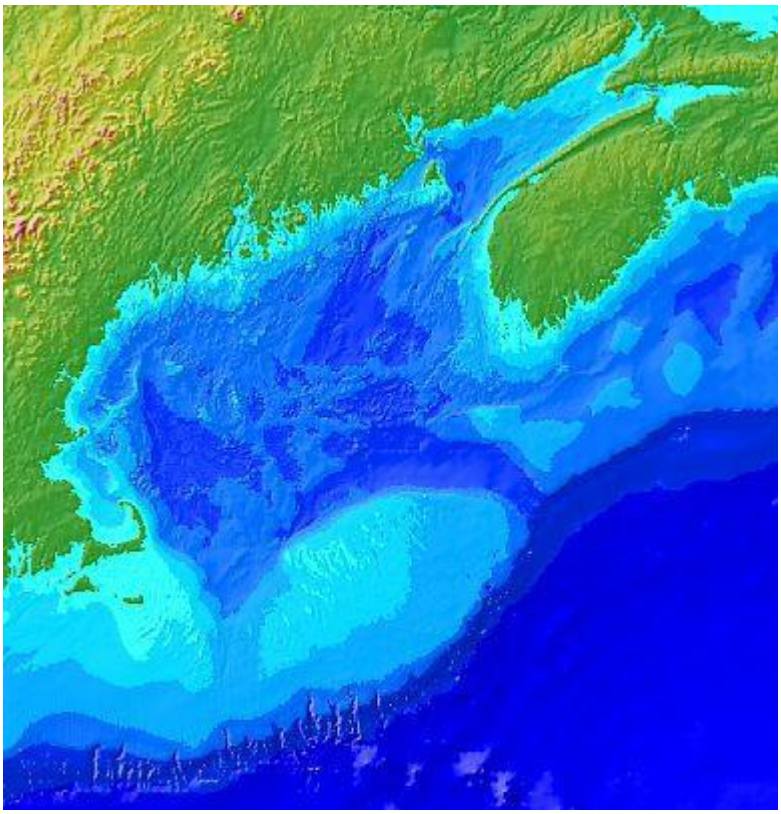
Harmful algal blooms

- NOAA introduction to phytoplankton and harmful algae http://www.nwfsc.noaa.gov/hab/habs_toxins/phytoplankton/
- Woods Hole Oceanographic Institute Harmful Algae Page http://www.whoi.edu/redtide/
- West Coast HAB species http://www.nwfsc.noaa.gov/hab/habs_toxins/hab_species/index.html Health Impacts:
- Center for disease control and prevention http://www.cdc.gov/hab/

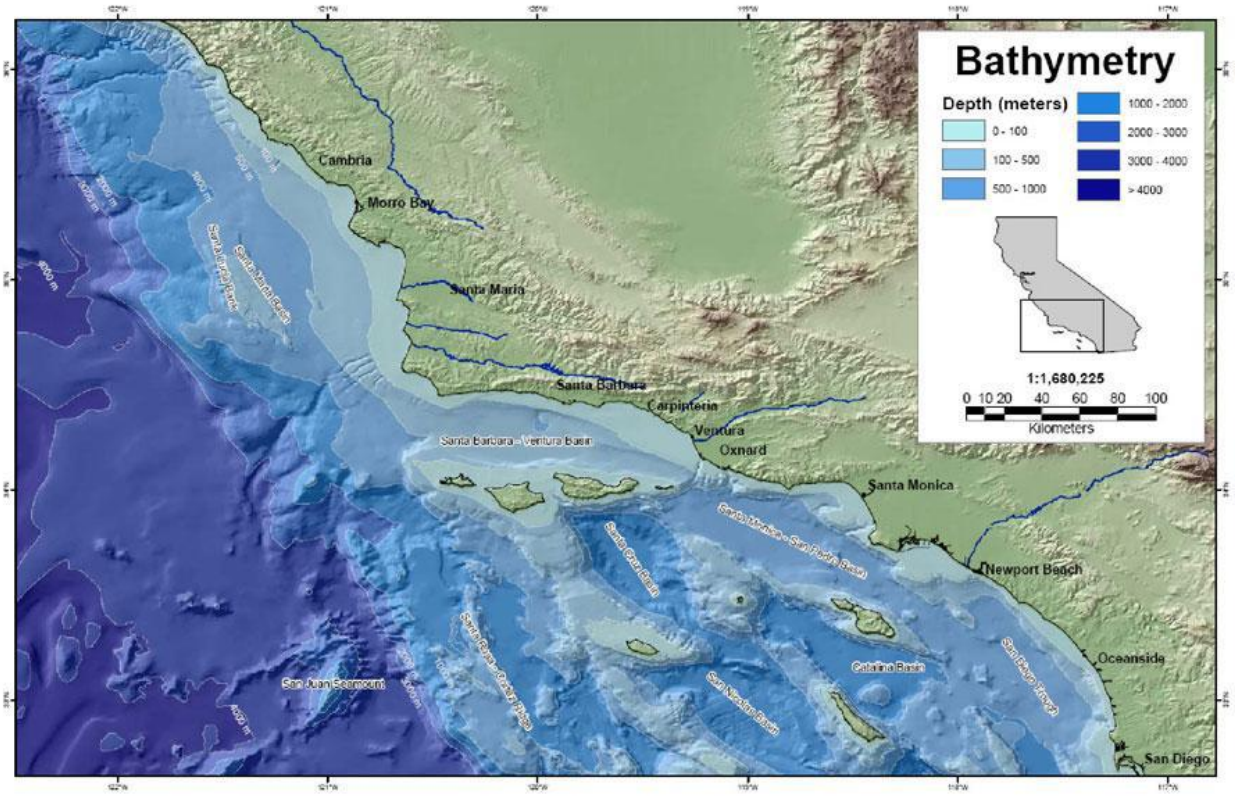
Satellite imagery

Great, easy to use interactive satellite imagery site http://podaac-tools.jpl.nasa.gov/soto/

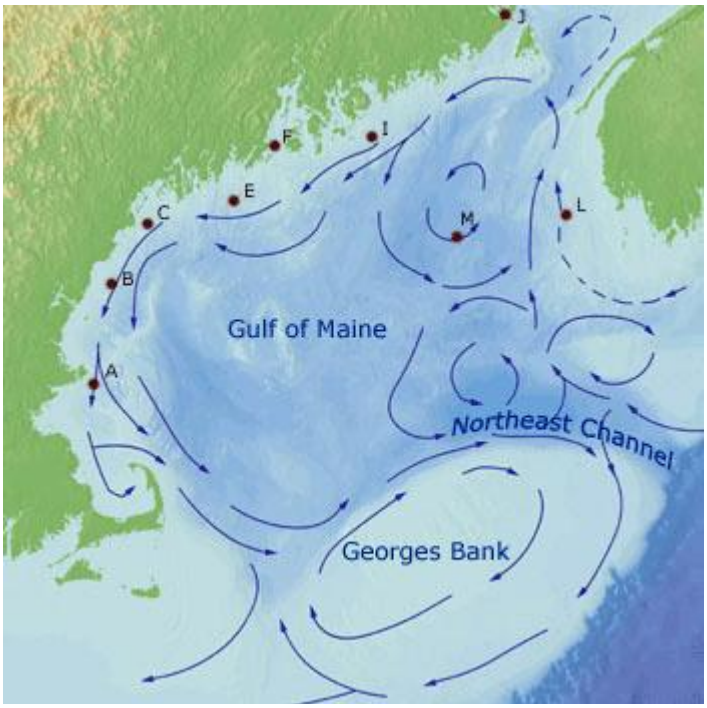
This lesson plan was provided by COSEE West. For more information, please contact Pat Harcourt, COSEE-West at pharcour@usc.edu



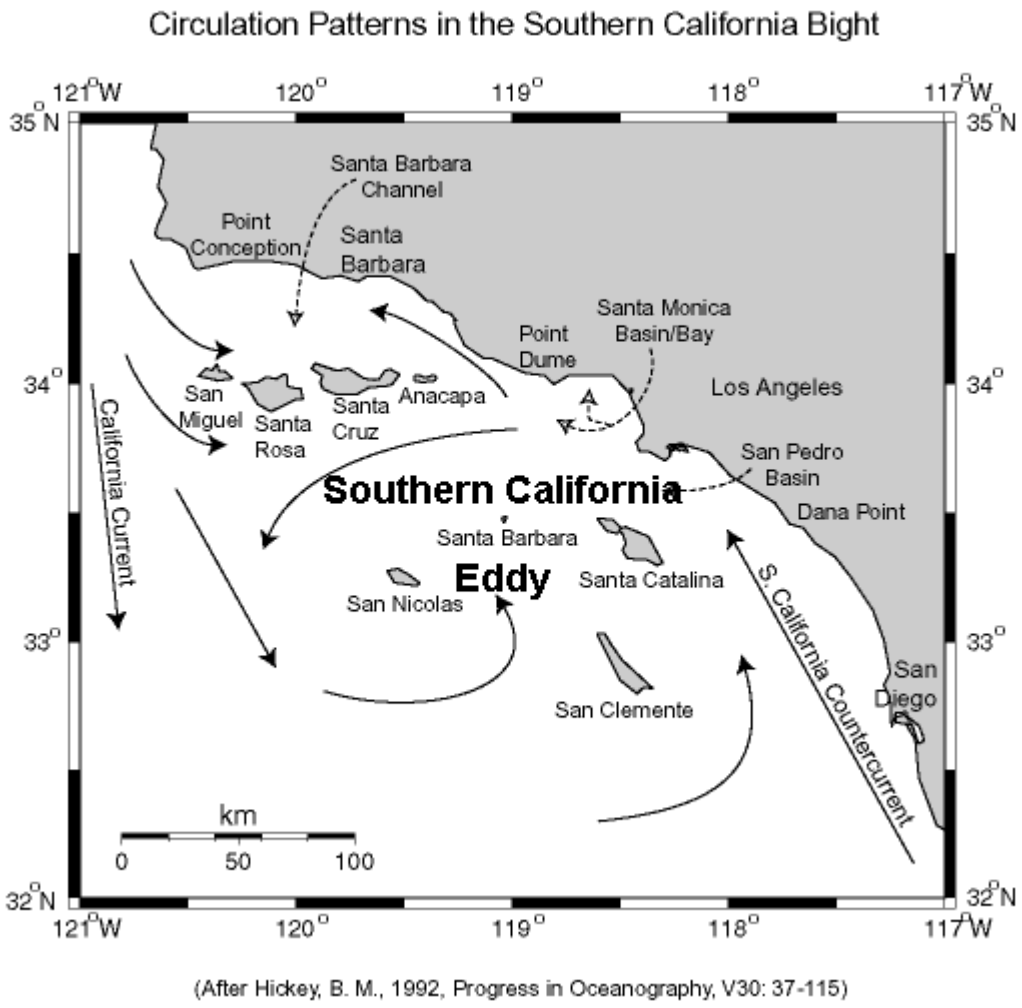
Bathymetry in the Gulf of Maine



Bathymetry in the Southern California Bight



Surface Circulation in the Gulf of Maine



(After Hickey, B. M., 1992, Progress in Oceanography, V30: 37-115)

Surface Circulation in the Southern California Bight