EaSiE Earth as a System is Essential

Seasons in the Gulf of Maine

Sea Surface Temperature and Chlorophyll

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This series of lessons was developed by the Maine Mathematics & Science Alliance and a group of Maine, Massachusetts, and New Hampshire middle school science teachers with funding from NOAA Environmental Literacy Grant NA07SEC4690002. For more information about the *Earth as a System is Essential: Seasons and the Seas* (EaSiE) project, visit www.mmsa.org/easie

Maine MATHEMATICS and SCIENCE Alliance

The guiding questions for this lesson are adapted from the EaSiE Project Summer Institute's presentation by Amy Cline, University of New Hampshire, 2008.

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Overview

The overarching goal of *Earth as a System is Essential: Seasons and the Seas* (EaSiE) is to transform the traditional middle school study of terrestrial seasons and weather into an exploration of the dynamic interactions between Earth's land, water, atmosphere, and the living world. In prior lessons, local air temperature measurements were collected daily and applied to develop a working definition of weather as the actual atmospheric conditions at a particular moment, and climate being the average conditions over a period of time (Weather & Climate lesson available at mmsa.org/easie). Additional lessons then provided opportunities to examine temporal and spatial weather data, and investigate questions about atmospheric weather patterns over land and over the Gulf of Maine (Data & Graphing lesson available at mmsa.org/easie).

This lesson applies the understandings of weather and climate to investigate seasonality in the Gulf of Maine. Monthly sea surface temperature climatologies are examined for patterns and trends over the course of a year. Monthly chlorophyll climatologies are then analyzed, and connections between the sea surface temperature and chlorophyll patterns are explored. Ideas related to changes with depth (thermoclines) in the Gulf of Maine region will be addressed in a subsequent lesson.

This lesson supports the big idea: Just as on land, there are seasonal changes in the Gulf of Maine.

> ***NOTE:*** *This lesson series is intended to serve as a relevant context for the teaching and learning of seasons-related ideas in middle school. It is not designed to replace a comprehensive curriculum, but rather enrich and integrate authentic Earth systems science content into instructional units using NOAA resources. It is suggested that teachers use the materials to supplement existing lessons aligned with the learning goal:*
>
> > Because the earth turns daily on an axis that is tilted relative to the plane of the earth's yearly orbit around the sun, sunlight falls more intensely on different parts of the earth during the year. The difference in intensity of sunlight and the resulting warming of the earth's surface produces the seasonal variations in temperature (Benchmarks for Science Literacy).

This lesson provides a foundation for developing an understanding of the Ocean Literacy Essential Principles and Fundamental Concepts (2006):

- The Earth has one big ocean with many features.
- The ocean is a major influence on weather and climate.

This lesson also sets the stage for developing an understanding of the Essential Principles of Climate Science (2009): http://www.noaa.gov/climate.html

Background Information:

Sea surface temperature (SST) is the water temperature close to the surface. Since the 1980s satellites have been increasingly used to measure SST and have provided a rich database that can be used to view spatial and temporal variation in SST. The satellite measurement is made by sensing infrared radiation, which can be translated to SST. Satellites contain a sensor that transmits data back to a computer on Earth. The computer then translates this data into images, which can be enhanced to look like photographs.

Chlorophyll is the green pigment that organisms use to absorb sunlight for photosynthesis. Living phytoplankton are the main source of chlorophyll in the Gulf of Maine. Satellites measure the color of the water to determine the amount of chlorophyll present, and can detect very small changes in the color as a result of the chlorophyll in phytoplankton. The more phytoplankton in the water, the greener it is; the less phytoplankton, the bluer it is. Thus, satellite imagery allows scientists to know how the distribution and abundance of phytoplankton changes in time and space.

Climatology maps are composite images generated from satellite data.

- Monthly SST SeaWiFS images can be obtained at http://wavy.umeoce.maine.edu/frames_merged.html
- Monthly chlorophyll SeaWiFS climatology images can be obtained at http://wavy.umeoce.maine.edu/frames_sw_clim.html

Classroom resources and background reference material about satellites and satellite imagery can be found at the NOAA Teacher Education resources site http://www.education.noaa.gov/

Essential Question:

Do bodies of water have seasons?

Knowledge and skills:

1. Interpret climatology maps.
2. Analyze data provided by satellite imagery.
3. Apply satellite data to understand the idea of seasonality in the Gulf of Maine.

Preparation:

Prepare copies of handouts:

Sea Surface Temperature Monthly Climatologies – one composite for each month (see "Background Information" for source of maps)

Chlorophyll Temperature Monthly Climatologies – one composite for each month (see "Background Information" for source of maps)

Time Required:

2 class periods.

Seasons Lesson

ELICIT/ENGAGE:

1. Ask students if they have ever been to the beach in the summer. How about in the winter? What are some of the biggest differences you would notice if you went to the beach in January instead of July? (Students will likely note that the air – and - the water are colder in January. They might also bring in other atmospheric differences, such as type of precipitation, wind speed.)

2. Remind students of the prior lessons where they collected air temperature measurements in their immediate backyard (Weather & Climate lesson available at mmsa.org/easie). If students collected this data and developed their working definition of weather and climate in their science notebooks, have students refer to this. Post the definitions of weather and climate that were developed during these lessons. The description should clarify the difference as being:

   Weather = the <u>actual</u> atmospheric conditions in a particular place at a particular time

   Climate = the <u>average</u> atmospheric conditions in a particular place over a period of time

   Post the following statement as a reminder of the distinction between weather and climate:

   "Weather is what you wear each day,
   and climate is what's in your closet!"

3. Remind students of prior lessons about seasons. Discuss the following:

   "What's the difference between climate and seasons?"

   Post the definition of seasons that was developed during these lessons. The description should clarify seasons as being divisions of the year, marked by changes in weather, ecology, and hours of daylight. In a particular area, you would expect certain climate conditions during a specific season. For example, in New England, we anticipate July and August to be warm and humid, with lots of flowers blooming and long daylight hours, and January and February to be cold and snowy, with little plant growth taking place, and shorter daylight hours.

4. If lessons leading up to this unit included the "reasons for the seasons" (the tilt of the Earth causes the Sun to be higher in the sky during the summer months which increases the solar flux), bring this into the discussion.

5. In small groups, have students discuss the following:

   "We think of weather as being the actual conditions in the air surrounding us. Do bodies of water such as the Gulf of Maine have 'weather'?"

   Guide a whole-group discussion to consider the idea that weather is the state of the atmosphere, and we can measure the weather conditions (temperature, wind speed, barometric pressure) of the atmosphere over a body of water such as the Gulf of Maine. But a body of water also has conditions we can measure, such as temperature.

   If we measure water temperature over an extended period of time, we could gather enough data to describe the "climate" of that particular body of water. Just as with air temperature, it would be important to consider the height at which we take the temperature measurements. We could, for example, take a series of temperature readings at increasing depths in the same location, or we could take a series of surface temperature readings across a region. Today, we're going to explore surface temperature readings across a region.

EXPLORATION OF SEASONS IN THE GULF OF MAINE:

6. The question we will be exploring today is, "Are there seasons in the Gulf of Maine?"

   Distribute the set of 12 Sea Surface Temperature (SST) Monthly Climatology maps. Assign at least two students to collaborate on each image.

   Explain how the data is collected using satellite sensors, averaged to represent a monthly "climate" condition, and then translated into a computer image (see Teacher Background notes for information resources).

   Review the color key that accompanies the satellite image. Remind students that this was computer-generated, to help us "see" the data. These colors are not the true colors. Note the 'negative images' – land is a background color, and only the bodies of water are translated into temperature zones. The maps are likely to be disorienting to students, who are familiar with terrestrial representations. Identify an easily recognizable landform such as Cape Cod as a point of reference.

7. Ask each group to describe what they see in the image. Have them write down some of the patterns they see in their image. It may be necessary to scaffold their interpretation of patterns, first having students describe patterns they see in the colors, then describing the patterns as data – using the key.

8. Have each student team share one pattern they see in their map with the larger group.

9. Ask the class to put the sea surface temperature images in sequential order of the months, lining them up on the floor.

10. Have each student group compare their image to the two images that touch theirs. How are the patterns in their month similar or different to the month before and the month after their image? Have students write down what similarities and differences they see in this series of three images.

11. Ask the whole group to share their ideas. Make a list on the board about what trends and patterns they see throughout the entire year.

EXPLANATION:

12. Review findings as a large group. What are the "hottest months" in the Gulf of Maine – as indicated by sea surface temperature? If students do not bring it up, point out the seasonal lag.

    Refer to the monthly SST data: Why might it be that what we think of as the "hottest months' (e.g. June) aren't reflected in the climatology maps – and that some of what we think as "cooler months" (e.g. Sept) are "hot Gulf of Maine months"?

    Depending on students' prior background, this might be a discussion based on observational experiences of temperature differences and interactions between gases and liquids, without incorporating technical terminology. Draw upon prior everyday knowledge; for example, if you bring a bottle of cold water into a hot car, the air around you feels a lot hotter than the water does. Eventually, that water would feel warm as well. Conversely, when you put a bottle of warm water into a cool refrigerator, it takes a while for the water to cool down.

    If students have had prior lessons pertaining to the large amount of thermal energy that is stored in bodies of water, this can lead to a discussion about heat transfer. Heat is transferred from warmer materials to cooler ones, and this interaction between air masses and bodies of water takes place at their interface.

    If you have been using the "systems" approach (see the EaSiE Systems lesson, available at mmsa.org/easie), use the systems guiding questions to discuss the thermal energy interactions, inputs and outputs.

    Depending upon students' prior background, you may also choose to expand the

discussion to consider the role the ocean plays in shaping the Earth's climate and weather patterns (Source: NOAA Ocean Service EducationTeacher Tutorial, Global Climate Patterns http://oceanservice.noaa.gov/education/pd/oceans_weather_climate/teacher_resources.html):

Warm ocean waters provide the energy to fuel storm systems that provide fresh water vital to all living things. Understanding and predicting precipitation is critical to farmers who decide which crops to plant, and how deep, based in part on soil moisture levels. Crop and food prices may increase when weather that is too wet or too dry adversely affects crops. Like precipitation, extreme heat and cold also affect livestock management.

Weather and climate are the result of the transfer of energy from the sun at and near the surface of the Earth. Solar radiation heats the ocean and air differently, resulting in the constant transfer of energy across the globe. Transfer of thermal energy at the boundaries between the atmosphere, land masses, and the ocean are influenced by dynamic processes such as cloud cover, and relatively static conditions such as the position of mountain ranges and the ocean. This transfer of thermal energy results in layers of different temperatures and densities in both the ocean and atmosphere. The action of gravitational force on regions of different density causes these layers to rise or fall, forming convection currents (cells). This circulation, influenced by the rotation of the Earth, produces winds and ocean currents.

NOTE: *The progression of understanding of weather-related ideas about heat transfer and transformation are depicted in the Atlas of Science Literacy "Weather and Climate" map: http://www.project2061.org/publications/atlas/sample/toc2.htm*

ELABORATION:

13. Distribute the set of 12 Monthly Chlorophyll maps. Again assign at least two students to collaborate on each image.

    Provide students with background information on how chlorophyll data is collected via satellite and how the monthly climatology maps are generated (See Teacher Background notes).

    Review the color key that accompanies the satellite image, reminding students that this was computer-generated, to help us "see" the data; these colors are not the true colors of the phytoplankton. Clarify the chlorophyll units of measurement.

14. Ask each group to describe what they see in the image. Have them write down what patterns they see in their image. Scaffold this interpretation as in Step 7.

15. Have each student team share one pattern they see in their map with the larger group.

16. Ask the class to put the chlorophyll images in sequential order of the months, lining them up on the floor.

17. Have each student group compare their image to the two images that touch theirs. How are the patterns in their month similar or different to the month before and the month after their image? Have students write down what similarities and differences they see in this series of three images.

18. Ask the whole group to share their ideas. Make a list on the board about what trends and patterns they see throughout the entire year.

19. Since the amount of chlorophyll is an indicator of phytoplankton activity, which months are the "most productive" and "least productive"? What areas in the Gulf of Maine are "most productive" and "least productive"?

20. Line the SST and CHL images up to look for patterns between the two. Do the patterns and trends coincide, or is there a 'lag'? Why might that be – what are some possible reasons? Are there any connections to the "most productive" and "least productive" months or areas?

21. Ask students, based upon our analysis of the SST and CHL images, what other questions do you now have that we might be able to explore? What data would you need to gather to answer your question? List these in a "Questions we have" chart.

22. Revisit the question, "Are there seasons in the Gulf of Maine?" If students have been building their operational definitions of weather, climate, and seasons and describing the SST and CHL climatology map patterns in their science notebooks, use these resources to guide the discussion. The discussion should be based upon their knowledge of what is meant by seasons (Steps 2 – 5), and on the evidence provided by the climatology data (Steps 6 – 20).