



## Seasonality in the Ocean

*Developed by: Katie Gardner and Kate Florio*

**Topic:** Explore the concept of seasonality within the ocean. Compare and contrast differences between seasons on land and seasons in the ocean. Discuss the reasons for the similarities and differences. Students will be introduced to ocean data in the form of sea surface color (chlorophyll) and sea surface temperature (SST).

**Audience:** Grades 8 – 12

**Length:** 30 to 45 minutes

### NJ State Standards:

- 5.1.A - Understand Scientific Explanations
- 5.4.A – Objects in the Universe
- 5.4.E – Energy in Earth Systems
- 5.4.F – Weather and Climate
- 5.4.G – Biogeochemical Cycles

### Objectives:

- Observe similarities and differences between seasons on land, and seasons in the ocean.
- Explain scientifically why differences are observed, and why there are similarities.
- Use understanding of seasons to interpret ocean observing system data products.

### Introduction:

This activity is meant to open discussion on the idea of seasonality within the ocean. How would students know what season it is if they didn't have a calendar? What things do they think of in the spring, summer, fall, winter? Does the ocean have seasons? Do all places in the world have the same seasons?

### Background:

The data products used for this activity are seven year monthly composites of Sea Surface Temperature (SST) and Ocean Color measured and compiled from the New York Bight region of the Atlantic Basin. Four months of the year (January, April, July, and October) were chosen as representative of a season.



SST data is measured using satellites, which record infrared radiation from the ocean surface in several different wavelengths. This can be a good real world application to discuss or review the electromagnetic spectrum. The temperature values measured are converted to a color in order to create a false color map. False color maps are created as a visual tool to observe patterns and differences within the data collected. These maps are not in true-life color nor are they photographs/pictures.

Ocean color is a satellite measure of how green the water appears. This measure is a proxy\* for the amount of chlorophyll in the ocean. Chlorophyll is a chemical in plants that facilitates photosynthesis, allowing plants to convert sunlight and CO<sub>2</sub> into organic compounds for energy and structure. Most varieties of this chemical are green, and this is why many plants are green. Chlorophyll is present in ocean plants too, the mostly microscopic forms of phytoplankton found in the surface ocean. More green means more chlorophyll, and hence more plants. This data is also presented as a false color map.

\*A proxy is measuring one thing, and directly relating it to another variable that we are interested in. Proxies are often used when direct measurement of a variable is not easily performed, or available.

**Materials:**

Color print outs of Temperature and Chlorophyll data sheets (*SeasonalDataSheets.pdf*)

One Plastic sheet protector for each print out sheet (optional)

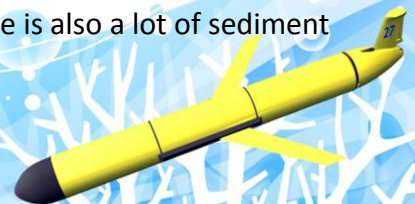
**Procedure:**

**I. Preparations**

- a. Print out one set of data sheets for each pair or group of students.
- b. Slide each sheet into a plastic sheet protector to reuse if desired.

**II. Activity**

- a. Hand out color copies of the chlorophyll/temperature data\* (*SeasonalDataSheets.pdf*). There are 4 pages of data; each page is one month of the year.
- b. Have students work in pairs or small groups of to decide which page is in each season, and order them winter, spring, summer, fall.
- c. Some questions that would help guide students could include:
  - i. When is the most chlorophyll present? Why?
  - ii. Does this data show seasons in the ocean the same way we think of seasons on land?
  - iii. What other data could you look up that would show changes in seasons?
- d. When viewing these data sheets, do not rely on the chlorophyll data directly along the coast. This coastal growth is seen year round. It grows on the nutrients entering the ocean in estuaries, as rivers bring their load in from the continent; there is also a lot of sediment



and other particles that can color the water in these areas (remember we are using color as a proxy for chlorophyll). Connections can be made between this and health of watersheds. Ocean blooms will be seen further from the coast.

e. Data Sheet Key:

- i. Fall (A) - highest water temperatures, bloom in the ocean is fading to yellow and small in size.
- ii. Winter (B) - low water temperatures, little to no phytoplankton in St. Georges Bank region.
- iii. Summer (C) - warm temperatures, slightly smaller orange bloom in ocean
- iv. Spring (D) - cold water temperatures, large bright red bloom in the ocean

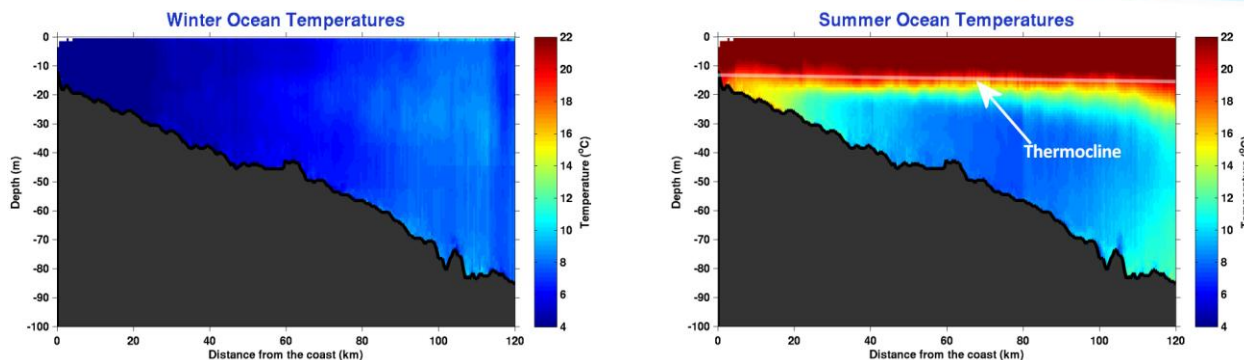
\* This data was provided by Rutgers University Coastal Ocean Observation Laboratory (RU COOL), specifically for this lesson. It is a 7 year composite from 2000-2006 of January, April, July, and October. Each data page represents one month. The use of composite data was chosen to focus students on patterns of temperature and chlorophyll.

**Evaluation:**

Have students share how they ordered the data sheets, and then explain whether they are correct or not. Students often need help understanding the discrepancies between what they think about seasons, and what is observed in the ocean. The temperature data can be misleading if you use your experience with air temperatures. Summer has the hottest months for air; however water has a much higher heat capacity than air. This means that it takes longer to heat up in the spring, and longer to cool down in the fall. The highest surface ocean temperatures are generally recorded in early September and slowly cool through the fall.

The growth of phytoplankton is related to two major factors: the availability of nutrients, and amount of sunlight. Focus on the bloom that occurs in the ocean off of Massachusetts' Cape Cod, not along the coastline. This region is known as St. Georges Bank, a productive fishery. During the short days of winter, there is little primary productivity seen in the section of ocean shown on the data sheets. Storms are common in the region throughout the winter months, and this serves to mix the water column, bringing up nutrients from deeper water. As the days lengthen, phytoplankton use the nutrients in the water to reproduce quickly, leading to the spring bloom. As spring progresses, warming temperatures will start to stratify the surface ocean, forming layers which block continued upwelling of nutrients. The phytoplankton use up their nutrients and the bloom reduces in size. There is some recycling of nutrients within the surface through the summer, and also heavy grazing by zooplankton. As the days shorten in the fall, productivity drops off. The cooler surface water is less stratified, and storms aid in mixing; starting the seasonal cycle over.





The above composite data is a cross section of temperatures produced by Slocum gliders off the coast of New Jersey. It is shown to illustrate what is meant by temperature stratification in summer vs. winter. A similar temperature pattern is seen in the St. Georges Banks region. Winter temperatures are similar from surface to bottom due to mixing. Summer temperatures are stratified. In this image, a thermocline has developed at 15m depth. A thermocline is a horizontal boundary across which a sharp change in temperature is measured. A connection to water density and the relationship to temperature can be made here.

**Extension:**

Following the activity and explanation, can students explain why one location on the coast experiences different climate than a location at the same latitude on the interior of a continent? (New York City vs. Chicago) Can students relate the heat capacity of water in the ocean to having a local effect on nearby land masses? What climate differences would students expect to observe based on their reasoning? Have students find climate data to support their reasoning.

**Resources:**

1. <http://serc.carleton.edu/eet/phytoplankton/primer.html> explains in more detail some of the dynamics associated with ocean blooms.
2. <http://www.thecoolroom.org/> is an ocean data source for public users
3. <http://rucool.marine.rutgers.edu/> is a source for a wider array of both real time and older ocean data.

