CARBON CYCLE GAME

This lesson plan developed by:

RUTGERS
THE STATE UNIVERSITY
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Overview:
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).

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

Materials:
- Color print outs of Temperature and Chlorophyll data sheets (set per group)
- One plastic sheet protector for each print out sheet (optional)

Set-up Prior to Activity:
- Print out one set of data sheets for each group of students
- Slide each sheet into a plastic sheet protector to reuse if desired

Duration:
30-45 minutes

Physical Activity:
Low

Seasonality in the Ocean (cont.)

Background:

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?

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 CO2 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.

Activity:

1. Hand out color copies of the chlorophyll/temperature data. There are 4 pages of data; each page is one month of the year.
2. Have students work in pairs or small groups of to decide which page is in each season, and order them winter, spring, summer, fall.
3. Some questions that would help guide students could include:
    - When is the most chlorophyll present? Why?
    - Does this data show seasons in the ocean the same way we think of seasons on land?
    - What other data could you look up that would show changes in seasons?
4. 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.

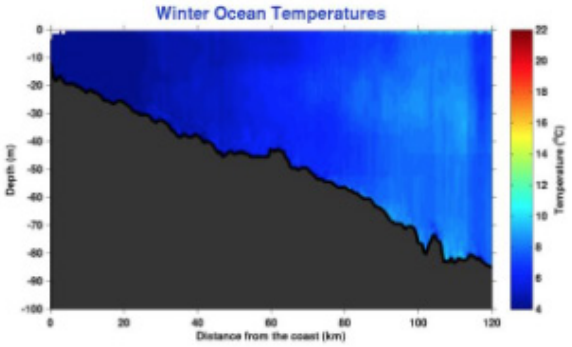
5. Data Sheet Key:
   A. Fall – highest water temperatures, bloom in the ocean is fading to yellow and small
   B. Winter – low water temperatures, little to no phytoplankton in St. Georges Bank region
   C. Summer – warm water temperatures, slightly smaller orange bloom in ocean
   D. Spring – cold water temperatures, large bright red bloom in ocean

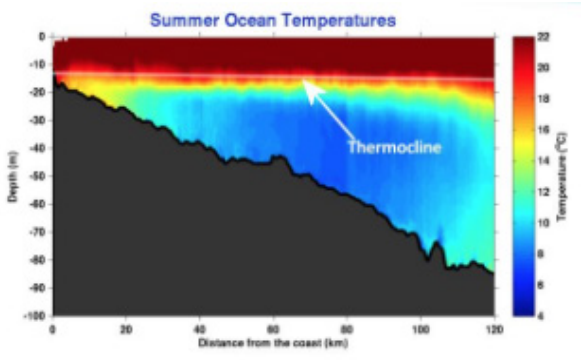
Discussion:

1. Discuss how the students ordered the data sheets. Why are they correct or not?
2. 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.
3. 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.
4. The below 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

Seasonality in the Ocean (cont.)

temperature is measured. A connection to water density and the relationship to temperature can be made here.





Ocean Literacy Principles:

Ocean literacy is an understanding of the ocean's influence on us, and our impact on the ocean. There are seven Ocean Literacy Essential Principles that all people of our blue planet should have an opportunity to learn and understand. This activity touches upon the following Essential Principles:

1. The Earth has one big ocean with many features
3. The ocean is a major influence on weather and climate
7. The ocean is largely unexplored

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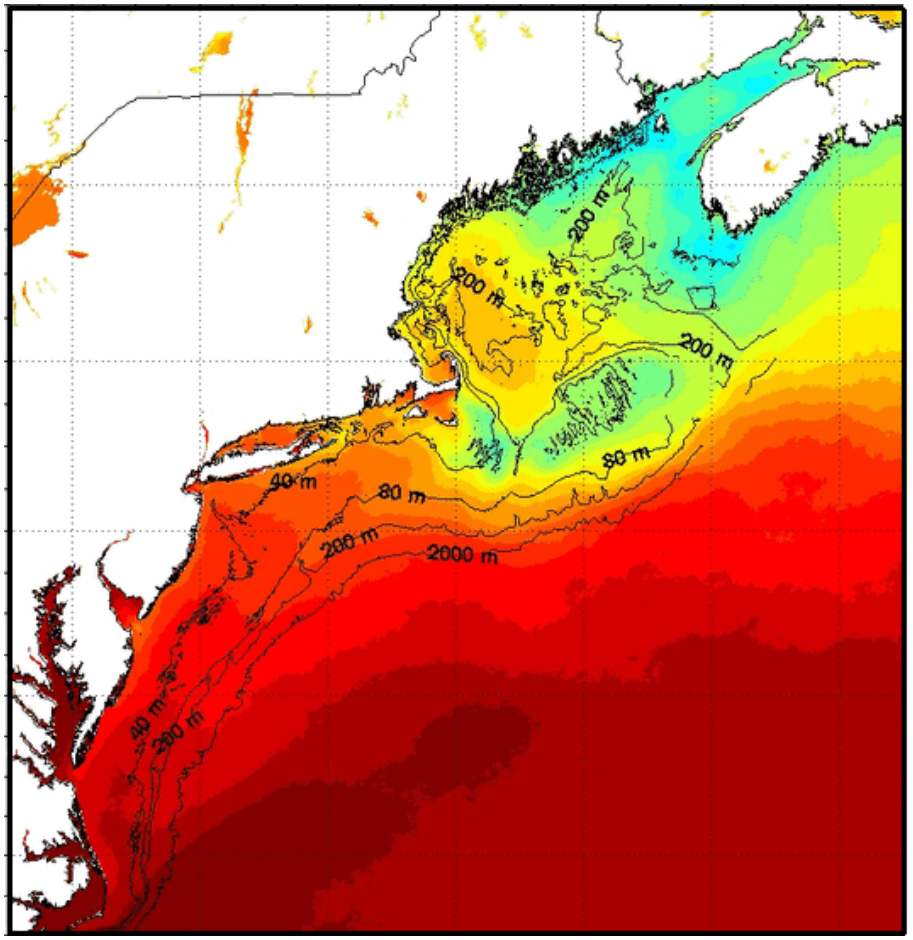
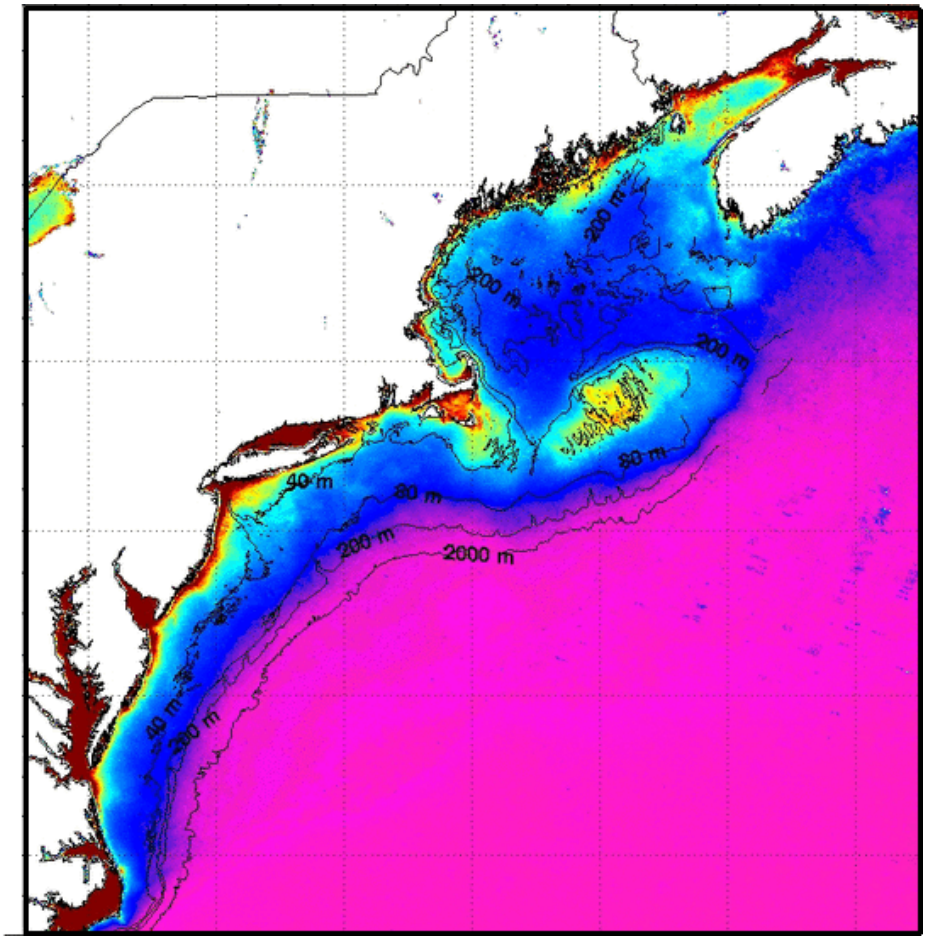
As sailors and water-lovers, you are among the first to notice changes to our seas such as fewer marine animals, more pollution and damaged marine habitat. Through our Green Boating initiative, Sailors for the Sea Powered by Oceana provides opportunities for you and your community to address pressing ocean health issues. As a Green Boater, you will be provided with the information, resources and access to combat marine plastic pollution, prevent habitat destruction, source responsible seafood and protect marine animals. From demanding plastic-free alternatives to choosing sustainable seafood, your voice and actions are an important part of restoring the abundance of our oceans and protecting marine habitats. Join our growing Green Boating Community today.





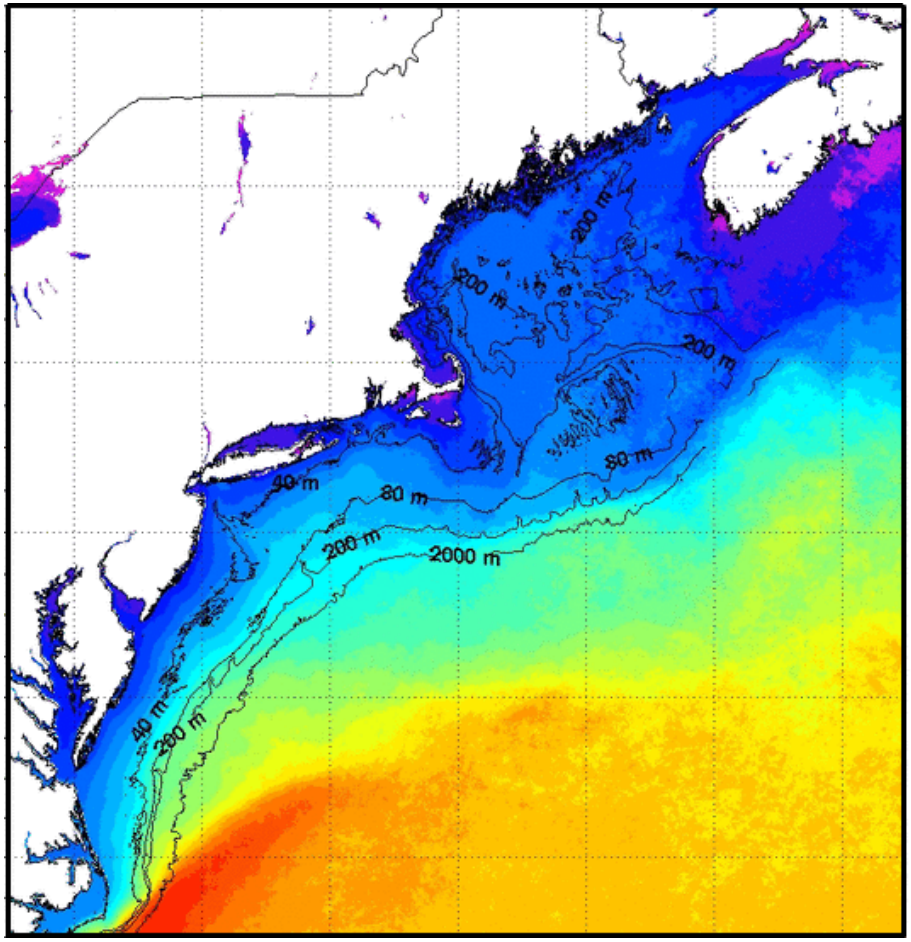
Temperature

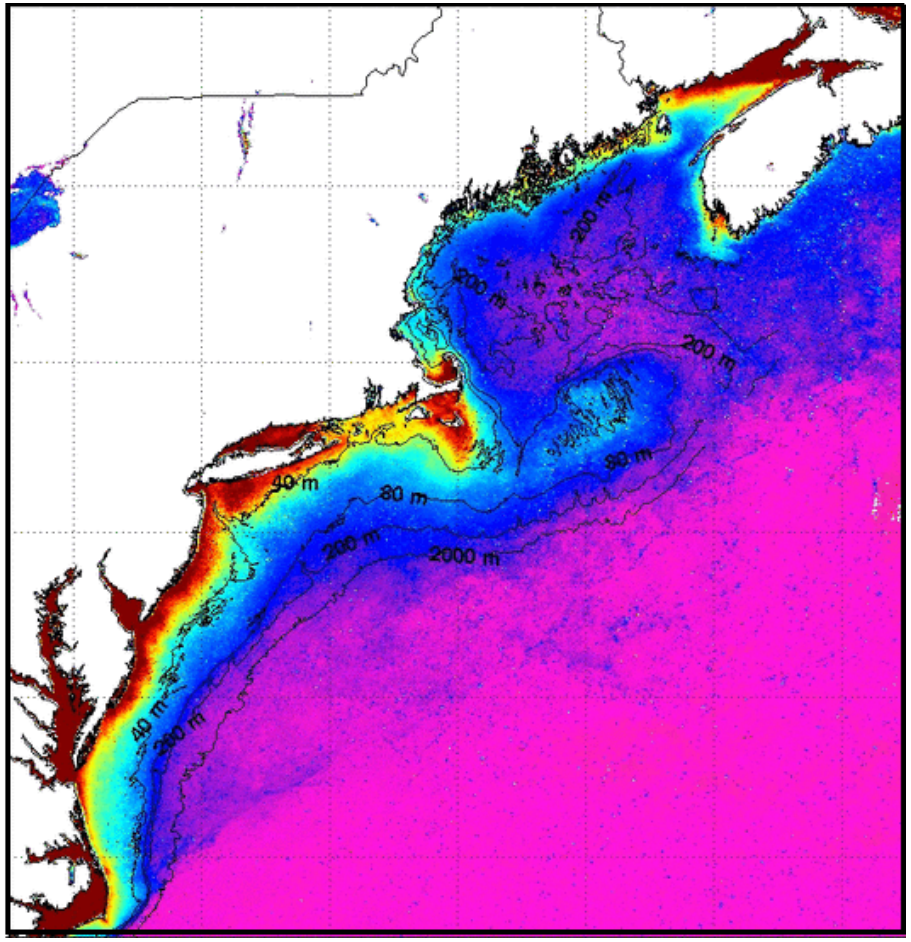
Hot — Cold

Chlorophyll

Lots of Plants — Few Plants — No Plants

A





Temperature

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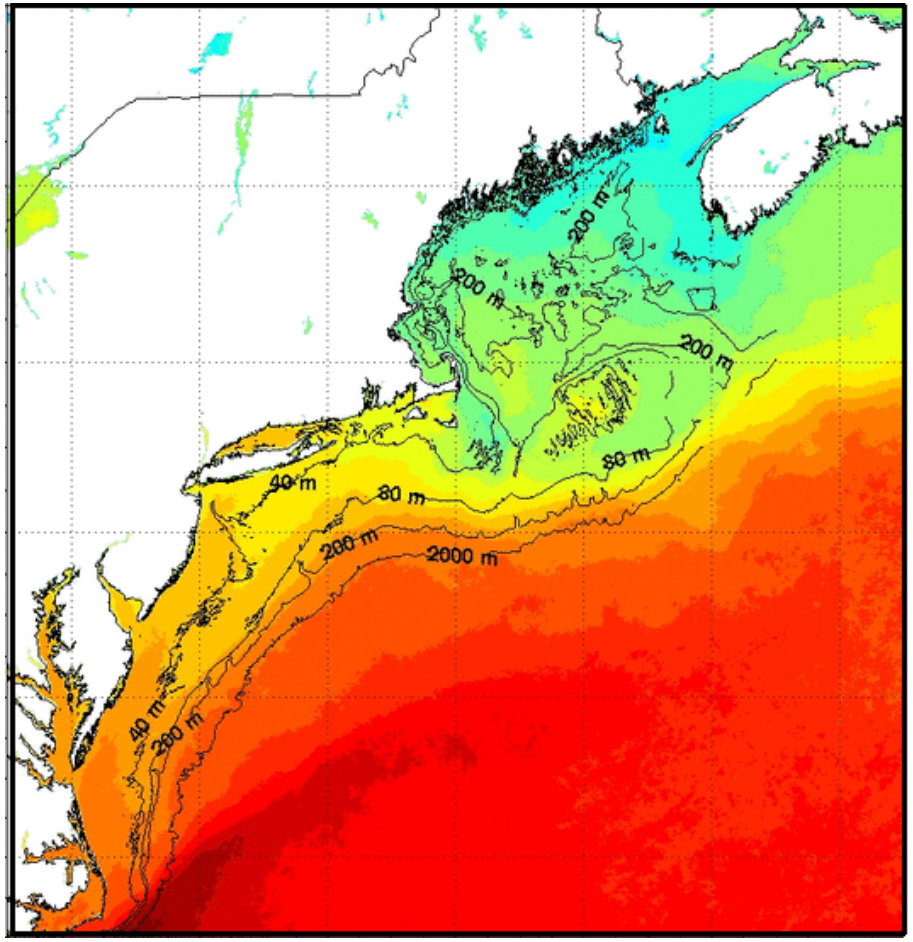
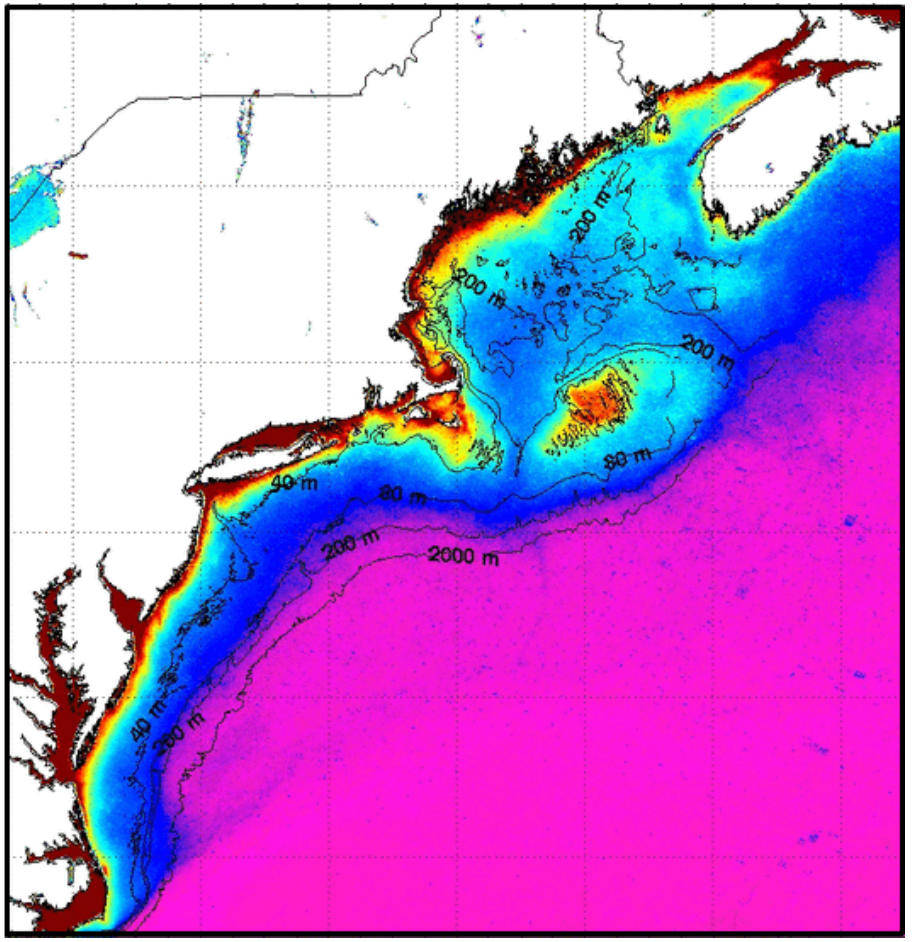
B





Temperature

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Chlorophyll

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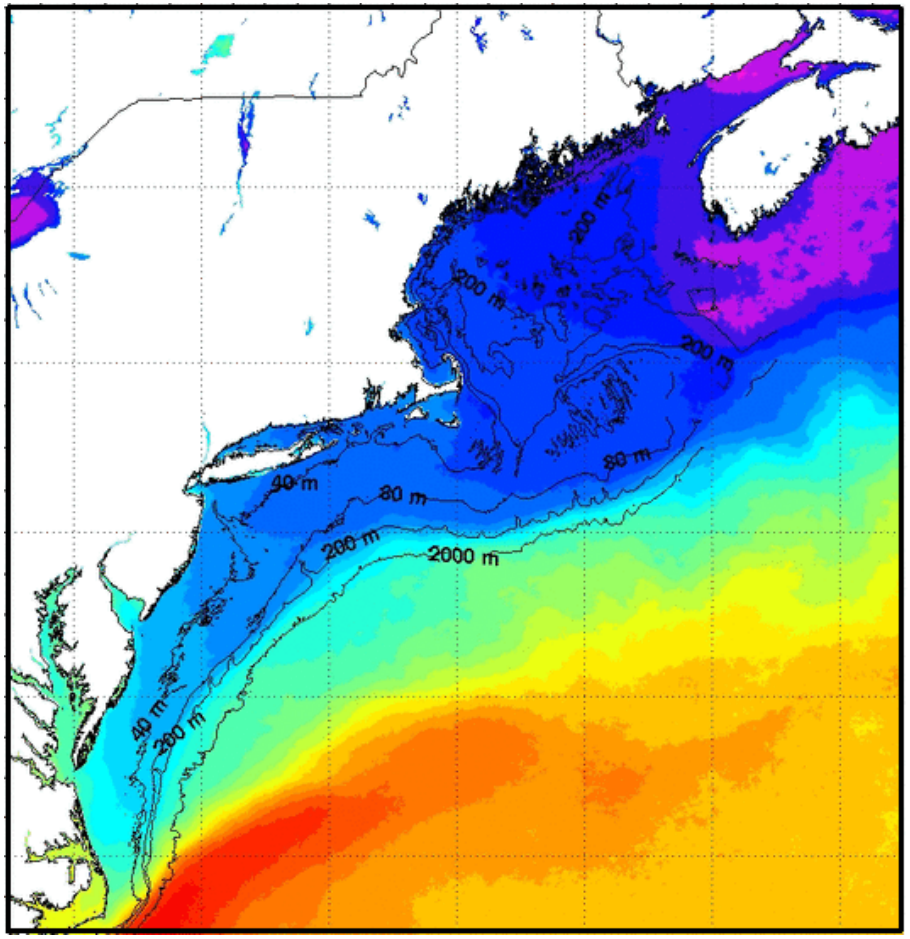
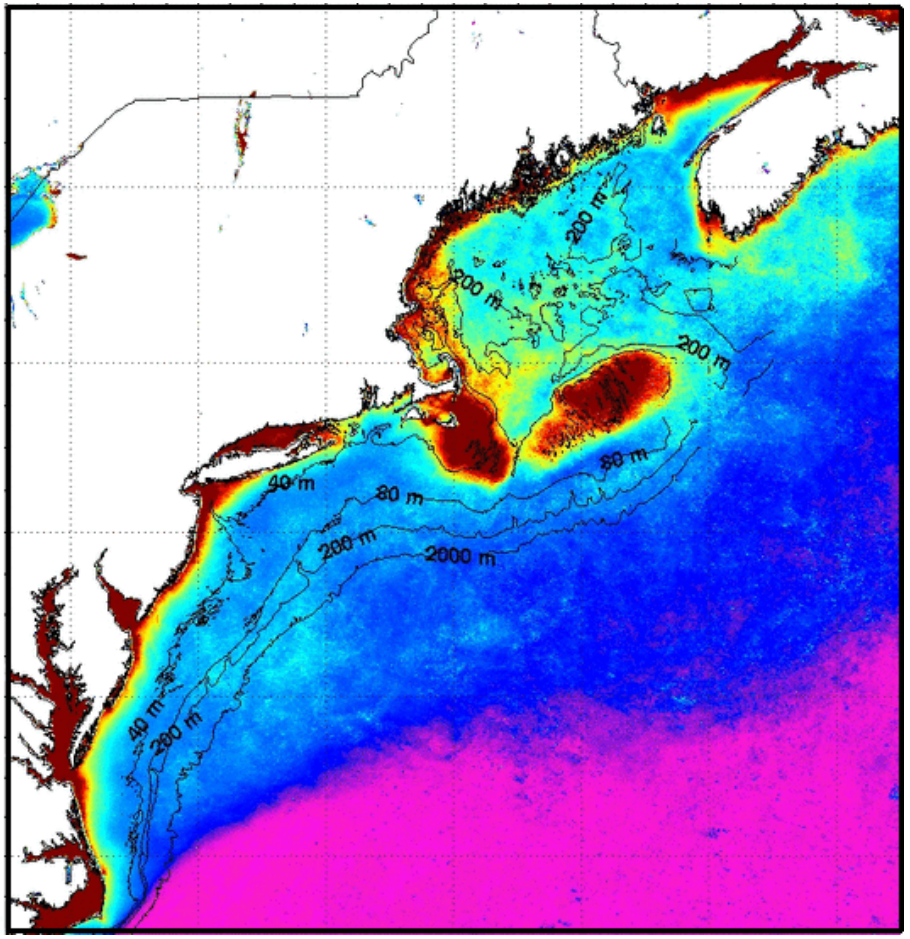
C





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D