Standard covered:

- 12CLS4.4 Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms.

http://serc.carleton.edu/eet/phytoplankton/case_study.htm
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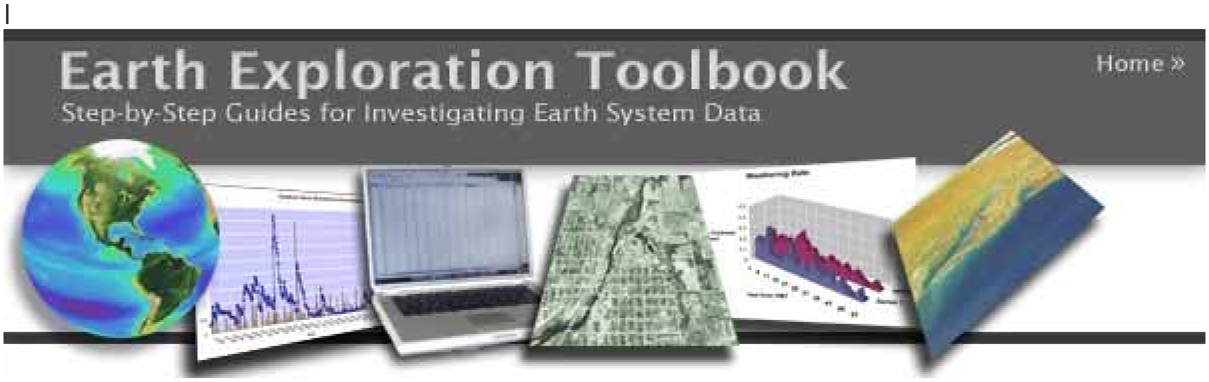

When is Dinner Served? Predicting the Spring Phytoplankton Bloom in the Gulf of Maine

Coccolithophore Phytoplankton Bloom in the Gulf of Maine

The bloom is the large bluish-green patch in the center of the image. Image acquired on July 11, 2002, by the Moderate-resolution Imaging Spectroradiometer (MODIS), flying aboard NASA's Terra spacecraft.

Image courtesy Jesse Allen, NASA Earth Observatory
Data courtesy MODIS Land Rapid Response Team

To a fish, nothing beats phytoplankton. These tiny, microscopic plants are eaten by very small fish that, in turn, get eaten by bigger fish. Since these larger fish feed even bigger fish (and humans!), it is hardly an exaggeration to state that phytoplankton sustain almost all life in our ocean. Bacteria in deep sea ecosystems provide an additional source of food for marine life through a process called chemosynthesis, although that will not be addressed in this chapter.

Like any plant, phytoplankton need sunlight, carbon dioxide, water, and nutrients to grow. Because sunlight is most readily available at or near the sea surface, phytoplankton also develop near the sea surface. Phytoplankton contain the pigment chlorophyll-a, which gives the plant a greenish color. Depending on the species found in abundance, the color of the ocean can range from green to brown to red. Since phytoplankton respond very quickly to changes in their environment, scientists use satellite imagery to monitor phytoplankton levels (via chlorophyll) as an indicator of the ocean's biological productivity. These same satellite images can also be used by scientists, commercial fishermen, commercial whale watching boats, and the public to locate areas of high concentrations of phytoplankton that may suggest where schools of juvenile fish, sand lance, mature fish, and possibly whales are feeding.

Phytoplankton also play a critical role in the global carbon cycle. Phytoplankton consume carbon dioxide from the ocean during photosynthesis and emit oxygen as a by-product. In fact, as previously mentioned, half of the oxygen we breathe is produced by ocean phytoplankton. As a result of photosynthesis, the oceans are a net sink (or consumer) for carbon dioxide. If the amount of phytoplankton in the global ocean is reduced, as a result of climate change for example, atmospheric carbon dioxide could increase.

Since carbon dioxide and water are readily available in the ocean surface, the main factors that limit phytoplankton development are the availability of nutrients and sunlight. These nutrients (such as nitrate, phosphate, and silicate) are found in the colder, deeper areas of the ocean. Shifting ocean currents (called upwellings) and mixing from fall and winter winds brings these nutrients to the sea surface. Spring brings warmer temperatures and increased sunlight and consequently, the phytoplankton bloom.

In this chapter, students will gain a better understanding of the critical role phytoplankton plays in the marine food chain by predicting the timing of the spring phytoplankton bloom in the Gulf of Maine. Students will obtain buoy data on the variables that influence the timing of the spring bloom: water temperature, salinity, and density. These data are available from buoy monitoring stations in the Gulf of Maine Ocean Observing System (GoMOOS). Students will then graph these data and from these graphs form a hypothesis as to when the bloom should occur based on oceanographic principles. They will then compare their predicted bloom date to observed chlorophyll levels that indicate the amount of phytoplankton in the ocean. Finally, students will acquire MODIS (Moderate Resolution Imaging Spectroradiometer) satellite images of this region from the University of New Hampshire's Coastal Observing Center to see how a satellite views a phytoplankton bloom from 400 miles above Earth.

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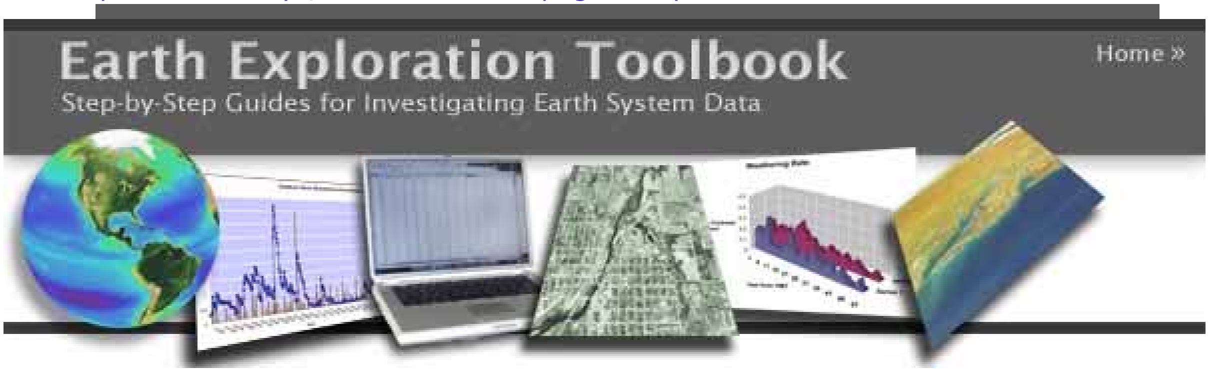
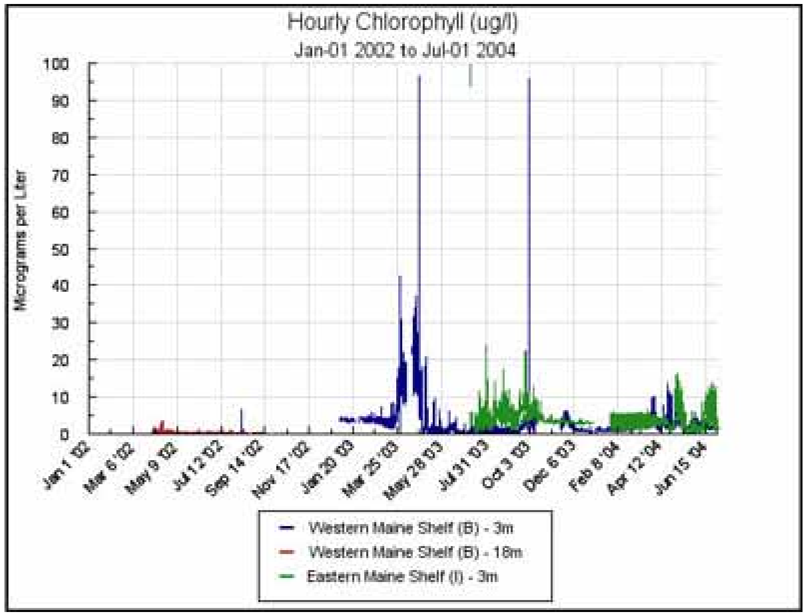


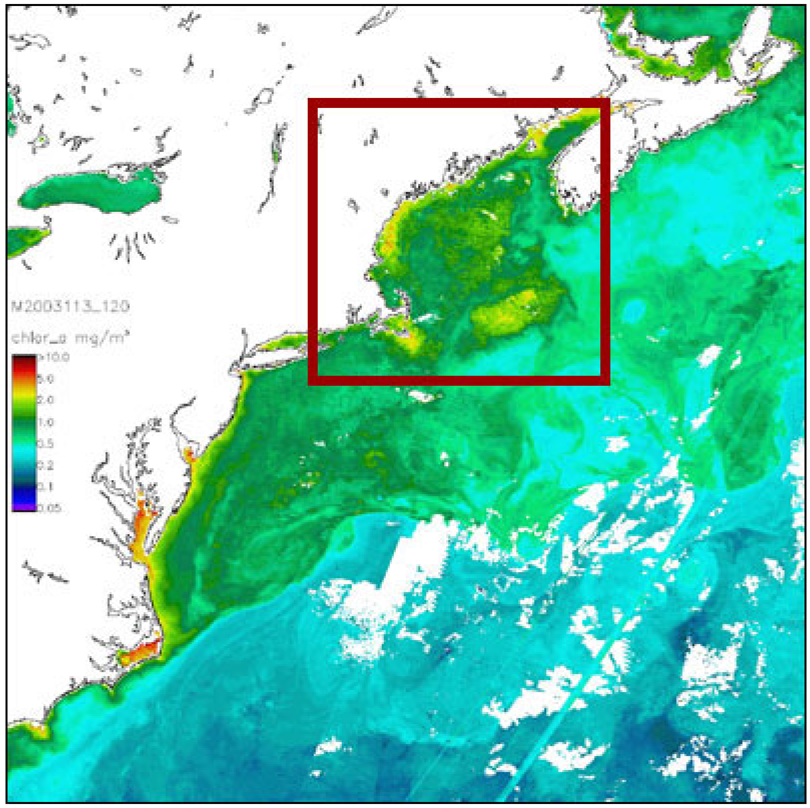
Teaching Notes

Example Output

Below is a chart downloaded from the GoMOOS website of hourly chlorophyll data recorded at buoys B and I taken at three different depths over a two year time period. The time frame ranges from Jan 1, 2002 through July 1, 2004. This multiyear graph illustrates that there are distinct fall and spring phytoplankton blooms that occur in the Gulf of Maine, although more information is needed to explain why this happens. For buoy locations please see the GoMOOS buoy map in Part 2 of the Step-by-Step Instructions.



This second figure is a map of the chlorophyll levels recorded from the MODIS (Moderate Resolution Imaging Spectroradiometer) sensor onboard the Terra satellite on April 23, 2003. The dark red areas show that levels of 10.0 mg/cubic meter of chlorophyll were detected. While this MODIS image and other MODIS images used in this chapter show the northeastern U.S. coast, our region of interest is the Gulf of Maine and is outlined in the red box:



As students gather more information about the water column, such as temperature and density at different depths for different locations, they can begin to compare and inquire about the causes of the spring bloom in the Gulf of Maine.

Grade Level

Grades 7-12

Learning Goals

After completing this chapter, users will be able to:

- Explain the ecological importance of phytoplankton
- Describe the components that influence a phytoplankton bloom
- Interpret satellite images in order to correlate buoy data

- Use the scientific process to predict the onset of the spring bloom based on background data
- Download and analyze graphs of oceanographic buoy data
- Identify geographic features in the Gulf of Maine

Learning Contexts

This chapter demonstrates how oceanographers study the phenomena of the spring phytoplankton bloom using a variety of different oceanographic technologies. Through understanding some of the basic factors that influence the productivity in the Gulf of Maine, students will be able to make educated guesses about when the spring bloom may occur based on buoy data and satellite images. This inquiry based method will teach students to ask questions in order to solve a puzzle which scientists are also actively trying to answer. Depending on how much explanation and preparation is done for the students this could involve students from a variety of learning levels.

Science Standards

The following National Science Education Standards are supported by this chapter:

- 12ASI1.1 Identify questions and concepts that guide scientific investigations. Students should form a testable hypothesis and demonstrate the logical connections between the scientific concepts guiding a hypothesis and the design of an experiment. They should demonstrate appropriate procedures, a knowledge base, and conceptual understanding of scientific investigations.

- 12ASI1.5 Recognize and analyze alternative explanations and models. This aspect of the standard emphasizes the critical abilities of analyzing an argument by reviewing current scientific understanding, weighing the evidence, and examining the logic so as to decide which explanations and models are best. In other words, although there may be several plausible explanations, they do not all have equal weight. Students should be able to use scientific criteria to find the preferred explanations.
- 12CLS4.4 Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms.

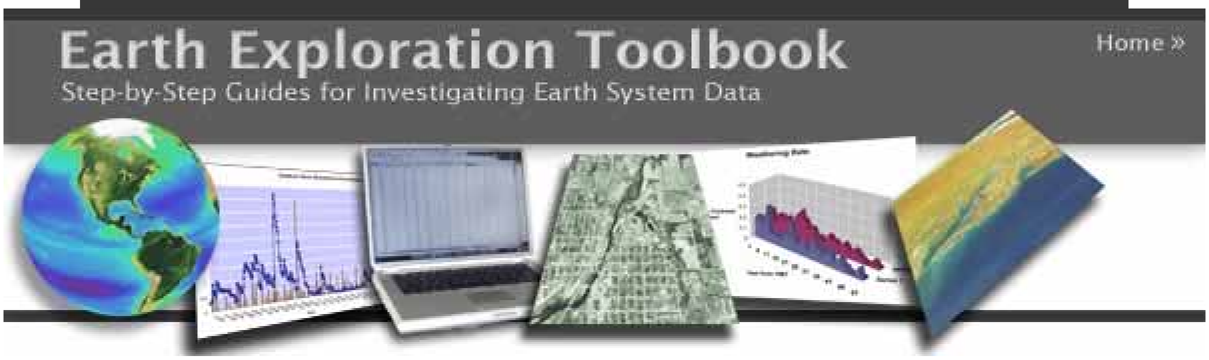
Time Required

Three 45 minute classes.

Other Resources

Graphs created in this chapter

This page includes all the graphs created in the chapter.



The instructions for this chapter have 6 main parts. Click each Part name to see the steps in that part.

Part 1-What Causes Phytoplankton to Bloom? A Quick Primer

Learn more about the seasonal cycle of phytoplankton development and the factors that trigger a phytoplankton "bloom". Here's a quick primer.

Part 2-Explore the Gulf of Maine Ocean Observing System (GoMOOS)

Learn more about the Gulf of Maine Ocean Observing System (GoMOOS), the data collected, and how these data are used.

Part 3-Retrieve and Graph Buoy Data from GoMOOS

Obtain temperature, salinity, and density data for 2004 from the Gulf of Maine Ocean Observing System (GoMOOS) and plot these data as an X-Y graph.

Part 4-Analyze the Graphs to Form a Hypothesis

Use the buoy plots to develop an estimate of when the phytoplankton should bloom.

Part 5-Retrieve and Graph Chlorophyll Data

Compare the hypothesized date of the spring bloom from the buoy data to the actual date of the bloom as indicated by observed chlorophyll (florescence) levels.

Part 6-Obtain MODIS Satellite Images for the Gulf of Maine

Obtain MODIS satellite images of the region and learn how a satellite "sees" a phytoplankton bloom.

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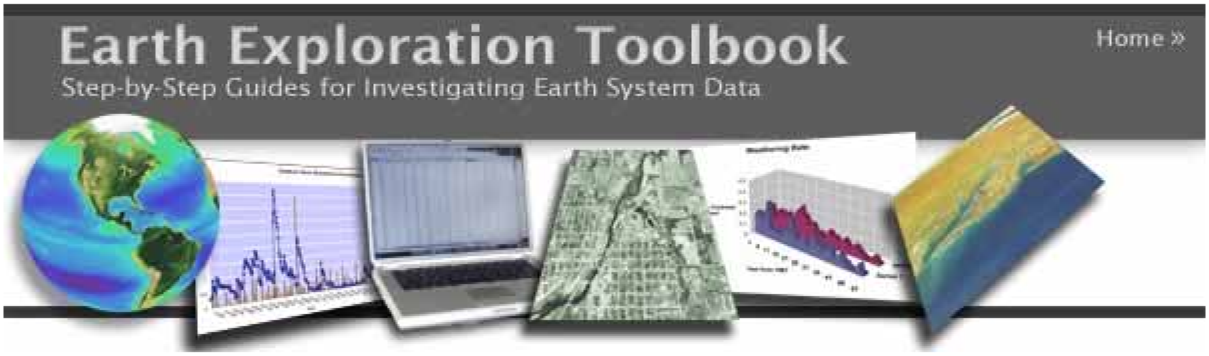

About the Tool and Data

Tool 1

Gulf of Maine Ocean Observing System (GoMOOS)

The Gulf of Maine Ocean Observing System (GoMOOS) provides hourly real-time data on weather and oceanagraphic conditions in the Gulf of Maine.

Tool Builder
Gulf of Maine Ocean Observing System
P.O. Box 4919
Portland, ME 04112-4919

Tool Cost
Free

Tool Help
info@gomoos.org

Tool 2

WebCOAST (a Web-based Coastal and Ocean Observing System)

WebCOAST is a digital library of free coastal ocean observation data from the University of New Hampshire. A complementary data distribution system, EOS-WEBSTER, offers free, customized terrestrial Earth science data.

WebCOAST is the portal for data and information products developed by researchers at the Coastal Observing Center. The Center's primary mission is to develop new methodologies for monitoring coastal marine ecosystems with a focus on the Western Gulf of Maine.

Tool Builder

WebCOAST
Dr. Annette Schloss, Project Manager
Complex Systems Research Center
Institute for the Study of Earth, Oceans, and Space
University of New Hampshire

Coastal Observing Center
Dr. Janet Campbell, Director
Ocean Process Analysis Laboratory
Institute for the Study of Earth, Oceans, and Space
University of New Hampshire

Science advisor for this chapter:
Dr. Ru Morrison
Ocean Process Analysis Laboratory
Institute for the Study of Earth, Oceans, and Space
University of New Hampshire

Tool Cost

Free

Tool Help

support@webcoast.sr.unh.edu
1-877-589-4909 (toll free)

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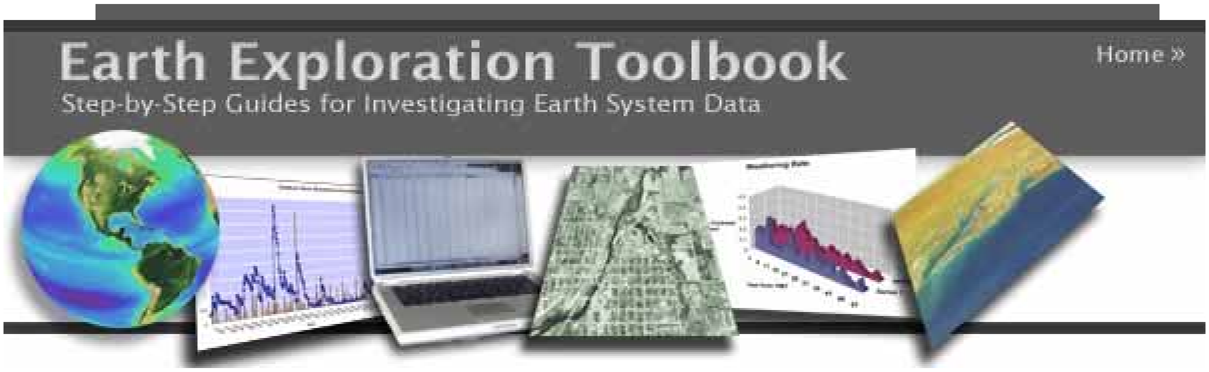

Conclusions

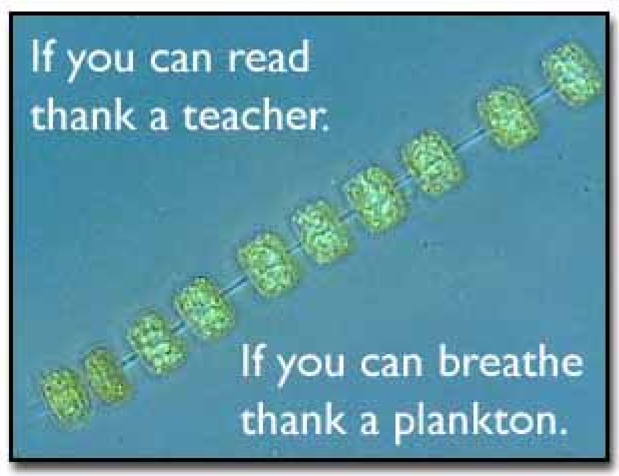

Image courtesy D.Townsend

This chapter provided an overview of the factors that trigger a phytoplankton bloom as well as an introduction to the data, techniques, and analysis tools used to study these blooms.

The Gulf of Maine is a complex marine ecosystem. Many factors interplay almost simultaneously to create a phytoplankton bloom and our understanding of these factors is incomplete. While we can't know precisely ***When Dinner is Served*** in the ocean, using the same data and tools scientists use to study these blooms we can make a reasonable prediction as to the timing, and in the process, gain a better appreciation of this unique oceanographic phenomenon.

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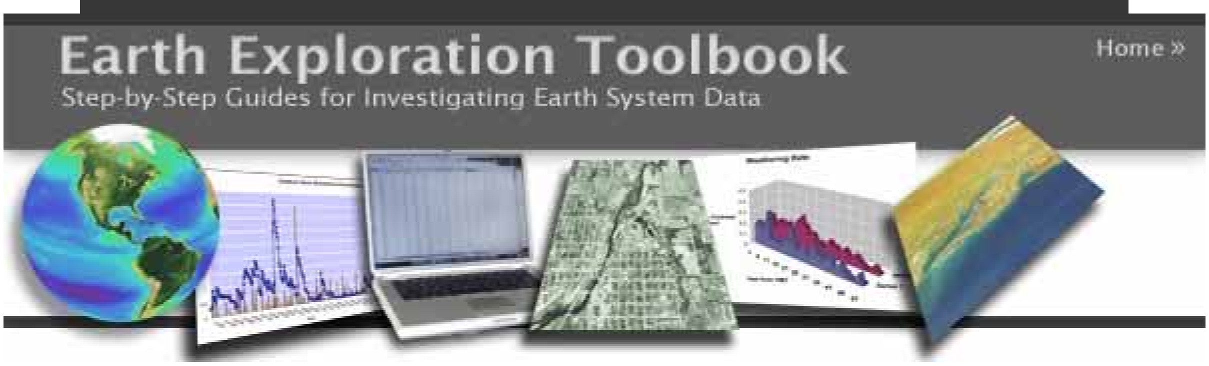


Going Further

Other Data

Satellite Images of Phytoplankton Blooms from Around the World

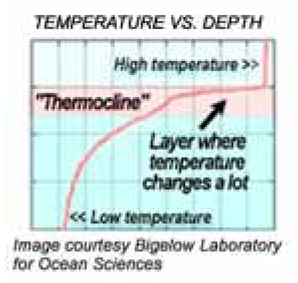
20 spectacular images from NASA's Visible Earth

▶ Show me the list

▼ Hide

Other Techniques

Create a Thermocline



As described in the primer, thermoclines are often viewed as temperature versus depth in vertical form. However, when many different depths are combined, the graph can look cluttered and confusing and can be difficult for students to understand. To give students a better understanding of the temperature/depth relationship in the ocean, have students draw a thermocline by using pencil and graph paper for a specific buoy at a specific depth either before or after they have created a GoMOOS graph. This may help orient them to the relationship of how temperature in the ocean can change as depth increases, depending on the season.

Other Tools

Phytopia: Discovery of the Marine Ecosystem

Phytopia is an educational CD-ROM produced by the Bigelow Laboratory for Ocean Sciences. The CD-ROM is free; shipping and handling for U.S. orders is $3.95. Learn more about Phytopia.

Ship Mates: Explore the Gulf of Maine As Oceanographers Do

Ship Mates, also from Bigelow Labs, is a suite of educational activities that interactively guide users through working with on-line oceanographic data.

Background Resources:

Miller, Charles. 2004. **Biological Oceanography**. Oxford,UK. Blackwell Science Ltd.

Garrison, Tom. 2005 **Oceanography: An Invitation to Marine Science** USA. Thomson Learning, Inc.

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