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Real-Time Ocean Data in the Classroom

Students use the internet to conduct ocean research

Laura Murray, Deidre Gibson, and Angela Ward

In this fast-paced world, students are using the internet to obtain information quicker than they can drive to the library. To apply students' savvy internet skills in the science classroom—as well as capture their interest in science and investigation, and provide opportunities for authentic research—introduce them to real-time data from ocean-observing systems. Buoys, satellite images, autonomous rovers, and other devices sense the "pulse" of the ocean by collecting data continuously and telecommunicating it to scientists, who then post it on the internet. Students can use data from these ocean-observing systems to discover the winds and waves from storms or to explore currents and predict marine-organism distribution.

The four web-based student activities presented in this article bring the world of high-tech instruments and real-time data information to the classroom. The first activity introduces ocean-observing systems; the second explores how the ocean affects local weather; the third uses ocean temperatures to predict the distribution of marine organisms; and the fourth provides insight into how ocean temperatures may change with predicted climate changes.

What are ocean-observing systems?

Ocean-observing systems include a variety of instruments that measure temperature, currents, wave height, salinity, and other parameters. Observing systems employ many types of technology, including: satellites that carry sensors, which provide ocean information from miles above the surface; moored (stationary) buoys, which carry sensors and then transmit that information directly to land-based computers; and roving self-guided sensors, which use sound navigation and ranging (SONAR) techniques to detect seafloor features and water-chemistry information, that is then radioed to receivers.

Most of the real-time information gathered from ocean-observing systems is posted on the web. Therefore, the data is accessible to any secondary science classroom with an internet connection and can be incorporated in the curriculum through student activities. The Center for Ocean Science Education Excellence–Mid-Atlantic (COSEE–MA) (see "On the web" at the end of this article) provides internet-based activities that have been classroom tested by teachers in "Taking the Pulse of Our Ocean" workshops. Four of these activities are described in this article.

Depending on students' computer skills, these activities can be conducted independently, in small groups with minimal supervision, or as a classroom project (by projecting the activities from a teacher-controlled computer). The only materials needed are at least one computer with an internet connection and the relevant activity worksheets. Although these activities can be conducted independently, they build upon one another if completed in the order described.

Exploring Ocean-Observing Systems

In "Exploring Ocean-Observing Systems," students investigate the many uses of these systems (Figure 1). To initiate the activity, introduce students to the following features of the ocean that scientists use to make predictions about weather and climate.

The ocean occupies over 70% of Earth's surface. Surface waters are constantly in motion, and these circulation patterns exert a strong effect on global and regional climate and weather. Ocean currents are generated by many different forces. Winds, created by differences in solar heating, drive the ocean's surface currents. Earth's rotation (and resulting Coriolis effect) and coasts shape the circulation (Garrison 2005). The deep circulation of the global ocean is driven by density differences between the cold polar regions and the rest of the ocean. Warm, salty water delivered to the polar regions is cooled, forming dense water that sinks to the depths and then spreads throughout the world's oceans.

Addressing the Standards.

"Exploring Ocean-Observing Systems," "Local Weather and the Ocean," and "Applications to Climate Change" meet Content Standards A (Science as Inquiry), B (Physical Science), D (Earth and Space Science), and E (Science and Technology) (NRC 1996, pp. 173, 177, 187, 191). The "Where Do the Organisms Live?" activity meets Content Standards A and C (Life Science) (NRC 1996, pp. 173, 181).

The interaction between the atmosphere and the ocean creates year-to-year changes that can have strong effects on our weather. One of the better-known changes is El Niño/La Niña Southern Oscillation (ENSO), which results from fluctuations in wind and ocean-surface temperature. Scientists use real-time data and information from ocean-observing systems to interpret ocean conditions and make predictions about weather and climate.

The ocean-observatory websites provided in Figure 1 (and in "On the web") can deliver ocean current and circulation data in real-time. The purpose of this exercise is to

- provide major ocean-circulation patterns information,
- explore ocean-observing systems and the types of information they provide, and
- investigate ENSO data from observing systems.

Local Weather and the Ocean

Students assess how the ocean affects air temperatures in "Local Weather and the Ocean" (Figure 2, p. 46).

FIGURE 1

Exploring Ocean-Observing Systems.

Objective: Students investigate the many uses of ocean-observing systems.

A. Ocean currents of the world

For information on ocean-circulation patterns, go to the following websites:

- University Corporation for Atmospheric Research's (UCAR) Window to the Universe *(www.windows.ucar.edu/cgi-bin/tour_def/earth/Water/ocean_currents.html)*
- Office of Naval Research's (ONR) Science and Technology Focus *(www.onr.navy.mil).*

Observe and record the flow direction of the major ocean currents.

Questions:

- Which current flows off the southeast coast of the United States? What is the temperature of this current?
- Which current flows off the California coast? What is the temperature of this current?
- In which direction do these currents flow?
- What current is responsible for El Niño events off the coast of South America? Is it a hot or cold current?

B. Observing systems locations and information

As an introduction to ocean-observing systems, explore the National Oceanic and Atmospheric Administration's (NOAA) National Data Buoy Center website *(www.ndbc.noaa.gov)* to familiarize yourself with ocean-observing systems and the parameters they measure. Click on a region to view individual buoys. Click on the buoys to determine what type of information each buoy provides.

Questions:

- List several types of information provided by the ocean-observing buoys.
- What is the ocean temperature off the coast nearest your home or your favorite ocean area?

C. Ocean-movement measurements using observing systems

In the Equatorial Pacific, ocean movement is measured by an array of buoys, which can predict events such as El Niño. Visit the NOAA's Tropical Atmospheric Ocean project website *(www.pmel.noaa.gov/tao/index.shtml)* to investigate how observing systems can predict changes in ocean-circulation patterns and the resulting effects on climate and weather.

Critical-thinking questions:

- Are sea-surface temperatures warmer in the eastern or western Pacific Ocean? What technology did you use to answer this question?
- Explain how ocean temperature drives El Niño events.

Discuss with students the concept of heat capacity and how the circulation of the ocean's waters, as described in "Exploring Ocean-Observing Systems," affects regional weather.

Ocean water has a high-specific heat capacity that results in the rather slow temperature changes of the ocean (Garrison 2005); in comparison, the low-specific heat capacity of air results in rapid changes in air temperatures. These two factors—ocean circulation and heat capacity—explain why the air temperatures in coastal locations (by the ocean) are often cooler in the summer and warmer in the winter than inland locations. The predominant wind patterns blow air affected by ocean-surface currents to these coastal locations.

The exercise in Figure 2 requires students to investigate the influence of the ocean by comparing temperatures in coastal and inland locations.

Where Do the Organisms Live?

As indicated by the name of the activity, in "Where Do the Organisms Live?" students determine where marine organisms live based on ocean temperatures (Figure 3). Aquatic organisms are greatly affected by their physical environment and abiotic factors such as temperature, salinity, dissolved oxygen, and depth. In the open and coastal ocean, temperature can be a strong determinant of animal distribution.

The exercise in Figure 3 challenges students to investigate the influence of ocean temperature on marine-organism distribution.

Applications to Climate Change

All three activities previously described have one major related theme—ocean temperature. Upon completing the three activities, students have investigated how ocean temperature affects the global climate, local weather, and organism distribution.

To apply all the factors in a single activity, students should study the graph in Figure 4 (p. 48), which shows the changes in land and ocean temperature from 1880 to the present ("anomaly" refers to the temperature above or below the average annual temperature).

Students can use the graph to determine the rate of change in ocean temperature over the past 50 years. Stu-

FIGURE 2

Local Weather and the Ocean.

Objective: Students assess how the ocean affects air temperatures.

A. Finding the present air temperature

Visit The Weather Channel's website *(www.weather.com).* Type in your city and record the air temperature at this time: ___ °C. Locate a city by the ocean nearest you and record the air temperature at this time: ___ °C. (**Note:** Comparisons are best made between cities near the ocean and those inland, but on the same latitude.) Check the ocean-observing buoys for wind speed and direction. To convert from Fahrenheit to Celsius, use the following equation: $(°F–32) \times 5/9 = °C$.

B. Finding the water temperature

To find ocean-water temperature, go to NOAA's National Data Buoy Center (NDBC) website *(www.ndbc.noaa.gov).* Locate a coastal area nearest you on the map. Click on the area. Click on a coastal-ocean buoy and scroll down to find the water temperature. Record the value___ °C. Compare your answer to the air temperature found in section A.

Questions:

- Which area's air temperature was the closest to the ocean temperature?
- How did the coastal area's air temperature compare to the ocean-water temperature?

C. Finding the monthly average high and low temperatures

Return to the weather conditions for your city *(www.weather.com).* Scroll down to the "36-hour forecast" and click on "averages." Under the "monthly averages" menu, select "compare locations"—enter your ocean-comparison city from section A and compare the average-high and average-low temperatures for the two cities.

Questions:

- Which city had the highest monthly summer temperatures?
- Which city had the lowest monthly winter temperatures?

Critical-thinking questions:

- What effect does the ocean have on coastal and inland air temperatures?
- Explain how the ocean affects local air temperatures.
- How does this effect change with the seasons?

dents should predict the change in temperature over the next 50 and 100 years if this rate of change remains the same. Also, students should consider how temperature changes on land compare with those in the ocean.

For this activity, students should

- describe how the rise in ocean temperature will affect the global climate (i.e., El Niño events);
- describe how the rise in ocean temperature will affect the air temperature in coastal and inland locations;
- describe how the rise in ocean temperature will affect the habitat for marine organisms; and
- explain how these changes in ocean temperature will affect our marine resources.

Extensions and conclusions

The activities described provide several ways to use real-time data from ocean-observing systems with students to increase their interest in science and technology and their ability to analyze data. Many more possibilities exist to use this information to engage students in inquiry-based investigations and research projects.

For instance, students can formulate a research question (or hypothesis) based on the parameters measured by ocean-observing systems, such as:

- How does wave height change with increased wind speed? Is this a linear process?
- Does water current speed or direction change with increased wind speed?
- How does rainfall affect surface salinities in estuaries, coastal waters, and the open ocean?
- Are sea-surface temperatures affected by major storm events?

Once students have formulated their research question, they can collect the necessary data from the ocean-observing systems, analyze the results, formulate a conclusion, and propose further investigations.

Because of the large number of available remote-data stations and the wealth of data generated, students can investigate data and research questions that may have not yet been addressed by practicing scientists. Such inquiry-based activities provide an

FIGURE 3

Where Do the Organisms Live?

Objective: Students determine where marine organisms live, based on ocean temperatures.

Visit NOAA's NDBC website *(www.ndbc.noaa.gov)* to locate water temperatures at several offshore sites from Maine to Florida on the east coast and from Oregon to southern California on the west coast. Record temperatures in Table 1.

Table 1

Location	Temperature °C
Maine	______
New York	______
Virginia	______
South Carolina	______
Florida (Miami)	______
California (Los Angeles area)	______
Oregon	______

Table 2 describes the optimal temperature ranges for these marine organisms. Using the data from Table 1, determine the potential location of the organism.

Table 2

Organism name	Optimal temperature (°C)	Potential location
Tarpon	20–35	______
Winter flounder	10–12	______
Striped bass	18–23	______
American lobster	8–14	______
Florida lobster	22–26	______
Eelgrass	0–25	______
Turtle grass	15–35	______
Pacific anchovy	20–26	______
Pacific herring	0–10	______

Questions:

- Which organisms would you expect to find in South Carolina at this time?
- Which organisms would you expect to find in Maine at this time?
- Which organisms would you expect to find in Oregon at this time?

Critical-thinking questions:

- List the organisms that might live anywhere from Maine to Florida to California.
- Explain how these organisms can live in many different locations.

opportunity for all science students to engage in authentic scientific investigation. ■

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National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academy Press.

On the web

Activity information and extensions:

COSEE–MA Taking the Pulse of the Ocean: *www.coseecoastaltrends.net/ocean_pulse*

Marine organism temperature ranges:

Central Florida East Coast Fishing (saltwater fish): *http://home.cfl.rr.com/floridafishing/temp.htm*

National Wetlands Research Center (Pacific herring): *www.nwrc.usgs.gov/wdb/pub/species_profiles/82_11-079.pdf*

University of New Hampshire lobster research (American lobster): *www.lobsters.unh.edu/offshore_fishery/faq/faq.html*

Ocean-circulation patterns:

UCAR Window to the Universe: *www.windows.ucar.edu/cgi-bin/tour_def/earth/Water/ocean_currents.html*

ONR Science and Technology Focus: *www.onr.navy.mil*

Ocean-observing systems:

NOAA Coastal Ocean-Observing Systems: *www.ncddc.noaa.gov/COOS*

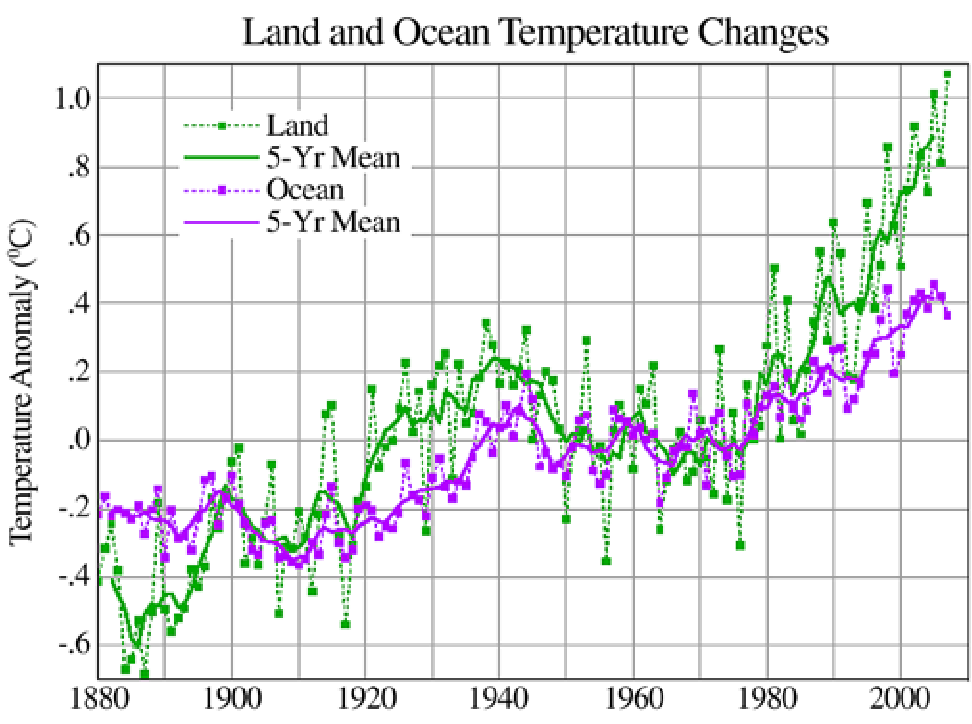
NOAA Nation Data Buoy Center: *www.ndbc.noaa.gov*

National Office for Integrated and Sustained Ocean Observations: *www.ocean.us*

The Weather Channel: *www.weather.com*

FIGURE 4

Changes in land and ocean temperature from 1880 to the present.



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