CENTERS FOR OCEAN SCIENCES EDUCATION EXCELLENCE
BEST OF COSEE HANDS-ON ACTIVITIES

Activity Title: How is Coastal Temperature Influenced by the Great Lakes and the Ocean?

Learning Objectives

The ocean is a major influence on weather and climate. With this set of lessons, middle school Earth systems science teachers can help their students build an understanding of how large bodies of water can serve as a heat source or sink at different times and how proximity to water moderates climate along the coast. The activity's combination of laboratory investigation, map study, and graphing applies different learning styles and provides practice in important science processes. The activities are adapted from *Earth Systems Education Activities for Great Lakes Schools: Great Lakes Climate and Water Movement* (V. J. Mayer et al. 1996).

Ocean Literacy Principles:

#3 --The ocean is a major influence on weather and climate.

b) The ocean absorbs much of the solar radiation reaching Earth. The ocean loses heat by evaporation. This heat loss droves atmospheric circulation when, after it is released into the atmosphere as water vapor, it condenses and forms rain. Condensation of water evaporated from warm seas provides the energy for hurricanes and cyclones.

Supplies and Materials

See below in the procedures for the two activities

Background

Ocean literacy essential principle 3 states that the ocean is a major influence on weather and climate the lakes. The development of climate patterns is a complex set of processes, but learning about coastal weather conditions serves as a step toward understanding how the atmosphere and ocean interact to create a maritime climate. It takes far more energy to change the temperature of water than the temperature of land or air. For this reason, temperatures over inland areas exhibit greater extremes and ranges than temperatures near large bodies of water. Activity 1 examines the principles behind such changes, and activity 2 demonstrates how the process plays out in modifying coastal temperatures.

Duration

The two activities can take 45 -60 minutes each to complete, or they can occur over several days if students gather their own data.

Audience

This activity is most appropriate for grades 6-8.

Procedure

Activity 1: What Happens to Heat Energy Reaching Water and Land?

Even as far back as the log cabin days, American pioneers would place a large container of water in a room to prevent foods from freezing on cold nights. The pioneers understood that water absorbs a great deal of heat energy and can, in turn, release this heat. In the first investigation, middle school students explore how bodies of water can affect the surrounding areas. This activity simulates the effects of sunlight on water and land.

Objectives

When students have completed this activity, they should be able to (1) describe how soil and water differ in their ability to absorb and release heat energy and (2) describe how this difference in heat absorbed or released affects the atmosphere immediately above the land and the water.

Materials for Each Lab Group

- Four thermometers
- One container of dark soil and one container of water (The containers should hold equal amounts, and the soil and water should be left out overnight to come to room temperature.)
- Two 30-cm rulers
- Masking tape
- Ring stand
- Lamp (at least 150 W) with reflector
- Safety goggles for each group member
- Graph paper

Setup

Teams should set up the materials according to the following directions. (See Figure 1 for a completed setup.)

1. Place the containers of soil and water about 3 cm apart. Lay one ruler across each container, resting it on the container's rim.
2. Place one thermometer in the soil, with the bulb just barely covered. Use masking tape to attach the thermometer to the ruler to hold it upright. Place another thermometer close to the first one, with the bulb about 1 cm above the soil. Attach it to the ruler, too.
3. In the water container, position the remaining two thermometers the same way, placing one just above and one just below the water surface. Attach both to the ruler above the water container.
4. Place the lamp on the ring stand, with the reflector pointing down. Position the lamp 30 cm above the containers and centered between them, being careful to shield the thermometer bulbs from the direct rays of the lamp. Containers may face each other for more even distribution of light, as long as the thermometers can be read.

With this apparatus, one can simulate alternate periods of heating and cooling and observe how temperature changes in and above the water and land. The situation might represent either light and darkness on a single day or seasons of heating and cooling with annual changes in insolation.

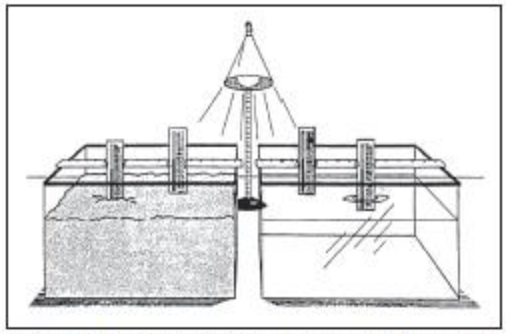

FIGURE 1. Setup for activity 1 investigation. Source: V. J. Mayer et al. 1996.

Procedure for Students

1) Construct a data table to show the temperatures of the four thermometers each minute for at least 24 minutes.
2) Wear safety goggles for this investigation.
3) The teacher should examine the setup before the lamp is turned on.
4) Turn on the lamp. At 1-min intervals, record the temperatures on each of the four thermometers. Continue for 12 min.
5) After 12 min, turn off the lamp. Continue recording temperatures at 1-min intervals for 12 min more.
6) Plot the data on a time–temperature graph. Use a different color for the data from each thermometer. Use the data to answer the following questions.
   a) When the light is on, does air heat up faster over the soil or over the water? (Answer: *over soil*)
   b) When the light is on, which changes more, the temperature of the soil or the temperature of the water? (Answer: *The soil heats more rapidly. Soil has a lower specific heat, and it absorbs all radiation close to the surface. Specific heat is the amount of heat in calories required to raise the temperature of 1 g of substance by 1°C. The specific heat of water is 1. All other common liquids and solids have a specific heat of less than 1.*)
   c) Which absorbs more energy, soil or water? (Answer: *water*) Students may have difficulty understanding this answer. The clue is in the air temperature curves. The air over the soil heats up much more rapidly than the air over the water because soil cannot hold on to the heat energy and returns it to the atmosphere. The difference in the curves, therefore, implies that the water has a greater capacity for storing heat energy.
   d) In the second 12-min interval, when the light is off, which changes more, the temperature of the soil or the temperature of the water? (Answer: *After the light is turned off, the soil cools more rapidly than the water because of its lower specific heat.*) See
7) Figure 2 to further explore this idea. Note that the curves for soil and water now show a drop at different rates in section B of the graph.
   a) Which changes most after the light is off, the temperature above the soil or the temperature above the water? (Answer: *above the soil*) Notice how the air lines on the graph cross at about 19 min and continue to diverge after that. This shows that water is acting as a source of

heat energy for the atmosphere.

b) Which loses heat faster, soil or water? (Answer: *soil*)

c) Which keeps heat energy longer, soil or water? (Answer: *water*)

d) Anything that adds heat energy to the atmosphere is called a *heat source*. A *heat sink* takes and stores energy from the atmosphere. Discuss whether soil or water could be considered a heat sink while the light is on. (Answer: *Normally, soil functions very briefly as a heat sink after the light is turned on. Shortly, however, it begins radiating energy back to the atmosphere—becoming a heat source—as indicated by the heating of the air above the soil. Water remains a heat sink and produces only a minimal rise in temperature of the air above.*)

e) After the light is turned off, is the soil a heat source? Is the water a heat source? Why? (Answer: *After the light is turned off, soil functions briefly as a heat source. Because the air temperature above the water remains higher than that of the water itself, it continues to act as a heat source for the entire recording period, until the surface water is the same temperature as the air over it.*)

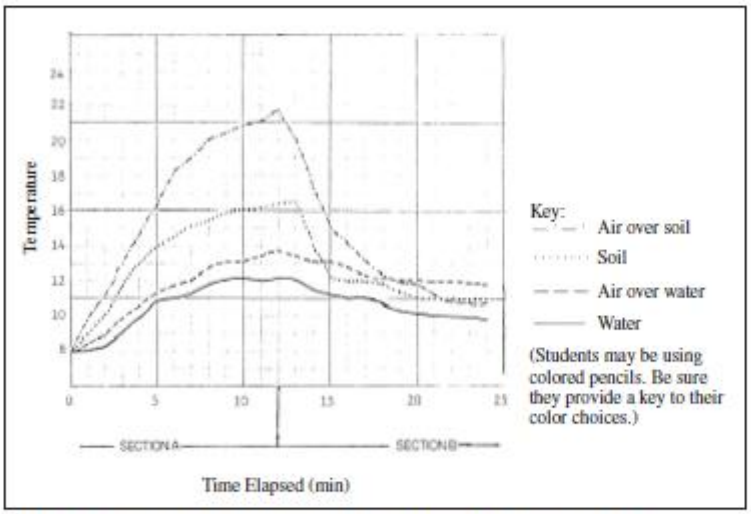

FIGURE 2. Sample of student graph results. Source: V. J. Mayer et al. 1996.

Technology Application

Use temperature probes in a local environment to collect daily water, air over water, land, and air over land temperature data for mornings and afternoons for several weeks in the spring. Have the class develop graphs that represent how the local soil, water, and air temperatures change during the day, as in activity 1. Cloud cover and passage of fronts will affect these data, so it may take several days for students to be able to generalize from their observations. If outdoor data collection is not possible, the Internet can be a data source. For example, the Web site http://weather .unisys.com/surface/previous/sfc_con_24temp-10.html provides a 24-hr map of atmospheric conditions for the current day, and the isotherms (in degrees Celsius) can be observed across periods of daylight and darkness over both land and water. Students can graph the range of temperatures in coastal areas to see if they can detect how the sea or Great Lakes are serving as heat sources or sinks for the atmosphere. Note that the general movement of air across the continental United States is west to east. Ask students to determine which coast of a lake or ocean is more likely to show effects of the water on air temperature. (Answer: *The air temperature over a coastal area downwind of water* *will likely show more effects of the water as a heat source or sink.*)

Assessment

Accuracy in graphing will be necessary for appropriate interpretation of results. Teachers should observe graphing techniques as one component of assessment. Answers to the questions are a second component, although class discussion may be necessary to bring out the principles involved in interpreting the data. Finally, ask students to apply what they have learned by answering the question discussed in the first paragraph of activity 1: Why would pioneers put a barrel of water in the apple shed to prevent fruit from freezing on a chilly night?

Activity 2: How Do the Ocean and the Great Lakes Affect Temperature?

In activity 1, students learned that a pan of water is a good heat sink when the lamp is on and a good heat source when the light is off. Soil also acts as a heat sink and source, but its capacity to hold energy is much lower than that of water. Therefore, soil becomes a heat sink soon after the light is turned on and stops acting as a heat source not long after the light is turned off. Water in the ocean and Great Lakes tends to increase in temperature all summer. This indicates that it is storing up extra energy from the atmosphere and acting as a heat sink throughout the summer. In the winter, however, there is less radiation from the sun. Then, oceans and lakes become heat sources, giving up their stored energy to the atmosphere.

Objectives

When students have completed this activity, they should be able to synthesize information about the effects of the ocean and Great Lakes on the temperature of the surrounding land. Students should work in pairs on this activity. Each pair will need copies of Figures 3–6.

Procedure for Students

1) Figures 3 and 4 are maps of Ohio with isotherms drawn on them. An *isotherm* is a line that connects points of equal temperature. The National Weather Service reports temperatures in Fahrenheit, so the temperatures on this map are in Fahrenheit. Average temperatures in July and January are shown in the figures, and the body of water north of Ohio is Lake Erie. Have the students answer the following questions using this pair of maps.

    a) What happens to the average temperature along line AB in Figure 3 as you approach Lake Erie from the west? (Answer: *Temperatures go up a little, then decrease as you approach the lake.*)

    b) What happens to the average temperature along line CD in Figure 4 as you approach Lake Erie from the west? (Answer: *Temperatures increase nearer to the lake.*)

    c) Explain the differences in temperature patterns between July and January. (Answer: *During the summer, the lake absorbs energy, but the land reradiates energy to the atmosphere. Therefore, the air over land is warmer than air over the water. In the winter, the energy absorbed by the lake water is gradually released to the atmosphere, making the air over the water warmer than the air over the land.*)

    d) Is Lake Erie a heat source or sink? Discuss. (Answer: *Lake Erie is both a heat source and a heat sink, depending on the season. In the late spring and summer, it is a heat sink; in the fall and winter, it is a heat source.*)

    e) Describe the effects of Lake Erie on the temperature of northern Ohio. (Answer: *Lake Erie acts as a moderator for northern Ohio's climate. It keeps the air cooler in the early summer and* *warmer in the rest of the fall and the winter than in other parts of the state.*)

2) The ocean affects temperatures in much the same way as large lakes. Figures 5–6 are maps of the world that show isotherms representing average temperatures in July and January. On these maps, the temperatures are in degrees Celsius.

    a) Follow parallel 60°N across Figure 5. How is temperature affected by the continents and by the ocean? (Answer: *As you follow 60°N across the map for July, the temperature rises over the continents and falls over the oceans.*) If students are familiar with how to make a topographic profile, they could make a temperature profile here to answer this question graphically. Teachers might also wish to look at other latitudes for examples of temperature differences.

    b) Follow parallel 60°N across Figure 6, just as in Figure 5. Describe the differences in average temperature. (Answer: *As you follow the line of latitude 60°N across the map for January, the temperature falls over the continents and rises over the ocean.*) For color maps showing similar data, see http://www.mapsofworld.com/world-maps/world-weather-map.html.

3) The ocean affects the temperature of the Great Lakes region, too. When the Great Lakes region has warm winter temperatures, it is under the influence of air that starts over the oceans. The cold frigid winter air comes from northern Canada, where the ocean does not have an effect.

    a) Do oceans act as heat sources or sinks? How do you know? (Answer: *Oceans act as heat sources in winter and heat sinks in summer, just as the Great Lakes do.*)

    b) Do continents ever act as heat sources? Explain. (Answer: *The continents act as heat sources in summer and heat sinks in winter, just like the land in Ohio does.*)

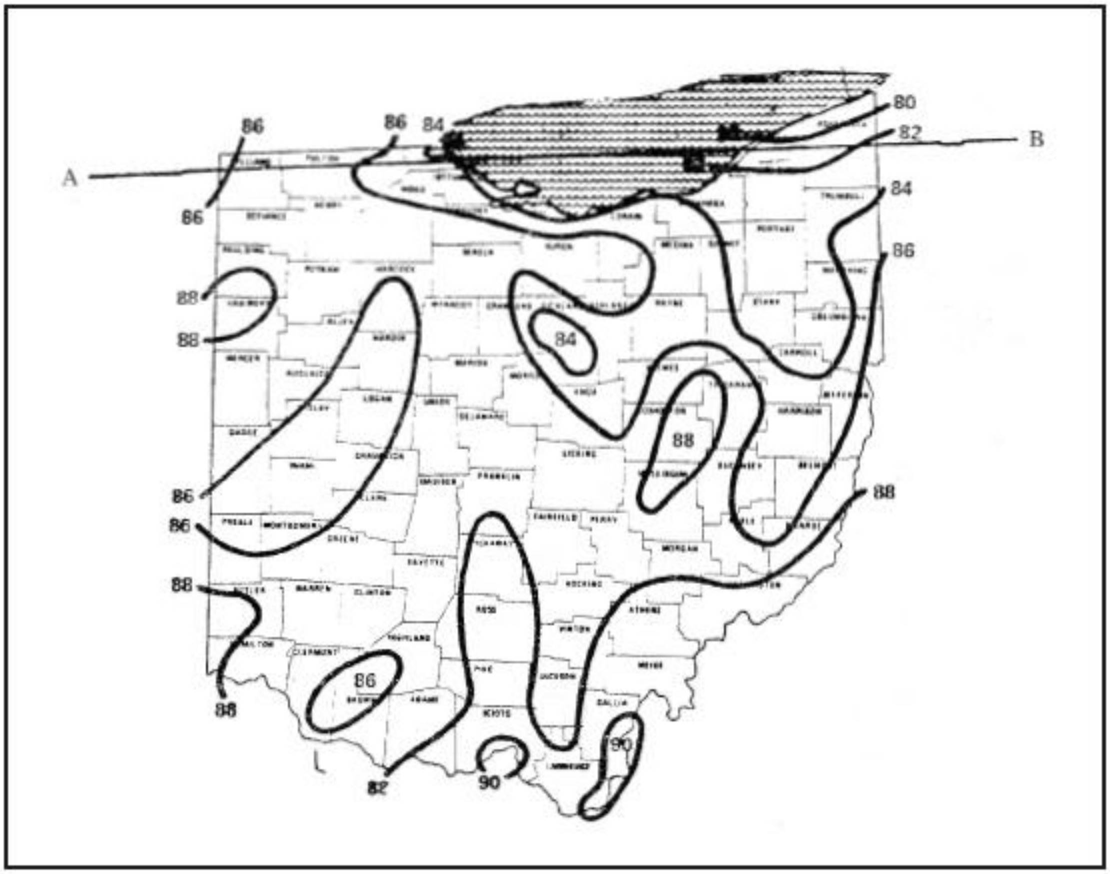

FIGURE 3. Mean maximum temperature of an average July in Ohio (°F). Source: V. J. Mayer et al. 1996.

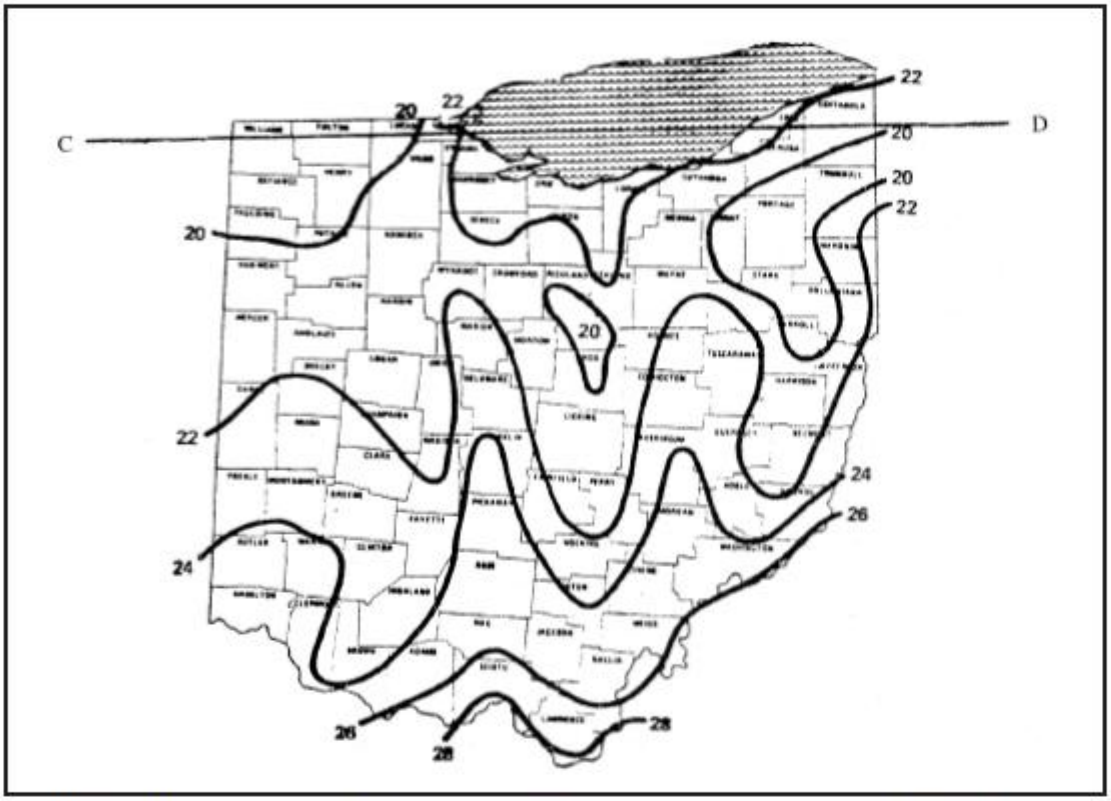

FIGURE 4. Mean maximum temperature of an average January in Ohio (°F). Source: V. J. Mayer et al. 1996.

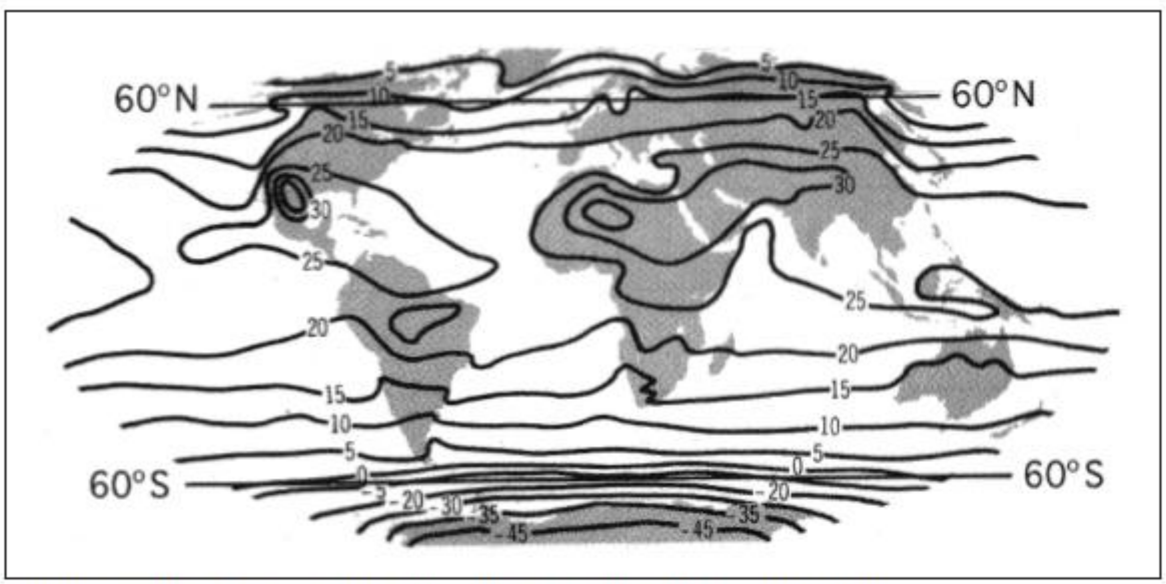

FIGURE 5. World map of average temperatures in July (°C). Source: V. J. Mayer et al. 1996.

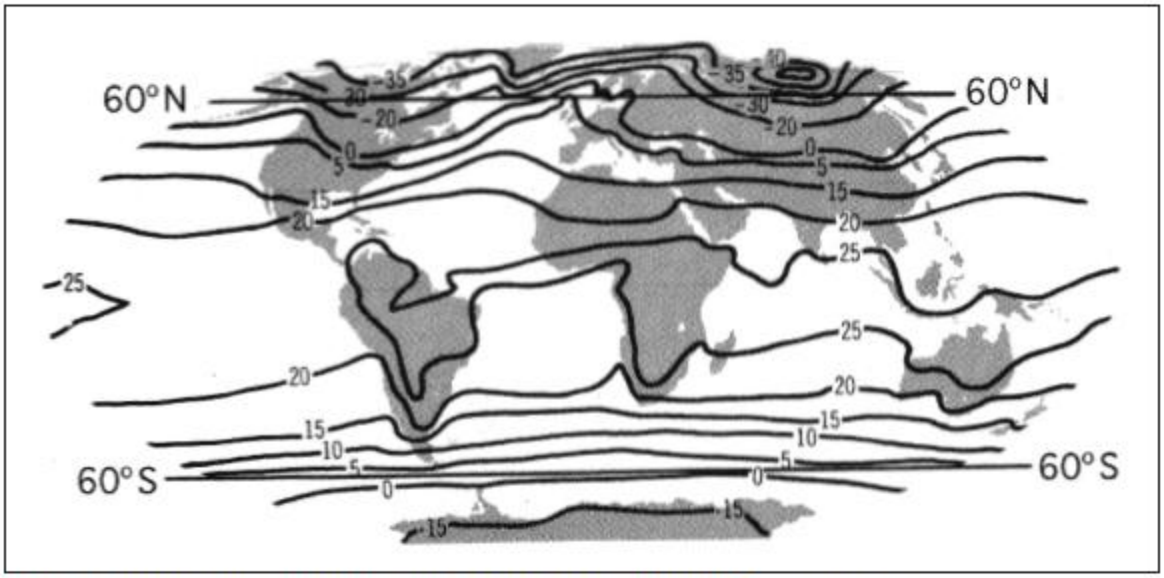

FIGURE 6. World map of average temperatures in January (°C). Source: V. J. Mayer et al. 1996.

Technology Application and Extension

The Smithsonian Ocean Planet Web site (http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/oceanography_currents_4.html) has a world map with 11 world cities marked. Have small groups of students examine the location of each city and hypothesize whether and how the ocean affects its temperatures. The Web site provides high and low temperatures for cities so students can evaluate their hypotheses. In some cases, the heat source–heat sink principles can explain the data, but ocean currents are also involved. This exercise demonstrates that ocean–climate interactions are much more complex than one can illustrate in a single lesson.

Assessment

Student understanding can be assessed by having small groups develop an advertising campaign for a coastal area in a particular season. Students may use a video, brochure, or other medium to convey their advertising message. Ads should synthesize information about seasonal effects of the nearby ocean or Great Lake and apply the information to a new situation.

Assessment

See assessments in procedure section.

Additional Resources

- Bigelow Laboratory's Web site explores sea surface temperatures, climate moderation by currents, day–night temperature changes, and related phenomena at http://www.bigelow.org/virtual/sst_sub1.html (accessed April 30, 2009).
- Centers for Ocean Sciences Education Excellence (COSEE) Ocean Systems has an award-winning ocean climate interactive Web site linked to http://cosee.umaine.edu/tools/oci/ (accessed April 30, 2009).
- Great Lakes Coastal Forecasting System has nowcast maps of water temperatures, available at http://www.glerl.noaa.gov/res/glcfs/ (accessed April 30, 2009).

- The National Oceanographic Data Center makes U.S. coastal water temperatures, including some monthly data, accessible at http://www.nodc.noaa.gov/dsdt/cwtg/all.html (accessed April 30, 2009).

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