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Steamship *Portland*

X-Storms

Focus
Extreme storms

Grade Level
9-12 (Earth Science)

Focus Question
What causes extreme storms such as the *Portland* Gale of 1898 and the Halloween Nor'easter of 1991?

Learning Objectives
Students will be able to identify and explain three factors that contributed to extreme storm conditions during the Halloween Nor'easter of 1991.

Students will understand how to obtain real-time and historical meteorological data.

Students will be able to compare and contrast: extra-tropical cyclone, tropical cyclone, hybrid storm.

Materials
❒ Internet access for student research
❒ Overhead transparency of the eastern United States

Audio/Visual Materials
❒ Overhead projector

Teaching Time
One 45-minute class period, plus time for student research

Seating Arrangement
Classroom style

Maximum Number of Students
30

Key Words
Portland Gale of 1898
Halloween Nor'easter of 1991
Perfect storm
Nor'easter
Oceanographic data buoy
Trough
Extra-tropical cyclone
Tropical cyclone
Hybrid storm

Background Information
On Thanksgiving Saturday, November 26, 1898, the passenger steamship *Portland* left Boston Harbor with 192 passengers and crew bound for Portland, Maine. During the night, New England was hit by a monster storm moving up the Atlantic coast with northeasterly winds gusting to 90 mph, dense snow, and temperatures well below freezing. At 5:45 a.m. on the morning of November 27, four short blasts on a ship's steam whistle told the keeper of the Race Point Life-Saving Station that a vessel was in trouble. Seventeen hours later, life jackets, debris, and human bodies washed ashore near the the Race Point station, confirming that the *Portland* and everyone aboard had been lost in one of New England's worst maritime disasters.

For 90 years, the location of the *Portland* wreck

was unknown, despite intense and continuing public interest. Then in April 1989, members of the Historical Maritime Group of New England found wreckage more than 300 feet deep that they were certain had been the *Portland*. Because of the depth, however, the discoverers were unable to obtain photographs or other evidence that could confirm their find. Thirteen years later, on August 29, 2002, the U.S. Commerce Department's National Oceanic and Atmospheric Administration (NOAA) confirmed that the wreck of the *Portland* had been found within NOAA's Stellwagen Bank National Marine Sanctuary. Using side-scan sonar and a remotely operated vehicle (ROV), scientists obtained high-quality video and side-scan images in a joint research mission of the Stellwagen Bank National Marine Sanctuary and the National Undersea Research Center at the University of Connecticut.

Storms can usually be classified into one of two types: extratropical cyclones and tropical cyclones. Extra-tropical cyclones are "ordinary" storms formed by the intersection of warm and cold air masses, and can form over land and water in mid-latitudes at all times of the year. The temperature difference or gradient between the air masses is the major source of energy for these storms. Tropical cyclones include hurricanes and typhoons, and are formed mainly during summer and fall over warm tropical oceans. Warm humid aid in these regions is loaded with water vapor that condenses as it rises into cooler air in the atmosphere. Condensation releases latent heat of vaporization, and this heat is the primary source of energy for tropical cyclones.

Occasionally, an extratropical cyclone will develop some of the characteristics of a tropical cyclone. This hybrid storm forms when thunderstorms begin to generate near the storm's center. When this happens, the central core of the storm is warmed as latent heat is released by water vapor condensing in the thunderstorms. Pressure in the core of the storm drops—sometimes very rapidly—and creates gale-force or hurricane force winds. The rapid drop in pressure is called "explosive deepening;" if the pressure steadily falls one millibar per hour for 24 hours or more, the storm is called a "bomb cyclone." At the same time, a tight temperature gradient is maintained on the northern side of the storm (in the northern hemisphere).

Typical weather patterns in New England states during late October and November are conducive to the formation of massive storms. At this time of the year, large cold air masses from Canada cross the midwestern states on a regular basis. At the same time, the Atlantic Ocean retains its summer heat and these warm waters sometimes spawn hurricanes. When the east-moving cold air masses encounter the warm, humid oceanic air, the result is what New Englanders call "Nor'easters:" storms that are often severe, and are often the cause of maritime disasters.

The Gale of 1989 (sometimes called the "Portland Gale") began as three air masses: an area of high pressure over the Ohio valley, a weak low-pressure area near Minnesota, and another low over the western Gulf of Mexico. By the evening of November 24, the high pressure area and Great Lakes low had both moved eastward. With the counterclockwise (cyclonic) circulation typical of air masses in the northern hemisphere, the Great Lakes low drew in Arctic air from central Canada, lowering temperatures dramatically across the northern plains. To the south, the Gulf of Mexico low was spreading rain across the southern states from Louisiana to Georgia.

By the morning of November 26, the high pressure area was off the New England coast, the Great Lakes low was centered over Detroit, and the southern low was just off the coast of South Carolina. At this point, the two low-pressure air masses were connected by an elongated area of low pressure known as a trough, which facilitated energy exchange between the air masses. As the Great Lakes low continued its eastward advance,

the southern low began to move up the east coast, gradually gaining strength and speed. By three o'clock, the southern low had almost completely absorbed the Great Lakes system and was spinning off Norfolk. As the weather system continued to grow, large amounts of moisture absorbed from the Gulf Stream became a massive snowfall that extended from Washington, DC to New York City.

As the storm moved north, a steep pressure gradient developed between the low pressure storm system and the area of high pressure to the northeast, as well as between the storm system and the Arctic high to the northwest of the storm. The result was unusually strong gales that battered central and southern New England for the entire day on November 27. By Monday, November 28, the storm had moved off to the northeast, leaving below-freezing temperatures, a devastated coastline, and shocked communities that only gradually learned of the *Portland*'s fate.

In this lesson, students will research the history of a more recent and familiar storm: the Halloween Nor'easter of 1991, also known as "The Perfect Storm." The purpose of this lesson is to acquaint students with some sources of meteorological information that can provide historical as well as real-time data on weather events.

Learning Procedure

1. You may want to download a copy of "The Portland Gale" from http://www.hazegray.org for more information on the *Portland* and the monster storm of 1898. Visit http://oceanexplorer.noaa.gov for up-to-date information on the 2003 Steamship *Portland* expedition.

2. Briefly review the story of the *Portland* and the gale of 1898. Using an overhead transparency of the eastern United States, sketch and discuss the weather systems that produced this storm.

3. Tell students that their assignment is to prepare a written report on the Halloween Nor'easter of 1991. You may want to allow them to discover for themselves that this is the famous "Perfect Storm." Their reports should include a chronological narrative of the storm's history, including descriptions of the weather systems that were involved. Reports should also answer the following questions:
   - Was this the deadliest storm on record? If not, what was?
   - Was this the most expensive storm on record? If not, what was?
   - What information did oceanographic data buoys provide about the maximum wind speeds and wave heights associated with the storm?
   - Why was the "unnamed hurricane" unnamed?

   The following websites have useful information for completing this assignment:
   http://www.ndbc.noaa.gov/Maps/northeast_hist.html – National Data Buoy Center website with real-time as well as historical data for data buoys in the northeast
   http://www.ncdc.noaa.gov/oa/satellite/satelliteseye/cyclones – National Climactic Data Center with information on extratropical cyclones
   http://www.nhc.noaa.gov – National Hurricane Center, with historical information on hurricanes

4. Lead a discussion of students' research results. Written reports should include most of the following points:
   - Like the Portland Gale, the Halloween Nor'easter of 1991 was the result of a collision between a cold front and a warm low-pressure area moving north along the US east coast.
   - The warm low-pressure area developed between October 23 and 25 and on the 25th was located at latitude 27.1°N, longitude 64.9°W, with wind speeds of 25 kt.
   - Between October 25 and 27, winds in the warm low-pressure system strengthened steadily to a tropical storm strength (60 kt).
   - On October 28, the warm low-pressure system strengthened to 65 kt and was named Hurricane Grace; at the same time, a cold low-

pressure area had moved off the east coast of Nova Scotia, and was strengthening; the low pressure of this cold system caused Hurricane Grace to turn sharply away from its northwest course and move eastward into the cold low-pressure system.
- On October 29, the cold low-pressure system absorbed Hurricane Grace and continued to strengthen, drifting first toward the southeast, and then toward the southwest.
- The storm reached peak intensity on October 30; a strong high pressure system that extended from the Gulf of Mexico along the Appalachians into Greenland contributed to a steep pressure gradient that generated strong winds where this system met the low-pressure area of the storm.
- NOAA buoy 44011 at 41.1°N, 66.6°W, reported maximum sustained winds of 49 kt with gusts to 65 kt; NOAA buoy 44011 at 41.1°N, 66.6°W, reported maximum sustained winds of 49 kt with gusts to 65 kt, and wave heights of 39 ft; NOAA buoy 44008 at 40.5°N, 69.5°W, reported maximum sustained winds of 53 kt with gusts to 63 kt, and wave heights of 31 ft; Canadian buoy 44137 at 42.26°N, 62.0°W, reported sustained winds of 80 kt and open-water wave heights of 101 ft.
- The southward track of the Halloween Nor'easter of 1991 carried it over the Gulf Stream on October 31. This added heat to the system, and caused a re-strengthening. On November 1, circulation at the center of the Halloween Nor'easter of 1991 reached hurricane intensity. The new hurricane weakened on November 2 and made landfall near Halifax, Nova Scotia later that day as a tropical storm.
- The second hurricane was unnamed because weather officials felt that naming the hurricane would cause major confusion and concern among the media, emergency management officials, and the public. The concern was that people might conclude that an entirely new storm had developed, when it fact it was another phase of the Halloween Nor'easter of 1991 that had already received a great deal of attention because of the destruction it had caused.
- The Halloween Nor'easter of 1991 was not the deadliest storm on record. A hurricane that struck Martinique, St. Eustatius, and Barbados in 1780 is reported to have killed more than 20,000 people.
- The Halloween Nor'easter of 1991 was not the most expensive storm on record. Hurricane Andrew in 1992 was the most expensive, causing more than $26 billion worth of damage.

The BRIDGE Connection

http://www.vims.edu/bridge/archive1200.html/
http://www.vims.edu/bridge/climate.html

The "Me" Connection

Have students write a short essay describing how real-time or historical meteorological information might be personally useful.

Connections to Other Subjects

English/Language Arts

Evaluation

Written reports prepared in Step 3 provide an opportunity for assessment.

Extensions

Log on to http://oceanexplorer.noaa.gov to keep up to date with the latest Steamship *Portland* discoveries.

Resources

Bachelder, P. D. and M. P. Smith. 2003. Four Short Blasts. The Gale of 1898 and the Loss of the Steamer *Portland*. The Provincial Press. Portland, ME.

http://www.hazegray.org/ – website with information on naval ships, photos, etc., and a page about the *Portland* Gale of 1898

http://www.ndbc.noaa.gov/Maps/northeast_hist.html – National Data Buoy Center website with real-time as

well as historical data for data buoys in the northeast

http://www.ncdc.noaa.gov/oa/satellite/satelliteseye/cyclones – National Climactic Data Center website with information on extratropical cyclones

http://www.nhc.noaa.gov – National Hurricane Center website, with historical information on hurricanes

http://pao.cnmoc.navy.mil/educate.neptune/quest/wavetide/waves.htm – Naval Meteorology and Oceanography Command website with information on waves and tides

http://school.discovery.com/lessonplans/programs/tidalwave/index.html – Discovery Channel School lesson plans on tsunamis (tidal waves)

National Science Education Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B: Physical Science

- Motions and forces
- Interactions of energy and matter

Content Standard D: Earth and Space Science

- Energy in the Earth system

Content Standard E: Science and Technology

- Abilities of technological design

Content Standard F: Science in Personal and Social Perspectives

- Natural and human-induced hazards

For More Information

Paula Keener-Chavis, National Education Coordinator/Marine Biologist
NOAA Office of Exploration
2234 South Hobson Avenue
Charleston, SC 29405-2413
843.740.1338
843.740.1329 (fax)
paula.keener-chavis@noaa.gov

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