

Changing Planet: Sea Levels Rising

Summary:	Students review topographic maps and use that knowledge to explore the impact sea level rise will have on coastal communities. Students will look at scientific data and analyze graphs and images to make discoveries about the social, economic and natural repercussions of global sea level rise.
Source:	<i>Developed by NESTA/Windows to the Universe team members Jennifer Bergman, Missy Holzer and Roberta Johnson. Includes an adaptation of Mapping Potato Island (http://www.windows2universe.org/teacher_resources/teach_taterland.htm).</i>
Grade level:	6-10
Time:	Part I - Review of Topographic Maps (20 minutes prep time, 30 minutes class time) Part II - A Look at the Issue of Rising Sea Level (60 minutes class time) Part III - Community Examples (30 minutes class time or could be assigned as homework)
Student Learning Outcomes:	<ul style="list-style-type: none"> • Students will construct a topographic map of model terrain. • Students will be able to explain what contour lines are and what they represent. • Students will be able to read a topographic map and make deductions from it about the impact of rising sea level on example coastal communities.
Lesson format:	Hands-on activity, map & data interpretation
National Standards Addressed:	<ul style="list-style-type: none"> • National Science Content Standards 5-12: Abilities necessary to do scientific inquiry • National Science Content Standards 5-8: Populations and Ecosystems • National Science Content Standard 5-8: Properties of Earth materials • National Science Content Standards 5-8: Structure of the Earth System • National Science Content Standards 9-12: Energy in the Earth System • National Science Content Standard 9-12: Interdependence of organisms
Materials:	<ul style="list-style-type: none"> • Student worksheet (http://www.windows2universe.org/teacher_resources/images/student_sea_rise3.pdf) • One potato for each student • One clear plastic deli tub for each student • One lid of a clear plastic container (larger than deli tub) • Dry erase marker for each student • Ruler (metric) for each student • Kitchen knife (one for teacher) • Sharpie marker (one for teacher) • Blue water (add a little blue food coloring) • Paper towels or clean rags • Computer/internet access for students • Colored pencils for students

DIRECTIONS:

1. For background information on sea level rise, watch Changing Planet: Rising Sea Levels

- (http://www.windows2universe.org/earth/changing_planet/sea_level_rising_intro.html). Also explore these topics on the Windows to the Universe website at the links listed below.
- Depending on time and interest this lesson can be done in its entirety or it may be done in pieces. The student worksheet has been set up to facilitate these lesson options. Gather supplies and print out and copy a student worksheet (http://www.windows2universe.org/teacher_resources/images/student_sea_rise3.pdf) for each student.
 - Part I - If students have no familiarity with topographic maps, it is suggested they start with an Activity like USGS's *What Do Maps Show? Unit*, Lesson 4-How to Read a Topographic Map (<http://egsc.usgs.gov/isb/pubs/teach-pack/mapshow/lesson4.html>). Otherwise, students will begin this lesson by making a topographic map of a potato. Teacher preparation includes cutting one end off of a potato with a kitchen knife to make one side of the potato flat (one potato per student). Place the potato in the plastic deli tub with its freshly cut flat side facing down. On the uncut, top side of the potato, mark a North arrow and all cardinal directions with the sharpie marker.
 - Distribute one deli container with potato in it to each student. Have students collect their materials and follow directions presented on their student worksheet. In this example, the potato represents the irregularity of the land surface. Choose potatoes that have an irregular surface, are not too straight-sided (i.e., do not make cliffs to the sea) and will not form overhangs. The surface of the blue water will be flat as long as the plastic tub is not moved, and thus provides a way to see what parts of the potato landscape are the same elevation. Closing one eye will help students draw the contour lines because it eliminates depth perception. End this part of the lesson by discussing differences students saw in their sample landforms, reviewing key concepts about topographic maps and having students share their responses about why topographic maps are useful and some of their limitations as well. If there was time, you could have students map their potatoes using different contour intervals.
 - After students have completed their student worksheet, have them dump their water out, leaving the potato and container for the next class. Ask students to wipe off dry erase marks on containers and lids with paper towel or clean rags, and return all other classroom supplies.
 - Part II - A Look at the Issue of Rising Sea Levels. Students will need access to computers with internet for this part of the Activity. Students may benefit from working together in pairs, but each student should fill out his/her own student worksheet. You may want to preload and familiarize yourself with the two sites that students will be exploring: NOAA's Sea Levels Online (<http://tidesandcurrents.noaa.gov/sltrends/sltrends.html>) and NASA's Climate Change: Key Indicators (<http://climate.nasa.gov/keyIndicators/index.cfm#SeaLevel>).
 - Part III - Community Examples. This part of the Activity has students look at topographic maps of two different communities. They will read the map, make deductions and answer questions on the student worksheet.

ASSESSMENT:

Assess student abilities to work together as a team, create and interpret topographic maps, analyze graphs and data plots, as well as apply learned information to make solid deductions about the social, economic and natural repercussions of sea level rise on coastal communities.

LAB SAFETY:

Use safe laboratory practices at all times.

CLEAN-UP:

Wash and dry all lab equipment and properly store for future use.

EXTENSIONS:

1. Have students explore the fact that sea level has changed many times in the past with the classroom activity Mapping Ancient Coastlines (http://www.windows2universe.org/teacher_resources/teach_bathymetry.htm).
2. Have students investigate various appliances and electronics to discover how much energy each uses and how much carbon dioxide (CO₂) is released to produce that energy. Use the classroom activity Plugged in to CO₂ (http://www.windows2universe.org/teacher_resources/teach_pluggedCO2.html).
3. Have students complete a homework assignment where they calculate their carbon footprint (http://www.windows2universe.org/earth/climate/what_can_i_do.html) and (depending on the grade level of student) their family's carbon footprint. After results have been calculated, lead students in a discussion about the following ways to reduce one's carbon footprint and add to the list by having students share their ideas from their student worksheet and from further brainstorming during the class discussion. Here's some ideas to get your class started:
 - Turn off electronics and electrical appliances when not in use
 - Turn down the heat 2 to 4 degrees
 - Turn up the air-conditioning 2 or more degrees
 - Turn down your water heating (2 degrees will make a significant saving)
 - Completely fill your dishwasher and washing machine before running them
 - Unplug your MP3 player, mobile phone, laptop, etc. as soon as it has finished charging
 - Install energy-saving light bulbs as the current ones burn out
 - Carpool to work or school
 - Use public transportation whenever possible
 - Don't buy bottled water if your tap water is safe to drink (especially if it has been shipped from far away)
 - Buy local fruit and vegetables, or even try growing your own
 - Don't buy fresh fruit and vegetables which are out-of-season
 - Try to buy products made closer to home
 - Buy organic produce
 - Recycle as much as possible
 - ...and many others!
4. Have students investigate one of the primary reasons for sea level rise - thermal expansion of sea water using the classroom activity Rising Ocean Temperatures - Rising Sea Levels (http://www.windows2universe.org/teacher_resources/ocean_temperatures.html).
5. Two research topics are written up in the Application and Extensions area of the Student worksheet. Assign these as a further investigation (or not - as time allows!).

BACKGROUND INFORMATION:

A topographic map is often a very large-scale map that shows the shape of the land's surface. Contour lines are imaginary lines that connect places of equal elevation. If you were taking a hike along a hillside and not walking either uphill or downhill, you would be walking on a contour line. When contour lines are close together, the slope is very steep. When contour lines are far apart, the slope is very shallow. This type of map is helpful when planning a hike. It is also used when planning the site for a building or the path of a new road. The shape of the land also greatly determines how sea level rise will affect a given coastal area.

Sea level change has happened at various times in Earth history. Global sea level can rise because glaciers melt, adding water to the oceans, or when plate tectonic movements diminish the ocean basins displacing water onto the edges of continents. It is a natural process that has gone on since there have been oceans (<http://www.windows2universe.org/earth/Water/ocean.html>) on Earth. Over recent geologic history, sea levels (http://www.windows2universe.org/earth/Water/sea_level.html) have changed rapidly by geologic standards due to the repeated formation and melting of glaciers.

One thing is certain - global warming is now causing a rapid rise in sea levels (http://www.windows2universe.org/earth/climate/sea_level_rise.html). Over the past 100 years, as the climate has warmed, sea level rise has accelerated, rising by about 7 inches, or 17 centimeters. Currently, global (or eustatic) sea level (http://www.windows2universe.org/earth/Water/sea_level.html) is rising about 3.3 mm per year (about 1/8 inch.) There is a high level of uncertainty about how much sea level rise we can expect for the 21st Century. The Intergovernmental Panel on Climate Change (<http://www.windows2universe.org/earth/climate/ipcc.html>) estimates between 18-59 centimeters (7-23 in) of sea level rise. Some scientists predict an even greater rise in sea level, anywhere from the conservative 7 inches to more than 3 feet, or 18 centimeters to more than a meter of sea level rise within this Century.

How does global warming (http://www.windows2universe.org/earth/climate/ipcc_feb2007.html) cause sea level to rise? There are two reasons. First, when climate warms, water that is on land in glaciers and ice sheets (http://www.windows2universe.org/earth/polar/cryosphere_glacier1.html) melts and makes its way down rivers (<http://www.windows2universe.org/earth/Water/river.html>) to the ocean (<http://www.windows2universe.org/earth/Water/ocean.html>). Second, as seawater warms up, the water molecules move further apart causing the water to expand. Scientists suspect that this expansion of seawater accounts for more than half the amount of sea level rise we see today.

There will be many social, economic, political and ecological repercussions of this rapid rise in sea level. The low-lying coast of Bangladesh in South Asia is home to millions of people, yet the amount of sea level rise predicted for the 21st Century is expected to change that, flooding homes with seawater and impacting an estimated 13 million people. Bangladesh is one of many coastal areas worldwide where homes, towns and cities are in jeopardy of being flooded as sea level rises due to global warming (http://www.windows2universe.org/earth/climate/ipcc_feb2007.html).

Worldwide, there are large human populations living in coastal areas that would be adversely affected by changes in sea level (http://www.windows2universe.org/earth/Water/sea_level.html). About half of the world population lives within 200 km (124 mi) of a coast. As sea level continues to rise, more of these people will be affected by flooding and coastline erosion. Freshwater supplies could become contaminated with salt water and in places like Bangladesh there will likely be less land suitable for growing rice or other crops. Sea level rise will also have ecological impacts like the destruction of established wetlands, natural beaches, and breeding grounds for many animals. Governments are already taking steps to reinforce coastal areas using new technologies, hopefully protecting them in some ways from rising seas. However, many countries do not have the financial resources to take such measures.

This photo was taken after a recent storm in the Outer Banks. It shows sea water breaching a temporary barrier (in this case sand bags) that was put there to keep sea water away. Sea level rises affect each area differently depending on the geology and geography of the area. The photo was taken by Dr. Benjamin Horton, who was featured in the Changing Planet video, and who does sea level research.



Courtesy of Professor Benjamin Horton, University of Pennsylvania
(<http://www.sas.upenn.edu/earth/benhorton.htm>)

RELATED SECTIONS OF THE WINDOWS TO THE UNIVERSE WEBSITE:

Rising Sea Levels (http://www.windows2universe.org/earth/climate/sea_level_rise.html)
Sea Level (http://www.windows2universe.org/earth/Water/sea_level.html)
Climate and Global Change (<http://www.windows2universe.org/earth/climate/climate.html>)
Oceans (<http://www.windows2universe.org/earth/Water/ocean.html>)
Effects of Climate Change Today (http://www.windows2universe.org/earth/climate/cli_effects.html)
Sea Ice in the Arctic and Antarctic - Includes Movies and Interactives of Dwindling Polar Sea Ice
(http://www.windows2universe.org/earth/polar/sea_ice.html)

OTHER RESOURCES:

Ocean Surface Topography from Space - NASA JPL (<http://sealevel.jpl.nasa.gov/>)
NASA's Climate Change for Educators (<http://climate.nasa.gov/education/>)
Dwindling Arctic Ice Article (<http://earthobservatory.nasa.gov/Features/ArcticIce/>)
EPA's Coastal Zones and Sea Level Rise (<http://www.epa.gov/climatechange/effects/coastal/index.html>
)
Rising Sea Levels Set To Have Major Impacts Around The World (includes links to many other articles)
(<http://www.sciencedaily.com/releases/2009/03/090310104742.htm>)
Sea Level Change/Coastal Inundation - Institute for Global Environmental Strategies
(http://esseacourses.strategies.org/module.php?module_id=142)