Global Climate Change and Sea Level Rise

GRADE LEVEL	5th – 8th; Standards for 5th – 8th
SUBJECTS	Investigation and Experimentation, Physical Sciences
DURATION	Preparation: 20 minutes Activity: 30-45 minutes over 4 hour span
SETTING	Classroom

Summary
Do sea levels rise when ice melts? Does it matter whether the ice is on land or in the ocean? Students design an experiment to find out. They collect data, graph their results, and interpret their findings. Along the way, they learn about density, displacement, and climate change.

Objectives

Students will:

1. Plan, carry out, and interpret results of a scientific investigation.
2. Explain why melting land ice causes sea levels to rise, but melting sea ice does not.
3. Recognize the far-reaching effects of global climate change.

Materials

- 2 identical clear food storage boxes (approximately 6 inches square) per group
- 8 sticks of classroom modeling clay per group
- 1 ruler per group
- 1 tray of ice cubes per group (may need to start storing ice cubes ahead of time)
- 1 liter of water per group
- Sea Level Rise Worksheets (1 per student)

Scientific Terms for Students

Global climate change: change in average global temperature, rainfall, and wind patterns as a result of increased greenhouse gases in the atmosphere

Greenhouse gases: gases in Earth's atmosphere that trap heat

Density: a measurement of compactness, measured as mass per unit volume

Displacement: the forced relocation of water due to a submerged or partially submerged object

Background for Educators

One consequence of climate change is the melting of ice caps, glaciers, and sea ice, including polar ice in Greenland and Antarctica. Substantial melt of these massive glaciers will cause a rise in sea level along coastlines throughout the globe (Climate Institute, n.d.). This activity explores how melting ice impacts sea level.

Water is an unusual liquid because it expands when it freezes. In general, liquids do not expand upon freezing, but rather contract and become denser as temperature drops. Like other liquids, as water begins to cool, it becomes more and more dense. But, because of the physical structure of the water molecule, it continues to become denser until just before freezing, when it expands. This expansion occurs at the point at which freezing begins (around 4°C). At this temperature water molecules arrange themselves into a crystal lattice structure that is significantly **less dense** than the liquid form. Because of this **decrease in density** at the point of freezing, ice always floats on water (US Geological Survey, 2014).

When objects are totally submerged in water, they displace an amount of water equal to their volume. However, because ice floats on water and is not completely submerged, ice does not displace an amount of water equal to its volume. Instead, it displaces less than its total volume of water. The water that floating ice displaces is equal to the volume that the ice would take up if it melted and became water again. In other words, floating ice **displaces** water equal to the mass of the ice. When ice melts, the mass of the ice is conserved, but the crystal lattice structure of ice disappears and the volume decreases and becomes equal to the volume of water it displaced in its ice form.

Therefore, when floating ice melts, the melted water is equal only to the volume of the ice that was submerged. This means that when floating ice melts, it contributes no additional volume to the body of water. We see this phenomenon when we let ice melt in a glass of water. The water does not overflow because the ice has already displaced water equal to the volume it will take up upon melting.

Ice already in the oceans does not contribute to sea level rise, but ice covering land will contribute to sea level rise upon melting. For a video on this topic featuring the same activity in this lesson plan, see: http://www.nps.gov/subjects/climatechange/explainingccvideos.htm.

The effects of sea level rise are global. According to maps created by the Bay Conservation and Development Commission for the San Francisco Chronicle (Kay, 2007), a 1 meter rise in sea level would submerge "parts of Corte Madera, San Rafael, Hayward, Newark and much of the Silicon Valley shoreline." In San Francisco, "Mission Bay housing and office developments, Caltrain tracks, Candlestick Point redevelopment, Heron's Head Park….parts of Treasure Island, and the San Francisco and Oakland airports" would all be under water.

Activity

Introduction

- Have a discussion about global climate change and sea level rise. Ask students where there is a lot of ice in the world. Is the ice on land or on water? Will one or both cause sea level to rise when they melt?
- *Tip: You can cover the explanation for why ice is less dense than water (and therefore floats) here, or you can wait until after the experiment.*
- Guide students through the development of a question about the melting of ice and sea level rise. Which type of melting will cause an increase in sea level? Have each student record the question and a prediction on the worksheet.

Design the Experiment

- Tell the students that they will be working in groups to design an experiment to answer their question.
- Introduce the materials. Give as much or as little guidance about how to use the materials as is appropriate for your class.
- *Tip: if appropriate for your class, discuss the importance of controlling variables that are not being tested.*
- Have students discuss their ideas with their small groups. Afterwards, discuss each group's ideas as a class. Make sure each group has a workable experimental design (see suggested procedure below). Have each student describe and/or draw their group's experimental design in the "methods" section of the worksheet.

Suggested Experiment Procedure

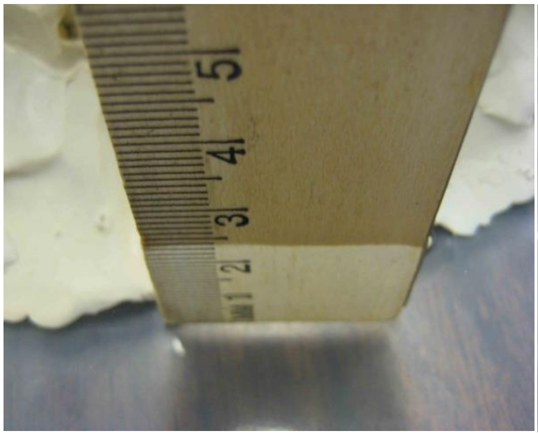
This procedure is only a suggestion - it's okay if your students come up with something slightly different. Check to make sure they are investigating the correct question and control the variables they are not testing (i.e., each container should contain the same number of ice cubes, the same amount and arrangement of clay "land," and should start with approximately equal water levels).

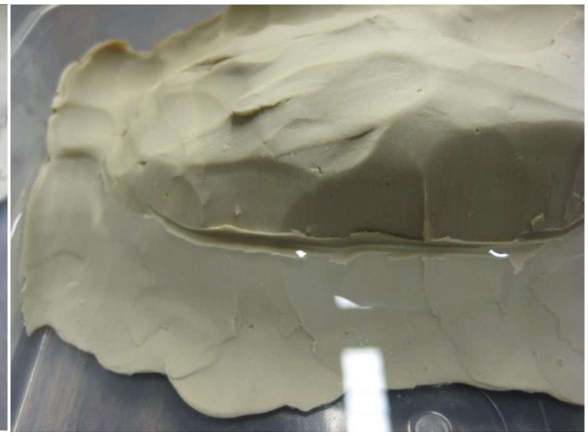
1. Place half of the clay into one side of each box. Form the clay to represent land rising out of the ocean.

2. Place about 6 ice cubes on the "land" in the first box. Place the same number of ice cubes next to the clay in the second box, so that they are resting on the bottom of the container.

3. Pour water into the container where the ice is resting on the bottom until the ice is floating (NOT resting on the bottom).
4. Pour water into the container with the ice resting on the clay until the water levels in the two containers are approximately equal.

5. Have students measure and record initial measurements of water depth (in mm). They may wish to draw a line in the clay at the initial water level.

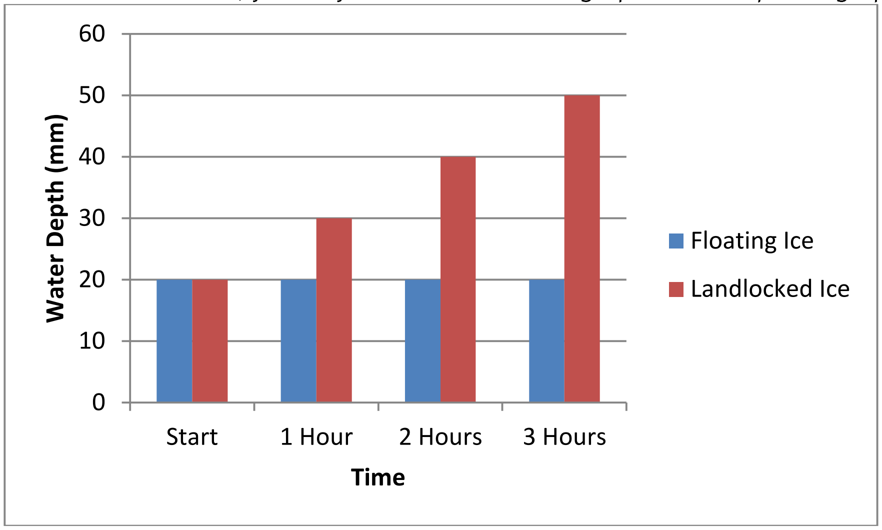




6. Leave the setup. Students should measure the water depth every hour (or other regular interval) and record the results, until the ice is completely melted.

Interpret the Data

- Have each group graph their results on the board, on chart paper, or on butcher paper (see sample graph below) and display the graphs so everyone can see.
- *Tip: You may wish to draw the axes ahead of time so the students can simply fill in their data. Younger students might find it easier to place Post-It notes on the board (1 Post-It per mm water depth) to form the bar graph, instead of drawing the graph. With older students, you may wish to make a line graph instead of a bar graph.*



- Lead a discussion about the results, using the information in the “Background for Educators” section to help students understand their results.
- Have each student write a conclusion on their worksheet summarizing what happened and why.

Conclusion

Have another discussion about global climate change. Use the following questions to generate discussion:

- Why might we be concerned about sea level rise? *(Coastal areas will be flooded. People will lose their homes. Some fresh water resources will become too salty to use. Habitat loss will occur.)*
- What can we do to help slow this process by using less fossil fuel? *(Take public transit instead of driving, eat local foods, turn off lights and electrical equipment when not in use, plant a tree, reduce, reuse and recycle.)*

Extension

- See lesson Densities of Fresh and Salt Water

Correlated California Content Standards

Grade Five

Investigation and Experimentation
6b. Students will develop a testable question.
6f. Students will select appropriate tools and make quantitative observations.
6g. Students will record data by using appropriate graphic representations, and make inferences based on those data.
6i. Write a report of an investigation that includes conducting tests, collecting data or examining evidence, and drawing conclusions.

Grade Eight

Physical Sciences: Density and Buoyancy
8a. Students know density is mass per unit volume.

Next Generation Science Standards

Science & Engineering Practices	Disciplinary Core Ideas	Cross Cutting Concepts
Developing and Using Models: Develop and/or use models to describe and/or predict phenomena. (3-5; 6-8) **Asking Questions and Defining Problems:** Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (3-5) **Planning and Carrying out Investigations**: Plan and conduct and investigation collaboratively to produce data to serve as the basis for evidence. (3-5) Collect data to produce data to serve as the basis for evidence to answer scientific questions. (6-8) **Analyzing and Interpreting Data:** Represent data in table and/or various graphical displays to reveal patterns that indicate relationships (3-5; 6-8). Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation (3-5). **Constructing Explanations and Designing Solutions:**Use evidence to construct or support an explanation or design a solution to a problem. (3-5) Construct an explanation using models or representations. (6-8)	**ESS3.C: Human Impacts on Earth Systems:** Human activities in agriculture, industry, and everyday life have had major effects on land, vegetation, streams, oceans, air and even outer space. (Grade 5) **PS1.A: Structure and Properties of Matter:** The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish (Grade 5). The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (6-8) **ESS3.D: Global Climate Change**: Human activities such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming) (6-8).	**Cause and Effect:** Cause and effect relationships are routinely identified, tested, and used to explain change. (3-5; 6-8) **Stability and Change:** Change is measured in terms of differences over time and may occur at different rates; Some systems appear stable, but over long periods of time will eventually change (3-5). Explanation of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales (6-8).

Related Performance Expectations

These activities outlined here are just one step toward reaching the Performance Expectations listed below. Additional lessons will be required.

5-PS1-2: Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.

MS-PS1-5: Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

References

Climate Institute. (n.d.). *Consequences of Climate Change on the Oceans.* Retrieved November 17, 2014 from http://www.climate.org/topics/sea-level/

Kay, Jane. (2007). Consequences of a rising bay/global warming: New set of maps reveals how melting polar ice could change shoreline and carry a high price for entire region. Retrieved November 17 2014, from http://www.sfgate.com/news/article/CONSEQUENCES-OF-A-RISING-BAY-GLOBAL-WARMING-2647936.php#photo-2127432

National Park Service. *Explaining Climate Change Videos.* Retrieved November 10, 2014 from http://www.nps.gov/subjects/climatechange/explainingccvideos.htm.

US Geological Survey. *Water density.* (2014). Retrieved November 17, 2014 from http://water.usgs.gov/edu/density.html