SEA LEVEL: ON THE RISE

DESCRIPTION

Students will understand the relationship between climate change and sea-level rise. In the first activity, they will learn that heated water causes sea level to rise through a process called thermal expansion. They will also perform an experiment to learn that melting land-based ice contributes to greater sea-level rise than melting sea ice.

BACKGROUND

In general, as water gets warmer, it takes up more space. Each drop of water only expands by a little bit, but when you multiply this thermal expansion of water over the entire depth of the ocean, it all adds up and causes sea level to rise.

Sea level is also rising because melting glaciers on land are adding more water to the oceans. Glaciers are large sheets of snow and ice that are found on land all year long. They are found in the western United States, Alaska, the mountains of Europe and Asia, and many other parts of the world. The giant ice sheets on Greenland and Antarctica are also considered glaciers. Warmer temperatures cause glaciers to melt faster than they can accumulate new snow. As giant ice sheets and smaller glaciers melt, they add more water into the ocean, which causes sea level to rise.

If people keep adding greenhouse gases to the atmosphere, the average sea level around the world by the end of this century (the year 2099) could be anywhere from 7 to 40 inches higher than it was in 2000. Sea level could rise even more if the big ice sheets in Greenland and Antarctica were to melt more quickly. If temperatures keep rising, glaciers will continue melting, and some could disappear completely.

Rising sea level is a threat to people who live near the ocean. Hundreds of millions of people around the world live in low-lying areas near the coast that could be flooded as sea level rises. Some low-lying areas will have more frequent flooding, and very low-lying land could be submerged completely.

Rising sea level also threatens the buildings and infrastructure of cities located along coastlines, as well as coastal ecosystems such as mangrove forests and coral reefs. Rising sea level and stronger storms caused by warmer oceans could erode beaches, damage many coastal wetlands, and even completely wipe out certain beaches and islands.

TIME: 60 to 75 minutes

LEARNING OBJECTIVES:

Students will:

- Learn that heated water has more volume and will cause sea level to rise through a process called thermal expansion.
- Learn that ice formations on land will cause a rise in sea level when they melt, whereas ice formations on water will not cause a substantial rise in sea level when they melt.
- Understand that ice displaces an amount of water equal to the mass of the ice.

NATIONAL SCIENCE STANDARDS:

- Content Standard A: Science as inquiry
- Content Standard B: Physical science
- Content Standard D: Earth and space science

ADAPTED FROM:

Atmospheric Radiation Measurement (ARM) Climate Research Facility: http://education.arm.gov/teacherslounge/lessons/Thermal-expansion-Gr-9-12.pdf.

California Academy of Sciences: http://www.calacademy.org/teachers/resources/lessons/global-climate-change-and-sea-level-rise.

VOCABULARY

Glaciers:

Glaciers are large sheets of snow and ice that are found on land all year long. They are found in the western United States, Alaska, the mountains of Europe and Asia, and many other parts of the world. The giant ice sheets on Greenland and Antarctica are also considered glaciers. Warmer temperatures cause glaciers to melt faster than they can accumulate new snow. As giant ice sheets and smaller glaciers melt, they add more water into the ocean, which causes sea level to rise.

Thermal expansion:

The increase in volume of a material as it gets warmer. For example, water generally expands as it is heated, causing each drop of water to increase in size. In the ocean, thermal expansion is one cause of rising sea level.

MATERIALS

- 500-milliliter conical flask (Erlenmeyer flask)
- Two-hole stopper
- Hollow glass tube
- Thermometer
- Stand with gauze mat
- Bunsen burner
- Two identical clear food storage boxes (approximately 6 inches square) for each group
- Eight sticks of classroom modeling clay for each group
- One metric ruler for each group
- One tray of ice cubes for each group (you may need to start storing ice cubes ahead of time)
- 1 liter of water per group
- "Sea-Level Rise Data" worksheets for each student

INSTRUCTIONS

These two activities can be performed as a demonstration or in student groups.

1. Discuss climate change and sea-level rise as a class. Tell the students that you will do an experiment to investigate how thermal expansion of water contributes to sea-level rise, then they will perform another experiment in groups to learn how melting of ice on land contributes to sea level rise, compared to the melting of ice formations on water (sea ice).

2. Gather the students around a table. Explain the concept of thermal expansion of water and how it relates to climate change.

3. Draw the following table on the chalkboard:

Measurement	Temperature (°C)	Water level (mm)
1		
2		
3		
4		
5		

4. Place stand with gauze mat over the Bunsen burner.

5. Fill the flask to the top with water. Place the hollow glass tube and thermometer in the stopper and gently press the stopper into the flask. Mount the ruler so the water level in the glass tube can be measured.

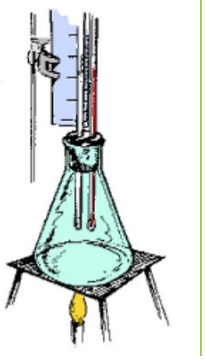
6. Place the flask on the gauze mat and heat the water slowly over the Bunsen burner.

7. Read out the water level at 2-degree Celsius intervals and have one of the students write down the temperature and water level on the chalkboard. Record the temperature and water level at least five times.

8. Ask the students to observe the data on the chalkboard and discuss the following questions:

   - What happened to the water level in the flask as the temperature increased? *[Answer: The water level rose as the temperature increased.]*
   - Explain why the water level in the flask changed over time. What caused this? *[Answer: Water increases in volume when heated. As the temperature increased, the volume of water in the flask increased (expanded), which caused the water level in the container to rise. This process is called thermal expansion.]*

Setup for class demonstration



9. Tell the students to return to their desks or tables.

10. Ask them where there is a lot of ice in the world. Is the ice on land or on water? Does it matter whether the ice is on land or water if it melts—will one or both cause sea level to rise when they melt?
[Note that ice is found in the giant ice sheets on Greenland and Antarctica, in small glaciers in mountain ranges around the world, and in the form of sea ice in places where the ocean freezes, particularly in the Arctic Ocean.]

11. Give each student the "Sea-Level Rise Data" worksheet. Guide students through the development of a question about the melting of ice and sea-level rise. Which type of melting will cause a greater increase in sea level? Have each student make a prediction.

12. Divide the students into groups of three. Give each group the food storage boxes, eight sticks of classroom modeling clay per group, a ruler, ice cubes, and water.

13. Direct the students to place half of the clay (four sticks) into one side of each box. Form the clay to represent land rising out of the ocean. In one box, form a level place at the highest part as shown below. Make rivers on the land if you like.

14. Place as many ice cubes as possible on the level place formed with the clay in the first box. Label the box as "Ice on Land." 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. Label the box as "Floating Ice."

15. Pour water into the container where the ice is resting on the bottom until the ice floats. Be sure to add enough water so the ice is floating, not resting on the bottom.

16. Pour water into the second container with the ice resting on the clay (be careful not to disturb the ice cubes) until the water levels in the two containers are approximately equal.

17. On their "Sea-Level Rise Data" worksheets, have students record initial measurements of water height (in millimeters) using a ruler. For a visual impression, you may wish to draw a line in the clay where the water height begins for each container.

18. Leave the experiment in place. If possible, have students take measurements at 15-minute intervals and record the results on their worksheets. You can also leave the setup for several hours or overnight and just record the final measurement after the ice has melted.

19. Have the students measure new water heights and make observations about what occurred once the ice melted. Make sure students record their measurements on their worksheets.

20. Have students answer the following questions in their conclusions on the worksheet.

    - In which situation did the water level rise more? *[Answer: "Ice on Land" container]*
    - How do the results compare with your predictions?
    - Why do you think this happened? *[Answer: When ice cubes sitting on the modeling clay melt, the water runs off and adds to the volume of water in the "ocean." Conversely, floating ice is already taking up space in the water—displacing a mass of water that is equivalent to the mass of the ice. When the ice melts, the water fills that existing space.]*

Floating Ice Ice on Land

Use a ruler to measure the water height

Floating Ice Ice on Land

- Ask students to name a few coastal cities or states. Discuss how sea-level rise could threaten the people, buildings, and ecosystems in these areas.

EXTENSION

Have students take the Maldives expedition on the Environmental Protection Agency's *A Student's Guide to Global Climate Change* website as in an in-class exercise or as homework (http://www.epa.gov/climatechange/students/expeditions/sea-level/index.html). This 12-minute video activity explains how climate change causes sea level to rise through thermal expansion of water and melting of ice. It also explores how sea-level rise puts low-lying communities and ecosystems around the world at risk. The video pauses to ask students questions, providing an interactive learning experience.

SEA LEVEL: ON THE RISE

SEA LEVEL RISE DATA

NAME: _____ **DATE:** _____

1. Research question:

2. Prediction or hypothesis:

3. Methods:

4. Results:

Measurements

Time (minutes)	Water height (mm)	
	Floating ice	Ice on land
15		
30		
45		
60		

Comments or notes:

5. Conclusions: