KELP SAILORS FOR THE SEA

KIDS ENVIRONMENTAL LESSON PLANS

This lesson developed by:

CALIFORNIA ACADEMY OF SCIENCES

Global Climate Change and Sea Level Rise

Overview:
Which type of ice causes a rise in sea level when it melts: formations on land, like glaciers, or formations in the water, like icebergs?

Ocean Literacy Principles:

1. The Earth has one big ocean with many features
2. The ocean and life in the ocean shape the features of Earth
3. The ocean is a major influence on weather and climate
6. The ocean and humans are inextricably interconnected
7. The ocean is largely unexplored

Key Concepts:

- Ice formations on land will cause a rise in sea level when they melt, whereas ice formations on water will not cause a rise in sea level when they melt.
- Ice is less dense than water.
- Ice displaces water equal to the mass of the ice.

Materials:

Per Group of Students:

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

Climate Change and Sea Level Rise (cont.)

For Extended Demonstration:

- one clear food storage box (approximately 6 inches square)
- 4 sticks of classroom modeling clay
- blue food coloring
- ice cube trays
- 4-5 intensely colored ice cubes
- salt
- ½ liter of refrigerated water

Set-up Prior to Activity:

- freeze 1 tray of ice cubes per group of students
- freeze ice cubes with blue food coloring (only for extended demonstration)

Duration:
Preparation time – 20 minutes; Activity time – 45 minutes over 4 hour period

Physical Activity:
Low

Background:
Global climate change is becoming a threat to our current way of life on Earth. 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. This activity will explore 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 that 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.

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. Greenland, for example, is covered by vast quantities of continental ice. The melting of this ice will contribute to sea level rise. The sea ice in the area of the North Pole is floating in water and thus the melting of this ice will not contribute to sea level rise.

In this activity, students will learn which masses of ice pose the biggest threat for rising global sea level and why.

Extended Demonstration Background:

Water is a wonderful solvent. This means many substances dissolve in water, adding molecules to the liquid. As molecules are added to a particular volume of water, the density increases. Thus, seawater is noticeably denser than fresh water and fresh water will float on the surface of seawater.

In the North Atlantic, a phenomenon based on this concept drives a process known as thermohaline circulation or the "great ocean conveyor belt." In this area, surface water moving north from lower latitudes becomes saltier (due to evaporation) and colder as it moves northward. This causes the density of the water to increase, and the water eventually sinks as it enters the North Atlantic. When the water sinks, it drives a current that plays a significant role in global ocean circulation. The sunken water (it's colder and more dense) slowly flows along the bottom of the ocean back toward the lower latitudes where it eventually rises, like a conveyor belt, to the surface and starts the journey north again. Thermohaline circulation is extremely important in maintaining hospitable climates around the globe because it contributes to the overall circulation of warm water from near the equator towards the poles.

Glacial melting in Greenland has caused some concern because of the potential for significant increase of fresh water in the North Atlantic. If melting rates continue to increase with global warming, a layer of freshwater could theoretically form in the North Atlantic. This fresh water could mix with the salty, dense water of the North Atlantic and stop the sinking of North Atlantic water, thereby altering the driving force behind the great ocean conveyor belt current. Although projections are speculative, scientists suggest that a disruption in this circulation could lead to a cold climate shift in Europe as well as unpredictable changes in other parts of the globe.

In this exercise, students will be able to visualize differences in water density and relate this to potential consequences of increased glacial melting.

Vocabulary:

- **global climate change**: the alteration of average global temperature, rainfall, and wind patterns as a result of increased atmospheric greenhouse gases
- **greenhouse gases**: gases in Earth's atmosphere that absorb and reradiate heat near the surface

of the planet

- **density**: a measurement of compactness. For solids, this is usually measured as mass per unit volume. For substances dissolved in water, this is usually measured as parts per thousand or million.
- **displacement**: the forced relocation of water due to a submerged or partially submerged object occupying fluid space

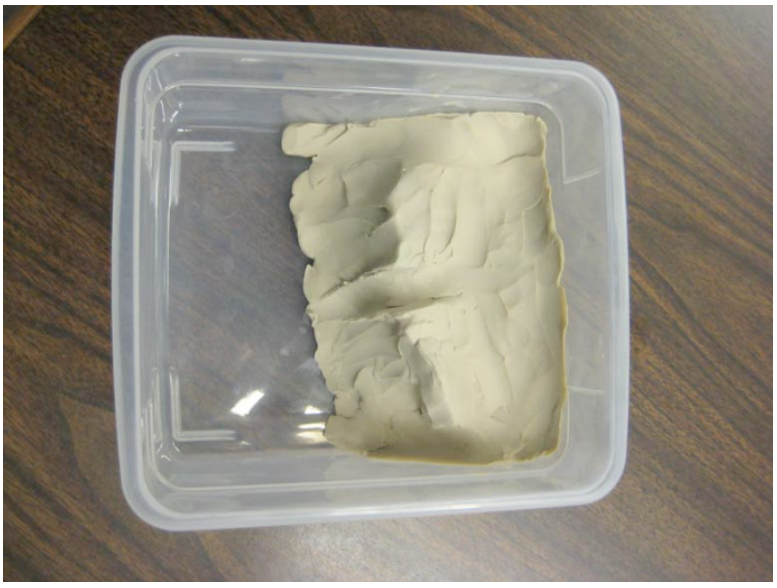
Activity:

Introduction

1. Have a discussion about global climate change and its impact on sea level rise. Ask students 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? Will one or both cause sea level to rise when they melt?
2. Give each student the Sea Level Rise worksheet.
3. 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?
4. Have each student make a prediction.

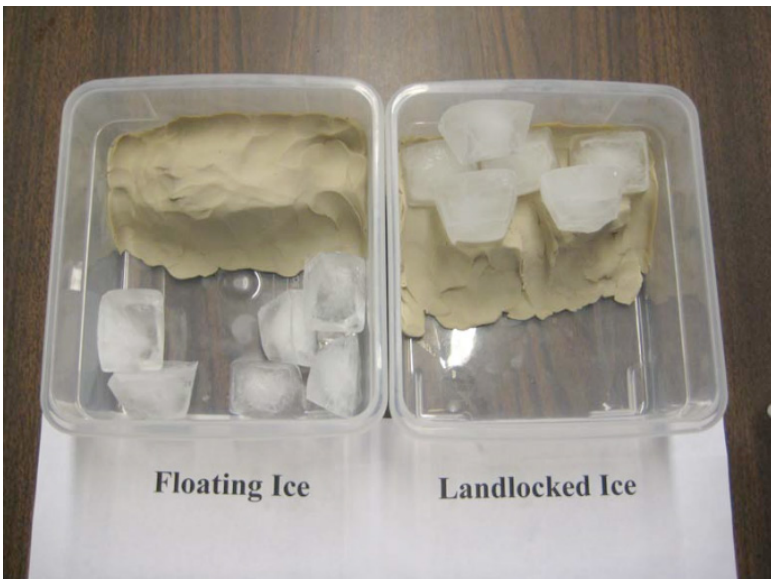
Procedure:

1. Place half of the clay 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.

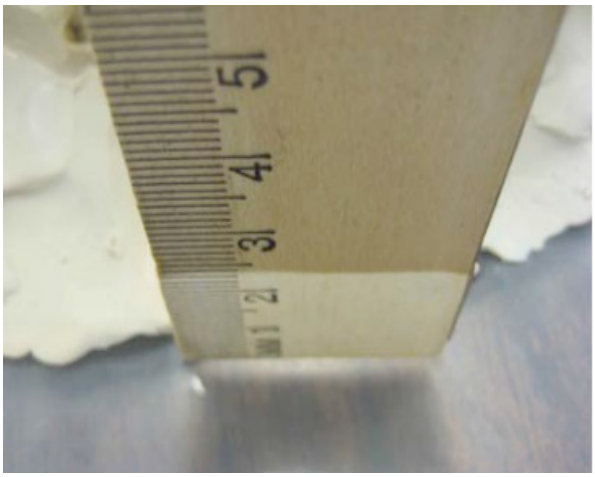


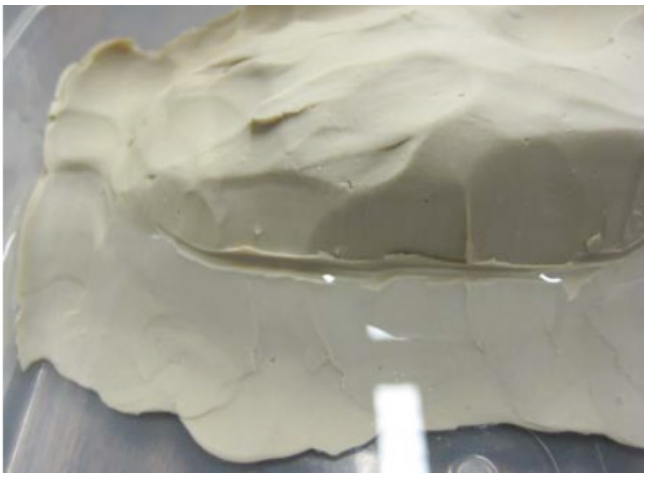
Climate Change and Sea Level Rise (cont.)

2. Place as many ice cubes as possible on the level place formed with the clay in the first box.
3. 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.



4. Pour water into the container where the ice is resting on the bottom until the ice floats. Be sure the ice is floating, not resting on the bottom. If this occurs, add more water.
5. 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.
6. On their Sea Level Rise Worksheets, have students record initial measurements of water height (in mm) using a ruler. For visual impression you may wish to draw a line in the clay where the water height begins in each container.





Climate Change and Sea Level Rise (cont.)

7. Leave the setup. If possible, have students take measurements every hour 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.

8. Have students measure new water heights and make observations about what occurred one the ice melted. Make sure students enter their measurements on their worksheets.

Discussion:

1. Have students answer the following questions:
2. Use the information in the background to help students understand their results.
    - In which "situation" did the water level rise more?
    - How do the results compare with your predictions?
    - Why do you think this happened?
3. Have another discussion about global climate change.
    - 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.*

Extended Demonstration Procedure:

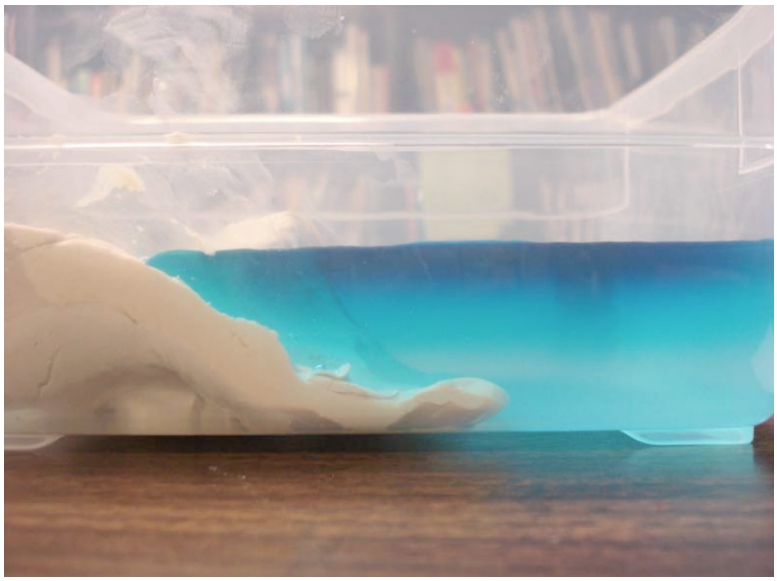
Conduct the extension activity as described for the original activity with the following modifications:

1. When freezing the ice cubes, put lots of blue food coloring into the water before filling the trays. This will make colored ice (the darker, the better).
2. Add salt to the water that will be poured into the box in a ratio of 3 tablespoons of salt to 1 liter of refrigerated water. This makes your water approximately the same salinity as the ocean. Teacher tip: It is important to use cold water for this activity because, as discussed earlier, liquids become denser as they cool. If the water from the melting ice is significantly colder than

the saltwater in the pan, the difference in density (caused by variation in temperature) may negate the effect of the difference in salinity. This could cause the colored fresh water to sink instead of float.

3. Use the colored ice in place of the regular ice, and build your "landlocked ice" box as previously outlined, using the cold, salty water to pour into the container.

4. Allow the ice to melt and watch where the fresh water (blue color) accumulates.



Climate Change and Sea Level Rise (cont.)

Extended Demonstration Discussion:

1. Have a discussion about density, and what causes the observed result. Ask students to write in their own words why the blue colored water floats on the clear water.
2. What are the potential problems associated with a layer of freshwater floating on the ocean in the North Atlantic (see extended demonstration background).

Sea Level Rise Worksheet

Question:

Predictions:

Measurements:

Time (hours)	Water Height (mm)	
	Floating Ice	Landlocked Ice
0		
1		
2		
3		