COSEE Networked Ocean World Presents:

Antarctica melting

Melting Glaciers

Overview

Today, in Antarctica, air temperatures are 2-3 ° C warmer than they have been in the past. While this temperature increase may seem insignificant, it is playing a major role in the retreat of the world's glaciers, the large masses of snow and ice found in the high mountains and on land. Nearly 90% of the Antarctic Peninsula's glaciers have retreated in the past 50 years due to increases in air and water temperatures (Cook et al. 2005).

If temperatures continue along this trend, it is estimated that approximately 50 years from now, the air temperatures will be 5–8°C warmer than the present.

This massive melting will cause large volumes of freshwater to enter the ocean and could lead to global sea level rise. If the West Antarctic ice sheet were to completely melt, global sea level would rise by 16 to 20 feet (5 to 6 meters). This experiment emulates the conditions in the past, present, and future of Antarctica. From this work, students can explore what will happen as temperatures continue to increase in the Antarctic Peninsula.

Motivating Question: What will happen to the water around Antarctica as a result of climate change?

Materials

Instructor:

- ✓ 6 Round plastic containers, approximately 8 cm deep and 10–12 cm in diameter (500–1,200 mL; the plastic pint containers in the deli section of the grocery store work well for this step. Ensure that every group has identical containers.)
- ✓ 300 mL beaker or graduated cylinder
- ✓ Berry Blue Kool-Aid
- ✓ Freezer space (Six groups will need about 10 × 15 cm of freezer space. The school's cafeteria staff may be able to help with this.)
- ✓ 6 Rocks, each slightly less than 10–12 cm in diameter that can fit in the bottom of the plastic container.
- ✓ 1,000 mL beaker or graduated cylinder
- ✓ Tap water
- ✓ 180 mg of Iodized or plain table salt (30 mg per container)
- ✓ Refrigerator space

Per Group:

- ✓ 1 Plastic shoebox-type containers that are approximately 34.5 cm × 20.5 cm × 10 cm (4.5 L)
- ✓ 1 piece of white paper
- ✓ 1 beaker containing 1,000 mL of cooled, colorless salt water
- ✓ 1 Mini-glacier (prepared as below)
- ✓ 1 75-watt lightbulbs with fixtures and stands (one per group observing the Present or Future environments)
- ✓ Paper towels
- ✓ 1 Metric ruler
- ✓ 1 Timer or wristwatch
- ✓ Graphing paper (one sheet per student) or a computer with a spreadsheet program (one per group)
- ✓ Pencils or pens

Revised: August 27, 2010

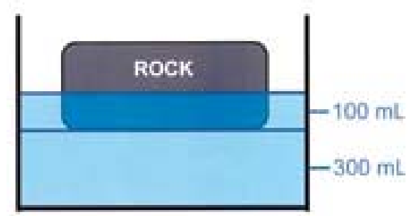
Activity Outline

Engage:	This activity will help the students convey their understanding about Antarctica and salinity. Also, it will provide the instructor with information on their background in this area.	10 minutes
Explore:	This activity seeks to introduce students to the mechanisms causing the melting of the Antarctic glaciers.	40 minutes
Make Sense:	This activity allows students to apply their understanding of how the melting glaciers will impact sea level rise and the organisms living in the region.	10 minutes
	Total:	60 minutes

Preparation

(Approximately 10 minute a day for 3 Days)

1. **Day 1**: Prepare the following two days before simulation:
   a. Dissolve one packet of Berry Blue Kool-Aid in 1,500 mL of water to make blue "fresh water." This brand, flavor, and concentration of Kool-Aid must be used to achieve desired visual results.
   b. Pour 300 mL of blue Kool-Aid into six round plastic container and freeze overnight.
2. **Day 2**: Prepare the following one day before simulation:
   a. Place one rock inside each plastic container so that it sits on top of the blue ice that has formed.
   b. Pour 100 mL of blue Kool-Aid over the rock.
   c. Freeze overnight so that the initial layer of blue ice, the rock, and the new layer of blue water will freeze together.
   d. Prepare 1,000 mL of salt water to simulate the actual salinity of the Southern Ocean by mixing 30 mg of table salt with 1,000 mL of water. Cool the salt water overnight in a refrigerator. Do not add Kool-Aid to the salt water.
3. **Day 3**: Prepare the following on the day of the experiment:
   a. Remove mini-glaciers from freezer and place at room temperature about 5 minutes before class.
   b. Place the necessary materials onto a tray for each group.



Instructor's Note

The most dramatic color changes in the ocean environment occur after mini-glaciers have been melting for 30 minutes or more. If class periods are 45 minutes or less, setting out the mini-glaciers at room temperature for 5–10 minutes before class begins will improve results.

Engage (10 minutes)

1. Define salinity as the measure of how much salt or ions are in the water.

2. Have the students work with a partner to identify some examples of fresh water and saltwater habitats and then have them share these examples with the group.

3. Handout or display the examples of freshwater and saltwater organisms

4. Ask students:

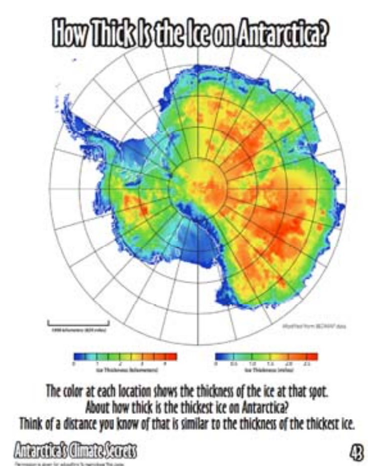
   Q. What would happen if you put saltwater animals directly into fresh water?
   Q. What would happen to saltwater animals if you slowly decreased the salinity of their water?

5. Introduce the topic of climate change in Antarctica by viewing: **Act I: A changing continent**.

Video: *Act 1: A Changing continent,* available at: http://coseenow.net/antarctica

6. Distribute the map of Antarctica and the "**How Thick Is the Ice on Antarctica?**" handout. Stimulate prior knowledge by discussing what students know about Antarctica and its major features (i.e. glaciers, Southern Ocean surrounding it).

7. Direct the students attention to the "How Thick Is the Ice on Antarctica?" handout. Ask them where the ice is the thickest and where it is the thinnest?



Handout: *How Thick is the Ice on Antarctica*

8. Explain to the students that as mentioned in the video, the glaciers (the large masses of snow and ice found in high mountains and on land) in Antarctica are melting at an alarming rate.

9. Point to the motivating question and ask:

   Q. What will happen to the water around Antarctica as a result of climate change?

10. Again, have students to share their ideas about the question with a partner and then with the group. Finally, ask volunteers to share the ideas from their group with the entire room. Tell them that we will now explore this question by collecting and analyzing data.

Explore (40 minutes)

1. Assign students to six groups so that there are two groups representing the past, two for the present, and two for the future.

2. Distribute instruction sheets and materials.

3. Have students follow steps 1 to 5 on their instruction sheets.

Data Tip

The areas in red have the thickest ice and the areas in blue have the thinnest.

4. When groups have finished, inform the students that this experiment will take 30 minutes and that you will be keeping track of time. You will inform them when 15 minutes has passed and it is time to take a measurement and you will inform them again after 30 minutes.

5. Have the students pool their data with the rest of the class by filling it in on data charts on the board.

Make Sense (10 minutes)

1. Using the pooled summer data from the class results, have the students create line graphs to compare changes in water level and salinity between the Past, Present, and Future Environments. In the salinity graph, place the salinity level on the vertical axis and the time periods/environments on the bottom. In the water-level graph, put the water-level scale on the vertical axis and the time periods/environments on the bottom.

2. Have the students return to the diagram they made of the experimental setup and add labels that describe the physical changes that occurred in each environment from winter to summer.

3. Answer the following questions:

    a. According to your graphs and your diagram, how has the level of the ocean changed from the Past to the Present Environment? How will it change in the Future?

    b. According to your graphs and your diagram, how has the salinity of the ocean changed from the Past to the Present Environment? How will it change in the Future?

    c. Did your results support the predictions you made in Step 8B? Why or why not?

    d. Predict how changes in water level and salinity will affect the plants and animals that live along the coast of Antarctica. (Teaching tip: If time is short, these questions can form the basis of a future class discussion.)

4. Return to the motivating question and ask:

   Q. What will happen to the water around Antarctica as a result of climate change?

5. Based on the discussion, provide the students with some or all of the following information:

    - ✓ This activity simulated how the Antarctic Peninsula changed over time. The Past Environment models conditions before climate change (at least 50 years ago) when Antarctica was warmer, the Present Environment models current conditions (2–3°C warmer than historical records), and the Future Environment models conditions approximately 50 years from now (5–8°C warmer than the present).
    - ✓ Nearly 90% of the Antarctic Peninsula's glaciers, which are composed of freshwater, have retreated in the past 50 years due to increases in air and water temperatures (Cook et al. 2005).
    - ✓ If this trend continues, there will be an increase in freshwater input into the ocean and a global rise in sea level (Dierssen, Smith, and Vernet 2002).
    - ✓ The increase in freshwater will change the composition of the plants and animals living in the water surrounding Antarctica. For example, it will impact the phytoplankton (single-celled plant-like organisms) that grow in that region. These phytoplankton form the base of the food web and will therefore impact the organisms at higher trophic levels.

References:

Cook, A.J., A.J. Fox, D.G. Vaughan, and J.G. Ferrigno. 2005. Retreating glacier fronts on the Antarctic Peninsula over the past half-century. Science 308 (5721): 541–44.

Dierssen, H.M., R.C. Smith, and M. Vernet. 2002. Glacial meltwater dynamics in coastal waters west of the Antarctic Peninsula. Proceedings of the National Academy of Sciences of the United States of America 99 (4): 1790–95.

Source: This lesson was quoted and adapted from "They're M-e-e-elting! An Investigation of Glacial Retreat in Antarctica" by Samuel R. Bugg IV, Juanita Constible, Marianne Kaput, and Richard E. Lee, Jr.

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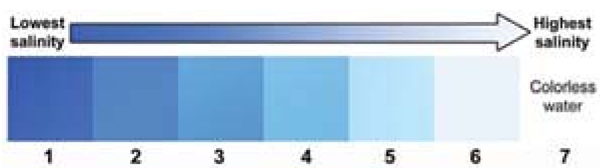
Student Instruction Sheet

Setting up your environment:

1. Place your plastic shoebox container on a piece of white paper and then pour 1,000 mL of cooled, colorless salt water into the container.
2. Label your shoebox "Past," "Present," or "Future," depending on which environment you were assigned to by your teacher.
3. Remove the mini-glacier from its round plastic container onto a paper towel. If the mini-glacier doesn't pop out easily, run warm water over the bottom of each container to free the ice (make sure the ice is facing down).
4. Once the mini-glacier is free from the container, wipe the ice and rock with a paper towel to remove any excess blue color on the surface of the mini-glacier.
5. Place the mini-glacier into your shoebox container so that the rock is on the bottom and the ice is on top.
6. Record the winter measurements for each environment (the salinity index is already filled in) on your data sheet. Measure the water level by placing one end of a ruler on the inside bottom corner of your shoebox container.
7. Use the salinity index below to match the color of the liquid (not frozen) water in each shoebox container on a scale of 1 to 7. If the water has no color at all, you will enter 7 in your data table. If the color of the water is between two values (e.g., somewhere between 1 and 2), enter the closest value in your table.



Salinity index

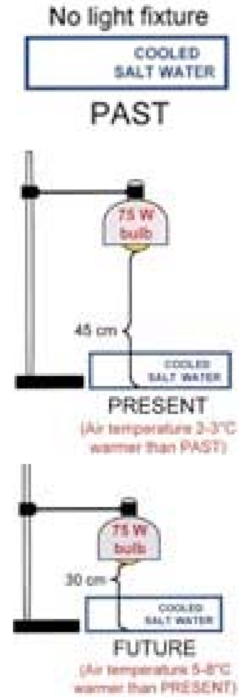
Let's Begin

1. Set up your light fixture but do not turn it on. (Safety note: Be careful when using electrical fixtures near water. Also, do not handle the light bulbs or light shade—they will be hot!)

a. If your group is responsible for the **Past Environment**, do not add an external heat source to your simulated environment.

b. If your group is responsible for the **Present Environment**, stand a 75-watt lightbulb and fixture directly over the shoebox container so the tip of the bulb is 45 cm from the bottom of the container. Measure distance from tip of lightbulb to bottom of salt water container. Turn on the light.

c. If your group is responsible for the **Future Environment**, stand a 75-watt lightbulb and fixture directly over the shoebox container so that the lightbulb is about 30 cm from the bottom of the container. Measure distance from tip of lightbulb to bottom of salt water container. Turn on the light.



2. While you are waiting for spring to arrive, answer the following questions.

   a. On the back of this paper, make a diagram of your experimental setup and label the parts of your setup that you believe represent the following:
   • Antarctic Peninsula • Southern Ocean • Atmosphere • Glacier
   (Hint: You will find each part in your experimental setup.)

   b. Predict what physical changes and evidence of these predicted changes might be observed in each of the experimental environments (Past, Present, and Future). Why do you think those changes will occur? How will the Future Environment differ from the Present Environment? How will the Present differ from the Past?

3. After 15 minutes, go back to the data sheet and record spring measurements.

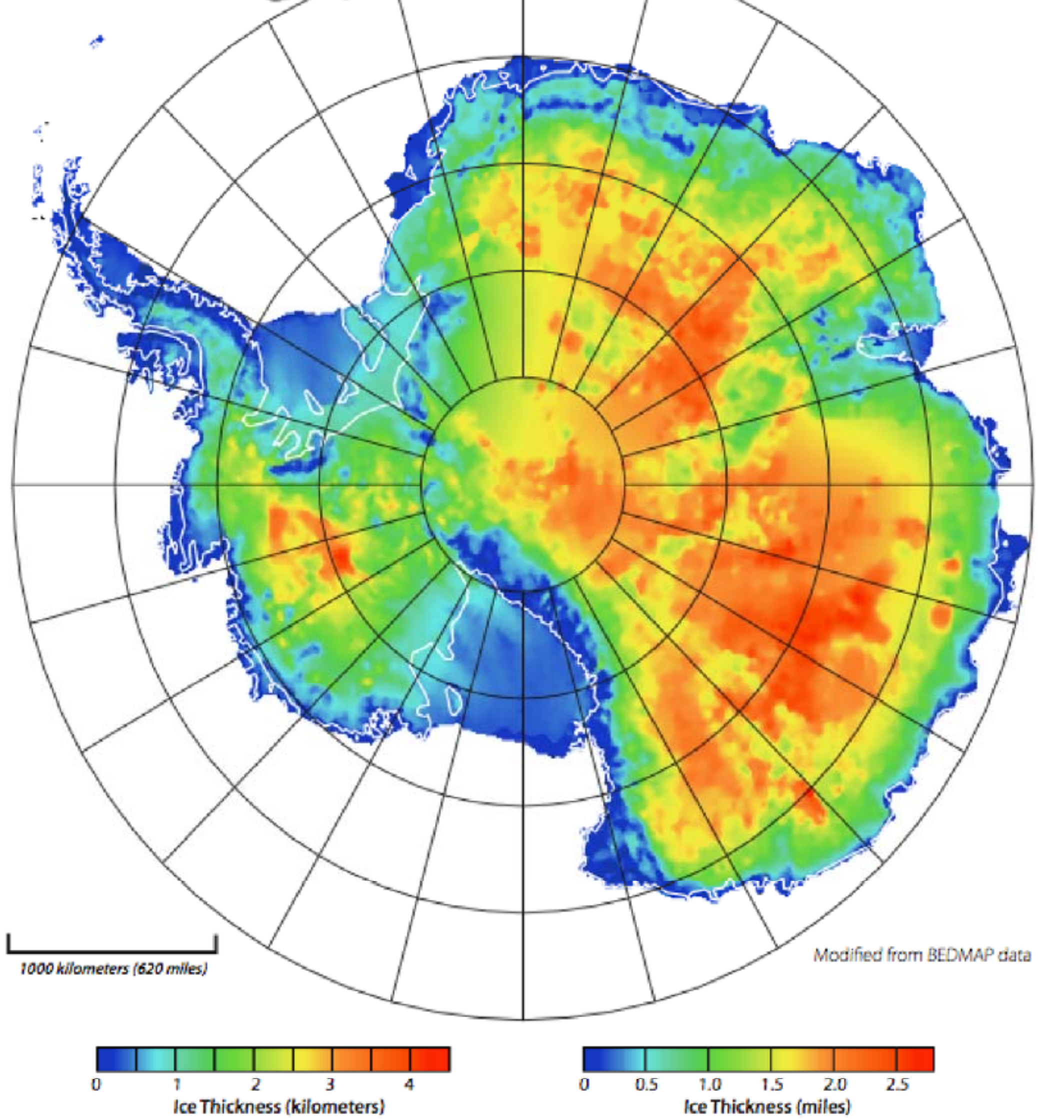
4. While you are waiting for summer to arrive, finish the questions in Step 2.

5. After 30 minutes, go back to the data sheet and record summer measurements.

6. Pool your data with the rest of the class.

		Past environment	**Present environment**	**Future environment**
Winter (0 min)	Salinity index (scale 0-7)	7	7	7
	Water level (mm)	mm	mm	mm
Spring (15 min)	Salinity index (scale 0-7)			
	Water level (mm)	mm	mm	mm
Summer (30 min)	Salinity index (scale 0-7)			
	Water level (mm)	mm	mm	mm

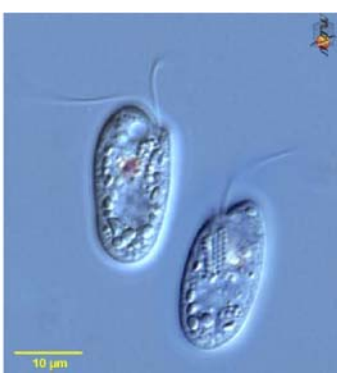
How Thick Is the Ice on Antarctica?



The color at each location shows the thickness of the ice at that spot.
About how thick is the thickest ice on Antarctica?
Think of a distance you know of that is similar to the thickness of the thickest ice.


Southern Ocean
South
Orkney
Islands
Queen Maud
Land
Weddell
Sea
Graham
Land
ice
shelf
South
Pole
Marie
Byrd
Land
Amundsen
Sea
Wilkes Land
ice
shelf
Ross
Sea
Victoria
Land
Southern
Ocean
0 400 800 km
0 400 800 mi

Freshwater Organisms

 AMAZON RIVER DOLPHIN	 AMERICAN ALLIGATOR	 RIVER OTTERS
 HIPPOPOTAMUS	 RED PIRANHA	 CATTAILS
 CRYOPHYTES (PHYTOPLANKTON)		

Saltwater Organisms

 MORAY EELS	 BASKING SHARK	 GRAY WHALE
 SALTWATER CROCODILE	 NORTHERN SEA LION	 RED MANGROVES
 TURTLE GRASS	 DIATOMS (PHYTOPLANKTON)	