Freshwater & Saltwater

ACTIVITY TIME

120 minutes

+ 2 - 4 hours for ice to freeze.

LEARNING OUTCOMES

- List the major differences between sea ice and freshwater ice.
- Explain the effect that salinity has on the freezing point of water.
- Explain why knowledge of sea ice is important for people living in the Arctic.
- Identify the importance of correlating Inuit knowledge with scientific knowledge.

OVERVIEW

WHY?

Saltwater and freshwater ice are composed differently and form ice types that vary in their freezing temperatures, flexibility, porous nature and activity in the environment.

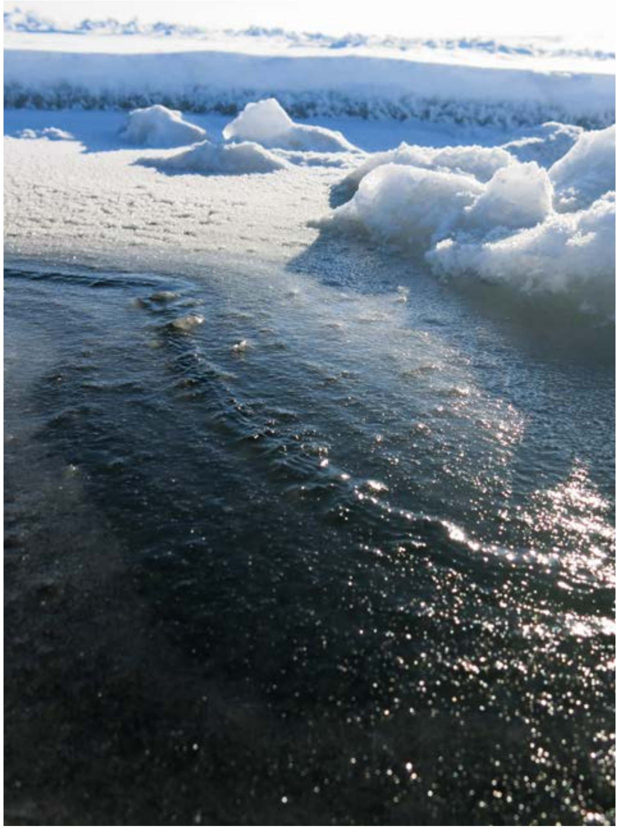
WHAT?

- Buoyancy of freshwater vs. saltwater ice cubes.
- Melting points of those ice cubes
- Strength of freshwater vs. saltwater ice.
- Qualitative and quantitative measuring tools.

HOW?

- Review the background section.
- Prepare for and complete the experiment.
- Record your results.
- Discussion questions.

CONTENTS



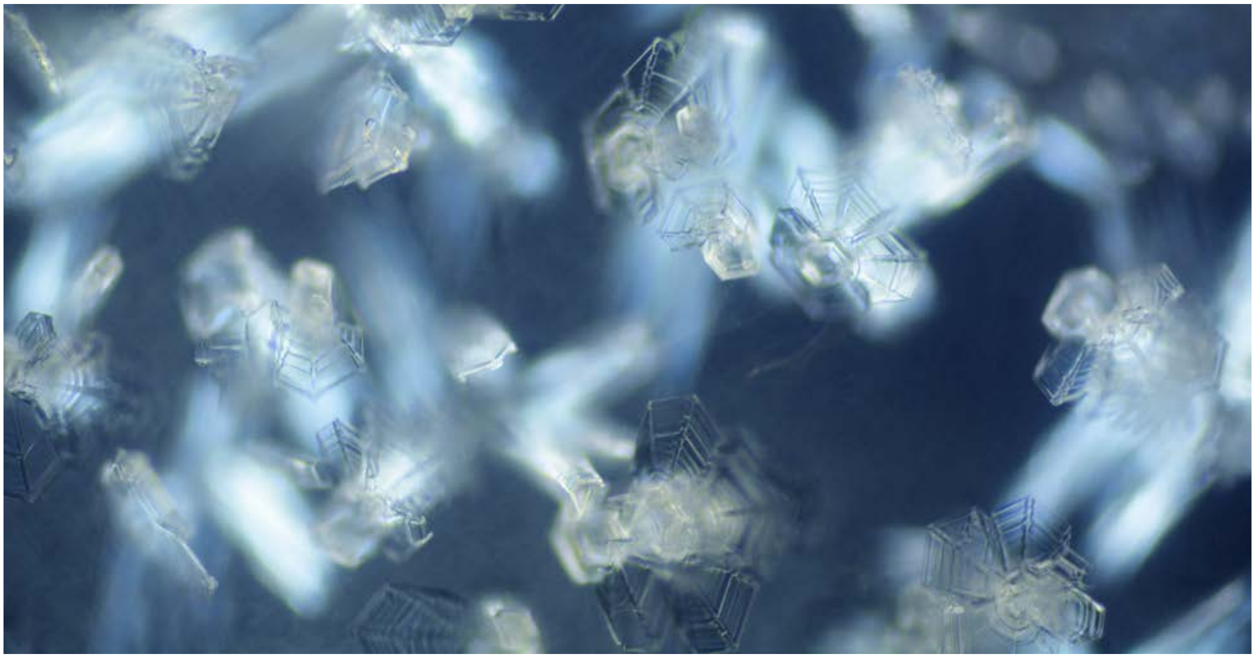


IMAGE 1 Saltwater ice, top-left, and freshwater ice, top-right (J.Heath). Top edges of ice crystals under microscope (M. Bilovitskiy).

BACKGROUND

Knowledge of sea ice is important to safely travel over it. In many areas of the North, sea ice dynamics are changing, and the ice conditions have become less predictable. For instance, in 2009, senior hunter Peter Kattuk from Sanikiluaq noticed that there was more snow than normal on the sea ice in some places: "The snow is not freezing. It's kind of warmer so it's not getting hard on the ground," Peter said, "So, it's like cooking oil. Melting the ice."(P. Kattuk).

Hudson and James bays are connected to the ocean and contain salt water, but many rivers bring freshwater to the bays as well. Systems with a mix of fresh and saltwater are called estuaries. An important trend has been observed in the Arctic; a freshening of the surface layer of seawater. This affects the formation and properties of the sea ice that forms in the fall, how it breaks and piles up during the winter, and how it breaks-up during the spring. Further complicating this issue are indications that large scale hydroelectric projects reverse the seasonality of rivers by dumping large amounts of freshwater into the ocean during the winter instead of during the spring melt. 2013 was a very cold winter in Quebec. This resulted in very high electricity usage and the associated release of freshwater from dams. Plumes of water, much fresher than normal, were detected in several locations near the Belcher Islands. Why is this important and what is the difference between sea ice and freshwater ice anyway?

The **freezing point** of freshwater is 0°C. The presence of dissolved salts in ocean water lowers the freezing point to about -1.8°C by disrupting the formation of **hydrogen bonds** between water molecules.

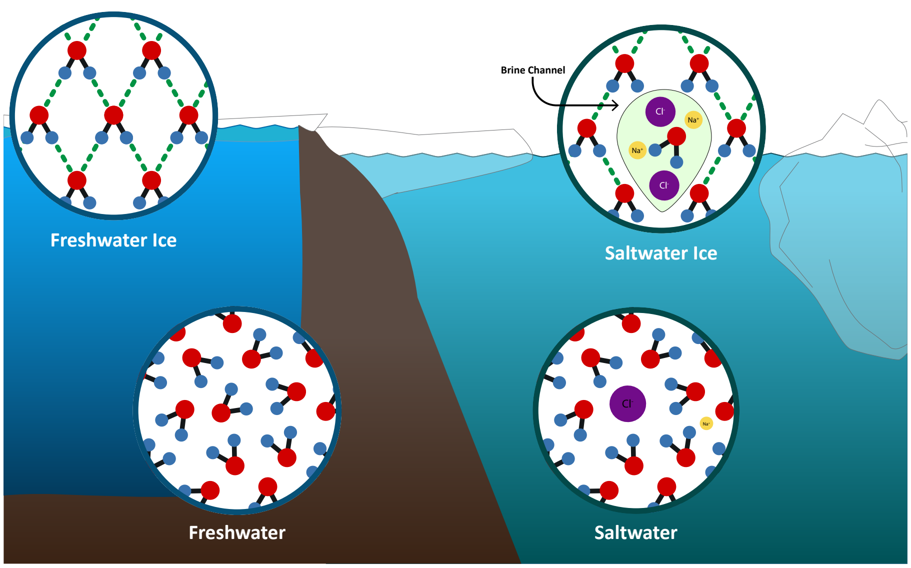


FIGURE 1 A 2D illustration of fresh and saltwater ice molecules are shown for clarity but a 3D representation is required to accurately depict atomic structure.

VOCABULARY

Qualitative: Observations based on what the observer sees. Often visual.

Quantitative: Describing or measuring a quantity (ex. temperature, length).

Estuary: A body of water where salty and freshwater come together, often found in bays near the mouths of rivers.

Salinity: The concentration of dissolved salts in a liquid.

Brine channels: Small holes in ice formed when salt is not completely forced out of developing sea ice by brine rejection.

Density: The mass of a substance per unit of volume.

Hydrogen bonds: Intermolecular bonds that form between the negatively charged oxygen atom of a water molecule and the positively charged hydrogen atoms of surrounding water molecules.

Lattice: A crystalline arrangement of atoms or molecules.

Qinu / frazil ice: The earliest stage of ice formation when ice has a slushy consistency suspended in water. This occurs when the ice particles are loose and soft and have not yet frozen to the point of becoming ice.

Freezing point: The temperature at which water becomes ice.

WORKSHEET

SET-UP

1. Label materials.

   - (A) Label 2 pitchers "Saltwater" and "Freshwater"
   - (B) Label 4 containers A through D
   - (C) Label containers A and C "Saltwater"
   - (D) Label containers B and D "Freshwater"

FIGURE 2 Set-up diagram

2. Fill each pitcher with 1L of warm water.
3. Add one heaping tablespoon of salt to the "Saltwater" pitcher.
4. Stir the saltwater to thoroughly to dissolve the salt.
5. Put the pitchers in the fridge.
6. At least 2 hours before the experiment, pour 250-500mL (1-2 cups) of freshwater and saltwater into the appropriate labelled trays. Set them in the freezer or outdoors to freeze (must be at least -2^{o}C).
7. Check on the ice every 30-45 minutes while it freezes and record the time, the water temperature and observations in *Table 1*.

Time	Temp A (˚C)	Temp B (˚C)	Observations

TABLE 1 Ice freezing data table.

EXPERIMENT

8. Take containers A and B out of the freezer. Measure the temperature of the water and the thickness of the ice. Record the values below and also on the board at the front of the class. Write down what the ice looks like and any observations that you think might be important.

   A. Temperature A: ________ Thickness A: __________

   Observations:

   ____

   ____

   ____

   ____

   B. Temperature B: ________ Thickness B: __________

   Observations:

   ____

   ____

   ____

   ____

9. Take containers C and D out of the freezer. They should both be frozen solid. What are the differences between the two different types of ice? Come up with 3-4 descriptive words for each.

C Words describing ice in container C:

____

____

____

____

D Words describing ice in container D:

____

____

____

____

10. Use a butter knife or pencil to test the hardness of the ice in containers C and D, simulating the harpoons used by Inuit to test the ice when traveling over it. Write down any observations. Also write your group's observations on the board.

C Observations when breaking ice in container C:

____

____

____

____

D Observations when breaking ice in container D:

____

____

____

____

DISCUSSION QUESTIONS

1. How would a freshwater ocean be different from a saltwater ocean in terms of sea ice?

2. Would sea ice be safer to travel over it was composed of fresher or saltier ice? Why?

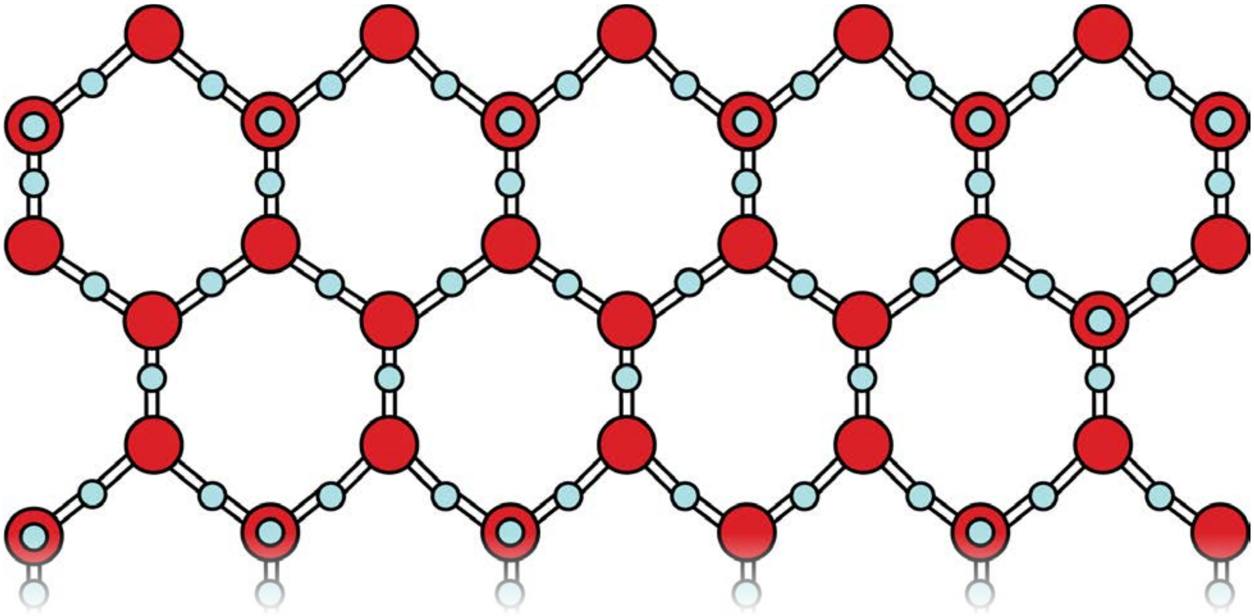


IMAGE 2 Hexagonal ice lattice diagram (J. Fries-Gaither)