SEA ICE POROSITY AND OCEAN ECOSYSTEMS

(Thanks to Josep Marlés Tortosa, Spain)

Lesson at a glance

Students use ice samples and a coloured dye to investigate differences in the structure of sea ice and freshwater ice.

Background

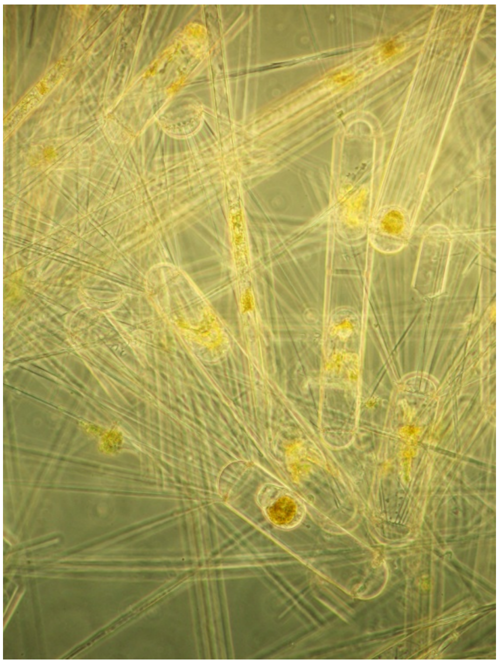
The structure of sea ice is critical to the stability of polar marine ecosystems. Sea ice is made up of a combination of solid ice, air, salt and brine. The existence of brine channels in the sea ice is a major difference between sea ice and freshwater ice. The brine channels extend through thousands of square kilometers of sea ice, and host entire microbial ecosystems. These ecosystems are an important food source for other marine organisms, especially during winter and early spring, when there is little other food in the water.

Brine channels form when saltwater freezes. The salts in the water cannot be incorporated into ice crystals, so they are expelled as the crystals grow. As a consequence, the salt concentration in the remaninig water increases, forming brines. Some of the brine remains in channels and cavities within the ice.

The main organisms living in the brine channels are algae (phytoplankton) and bacteria. The algae are the primary producers and provide the initial food source for heterotrophic organisms such as bacteria, protists and eventually crustaceans and larger organisms.

Bacteria in all ecosystems, including those which occur in the sea ice, grow by breaking down dissolved organic matter. The dissolved organic matter comes from the excretion of organisms living in the ice and the cells of dead organisms. The transformation of organic molecules into inorganic matter (remineralisation) is an essential mechanism for the life of the algae, because the algae require the inorganic molecules as nutrients.

Algae constitute the primary producers in the marine ecosystem, since they are the base of the food web. The growth of these algae in the interior of the pack ice during the months of melting is fundamental for providing necessary nutrients for the existence of all the organisms that are part of the polar ecosystems.



Diatoms, a common algae found in sea ice brine channels (Photo: Patti Virtue)

Time

Preparation: Several hours to freeze ice cubes

Class time: 45 minutes

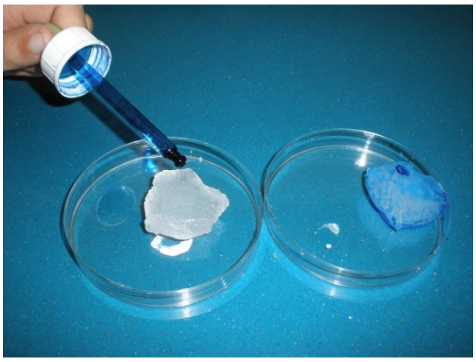
Materials

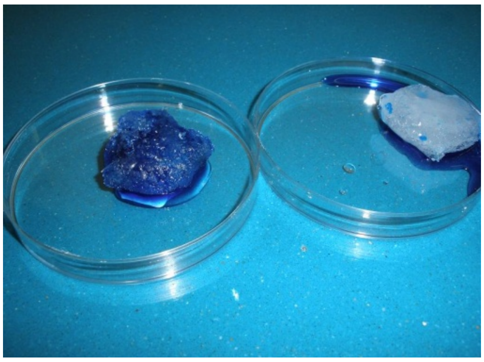
(per group of 3-4 students)

1 saltwater ice cube and 1 freshwater ice cube
Dropper bottle of dye in alcohol solution (e.g., food colouring dissolved in rubbing alcohol)
Shallow plastic dishes to place the ice cubes

Activity Directions

1. The day before doing the activity, prepare two different types of ice cubes – freshwater and saltwater. To prepare the saltwater ice, dissolve 3.5 grams of kitchen salt in 100 milliliters of desmineralised water.
2. Give each group of students one saltwater ice cube, one freshwater ice cube and a dropper bottle of dye. Instruct them to place a drop of dye on each of the ice cubes and observe what happens.
3. Discuss their observations and the significance of the differences.

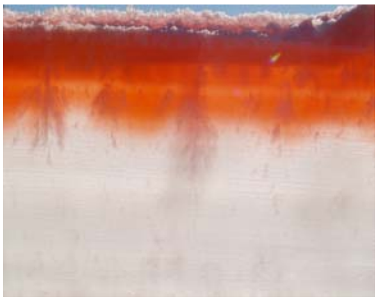




The ice fragment on the right is freshwater ice, the fragment on the left is saltwater ice. The photo on the right shows the colour difference a few minutes after the dye was place on the samples. (Photos: Josep Marlés Tortosa)

Discussion

1. What differences did you observe between the two ice samples? *(After some minutes, the dye has run off the freshwater ice. On the other hand, the saltwater ice conserves the colouring.)* What caused the differences? *(The dye passed into the brine channels in the saltwater ice. The freshwater ice is not porous enough to absorb the colour.)*
2. What can you deduce from the porosity of the ice?
3. Why is it important for sea ice to be porous? *(Many organisms live in the brine channels, and these form an important part of the ocean food web – see Background information for more detail.)*
4. Why was it necessary to dissolve the colouring in alcohol before doing this experiment? *(Adding alcohol lowers the freezing temperature of the dye. Without alcohol, the dye may freeze before it has time to percolate down into the brine channels.)*



Real Science: Sea Ice Porosity Research in Antarctica

Although it may look like some kind of bizarre art project, Dr Ken Golden, a theoretical mathematician from the University of Utah, was studying sea ice porosity during the IPY SIPEX voyage in the Antarctic.

He and his assistants cut rectangular blocks of sea ice with a chainsaw and hauled them out of the water. They turned one block so that it was right side up and another so that the underside of the ice was facing up. After cutting a couple of grooves in the tops of the blocks, they poured water tinted with red-orange food dye into the grooves and watched what happened.

The purpose of the experiment was to improve their understanding of how fluids such as brine or seawater move up and down through sea ice – an important factor in both biological and physical studies. The speed with which the coloured water percolated down through the ice showed how porous the ice was. The coloured water also highlighted the structure of the brine channels.

Sea ice porosity depends on temperature and salinity, with warmer ice being much more porous. The underside of the ice block, which had been in contact with the ocean water, was much warmer than the surface, which had been in contact with the colder air. When the coloured water was poured on the upside down block, it spread downward through the ice much more rapidly than it did on the block that was right side up.

Illustrations (top to bottom): Pouring the dye, timing the percolation in the two blocks; brine channels highlighted by the dye

(Photos: Sandra Zicus)