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Arctic Ocean Exploration

Life in the Crystal Palace

Focus
Sea ice communities in the Arctic Ocean

Grade Level
5-6

Focus Question
What organisms and ecosystem processes characterize biological communities in Arctic Ocean sea ice?

Learning Objectives
Students will be able to identify major groups of organisms found in Arctic sea ice communities.

Students will be able to describe major physical features of sea ice communities, how these features change during summer and winter, and will be able to explain how these changes affect biological activity within these communities.

Students will be able to describe interactions that take place between sea ice communities, and will be able to explain the importance of sea ice communities to Arctic ecosystems.

Additional Information for Teachers of Deaf Students
In addition to the words listed as key words, the following words should be part of the vocabulary list.

Continental shelf
Chukchi Sea
Atlantic Ocean
Greenland Sea
Submarine ridges
Alpha Ridge
Lomonosov Ridge
Arctic Mid-Oceanic Ridge
Canadian Basin
Biological communities
Sea-ice realm
Diatoms
Algae
Photosynthesis
Bacteria
Viruses
Fungi
Energy source
Flatworms
Crustaceans
Jellyfishes
Squids
Detritus
Sponges
Polychaete worms
Sea anemones
Tunicates
Ascidians
Organism
Primary productivity
Bacteria
Concentrated
Salinities
Precipitate
Opaque minerals
Ice crystals
Organic
Molecules
Insulating
Organism
Nutrients

Filaments
Polar marine ecosystems
Predators
Migration
Pollutants

The key words are integral to the unit but will be very difficult to introduce prior to the activity. They are really the material of the lesson. There are no formal signs in American Sign Language for any of these words and many are difficult to lipread. Give the list as a handout to the students to refer to after the lesson. Copy the Background Information and give as a handout to read before conducting the activity.

Materials

- ❒ Felt board or poster materials
- ❒ Internet access or copies of Web pages from http://www.arctic.noaa.gov/essay_krembsdeming.html and http://www.unikiel.de/ipoe/Websitealt/resgroup/seaice.html

Audio/Visual Materials

None

Teaching Time

Two 45-minute class periods

Seating Arrangement

Classroom style for discussion portions of the activity; floor or work tables for poster construction

Maximum Number of Students

20

Key Words

Pelagic
Benthic
Sympagic
Brine channel
Algae
Protozoa
Nematode
Ciliate
Turbellaria
Amphipod
Copepod

Background Information

The Arctic Ocean is the smallest of the world's four ocean basins with a total area of about 5.4 million square miles or 14 million square kilometers (roughly 1.5 times the size of the United States). It is bordered by Greenland, Canada, Alaska, Norway, and Russia. The Arctic Ocean has the widest continental shelf of any ocean, extending 750 mi (1,210 km) from the coast of Siberia, but also has areas that are quite deep. The average depth is 12,000 ft (3,658 m) and the maximum depth is 17,850 ft (5,441 m). The Chukchi Sea provides a connection with the Pacific Ocean via the Bering Strait, but this connection is very narrow and shallow, so most water exchange is with the Atlantic Ocean via the Greenland Sea.

The floor of the Arctic Ocean is divided by three submarine ridges (Alpha Ridge, Lomonosov Ridge, and the Arctic Mid-Oceanic Ridge) one of which (the Lomonosov Ridge) creates a relatively isolated area known as the Canadian Basin. This area is particularly interesting to scientists because its isolation could mean that it contains unique life forms that are found nowhere else on Earth. But the Arctic Ocean is not easily explored: it is almost entirely covered with ice for eight months of the year, a drifting polar ice pack covers the central and western portions year-round, and sea temperature seldom rises above 0°C. Although the Arctic is still the world's least explored ocean, new expeditions are about to give us much greater knowledge of the mysteries of this polar frontier.

At this point, we know that there are at least three distinct biological communities in the Arctic Ocean. The Sea-Ice Realm includes plants and animals that live on, in, and just under the ice that floats on the ocean's surface. Because only 50% of this ice melts in the summer, ice flows can exist for many years and can reach a thickness of more than six ft (2 m). This activity is focused on the Sea-Ice Realm, and more details of this community are given below.

The Pelagic Realm includes organisms that live in the water column between the ocean surface and the bottom. Melting sea ice allows more light to enter the sea, and algae grow rapidly since the sun shines for 24 hours a day during the summer. These algae provide energy for a variety of floating animals (zooplankton) that include crustaceans and jellyfishes. Zooplank-ton, in turn, is the energy source for larger pelagic animals including fishes, squids, seals, and whales.

When pelagic organisms die, they settle to the ocean bottom, and become the energy source for inhabitants of the Benthic Realm. Sponges, bivalves, crustaceans, polychaete worms, sea anemones, bryozoans, tunicates, and ascidians are common members of Arctic benthic communities. These animals provide energy for bottom-feeding fishes, whales, and seals. Most of our knowledge about biological communities in the Arctic Ocean comes from studies on portions of the ocean near the continental shelves. Very little research has been done on the sea ice, pelagic, and benthic realms in the deepest parts of the Arctic Ocean. These areas are the focus of the 2002 Ocean Exploration Program's Arctic Ocean Expedition.

This activity is focused on the Sea Ice Realm. Sea ice is not usually solid like an ice cube, but is riddled with a network of tunnels called brine channels that range in size from microscopic (a few thousandths of a millimeter) to more than an inch in diameter. Diatoms and algae inhabit these channels and obtain energy from sunlight to produce biological material through photosynthesis, a process known as primary productivity. Bacteria, viruses, and fungi also inhabit the channels, and together with diatoms and algae provide an energy source (food) for flatworms, crustaceans, and other animals. This community of organisms is called sympagic, which means "ice-associated."

In autumn, temperatures at the upper surface of the ice decrease with the approach of winter causing more ice to build up. As the ice solidifies, brine channels become smaller and the liquid (brine) between the ice crystals becomes more concentrated (i.e., the salinity of the brine increases). Brine salinities may reach 250 parts per thousand near the surface of the ice (normal seawater has a salinity of about 35 parts per thousand). At these high salinities, salts begin to precipitate as opaque minerals. Survival of ice-dwelling organisms under these conditions depends on the organisms' ability to prevent the formation of ice crystals in their bodies, and many organisms accumulate large deposits of organic molecules and fat-like materials for this purpose. The ice itself has insulating properties, so while temperatures at the surface of the ice may be as cold as -35°C, the temperature at the bottom of the ice is the same as the adjacent seawater (about -2°C).

In the spring, melting ice releases organisms and nutrients that interact with the ocean water below the ice. Large masses of algae form at the ice-seawater interface and may form filaments several meters long. On average, more than 50% of the primary productivity in the Arctic Ocean comes from single-celled algae that live near the ice-seawater junction, and this interface is critical to the polar marine ecosystem. In addition to providing an energy source (food) for many organisms, the sea-ice interface provides protection from predators. Arctic cod use the interface area as nursery grounds, and in turn provide an important food source for many marine mammals and birds.

On the ice surface, polar bears use the ice for migration routes. In the spring, the solid ice cover breaks into floes of pack ice that can transport organisms, nutrients, and pollutants over thousands of kilometers. Partial melting of sea ice during the summer months produces ponds on the ice surface that contain their own communities of organisms.

In this activity, students will construct models of a sea ice community during summer and winter.

Learning Procedure

1. Have students visit http://www.arctic.noaa.gov/essay_krembsdeming.html and http://www.unikiel.de/ipoe/Websitealt/

resgroup/seaice.html to obtain background information on sea ice communities, or provide copies of pages from these sites. Assign one group of students to develop a model of a sea ice community during winter, and another group to develop a model of a sea ice community during summer.

2. Have each group prepare a plan for their models, including the size of the model, key features, and biological organisms to be included. You should approve these plans before students begin constructing their models.

3. Have students complete their models using felt or paper cutouts. Individual students should be assigned responsibility for specific portions of each poster to ensure uniform participation and completion of the activity in a reasonable amount of time.

4. Have each group describe conditions in the sea ice community as illustrated by their models.

5. Lead a discussion about relationships among organisms, and how these organisms use the physical features of the sea ice community to survive. Key points are the changes in the brine channels between summer and winter, increased salinity of the brine liquid in the winter months, the insulating effect of the sea ice layer, use of brine channels as habitats by algae and animals, and the ways in which the sea ice community affects animals in adjacent communities such as polar bears, fishes, and seals.

The BRIDGE Connection

www.vims.edu/BRIDGE/polar.html

The "Me" Connection

Have students write excerpts from an imaginary diary kept by a researcher on a year-long assignment to a research camp based on an Arctic Ice floe whose mission is to study biological activity within the ice and at the ice-seawater interface. Excerpts should cover all four seasons, and describe some of the things they might have observed at various times of the year.

Connections to Other Subjects

English/Language Arts, Geography, Environmental Science, Earth Science

Evaluation

Following presentations in Step 4, you may have each student write a short (1-2 page) description of the relationships between organisms in sea ice communities, and how the relationship of physical conditions in the communities to biological activity changes with the seasons. Overall quality of the posters may also be used to evaluate performance of group members.

Extensions

1. Have students visit http://oceanexplorer.noaa.gov to find out what actually happened on the Arctic Ocean Expedition.

2. Visit www.nsf-gov/of/ipa/nstw1996/ice/start.htm for an activity to design a research community for polar conditions.

Resources

http://oceanexplorer.noaa.gov – Find out more about the Arctic Ocean Expedition and read daily documentaries and reports of discoveries posted for your classroom use.
http://www.arctic.noaa.gov/ – NOAA's Arctic theme page with numerous links to other relevant sites.

http://maps.grida.no/arctic/ – Thematic maps of the Arctic region showing populations, ecoregions, etc.

http://www.thearctic.is/ – A web resource on human-environment relationships in the Arctic.

http://www.dfo-mpo.gc.ca/regionhs/CENTRAL/arcexplor – Website produced by Fisheries and Oceans Canada on the Arctic.

National Science Education Standards

Content Standard A: Science As Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard C: Life Science

- Populations and ecosystems
- Diversity and adaptations of organisms

For More Information

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