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Arctic Ocean Exploration

Polar Bear Panic!

Focus
Climate change in the Arctic Ocean

Grade Level
5-6 (Life Science)

Focus Question
What is the potential impact of observed reduction in sea ice in the Arctic Ocean?

Learning Objectives
Students will be able to identify the three realms of the Arctic Ocean, and describe the relationships between these realms.

Students will be able to graphically analyze data on sea ice cover in the Arctic Ocean, and recognize a trend in these data.

Students will be able to discuss possible causes for observed trends in Arctic sea ice, and infer the potential impact of these trends on biological communities in the Arctic Ocean.

Additional Information for Teachers of Deaf Students
Additional materials needed: map showing the Arctic Ocean

In addition to the words listed as key words, the following words should be part of the vocabulary list.
Benthic
Pelagic
Zooplankton
Phytoplankton
Sympagic
Primary productivity
Continental shelf
Diatoms
Algae
Photosynthesis
Chemosynthesis
Primary production
Submarine
Brine channels

There are no formal signs in American Sign Language for any of the key words and many are difficult to lipread. To adapt this to higher grade levels, it may be necessary to add an additional class period if some of these terms have not already been covered in your class. Some of these terms may be difficult for students in Grades 5-6, however the lesson may be abbreviated by supplying only key information necessary to compare graphs.

Materials
- ❒ "Polar Ice Data Sheets," one sheet for each student group
- ❒ Graph paper

Audio/Visual Materials
None

Teaching Time
One 45-minute class period

Seating Arrangement
Groups of 4-6

Maximum Number of Students

24

Key Words

Pelagic
Benthic
Sympagic

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), and 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 Arctic 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). 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. 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." Partial melting of sea ice during the summer months produces ponds on the ice surface that contain their own communities of organisms. Melting ice also releases organisms and nutrients that interact with the ocean water below the ice.

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. Zooplankton, in turn, are the energy source for larger pelagic animals including fishes, squids, seals, and whales. Polar bears, which inhabit the Sea-Ice Realm, also depend upon the Pelagic Realm for food.

When pelagic organisms die, they settle to the ocean bottom as detritus, 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 Arctic Ocean Expedition.

Some scientists believe there is a particular urgency to the Arctic Ocean Expedition: the polar ice is shrinking, and no one is sure why. One explanation is that this is part of long-term climate cycles (like El Niño) that bring warm air and Atlantic Ocean water into the region. But other scientists think increased greenhouse gases in the atmosphere may have caused unusually severe changes to the Arctic climate that are affecting many species.

Learning Procedure

In this activity, students will analyze data from several sources to look for trends in the extent and thickness of Arctic Ocean sea ice, and will infer what these trends might mean for the Ocean's biological communities.

1. Review the Background Information on the Arctic Ocean and its three known biological realms with your students. Emphasize that the three realms are coupled, and that photosynthesis by microscopic algae (phytoplankton) provides the energy for other organisms in these realms (i.e., the algae are the "base of the food chain"). Have the students (individually or in groups) prepare a diagram showing the groups of organisms you discuss, and how these groups are linked.

2. Distribute one of the "Polar Ice Data Sheets" to each student group, and have each group prepare a graph of these data.

3. Have each group describe their graph. Lead a discussion of the significance of these data. Students should recognize that data from three different sources show a similar trend of declining extent of Arctic sea ice, and a fourth source shows that the ice is getting thinner as well. Students should refer to their diagrams of interactions between species, and infer what would happen if the Arctic sea ice were to continue to shrink. While it is likely that some species (particularly those that live on the surface of the ice) would be adversely affected and might even disappear, other species might become more abundant. Be sure students realize that the cause of these trends could be natural climate cycles, or "greenhouse warming," or a combination of both.

   Ask the students what they think should be done; is this a situation that requires urgent action, or should we wait for scientists to do more research into the cause? Are there things that could or should be done regardless of the cause? Is this really a problem, and whose problem is it, anyway?

   You may wish to have students read "Arctic Life, On Thin Ice" (Science 291:424-425, January 19, 2001) as the basis for a more in-depth discussion.

The BRIDGE Connection

www.vims.edu/bridge/polar.html
www.vims.edu/bridge/endangered.html

The "Me" Connection

Have students write an essay on why polar bears are important (or are not important) to them as individuals.

Connections to Other Subjects

English/Language Arts, Mathematics, Earth Science

Evaluation

Individual graphs prepared by each student group may be collected to assess the thoroughness of their work. Additionally, students may be asked to prepare individual written interpretations of the pooled results before participating in a group discussion.

Extensions

1. Have students visit http://oceanexplorer.noaa.gov to

keep up to date with the real-time exploration of the deep Arctic Ocean, and to find out what organisms researchers actually find in the three realms.

2. Have students research the greenhouse effect and global climate change, and prepare written or oral reports on the causes, potential impacts, and possible solutions.

Resources

http://oceanexplorer.noaa.gov – Follow the Arctic Ocean Expedition daily as documentaries and discoveries are posted each day for your classroom use. A wealth of information can also be found at this site.

http://www.sciencegems.com/earth2.html – Science education resources

http://www-sci.lib.uci.edu/HSG/Ref.html – References on just about everything, including sources for information on invertebrate feeding habits

Vinnikov, K. Y., A. Roboc k, R. J. Stouffer, J. E. Walsh, C. L. Parkinson, D. J. Cavalieri, J. F. B. Mitchell, D. Garrett and V. F. Zakharov, 1999. Global warming and northern hemisphere sea ice extent. Science 286:1934-1937 – Scientific journal article on which this activity is based.

Johannessen, L. M., E. V. Shalina, and M. W. Miles. 1999. Satellite evidence for an Arctic sea ice cover in transformation. Science 286:1937-1939 – Scientific journal article on which this activity is based

Krajick, K. 2001. Arctic life, on thin ice. Science 291: 424-425. News magazine-style report on the effects of warming in 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

- Population and ecosystems

Content Standard F: Science in Personal and Social Perspectives

- Populations, resources, and environments

For More Information

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Student Handout

Polar Ice Data Sheet #1

Northern Hemisphere Sea Ice
(Source: Vinnikov *et al.*, 1999)

Year	Sea Ice Extent (million km^2)
1970	12.85
1971	12.76
1972	12.84
1973	12.41
1974	12.36
1975	12.10
1976	12.61
1977	12.41
1978	12.58
1979	12.37
1980	12.42
1981	12.24
1982	12.62
1983	12.48
1984	12.19
1985	12.28
1986	12.27
1987	12.54
1988	12.59
1989	12.37
1990	11.72
1991	11.85
1992	12.27
1993	12.08
1994	12.15
1995	11.62
1996	11.95
1997	11.89
1998	11.91

Student Handout

Polar Ice Data Sheet #2

Northern Hemisphere Sea Ice

(Source: Vinnikov *et al.*, 1999)

Year	Sea Ice Extent (million km^2)
1979	12.15
1980	12.16
1981	11.99
1982	12.28
1983	12.19
1984	11.79
1985	11.81
1986	12.06
1987	12.08
1988	12.06
1989	11.85
1990	11.56
1991	11.63
1992	12.00
1993	11.80
1994	11.86
1995	11.36
1996	11.70
1997	11.39

Student Handout

Polar Ice Data Sheet #3

Arctic Ocean Multi-Year Sea Ice
(Source: Johannessen *et al.*, 1999)

Year	Sea Ice Extent (million km^2)
1979	4.4
1980	4.3
1981	4.25
1982	3.95
1983	4.1
1984	4.3
1985	4.05
1986	4.1
1987	4.15
1988	4.95
1989	4.2
1990	4.2
1991	3.5
1992	3.6
1993	3.85
1994	3.65
1995	3.75
1996	3.2
1997	4.55
1998	3.9