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Arctic Ocean Exploration

Let's Get to the Bottom of the Arctic!

Focus
Benthic communities in the deep Arctic Ocean

Grade Level
9-12

Focus Question
What factors influence community composition in the benthic realm of the deep 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 describe different species associations in a benthic community.

Students will be able to infer probable feeding strategies used by benthic organisms and relate these strategies to sediment characteristics.

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
Grabs
Dredges
Cores
ROPOS
ROV
Manipulator
Sampling
Relative abundance
Microscopic algae
Hydrothermal vents
Chemosynthesis
Silt
Biomass
Sediment
Carnivorous species

There are no formal signs in American Sign Language for any of these words and many are difficult to lipread. Having the vocabulary list on the board as a reference during the lesson will be extremely helpful. Since the vocabulary list is so long, you may prefer to give the list as a handout to the students to refer to during and after the lesson.

Step 3 of the Learning Procedure requires the students to calculate average and percent. You may need to review this portion of the activity with your students.

Materials

- ❒ "Benthic Sampling Data Sheets," one for each student group (copy from master included in lesson plan)
- ❒ Reference materials on invertebrate feeding habits, or Internet access

Audio/Visual Materials

Chalkboard, marker board, flip chart, or overhead projector to facilitate presentations of data summaries

Teaching Time

Two or three 45-minute class periods, depending upon length of time devoted to discussions, evaluations, and extensions; includes time for research on feeding habits

Seating Arrangement

Four groups of 4-6

Maximum Number of Students

24

Key Words

Pelagic
Benthic
Sympagic
Zooplankton
Total organic carbon
Diversity
Amphipod
Bivalve
Polychaete
Bryozoan
Ascidian
Echinoid
Ophiuroid
Zoanthid

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.

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.

This activity is focused on the Benthic Realm. Because the deep Arctic Ocean is virtually unexplored, the first questions researchers want to investigate are pretty basic: what are the physical conditions of the Benthic Realm, what organisms make up the realm's biological communities, and how do these organisms obtain energy? Traditionally, investigations of benthic communities have used various mechanical devices (such as grabs, dredges, or cores) to obtain samples of sediments and living organisms. These devices often damage living specimens, and often miss some species entirely, since only a small fraction of the total habitat can actually be sampled, and some species are able to avoid the sampling device. To reduce these problems, researchers on the Arctic Ocean Expedition will use a deep-diving remotely-operated vehicle (ROV), known as ROPOS, to obtain photographs and video recordings of the study area. This ROV also has a variety of manipulator arms and sampling devices, so researchers will also be able to obtain specimens of organisms they see on video for further examination and identification.

When ecologists describe biological communities, they often refer to the idea of "diversity." This concept includes two components: variety (for example, the total number of species) and relative abundance (for example, the number of individuals in each species). Considering these two components, two communities could have 10 species and one hundred individuals, but if 90 individuals in one community belonged to a single species, that community would be less diverse than if there were 10 individuals in each species.

Learning Procedure

In this activity, students will analyze benthic sample data to draw inferences about community structure

and strategies used by individual species to obtain energy.

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"). You may want to mention that other marine systems (such as those in the vicinity of hydrothermal vents) are not dependent on photosynthesis for energy, but rely on chemosynthesis instead (see http://oceanexplorer.noaa.gov/explorations/02galapagos/galapagos.html and http://oceanexplorer.noaa.gov/explorations/02fire/welcome.html for lesson plans and background information on these systems).

2. Distribute copies of "Benthic Sampling Data Sheets," one data sheet for each student group. Explain that these data were obtained from four different areas in the Arctic Ocean, with three samples taken from each area. Be sure students understand that "silt" is relatively fine organic and mineral matter similar to ordinary dirt.

3. Have the students calculate the total average biomass for their three samples (by adding all of the biomass figures and dividing by three), and the percent of that total represented by each type of organism. Students should also research the feeding habits of the organisms found in their samples.

4. Have each group summarize their data for the entire class. Each group should state what organisms were present, the feeding habits of each type of organism, the relative abundance of each type of organism, the average total biomass for their site, the type of sediment found at the site, and the total organic carbon found in the sediment. Be sure students understand that total organic carbon is a measure of the food value or energy available to organisms that consume the sediment.

5. Lead a discussion to interpret the pooled results. Begin by asking what the relationship is between sediments and the types of organisms present at the sites. Students should realize that the sediments provide the primary source of energy (food) for the benthic communities, though they should also realize that carnivorous species will obtain their energy by eating other organisms. The physical form of the sediment has a major influence on the types of organisms present (for example, filter feeders, such as bivalves, are better suited to sites with fine silt, while animals such as amphipods that are adapted to grazing the surface of small particles are better suited to sites with sandy sediments). In addition, the total organic content of the sediments determines how many organisms can be supported (sites with higher organic content can support more animals).

   Ask the students to comment on the diversity of organisms at their sites. They should consider both the total quantity of organisms present (average total biomass) as well as the relative quantities of each type of organism present ("evenness"). They should realize that sites with higher potential food value (measured by total organic carbon) are likely to have more organisms (higher total biomass; Sites I and II). In addition, sites with a greater variety of sediment types (Sites I and III) provide feeding opportunities for a greater variety of organisms (so sites dominated by one type of sediment are more likely to be dominated by a few species particularly adapted to feeding on that type of sediment).

The BRIDGE Connection

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

The "Me" Connection

Have students write a short essay or prepare a brief oral presentation on how knowledge of unexplored biological communities might benefit them personally, and/or why they think this knowledge is (or is not) important. Ask students to share their thoughts with the rest of the class.

Connections to Other Subjects

English/Language Arts, Mathematics

Evaluation

Individual data summaries 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. Visit http://www.ropos.com to find out about the ROV being used to explore biological communities during the Arctic Ocean Expedition.

3. Investigate other Arctic Ocean exploration programs. Search for keywords "Shelf Basin Interactions" and "Canadian Arctic Shelf Exchange Study"

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

Grebmeier, J. M., H. M. Feder, and C. P. McRoy, 1989. Pelagic-benthic coupling on the shelf of the northern Bering and Chukchi Seas. II. Benthic community structure. Marine Ecology Progress Series 51:253-268. – Scientific journal article on which this activity is based

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

- Interdependence of organisms
- Matter, energy, and organization in living systems

For More Information

Paula Keener-Chavis, National Education Coordinator/Marine Biologist
NOAA Office of Exploration
Hollings Marine Laboratory
331 Fort Johnson Road, Charleston SC 29412
843.762.8818
843.762.8737 (fax)
paula.keener-chavis@noaa.gov

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Student Handout

Benthic Sampling Data Sheet
Site I

Species Group	Biomass (g/m^2) Sample 1	Sample 2	Sample 3
Ascidians	151	465	166
Bivalves	58	179	64
Polychaetes	55	170	61
Others	26	80	29

Sediment Analysis:

Silt & Clay	16%
Fine Sand	36%
Medium Sand	31%
Coarse Sand	17%
Total Organic Carbon	4.9 (mg carbon per g sediment)

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Benthic Sampling Data Sheet
Site II

Species Group	Biomass (g/m^2) Sample 1	Sample 2	Sample 3
Amphipods	261	182	123
Bivalves	275	192	130
Others	189	132	89

Sediment Analysis:

Silt & Clay	47%
Fine Sand	45%
Medium Sand	6%
Coarse Sand	2%
Total Organic Carbon	7.2 (mg carbon per g sediment)

Student Handout

Benthic Sampling Data Sheet
Site III

Species Group	Biomass (g/m^2)		
	Sample 1	Sample 2	Sample 3
Tunicates	94	198	17
Bivalves	23	49	4
Polychaetes	23	49	4
Others	55	115	10

Sediment Analysis:

Silt & Clay	42%
Fine Sand	35%
Medium Sand	13%
Coarse Sand	10%
Total Organic Carbon	2.1 (mg carbon per g sediment)

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Benthic Sampling Data Sheet
Site IV

Species Group	Biomass (g/m^2)		
	Sample 1	Sample 2	Sample 3
Amphipods	63	23	10
Bivalves	23	8	4
Polychaetes	22	8	4

Sediment Analysis:

Silt & Clay	11%
Fine Sand	10%
Medium Sand	67%
Coarse Sand	12%
Total Organic Carbon	1.2 (mg carbon per g sediment)