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2005 Hidden Ocean Expedition

Getting to the Bottom

Focus

Benthic communities in the Canada Basin

Grade Level

7-8 (Biology)

Focus Question

What organisms are characteristic of deep benthic communities in the Arctic Ocean, and what processes affect the species composition of these communities?

Learning Objectives

Students will be able to identify major taxa that are dominant in deep benthic communities of the Arctic Ocean.

Given distribution data for major taxa in different Arctic benthic communities, students will be able to identify patterns in the distribution of these taxa and infer plausible reasons for these patterns.

Materials

❒ Copies of "Canada Basin Benthic Samples, 2002," one copy for each student

Audio/Visual Materials

❒ None

Teaching Time

One or two 45-minute class periods, plus time for student analyses

Seating Arrangement

Classroom style

Maximum Number of Students

30

Key Words

Benthic community
Arctic Ocean
Canada Basin

Background Information

The Arctic Ocean is the most inaccessible and least-studied of all the Earth's major oceans. Although it is the smallest of the world's four ocean basins, the Arctic Ocean has a total area of about 14 million square kilometers (5.4 million square miles); roughly 1.5 times the size of the United States. The deepest parts of the Arctic Ocean (5,441 m; 17,850 ft), known as the Canada Basin, are particularly isolated and unexplored because of year-round ice cover. To a large extent, the Canada Basin is also geographically isolated by the largest continental shelf of any ocean (average depth about 50 meters) bordering Eurasia and North American. 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. This isolation makes it likely that unique species have evolved in the Canada Basin.

The 2002 NOAA Ocean Exploration expedition to the Arctic Ocean focused specifically on the biology and oceanography of the Canada Basin. These explorations included three distinct biological communities:

- The Sea-Ice Realm includes plants and animals that live on, in, and just under the ice that floats on the Ocean's surface;
- The Pelagic Realm includes organisms that live in the water column between the ocean surface and the bottom;
- The Benthic Realm is composed of organisms that live on the bottom, including sponges, bivalves, crustaceans, polychaete worms, sea anemones, bryozoans, tunicates, and ascidians.

These realms are linked in many ways, and food webs in each realm interact with those of the other realms.

Sea ice provides a complex habitat for many species that are called sympagic, which means "ice-associated." The ice 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 called "primary production"). 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. 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 production in the Arctic Ocean comes from single-celled algae that live near the ice-seawater junction. This interface is critical to the polar marine ecosystem, providing an energy source (food) for many organisms, as well as 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, as well as migration routes for polar bears. 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 called polynyas that contain their own communities of organisms. 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 2 m (6 ft).

When sea ice melts, more sunlight enters 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 pelagic organisms, including floating crustaceans and jellyfishes called zooplankton, which are 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. These animals, in turn, provide energy for bottom-feeding fishes, whales, and seals.

Exploration of the Arctic Ocean, especially the Canada Basin, has become increasingly urgent because the Arctic environment is changing at a dramatic rate. A 2004 report from the Arctic Council states that temperature in the Arctic is increasing at nearly twice the rate of increase as the rest of the world. One visible result is rapid loss of glaciers and sea ice. Less visible are the impacts on living organisms that depend upon glaciers and sea ice for their habitat. Loss of these habitats can also have direct effects on human communities. The Greenland Ice Sheet, for example, holds enough water to raise global sea levels by as much as 7 meters. Sea level increases at this magnitude would be sufficient to flood many coastal cities, including most of the city of London.

A key objective of the 2005 Hidden Ocean expedition is to make significant contributions to the Arctic Ocean Census of Marine Life, which is aimed at documenting present Arctic Ocean biodiversity throughout the Arctic region. This information is essential to monitoring the effects of Arctic climate change, since it provides the "baseline" that allows change to be detected and quantified. The deep benthic realm, in particular, has been poorly studied because of year-round sea ice and extreme depth (exceeding 3,000 meters in some places). The 2002 Hidden Ocean expedition made the first observations of deep benthic communities in the Canada Basin using a remotely operated vehicle, and also collected samples from these communities using a box corer. In this lesson, students will analyze some of these data and make general inferences about deep benthic communities in the Arctic Ocean.

Learning Procedure

1. To become more familiar with the Hidden Ocean expedition, you may want to visit the expedition's Web page (http://oceanexplorer.noaa.gov/explorations/05arctic/welcome.html) for an overview of the expedition and background essays. You should also review the "Deep Sea Benthos" essay from the 2002 Hidden Ocean expedition (http://oceanexplorer.noaa.gov/explorations/02arctic/background/benthos/benthos.html)

   This lesson assumes that students have a basic knowledge of major invertebrate groups. If students are not familiar with these groups, it will be necessary to provide an orientation to the overall morphology and feeding habits of the groups listed on the worksheet. Alternatively, students could be required to obtain this information as part of their assignment. The lesson plan "Meet the Arctic Benthos" (http://oceanexplorer.noaa.gov/explorations/02arctic/background/education/media/arctic_benthos.pdf) provides an introduction to major invertebrate groups of the benthic realm.

2. Briefly review the geography of the Arctic Ocean, highlighting the location of the Canada Basin and the activities of the Hidden Ocean expedition. Introduce the "three realms" of marine life in the Canada Basin. You may also want to briefly discuss Arctic climate change and why it is so important to gather information on species that presently inhabit the three realms as soon as possible.

3. Provide each student with a copy of "Canada Basin Benthic Samples, 2002." Tell students that their assignment is to analyze the data in Table 1 in a way that will allow them to answer the questions at the end of the worksheet.

4. Lead a discussion of students' answers to the worksheet questions.

   Data in Table 1 indicate a trend of declining total abundance with increasing water depth. A similar, but even more striking, trend is indicated for the relationship between total biomass and depth, with a difference of two to three orders of magnitude between the shallowest and deepest stations. Students may offer a variety of hypotheses to explain these trends, but the hint should lead toward a recognition that food becomes increasingly scarce with increasing depth. Invite students to infer the source of food for deep benthic animals. They should realize that the most likely sources are organic material produced at shallower depths in the water column above the benthic habitats, and material transported horizontally from other areas by ocean currents. In both cases, potential food materials are available to many other organisms before these materials reach the bottom. In a sense, at least some of the food available to deep benthic organisms has already been "picked over" by pelagic species, so what arrives at the bottom has either been missed or rejected by pelagic organisms. The fundamental point is that food availability is a primary limiting factor for benthic communities. An exception, of which some students may be aware, is the case of benthic communities whose primary source of nutrition is chemosynthetic production, such as is found in the vicinity of hydrothermal vents and methane seeps (see https://homes.bio.psu.edu/people/faculty/fisher/cold_seeps/ and http://library.thinkquest.org/18828/ for more information on these communities).

Polychaetes, nematodes, and crustacea are abundant in both deep and shallow benthic communities. Students should recognize that these organisms represent several different feeding strategies including deposit feeding, scavenging, and predation. Pogonophora were conspicuous members of shallower benthic communities, and together with sponges, cnidarians, and crinoids suggest that suspension feeding is a viable nutritional strategy in these habitats. Note that "scyphozoa" reported from stations AG and NW1 were not "jellyfish" but were polyp tubes resembling those of the polyp stage of scyphozoan medusae genus *Nausithoe*.

The fact that Station AG near the northern coast of Canada had the highest biomass should lead students to infer that food was less limited at this station than at other sample sites. They may also infer that this may be related to its proximity to the continental mainland, which could provide nutrients and food materials via runoff to the coastal ocean.

The BRIDGE Connection

www.vims.edu/bridge/polar.html

The "Me" Connection

When many people think of the Arctic (if they think of it at all) they envision a barren, hostile landscape that has little or no connection to their own lives. Have students write a brief essay defending or challenging this perception. In other words, why is the Arctic region personally important or unimportant?

Connections to Other Subjects

English/Language Arts, Geography

Evaluation

Student reports prepared in Learning Procedure Step 3 and group discussion in Step 4 provide opportunities for assessment.

Extensions

1. Have students visit http://oceanexplorer.noaa.gov/explorations/05arctic/welcome.html to keep up to date with the latest 2005 Hidden Ocean Expedition discoveries.
2. Visit http://oceanexplorer.noaa.gov/explorations/02arctic/background/education/media/arctic_lessonplans.html for more lesson plans and activities related to the 2002 Hidden Ocean expedition.

Resources

Bluhm, B. A., I. R, MacDonald, C. Debenham, and K. Iken. 2005. Macro- and megabenthic communities in the high Arctic Canada Basin: initial findings. Polar Biology 28: 218-231 – The technical journal article on which this lesson is based.

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.

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/regions/central/index-eng.htm — Web site 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
- Understandings about scientific inquiry

Content Standard C: Life Science

- Populations and ecosystems
- Diversity and adaptations of organisms

Content Standard F: Science in Personal and Social Perspectives

- Populations, resources and environments

For More Information

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Student Handout
Canada Basin Benthic Samples, 2002

Table 1
Number of individuals per 0.04 m²
(adapted from Bluhm *et al.*, 2005)

Taxon	Species	Station [water depth]					
		AG [640 m]	**AL7** [1,570 m]	**AL10** [3,250 m]	**NW5** [1,850 m]	**NW1** [800 m]	**NA5** [1,350 m]
Porifera	Polymastiid					1	
	Calcareous					1	
	Unidentified				1		
Cnidaria	Hydrozoa	1	3	1			
	Scyphozoa	9				25	
	Anthozoa		2		1		
Bryozoa				1	13		
Sipunculida		1			1		1
Nematoda		56	1	4	12	3	49
Mollusca	Bivalvia	15	2	2			
	Scaphopoda						4
Annelida	Polychaeta	50	14	3	92	42	128
Pogonophora		66	4		40	2	11
Echiurida		2					
Crustacea		47	15	2	16	11	83
Enteropneusta							2
Echinodermata		8					
Tunicata		1					1
Unidentified		13	2	2	4	9	2
Biomass		220	100	<1	55	170	50
(mg wet wt/0.04 m²)							

1. What relationship do these data suggest between water depth and total abundance (total number of individuals)?

2. What relationship do these data suggest between water depth and total biomass?

3. What is a plausible ecological explanation for the relationships you identified in questions 1 and 2? (Hint: consider how these organisms obtain their food)

4. Which organisms are most abundant in the deepest area sampled?

5. Which organisms are most abundant in the two shallowest areas sampled?

6. Station AG is located in the Amundsen Gulf near the northern coast of Canada. What is a plausible ecological explanation for the finding that this station had the highest biomass?