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2005 Hidden Ocean Expedition

Just Jelly

Focus
Water masses and gelatinous zooplankton in the Canada Basin

Grade Level
9-12 (Biology)

Focus Question
What are the common gelatinous zooplankton in the Canada Basin, and what is their ecological role?

Learning Objectives
Students will be able to compare and contrast the feeding strategies of at least three different types of gelatinous zooplankton.

Students will be able to explain why gelatinous zooplankton may function at several trophic levels within a marine food web.

Given information on the vertical distribution of temperature in a water column, students will be able to make inferences about potential influences on the distribution of planktonic species in the water column.

Materials
❒ Copies of "Observations on Gelatinous Zooplankton in the Canada Basin," one copy for each student

Audio/Visual Materials
❒ None

Teaching Time
One or two 45-minute class periods, plus time for student analysis

Seating Arrangement
Classroom style

Maximum Number of Students
30

Key Words
Pelagic realm
Benthic realm
Sea ice realm
Gelatinous zooplankton
Cnidaria
Ctenophora
Chaetognatha
Larvacea
Water mass
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 geographi-

cally isolated by the largest continental shelf of any ocean basin (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.

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.

The 2002 NOAA Ocean Exploration expedition to the Arctic Ocean focussed 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.

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.

A significant obstacle to understanding pelagic food webs is a general lack of knowledge about gelatinous zooplankton. This is particularly true for marine ecosystems of the Arctic Ocean. Gelatinous animals are found throughout Earth's oceans, yet relatively little is known about these animals compared to knowledge about planktonic crustaceans. The 2002 NOAA Arctic Exploration expedition focused specifically on this problem. In this lesson, students will analyze some of the data gathered by this expedition, and draw inferences about the role of gelatinous zooplankton Arctic marine ecosystems.

Learning Procedure

1. To become more familiar with the Hidden Ocean expedition, you may want to visit the expedition's webpage (http://oceanexplorer.noaa.gov/explorations/05arctic/welcome.html) for an overview of the expedition and background essays. You should also review the "Spineless Wonders" and "An ROV Dive" essays from the 2002 Arctic Exploration expedition (http://oceanexplorer.noaa.gov/explorations/02arctic/background/fauna/fauna.html and http://oceanexplorer.noaa.gov/explorations/02arctic/logs/aug31/aug31.html)

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

3. Provide each student with a copy of "Observations on Gelatinous Zooplankton in the Canada Basin." Tell students that their assignment is to analyze these data as necessary to answer the questions on the worksheet. Depending upon their knowledge of the invertebrate groups represented, students may also need to do some additional research to develop plausible answers to these questions. If students are not familiar with logarithmic graph scales, you may want to refer them to the tutorial at http://www.physics.uoguelph.ca/tutorials/GLP/ or copy these materials for student use.

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

   There are a variety of factors that may limit the vertical distribution of pelagic species, and it is plausible that one or more physical factors (e.g, temperature, salinity, pressure) may be limiting to any of these organisms. Students should also recognize, however, that all of these organisms are active predators, and are also confined to areas where they can find suitable prey. Animals that primarily consume herbivorous zooplankton may thus be confined to shallow water were light penetration is adequate for photosynthesis.

   Cnidarians, ctenophores, chaetognaths, and larvaceans have distinctly different feeding strategies: Cnidarians dangling tentacles armed with stinging cells (nematocysts or cnidocysts) that paralyze animals that blunder into the tentacles. Ctenophores have lobes or tentacles containing sticky cells (colloblasts) that adhere to prey organisms. Chaetognaths have a series of movable spines on their head which are used to capture food, and are more active hunters of prey organisms than the other groups. Larvaceans have a complex and highly efficient filtering apparatus that can capture particles as small as one micron. The ability to use very small particles of organic material may make the larvaceans less dependent upon particular types of prey organisms than the other three groups.

Since the groups of gelatinous zooplankton represented in the table employ a variety of feeding strategies, it is likely that they feed on a variety of materials that might include herbivores, secondary or tertiary carnivores, microscopic organisms, and particulate organic matter. These materials would inevitably be derived from several trophic levels, and for this reason it is likely that there would be corresponding differences in nitrogen isotope ratios.

The life cycle of many cnidarians, including Scyphozoa, includes a jellyfish-like stage (called a medusa) as well as an anemone-like stage (called a polyp). The Scyphozoan specimens in the core samples were the polyp stage of these cnidarians.

The are many hypotheses that might account for the temperature profile documented by data in Table 1. (See page 7).

Students' graphs of water temperature vs depth should indicate a minimum temperature at about 150 meters and a maximum temperature at about 500 meters. While there are many hypotheses that might account for the temperature profile documented by data in Table 1, the hint should lead students to consider the influence of the neighboring North Atlantic and North Pacific Oceans. The Canada Basin is generally regarded as a complex of several water masses. The upper 25 m known as the Mixed Zone consists of near-surface waters that are well-mixed with fairly uniform temperature, and are strongly influenced by sea water freezing and ice melting. Below the Mixed Zone, temperature increases to a depth of about 40 m where Pacific Waters show a a steady decrease to the minimum temperature at about 160 - 180 m. This minimum temperature marks the transition to the Atlantic Waters which enter the Arctic through the Fram Strait, causing temperature to increase to a maximum at about 400 m. Below 600 m the waters are considered to be uniquely Arctic, and there is little mixing below about 2,000 m . In the deepest areas of the Canada Basin below 2,400 m there is evidence of geothermal warming from Earth's core (see http://oceanexplorer.noaa.gov/explorations/02arctic/logs/mis_sum_physical/physical.html for more information). The existence of these distinct water masses could affect distribution of gelatinous zooplankton in several ways. The most obvious is temperature itself; predator or prey species with specific temperature requirements would be confined to those portions of the water column with suitable temperatures. Nutrient content might also vary in waters from different sources, which in turn influence primary production by phytoplankton and the production of herbivorous prey species for gelatinous predators. In addition, density differences between different water masses create convergences where these masses meet, and there are many examples of high densities of gelatinous species at these convergences.

The primary obstacle to detailed observations and research on gelatinous zooplankton has been the fragility of these species, and their transparency. Since these organisms were usually seen only as mangled "jelly" in sampling nets, or not seen at all, it is not surprising that information is scarce. What should be surprising, though, is that this absence of data led some to conclude that these species were unimportant in the food web. This is a good example of how applying new technology in unexplored areas can reveal key ecosystem components that have been previously ignored or not known at all.

The BRIDGE Connection

www.vims.edu/bridge/polar.html

The "Me" Connection

Have students write a brief essay describing an example of how new information about an organism or process that presently appears insignificant might reveal unexpected importance and personal relevance.

Connections to Other Subjects

English/Language Arts, Geography, Physical Science

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.

3. Visit http://jellieszone.com/ for more information about jellyfishes, including the deadly cubomedusae of Australia, as well as how jellyfish can be kept in aquaria (with a lot of work!).

Resources

Raskoff, K. A., J. E. Purcell, and R. R. Hopcroft. 2005. Gelatinous zooplankton of the Arctic Ocean: in situ observations under the ice. Polar Biology 28:207-217 – The technical journal article on which this lesson is based.

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 B: Physical Science
- Motions and forces

Content Standard C: Life Science
- Interdependence of organisms
- Matter, energy, and organization in living systems
- Behavior of organisms

Content Standard D: Earth and Space Science
- Energy in the Earth system

Content Standard E: Science and Technology
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives
- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

Content Standard G: History and Nature of Science
- Nature of scientific knowledge

For More Information

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Student Handout

Table 1
Observations on Gelatinous Zooplankton in the Canada Basin

Depth (M)	Temp. (°C)	Number of Individuals Observed: Hydromedusae	Scyphozoa	Siphonophora	Ctenophores	Chaetognaths	Larvacea
25	-0.9		12		120		
50	-0.2		22	4		4	3
100	-1.2						
150	-1.5					4	
200	-1.4					7	
250	-1.0			6			5
500	0.5	47		2			
750	0.2	15		13	3	15	11
1000	0.0	16					
1250	-0.3	49		16	5		6
1500	-0.4	4					
1750	-0.5						
2000	-0.4						
2250	-0.3						11
2500	-0.3						18

Student Handout

Questions based on Table 1:

1. With the exception of larvacea, all other groups of gelatinous zooplankton appear to be confined to one or two depth ranges. What factors might limit the depth range of these groups? Note that most of groups contain more than one species, so the range for a single species may be less than the range for the entire group.

2. What is different about larvacea that might account for their appearing over a wide depth range?

3. Compare and contrast the feedings strategies of cnidaria, chaetognatha, and larvacea.

4. Ratios of stable nitrogen isotopes in an animal's tissues can be used to determine the trophic level at which the animal is feeding. If nitrogen isotope data were available for the groups listed in the table, would you expect the ratios to be the same or different?

5. Core samples from deep bottom habitats contained specimens that were identified as Scyphozoa. Since the class Scyphozoa consists of the "true jellyfish," why were these specimens found in samples of benthic habitats?

6. Graph water temperature data with temperature on the y-axis. Use a logrithmic scale for the y-axis. At what depth does the minimum temperature occur? What is the depth at which the maximum temperature occurs? What causes this temperature distribution (Hint: Look at a map of the Arctic region and neighboring water masses)? How might this affect the distribution of gelatinous zooplankton?

7. Compared to other pelagic organisms, relatively little research has been done on gelatinous zooplankton, and until recently these organisms were considered to be unimportant to marine food webs. Why?