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2006 Tracking Narwhals in Greenland

The Ocean Unicorn

Focus
Biology and ecology of narwhals

Grade Level
5-6 (Life Science)

Focus Question
What are narwhals, and how are they being affected by changes in the Arctic climate?

Learning Objectives
Students will be able to describe key elements of the life history and ecology of narwhals, including overall morphology, preferred habitat, geographic range, and feeding habits.

Students will be able to identify and explain three possible explanations for the apparent decline in the size of narwhal populations.

Materials
❒ Copies of "Guidance Questions for Investigating the Life of Narwhals," one copy for each student or student group

Audio/Visual Materials
None

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

Seating Arrangement
Classroom style or groups of 3-4 students

Maximum Number of Students
30

Key Words
Narwhal
Arctic
Baffin Bay
Thermohaline circulation
Climate change

Background Information
Global climate is heavily influenced by the Earth's ocean. One of the most significant climatic influences results from the "deep ocean thermohaline circulation" (THC). This circulation is driven by changes in seawater density, and has a major influence on water movements between the Atlantic, Antarctic, Pacific, and Indian Oceans. The causes and effects of the THC are not fully known. But we do know that it affects almost all of the world's ocean and plays an important role in transporting dissolved oxygen and nutrients. For this reason, the deep ocean THC is often called the "global conveyor belt." We also know that the THC is at least partially responsible for the fact that countries in northwestern Europe (Britain and Scandinavia) are about 9°C warmer than other locations at similar latitudes.

In recent years, changes in the Arctic climate have led to growing concerns about the possible effects of these changes on the deep ocean THC. In the past 30 years, parts of Alaska and Eurasia have warmed by about six degrees Celsius. In the last 20 years, the extent of Arctic sea ice has

decreased by at least 5%, and in some areas, sea ice thickness has decreased by 40%. Dense water sinking in the North Atlantic Ocean is one of the principal forces that drives the circulation of the global conveyor belt (see "More About the Deep Ocean Thermohaline Circulation," below). Since an increase in freshwater inflow (such as from melting ice) or warmer temperatures in these areas would weaken the processes that cause seawater density to increase, these changes could also weaken the global conveyor belt.

Changes are being seen in Arctic regions where dense seawater formation occurs, but the significance of these changes is not yet clear. Although the Arctic as a whole is getting warmer, air and sea surface temperatures near western Greenland show a significant cooling trend, and sea ice concentrations in Baffin Bay have increased significantly since 1953. At the same time, deep (400 m and below) water temperatures in Baffin Bay are slowly increasing. Some of this warmer water flows into the Labrador Sea, which is one of the sources for the cold, dense water that drives the deep ocean THC. Because it is a global process, some scientists wonder whether the THC may be related in some way to other changes being seen in Earth's ocean. One such change is an apparent decline in net oceanic primary productivity; more than six percent globally in the last two decades (Gregg, et al., 2003). Nearly 70 percent of the decline occurred in high latitudes (above 30 degrees) in the North Pacific and North Atlantic Basins. These observations, coupled with very limited understanding of how the global ocean influences life on Earth, illustrate why many scientists believe that it is critical to learn more about about the deep ocean THC and how it is being affected by climate change—especially in the Arctic.

Profiles of salinity, temperature, and depth are among the most fundamental pieces of information used by biological and physical oceanographers, and are particularly relevant when studying movements of cold, dense water masses. But extreme cold, six-month nights, and ocean areas blocked by sea ice have prevented these kinds of measurements in many parts of the Arctic, particularly during winter. The Tracking Narwhals in Greenland Exploration plans to overcome these difficulties through an unusual partnership between humans and the narwhal whale.

One of the species likely to be affected by climate changes in the Arctic is the narwhal, a whale best known for its unicorn-like tusk. Narwhals spend their entire lives in the Arctic, and prefer habitats that are in or near sea ice. But increasing concentrations of sea ice may be "too much of a good thing" for narwhals, since they need some open water to survive. One of the largest populations of narwhals spends most of the winter in Baffin Bay, where they dive repeatedly to depths that exceed 1,500 m in search of food. The Tracking Narwhals in Greenland Exploration plans to enlist the help of narwhals to learn more about climate change in the Arctic and its impact on ocean ecosystems.

Instrument packages called "satellite tags" will be attached to narwhals to record temperature and depth as the whales dive for food. A transmitter in each tag will send the data to a satellite in polar orbit above Earth. Later, the data will be downloaded back to Earth to give scientists the first-ever information on deepwater winter temperatures in Baffin Bay. The purpose of the Tracking Narwhals in Greenland Exploration is to improve our understanding of climatic changes occurring in an offshore ecosystem of Baffin Bay, and how these changes may affect narwhal populations that are part of that ecosystem. Expedition activities are directed toward three objectives:

- To employ narwhals as oceanographic sampling platforms to collect temperature data from deep waters in Baffin Bay;
- To identify narwhals' response to movement of openings in pack ice; and
- To describe relationships between narwhal behavior and properties of the pack ice habitat.

In this lesson, students will learn about the basic biology of narwhals, and some of the ways in which climate change may be affecting these "ocean unicorns."

Learning Procedure

1. To prepare for this lesson, read the introductory essays for the Tracking Narwhals in Greenland Exploration at http://oceanexplorer.noaa.gov/explorations/06arctic/welcome.html. If students will not have access to the internet for research, you may want to make copies of selected reference materials listed under "Resources," or ensure that adequate materials are available in libraries that are available for student use.

2. Briefly review the concept of the deep ocean THC, highlighting the importance of cold, dense water formation in the Arctic. Briefly discuss students' ideas about how global climate change may be affecting the Arctic region. Be sure students realize that an "average temperature increase" does not mean that temperature is increasing everywhere, and that some parts of the Arctic (e.g., western Greenland and Baffin Bay) have been getting colder in recent decades. Introduce the Tracking Narwhals in Greenland Exploration. Have students discuss the difficulties of working in the Arctic region, especially during winter, and "brainstorm" ways in which these difficulties might be overcome. Briefly discuss how scientists plan to use narwhals as "partners" to collect information about winter oceanographic conditions in Baffin Bay.

3. Tell students that their assignment is to learn about the basic biology of narwhals. Provide each student or student group with a copy of "Guidance Questions for Investigating the Life of Narwhals." You may want to require that answers be submitted in several paragraphs (i.e., report format) or simply as short statements ("short answer" format). Depending upon time and resources available, you may also want to require students to include appropriate illustrations and/or a map locating the narwhals' geographic distribution.

4. Lead a discussion of students' answers to worksheet questions. The following points should be included:
   - Narwhals belong to the genus *Monodon* and the species *monoceros*.
   - Narwhals belong to the class Mammalia and the order Cetacea.
   - Male and female narwhals have two teeth, in the upper jaw. In most female narwhals, the teeth never erupt through the gum. In most males, the left tooth forms a long tusk. In rare cases, males may develop two tusks, and females may also develop one or two tusks.
   - The most widely accepted hypothesis for the function of the narwhal's tusk is that it is a secondary sexual characteristic, possibly involved with mating behavior or as a weapon in battles over possession of females.
   - Narwhals spend their entire lives in the Arctic.
   - Narwhals eat fish (including polar cod, Greenland halibut, flounder, salmon, and herring), cephalopods (squids and octopuses), and shrimp.
   - Narwhals can dive to depths of 1,500 m (4,900 ft) or more.
   - Narwhals need to come to the surface of the ocean periodically, because they are mammals and must surface to breathe air.
   - Narwhals seem to prefer deep water near loose pack ice. In the summer, they occupy deep bays and fjords in the Canadian High Arctic and Greenland. As winter approaches,

narwhals migrate into the pack ice of Baffin Bay, the northern Davis Strait, and adjacent waters.

- Normally, a female narwhal produces one calf at a time.
- Narwhals can live for 50 years or more.
- Narwhals have been traditionally hunted by by indigenous Arctic peoples who value them as a staple food (the skin is rich in vitamin C), as well as for their tusks (though international efforts to control the global ivory trade may have reduced tusk sales in recent years). Narwhal sinews may also be used as thread.
- Three possible reasons for the apparent decrease in narwhals are:
  - Hunting;
  - Increased competition for food, due to the development of an inshore fishery for Greenland halibut; and
  - Climate change (in contrast to the overall trend in the Arctic, sea ice in Baffin Bay has been increasing over the last several decades, increasing the risk of entrapment).

The Bridge Connection

www.vims.edu/bridge/ – Enter "greenhouse" in the "Search" box, then click "Search" to display entries on the Bridge Web site for global climate change and the greenhouse effect.

The "Me" Connection

Have students write a brief essay describing a hypothetical instance in which scientists partner with another species to conduct a scientific investigation about climate change.

Connections to Other Subjects

English/Language Arts, Geography, Physical Science

Assessment

Students' answers to worksheet questions and participation in class discussions provide opportunities for assessment.

Extensions

1. Visit http://oceanexplorer.noaa.gov/explorations/06arctic/welcome.html for daily logs and updates about discoveries being made by the Tracking Narwhals in Greenland Exploration.
2. Visit http://oceanography.geol.ucsb.edu/Ocean_Materials/Mini_Studies/Greenhouse_gases/Greenhouse_gases.html for more information and activities related to the greenhouse effect.

Resources

NOAA Learning Objects

http://www.learningdemo.com/noaa/ Click on the link to Lesson 8 - Ocean Currents.

Other Relevant Lesson Plans from the Ocean Exploration Program

Three Cold Realms

http://oceanexplorer.noaa.gov/explorations/05arctic/background/edu/media/arctic05_threecoldrealms.pdf
(5 pages, 267k) (from the Hidden Ocean, Arctic 2005 Expedition)

Focus – (Biology) Pelagic, benthic and sea ice realms

In this activity, students will be able to compare and contrast the pelagic, benthic and sea ice realms of the Arctic Ocean, name at least three organisms that are typical of each of these three realms, and explain how the pelagic, benthic and sea ice realms interact with each other.

The Big Burp: A Bad Day in the Paleocene

http://oceanexplorer.noaa.gov/explorations/03windows/background/education/media/03win_badday.pdf
(5 pages, 364k) (from the 2003 Windows to the Deep Expedition)

Focus: Global climate change and the Paleocene extinction (Earth Science)

In this activity, students will be able to describe the overall events that occurred during the Paleocene extinction event, describe the processes that are believed to result in global climate change, and infer how a global climate change event could have contributed to the Paleocene extinction event.

Polar Bear Panic!

http://oceanexplorer.noaa.gov/explorations/02arctic/background/education/media/arctic_polarbears.pdf
(8 pages, 476k) (from the 2002 Arctic Exploration Expedition)

Focus: Climate change in the Arctic Ocean

In this activity, students will be able to identify the three realms of the Arctic Ocean, and describe the relationships between these realms; graphically analyze data on sea ice cover in the Arctic Ocean, and recognize a trend in these data; discuss possible causes for observed trends in Arctic sea ice; and infer the potential impact of these trends on biological communities in the Arctic.

Life in the Crystal Palace

http://oceanexplorer.noaa.gov/explorations/02arctic/background/education/media/arctic_crystal.pdf
(6 pages, 464k) (from the 2002 Arctic Exploration Expedition)

Focus: Sea ice communities in the Arctic Ocean

Students will be able to identify major groups of organisms found in Arctic sea ice communities, describe major physical features of sea ice communities and 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 also 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.

Other Links and Resources

The web links below are verified at the time of publication, but over time, some links may change or become obsolete. Searching with key words may help to locate an updated site.

http://oceanexplorer.noaa.gov/explorations/06arctic/welcome.html – Follow the Tracking Narwhals in Greenland Exploration daily as documentaries and discoveries are posted each day for your classroom use.

http:nmml.afsc.noaa.gov/education/cetaceans/narwhal2.htm – General information on narwhals.

http://www.mi.mun.ca/mi-net/Fishdeve/cetace14.htm – Extensive information on narwhals.

http://www.narwhal-whales.com/narwhals-links.htm – Links to information about narwhals.

http://www.narwhal.info/ – Web site dedicated to gathering and sharing information about narwhals

http://www.nasa.gov/centers/goddard/news/topstory/2003/0815oceancarbon.html – "Ocean Plant Life Slows Down and Absorbs Less Carbon;" article about decreasing ocean primary productivity

http://www.nasa.gov/home/hqnews/2003/jun/HQ_03182_green_garden.html – "Global Garden Grows Greener;" article about increases in terrestrial primary productivity

Laidre, K. L. and M. P. Heide-Jørgensen. 2005. Winter feeding intensity of narwhals. Marine Mammal Science 21(1):45-57. http://faculty.washington.edu/klaidre/docs/LaidreandHJ_2005b.pdf

Laidre, K. L. and M. P. Heide-Jørgensen. 2005. Arctic sea ice trends and narwhal vulnerability. Biological Conservation 121:509-517. http://faculty.washington.edu/klaidre/docs/LaidreandHJ_2005a.pdf

Laidre, K. L., M. P. Heide-Jørgensen, M. L. Logsdon, R. C. Hobbs, P. Heagerty, R. Dietz, O. A. Jørgensen, and M. A. Treble. 2004. Seasonal habitat associations of narwhals in the high Arctic. Marine Biology 145:821-831. http://faculty.washington.edu/klaidre/docs/Laidreetal_2004c.pdf

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Heide-Jørgensen, M. P., R. Dietz, K. L. Laidre, P. Richard, J. Orr, and H. C. Schmidt. 2003. The migratory habits of narwhals. Canadian Journal of Zoology 81:1298-1305. http://faculty.washington.edu/klaidre/docs/HJetal_2003b.pdf

http://www.tyndall.ac.uk/publications/tyn_symp/arctic.pdf – Synopsis of a conference on "Climate Change, the Arctic and the United Kingdom: directions for future research;" 8 May 2002, University of East Anglia

http://www.arctic-council.org – Arctic Council Web site.

http://www.acia.uaf.edu – Web page for the Arctic Climate Impact Assessment secretariat

http://www.ngdc.noaa.gov/paleo/ctl/about4.html – "Overview of Climate Processes" from NOAA's Paleoclimatology Web site

http://www.uky.edu/KGS/education/geologictimescale.pdf and http://www.uky.edu/KGS/education/activities.html#time – Great resources on geological time and major events in Earth's history

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

- Structure and function in living systems
- Populations and ecosystems
- Diversity and adaptations of organisms

Content Standard E: Science and Technology

- Abilities of technological design
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

- Populations, resources, and environments
- Natural hazards
- Risks and benefits
- Science and technology in society

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 1.
The Earth has one big ocean with many features.

- *Fundamental Concept a.* The ocean is the dominant physical feature on our planet Earth— covering approximately 70% of the planet's surface. There is one ocean with many ocean basins, such as the North Pacific, South Pacific, North Atlantic, South Atlantic, Indian and Arctic.
- *Fundamental Concept c.* Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of the Earth's rotation (Coriolis effect), the Sun, and water density differences. The shape of ocean basins and adjacent land masses influence the path of circulation.

- *Fundamental Concept e.* Most of Earth's water (97%) is in the ocean. Seawater has unique properties: it is saline, its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is slightly basic. The salt in seawater comes from eroding land, volcanic emissions, reactions at the seafloor, and atmospheric deposition.

Essential Principle 3.
The ocean is a major influence on weather and climate.

- *Fundamental Concept a.* The ocean controls weather and climate by dominating the Earth's energy, water and carbon systems.
- *Fundamental Concept b.* The ocean absorbs much of the solar radiation reaching Earth. The ocean loses heat by evaporation. This heat loss drives atmospheric circulation when, after it is released into the atmosphere as water vapor, it condenses and forms rain. Condensation of water evaporated from warm seas provides the energy for hurricanes and cyclones.
- *Fundamental Concept f.* The ocean has had, and will continue to have, a significant influence on climate change by absorbing, storing, and moving heat, carbon and water.
- *Fundamental Concept g.* Changes in the ocean's circulation have produced large, abrupt changes in climate during the last 50,000 years.

Essential Principle 6.
The ocean and humans are inextricably interconnected.

- *Fundamental Concept g.* Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

Essential Principle 7.
The ocean is largely unexplored.

- *Fundamental Concept a.* The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.
- *Fundamental Concept b.* Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.
- *Fundamental Concept d.* New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.
- *Fundamental Concept f.* Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking.

Send Us Your Feedback

We value your feedback on this lesson. Please send your comments to:
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For More Information

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Student Handout
Guidance Questions for Investigating the Life of Narwhals
Teacher Answer Key

1. What are the genus and species names of narwhals?
   Monodon monoceros

2. Narwhals belong to which class and order?
   Class Mammalia, order Cetacea

3. How many teeth do male and female narwhals have?
   Two teeth. In most female narwhals, the teeth never erupt through the gum. In most males, the left tooth forms a long tusk. In rare cases, males may develop two tusks, and females may also develop one or two tusks.

4. What is the most widely accepted hypothesis for the function of the narwhal's tusk?
   It is a secondary sexual characteristic, possibly involved with mating behavior or as a weapon in battles over possession of females.

5. Narwhals spend what part of their lives in the Arctic?
   Narwhals spend their entire lives in the Arctic.

6. What do narwhals eat?
   Fish (including polar cod, Greenland halibut, flounder, salmon, herring), cephalopods (squids and octopuses), and shrimp

7. How deep can narwhals dive?
   1,500 m (4,900 ft) or more

8. Why do narwhals need to come to the surface of the ocean periodically?
   Since they are mammals, narwhals must surface periodically to breathe air.

9. Where do narwhals live during the summer? Where do they live during the winter?
   Narwhals seem to prefer deep water near loose pack ice. In the summer, they occupy deep bays and fjords in the Canadian High Arctic and Greenland. As winter approaches, narwhals migrate into the pack ice of Baffin Bay, the northern Davis Strait, and adjacent waters.

10. Normally, about how many offspring does a female narwhal produce at once?
    One

11. About how long can narwhals live?
    Narwhals live 50 years or more.

12. Why are narwhals hunted by indigenous Arctic people?
    Narwhals have been traditionally hunted by by indigenous Arctic peoples who value them as a staple food (the skin is rich in vitamin C), as well as for their tusks (though international efforts to control the global ivory trade may have reduced tusk sales in recent years).

13. The overall number of narwhals in the Arctic appears to be slowly decreasing. What are three possible reasons for this?
    - *Hunting;*
    - *Increased competition for food, due to the development of an inshore fishery for Greenland halibut; and*
    - *Climate change (in contrast to the overall trend in the Arctic, sea ice in Baffin Bay has been increasing over the last several decades, increasing the risk of entrapment)*

Student Handout

Guidance Questions for Investigating the Life of Narwhals

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