Section 9

Exploring Potential Human Impacts

Environmental Change

The history of the Earth is a story of change. The Earth and the living things that inhabit it are dynamic systems. Ecologists and geologists alike now recognize that change is a constant process. Sometimes change occurs on a time scale that makes it hard to recognize, taking place over millions of years. We also know that geologic changes may be instantaneous—the eruption of a volcano—or take place over a few thousand years like the end of the last Ice Age that changed our landscape and sea shores dramatically. Human induced change can also be relatively rapid and easily observable to humans. Urbanization, deforestation, desertification, introduction of alien species—all are examples of relatively rapid change caused by human actions. Hardest to study is change that involves both human and natural possible causes like global climate change. We can measure the inexorable increase in the greenhouse gas, carbon dioxide, in the atmosphere due largely to our dependence on fossil fuels, but cannot predict with absolute accuracy what its consequences will be. A meltdown of a major gas hydrate field could release massive amounts of the greenhouse gas, methane. The trigger could be natural or human induced. The impact might be immediate.

NOAA's Ocean Exploration Expeditions

This section focuses on those things over which humans have some control. NOAA's Ocean Exploration program includes both searches for new ocean resources and examination of the impact of past uses. Expeditions to several sites with deepwater corals looked at the results of trawl fishing. Work on the Hudson Canyon explored possible consequences of years of ocean sewage sludge dumping on the shelf. Trips to the Gulf of Mexico and in the South Atlantic Bight included exploring areas of methane hydrate deposits. The term exploration implies looking forward to new discoveries, but Ocean Exploration also seeks information on ecological changes—both human induced and natural—to explain the past on many expeditions.

Classroom Activities about Environmental Change in this Section

Several expeditions have a bioprospecting component —searching for new and unique biological compounds that may be of value in medicine or industry. The need to preserve unique species while looking for potential useful products is clearly demonstrated in the Ocean Exploration expeditions. *Seals, Corals and Dollars…* examines these issues as well as the management of endangered marine animals dependent on the deepwater coral communities.

Polar Bear Panic! uses long term data sets to ask questions about changes in the extent and thickness of Arctic ice. These are real data taken from published papers. Students practice graphing skills as well as data analysis. While no one is positive about the causes of observed changes, they may well have serious implications for polar bears that hunt and travel on the ice. This activity integrates the biology of a single species with climate change data.

Additional Activities on the OE Web Site or CD

Four additional potential human impact OE exercises found on the OE website or the OE CD are:

- *Down in the Dumps* focuses on ocean dumping from 2001 Deep East.
- *Is there Sewage in My Sample* from the 2002 Hudson Canyon Cruise.
- *Feeling Crabby?* looks at fisheries management from Exploring Alaska's Seamounts 2002.
- *The Puzzle of the Ice Age Americans* examines natu-

ral global climate change as the key to human occupation of the New World due to sea level changes from Submarine Ring of Fire 2002.

Lesson Plan 25

Seals, Corals and Dollars...

Focus
Ecological relationships and resource management of Hawaiian monk seals and precious corals

Focus Question
Do additional actions need to be taken to manage monk seals and precious coral resources in the Northwestern Hawaiian Islands?

Learning Objectives
Students will describe the ecological relationships between Hawaiian monk seals and deep-water precious corals.

Students will explain at least two different viewpoints on how monk seals and precious coral resources might be managed in the Northwestern Hawaiian Islands.

Students will list at least four reasons that Hawaiian monk seals are endangered.

Students will propose a management strategy for monk seals and precious coral resources and explain their rationale for selecting this strategy.

Materials
❒ Internet access or copies of pages from web sites listed in the Learning Procedure

Audio/visual Materials
None

Teaching Time
One 45-minute class period plus time for research and report preparation which may be done as homework

Seating Arrangement
Classroom-style or groups of four students

Key Words
Hawaiian monk seal
Precious coral
Endemic
Indigenous
Alien species
Endangered
Sustainable harvest

Background Information
Deepwater corals and the communities associated with them are the subject of several NOAA Ocean Explorations, including the Northwestern Hawaiian Islands expedition to the chain of small islands and atolls that stretches for more than 1,000 nautical miles (nm) northwest of the main Hawaiian Islands. While scientists have studied shallow portions of the area for many years using SCUBA, little is known about deeper habitats. A few explorations with deep-diving submersibles and remotely-operated vehicles (ROVs) have discovered new species as well as species previously unreported in Hawaiian waters. The possibility of discovering new species has commercial importance as well as scientific interest. Black corals and other precious corals have been harvested under Hawaiian government regulation for local artists who produce jewelry for sale to tourists. The concept is to provide expensive

handcrafted tourist items while supporting local artists. Additionally deepwater corals may be a source of biological products of use to medicine or industry. Bioprospecting for new compounds is a focus of many Ocean Exploration expeditions. See the Individual Species in the Deep Sea section for a discussion.

The Northwestern Hawaiian Islands are home to Hawaiian monk seals—one of two remaining monk seal species. The Caribbean monk seal was declared extinct in 1994. The Northwestern Islands may be an important seal feeding area. Seals appear to feed on fish that live among deep-water coral communities. These corals are also of interest—some because they are commercially valuable for jewelry and others for the unique natural product chemicals they produce. The 2002 Ocean Exploration Expedition to the Northwestern Hawaiian Islands studied the ecological relationships between monk seals and the deep-sea environments of the Northwestern Islands, as well as mapping the previously unexplored deep-sea regions around the islands, investigations of deepwater fishes, and exploration of deepwater habitats.

This activity focuses on management issues posed by an endangered species—the Hawaiian monk seal—that depends to an unknown extent upon deep-water habitats that have commercial value and are being considered for exploitation.

Learning Procedure

1. Introduce the location of the Northwestern Hawaiian Islands and point out some of the features that make this area important.

2. Challenge the student groups to prepare a report based on one of the following web pages containing information about monk seals and/or precious corals. Be sure students note the date their pages were posted!:
   a. http://leahi.kcc.hawaii.edu/~et/wlcurric/seals.html
   b. www.oar.noaa.gov/spotlite/archive/spot_corals.html
   c. www.soest.hawaii.edu/HURL/precious_corals.html
   d. www.planet-hawaii.com/environment/199wtch.htm
   e. http://www.greenhawaii.org/kelly/articles/2001/ Gold.html
   f. http://swfsc.nmfs.noaa.gov/western_pacific_ fishery_ manageme.htm

   Sites (c) and (f) are quite short, but contain links to other sites with more in-depth information.

3. Have each group present its report in the order given above. Lead a discussion of these reports, including the following:
   a. What is the distinction between endemic, indigenous, and alien species?
   b. What are the feeding and habitat preferences of Hawaiian monk seals?
   c. Why are Hawaiian monk seals endangered?
   d. Why are precious corals important? Students should identify commercial importance as well as the role of these corals in natural ecosystems.
   e. What groups have expressed views about the need to manage precious corals, and how do these views differ? Do any of them have a vested interest—that is, they are going to make money on them? Students should distinguish between management objectives directed toward a sustainable harvest of precious corals and bioprospecting and objectives directed toward maintaining the corals as a key habitat element for an endangered species.
   f. What options should be considered in developing management plans for monk seals and precious corals in the Northwestern Hawaiian Islands? Students should recognize that the interests of commercial exploitation and conservation are in potential conflict and that options range from “Do nothing” to “Ban all human interaction with these species.” Resource managers generally try to balance desired uses; however, the monk seals are protected by the U.S. Endangered Species Act as well as the Marine Mammal Protection

Act that limit management options.

g. What formal management measures have been taken to address concerns about monk seals and precious corals? Do students believe these measures are sufficient?

The BRIDGE Connection

www.vims.edu/bridge/pacific.html

The "Me" Connection

Have students write a short essay on why endangered species should or should not be protected, and how this might be of personal importance to their own lives.

Ask if any students have traveled in Hawaii and seen monk seals. They are relatively common at the U.S. Fish and Wildlife Service refuge on the north shore of Kawai where they can be viewed through binoculars.

Connection To Other Subjects

English/Language Arts, Social Studies

Evaluation

Develop a grading rubric that includes performance on the group research and report (Step #2) and participation in the overall discussion (Step #3). Alternatively, following the oral reports in Step #3, you may want to have students prepare individual written responses to the questions prior to discussing these questions with the entire class.

Extensions

Visit http://www.radiojerry.com/frigate/ for an "up close and personal" account of life on French Frigate Shoals and encounters with monk seals.

Resources

http://oceanexplorer.noaa.gov – NOAA's Ocean Exploration web site

http://leahi.kcc.hawaii.edu/~et/wlcurric/seals.html – Background information on monk seals

www.oar.noaa.gov/spotlite/archive/spot_corals.html – Article on precious corals

www.soest.hawaii.edu/HURL/precious_corals.html – Article on managing precious corals and monk seals

www.planet-hawaii.com/environment/199wtch.htm – Article on ecological relationship between monk seals and precious corals

http://www.greenhawaii.org/kelly/articles/2001/Gold.html – Article on the "new Hawaiian gold rush"

http://swfsc.nmfs.noaa.gov/western_pacific_fishery_manageme.htm – Press release on management measures adopted by the Western Pacific Fishery Management Council

http://www.radiojerry.com/frigate – Personal account of life on French Frigate Shoals and another perspective on the impact of human activities on local marine life

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

Content Standard F: Science in Personal and Social Perspectives
- Natural resources

Activity developed by Mel Goodwin, PhD, The Harmony Project, Charleston, SC

Lesson Plan 26

Polar Bear Panic!

Focus
Climate change in the Arctic Ocean

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

Learning Objectives
Students will graphically analyze data on sea ice cover in the Arctic Ocean and recognize a trend in these data.

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

Materials
❒ One *Polar Ice Data Sheet* per group
❒ Graph paper

Audio/visual Materials
None

Teaching Time
Two 45-minute class periods

Seating Arrangement
Groups of 4

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 or roughly 1.5 times the size of the United States. The Arctic Ocean is not explored easily. It is almost 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.

The Arctic Ocean 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 Siberian coast, 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 Arctic Ocean floor 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 because its isolation may have resulted in selection for unique life forms. The 2002 Arctic Ocean Exploration expedition studied this isolated area, giving us greater knowledge of the mysteries of this polar frontier.

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. Because only 50% of this ice melts in each summer, ice flows exist for many years, reaching a thickness of more than six ft. (2 m). Sea ice is riddled with a network of tunnels, called brine channels, ranging in size from microscopic to more than an inch in diameter. Diatoms and algae live in them, using energy from sunlight for photosynthesis. Bacteria and fungi also inhabit the channels. Together with diatoms and algae, they provide food for flatworms, crustaceans, and other tunnel dwellers. This community is called sympagic, meaning ice-associated. Partial sea ice melting during summer produces ponds on the ice surface that develop their own communities of organisms.

Melting ice releases organisms and nutrients to the ocean below the ice. The ocean's Pelagic Realm includes organisms that live in the water column between the ocean's surface and bottom. Melting ice also increases light entering the sea, allowing rapid algal growth 24 hours a day during the summer. These algae provide energy for zooplankton, drifting animals such as crustaceans and jellyfishes. Zooplankton are food for larger pelagic animals, including fish, squid, seals and whales. Polar bears live on the Sea-Ice Realm, but feed in the Pelagic Realm. They have to have ice on which to move out over the ocean to holes where they feed.

When pelagic organisms die, they settle to the ocean bottom as detritus, becoming food for Benthic Realm invertebrates. Sponges, bivalves, crustaceans, polychaete worms, sea anemones, bryozoans, tunicates, and ascidians are common in Arctic benthic communities. These animals provide energy for bottom-feeding fish, whales, and seals.

Most of our knowledge about Arctic Ocean biological communities comes from studies near the continental shelves. Very little research has been done on the sea ice, pelagic, and benthic realms in deeper water. These areas were the focus of the 2002 Arctic Ocean Expedition. Some scientists believe there is a particular urgency to understanding the Arctic Ocean: the polar ice is shrinking, and no one is sure why. One explanation is that this is part of short-term climate cycles like El Niño that bring warm air and Atlantic Ocean water into the region. Other scientists think increased greenhouse gases in the atmosphere may be causing long-term changes to the Arctic climate that will affect many species, including the polar bears that hunt on the sea ice.

Learning Procedure

In this activity, students analyze data from several sources to look for trends of change in the extent and thickness of Arctic Ocean sea ice. They then are asked to 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 food and energy for other organisms. Have the students prepare a diagram showing the groups of organisms you discuss, and how these groups are linked spatially and in the food chain

2. Distribute *Polar Ice Data Sheets* to each group. Assign one data set to each group. The students should average the numbers in the data set assigned to them. Then they should identify the range—the lowest and the highest numbers. They should plot each year on a graph that has the average as the location of the x-axis. The x-axis will be divided into years. The y-axis extends above and below the average just far enough to include the highest and lowest numbers with a scale that is expanded sufficiently for the students to read it easily. For example, the x-axis on the Northern Sea Ice table would range from 1970 to 1998 and the y-axis would range from a low of about 11.50 to a high of about 13 m sq km. Plotted points will fall around the average.

3. Have each group describe its graph. Copying each groups graph on overhead transparencies

would facilitate discussion and allow different data sets to be compared if the yearly scale is identical for each group. 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. The 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 human-induced greenhouse gas changes, or a combination of both.

For polar bears, loss of ice would be a disaster as they could no longer walk out onto the ice to hunt for seals.

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 prepare individual written interpretations of the pooled results before participating in a group discussion.

Extensions

Have students visit http://oceanexplorer.noaa.gov for the 2002 exploration of the deep Arctic Ocean, and to find out what organisms live in the three realms.

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

Have students do a web search for information on changes in distribution of polar ice in the southern hemisphere. There have been some major changes recently.

Have students research information on polar bears and their biology with emphasis on their time out on the ice. Also consider the difficulty in managing a species that ranges through several countries at the top of the world during their lives.

Resources

http://oceanexplorer.noaa.gov – The 2002 Arctic Ocean Expedition documentaries and discoveries.

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

Activity developed by Mel Goodwin, Ph.D., The Harmony Project, Charleston, SC

Student Handout

Polar Bear Ice Data

Year	Polar Ice Data Sheet #1 Northern Hemisphere Sea Ice (Source: Vinnikov et al., 1999) Sea Ice Extent (million km²)	Polar Ice Data Sheet #2 Northern Hemisphere Sea Ice (Source: Vinnikov et al., 1999) Sea Ice Extent (million km²)	Polar Ice Data Sheet #3 Arctic Ocean Multi-Year Sea Ice (Source: Johannessen et al., 1999) Sea Ice Extent (million km²)
1970	12.85	NA	NA
1971	12.76	NA	NA
1972	12.84	NA	NA
1973	12.41	NA	NA
1974	12.36	NA	NA
1975	12.10	NA	NA
1976	12.61	NA	NA
1977	12.41	NA	NA
1978	12.58	NA	NA
1979	12.37	12.15	4.4
1980	12.42	12.16	4.3
1981	12.24	11.99	4.25
1982	12.62	12.28	3.95
1983	12.48	12.19	4.1
1984	12.19	11.79	4.3
1985	12.28	11.81	4.05
1986	12.27	12.06	4.1
1987	12.54	12.08	4.15
1988	12.59	12.06	4.95
1989	12.37	11.85	4.2
1990	11.72	11.56	4.2
1991	11.85	11.63	3.5
1992	12.27	12.00	3.6
1993	12.08	11.80	3.85
1994	12.15	11.86	3.65
1995	11.62	11.36	3.75
1996	11.95	11.36	3.2
1997	11.89	11.39	4.55
1998	11.91	NA	3.9