Impact of Climate Change on Hawaiian Monk Seals
Activity 1: Mapping Deep-Sea Habitats

Region: Pacific Islands

Grade Level(s): 5-6, 7-8 (Earth Science)

Time Required: Two class periods (approximately 90 minutes)

Focus Questions:
- How can deep-sea areas of the Northwest Hawaiian Islands be mapped to facilitate their exploration with a manned submersible?

Learning Objectives:
- The students will be able to create a two-dimensional topographic map given bathymetric survey data.
- The students will be able to create a three-dimensional model of landforms from a two-dimensional topographic map.
- The students will be able to interpret two- and three-dimensional topographic data.

Materials:
(All data sheets available at:
http://oceanexplorer.noaa.gov/explorations/02hawaii/background/education/media/nwhi_mapping.pdf)
- Copies of "Loihi Submarine Volcano Bathymetric Data" – one for each student group
- Copies of "Bathymetric Data Reduction Sheet" – one for each student group
- Copies of "Appendix A Supplemental Data Sets" – one for each student group (optional)
- Tracing paper
- Pieces of foamcore display board – 7 for each student group (8 ½" x 11" x 5/32" thick or 11" x 17" x ¼" thick if students' maps are enlarged 200%)
- Glue (preferably spray type used for mounting photographs)
- Sharp scissors of X-Acto knives for cutting cardboard
- Exit slips (See References for information about exit slips)

Background:

- Coral reefs are abundant in the Northwestern Hawaiian Islands and protecta chain of small islands and atolls that stretches for more than 1,200 nautical miles (nm) northwest of the main Hawaiian Islands. While scientists have studied these shallow areas for many years, almost nothing is known about deeper ocean habitats below the range of SCUBA divers. Only a few explorations have been made with deep-diving submersibles and remotely-operated vehicles (ROVs), and these explorations have yielded discoveries of new species and species previously unreported in Hawaiian waters. Northwestern Hawaiian Islands are home to the Hawaiian monk seals, one of only two species of monk seals remaining in the world (the Caribbean monk seal was declared extinct in 2008; the other remaining species is the Mediterranean monk seal). Waters around the Northwestern Islands are an important feeding area for the seals, some of which appear to feed on fishes, octopus, and crustaceans that find shelter among colonies of deep-water corals. These corals are also of interest, because they include several species that are commercially valuable for jewelry. The possibility of discovering new coral and sponge species also has commercial importance as well as scientific interest, since some of these species may produce materials of importance to medicine or industry.

A major constraint to exploration of deep-water regions around the Northwestern Hawaiian Islands is the absence of accurate maps of the area. In fact, recent expeditions have found that some islands are not where they are supposed to be according to official nautical charts. Since underwater exploration time in submersibles is severely limited, every dive must be carefully planned to ensure that the submersible can go directly to places that are most likely to provide the information the scientists need. For this reason, underwater mapping is a top priority for the Ocean Exploration 2002 Northwestern Hawaiian Islands Expedition.

Scientists aboard the University of Hawaii's research vessel Kilo Moana will use multibeam swath bathymetry to create detailed pictures of the underwater topography around the Northwestern Hawaiian Islands. Multibeam swath bathymetry (also called "high-resolution multibeam mapping") uses a transducer (a sort of combination microphone/loudspeaker) mounted on the ship's hull to send out pulses of sound in a fan-shaped pattern below the ship, and then records sound reflected from the seafloor through a set of narrow receivers aimed at different angles on either side of the ship. This system collects high resolution water-depth data that can distinguish differences of less than a meter. The system also measures the amount of sound energy returned from the seafloor (called "backscatter"), which can help identify different materials (such as rock, sand, or mud) on the seafloor. The multibeam system is coupled to a global positioning system (GPS) that can pinpoint sea-floor locations within one meter. All data are collected in digital form, which allows them to be processed by computer to produce maps, three dimensional models, or even "fly-by" videos that simulate a trip across the area being mapped in a high-speed submersible! Topographic maps are one of the most common outputs from these systems. On these maps, areas with the same depth are connected by lines, so that mountains (or valleys) are shown as a series of concentric, irregular closed curves. Curves that are close together indicate steep topography, while curves that are farther apart show more gentle slopes.

Procedures/Instructional Strategies:

1. Introduce the location of the Northwestern Hawaiian Islands, and point out some of the features that make this area important (discussed above). Discuss the need for accurate maps in planning diving expeditions to deep-sea regions, and explain the general concept of multibeam swath bathymetry. You may need to review the basic idea of topographic maps if students are unfamiliar with these.

2. Break students into groups of four. Distribute copies of "Loihi Volcano Bathymetric Data" and "Bathymetric Data Reduction Sheet" to each student group. Tell the students that

the bathymetric data are part of a data set that was produced by a research vessel using multibeam bathymetry. Be sure students understand that each data point represents the depth of water below the research vessel when the vessel was at the location described by the grid coordinates. If you want to relate the grid to an actual map location, the lower left corner of grid cell 1,1 corresponds to latitude 18°-45'N, longitude 155°-20'W. Each grid cell interval corresponds to one minute of latitude or longitude. Note that for the purposes of this exercise, we are not dealing with all of the side-scan data, which would include more than a hundred additional depth readings in each grid cell, and would be much more difficult to process without computer analysis.

3. Have each group enter the depth readings from the bathymetric data sheet into the corresponding grid cells on the "Bathymetric Data Reduction Sheet." Next, have the students draw contour lines on the Data Reduction Sheet for depths of 1,000 m, 2,000 m, 3,000 m, and 4,000 m. Tell the students to assume that the depth reading was taken at the center of each grid cell (indicated on the Data Reduction Sheet by the light crossed diagonal lines). In most cases, students will have to interpolate the position of the contour lines; for example, if one grid cell has a depth reading of 2,800 m and an adjacent cell has a depth reading of 3,200 m, students should assume that the 3,000 m contour line passes halfway between the center points of the two cells. Once these three contour lines are drawn, have students draw intermediate contour lines at 500 m intervals (i.e., 1,500 m, 2,500 m, and 3,500 m). When students have completed their contour maps, have them make a master tracing, and seven photocopies. If you want them to make larger models, they can enlarge their master tracing on the photocopier.

4. Have the students mount each copy of their contour map onto a piece of cardboard. Be sure to use enough glue to cover the entire surface of the cardboard. Next, students should prepare the seven layers of their three dimensional model by cutting along the 4,000 m contour line on one mounted map, then cutting along the 3,500 m contour on the next mounted map, and so on until three layers have been cut out corresponding to each of the seven contour lines constructed on the Data Reduction Sheet. If students are using X-Acto knives, be sure to have a suitable backing (heavy cardboard, cutting board, etc.) to protect work surfaces.

5. Starting with the 4,000 m contour, carefully glue successive contours together to build the three-dimensional model of the volcano.

6. Using the models the students have produced, discuss the advantages of various locations on the volcano for diving missions. Flat regions are more likely to have accumulations of sediment, and will provide different habitats than very steep areas. On the other hand, steep areas obviously have a greater range of depths within a short distance, so these are better sites to study how depth influences the distribution of various species. Identify areas that are likely to offer a variety of habitat types within a short distance. These offer some of the best opportunities to get the most out of limited diving time.

7. Have the students compare their models with the bathymetric image of the Loihi volcano at http://www.oar.noaa.gov/spotlite/archive/spot_loihi.html. This image provides much more detail than the students' topographic maps because it includes thousands more data points. This sort of detailed mapping is only possible when computer analysis is available.

8. Have the students write a description of the Loihi volcano based on their model. Have them include geographic location (north-south-east-west directions and/or latitude and longitude), topography (steepness), and depth. Ask them to discuss the advantages and disadvantages of two-dimensional and three-dimensional topographic maps.

9. To evaluate the students, have them fill out the exit slip question before they leave:
- What is the relationship between habitat destruction and the population of Hawaiian monk seals?

10. Evaluate students answers based on the following criteria:

Check plus	Makes the correlation between habitat and monk seal population
Check	Has the right idea but needs some clarification
Check minus	Is not on the right track and needs assistance

11. The following day, pair students who received a "check plus" with those that received a "check minus" or "check" (sometimes "checks" may be paired with other "checks"). Give the students 5 minutes to discuss the question and revise their work.

Extensions:
- Have students write a first-hand account of an exploratory mission to the Loihi volcano, referring to topographic features revealed by their model.
- Have students visit http://oceanexplorer.noaa.gov to follow the progress of deep-sea mapping in the vicinity of the Northwestern Hawaiian Islands. Additional data sets for topographic map construction may be posted here as the Expedition proceeds.

National Science Education Standards:

Science as Inquiry

- Developing the abilities necessary to do scientific inquiry.

- Developing understandings about scientific inquiry.

Regulation and Behavior

- Behavior is one kind of response an organism can make to an internal or environmental stimulus. A behavioral response requires coordination and communication at many levels, including cells, organ systems, and whole organisms. Behavioral response is a set of actions determined in part by heredity and in part from experience.

- An organism's behavior evolves through adaptation to its environment. How a species moves, obtains food, reproduces, and responds to danger are based in the species' evolutionary history.

Populations and Ecosystems

- A population consists of all individuals of a species that occur together at a given place and time. All populations living together and the physical factors with which they interact compose an ecosystem.

- Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some micro-organisms are producers--they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem.

- For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs.

- The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem.

Diversity and Adaptations of Organisms

- Biological evolution accounts for the diversity of species developed through gradual processes over many generations. Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.

- Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival. Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on the earth no longer exist.

Earth Science – Structure of the Earth System

- Water, which covers the majority of the earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle". Water evaporates from the earth's surface, rises and cools as it moves to higher elevations, condenses as rain or snow, and falls to the surface where it collects in lakes, oceans, soil, and in rocks underground.

- Water is a solvent. As it passes through the water cycle it dissolves minerals and gases and carries them to the oceans.

- Clouds, formed by the condensation of water vapor, affect weather and climate.

- Global patterns of atmospheric movement influence local weather. Oceans have a major effect on climate, because water in the oceans holds a large amount of heat.

Physical Science

- The sun is a major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation.

Additional Resources:

- National Marine Sanctuary Maps
  http://sanctuaries.noaa.gov/pgallery/atlasmaps/nwhimnm.html
- Hawaiian Monk Seals
  http://www.earthtrust.org/wlcurric/seals.html
- Crittercam
  http://www.nationalgeographic.com/crittercam/
- NOAA Ocean Explorer
  http://oceanexplorer.noaa.gov
- Loihi Submarine Volcano
  http://www.oar.noaa.gov/spotlite/archive/spot_loihi.html
- Loihi Volcano
  http://www.soest.hawaii.edu/GG/HCV/loihi.html

References:

1. Mapping Deep-Sea Habitats Lesson Plan, NOAA
   http://oceanexplorer.noaa.gov/explorations/02hawaii/background/education/media/nwhi_mapping.pdf

2. Information About Exit Slips
   http://wblrd.sk.ca/~bestpractice/exit/resources.html

3. Article About Exit Slips
   http://www.education-world.com/a_curr/profdev/profdev091.shtml