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Northwestern Hawaiian Islands Exploration

Hawaiian Bowl!

Focus
Northwestern Hawaiian Islands Ocean Expedition

Grade Level
7-8 Life Science/Physical Science

Focus Question
What unusual or unique features characterize the Northwestern Hawaiian Islands and their associated deep-sea environments?

Learning Objectives
Students will be able to describe the movement of tectonic plates in the Hawaiian archipelago region.

Students will be able to describe how a combination of hotspot activity and tectonic plate movement could produce the arrangement of seamounts observed in the Hawaiian archipelago.

Students will be able to describe the importance and distinguishing features of precious corals.

Students will be able to discuss the reasons for the endangered status of the Hawaiian monk seal.

Students will be able to describe at least three preliminary findings from the 2002 Northwestern Hawaiian Islands Expedition.

Additional Information for Teachers of Deaf Students
In addition to the words listed as key words, the following words should be part of the vocabulary list.
Atoll
Nautical
SCUBA
Exploration
ROV
Coral

There are no formal signs in American Sign Language for any of these words and many are difficult to lipread. This entire activity may be used as a fun evaluation tool for the other Northwestern Hawaiian Islands Exploration lessons posted on the Ocean Explorer web site (http://oceanexplorer.noaa.gov). You can also use this activity with your students as a group project. You may want to take a class period or two and teach all of the material in the Background Information section first. You may also want to give the Background Information to your students as a handout and then ask the questions "Jeopardy-style."

Materials
- ❒ "Hawaiian Bowl! Question List"
- ❒ copies of essays and daily logs from the 2002 Ocean Exploration Expedition to the Northwestern Hawaiian Islands (download from http://oceanexplorer.noaa.gov)

Audio/Visual Materials
None

Teaching Time
One or two 45-minute class periods

Seating Arrangement
Groups of four or five students

Maximum Number of Students

32

Key Words

Tectonic plates
Lithosphere
Asthenosphere
Transform plate boundaries
Fault
Rift
Magma
Basalt
Subduction
Hotspot
Hawaiian monk seals
Northampton Seamounts
Pisces IV
Gold coral
Bamboo coral
Black coral
Spicule
Spongehead catshark

Background Information

Nearly 70% of all coral reefs in U.S. waters are found around the Northwestern Hawaiian Islands, a 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, 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 have led to the discovery of new species and species previously unreported in Hawaiian waters.

The islands of the Hawaiian archipelago were formed by a series of volcanic eruptions that began more than 80 million years ago. Volcanoes are often associated with movement of the tectonic plates that make up the Earth's crust. The outer shell of the Earth (called the lithosphere) consists of about a dozen large plates of rock (called tectonic plates) that move several centimeters per year relative to each other. These plates consist of a crust about 5 km thick, and the upper 60 - 75 km of the Earth's mantle. The plates that make up the lithosphere move on a hot flowing mantle layer called the asthenosphere, which is several hundred kilometers thick. Heat within the asthenosphere creates convection currents (similar to the currents that can be seen if food coloring is added to a heated container of water). These convection currents cause the tectonic plates to move. Plates may slide horizontally past each other at transform plate boundaries. The motion of the plates rubbing against each other sets up huge stresses that can cause portions of the rock to break, resulting in earthquakes. Places where these breaks occur are called faults. A well-known example of a transform plate boundary is the San Andreas fault in California.

Where tectonic plates move apart (for example, along the mid-ocean ridge in the middle of the Atlantic Ocean) a rift is formed, which allows magma (molten rock) to escape from deep within the Earth and harden into solid rock known as basalt. Where tectonic plates come together, one plate may descend beneath the other in a process called subduction, which generates high temperatures and pressures that can lead to explosive volcanic eruptions (such as the Mount St. Helens eruption which resulted from subduction of the Juan de Fuca tectonic plate beneath the North American tectonic plate). Volcanoes can also be formed at hotspots, which are thought to be natural pipelines to reservoirs of magma in the upper portion of the Earth's mantle. The Hawaiian islands are the result of volcanic activity associated with a hotspot that appears to deeply penetrate the mantle to the boundary between the mantle and the Earth's metallic core. The Hawaiian hotspot is presently located beneath the Big Island of Hawaii at the southeastern end of the archipelago.

The Pacific tectonic plate is presently moving over the asthenosphere toward the northwest at a rate of 5 to 10 cm per year. As the plate moves over the Hawaiian hotspot, magma periodically erupts to form volcanoes that become islands. The oldest

island is Kure at the northwestern end of the archipelago. The youngest is the Big Island of Hawaii at the southeastern end. Loihi, east of the Big Island, is the newest volcano in the chain and may eventually form another island. As the Pacific plate moves to the northwest, islands are carried farther away from the hot spot, and the crust cools and subsides. At the same time, erosion gradually shrinks the islands, and unless these is further volcanic activity (or a drop in sea level) the islands eventually submerge below the ocean surface. To the northwest of Kure, the Emperor Seamounts are the submerged remains of former islands that are even older than Kure.

Scientists recognize eight stages of growth and erosion in the islands of the Hawaiian archipelago:

1. **The deep submarine stage** begins with submarine eruptions, which eventually reach the ocean surface (Loihi is in this stage);
2. **The shallow submarine stage** features an above-water crater, which spouts lava from rifts on the side of the cone;
3. **The subaerial shield-building stage** begins with collapse of the highest point (summit) on the volcanic cone to form a caldera. The volcano continues to emit lava from the summit and from rifts in the side of the cone (Mauna Loa and Kilauea are in this stage);
4. **The post-caldera stage**, in which lava fills and overflows the caldera to form a rounded summit. While overall volcanic activity may slow down, significant lava flow still continues (the Kohala Mountains, Mauna Kea, and Hualalai are in this stage; Haleakala is also in this stage, even though the caldera is not filled and still has a crater shape);
5. **The erosional stage**, in which lava is no longer being added, and the volcanic cone is attacked by erosion from the ocean and rainfall. A sea bluff, deep valleys and sharp ridges are characteristic features of this stage (Kauai, Oahu, and portions of all the major Hawaiian Islands are in this stage);
6. **The stage of reef growth** occurs when volcanic mountains are eroded to the point that they are only rocks that barely break the ocean's surface. The volcanic island is slowly sinking at this stage, but it is often possible for a coral growth to keep pace with the sinking so that reefs can form (French Frigate Shoals is in this stage);
7. **The stage of post-erosional eruptions** is marked by minor renewal of volcanism through which a few small cones or lava flows may be formed (portions of West Maui are in this stage);
8. **The atoll stage** occurs when lava rock has been eroded below sea level, and only the coral reef remains at the surface (Pearl and Hermes Reef and Kure are in this stage).

The Northwestern Hawaiian Islands are regularly visited by Hawaiian monk seals, one of only two species of monk seals remaining in the world (the Caribbean monk seal was declared extinct in 1994). Waters around the Northwestern Islands may be an important feeding area for the seals, which appear to feed on fishes 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 species also has commercial importance as well as scientific interest, since some of these species may produce materials of importance to medicine or industry.

The 2002 Ocean Exploration Expedition to the Northwestern Hawaiian Islands included mapping the previously unexplored deep-sea regions around the islands; investigations of deepwater fishes and corals; exploration of deepwater habitats; and studies of ecological relationships between monk seals and the deepsea environments of the Northwestern Islands.

This activity focuses on the basic geological history of the Northwestern Hawaiian Islands and on preliminary findings from the 2002 Ocean Exploration Expedition.

Learning Procedure

1. Introduce the location of the Northwestern Hawaiian Islands, and point out some of the features that make this area important (discussed above). Describe how the island were formed, and explain the eight stages of growth and erosion. Be sure students understand how the interaction between movement of the Pacific tectonic plate and the Hawaiian hotspot has caused the Hawaiian islands to have the the form and distribution that we see today.

2. Distribute copies of summary logs and background essays to each student group. Explain that groups will compete against each other to answer a series of questions about the Northwestern Hawaiian Islands and the 2002 Ocean Exploration Expedition. The simplest way to play the game is to have each group attempt to answer a set number of questions, and to decide the winning group based on the number of correct answers. If a group answers a question incorrectly, you may want to allow other groups to attempt to answer it. You may also want to keep track of how long it takes each group to answer their question, and factor this into the scoring (for example, by dividing the total number of correct answers by the total time required to produce the answers; thus, the more time used, the lower the score).

3. Ask each group a minimum of five questions. Score according to one of the systems described in Step #2.

The BRIDGE Connection

www.vims.edu/bridge/pacific.html

The "Me" Connection

Have students write a short essay on what they think the most interesting activity or discovery was on the 2002 Ocean Exploration Expedition to the Northwestern Hawaiian Islands.

Connections to Other Subjects

English/Language Arts, Biology, Geography

Evaluation

Develop a grading rubric that includes individual participation and overall group success in the contest. You may also want to ask for individual written answers to additional questions to broaden the rubric.

Extensions

Visit http://explorers.bishopmuseum.org/nwhi/geoact.shtml for others activities relevant to the Northwestern Hawaiian Islands.

Resources

http://oceanexplorer.noaa.gov – The Ocean Expeditions website

http://www.soest.hawaii.edu/GGHCV/haw_formation.html – Hawaii Center for Volcanology website about the formation of the Hawaiian Islands

http://www.hawaiireef.noaa.gov/maps/maps.html – Information about the Northwestern Hawaiian Islands region

National Science Education Standards

Content Standard A: Science As Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard B: Physical Science

- Interactions of energy and matter

Content Standard C: Life Science

- Interdependence of organisms

Content Standard D: Earth and Space Science

- Origin and evolution of the Earth system

For More Information

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