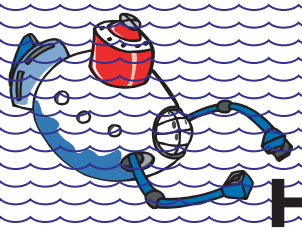

Hawaiian Bowl!

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

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

Hawaiian Bowl! Question List – Teacher's version

Question [answer; source]

1. The Northwestern Hawaiian Islands include more than 70% of all BLANK found in U.S. waters. [coral reefs; Activity Background Information]

2. Volcanoes are often associated with movement of the BLANK that make up the Earth's crust. [tectonic plates; Activity Background Information]

3. What is the name scientists use for the outer shell of the Earth? [lithosphere; Activity Background Information]

4. The plates of the Earth's crust move on a hot flowing mantle layer called the BLANK. [asthenosphere; Activity Background Information]

5. Heat within the Earth creates BLANK that cause the plates of the Earth's crust to move. [convection currents; Activity Background Information]

6. When the plates of the Earth's crust slide horizontally past each other, they form BLANK. [transform plate boundaries; Activity Background Information]

7. The motion of the Earth's plates rubbing against each other sets up huge stresses that can result in BLANK. [earthquakes; Activity Background Information]

8. Places where motion of the Earth's plates causes the rocks of the crust to break are called BLANK. [faults; Activity Background Information]

9. What geological structure is formed where the Earth's plates move apart (for example, along the mid-ocean ridge in the middle of the Atlantic Ocean)? [rift; Activity Background Information]

10. Molten rock from deep within the Earth is called BLANK. [magma; ; Activity Background Information]

11. Molten rock that escapes from deep within the Earth hardens into solid rock known as BLANK. [basalt; Activity Background Information]

12. Where tectonic plates come together, one plate may descend beneath the other in a process called BLANK. [subduction; Activity Background Information]

13. Natural pipelines to reservoirs of molten rock in the upper portion of the Earth's mantle are called BLANK. [hotspots; Activity Background Information]

14. What geological feature believed to be responsible for the formation of the Hawaiian islands is presently located beneath the Big Island of Hawaii? [the Hawaiian hotspot; Activity Background Information]

15. The oldest island in the Hawaiian archipelago is located at which end of the island chain? [northwestern; Activity Background Information]

16. BLANK are submerged remains of former islands at the northwestern end of the Hawaiian archipelago. [Emperor Seamounts; Activity Background Information]

17. The last stage in the growth and erosion of islands of the Hawaiian archipelago occurs when lava rock has been eroded below sea level, and only a BLANK remains at the sur-

face. [atoll or coral reef; Activity Background Information]

18. The Northwestern Hawaiian Islands are regularly visited by what endangered species? [Hawaiian monk seals; Activity Background Information]

19. How long can Hawaiian monk seals can remain submerged? [30 minutes; Log from September 17, 2002]

20. How deep can Hawaiian monk seals dive? [1,500 ft or more; Log from September 17, 2002]

21. Hawaiian monk seals like to feed in sand fields where they find what type of food? [flatfishes; Log from September 17, 2002]

22. Hawaiian monk seals like to feed in fields of whip coral where they find what type of food? [eels; Log from September 17, 2002]

23. The Northwestern Hawaiian Islands Expedition visited two submerged peaks that had never been explored before. What is the name of these peaks? [Northampton Seamounts; Log from September 18, 2002]

24. What is the name of the deep-diving submersible used by scientists on the Northwestern Hawaiian Islands Expedition? [Pisces IV; Log from September 18, 2002]

25. Before a manned submersible dive on the Northampton seamounts, preliminary explorations were conducted using what equipment? [a ROV and multibeam mapping equipment; Logs from September 17 and 18, 2002]

26. Why did scientists exploring the Northampton Seamounts hope that the steep slope would consist of hard substrate? [Because hard substrate provides good hiding places for fish and areas where corals can attach; Log from September 18, 2002]

27. During the first two dives on the Northampton Seamounts aboard Pisces IV, what did scientists observe about fish and corals in the depths where monk seals forage? [there were fewer fish and corals than scientists had expected; Log from September 20, 2002]

28. What unusual animals did scientists see in deep water near the Northampton Seamounts? [rare bathygadid fishes and what appears to be a colonial anemone attached to the shell of a hermit crab; Log from September 20, 2002]

29. What are two reasons that some scientists feel it is easier to survey fishes from a submersible? [you do not have to worry about your air running out, you do nott have to deploy and retrieve a tape to mark transects, and nothing can eat you; Log from September 21, 2002]

30. What seems to be the main reason for the lack of coral beds at the Northampton Seamounts? [sand covering the rocks; Log from September 22, 2002]

31. Gold coral is a parasite that grows on what other species? [bamboo coral; Log from September 22, 2002]

32. Why do scientists aboard the deep-diving submersible Pisces IV avoid drinking anything just before and during their dives? [because there is no bathroom on board; Log from September 22, 2002]

33. Scientists finally found a large bed of gold coral at the Northampton Seamounts, but ran into another problem that eventually forced them to end their dive earlier than planned.

What was this problem? [strong currents that, at one point, pinned the sub against an underwater cliff; Log from September 22, 2002]

34. What is the second largest ecosystem reserve in the world? [The Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve; essay on NWHI Coral Reef Ecosystem Reserve]

35. Reefbuilding hard coral produce an exoskeleton of what substance? [calcium carbonate; essay on Precious Corals]

36. Internal support for soft corals is provided by what structures? [spicules of calcium carbonate; essay on Precious Corals]

37. How does the support structure of precious corals differ from that of hard corals or soft corals? [precious corals secrete an endoskeleton made of calcite or protein or both, while hard corals have a calcium carbonate exoskeleton and soft corals contain calcium carbonate spicules that provide support; essay on Precious Corals]

38. Black and gold corals have endoskeletons composed of what material? [protein; essay on Precious Corals]

39. Which precious corals are bioluminescent? [gold and bamboo corals; essay on Precious Corals]

40. What destructive method for harvesting precious corals is now banned in the U.S.? [dragging nets over the seafloor; essay on Precious Corals]

41. How are precious corals important to others species? [they provide habitats for other invertebrates and fishes; essay on Precious Corals]

42. Name three causes for the decline of monk seals. [hunting, disturbance, loss of habitat, reduction in food resources, fishing interactions, disease, marine debris; essay on Monk Seals]

43. Are Hawaiian monk seals commonly found in groups? [no, they tend to be solitary; essay on Monk Seals]

44. Where are Hawaiian monk seals most often found? [in the Northwestern Hawaiian Islands, particularly around French Frigate Shoals; essay on Monk Seals]

45. When do monk seals leave the water? [when they are molting, birthing, or resting; essay on Monk Seals]

46. Name two common foods consumed by monk seals. [fish, octopus, and crustaceans; essay on Monk Seals]

47. What technologies are used to help study monk seals? [satellite transmitters and video cameras; essay on Monk Seals]

48. Which species of precious coral is found within SCUBA diving range? [black coral, Antipathidae; essay on Precious Corals]

49. What fish species was seen for the first time alive in its natural habitat near the Northampton Seamounts? [the spongehead catshark; Summary Log from September 22, 2002]

50. Greater coral abundance and size are related to what oceanographic conditions? [higher current flow; Summary Log from September 22, 2002]

Hawaiian Bowl! Question List

1. The Northwestern Hawaiian Islands include more than 70% of all _____found in U.S. waters.

2. Volcanoes are often associated with movement of the _____ that make up the Earth's crust.

3. What is the name scientists use for the outer shell of the Earth?
_____

4. The plates of the Earth's crust move on a hot flowing mantle layer called the _____.

5. Heat within the Earth creates _____that cause the plates of the Earth's crust to move.

6. When the plates of the Earth's crust slide horizontally past each other, they form _____.

7. The motion of the Earth's plates rubbing against each other sets up huge stresses that can result in _____.

8. Places where motion of the Earth's plates causes the rocks of the crust to break are called _____.

9. What geological structure is formed where the Earth's plates move apart (for example, along the mid-ocean ridge in the middle of the Atlantic Ocean)? _____

10. Molten rock from deep within the Earth is called _____.

11. Molten rock that escapes from deep within the Earth hardens into solid rock known as _____.

12. Where tectonic plates come together, one plate may descend beneath the other in a process called _____.

13. Natural pipelines to reservoirs of molten rock in the upper portion of the Earth's mantle are called _____.

14. What geological feature believed to be responsible for the formation of the Hawaiian islands is presently located beneath the Big Island of Hawaii? _____

15. The oldest island in the Hawaiian archipelago is located at which end of the island chain?
_____

16. _____ are submerged remains of former islands at the northwestern end of the Hawaiian archipelago.

17. The last stage in the growth and erosion of islands of the Hawaiian archipelago occurs when lava rock has been eroded below sea level, and only a _____ remains at the surface.

18. The Northwestern Hawaiian Islands are regularly visited by what endangered species?
_____

19. How long can Hawaiian monk seals remain submerged?
_____

20. How deep can Hawaiian monk seals dive? _____

21. Hawaiian monk seals like to feed in sand fields where they find what type of food? _____

22. Hawaiian monk seals like to feed in fields of whip coral where they find what type of food? _____

23. The Northwestern Hawaiian Islands Expedition visited two submerged peaks that had never been explored before. What is the name of these peaks?
_____

24. What is the name of the deep-diving submersible used by scientists on the Northwestern Hawaiian Islands Expedition? _____

25. Before a manned submersible dive on the Northampton seamounts, preliminary explorations were conducted using what equipment?_____
_____

26. Why did scientists exploring the Northampton Seamounts hope that the steep slope would consist of hard substrate? _____
_____
_____

27. During the first two dives on the Northampton Seamounts aboard Pisces IV, what did scientists observe

about fish and corals in the depths where monk seals forage?

_____
_____
_____

28. What unusual animals did scientists see in depth water near the Northampton Seamounts?

_____
_____
_____

29. What are two reasons that some scientists feel it is easier to survey fishes from a submersible?

_____
_____
_____
_____
_____
_____

30. What seems to be the main reason for the lack of coral beds at the Northampton Seamounts?

_____
_____
_____

31. Gold coral is a parasite that grows on what other species?

_____

32. Why do scientists aboard the deep-diving submersible Pisces IV avoid drinking anything just before and during their dives?

_____
_____

33. Scientists finally found a large bed of gold coral at the Northampton Seamounts, but ran into another problem that eventually forced them to end their dive earlier than planned. What was this problem?

_____
_____
_____

34. What is the second largest ecosystem reserve in the world?

_____
_____
_____

35. Reefbuilding hard coral produce an exoskeleton of what substance?

_____

36. Internal support for soft corals is provided by what structures?

_____
_____
_____

37. How does the support structure of precious corals differ from that of hard corals or soft corals?

_____
_____
_____
_____
_____
_____

38. Black and gold corals have endoskeletons composed of what material?

_____

39. Which precious corals are bioluminescent?

_____
_____

40. What destructive method for harvesting precious corals is now banned in the U.S.?

_____

41. How are precious corals important to others species?

_____
_____
_____

42. Name three causes for the decline of monk seals:

_____
_____
_____

43. Are Hawaiian monk seals commonly found in groups?

_____
_____

44. Where are Hawaiian monk seals most often found?

_____
_____
_____

45. When do monk seals leave the water?

_____
_____
_____

46. Name two common foods consumed

by monk seals

_____

_____

47. What technologies are used to help study monk seals?

_____

_____

48. Which species of precious coral is found within SCUBA diving range in the Northwestern Hawaiian Islands?

_____

_____

49. What fish species was seen for the first time alive in its natural habitat near the Northampton Seamounts?

_____

_____

50. Greater coral abundance and size are related to what oceanographic conditions?

_____

_____

Notes/Thoughts/Inspirations