Section 8

Community Ecology and Sampling

Sampling the Deep Ocean

Just as with the *Challenger* Expedition, modern Ocean Exploration requires complex planning, strong teamwork, and expensive use of ship time and technological equipment. Ocean exploration teams include technical staff that run the ship and keep the equipment functioning as well as scientists from a broad range of disciplines and levels of education and science educators. Each person has an important role, including the cook that feeds a crew working 24 hours a day.

Ecological Activities in this Section

Ship, submersible and ROV time is limited and expensive. When a mission objective includes the study of complex ecological communities like those of seamounts or deep vents, planning and effect use of equipment becomes even more critical. This section examines ecological studies of two biological communities—hydrothermal deep vents and seamounts. They are *Who Promised You a Rose Garden?* and *Biological Communities of Alaska Seamounts*. Each exercise asks questions about the distribution and abundance of species within the community as well as questions about change over time in relation to geological events. In other words, they are classical ecological studies. While doing these activities, your students will not only learn about the organisms within these communities, but also the ecological relationships among them and the impact of physical factors on distribution and abundance—both biotic and abiotic factors.

Sampling Activity in this Section

The third exercise—*Would You Like a Sample?*—is one of many OE activities that seek to model the difficult problems associated with getting representative samples that provide a true picture of the ocean floor and its inhabitants. The Arctic Ocean Exploration provided data for this exercise. Seasons when scientists can safely work at sea are limited especially in the Arctic. Ships, staff and equipment are expensive. Time underwater for submersibles is limited. ROVs can stay down longer, but still are limited by weather and length of expeditions. Your students will do the same kind of planning ocean scientists do before going on their expedition to study the Arctic benthos. This exercise requires extensive preparation the first time it is done, but then is ready to go for future classes. It is a model based on real species and real communities and challenges the students to design their own expedition.

Ocean Exploration

Ocean science has addressed these issues in recent years by concentrating funding on fixed, permanent arrays of instruments and drifting equipment packages. There are also powered unmanned mini subs that range the seas in a programmed pattern, surfacing periodically to radio back their observations. As useful as these are, nothing beats seeing what is there in person or by driving a ROV in response to images it returns to the ship. NOAA's Ocean Exploration program goes to new sites and enables humans to actually see what is there. It pushes back the ocean frontiers.

Where to Find Other Ecological and Community Activities on the OE Web Site or CD

Other ecological and sampling exercises on the Ocean Exploration web site or the OE CD include:

- *The Sea with No Shores* and *Reef Fish Real Estate* in the South Atlantic Bight from 2002 Islands in the Stream
- *Living with the Heat* from 2002 Submarine Ring of Fire
- *Breaking Away (Or Not..)* from Exploring Alaska's Seamounts 2002

- *Let's Get to the Bottom of the Arctic!*, *Life in the Crystal Palace*, and *Meet the Arctic Benthos* all from the 2002 Arctic Exploration
- *Hawaiian Bowl!* in the Northwest Hawaiian Islands Exploration

Exercises focused more on obtaining samples and designing sampling patterns are:
- *Living in Extreme Environments* from Deep East 2001
- *Designing Tools for Ocean Exploration* from Deep East 2001 and the 2002 Galapagos Rift Exploration
- *What on Earth is That, and How Can I Get One?* from Deep East 2001
- *Submersible Designer* from Galapagos Rift 2002

Lesson Plan 22

Who Promised You a Rose Garden?

Focus
Biological communities associated with hydrothermal vents along the Galapagos Rift

Focus Questions
What are the animals in the communities associated with deep hydrothermal vents?

Are the animals at vents evenly distributed?

Do vent communities change over time?

Learning Objectives
Students will conduct independent research to discover what types of organisms live near hydrothermal vents.

Students will interpret a map of the vent community associated with the Rose Garden at the Galapagos Rift.

Additional Information for Teachers of Deaf Students
The vocabulary words are integral to the unit but will be very difficult to introduce prior to the activity. They are really the material of the lesson. There are no formal signs in American Sign Language for any of these words and many are difficult to lipread. If some of this information has not already been covered in your class you may need to add an additonal class period to teach vocabulary and teach some of the background information to the students prior to the activity. Having the vocabulary list on the board as a reference during the lesson will be extremely helpful.

Materials
- ❒ Ocean map or overhead showing locations of spreading ridges and the Galapagos rift site pictures of hydrothermal vents and animals from web site http://www.divediscover.whoi.edu
- ❒ One *Student Research Sheet* per student
- ❒ One *Map of the Rose Garden* per group
- ❒ One *Student Inquiry Sheet* per student

Audio/visual Materials
- ❒ National Geographic/NOVA video or film *Dive to the Edge of Creation* if available
- ❒ Internet connection for student use

Teaching Time
Two 45-minute periods

Seating Arrangement
Individually or in groups of four

Key Words
Hydrothermal vent
Galapagos rift
Ocean ridges
Ocean plates
Mutualistic symbiosis
Plume
Distribution
Hydrothermal fluid
Dissolved
pH
Oases
Chemosynthesis
Colonize

Background Information

This activity builds on vent-related exercises and information found in the Ocean Geologic Features, Ocean Primary Production and Individual Species in the Deep Sea sections. The first part involves students in independent research to describe the unique animals that make up a thriving vent community—the Rose Garden. The second section enables students to use their mapping skills to describe some of the discoveries Dr. Hessler and his team of scientists made in 1985 as they explored the Rose Garden. Students should then compare this information with the findings from the 2002 Galapagos Rift Expedition and may also compare the Galapagos communities with those found at other sites at vents on mid-oceanic ridges in both the Pacific and the Atlantic Oceans.

Deep hydrothermal vents were found by using towed cameras off the Galapagos Islands in 1976. The following year an expedition returned with the submersible *Alvin*, enabling scientists to see newly discovered deepsea structures first hand. One of the best NGS/NOVA films ever made, *Dive to the Edge of Creation*, documented this amazing voyage of discovery. Scientists observed aqua-colored plumes of shimmering water rising from the seafloor—the first hydrothermal vents. Water heated inside the Earth's crust to as much as 400°C carries dissolved metals and other chemicals like hydrogen sulfide from deep beneath the ocean floor. This water, with a pH of 3 to 5, was venting from cracks near the mid-oceanic ridge opened by sea floor spreading along the rift.

What really startled scientists were areas around the vents that hosted thriving communities of animals—mini oases—on the relatively barren ocean floor. Since then hydrothermal vent community productivity has been found to rival that of salt marshes and coral reefs—highly productive communities. Bacteria using chemosynthesis thrive on hydrogen sulfide and synthesize sugars using energy from these chemicals. They are the base of the food chain in hydrothermal vent communities. Some of these bacteria are also thermophyllic, or heat loving, and can survive temperatures over 100°C. Many animals living in vent communities host mutualistic bacterial symbionts that synthesize sugars which are shared with their host while the host provides a safe refuge and a supply of substrate for the bacteria.

Scientists named these vent communities of tube-worms and other species. Among these names are "Rose Garden," "Garden of Eden," and "East of Eden." This activity includes student research and use of a map from the Rose Garden produced by Dr. Robert R. Hessler from Scripps Institution of Oceanography at the University of California, San Diego, in 1985.

Dr. Hessler and a scientific team revisited the Rose Garden first studied in 1979 on the Galapagos Rift in 1985. They collected data on the distribution and abundance of animals in this vent area. Their goal was to compare their observations with those made in 1979. Scientists towed a camera system that generated over 2,000 photographs, forming a complete picture of the Rose Garden.

Below are some of the organisms observed at the Rose Garden, so named because the red tube-worms remind scientists of roses in a garden. Since rifts extrude magma periodically, they are both highly dynamic sites, requiring adaptations to constantly changing conditions and excellent sites for invertebrates since they have hard, rocky substrates. Look for adaptations to both in these descriptions.

Giant tubeworms reach lengths of over six feet and grow attached to the substrate. They have a bright red plume filled with red blood at the end of a long white tube. This bright red plume functions as a gill and takes up sulfur, oxygen, and carbon dioxide from the water. They may retreat into their tubes if disturbed. Adults lack mouths, stomachs, and anuses. They have an odd-looking organ that fills most of the tube which houses sulfide-loving bacteria. Tubeworms provide sulfide to the bacteria and, in return, the bacteria produce sugars for the tubeworms in a mutualistic symbiotic relationship.

Giant tubeworms thrive in rapid vent flows. When the flow slows or stops, the giant tubeworms begin to die and are replaced or eaten by other organisms. Tubeworms are among the first animals to colonize a hydrothermal vent area. In 1979, the Rose Garden had tubeworms everywhere. In 1985 they were scarce. The difference is likely due to changes in the vent flow.

Mussels are early colonizers of a new vent site. They grow in clumps in seafloor cracks. Bacteria in their large, fleshy gills produce sugars from hydrogen sulfide, carbon dioxide and water. These bacteria release sugars to the mussels while the mussels provide refuge to the bacteria. This mutualistic symbiosis benefits both partners. Mussels also filter particulate food from sea water; so if hydrothermal fluid stops flowing, the mussels can survive for a short time.

Mussels attach to hard substrate with strong threads they secrete. They may shoot out the thread and then reel themselves into a new position. Movement allows the mussels to travel short distances to a higher vent flow in the dynamic vent area. Tubeworms are permanently attached. Crabs and shrimp eat mussels. In 1979 and 1985, mussels were abundant at the Rose Garden; in 1985, the mussel population seemed larger throughout the vent area.

Clams colonize hydrothermal vents after mussels become established. They have a big muscular foot that wedges into cracks. The foot also enables them to move. Like mussels, clams depend on the symbiotic bacteria in their gills. Crabs and octopi eat the clams. In 1979, clams were not present in the Rose Garden in large numbers. By 1985, there was a notable increase in the clam population at the Rose Garden.

Anemones are related to jellyfish and corals. They prey on other animals using stinging cells with nematocysts on their tentacles. At the Rose Garden, anemones were abundant in 1979 and in 1985. Anemones typically live farther away from the vent openings than tubeworms, mussels, and clams. Anemones, however, are found closer to vent openings than serpulid worms.

Serpulid worms build curly tubes of calcium carbonate. They are sometimes called featherduster worms because they collect tiny food particles with plume-like tentacles resembling an old-fashioned feather duster at the tube top. When disturbed, they withdraw into the tube. They form dense beds at vent field edges. Compared to tubeworms, mussels, clams, and anemones, serpulid worms live furthest from vent openings at the Rose Garden.

Bacteria are microbes found at hydrothermal vents. They are the primary producers of hydrothermal vent communities. They are chemoautotrophic, using energy from chemicals dissolved in water flowing out of vents to build sugars from carbon dioxide. Bacteria grow everywhere! Some bacteria live inside clams, tubeworms, and mussels in symbiotic relationships with these animals. Different bacterial species are adapted to specific water temperatures and use energy from different chemicals, including hydrogen, hydrogen sulfide, and iron. Scientists are intensely interested in these deepsea bacteria, both for research and for economic reasons. They use genetic techniques to identify new species and study their biochemical metabolism.

These are just a few of the organisms living near hydrothermal vents. Your students will find many more! These may include the squat lobsters, shrimp, octopus, so-called dandelions that are siphonophores related to jellyfish and zoarcid fish. The web sites and articles listed in the Resources section provide information for your students' literature search.

There are many factors that alter vent flow. Faulting at the spreading centers alters the shape and the distribution of the flow. Some new sites open, while others areas may stop flowing altogether. Some flow channels may clog up over time. Flow pattern changes create new vents. Others become extinct. Animals, like the giant tubeworms, that require high vent flow may suffer when vent flow is suddenly reduced. Other animals, like mussels and clams, rely on vent flow to support the bacteria living in their gills, but also filter feed in the absence of vent flow. As your students study the 1985 Rose Garden map, tell them that tubeworms were very abundant in 1979. What would account for fewer tubeworms in 1985?

Learning Procedure

1. Review the physical characteristics of hydrothermal vents, using pictures and maps to support your introduction.

2. Challenge your students to search for information on the animals associated with hydrothermal vents and the sources of food for these animals in this harsh environment. Have each group of students research three or more organisms from the list above that live along hydrothermal vents, using resources listed here. They should record their findings, including specific adaptations, on their *Student Research Sheets*. Give them a week to work independently.

3. The following week, discuss the biology of hydrothermal vents using student information from their searches. Use their pictures and string to create a vent food web on a bulletin board.

4. Lead a discussion of the organisms' adaptations, including a discussion of chemosynthesis as the source of primary production.

5. Give a *Rose Garden Map* to each group of students and review what the map represents and how the data were collected.

6. Provide an *Inquiry Sheet* to each student. If your students work more effectively in groups, then divide the class into teams of four to work together, but each student should write his/her own responses.

7. Provide 20 minutes for your students to complete the *Inquiry Sheet*. Then lead a discussion of their answers.

The BRIDGE Connection

www.vims.edu/bridge - Choose Ecology from the sidebar and go to the Deep Sea Link. There are numerous reviewed links to sites about hydrothermal vents.

The "Me" Connection

Ask students to consider how humans could ever harness and utilize the energy produced at hydrothermal vents.

Connection To Other Subjects

Biology, English/Language Arts

Evaluation

Have students write a "Home Wanted" ad for two hydrothermal vent organisms. Include a picture of the ideal home and a full description of those items the organism would need to find in its new home.

Extensions

Have your students visit http://oceanexplorer.noaa.gov/explorations/02galapagos/welcome.html and www.divediscover.whoi.edu for Galapagos Rift Expedition discoveries.

Have students create a 3-D model of a hydrothermal vent area.

Resources

http://oceanexplorer.noaa.gov/explorations/02galapagos/welcome.html and www.divediscover.whoi.edu -The 2002 Galapagos Rift Expedition daily documentaries and discoveries. A wealth of resource information is found at both of these sites.

http://www.nationalgeographic.com

http://www.whoi.edu/page.do?pid=8422

http://www.ocean.udel.edu/deepsea

http://life.bio.sunysb.edu/marinebio/hotvent.html

http://amnh.org/nationalcenter/expeditions/blacksmokers

http://www.pbs.org/wgbh/nova/abyss/life/extremes.html

http://www.ocean.washington.edu/exploraquarium/vent/intro.htm

http://www.pmel.noaa.gov/vents/

http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/oceanography_recently_revealed1.html

http://www.divediscover.whoi.edu/vents/video.html

Articles from past issues of *National Geographic Magazine*

Oases of Life in the Cold Abyss, October, 1977
Return to the Oases of the Deep, November, 1979
Light in the Abyss Reveals Life, November, 1994
Rebirth of a Deep-sea Vent, November, 1994
Life at the Bottom, May, 1998
Deep-sea Geysers of the Atlantic, October, 1992
Deep Sea Vents: Science at the Extreme, October, 2000
Rebirth of a Deep-Sea Vent, November, 1994
Deep-Sea Geysers of the Atlantic, October, 1992

Research paper on the Rose Garden

Hessler, Robert R. et. al. 1988. "Temporal change in megafauna at the Rose Garden hydrothermal vent." Deep-Sea Research, Vol. 35(10-11): 1681-1709.

Books

Van Dover, Cindy Lee. 1996. The Octopus's Garden: Hydrothermal Vents and Other Mysteries of the Deep Sea. Perseus Press.
Van Dover, Cindy Lee. 2000. The Ecology of Deep-Sea Hydrothermal Vents. Princeton University Press.
Woodman, Nancy. 1999. Sea-Fari Deep. National Geographic Books.

National Science Education Standards

Content Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard C: Life Science
- Structure and function in living systems
- Populations and ecosystems

Content Standard D: Earth and Space Science
- Structure of the Earth system

Activity developed by Stacia Fletcher, South Carolina Aquarium

Additional information for teachers of deaf students developed by Denise Monte, Teacher of the Deaf and Audiologist, American School for the Deaf, West Hartford, Connecticut

Student Handout

Student Research Sheet
Hydrothermal Vent Organisms

Name: ______________________________

Name of Organism: ______________________________

Drawing of Organism:

Description of Organism, including Adaptations for Survival:

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Student Handout

Student Inquiry Sheet

Name: ____

1. What animals did Dr. Hessler find at coordinates C,8?

    ____

2. What organisms are most abundant on the northern-most edge of the vent field?

    ____

3. Which animals are most abundant on the southern edge of the vent field?

    ____

4. Of the animals listed on the key, which do you think were least abundant at the Rose Garden in 1985?

    ____

5. Which two animals are found in similar locations?

    ____

    ____

6. If you were a hungry octopus looking for a mussel to eat, what is one set of coordinates where you could be sure to find a yummy meal?

    ____

7. How many meters across, from north to south, is the largest clump of tubeworms?

    ____

8. Why do you think the tubeworms can only be found in two small pockets along the hydrothermal vent in 1985 when they were much more abundant in 1979?

    ____

    ____

9. Why would scientists create a map like the one of the Rose Garden in 1985?

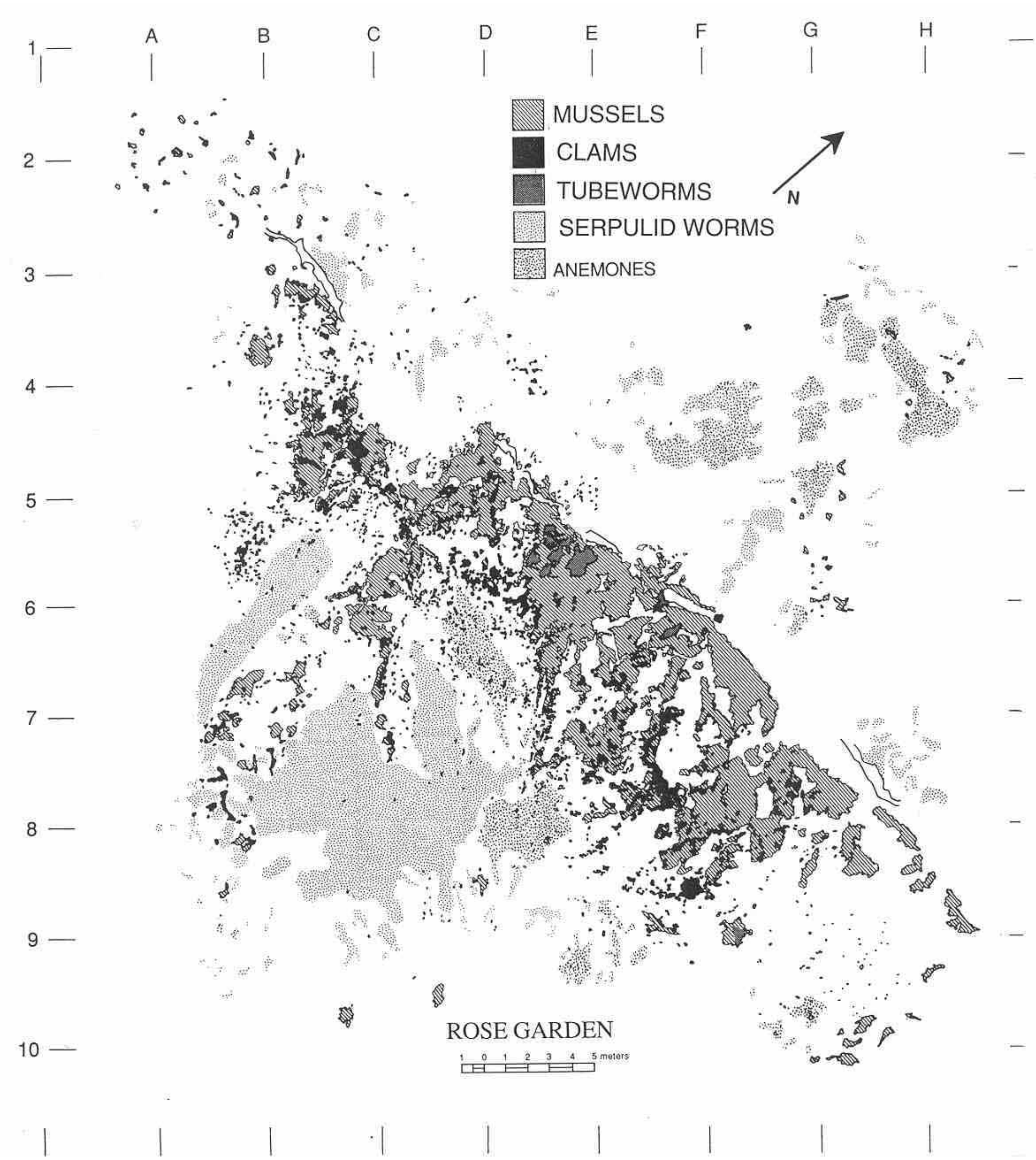
    ____

    ____

    ____

Student Handout

Map of the Rose Garden



Lesson Plan 23

Biological Communities of Alaska Seamounts

Focus

Biological community species composition on seamounts

Focus Question

What is the relationship between distance on a chain of seamounts and the community species composition of each seamount?

Learning Objectives

Students will infer why biological communities on seamounts are likely to contain unique or endemic species.

Students will calculate an index of similarity between two biological communities given species occurrence data.

Students will make inferences about reproductive strategies in species that are endemic to seamounts.

Students will explain the implications of endemic species on seamounts to the conservation and potential for the extinction of these species.

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:

Productivity
Habitats
Microbial
Invertebrates
Commercial trawl fishing
Deep-Sea coral reefs
The words listed as Key Words should be introduced prior to the activity. There are no formal signs in American Sign Language for any of these words and many are difficult to lipread. If some of this information has not already been covered in your class, you may need an additional class period to teach the vocabulary and some of the background information to the students prior to the activity. This will allow the students to make more meaningful comments on the data.

This is a very visual activity and represents the concept well to the students.

The "Me" Connection activity would provide an excellent evaluation for this lesson.

Materials

- ❒ One *Seamount Species Checklist* per group
- ❒ One *Gulf of Alaska Seamounts Map* per group
- ❒ One ruler per group

Audio/visual Materials

None

Teaching Time

One 45-minute period

Seating Arrangement

Groups of two to four students

Key Words

Seamount
Endemic
Extinction
Coefficient of community
Biological community

Background Information

Seamounts are undersea mountains that rise from the ocean floor, often to heights of 3,000 m (10,000 ft) or more. Compared to the surrounding ocean waters, seamounts have high biological productivity and provide habitats for a variety of plant, animal, and microbial species. Numerous seamounts occur in the Gulf of Alaska. Many exist in long chains that parallel the west coast. One of the longest, the Axial-Cobb-Eikelberg-Patton chain, was intensively studied by the Ocean Exploration 2002 Gulf of Alaska Expedition.

Because seamounts are often isolated from coasts as well as from each other, biologists expect to find new species when they visit unexplored seamounts. In fact, a single research cruise to explore Australian seamounts collected 259 invertebrate species, about a third of which were new to science, many of which probably occur only on seamounts in the region. Seamount communities are easily damaged by commercial trawl fishing that targets these species-rich areas. At the First International Symposium on Deep Sea Corals (August, 2000), scientists warned that more than half of the world's deep-sea coral reefs have been destroyed. Some believe that destruction of deep-sea corals by bottom trawlers is responsible for the decline of major fisheries, such as cod.

Seamounts in the Gulf of Alaska appear to be relatively undisturbed, but their biological inhabitants have not been thoroughly studied. They may have unique species found nowhere else. Describing biological communities on these seamounts was a major objective of the 2002 Gulf of Alaska Expedition. If they have unique species, what should be done to protect them from extinction? Are the biological communities on seamounts sufficiently similar that protecting one or two seamounts would be sufficient or is every seamount different? How similar are biological communities on Alaskan seamounts? Are they less similar as the distance between seamounts increases?

Learning Procedure

NOTE: This activity uses a hypothetical data set. These are real species that do live on Cobb Seamount, but their presence or absence on other seamounts has not been confirmed. The technique of comparing communities using the coefficient of community will apply to actual data from the Gulf of Alaska Expedition as this information becomes available.

1. Review the origin of seamounts using the Ocean Geologic Features section. Having completed other seamount exercises will improve student understanding of this activity.

2. Review seamount biology. You may let students explore the OE web site or CD to establish background knowledge. Although seamounts have not been extensively explored, expeditions to seamounts report many new species that appear to be endemic to a particular group of seamounts. Ecological studies of islands tells us that any isolated site provides the opportunity for the development of new species due to natural selection, the founder effect and genetic drift. Seamounts are effectively islands, they just have not broken the surface yet. They have all the same characteristics related to recruitment and migration that islands do except that their inhabitants come from other seamounts rather than from adjacent land.

3. The question for students is whether communities on seamounts that are far apart are less similar than those that are closer together. Does it appear that distance affects settlement rates?

4. Distribute the *Seamount Species Checklist* and *Gulf of Alaska Seamounts Map*. Assign each group one pair of the three seamounts for comparison. Students can calculate the coefficient of community for each pair of seamounts using this formula $C = 2a/(b + c)$, where C is the coefficient of community, a is the number of

species in common to both seamounts, b is the total number of species found on one of the seamounts, and c is the total number of species found on the other seamount. Students should also measure the distance between their seamounts.

5. Make a graph on the blackboard plotting the coefficient of community (y axis) against distance between seamounts (x axis). Have students put their results on the graph. Then ask them to describe the trend shown by the data: similarity decreases with increasing distance between seamounts. Lead a discussion of what these findings suggest about reproduction in seamount communities and about the implications of these findings to the danger of extinction. Students should recognize that the data suggest that juveniles or larvae of many species are not easily exchanged between seamounts and are either retained near the seamounts where they are produced or do not survive long trips between seamounts. This means that species endemic to particular seamounts are vulnerable to extinction. A relatively localized event could sweep away all individuals of these species, resulting in immediate extinction.

The BRIDGE Connection

http://web.vims.edu/bridge/ – Scroll over "Ocean Science Topics" in the menu on the left, then "Biology," then click "Biodiversity" for links about ocean communities

The "Me" Connection

Have students write a paragraph on why they should care about what happens to biological communities on seamounts or have groups of students debate this question.

Connection To Other Subjects

English/Language Arts, Geography, Mathematics

Evaluation

For individual evaluations, have students prepare written interpretations of the summarized data prior to leading a group discussion.

Extensions

Have students visit http://oceanexplorer.noaa.gov/explorations/explorations.html to look at all the seamount explorations, including 2002 Gulf of Alaska and Davidson as well as 2003 New England Seamount Expeditions. Compare findings from each.

Resources

http://oceanexplorer.noaa.gov/explorations/02alaska/welcome.html – 2002 Gulf of Alaska Expedition documentaries and discoveries.

http://www.marine-conservation.org.uk/seamounts.html – Web page about seamounts from the Marine Conservation Society

http://www.sciencegems.com/earth2.html – Science education resources

http://www.martindalecenter.com/ – References on just about everything

Paper on which this activity was based:

de Forges, B. R., J. A. Koslow, and G. C. B. Poore, 2000. Diversity and endemism of the benthic seamount fauna in the southwest Pacific. *Nature* 405:944-947.

National Science Education Standards

Content Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

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

Additional information for teachers of deaf students developed by Denise Monte, Teacher of the Deaf and Audiologist, American School for the Deaf, West Hartford, Connecticut

Student Handout

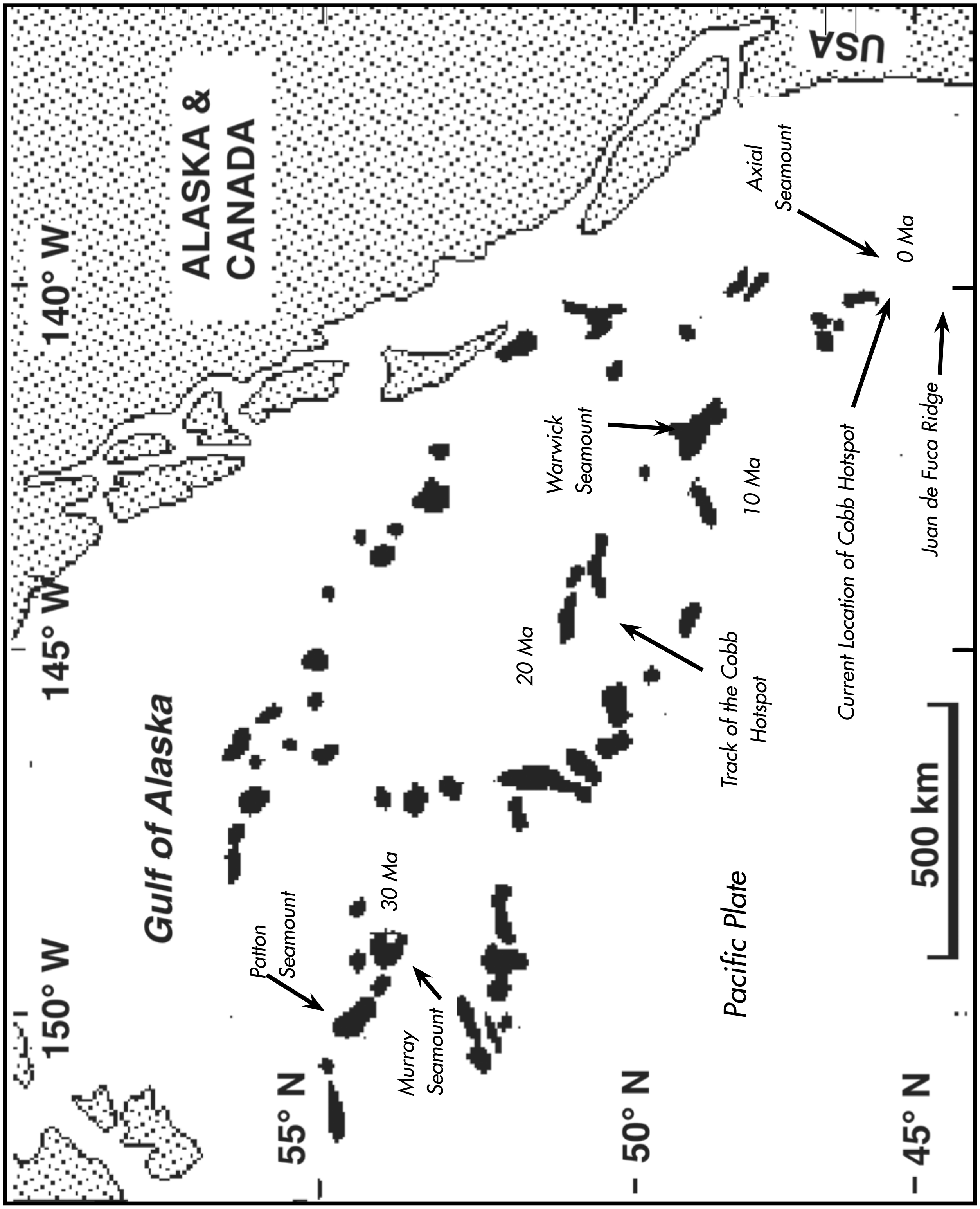
Seamount Species Checklist

(based on Parker and Tunnicliffe, 1994)

Phylum	Class	Species	Found on Seamount Axial	Found on Seamount Warwick	Found on Seamount Patton
Porifera	Desmospongiae	*Halichrondria panicea*	•		•
Cnidaria	Hydrozoa	*Allopora verrilli*		•	•
	Anthozoa	*Metridium senile*	•		
		Corynactis californica	•	•	•
Annelida	Polychaeta	*Crucigera zygophora*		•	•
		Northria conchylega	•	•	
		Phyllochaetopterus prolifica	•		
		Protula pacifica	•	•	•
		Lumbrineris inflata		•	
Arthropoda	Amphipoda	*Caprella alaskana*	•	•	
		Caprella laeviuscula	•		
		Proboloides sp.	•	•	•
		Micropleustes sp.			•
		Parapleustes sp.	•	•	
		Maera sp.	•	•	
	Isopoda	*Ianiropsis tridens*	•		•
		Munna uniquita	•	•	
		Munna chromatocephala	•	•	
	Tanaidacaea	*Leptochelia* sp.			•
		Paratanais sp.	•	•	
	Malacostraca	*Chorilia longipes*		•	•
		Oregonia gracilis	•	•	
Mollusca	Gastropoda	*Margarites marginatus*		•	•
		Calliostoma annulatum	•	•	
		Calliostoma ligatum		•	•
		Diodora aspera	•		
		Searlisia dira	•	•	•
		Granulina margaritula	•	•	
	Bivalvia	*Crassodoma gigantea*	•	•	•
		Macoma balthica		•	•
		Modiolus modiolus	•	•	
		Petricola pholadiformis	•	•	
Brachiopoda	Articulata	*Platidia hornii*	•		•
Bryozoa	Cyclostomata	*Bicrisia edwardsiana*			•
		Crisia occidentalis	•	•	
		Filicrisia franciscana	•	•	
	Cheilostomata	*Bugula* sp.			•
		Lyrula sp.	•		
Sipuncula		*Phascolosoma agassize*	•		
Echinodermata	Asteroidea	*Pycnopodia helianthiodes*			•
		Crossaster papposus	•	•	
		Henricia sanguinolenta	•	•	
		Henricia leviuscula	•		•
		Leptasterias hexactis	•	•	•
	Crinoidea	*Florometra serratissima*	•		
	Echinoidea	*Strongylocentrotus franciscanus*	•	•	

Student Handout

Student Handout:
Gulf of Alaska Seamount Map



http://geo.oregonstate.edu/~kellerr/GofAseamounts.html
College of Oceanic and Atmospheric Sciences, Oregon State University

Lesson Plan 24

Would You Like a Sample?

Focus
Designing and testing sampling strategies for biological communities

Focus Question
How well do biological samples represent the actual biological communities from which they are taken and how can their accuracy be improved?

Learning Objectives
Students will test the advantages and limitations of several sampling techniques to study biological communities.

Additional Information for Teachers of Deaf Students
In addition to the words listed as Key Words, the following word should be part of the vocabulary list:

Benthic

There are no formal signs in American Sign Language for any of the Key Words and many are difficult to lipread. Having the vocabulary list on the board as a reference during the lesson will be extremely helpful. Additional information regarding ROV's can be added and will enhance students' understanding of the potential limits and advantages of this technology.

Materials
- ❒ One large *Sampling Grid* per group – must use OE CD or web site to download grid pages 7- 26 from *Would You Like a Sample?*, grades 7-8, 2002 Arctic Ocean Exploration and prepare ahead of time
- ❒ One *Sampling Plan Sheet* per student
- ❒ One *Sampling Plan Data Sheet* per student
- ❒ A copy of the *Complete List of All Organisms in the Model Community* on an overhead transparency
- ❒ One copy of a random numbers table per group or pages from an old telephone directory
- ❒ One ream cardstock (110 lb paper)
- ❒ Large roll of invisible tape

Audio/visual Materials
- ❒ Overhead projector to facilitate discussion

Teaching Time
Two 45-minute class periods

Seating Arrangement
Groups of four or five students

Key Words
Transect
Quadrat
Grid
Random

Background Information
This exercise models data similar to that collected on benthic invertebrates on the 2002 Arctic Ocean Expedition. Details about the biology of the three communities studied on this expedition are found on the OE web site or the OE CD. This exercise is not about students learning about the organisms, but rather focuses on how scientists learn what they "know" and what uncertainties exist. It is a bit time-consuming to build the sampling boards, but once they are done, they may be used repeatedly with no prep time.

Ocean exploration is expensive and seasons in which expeditions are safe and possible are restricted. Nowhere is this more true than in the Arctic Ocean. It is almost entirely 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. All of these problems, plus remote location mean that biologists have to plan their sampling strategies very carefully to get the maximum data in the minimum amount of time with the best possible accuracy. Organisms found in the Benthic Realm of the Arctic Ocean include sponges, bivalves, crustaceans, polychaete worms, sea anemones, bryozoans, tunicates, and ascidians.

Researchers have developed systems for taking samples from a community. They then use these samples to draw conclusions about the community as a whole. There is always a question, though, of how well the samples represent the community. The situation becomes even more complicated when organisms are hidden under rocks or in sediment, or are very small, or very large, or very fast. Scientists used to take grab samples from the bottom with a clam-shell tool somewhat like a steam shovel head. But how do you decide where to make the grabs in the vast space available? New technologies, including remotely operated vehicles (ROVs), underwater video recorders, high resolution digital cameras, and side scan sonar were used by researchers on the Arctic Ocean Expedition to overcome some of the difficulties of sampling biological communities. Despite the new technology, the researchers know that some organisms went undetected.

Learning Procedure

In this activity, students use several common sampling techniques to investigate an unknown biological community. They then compare the strengths and weaknesses of these techniques in giving an accurate impression of the community's organisms.

1. Copy each page of grid cells enough times to make one complete set for each student group. Use heavy card stock copier paper – 110 lb paper works well in modern printers. Cut the margins from each page, leaving all 20 cells in the grid in one sheet. Arrange the sheets from one set face up in the order shown on the *Complete List of All Organisms*. There should be 4 rows of 5 cards. Using invisible tape, tape each row into a long sheet of 5 cards. Turn over and tape the seams on the back as well. These are folded for storage. You will have 4 rows of 5 cards per group. Ideally, this work would be done by parent volunteers under your supervision. Cell labeled "1,1" is in the lower left corner, and the cell labeled "20,20" is in the upper right corner.

2. You may have students research information on the species appearing here before doing this or they may already know a good bit about them.

3. Show the students the grid boards and demonstrate taking a sample by picking a square and recording the species found there. Ecologists seek to describe distribution and abundance of species. Your students are going to do the same thing for this model Arctic Ocean benthic community. How do they decide which ones to turn over?

4. Challenge your students to develop a sampling plan for this benthic community 10,000 feet deep the Arctic Ocean. Side scan sonar indicates that the area is almost completely flat, with no large rocks or other distinct features. Using precision mapping and global positioning equipment, the site has been divided into a grid of 400 squares. Give them the *Sample Plan Sheet* to show this. The plan is to send a ROV to collect video and actual samples, but sampling time is limited. Only 25 grid squares can be sampled from this site.

5. Lead a discussion with the students of how they might arrange their sampling program. One commonly used sampling system is to establish one

or more lines, called transects, across the study area and take samples at fixed intervals along the transect line. For visual surveys, these samples are often taken within a square area of fixed size, called a quadrat. In the case of our model community, individual quadrats are represented by the individual grid squares.

An alternative technique would be to collect randomly-selected samples throughout the community. To apply a random sampling system to the model community, each grid square is assigned a pair of coordinates beginning with 1,1 for the square in the lower left corner and ending with 20,20 for the square in the upper right corner, similar to coordinates on graph paper. Then grid squares to be sampled would be selected using a random number table, taking four at a time where the choices are 0 to 9. For example, if four numbers in the table were 1,3,0,7, the first square to be sampled would be 13 squares across and seven squares up. Coordinate pairs greater than 20,20 are skipped. A telephone directory can be substituted, using the last digit of each number on a page.

6. Have each student group select a sampling technique and diagram it on the *Sampling Plan Sheet,* selecting 25 squares. Try to have some groups use a random sampling system and others use a transect system.

7. Now hand out the sets of *Sampling Grids*. Have the students lay them out face up to form a large sheet oriented in the same way as the *Complete List of All Organisms.*

8. Hand out the *Sampling Plan Data Sheets*, discuss the abbreviations for the animal names and practice recording data from a grid.

9. Record the quadrat number and check off the species found for each of the 25 quadrats selected on the *Sampling Plan Data Sheet*. Then add up how many times each group was found. This gives some idea of abundance as well as distribution in the grid.

10. Have each group analyze its data to address the three questions listed in Step 11. Make a list of all the species groups found; this answers question (a). Next, tally the number of quadrats in which each group occurred. Classify groups as Abundant if they occurred in more than 50% of the samples, Common if more than 20% but less than 50%, and Rare if in less than 20% of the samples. This answers question (b). Finally, identify species groups that are commonly found together. One way to do this is to make a matrix, listing all species groups in vertical columns, and all species groups in horizontal rows. In each matrix cell, fill in the number of quadrats in which each species group was found with the other groups. This gives an answer to question (c).

	Group A	**Group B**	**Group C**	**Group D**	**etc.**
Group A	20	3	18	12	
Group B		15	5	10	
Group C			23	1	
Group D				14	
etc.					

11. Ask the students to discuss the following questions, using the data they have collected:
(a) What species groups are present in the model community—did they all get the same answers?
(b) What was the relative abundance of the groups?
(c) Which species groups tended to occur together? These associations give clues as to how different species groups may be interacting in the community.

12. Discuss the total number of species found, the relative abundance of each species, and which species appear together in more than three samples. Record these summaries on a marker board, flip chart, or overhead transparency. Lead a discussion comparing the results of the different techniques and speculate about what features of the model community might lead to the results they obtained. Organisms in nature are seldom distributed randomly. They are more often clumped, although territorial species may be over dispersed due to spacing mechanisms.

13. Compare the students' results with the *Complete List of All Organisms in the Model Community*. This sort of list is almost never available in actual research situations, but should show how difficult it is for a single sampling program to detect all of the species in a community. Be sure the students understand that they were able to sample 1/16th of the entire model community. Coverage with most real sampling programs is much less. How would they use their results to design a follow-up sampling program?

The BRIDGE Connection

www.vims.edu/bridge/polar.html
www.vims.edu/bridge/benthos.html

The "Me" Connection

Have students write a short essay or prepare a brief oral presentation on how knowledge of unexplored biological communities might benefit them personally, and/or why they think this knowledge is (or is not) important. Ask students to share their thoughts with the rest of the class.

Connection To Other Subjects

Mathematics, Earth Science, Physical Science

Evaluation

Individual sampling plans and data summaries prepared by each student group may be collected to assess the thoroughness of their work. Additionally, students may be asked to define key words and/or address discussion points in writing before participating in a group discussion.

Extensions

Have students visit http://oceanexplorer.noaa.gov/explorations/02arctic/welcome.html to see exploration of the deep Arctic Ocean.

Visit http://www.ropos.com to find out about the ROV used on the Arctic Ocean Expedition to explore biological communities.

Have students research species groups and present a brief report describing these groups.

Resources

http://oceanexplorer.noaa.gov/explorations/02arctic/welcome.html – The 2002 Arctic Ocean Expedition documentaries and discoveries.

http://www.sciencegems.com/earth2.html – Science education resources.

http://www.martindalecenter.com/ – References on just about everything.

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

- Populations and ecosystems

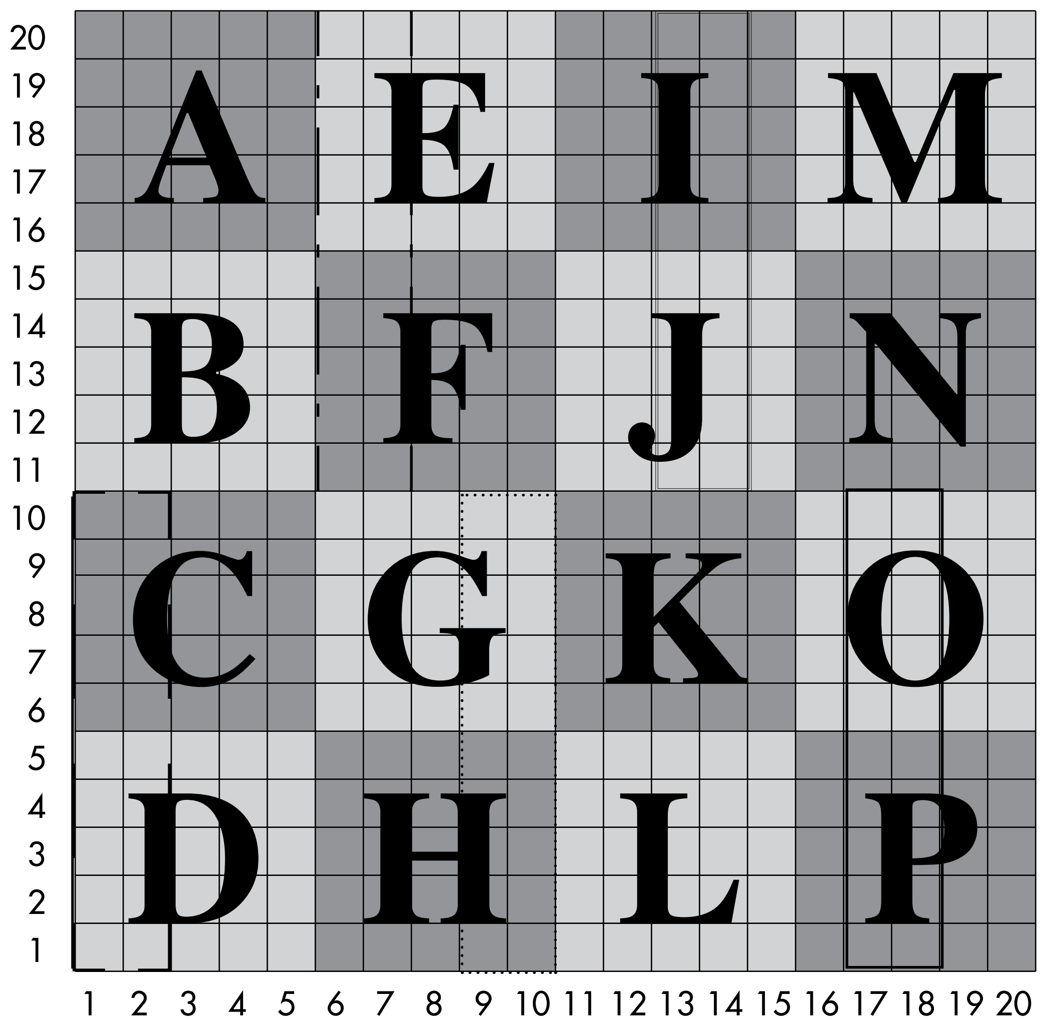
Activity developed by Mel Goodwin, PhD, The Harmony Project, Charleston, SC

Additional information for teachers of deaf students developed by Denise Monte, Teacher of the Deaf and Audiologist, American School for the Deaf, West Hartford, Connecticut

Student Handout

Complete List of All Organisms in the Model Community

All Quadrats in Columns 1 - 5 Contain:	All Quadrats in Columns 6 - 10 Contain:	All Quadrats in Columns 11 - 15 Contain:	All Quadrats in Columns 16 - 20 Contain:
Sand Dollars Sipunculids	**Sea Urchins Ascidians**	**Sand Dollars Sipunculids**	**Sea Urchins Ascidians**



All Quadrats in Rows 16 - 20 Contain: **Bivalves**

All Quadrats in Rows 11 - 15 Contain: **Bivalves**

All Quadrats in Rows 6 - 10 Contain: **Tunicates**

All Quadrats in Rows 1 - 5 Contain: **Tunicates**

The 25 quadrats labelled C, D, G, H, and L also contain **Brittle Stars** and **Sea Anemones.**
The 25 quadrats labelled D, H, L and P also contain **Snails.**
The 25 quadrats labelled C, G, K, and O also contain **Isopods.**
The 25 quadrats labelled A, B, E, F, and J also contain **Polyplacophora.**

These contain **Polychaetes** and **Amphipods.**

These contain **Bryozoans** and **Sea Cucumbers.**

These quadrats also contain **Cumaceans.**

These quadrats also contain **Priapulida.**

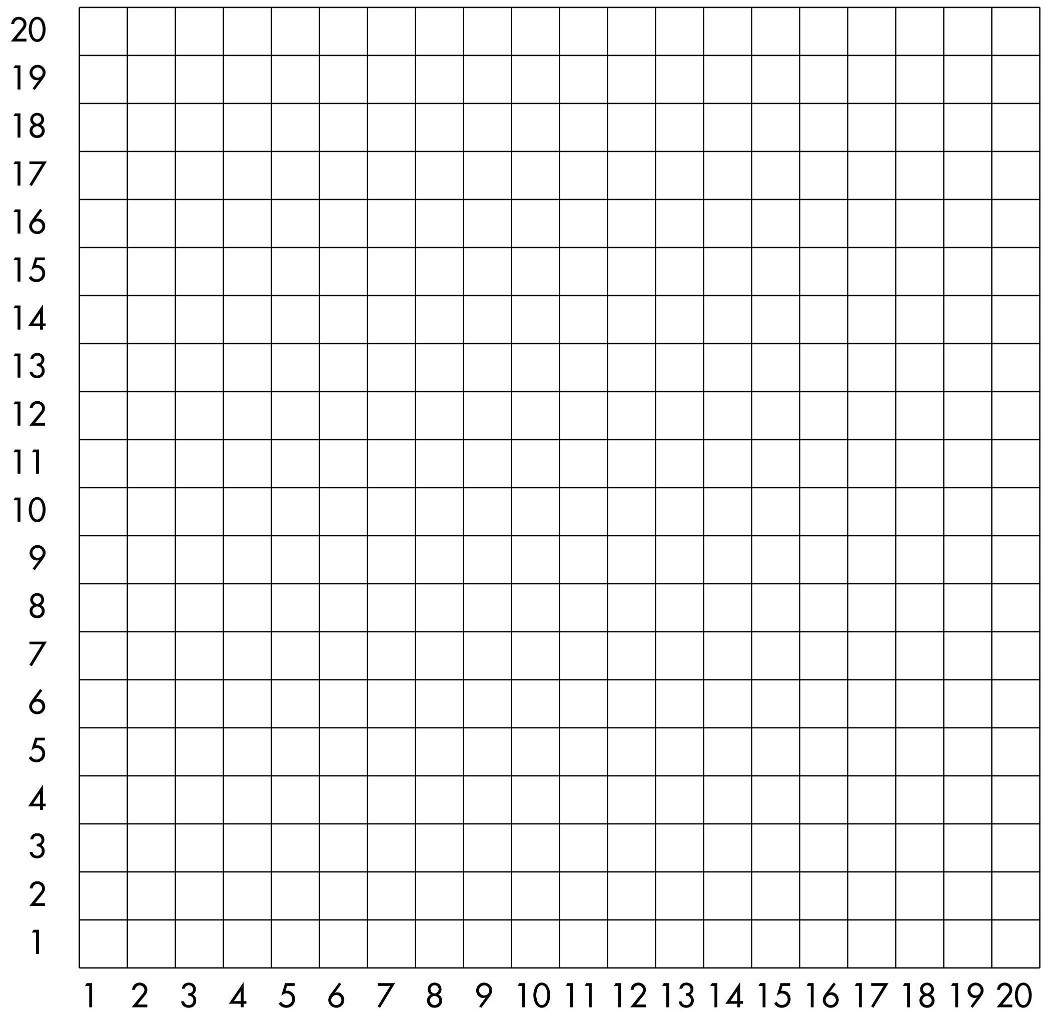
These quadrats also contain **Ectoprocta.**

These quadrats also contain **Nemertine Worms.**

Student Handout

Sampling Plan Sheet

Mark 25 quadrats to be sampled.



Student Handout

Sampling Plan Data Sheet

The columns are labeled with the first letter of each word; if there is one word, the first three letters are used except for PLC (polychaetes) and PLP (polyplacophorans)

Quadrat	AMP	ASC	BIV	BR	BS	CUM	ECT	ISO	NEM	PLC	PLP	PR	SA	SC	SD	SIP	SNA	SU	TUN
Total																			