Deep Sea Communities: Diversity of the Deep

A Classroom Activity for Ocean Gazing Episode #29: A 60-ton wakeup call

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Grade Level: 9-12

Lesson Time: 1.25 hr

Materials Required

Ridge Excel datasheet

Summary

Students calculate species richness, evenness and diversity for collections of deep sea organisms using data collected from the Juan de Fuca Ridge in the Pacific Ocean.

Objectives

- ✓ Describe hydrothermal vent habitats, chemosynthesis, and extremophiles.
- ✓ Recognize characteristics of a community and evaluate deep sea community biodiversity.
- ✓ Analyze and calculate indices of diversity in deep sea communities.

Vocabulary

Abiotic environment, Biotic environment, Diversity, Evenness, Richness, Species

Introduction

Do the words "deep sea creature" conjure up images of Jules Verne's giant octopus or even the recently caught colossal squid? In 1977, less than 30 years ago, scientists discovered communities of deep sea organisms that are very different from these giant monsters. While studying the ocean floor near the Galapagos Islands, scientists happened upon hydrothermal vents complete with their own assemblage of organisms living on or around them. One of the unique things about these communities is that food production is not based on energy from the sun, but on energy from within the earth. In an effort to learn more about this unique environment and the extreme organisms inhabiting it, the National Science Foundation established Ridge 2000, a research program that studies the links between the biology and geology of these ecosystems.

Typically, animals that live on the bottom of the ocean are small and sparsely distributed in thick sediment, but at mid-ocean ridges, many of the resident animals are large and cluster around cracks in the rocky substrate. Some of these cracks are on the ocean floor; others are along sides of walls or chimney-like structures. Percolating or diffusing from these cracks are heated fluids that have high concentrations of reduced chemicals and heavy metals. Areas where hot, mineral-rich fluids escape the seafloor are known as hydrothermal vents.

Hydrothermal vents are one of the most fascinating and challenging places to study ecology. The variation in temperature and chemistry in this environment makes it uninhabitable to most organisms; however, a unique assemblage of animals has been discovered to thrive here. Extremophiles like these organisms are able to survive under environmentally extreme conditions. The chemicals in the hydrothermal fluid react with the overlying ocean water, and bacteria use the energy from this chemical reaction to make food, in a process called chemosynthesis. The food that the bacteria make is eventually assimilated, or taken up, by all of the species at hydrothermal vents. Among the organisms that live in this extreme environment are tubeworms, polychaete worms, gastropods (limpets & snails), and pycnogonids (sea spiders).

Unlike areas of high species diversity like tropical rainforests and coral reefs, hydrothermal vents are typically described as having low species diversity. Although there are many organisms found at these vents (particularly in comparison to the bare rocks on the surrounding young sea floor), the number of different species is low and not all of the species coexist all of the time or in all areas. In the following data activity, we will use a number of methods to examine the species assemblages found at a hydrothermal vent.

Ecologists use statistics or indices to examine patterns in the different assemblages of organisms. A group of organisms that live in a particular area or have a similar lifestyle is often called a community. Some of the indices used by ecologists to characterize communities include species richness (the number of species), species evenness (the number of individuals per species), and species diversity (a combination of the species richness and evenness). The number of species in a community is always considered to be the species richness, however different scientists and mathematicians have used different formulae to calculate species evenness and diversity. The most common indices are Pielou's species evenness and Shannon-Wiener's species diversity. To understand how animal communities respond to the highly variable environment at hydrothermal vents, it is important to first determine the composition and the structure of the different types of communities, including the species richness, evenness and diversity.

Data Activity

Pre-Activity Discussion

An assemblage of organisms can be described as a community. Just as you might describe your community in your hometown, ecologists use statistics to characterize communities and track their changes over time and space.

- ✓ In general terms, how would you describe your community (or neighborhood) in your hometown? What kind of statistics or indices would you use to describe it?
- ✓ Does one household accurately represent the overall community?
- ✓ How does your community differ from another community in another town?
- ✓ How would your community change if a new company built a large factory in your town?

Hydrothermal Vent Organisms
(click here for the classification tree of these organisms)

Tubeworms	*Ridgeia piscesae*
Sessile Polychaetes (worms)	*Paralvinella palmiformis* *Paralvinella pandorae* *Paralvinella sulfincola* *Amphisamytha galapagensis*
Mobile Polychaetes (worms)	*Lepidonotopodium piscesae* *Branchinotogluma sandersi* *Branchinotogluma grasslei* *Branchinotogluma hessleri* *Opisthotrochopodus tunnicliffeae*
Gastropods (limpets & snails)	*Lepetordilus fucensis* *Depressigyra globulus* *Provanna variabilis*
Pycnogonids (sea spiders)	*Ammothea verenae*

Data Activity & Discussion
In September 1999, a deep-sea sampling device was used to collect five different assemblages of animals from one sulfide edifice in the Main Endeavour Field of the Endeavour Segment at the Juan de Fuca Ridge (NE Pacific Ocean). The samples were brought back to the lab, sorted by species, identified and counted. All of the different species and the number of individuals of each species are listed in an Excel table. Using these data, determine species richness, evenness and diversity for each of the five samples.

Divide the class into five groups and assign each group one of the collections. Using the steps below, have each group calculate species richness, evenness and diversity for their collection. Compare results for the five collections and answer the discussion questions.

Calculating Diversity
1. Access the Ridge Excel datasheet. For each sample there is a list of species and the abundance (number) of each species found. There are also three empty columns, for which we will calculate values that will be used to determine Shannon-Wiener's species diversity index (*H'*) and Pielou's species evenness (*J'*).
2. From Column A, count the total number of species for your collection. **This is the Species Richness (*S*)**. Enter this value in the cell for *S*. (Remember if the number of individuals found for a species is zero, then do not include this species in the total species count.)
3. From Column B, total the number of individuals for all species. Enter this value in the cell for **Total Number of Individuals (*N*)**.
4. For Column C, calculate the **Relative Abundance (P_i)** for each species and enter the values in the corresponding cells. To do this, take the number found for that species (Column B) and divide it by the Total Number of Individuals (*N*). Repeat for each species.
5. In Column D, take the natural logarithm of the Relative Abundance (Column C). Repeat for each species.
6. In Column E, multiply the Relative Abundance (Column C, before rounding) by the natural logarithm of Relative Abundance (Column D, before rounding). Repeat for each species.

7. Add all of the numbers in Column E and multiply by -1. This is the **Shannon-Wiener Index of Diversity (*H'*)**. Enter this value in the cell for *H'*.
8. Divide the Shannon-Wiener Index of Diversity (*H'*) by the natural logarithm of Species Richness (*S*). **This is the Pielou's Species Evenness (*J'*)**. Enter this value in the cell for *J'*. Compare your values to the answer sheet.

Discussion Questions

- ✓ Which sample had the highest species richness?
- ✓ Which sample had the highest species evenness?
- ✓ Which sample had the highest species diversity?
- ✓ What are the advantages and disadvantages of using species richness, evenness and diversity to describe the structure of different communities?
- ✓ Did the sample with the greatest number of species (species richness) also have the highest species diversity? Why not?
- ✓ Choose the two collections with the highest diversity, and plot relative abundance. Look at the top four dominant species. Are they the same in each collection? If not, what's different? Can you think of reasons why they would be different?

Data Source

Govenar, B.W., D.C. Bergquist, I.A. Urcuyo, J.T. Eckner & Fisher C.R. 2002. Three Ridgeia piscesae assemblages from a single Juan de Fuca Ridge sulphide edifice: structurally different and functionally similar. *Cahiers de Biologie Marine* 43:247-252.

Related Resources

General Marine Life, Biodiversity, Molluscs, Deep Sea

References

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Sarrazin, J., V. Robigou, S.K. Juniper, and J.R. Delaney. 1997. Biological and geological dynamics over four years on a high-temperature sulfide structure at the Juan de Fuca Ridge hydrothermal observatory. *Marine Ecology Progress Series* 153: 5-24.

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Ocean Gazing Podcast

The related podcast episode for this activity can be found by going to the podcast section of www.oceangazing.org