

Marine Biodiversity: Hydrothermal Vents

By Nathan Steeves
Grade Twelve
Bernice MacNaughton High School
Moncton, New Brunswick
January 13, 2004
Atlantic Canada Marine Biodiversity Essay Contest

It is remarkable that far below the surface of the water, on the ocean floor, where absolutely no sunlight reaches, in a place inconceivable of hosting any form of life, an assortment of organisms thrives on chemicals excreted from cracks in tectonic plates on the ocean floor. Hydrothermal vents are but one of many examples of marine biological diversity. Marine Biological Diversity, or Biodiversity, is “the variability among living organisms from marine ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.” (1)

Once governments all over the world realized how important biodiversity was, they came to the conclusion that something had to be done to improve the ways we use biological resources to benefit both current and future generations. At the 1992 Earth Summit in Rio de Janeiro, world leaders agreed on a comprehensive strategy for “sustainable development”. Sustainable development means “meeting our needs while ensuring that we leave a healthy and viable world for future generations.” (2)

One of the key agreements adopted at the Earth Summit was the Convention on Biological Diversity. The Convention established three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources. (2) In 1992, World Resources Institute released the *Global Biodiversity Strategy: Guidelines for Action to Save, Study, and Use Earth's Biotic Wealth Sustainably and Equitably*, a detailed strategy on how to conserve global biodiversity. This book took 3 years of intensive research involving more

than 45 partners and 500 individuals from all parts of the world. It was an integral part in shaping the legally binding Convention on Biological Diversity. During the Earth Summit in June 1992, the European Union and 156 signed the Convention on Biological Diversity, and as of October 1998, more than 170 countries had become Parties.

In signing the Convention on Biological Diversity, these governments agreed to accept the responsibility to protect and understand the abundance of species, genetic materials, habitats, and ecosystems that make up the natural world. They also agreed to help develop and maintain biological resources, to recognize each nation's authority over the biodiversity found in its territory, and to correct the imbalance between who benefits and who pays for protecting biodiversity.

Generally, there is considered to be three main categories of diversity of organisms, the first being genetic diversity, the second being species diversity and the third being ecosystem diversity. (1)

An organism's genetic diversity is "the variation in the amount of genetic information within and among individuals of a population, a species, an assemblage, or a community." (1) Genetic diversity is shown through the level of similarities and differences in the genetic makeup of individuals, populations and species. These similarities and differences may evolve as a result of many different processes. Even though genetic diversity is not always obvious, it is required so that organisms can evolve and adapt to changing environments.

Species diversity is “the variation in the number and frequency of species in a biological assemblage or community.” (1) The number of species or subspecies of plants, animals, and microorganisms usually measures the biodiversity of a particular environment. This is why species diversity is the most commonly used synonym for biodiversity, where the number of species in a given habitat is used to measure its biodiversity. The diversity of species is primarily important to the ecosystem functioning naturally; therefore, it is considered an indication of the health of an environment. It is estimated that the total number of species on earth is approximately 12.5 million, however the total number that could exist ranges from 50 to 100 million.

Ecosystem diversity is “the variation in the collection of assemblages, communities, and habitats within a region.” (1) An ecosystem is comprised of all living and non-living things in a particular area. Ecosystems include a combination of animals, plants, microorganism and physical characteristics that define the location. There are a number of new habitats that continue to be discovered and there may be more ecosystems waiting to be revealed. For example, in the ocean, hydrothermal vents were only discovered less than 25 years ago.

In 1977, the first ecosystem that did not rely on plant photosynthesis as its energy was discovered at the bottom of the ocean. This ecosystem was discovered close to deep-sea hydrothermal vents near the Galapagos Islands, a group of islands in the Pacific Ocean off the western coast of South America.

A hydrothermal vent is a hot spring on the ocean floor, where hot water laced with chemical compounds, such as hydrogen sulfide, called hydrothermal fluid is secreted from cracks in the Earth's crust where tectonic plates are spreading apart. Most hydrothermal vents occur along the central axes of mid-ocean ridges. Mid-ocean ridges are a chain of underwater mountain ranges present in all of the deep oceans that extend more than 60,000 km across the ocean floor. Hydrothermal vents are also found over hot spots, in back-arc basins, in shallow geothermal systems, and on the flanks of some underwater volcanoes and seamounts. The sites where hydrothermal vents are found may cover areas from tens to hundreds of square metres. Hydrothermal vents may be separated along mid-ocean ridges by more than 1600 kilometres. The water at hydrothermal vents can reach temperatures of as much as four hundred degrees Celsius. The distribution of organisms, at individual vents and at different vent sites, appears to be very closely related to the temperature and fluid composition around the vents.

Biologically, hydrothermal vents are one of the most productive ecosystems on Earth. The hydrothermal vents that are best studied are situated at tectonic spreading centers on the East Pacific Rise and at the Mid-Atlantic Ridge. There is an amazing abundance of life in concentrated areas around the vents. Despite being surrounded by deserts on the ocean floor, hydrothermal vents have one of the highest levels of microscopic organisms and abundance of animals. These ecosystems can host up to half a million animals per square meter. Globally, hydrothermal vents are home to numerous unique species of

animals. Approximately 450 animal species have now been identified around hydrothermal vents. Of these animals, about 95% of these have been species new to science. (3) However, once the hydrothermal fluid coming from these vents diminishes to only a trickle, the animals disappear.

Hydrothermal vents tend to be dominated by mollusks, annelids, and crustaceans, however most other hard bottom habitats are mostly comprised of cnidarians, sponges, and echinoderms. Large mussels and clams are found in almost all vent systems, as well as an assortment of limpets and other gastropods. The animals found at hydrothermal vents are also highly endemic, meaning that they are “species of organism that are confined to a particular geographical region.” (4) Some of these species have even evolved in isolation since the Mesozoic Era (65 - 225 million years ago), providing us with a unique prospective as to how ancient marine organisms adapted to their environment. The physical and chemical condition at hydrothermal vents would be lethal to most marine animals, but vent species have adapted to the conditions there.

Normally, food is very scarce on the ocean floor, so how can these organisms survive at hydrothermal vent sites? In most ecosystems, the animal life depends on food produced through photosynthesis. Photosynthesis is the process in which “inorganic carbon is converted to useful sugar by plants using light energy”. (3) However the organisms that live at hydrothermal vents obtain most of their food through a process called chemosynthesis. Chemosynthesis is the manufacturing of complex substances from simpler chemical building blocks within living organisms. This process of chemosynthesis produces the same

nutrients as photosynthesis does, only using chemical energy instead of energy from the sun. Specialized bacteria that exploit the energy in chemical bonds accomplish this process of chemosynthesis. They convert inorganic carbon to sugars by controlling the oxidation of hydrogen in hydrogen sulfide in hydrothermal fluid. These specialized bacteria live in environments such as hydrothermal fluids, in mats on the sea floor, or in symbiotic relationships with other organisms. These chemosynthetic bacteria are highly significant in deep-sea hydrothermal vent communities as many invertebrate animals that colonize these extreme habitats contain large populations of symbiotic bacteria that provide them with organic nutrients. Instead of a digestive system, some of these animals contained as much as 285 billion bacteria per ounce of tissue. At this great depth and pressure, a few species of octopus have been known to prey on these shelled invertebrates. A few vent animals have also been known to use methane gas as a source of energy and carbon.

In 1982, a major site of hydrothermal vents was discovered along portions of the Juan de Fuca Ridge off the coast of British Columbia. The discovery of this hydrothermal vent shows how major marine ecosystems can go completely unnoticed due to its remoteness. The hydrothermal vents that were discovered were located in water 2,250 metres deep, and 250 kilometres southwest of Vancouver Island in the Pacific Ocean. These vents were later named the Endeavour Hydrothermal Vents. There are five known vent fields along this stretch of hydrothermal vents that are separated by about two kilometers from one another. Since its discovery, the Endeavour Hydrothermal Vents have been

a focus of research by Canadian and international scientists. Both the manned American submersible Alvin and the unmanned vehicle Jason have engaged in a number of missions in the area.

At certain vents, like those of the Endeavour Hydrothermal Vents, the chemicals spewing out of the vents resemble chimneys, which scientists call “black smokers.” These large polymetallic sulphide chimneys are formed when the dissolved minerals and metallic ions carried upward by the smokers precipitate when they come in contact with the cold seawater. The Endeavour Hydrothermal Vents rise about 300 metres into the water above, but some of these black smokers can be as tall as a fifteen story building. The temperature in most black smokers is typically around three hundred degrees Celsius.

The Endeavour Hydrothermal Vents are hosts to rich, diverse ecosystems unlike anywhere else on earth. There are over 60 distinct species that are native to the Juan de Fuca Ridge. Many of these species are the first in the world to be identified. The Endeavour Hydrothermal Vents are home to 12 species that do not exist anywhere else in the world. (5)

On March 7th, 2003, the Minister of Fisheries and Oceans Canada announced the Endeavour Hydrothermal Vents as Canada’s first Marine Protected Area. This marked the first major step in an effort to develop a number of protected areas across Canada. Given the evident threat from mineral development on hydrothermal vent biology, and the importance of these areas to science, many Marine Protected Area proponents have identified hydrothermal vents as key features in an overall Marine Protected Area strategy. Now that the

Endeavour Segment Hydrothermal Vent has been categorized as a Marine Protected Area, government agencies, conservation groups and marine stakeholders now have the opportunity to develop Marine Protected Area management plans for this extraordinary offshore site.

The Endeavour Hydrothermal Vents was designated as a Marine Protected Area to ensure that hydrothermal vents, and their unique ecosystems, are fully protected. Being a Marine Protected Area, it prohibits the removal, disturbance, damage or destruction of the hydrothermal vents and the marine organisms that live around them. This will allow scientists to further research these areas, in order to further understand the hydrothermal vents ecosystem.

Scientific research within this Marine Protected Areas can further scientific knowledge of how hydrothermal vent ecosystems work and how conservation strategies can help recover marine species and ecosystems. As a result of this designation, many other potential Marine Protected Area benefits may appear. Some of these benefits may include the protection of unique features where rare species are endemic to a single habitat area, the protection of an ecosystem's functions, the genetic pools that support populations, and food chain linkages. In order for the criteria of a Marine Protected Area to be met, it will require specific protection measures, including the minimum protection standards proposed by CPAWS and WWF Canada, which comprises of no bottom trawling, dragging, dredging, dumping and non-renewable resource extraction. The primary responsibility of implementing these standards will be to Fisheries and Oceans Canada under the Oceans Act.

Although hydrothermal vents are relatively inaccessible, numerous companies have expressed interest in their potential for mineral development. Some American groups have even made proposals to dredge hydrothermal vents in the northern Atlantic Ocean. However, scientists and conservationists concerned about the impact on the unique and unusual habitats surrounding venting ridges have opposed these offers. Researchers have already determined that dredging, drilling and submersible activities around hydrothermal vents are very intrusive. Luckily, as far as scientists can tell, hydrothermal vents have not yet been affected by human activities.

As important as it is to continue to explore and discover new sources of Marine Biodiversity, it is even more crucial that we preserve and protect the current sites of Marine Biodiversity. Hydrothermal vents are ecosystems unlike any other, and host a diverse number of organisms. We must first educate others of these sites like these, and then work towards taking further steps in order to protect them further.

Work Cited

- 1) Unknown. What is Biodiversity? Centre of Marine Biodiversity. <<http://marinebiodiversity.ca/en/what.html>>.
- 2) Unknown. Sustaining Life on Earth. Convention on Biological Diversity. <<http://www.biodiv.org/doc/publications/guide.asp>>.
- 3) Symington, Keith. New Marine Protected Areas Announced. British Columbia Environmental Network. <<http://www.bcen.bc.ca/bcerart/Vol9/newmarin.htm>>.
- 4) "Endemic." Microsoft Encarta Encyclopedia 98. CD-ROM. 1998.
- 5) Unknown. Designated Marine Protected Areas. Department of Fisheries and Oceans Canada. <http://www.dfo-mpo.gc.ca/canwaters-eauxcan/oceans/mpa-zpm/dmpa_e.asp>.