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Feature

Oases on the ocean floor

By Emma Duncan

Discovered only 25 years ago, the unique inhabitants of deep-sea hydrothermal vents have revolutionized biology, widening our understanding of the extreme conditions in which organisms can survive and providing clues to the origins of life itself. The Azores government recently declared two vent fields in the North-East Atlantic Ocean as Marine Protected Areas - an important step towards the conservation of these fragile ecosystems about which much is still unknown.

A geyser spewing poisonous, super-hot water into the sunless and otherwise chilly depths of the ocean seems an unlikely place to find life. But in fact such geysers — or deep-sea hydrothermal vents — are the most densely inhabited areas of the entire deep-sea floor.

Crab and mussels at Menez Gewn hydrothermal vent field.
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Located hundreds of metres below the ocean surface, deep-sea hydrothermal vents form as a result of volcanic activity on the ocean floor. Water seeps through cracks in the Earth's crust, dissolving metals and minerals as it becomes super-heated from nearby magma. This water — which can reach temperatures of 400°C — eventually rises back through the ocean floor, erupting as a geyser from a hydrothermal vent. The dissolved minerals and metals precipitate on contact with the cold sea water, forming a chimney around the vent.

Although not discovered until 1977, scientists had long suspected their existence. But no one ever dreamed that deep-sea hydrothermal vents would support thriving communities that include blind shrimp, white crabs, giant tubeworms, clams, shell-less snails, anemones, and fish. These rare geological features turned out to be veritable oases in the deep sea, with a biomass equivalent to that of a rainforest.

At first glance, the animals inhabiting deep-sea hydrothermal vents may seem not so dissimilar to those inhabiting the rock pools and shallow seas of the world. In fact, they are unlike any other life on Earth.

Sunlight never reaches the deep ocean floor, making the harnessing of the sun's energy through photosynthesis — the basis of most life on Earth — impossible at these depths.

Instead of sunlight, the life that colonizes the vents relies on hydrogen sulfide — more commonly known as rotten egg gas and toxic to most land-based life. Hydrogen sulfide is one of the chemicals present in the mineral-rich water pouring out of the vents. Similar to the way that plants use the sun's energy for photosynthesis, the energy created when hydrogen sulfide oxidizes can be used by some bacteria for growth, in a process called chemosynthesis. These bacteria form the bottom level of the food chain in these ecosystems, upon which all other vent animals are dependent.

The reliance on chemosynthesis instead of photosynthesis is not the only unique feature of the animals living around deep-sea hydrothermal vents. These animals survive pressures up to 200 times that on the Earth's surface, a witch's cauldron of toxic chemicals, and huge extremes of temperature. Vent microorganisms can survive temperatures of up to 113°C, the highest temperature recorded at which an organism can live. Apart from hydrogen sulfide, vent water also contains poisonous heavy metals and is more acidic than vinegar. Biologists still don't know exacty how vent animals survive in these conditions.

But survive they do. More than 300 species have so far been identified in deep-sea hydrothermal vent ecosystems, of which over 95 per cent are new to science. Many are restricted to a particular vent field, making each ecosystem unique.

Amazingly, vent life has changed little over time. A whole new domain of life was discovered in vent ecosystems — Archaea, an ancient form of life most closely related to the first life on Earth. Other vent life also appears to be more closely related to ancient animals than to animals living closer to the ocean's surface. Indeed, vent animals on opposite sites of the globe are more closely related to each other than to those living outside the vent ecosystem, just a few metres away. Some researchers have speculated that life began in extreme environments similar to hydrothermal vents. Others have even suggested that if these environments exist on other planets, then life might very well exist there too.

Much is still unknown about deep-sea hydrothermal vent ecosystems. But ironically, the quest to find out more is threatening these fragile areas.

The biggest danger facing most deep-sea vent ecosystems is physical damage caused by human activity. Some vents are visited multiple times each year for research purposes, which are often uncoordinated and unregulated. The possibility that vent microorganisms could be useful for cleaning up industrial pollution containing hydrogen sulfide and heavy metals, for example, makes bioprospecting very attractive. In addition, many vent chimneys are a potential bonanza of gold, silver, and copper, and maybe even oil. There is also a growing interest in deep-sea hydrothermal vents for deep-sea tourism.

Hydrothermal vents are small and each individual vent ecosystem is absolutely dependent on the unique mix of chemicals and temperatures created by the vent. Destroying vent structures through mining would completely destroy a vent ecosystem. Unregulated scientific sampling could also have devastating consequences on a vent ecosystem, through alteration of the vent habitat as well as dispersion of organisms between sites and introduction of exotic species.

Clearly, forward-thinking measures are needed to ensure the long-term protection of deep-sea hydrothermal vents before such damage occurs. However, the deep sea is a relatively new concern to conservation. "The necessity for legal protection of deep-sea hydrothermal vents, and marine offshore environments in general, is not yet a high priority in most countries," points out Simon Cripps, Director of WWF's Endangered Seas Programme.

Canada was the first country to protect a deep-sea hydrothermal vent system. In 1998 the Endeavour Hydrothermal Vents, located 250km southwest of Vancouver Island, were designated as a Marine Protected Area. This designation provides for long-term protection of the vent ecosystem by prohibiting the removal, disturbance, damage, and destruction of anything within the protected area. The protection also includes a comprehensive management system to safeguard the vents against unregulated human activities.

This year the regional government of the Azores became the second government to demonstrate similar forward thinking. Following concerns expressed by scientists involved in biological surveys of the Lucky Strike and Menez Gwen vent fields, the Azorean government began the process of designating these two areas as Marine Protected Areas, with implementation expected to be complete in 2003. WWF will tomorrow recognize these designations as a Gift to the Earth — the organization's highest recognition for conservation achievement.

The Lucky Strike and Menez Gwen vent fields are located within the Portuguese Exclusive Economic Zone (EEZ) on the Mid-Atlantic Ridge, at a depth of 1700m and 850m, respectively. Their proximity to land and relatively shallow location make the sites easy to access, and both have been the subject of a number of scientific explorations.

Similar to the Endeavour Hydrothermal Vents, protection of the Lucky Strike and Menez Gwen vent fields will involve a carefully thought out management plan to ensure that further scientific research and monitoring activities are carried out in a responsible way. A workshop involving scientists, environment managers, WWF, and the Portugese navy has been held over the past two days to come up with an effective management plan. "WWF hopes that this plan will be used as a blueprint in efforts to protect and manage similar environments elsewhere in the offshore and deep-sea environment of Europe's seas", says Stephan Lutter, Director of WWF's North-East Atlantic Programme.

The deep sea plays an important role in sustaining life on our planet. Apart from their geological and ecological importance, deep-sea hydrothermal vents regulate both the temperature and chemical balance of the world's oceans. The deep sea also absorbs greenhouse gases and maintains large-scale processes necessary for life on Earth. Proper management of human activities in the deep sea is absolutely vital. The voluntary actions of the Canadian and Azores governments in protecting these fragile ecosystems set a unique precedent and should be an example to us all.

(1233 words)

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Further information:

Archaea
Archaea are an ancient form of life, the first species of which — *Methanococcos jannaschii* — was discovered near a hydrothermal vent in the Northern East Pacific Rise in 1982. Prior to its discovery, scientists had recognized only two domains: prokaryotes (cells without a nucleus, such as bacteria) and eukaryotes (cells with a nucleus, such as those of yeast, plants, and

animals). Archea have no nucleus, and half to two-thirds of their genes are unlike those of any other life on Earth. This group of organisms was therefore recognized as a third domain of life.

WWF's work in the North-East Atlantic
WWF's North-East Atlantic Programme aims to protect and, where necessary, restore biodiversity and maintain the natural productivity and status of the North-East Atlantic marine environment. Its special focus is on the land-sea interface, land-based activities in the catchment area, and commonly shared resources. The programme has prepared a map of offshore marine areas in the North-East Atlantic that WWF has proposed for protection.

WWF supports the work of the 15 contracting parties to the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) to establish an ecologically coherent network of well-managed Marine Protected Areas in the North-East Atlantic. The Azorean Regional Government's decision to protect the Lucky Strike and Menez Gwen sites makes way for the first offshore deep-sea Marine Protected Area in the North-East Atlantic under this framework.

Gifts to the Earth
A Gift to the Earth is a public celebration by WWF of a conservation action by a government, a company, or an individual which is both a demonstration of environmental leadership and a globally significant contribution to the protection of the living world.

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