DOSI
DEEP-OCEAN STEWARDSHIP INITIATIVE

INFORMATION SHEET | July 2023

What Does the Deep Ocean Do for You?

Hydrothermal Vent Ecosystems

Key Messages

- Active hydrothermal vents are small, globally rare sites where emergent hot fluids sustain unique ecosystems designated as Vulnerable Marine Ecosystems.
- The abundant, mostly endemic, life around active vents provides many ecosystem services in most categories such as novel marine genetic resources and inspiration for space exploration.
- Inactive hydrothermal vents are home to long-lived, vulnerable animals, such as corals and sponges; this habitat and associated ecosystem services are poorly studied.
- Influences of these ecosystems reach across the seabed and upwards into the water column.
- Disturbance of inactive hydrothermal vents may affect nearby active venting.

Hydrothermal Vents

Active vents support unusual ecosystems dependent on chemical energy from fluids emerging from the seafloor. Where this fluid exceeds ~130°C, 'black smoker' chimneys can form where metals from the fluid precipitate. Over time, large deposits of polymetallic sulphides may accrete. Vents are clustered in vent fields and separated by surrounding seafloor. While a vent field may encompass an area of several soccer fields, active venting is typically confined to a few square meters of seabed; globally, the habitat is estimated to occupy only about 50 km^2.

Many vent inhabitants are 'extremophiles' that thrive in extreme conditions of heat, acidity, low oxygen and toxic compounds. They can create very high biomass and abundance (Figure 1), such as smokers covered with dense swarms of shrimp and aggregations of snails piled high over venting cracks. However, most vent species live only in this ecosystem. The 'sphere' of vent influence can reach far beyond the field area. If fluid venting eventually ceases, the vent becomes temporarily inactive or extinct. Active and inactive vents within a vent field are interconnected via subsurface conduits and by currents at the seabed.

Inactive and extinct vents are polymetallic sulphide deposits no longer venting. Inactive vents may reactivate whereas extinct vents likely will not. Inactive vents are often located near active vents within the same vent field. Both deposits can be home to unique microbial communities and fauna such as aggregations of corals and sponges (Figure 1) that benefit from access to the enhanced currents and food supply from the nearby active vents. These ecosystems are rarely studied but appear to comprise animals that are often poorly known and/or new to science.

Hydrothermal Plumes

Plumes from vigorous fluid emissions rise from active vents spreading large distances from their source. Distinctive physical seawater layers harbour unique microbial communities, form connectivity highways for animal larvae, and export nutrients to the broader ocean, sometimes with links to surface waters enhancing productivity. The global cycling of some elements (e.g., iron, sulphur) is largely affected by these plumes and microbes.

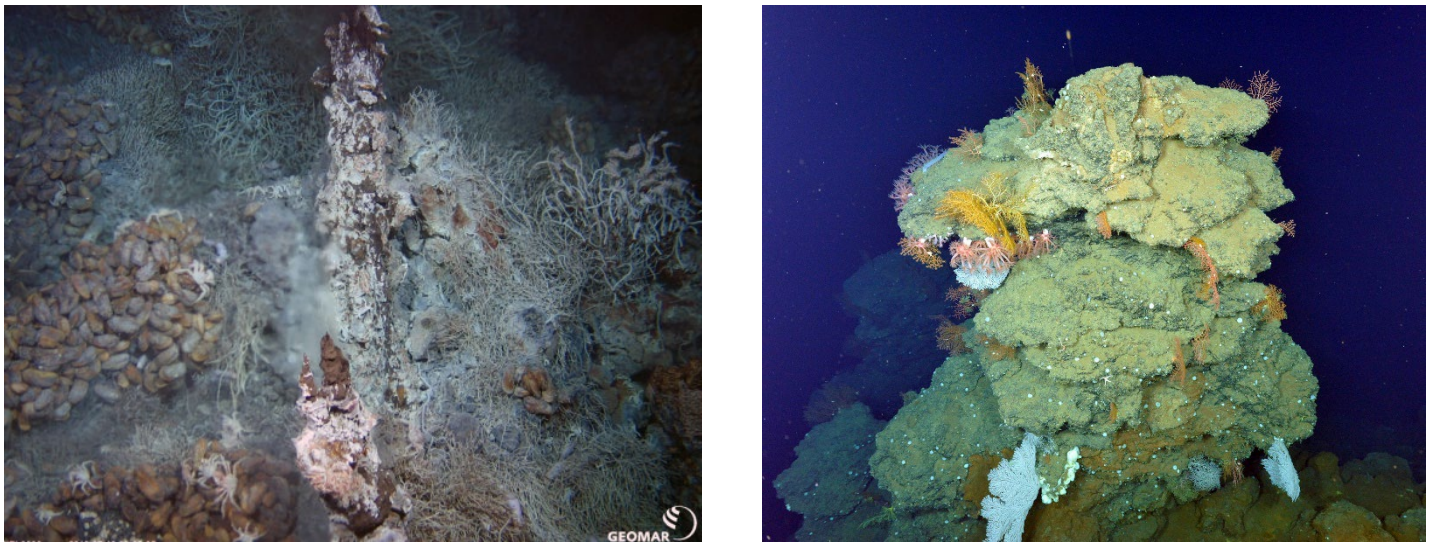


Figure 1: Left: Active vent with mussels, tubeworms and crabs clustered around a small chimney at 1870 m depth off Vanuatu (credit GEOMAR). Right: Inactive vent deposit with corals and sponges at Endeavour site, Juan de Fuca Ridge (credit Tunnicliffe, CSSF).

Ecosystem Services Provided by Hydrothermal Vents

Vent ecosystems provide four categories of ecosystem services – provisioning, regulating, supporting and cultural. Figure 2 presents a cross-section of a mid-ocean ridge seafloor to illustrate how active vents, inactive deposits and plumes can be situated. The ecosystem services depicted have a major impact on humans. For example, the discovery of life at vents has stimulated the search for life elsewhere in the solar system where volcanic activity is present. The search continues for genetic resources such as Fuelzyme™-LF isolated from a vent microbe; it is used in ethanol extraction from corn.

Human Threats to Vent Ecosystem Services

The main threats to hydrothermal vent ecosystems are from deep-sea mining and climate change. Deep-sea mining will focus largely on inactive or extinct vents where there is little baseline knowledge from which to predict impacts. Where long-lived, vulnerable species, such as corals and sponges, inhabit inactive or extinct vents, the impacts on ecosystem services could be high.

Excavation will destroy local habitats and could reactivate venting at inactive vents by re-connecting to the subsurface conduits. Consequences for nearby active vents could include changes in flows and heat that alter community composition and extent. Mining plumes smother fauna and release toxins from crushed rock. Since most vent animals disperse as larvae in the water column, plumes (and possibly noise) may impact vent organisms during their dispersal stages.

Figure 2: Ecosystem Services

Active hydrothermal vents and their plumes

Education and outreach
e.g., basis for numerous media products on the extraordinary hydrothermal vent ecosystem

Scientific research
e.g., i) Fruitful area for fundamental, interdisciplinary scientific research; ii) transformative insights for origins of life on Earth and for other settings in our solar system; iii) most organisms are endemic to vents and new to science; iv) many new discoveries in basic metabolic processes, symbioses and adaptations to extreme conditions

Biogeochemical cycling
e.g., microbial metabolism in the hydrothermal plume has broad oceanic influence on the cycling of key elements such as sulphur and nitrogen

Carbon cycling
e.g., subsurface and deep-sea carbon dioxide is fixed to organic carbon at vents; iron from plumes can stimulate productivity in ocean surface waters

Non-living resources
e.g., polymetallic sulphides

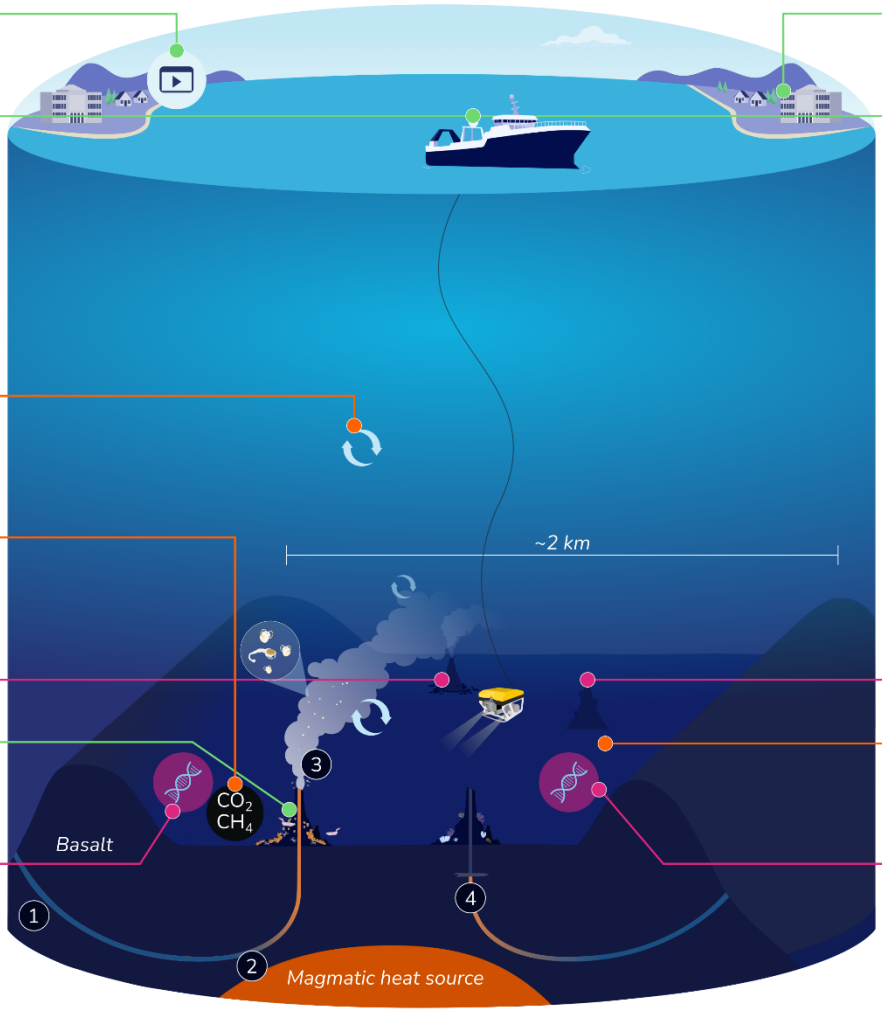
Biomimicry
e.g., bilayer material design template from a vent snail shell that resists transmission of thermal impulses

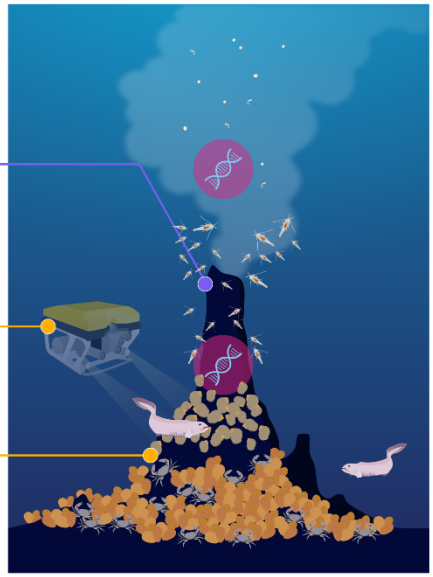
Marine genetic resources
e.g., i) enzymes from vent bacteria that are highly efficient at degrading hydrocarbons in oil spills; ii) numerous patented bioproducts from vent products such as Fuelzyme™-LF that improves efficiency of ethanol extraction from corn; iii) >100 chemical compounds from vent organisms with structures exhibiting bioactivities that are of interest to biosynthesis research

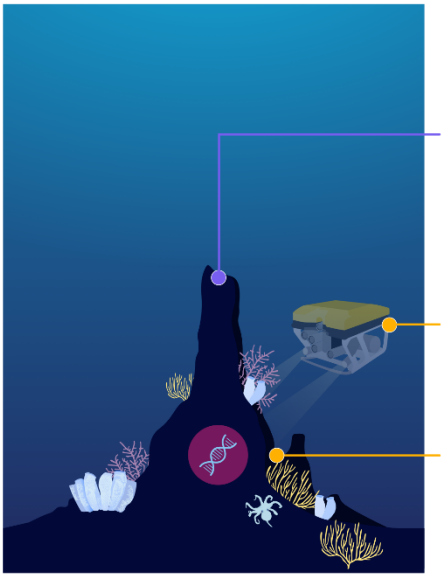
Habitat and trophic support
e.g., i) habitat creation by chimney structures; ii) feeding grounds for animals; iii) productivity from vents is disseminated to the deep ocean via plumes and currents

Stewardship and bequest value
Maintaining or preserving this ecosystem for current and future generations

Existence value
The value of knowledge that a species or habitat exists; a reservoir of marine genetic resources







Inactive hydrothermal vents

Education and outreach

Scientific research
e.g., fruitful area for fundamental. interdisciplinary scientific research; ii) an important target for scientific discovery

Non-living resources
e.g., polymetallic sulphide

Regulating services
May regulate seafloor roughness and turbulence around structures

Marine genetic resources
Likely to include e.g., new bioproducts from microbial intermediaries in the transformation of reactive minerals in these deposits

Habitat and trophic support
e.g., i) habitat creation and shelter provision by colonizing foundation species such as corals and sponges on inactive chimneys; ii) nursery grounds for fish and cephalopods

Stewardship and bequest value
Maintaining or preserving this ecosystem for current and future generations

Existence value
The value of knowledge that a species or habitat exists; a reservoir of marine genetic resources

KEY

- **Provisioning services**: result in tangible goods and/or products
- **Regulating services**: contribute to the natural production and resilience of habitats and ecosystem processes, and often derive from export of vent influences
- **Supporting services**: underlying ecosystem functions that are essential to produce other services
- **Cultural services**: non-material benefits deriving from nature
- **Biodiversity values**: biodiversity has intrinsic value, but is also the source of most ecosystem services

Figure 2 Description: The hydrothermal vent ecosystem and associated ecosystem services at active (left) and inactive (right) vents. Active vents are characterised by hot metal-rich venting fluids that fuel microbial productivity in the deep ocean. Fluids derive from ocean water that (1) percolates through the Earth's crusts, (2) is heated by the magmatic heat source and enriched in metals, and (3) exits through conduits in the seafloor, precipitating metals when it contacts cold seawater. Inactive vents (4) can occur within an active vent field, where fluid conduits are blocked. Disturbance at inactive vents may affect nearby active vents if reactivated. Extinct vents (not illustrated) are severed from the heat source and do not reactivate. Ecosystem services at inactive and extinct vents are likely similar but poorly documented. Ecosystem services at active vents are well described.

Human Threats to Vent Ecosystem Services (Continued)

A key concern to consider for hydrothermal vent ecosystems is the unintended consequences of mining that may eliminate or alter the habitat of vent animals. Extinction is a distinct possibility as most species are highly limited in the locations they occupy; vent populations depend on the connectivity among isolated sites.

Climate change is leading to a warmer, more acidic, deoxygenated and more stratified ocean. These changes will have unknown consequences for vent species, including the larvae of some species that use shallower oceanic currents for dispersion.

Protection of Vent Ecosystem Services

The high natural value of active vents is globally recognised. These ecosystems meet criteria that identify vulnerable, sensitive, and ecologically or biologically significant ecosystems in need of protection. Such criteria were developed by intergovernmental organisations, including Food and Agriculture Organization (FAO) for VMEs (Vulnerable Marine Ecosystems), Convention on Biological Diversity (CBD) for EBSAs (Ecologically or Biologically Significant Areas), IMO (International Maritime Organization) for PSSAs (Particularly Sensitive Sea Areas), and OSPAR's "Texel-Faial criteria".

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About DOSI:

The Deep-Ocean Stewardship Initiative is a global network of experts that integrates science, technology, policy, law and economics to advise on ecosystem-based management of resource use in the deep ocean, and on strategies to maintain the integrity of deep-ocean ecosystems within and beyond national jurisdiction.

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