Chapter 45. Hydrothermal Vents and Cold Seeps

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1. Inventory

Hydrothermal vents and cold seeps constitute energy hotspots on the seafloor that sustain some of the most unusual ecosystems on Earth. Occurring in diverse geological settings, these environments share high concentrations of reduced chemicals (e.g. methane, sulphide, hydrogen, iron II) that drive primary production by chemosynthetic microbes (Orcutt et al. 2011). Their biota are characterized by a high level of endemism with common specific lineages at the family, genus and even species level, as well as the prevalence of symbioses between invertebrates and bacteria (Dubilier et al., 2008; Kiel, 2009).

Hydrothermal vents are located at mid-ocean ridges, volcanic arcs and back-arc spreading centres or on volcanic hotspots (e.g. Hawaiian archipelago), where magmatic heat sources drive the hydrothermal circulation. Venting systems can also be located well away from spreading centres, where they are driven by exothermic, mineral-fluid reactions (Kelley, 2005) or remanent lithospheric heat (Wheat et al., 2004). Of the 521 vent fields known (as of 2009), 245 are visually confirmed, the other being inferred active by other cues such as tracer anomalies (e.g. temperature, particles, dissolved manganese or methane) in the water column (Beaulieu et al., 2013) (Figure 1).

Sediment-hosted seeps occur at both passive continental margins and subduction zones, where they are often supported by subsurface hydrocarbon reservoirs. The migration of hydrocarbon-rich seep fluids is driven by a variety of geophysical processes to the dissociation of methane hydrates. The systematic survey of continental margins has revealed an increasing number of cold seeps worldwide (Foucher et al., 2009; Talukder, 2012). However, no recent global inventory of cold seeps is available

of the Florida escarpment in the Gulf of Mexico in 1984 (Paull et al., 1984). Compared to other deep-sea settings, the exploration of vent and seep habitats is thus recent (Ramirez-Llodra et al., 2011). In the last decade, high-resolution seafloor mapping technologies using remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs) have yet enhanced the capacity to explore the deep seabed.

Since the last global compilation (Baker and German, 2004), the known number of active hydrothermal vent fields has almost doubled, with of

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3. Major pressures linked to the trends

The deep-sea is being seen as a new frontier for hydrocarbon and mineral resource extraction, as a response to increasing demand for raw materials for emerging high-technology industries and worldwide urbanization. As a consequence, vent and seep ecosystems, so far preserved from direct impacts of human activities, are confronted with increasing pressures (Ramirez-Llodra et al., 2011; Santos et al., 2012).

Offshore oil extraction increasingly occurs in waters as deep as 3000 m and exploration for oil and gas now predominantly occurs in deep water (> 450m) or ultra-deep water (> 1500m depth), where typical seep ecosystems are found. Seafloor installations can directly affect cold seep communities in their impact area, if visual surveys and Environmental Impact Assessments (EIAs) are not completed prior to drilling. In addition, an increasing threat exists of large-scale impacts from accidental spills, such as the 2010 Deepwater Horizon blowout in the Gulf of Mexico, which was the largest accidental release of oil into the ocean in human history (McNutt et al., 2012) with a significant impact on surrounding deep-seabed habitats (Montagna et al., 2013; Fisher et al., 2014).

Further pressures on cold seep communities may arise from the combined effects of increasing demand for energy and technological progress in the exploitation of new types of energy resources. This type of development is shown by the world's first marine methane hydrate production test in the Nankai Trough in 2013. Sequestration of CO_2 in deep-sea sedimentary disposal sites and igneous rocks (Goldberg et al., 2008) should also be considered a potential threat specific to these communities (IPCC, 2005).

The increased demand for metals is promoting deep-sea mineral resource exploration both within Exclusive Economic Zones (EEZs) and in the Area (as defined in the United Nations Convention on the Law of the Sea), raising the issue of potential impacts on vent ecosystems (Van Dover, 2012). In 2011, the granting of a

2012). It is important to note that, in the context of vents and seeps, natural variability is acknowledged to underlie many of the changes that are happening. Knowledge gaps concerning the ecological dynamics and responses to combined pressures, therefore, currently make it difficult to devise effective conservation measures. In any case, implementation of such measures would require actions at the national, regional and (in some cases) global level to be coordinated with each other.

At present, in the absence of any formal framework for general coordination, voluntary cooperation among the International Seabed Authority (ISA) and RFMOs is taking place. Without further efforts to promote cooperation between the relevant sectoral regulatory authorities and to close gaps in knowledge, both the effectiveness of on-going conservation measures and the development of more wide-ranging protection for vents and seeps are likely to be put at risk.

Table 1. Summary of vent and seep ecosystems protected to date under national or international law (Santos et al. 2012; Calado et al. 2011; ISA 2011; USFWS 2012; NTL 2009-G40; New Zealand ENMS circular 2007; Gouvernement de Nouvelle Calédonie)

Ocean region	Name of site	Type of chemosynthetic ecosystem	Depth & location	Legal framework
North East Pacific	Endeavour hydrothermal vents MPA	Five vent fields including black smokers	2250m depth, 250km SW of Vancouver Island in Canadian EEZ.	Protected under the Canadian Government's Ocean Act.
North East Pacific	Guaymas Basin Hydrothermal Vents Sanctuary	Hydrothermal vents located in a sedimented seabed.	Gulf of California, depth of ~2500m, Within Mexican EEZ.	Protected under Mexican State Law.
North East Pacific	Eastern Pacific Rise Hydrothermal Vents Sanctuary	Hydrothermal vents located on the East Pacific Rise	East Pacific Rise, depth of ~2800m, in Mexican EEZ.	Protected under Mexican State Law.
North West Pacific	Mariana Trench National Monument	Hydrothermal vents, CO_2 vents, sulphur lake.	Located around three northernmost Mariana Islands & Mariana Trench 10m - 1650m depth.	Protected under US Law following Presidential Proclamation.
South West Pacific	Several deep-			

		conservation under the EU habitats directive)		

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