Hydrothermal Vent Ecosystems and Conservation

BY CINDY LEE VAN DOVER

A decade of Ridge 2000 and related research has yielded new and refined understanding of events and processes that occur on mid-ocean ridge and back-arc spreading centers, as reported in this special issue of *Oceanography*. Exciting exploration has also continued, with the past decade witnessing discovery of vent ecosystems in the Arctic (Pedersen et al., 2010), a new vent biogeographic province in the Southern Ocean (Rogers et al., 2012), and what may be a new vent province in the Caribbean, where the deepest known vent site was found on the Cayman Rise (Connelly et al., 2012). These recently discovered sites are home to many species new to science, some of which are especially strange in their abundance and distribution, including relatives of the yeti crab (Macpherson et al., 2006) reported from vents of the Scotia back arc (Rogers et al., 2012).

This same decade also witnessed an escalation in activities and products directed toward management and conservation of hydrothermal systems,

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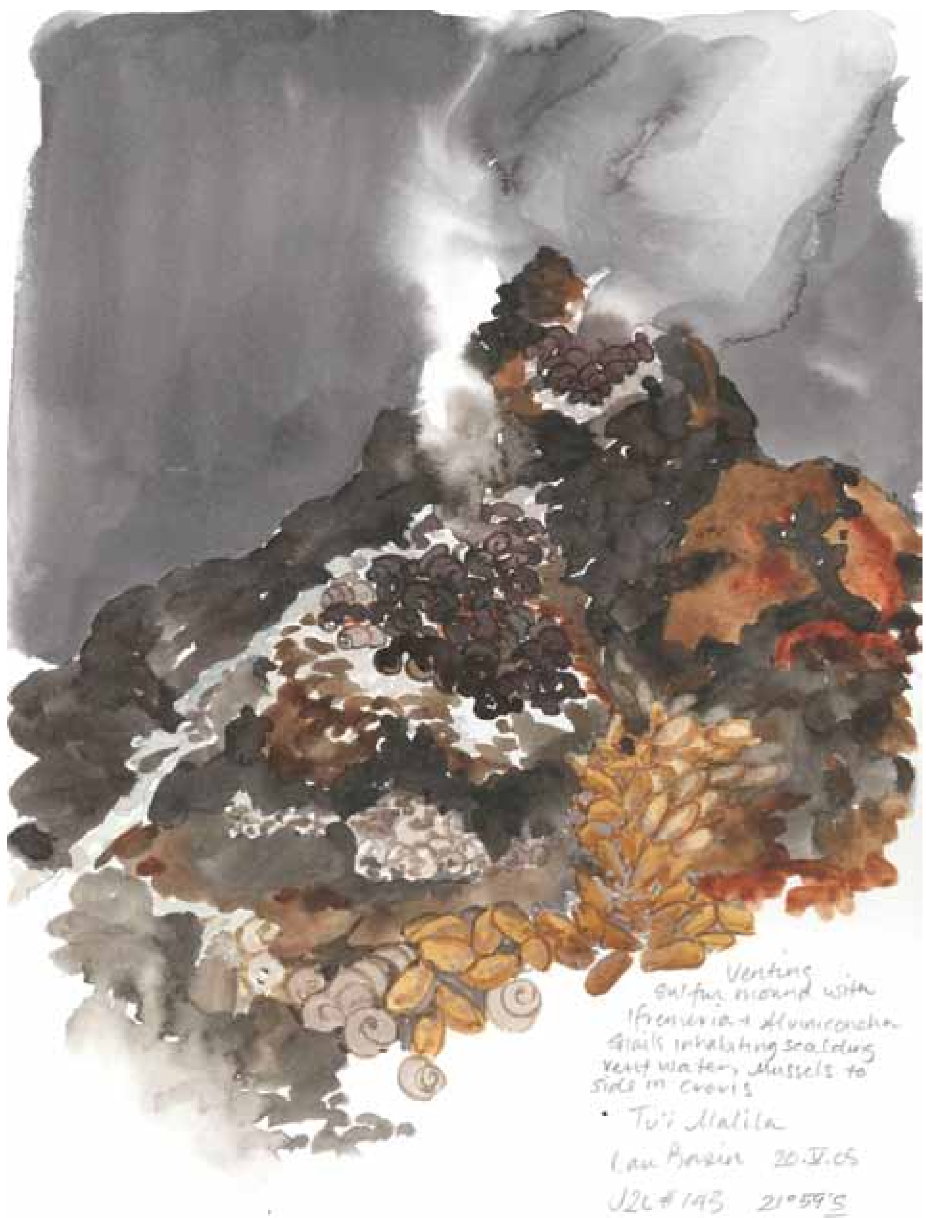

Tu'i Malila hydrothermal vent and seafloor massive sulfide deposit, Lau Basin. *Watercolor study by Karen Jacobsen, In Situ Science Illustration* many of which involved or were initiated by the scientific community. A position paper on deep-sea sanctuaries at hydrothermal vents (Mullineaux et al., 1998) set the stage for an InterRidge workshop on Management and Conservation of Hydrothermal Vent Ecosystems (Dando and Juniper, 2001) and the InterRidge Statement of Commitment for Responsible Research at Hydrothermal Vents (Devey et al., 2007). The Oslo-Paris Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) subsequently adopted a code of conduct for responsible marine research based on the InterRidge code. Glowka (2003), and more recently Godet et al. (2011), elaborated on the role of scientists as stakeholders in the conservation of vent ecosystems, noting that scientific activities must be managed for conservation for the same reasons that other human activities are managed, and that scientists as stakeholders have a special responsibility for exemplary behavior. Scientists have also been challenged to fill knowledge gaps that can inform conservation and environmental management strategies, including defining natural conservation units (genetic, species-specific, and biogeographic) for chemosynthetic ecosystems, increasing our understanding of processes and factors influencing connectivity among populations of invertebrates at chemosynthetic ecosystems, developing guidelines for networks of chemosynthetic ecosystem reserves, and testing mitigation and restoration strategies that may be effective for systems subject to significant adverse environmental impact (International Seabed Authority, 2011; Van Dover, 2011a).

"WE HAVE THE OPPORTUNITY NOW TO PUT IN PLACE CONSERVATION MEASURES THAT ENSURE THESE [HYDROTHERMAL VENT] ECOSYSTEMS ARE SUSTAINED AND CELEBRATED INTO THE FUTURE AS LIVING LIBRARIES WHERE WE CAN CONTINUE TO LEARN ABOUT EARTH PROCESSES AND BIODIVERSITY."

National and international interest in the conservation of deep-sea hydrothermal vents has developed in the past decade. Since 2000, international governance actions have designated hydrothermal vents as priority habitats (OSPAR), as meeting criteria for Vulnerable Marine Ecosystems (United Nations General Assembly), and as meeting criteria for Ecologically and Biologically Significant Areas (Convention on Biological Diversity). Further, Marine Protected Areas have been established at deep-sea hydrothermal fields in Canadian, US, Mexican, and Portuguese waters. Most recently, international experts in ocean science, governance, and industry have called again for designation and management of networks of chemosynthetic ecosystem reserves in the deep sea (Van Dover et al., 2012), and there has been repeated notice that there are critical regulatory and governance gaps in national and international waters relating to conservation and management of hydrothermal vents, including their genetic resources (e.g., Halfar and Fujita, 2007; Leary, 2007; Gjerde et al., 2008; Arrieta et al., 2010; Detjen, 2010; Arnaud-Haond et al., 2011; Van Dover, 2011b). Among the gaps enumerated by Gjerde et al. (2008) is the lack of an institution or process to ensure that modern conservation principles and management tools are applied to human activities in the deep sea. Without such an institution or process, human activities that cause significant disturbance to the seafloor environment might be permitted without networks of representative reserves in place, without strategic environmental assessments, without environmental impact assessments, without effective practices for establishing baselines, and without monitoring strategies and appropriate responses to differing degrees of environmental degradation induced by acute and cumulative impacts.

Human activities and their impacts on hydrothermal vent ecosystems have been enumerated and assessed in a number of publications, including Dando and Juniper (2001), Baker et al. (2010), and Ramirez-Llodra et al. (2011). Of the activities typically considered, including scientific research, tourism, bioprospecting, and exogenous effects such as ocean acidification and climate change, experts deem mineral extraction to be the activity most likely to take place *and* to have the most intense direct impact on hydrothermal vent ecosystems. Economic interest in deep-sea massive sulfide deposits at vents has occurred in tandem with vent discoveries; indeed, exploration and mapping of vents was anticipated in the case of a proposed polymetallic sulfide minerals lease offering in the early 1980s for the Gorda Ridge Area offshore Oregon and Northern California (McMurray, 1990).

The International Seabed Authority (ISA) is the autonomous international organization charged with administering mineral resources of the seabed beyond the limits of national jurisdiction (called the "Area") and with protection of the marine environment from harmful effects that may arise from exploitation of mineral resources. During the Ridge 2000 decade, ISA increased its activities related to promoting exploitation of seafloor massive sulfides in the Area, including sponsoring a 2004 workshop on environmental baselines and monitoring programs for seafloor massive sulfides (International Seabed Authority, 2007) and cosponsoring a 2010 workshop on spatially based approaches to environmental management of chemosynthetic ecosystems (International Seabed Authority, 2011). Regulations for prospecting and exploration for polymetallic sulfides in the Area, to be carried out for the benefit of humankind as a whole, were issued in May 2010 as part of the Mining Code (http://www.isa.org.jm/en/documents/mcode). The exploration regulations include requirements that prospectors minimize or eliminate adverse environmental effects and minimize or eliminate actual or potential interference with existing or planned scientific research activities. China and the Russian Federation both signed contracts with the ISA in 2010 for exploratory work on slow-spreading ridge axes, where the largest deposits are located (Hannington et al., 2011). The ISA has not yet issued regulations for extraction of seafloor massive sulfides in the Area.

As the ISA continues to develop a regulatory framework for exploitation of polymetallic sulfides in the Area, commercial interests are focused on sulfide deposits in national waters associated with back-arc basins and arc volcanoes in the Southwest Pacific (Halfar and Fujita, 2007; Hoagland et al., 2010). With rising commodity prices, it seems likely that seabed mineral extraction will take place within the next decade. Some argue that mineral extraction for economic reasons alone is not sufficient: "The mere fact that the sites are commercially attractive as ore is not an adequate reason to exploit them, any more than the existence of the giant redwoods of the Sierra Nevada justifies harvesting them for shingles. The vents are a window onto the history of life" (Woodwell, 2011). Pacific rights advocacy groups, including the Fiji-based Pacific Network on Globalization (PANG), also raised their voices in opposition to experimental seabed mining (*The Fiji Times* Online, June 2, 2011). PANG wants to ensure that citizens of Pacific nations, where deep-sea mineral extraction seems to be fast-tracked, have an opportunity to understand ocean mining and associated environmental and cultural issues before regional regulatory frameworks for mineral exploration and extraction are put into place. Establishing frameworks first, they argue, could be interpreted as tacit approval for deep-sea extractive activities by the citizenry.

The next decade of discovery, science, and—perhaps—exploitation of hydrothermal vent ecosystems lies ahead of us. We have the opportunity now to put in place conservation measures that ensure these ecosystems are sustained and celebrated into the future as living libraries where we can continue to learn about Earth processes and biodiversity.

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