SPOTLIGHT 8 | Vailulu'u Seamount

14°12.96'S, 169°03.46'W

By Anthony A.P. Koppers, Hubert Staudigel, Stanley R. Hart, Craig Young, and Jasper G. Konter

Vailulu'u seamount is an active underwater volcano that marks the end of the Samoan hotspot trail (Hart et al., 2000). Vailulu'u has a simple conical morphology (Figure 1) with a largely enclosed volcanic crater at relatively shallow water depths, ranging from 590 m (highest point on the crater rim) to 1050 m (crater floor). The crater hosts a 300-m-high central volcanic cone, Nafanua, that was formed between 2001 and 2004. Seismic activity at Vailulu'u included a series of globally recorded magnitude 4.1–4.9 earthquakes in 1973 and 1995, and substantial volcano-tectonic activity recorded over 45 days in 2000, with an average of four earthquakes per day and a maximum of 40 per day (Konter et al., 2004). Hypocenter locations are located directly below the major hydrothermal vent areas (Staudigel et al., 2006).

Extreme hydrothermal activity at Vailulu'u continually produces very turbid waters in its crater (Figure 2) and warms the crater water mass by about 0.5°C compared to open ocean water. Large temperature spikes up to 1°C have been observed in hydrocasts in close proximity to hydrothermal vent areas (Staudigel et al., 2004). Crater ventilation is controlled by the interplay of vigorous 85°C venting in the northern portion of the crater and the intrusion of colder (and denser) open ocean water, in particular during times of 50–100-m internal ocean oscillations near the breaches in the crater rim. This interaction surrounds the volcano with a transient, 200-m-thick doughnut-shaped ring of turbid waters whose traces have been detected as far as 7 km away. Vailulu'u's overall heat output has been estimated at 760 MW, the equivalent of 20–100 black smokers found at the mid-ocean ridges. High manganese (Mn) concentrations (up to 7.3 nmol kg^{-1}) in the water result in manganese export fluxes of 240 kg day^{-1} (Hart et al., 2003).

The interaction of hydrothermal activity with the open ocean waters creates a natural laboratory where a series of distinct ecological settings may be used to explore the responses of microbial and metazoan communities to hydrothermal pollution. These settings include the deep crater floor that is hydrothermally dominated, allowing study of hydrothermal (over) exposure, and the top of Nafanua and the crater breach areas, where exposure to intense hydrothermal activity is regularly interchanged with influxes of open ocean water. Crater floor settings include substantial metazoan mortality where acid-tolerant polychaetes (*Polynoidae*) feed on bacteria

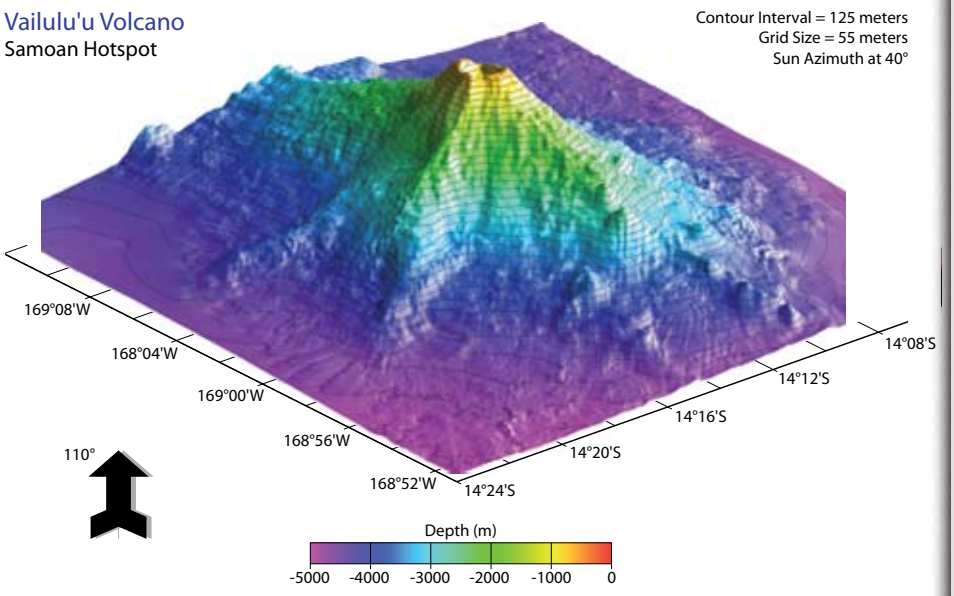

Figure 1. The seamount Vailulu'u (meaning "sacred sprinkling of rain that attends the King's visit to his people") and the cone Nafanua (meaning "Samoan warrior goddess") that formed inside the volcano crater between 2001 and 2004. Although Vailulu'u Seamount was first discovered in 1975 by Rockne Johnson, its volcanic morphology and activity was not recognized until 1999 during two R/V *Melville* AVON expeditions. *Diagram from Hart et al. (2000)*

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from decaying fish carcasses (Staudigel et al., 2006) and where diverse microbial communities include Fe-, Mn-, H_2S-, and CH_4-oxidizing *Proteobacteria*. Near the southeastern crater breach, influx of nutrient-rich open ocean water permits distinct metazoan populations of demosponge (*Abyssocladia Brunei*) and a colony of cutthroat eels (*Dysommina rugosa*) to thrive on Nafanua's summit (Figure 3).

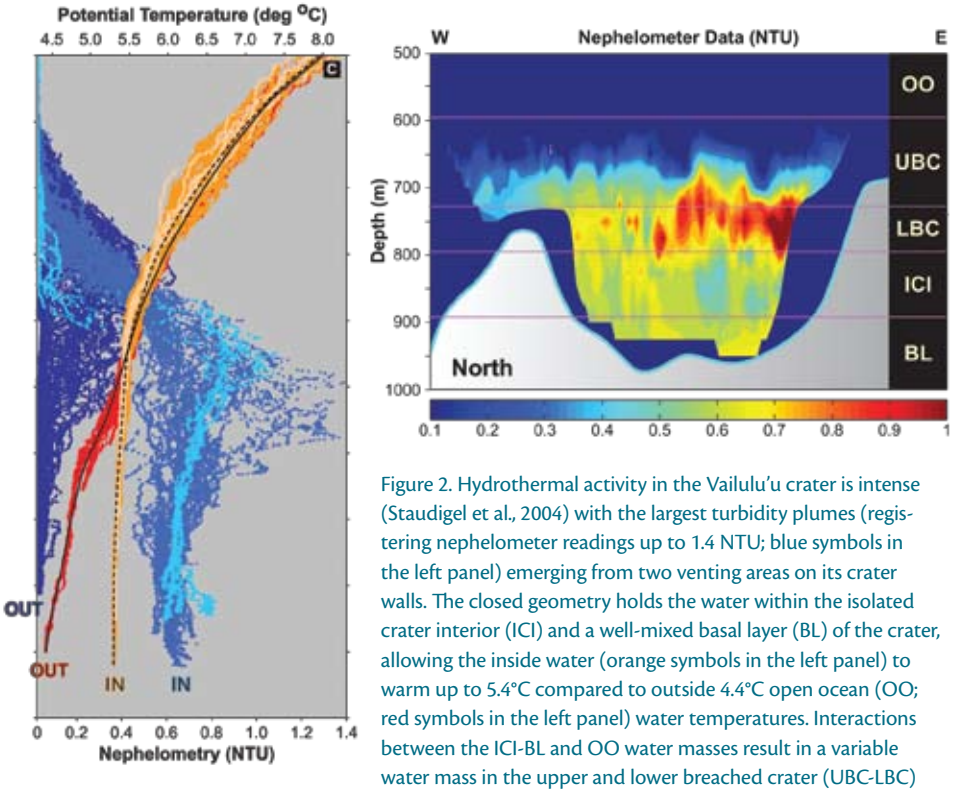

Figure 2. Hydrothermal activity in the Vailulu'u crater is intense (Staudigel et al., 2004) with the largest turbidity plumes (registering nephelometer readings up to 1.4 NTU; blue symbols in the left panel) emerging from two venting areas on its crater walls. The closed geometry holds the water within the isolated crater interior (ICI) and a well-mixed basal layer (BL) of the crater, allowing the inside water (orange symbols in the left panel) to warm up to 5.4°C compared to outside 4.4°C open ocean (OO; red symbols in the left panel) water temperatures. Interactions between the ICI-BL and OO water masses result in a variable water mass in the upper and lower breached crater (UBC-LBC) area, where tidal heave causes clear and colder OO water to pour into the crater and mix with the hydrothermally warmed and turbid waters generated inside Vailulu'u's crater.

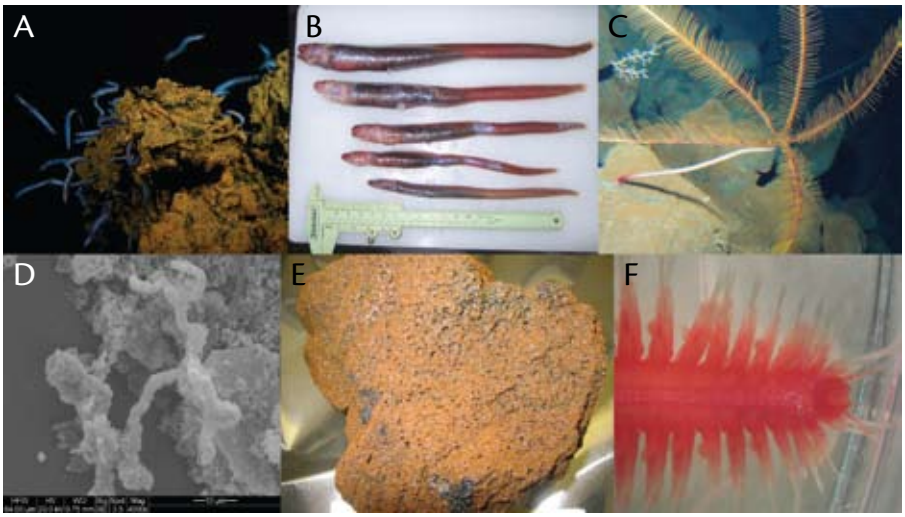

Figure 3. After formation of Nafanua volcanic cone, a colony of *Dysommina rugosa* cutthroat eels took hold on its summit (http://oceanexplorer.noaa.gov/explorations/05vailuluu/welcome.html), although all other macrofauna seem to concentrate on the crater walls and near breach areas (Staudigel et al., 2006). Despite abundant evidence for macro- and microbiological life, toxic hydrothermal fluids pond and form "death" traps in the deepest basins on Vailulu'u's crater floor. (A) Eel City. (B) Five captured *Dysommina rugosa* cutthroat eels. (C) Unidentified large isocrinid crinoid from the western rift. (D) Scanning electron microscope image of bacterial mat structures found on basalt surface samples. (E) Fe-mat-covered basalt collected using the *Pisces V* submersible. (F) A *Polynoid Polychaete* collected from a fish carcass present on the deepest part of the crater floor.

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