Exploration of an Unnamed Seamount Chain

By Adam Soule, Steve Auscavitch, Allison Fundis, Robert D. Ballard, Coralie Rodriguez, Erin Heffron, and Kelly Moran

E/V *Nautilus* expedition NA135 conducted the first human exploration of an unnamed seamount chain ~240 km west of the Hawaiian island of Kauai in the Central Pacific. The chain is composed of seven seamounts that rise roughly 2,000 m from the abyssal seafloor to summit depths of 1,800 m to 1650 m. The seamounts are each 15–25 km in diameter and display typical structures, including elevated ridges or rift zones arrayed radially around the summit. The seamount chain sits between the Mid-Pacific Mountains to the southwest and the Hawaiian chain to the northeast and is bracketed in the northwest and southeast by Necker Ridge and the Molokaʻi Fracture Zone, respectively (Figure 1).

The primary exploration objectives were to map the seafloor to fill bathymetric gaps, identify the distribution and abundance of deep-sea benthic fauna, and evaluate the extent and conditions of iron-manganese (Fe-Mn) crust formation on seafloor rocks. We conducted ROV transects with *Hercules* from the seamount flanks, near their bases, to their summits, crossing potential depth-dependent biological gradients. A total of five ROV transects were run on five seamounts (provisionally identified as B, C, D, F, G), each along a distinct radial azimuth in order to evaluate the potential role of prevailing current directions on biological density and diversity and Fe-Mn crust development (Figure 2).

Seamount chains provide important markers for paleo-tectonic reconstructions, illustrating when and where magmatic activity occurred and how plate motion has varied through time. The origin of this unexplored seamount chain remains in question. Early geophysical studies of the seamounts' magnetic orientation suggest a Cretaceous age (>250 million years) and a location of origin more than 2,000 nautical miles to the southeast (Schimke and Bufe, 1968), consistent with the Mid-Pacific Mountains and other magmatic features of the region. Alternatively, the seamounts may have formed more recently (~5 million years ago) from the Hawaiian mantle plume, as their position is also consistent with the Hawaiian Arch that forms a volcanic "halo" around the Hawaiian chain (Normark and

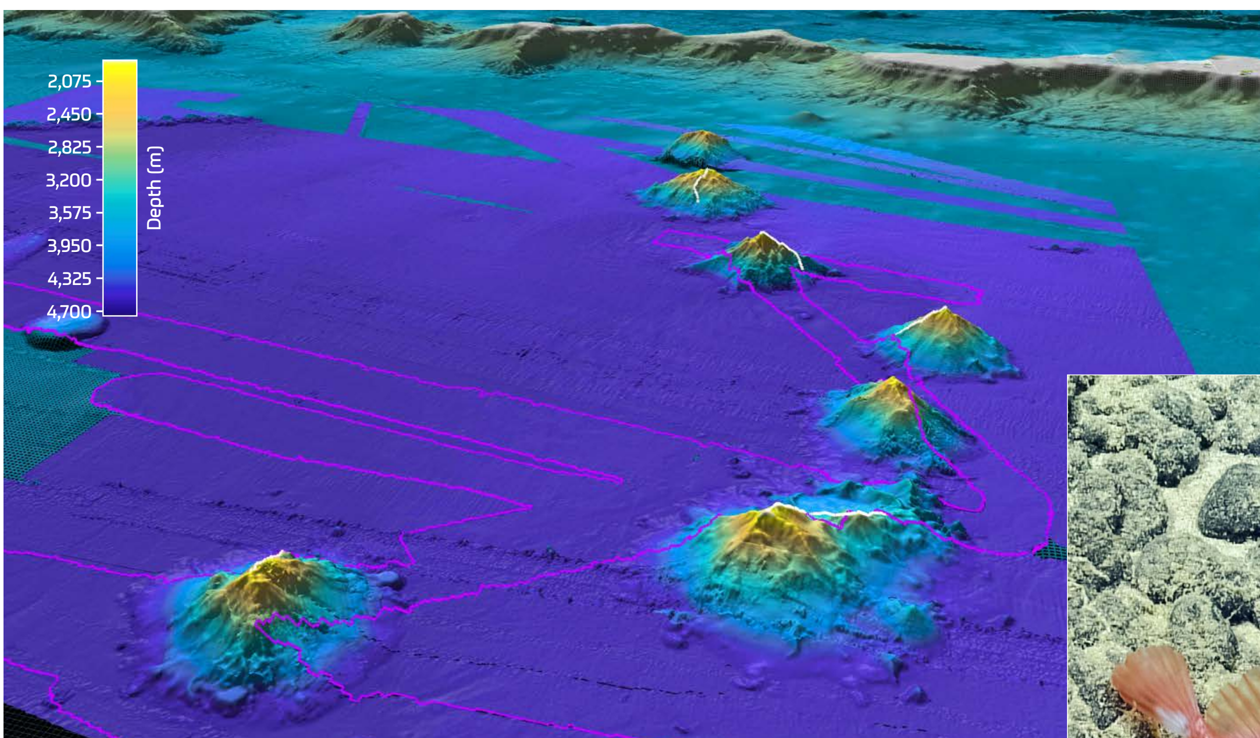

FIGURE 1. Perspective view to the north of the unnamed seamount chain. The summits of these seamounts rise to ~2,000 m depth from the abyssal seafloor at ~5,000 m depth. Newly mapped seafloor that filled bathymetric gaps is highlighted in magenta. White lines show ROV *Hercules* dive tracks.

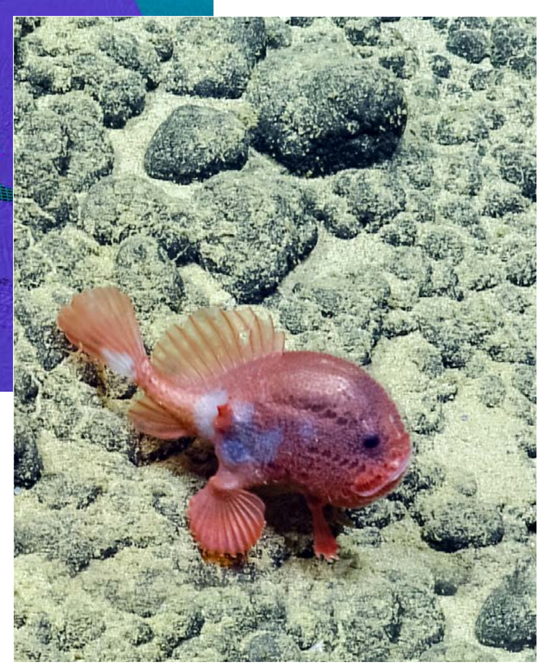

FIGURE 2. The bathyal fish *Chaunacops roseus* rests on lightly sedimented Fe-Mn oxyhydroxide coated basalt on the flanks of an unexplored seamount.

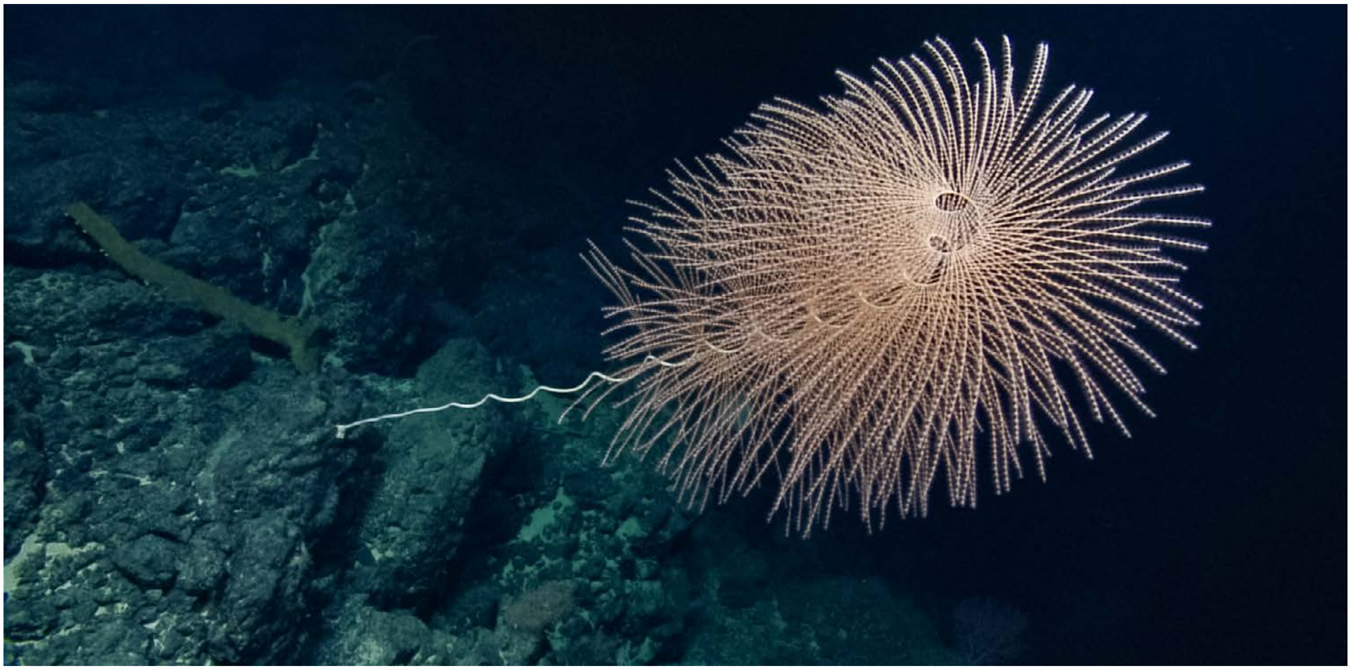

FIGURE 3. *Iridigorgia* soft corals were common on the seamount flanks, especially on ridges where their upright habit allows them to take advantage of upwelling currents.

Shor, 1968). Geochemical analyses of recovered samples will help constrain the magmatic source and provide critical evidence of the seamounts' age, which will yield important context for the distribution and grade of rare metals contained in their Fe-Mn crusts, as well as the thickness and thus total metal content of their deposits.

Our initial exploration of this region showed that all hard surfaces displayed a thick Fe-Mn crust. Despite this observation, it was possible to identify the volcanic and geologic morphology of the seafloor. We found a wide range of lava morphologies on the seamounts, including smooth sheet flows on steep slopes, pillow lavas on ridges, lobate lavas on low-relief benches on the flanks, and massive, columnar-jointed flows most commonly near the summits. Between the seamount ridges/rift zones, we found valleys filled with volcanic breccia as well as regions of heavy sedimentation, most of which were blanketed by extensive fields of manganese micro-nodules. The micro-nodules ranged in size from 10 mm to 60 mm in diameter and were surrounded by small, angular basalt fragments and sediment. In addition to micro-nodules, sedimented regions were found to be coated by Fe-Mn pavement that likely represents the coalescence of Fe-Mn micro-nodules. Many of the nodule fields showed evidence of active downslope movement of material, including the collection of nodules in the downslope shadows of large boulders, sorting of nodules by size, and the partial burial of nodule fields by sediment.

A total of 41 rock samples were collected on ROV dives at roughly equally spaced depths between the seamounts' bases and their summits for subsequent geochemical analyses of the basalt and Fe-Mn crusts. At most rock sample locations, a companion seawater sample was collected for comparison to crust trace metal concentrations. In addition, a few samples of manganese micro-nodules were collected using the ROV scoop. The thickness of Fe-Mn crust, examined on a small subset of samples, was 35–40 mm, much thinner than the crusts on intact volcanic surfaces.

Seamounts within the chain, along with others in the Central Pacific, provide hard substrate for sessile fauna; span significant depth-dependent chemical, light, and pressure gradients; and induce complexity in seawater currents, which makes them an important marine habitat. Because of these characteristics, seamounts are viewed as potential oases of benthic life in the deep ocean. The isolation of individual seamounts and chains of seamounts in the Central Pacific provide a natural laboratory for examining the range and potential endemism of benthic fauna. This seamount chain is proximal to ridges (e.g., Necker Ridge) that are hypothesized to act as genetic conduits, but their isolation and greater depth may make them less viable for genetic flow. Benthic organisms observed were dominated by sponges and corals (Figure 3), and differences in community composition were noted between abyssal and bathyal depths. At abyssal depths, sediment mounds created by burrowing organisms were observed, and spoon worms were identified at some of the mounds. At seamount summits, bamboo corals dominated high densities of deep-water corals that were found in patches.

The livestream of the expedition was viewed over 280,000 times, and during the cruise we connected with approximately 3,000 students across 17 US states, Canada, Czech Republic, and South Korea via 46 ship-to-shore connections.