Lu‘uaeaahikiikapapakū: Ancient Volcanoes in Papahānaumokuākea Marine National Monument

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E/V *Nautilus* expedition Lu‘uaeaahikiikapapakū (NA134) ROVs *Hercules* and *Argus* along with the ship’s EM302 multibeam sonar to explore the Voyager Seamounts located in the southern “expansion” area of Papahānaumokuākea Marine National Monument (PMNM). The lineation of these seamounts suggests they could be a southerly extension of the poorly delineated Wentworth seamount chain located north of the Hawaiian Ridge. Given the lack of geochemical constraints and age determinations of these seamounts, we tentatively hypothesize that they are an extension of the Wentworth chain comprising an age-progressive seamount track (Garcia et al., 1987; Pringle and Dalrymple, 1993). A major focus of the expedition was to sample rocks from these seamounts to test this geologic origin hypothesis.

Thirteen ROV dives were completed on nine of the Voyager Seamounts, none of which had been previously explored with modern techniques (Figure 1). During the ROV surveys, 91 rock samples were collected for $^{40}Ar/^{39}Ar$ age determinations and for chemical analyses to determine the similarity of their basalts to those of the Wentworth seamounts. Eighteen highly altered rocks with parallel water samples plus two sediment cores were collected to determine microbial ecosystem services and mineral content for the purpose of examining microbe-mineral interactions in ferromanganese crusts (Figure 2).

In addition to geological sampling, ROV surveys documented the seamounts’ biological communities, particularly looking for high density coral and sponge communities similar to those previously observed in the Musicians Seamounts and on a number of banks within the

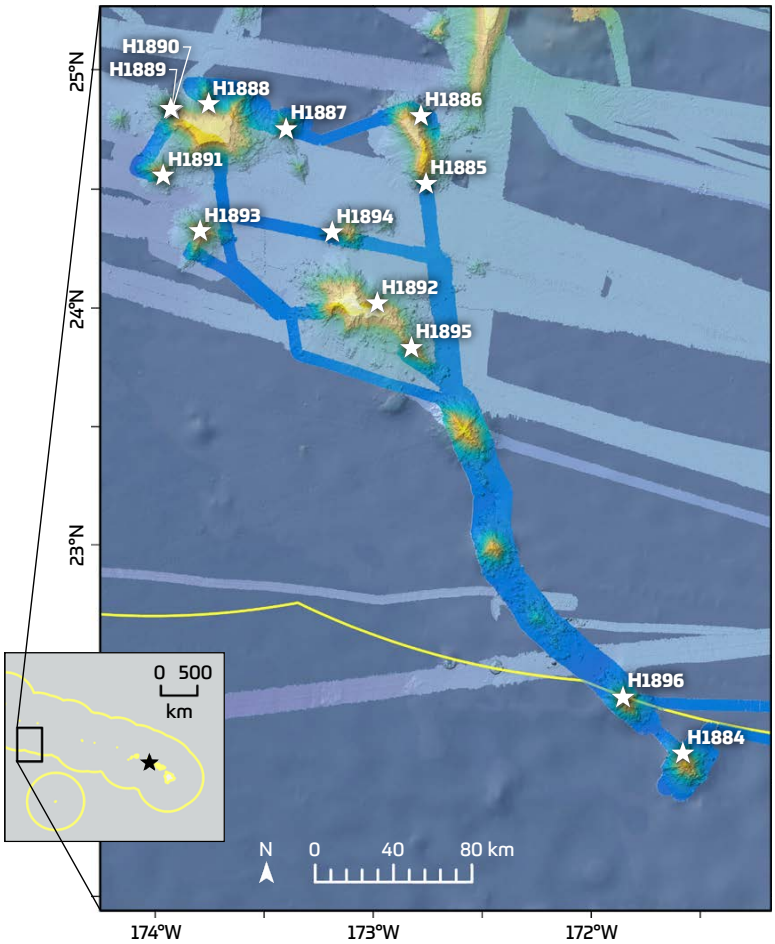
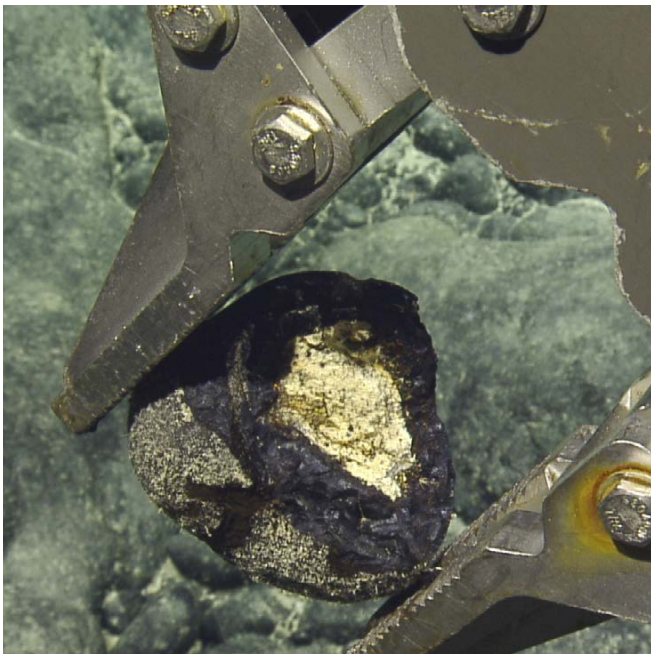


FIGURE 1. Map showing the dive locations (white stars) during E/V *Nautilus* expedition Lu‘uaeaahikiikapapakū in the Voyager Seamounts. The inset map shows the location of the expedition in relation to the main Hawaiian Islands, with Honolulu marked by a black star. Dark blue areas are unmapped seafloor, light blue areas were previously mapped, and bright blue indicates seafloor mapped on this expedition (NA134). The yellow line denotes the limits of the US Exclusive Economic Zone. *Image credit: Erin Heffron*

FIGURE 2. The arm of ROV *Hercules* collects an altered rock sample for analysis of microbial ecosystem services and mineral content in seamount rocks.



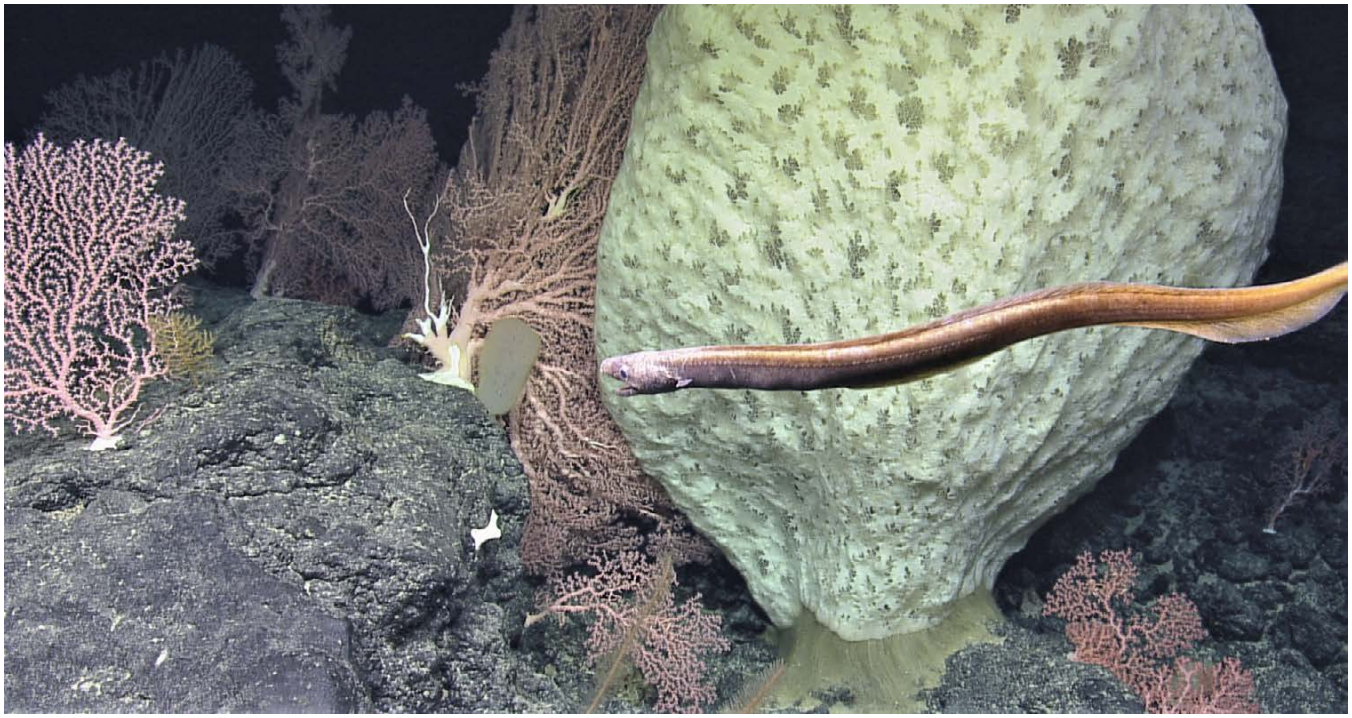


FIGURE 3. Video capture of the high density Tamana Seamount animal community, including several species of corals and sponges along with a cutthroat eel (family Synaphobranchidae).

PMNM. Eventual annotation of the video will determine, among other things, the diversity and density of animals observed during each of the dives. Even before these data are available, it is clear that at least two of the seamounts, Don Quixote and Tamana, host very high densities of corals and sponges while there are moderately high density communities on Haʻaheo and Hoʻoikaika (Figure 3). Very sparse communities were observed on several other seamounts, including Euphemia and Sovereign. Whether a seamount has a volcanic summit or is flat-topped (i.e., a guyot) does not seem to be a particularly important factor in determining the density of communities: Don Quixote and Haʻaheo are guyots while Hoʻoikaika is not. Although Tamana is a guyot, the dive site was a large volcanic ridge extending southeast from its base that may have been created from a different eruptive event than the main guyot. It is important to note that dive site selection was biased toward rift zone ridges at 1,000–3,000 m depth on virtually all seamounts, because these features were known to have suitable rocks for age dating as well as suitable environmental conditions (i.e., strong current flow) for high density community development. During dives, there was minimal evidence of marine debris, and one fossilized beaked whale bone was observed on Don Quixote Seamount.

Ninety-four macrobiology specimens were collected, some of which may prove to be potential new species or new records of species for the PMNM. These included 15 sponges, all but three of which (*Asbestopluma* sp., *Abyssocladia,* and an unidentified demosponge) were hexactinellids. The cnidarians included 11 hexacorals (five Actiniaria, four Antipatharia, two Scleractinia) and 16 octocorals. Other invertebrates included stalked and unstalked crinoids, polyplacophoran mollusks, and a chirostylid squat lobster.

Forty-seven water samples were collected to support an eDNA study of deep-sea coral habitats in the monument that began in 2018 during *Nautilus* expedition NA101. Thirty-six of these samples were collected where the animal community density was higher, with 11 samples as background from lower density areas.

The total area mapped by multibeam sonar was 21,328 km^2 (18,817 km^2 in the US Exclusive Economic Zone), including filling in of some gaps in existing coverage. In addition, previously undocumented Voyager Seamounts that were completely mapped included Paul, Starling, Akamai, Hoʻoikaika, an unnamed seamount east of Don Quixote, and the group's most southerly seamount, which we temporarily designated "Seamount A." All of the newly mapped seamounts were conical in shape, indicating that they had never reached above the sea surface. Complete or near complete coverage now exists for all 14 Voyager Seamounts.

In accordance with guidance from the Native Hawaiian Cultural Working Group of the Office of Hawaiian Affairs, ceremonial protocol was observed at the beginning and end of each science operation in the PMNM, as well as during all ROV dives, in recognition that the working area is considered sacred in Native Hawaiian culture. Shipboard speakers of ʻŌlelo Hawaiʻi (Hawaiian language) helped visiting scientists and crew to learn these protocols and led engagement with Native Hawaiian audiences during the expedition. In total, 77 live ship-to-shore interactions were conducted, including 11 in ʻŌlelo Hawaiʻi.