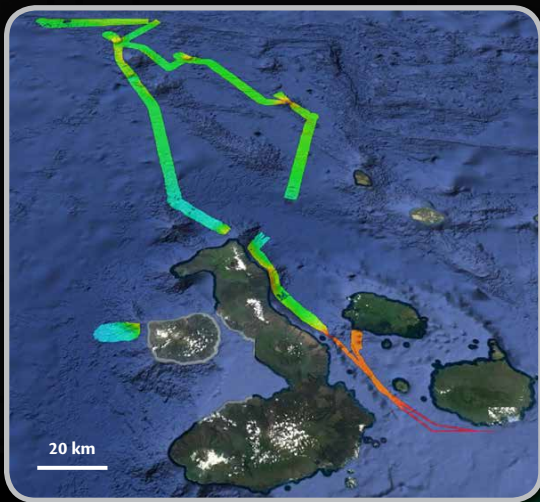


Mapping the Eastern Pacific Ocean: Nautilus Mapping 2015

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E/V *Nautilus* conducts multibeam mapping surveys to create accurate bathymetric maps for science and for remotely operated vehicle (ROV) navigation. In addition, the ship collects bathymetric data during transits between ROV dive locations in previously unmapped areas that may lead to opportunities for future exploration. Between 2013 and 2015, *Nautilus* mapped over 211,355 km² of seafloor in the Mediterranean, Atlantic, Caribbean, Gulf of Mexico, and eastern Pacific regions. Nearly 87,000 km² were collected in 2015, due in large part to two long-distance transits from Galveston, TX, to the Galápagos, and from the Galápagos to San Diego, CA. The following summarizes *Nautilus* mapping during the 2015 field season, including some highlights.

Figure 2. Galápagos Marine Reserve mapping coverage by *Nautilus*.

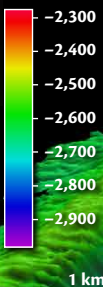


GALÁPAGOS RIFT AND MARINE RESERVE

The US Navy first mapped the Galápagos Spreading Center in 1976 with their then-classified cutting-edge mapping technology, the Sonar Array Sounding System (SASS), on USS *Bowditch*. Their 12 kHz system produced 60 discrete depth points per swath. By comparison, the EM 302 installed on *Nautilus*, a 30 kHz system, can collect up to 864 soundings per ping. The maps made by SASS were used by scientists to plan deep-towed camera surveys that led to revolutionary scientific discoveries such as hydrothermal vents that host chemosynthetic life forms (van Andel and Ballard, 1979). Since their initial discovery, these sites have been resurveyed several times, including with the Autonomous Benthic Explorer (ABE), which collected data for making high-resolution seafloor maps (Shank et al., 2003). In 2015, *Nautilus* mapped the area from the Rosebud and Rose Garden vents to the area where a water column anomaly was detected in 2011 by *Okeanos Explorer* (Figure 1). Despite the remarkable accuracy of the SASS maps, and the fact that the seafloor is changing rapidly at this spreading center (average seafloor spreading rate of 5–6 cm yr⁻¹, resulting approximately 2.3 m of motion over 39 years), changes are not detectable at the 25 m horizontal grid resolution of the maps.

Additionally, *Nautilus* mapped over 5,600 km² in the Galápagos Marine Reserve to fill in gaps in existing data (Figure 2). The combined mapping products are being assembled by scientists at Woods Hole Oceanographic Institution to provide information to Ecuador to aid in their current Marine Reserve rezoning project.

Figure 1. Galápagos Spreading Center digital elevation model from *Nautilus* EM 302 data looking westward along the rift, 25 m grid, 3x vertical exaggeration. Note the long, linear faults that bound the central, elongated volcanic edifice that is also cut by faults.



GALÁPAGOS TO SAN DIEGO

Nautilus completed its second longest mapping transit to date between the Galápagos Islands, Ecuador, and San Diego, CA. The transit provided an opportunity to survey previously unmapped areas and also to train the science team on multibeam and sub-bottom sonar mapping and processing procedures. With a limited staff to maintain 24-hour mapping watches, the small group size allowed all participants to become immersed in the seafloor mapping process. From data acquisition to processing and creating products, each watchstander gained hands-on experience on the proper execution of each step.

During the transit, *Nautilus*' multibeam echosounder was able to discern features on the seafloor that global satellite-derived altimetry had never detected. The multibeam echosounder on *Nautilus* has a horizontal resolution of ~50 m in a water depth of 3,500 m, while satellite-derived bathymetry can resolve features to only ~5 km. *Nautilus*' sonar system was able to map in detail entire seamounts and abyssal hills that do not appear in satellite-derived terrain models.

On this transit, the *Nautilus* mapped nearly 44,700 km² of seafloor, second only to the trans-Atlantic crossing in 2013. After creating digital elevation models from the data, watchstanders imported the maps into Google Earth and compared the echosounder maps to the mostly satellite-derived seafloor terrain to identify new features. Several were detected, including a roughly circular seamount with a crater (8 × 5 km) that rises 350 m above the abyssal depths of 3,750 m, 1,000 nm west of Colombia (Figure 3). The crater likely formed by collapse, or partial collapse, during or following a volcanic eruption.

A two-day mapping survey of areas of interest in the California Borderland helped identify and locate active methane seeps. This knowledge was then used to determine larger areas for mapping surveys and ROV dive sites on the subsequent two cruises (Figure 4).

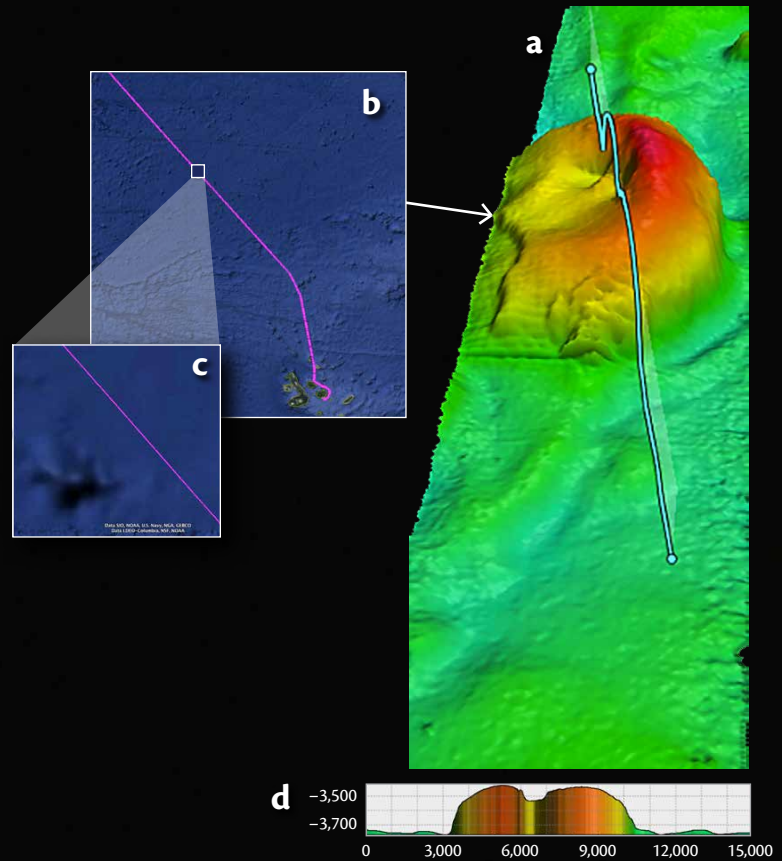


Figure 3. (a) A roughly circular seamount with a crater was discovered during the *Nautilus* mapping transit (pink line in b) between the Galápagos and San Diego. (c) An earlier, mostly satellite-derived, seafloor terrain map of the same area showed no indication of the crater. (d) NW-SE profile from across the crater at 6x vertical exaggeration.

CALIFORNIA BORDERLAND

Four new seeps were discovered offshore of California between Los Angeles and San Diego. One of the seeps was located on Redondo Knoll, a feature fully mapped for the first time by *Nautilus*, while a second was located to the northwest of the knoll. Seeps were also discovered along a submarine river channel off Point Dume (see pages 41–42). Additional mapping off of Catalina Island helped reveal new details around Catalina Canyon. The data have been provided to the Channel Islands National Marine Sanctuary to aid in a multi-institution mapping effort. *Nautilus* will return to the region in 2016 to continue to map and discover new seafloor features and habitats in our own backyard.

Given that only about 10% of the seafloor has been mapped by multibeam echosounders, the discoveries made with *Nautilus*' 2015 mapping data clearly indicate that much is left to be discovered on the seafloor.

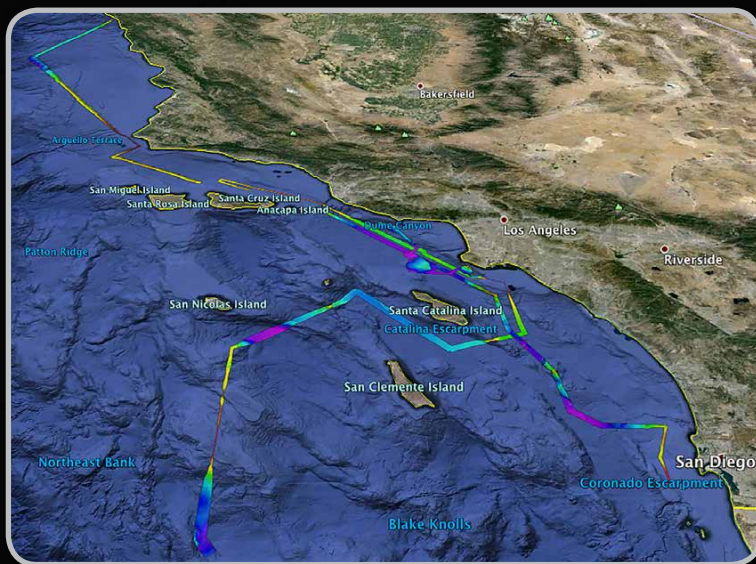


Figure 4. *Nautilus* multibeam data visualized in Google Earth shows the coverage in the California Borderland area from the 2015 cruises.