Seafloor Mapping Surveys at 1-cm Resolution using an Articulating ROV Toolsled

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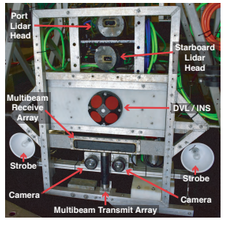
Introduction

The Monterey Bay Aquarium Research Institute (MBARI) has developed a low altitude, ROV-based seafloor mapping system that combines lidar laser ranging, multibeam sonar, and stereo photographic imagery to survey steep and complex terrain. When operated at a 3 m standoff, this system maps seafloor topography with a 1 cm lateral resolution and simultaneously collects 2 mm resolution color photography. The survey sensor frame is articulated within the toolsled from downward looking to forward looking to keep the sensors oriented normal to the seafloor being surveyed.

Here we present two surveys using MBARI's ROV Ventana on Sur Ridge, offshore Central California. These data demonstrate the utility of combined acoustic and optical sensors for mapping benthic habitats at the scale of the animals that live there, and for mapping large sessile animals such as sponges and corals.

Additional 2018 survey targets included a methane gas seep mound at 800-m depth in Santa Monica Basin and the trace of the active San Diego Trough Fault where it crosses the San Gabriel Channel, both offshore Southern California. The system was also integrated without articulation on the Schmidt Ocean Institute's ROV SuBastian and used to survey the Auka Hydrothermal Vent Field in the South Pescadero Basin, Gulf of California, during the November 2018 R/V Falkor expedition FK181031.

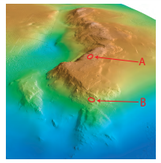


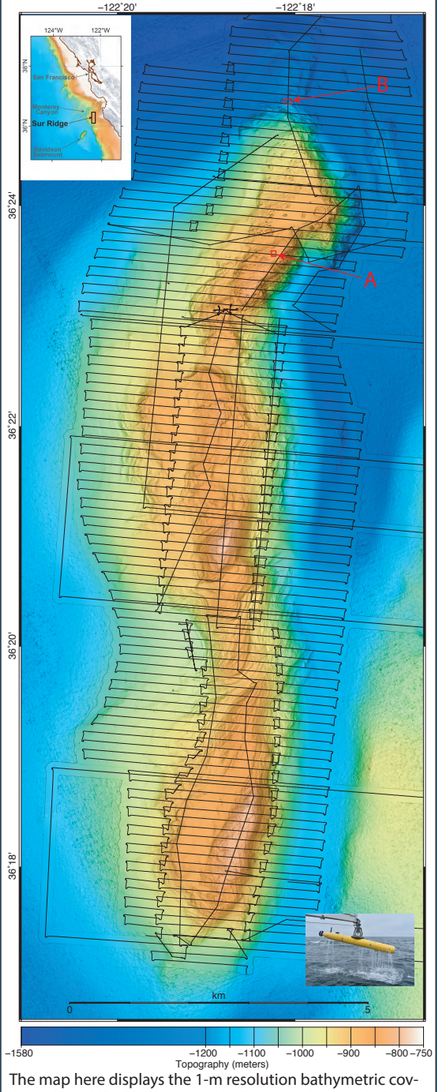
The MBARI Low Altitude Survey System

The highest resolution bathymetry data are collected using a newly developed 3D at Depth Wide Swath Subsea Lidar (WiSSL) laser scanner. This lidar scans continuously across a 90° field of view, achieving a 1 cm sounding spacing at a 3 m altitude for speeds <= 1.0 m/s. Each sounding has a laser footprint of 0.8 cm. A 400-kHz Reson 7125 multibeam sonar provides 5 cm lateral resolution bathymetry across a 135° swath. Dual Prosilica GX1920 2.4 Mpixel color cameras provide color stereo photography of an 80° field of view illuminated by dual xenon strobes with a 2 mm raw image pixel resolution. Position and attitude data are provided by a Kearfott SeaDevil Inertial Navigation System (INS) integrated with a 1200 kHz Teledyne RD Instruments Doppler velocity log (DVL) and a Paroscientific pressure sensor. The sensor package is mounted into an articulating frame within an ROV Ventana toolsled that rotates from pointing the sensors vertically down to horizontally forward, allowing surveys of flat to vertical seafloor. The articulation is automated by closing a control loop around the difference between the forward and backward beams of the DVL. The ROV survey paths are controlled autonomously in two modes. On slopes less than 20°, survey lines defined by waypoints are achieved by line-following using the realtime INS data. On steeper slopes, survey lines are defined as constant-heading depth transects. In either case, a 3-m survey line spacing insures overlapping coverage between adjacent lines.

Sur RIdge

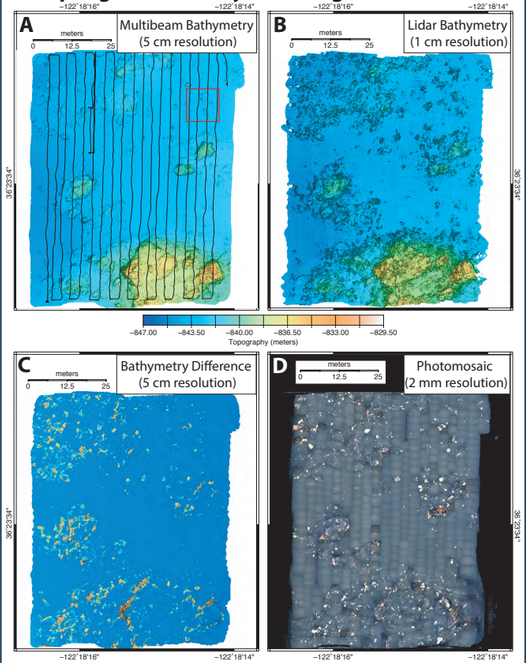
Sur Ridge is located south of Monterey Bay within the Monterey Bay National Marine Sanctuary. The crests and slopes of this 3 km east-west, 20 km north-south ridge have robust communities of deep sea sponges and corals.



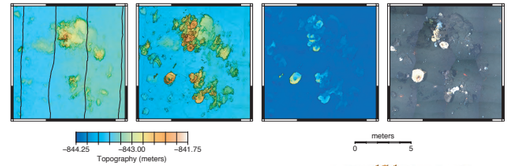


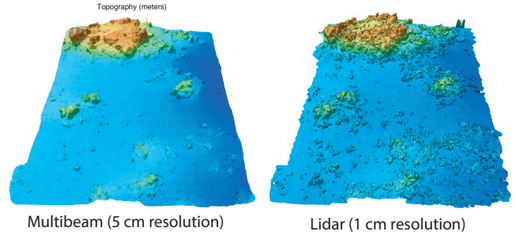
The map here displays the 1-m resolution bathymetric coverage from MBARI Mapping AUV Surveys, along with the locations of the two low altitude surveys shown to the right. Site A on the northern crest of Sur Ridge is dominated by sponges. Site B on the steep northern slope is dominated by deep sea corals.

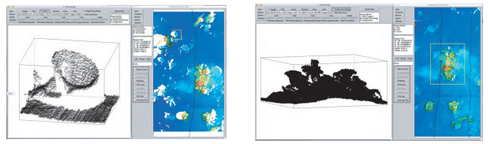
A: Sponge Community - Sur Ridge Northern Crest



A) ROV track lines overlain on multibeam bathymetry (5 cm resolution). The red box shows the detailed map location. B) Lidar bathymetry (1 cm resolution). C) Difference between lidar and multibeam bathymetry, revealing soft animals detected by the lidar but not the multibeam (5 cm resolution). D) Photomosaic of uncorrected images at 2 mm resolution.

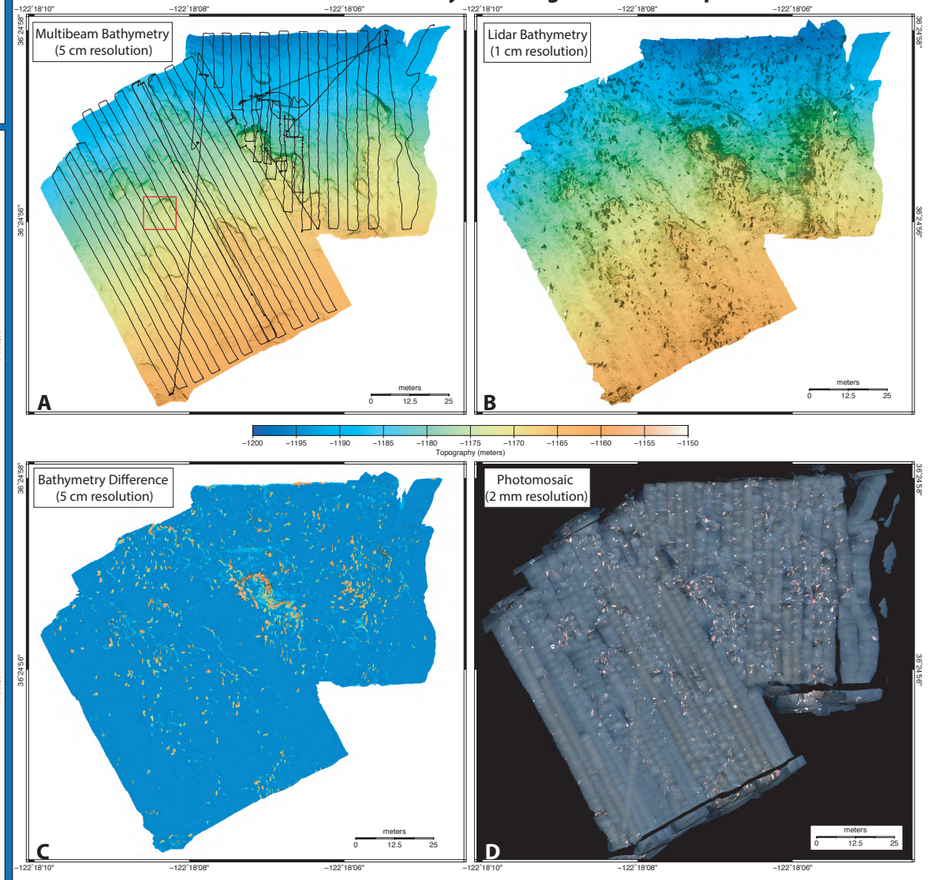




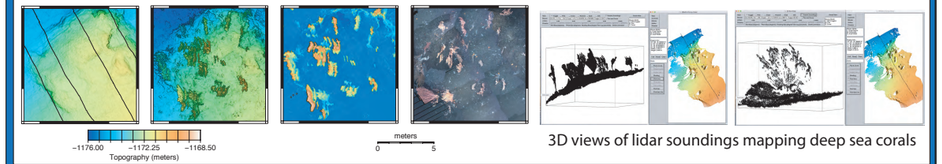


3D views of lidar soundings mapping sponges

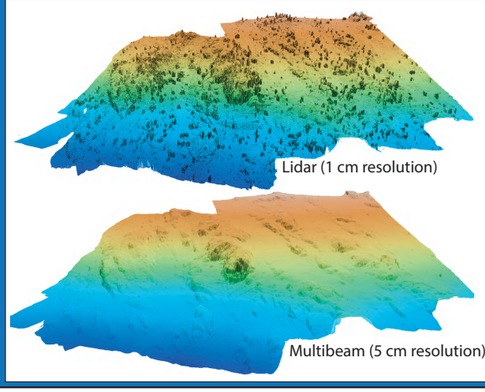
B: Soft Coral Community - Sur Ridge Northern Slope

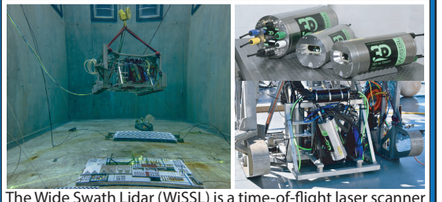


A) ROV track lines overlain on multibeam bathymetry (5 cm resolution). The red box shows the location of the detailed maps below. B) Lidar bathymetry (1 cm resolution). C) Difference between lidar and multibeam bathymetry, revealing soft animals detected by the lidar but not the multibeam (5 cm resolution). D) Photomosaic of uncorrected images at 2 mm resolution.



3D views of lidar soundings mapping deep sea corals





The Wide Swath Lidar (WiSSL) is a time-of-flight laser scanner (lidar) with two optical heads. Each head scans a 50° field of view. With a 6° overlap, the overall swath width is 94°, or about twice the altitude wide. In moderately clear water, about 70,000 useful soundings per second are recorded. The maximum range in clear water is about 15 m. The WiSSL was designed and built by 3D at Depth to MBARI specifications.

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