Enabling New Techniques in Environmental Assessment Through Multi-Sensor Hydrography

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Over the past fifteen years, improvements in autonomous underwater vehicles (AUV) and sonar technologies have yielded AUVs optimized for 1-m scale seafloor mapping at abyssal depths. The availability of these higher definition mapping tools has revealed a variety of seafloor features not seen before, and allowed for measurement of seafloor changes associated with phenomena such as submarine volcanic eruptions and sediment transport in canyons. A group of scientists and engineers at the Monterey Bay Aquarium Research Institute are developing a suite of complementary survey tools aimed at producing 1-cm resolution bathymetric models co-registered with 2-mm pixel color photography. The goal is to produce quantitative documentation of both geological and biological features that will allow change over time to be assessed at vertical and lateral scales approaching one centimeter. The current suite of tools combines multibeam sonar, stereo cameras with dual xenon strobes, lidar, and an inertial navigation system (INS) aided by Doppler velocity log (DVL). This sensor package is mounted beneath remotely operated vehicles (ROVs) and used to map the seafloor from altitudes of two to three meters. Moderately clear water conditions allow for a 3-m altitude and 1.5 m line spacing, in turn allowing a 100-m by 100-m survey to be accomplished in a single 10-hour on bottom ROV dive. All surveys are conducted with scripted station-keeping control loops operating on the ROV, resulting in more efficient area coverage through tended automation. The ultimate goal of this development project is to field this low-altitude survey system from an AUV to map complex terrain in the deep ocean.

Surveys conducted with this prototype system clearly show the benefits for studying fine scale changes in the seafloor. Repeat surveys over multiple years have been conducted at two sites in the morphologically active floor of Monterey Canyon. The initial results show how progressive changes in seafloor morphology can be quantified at this resolution. Surveys of a chemosynthetic biological community at 2850-m depth show that individual chemosynthetic clams can be observed in both lidar bathymetry and photographic imagery. The centimeter scale bathymetry also resolves trails left by moving individual animals that are not visible in the photography. Repeated surveys succeed in quantitatively measuring how the community changes over time. Similarly, repeated surveys of the Monterey Canyon axis at 1850-m depth resolve subtle transitions from depositional to erosional textures, and reveal the changes associated with frequent sediment transport events down the active canyon. Two low-altitude surveys have been conducted on the 800-m deep crest of Sur Ridge, offshore Pt. Sur in Central California. This rocky, high relief environment hosts sponge and deep water coral communities. Here the combination of acoustic and optical sensing proves particularly useful for quantitatively characterizing the benthic community. The multibeam sonar measures bathymetry without sensing soft animals, while the lidar measures a surface that includes these animals. Subtracting the multibeam bathymetry from the lidar bathymetry maps the locations and volumes of soft animals. Simultaneously, the photographic imagery allows the animal health to be assessed (e.g. live sponges are white, dead sponges are brown).