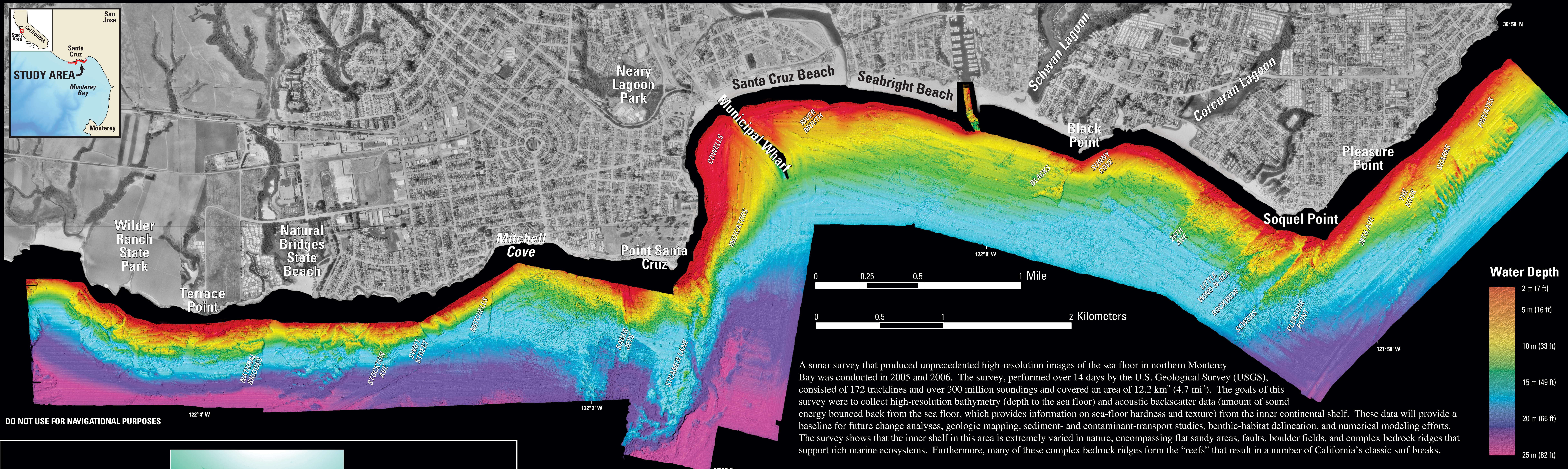
Views of the Sea Floor in Northern Monterey Bay, California

Curt D. Storlazzi, Nadine E. Golden, and David P. Finlayson

2008

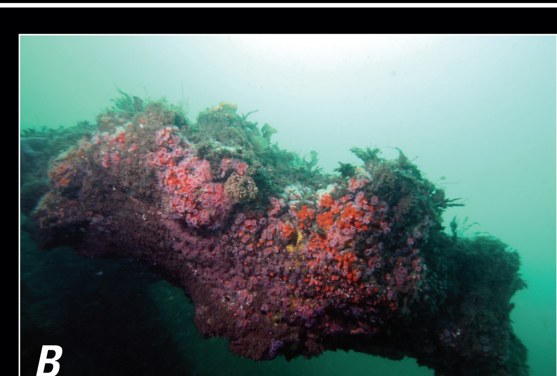


A sonar survey that produced unprecedented high-resolution images of the sea floor in northern Monterey Bay was conducted in 2005 and 2006. The survey, performed over 14 days by the U.S. Geological Survey (USGS), consisted of 172 tracklines and over 300 million soundings and covered an area of 12.2 km^2 (4.7 mi^2). The goals of this survey were to collect high-resolution bathymetry (depth to the sea floor) and acoustic backscatter data (amount of sound energy bounced back from the sea floor, which provides information on sea-floor hardness and texture) from the inner continental shelf. These data will provide a baseline for future change analyses, geologic mapping, sediment- and contaminant-transport studies, benthic-habitat delineation, and numerical modeling efforts. The survey shows that the inner shelf in this area is extremely varied in nature, encompassing flat sandy areas, faults, boulder fields, and complex bedrock ridges that support rich marine ecosystems. Furthermore, many of these complex bedrock ridges form the "reefs" that result in a number of California's classic surf breaks.

DO NOT USE FOR NAVIGATIONAL PURPOSES

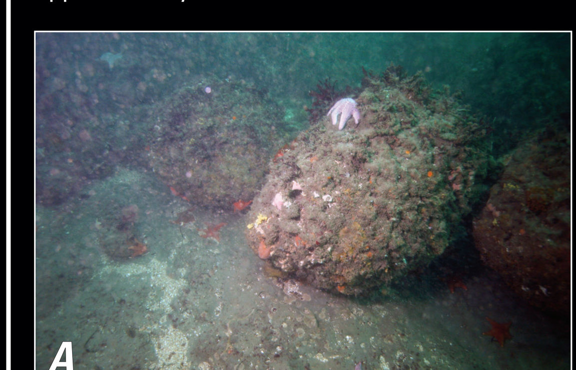
Figure 1. Map view of northern Monterey Bay showing the extent of sea-floor mapping. Labels in all-uppercase letters are names of surf breaks; the names are offset offshore of the reefs in the direction of wave propagation to preserve the detail of the reefs where the waves break. The sea floor is portrayed as a shaded-relief surface created from a 1-m grid that is color-coded by depth, with reds for the shallowest values and purples for the deepest; black denotes regions where no data were collected. The land regions are depicted by USGS digital orthophotographs overlaid on USGS digital elevation models. The flat, smooth regions are generally sandy areas, while the rough, complex regions are areas where bedrock crops out on the sea floor. Many of these bedrock outcrops support the extensive kelp forests that typify most of the bay's northern coastline. The shore-parallel lineations observed in flat areas are data artifacts caused by motion of the survey vessel in rough seas and thus are not real features of the sea floor. As waves propagate into shallow water, they begin to interact with the sea floor (a process known as "shoaling") and their crests slowly bend to try to maintain their roughly parallel orientation to the bottom contours (known as "refraction"); wave energy moves perpendicular to the wave crests. In areas where the wave energy converges over the steep, abrupt topography of the bedrock reefs, such as off Point Santa Cruz (fig. 2) and Soquel Point (fig. 4), the waves rapidly slow down, shorten in length, and substantially increase in height relative to the areas on either side of the reefs. Northern Monterey Bay's spectacular surf breaks are created by this complex interaction between the geologic setting and oceanographic processes.

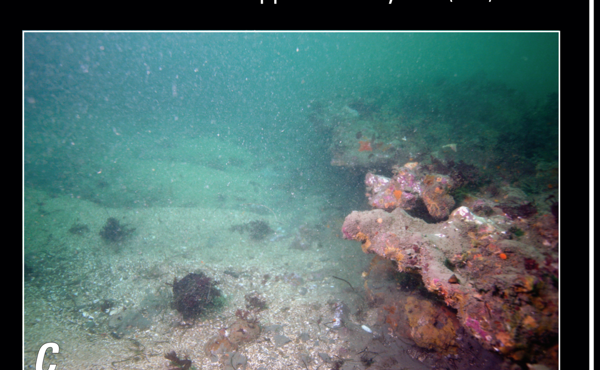
A. Photograph of three boulders, hypothesized to be resistant bedrock concretions eroded from the Santa Cruz Mudstone to the west, sitting on the relatively flat bedrock of the Purisima Formation southwest of Point Santa Cruz. The field of view is approximately 2 m (7 ft).



B. Photograph of a resistant bedrock layer covered by numerous types of colorful algae and cup corals off Point Santa Cruz. The field of view is approximately 1 m (3 ft).

C. Photograph of the eastern edge of the channel incised in a bedrock ridge off Point Santa Cruz. Large, shore-parallel sand waves cover the sand-filled channel. The field of view is approximately 2 m (7 ft).





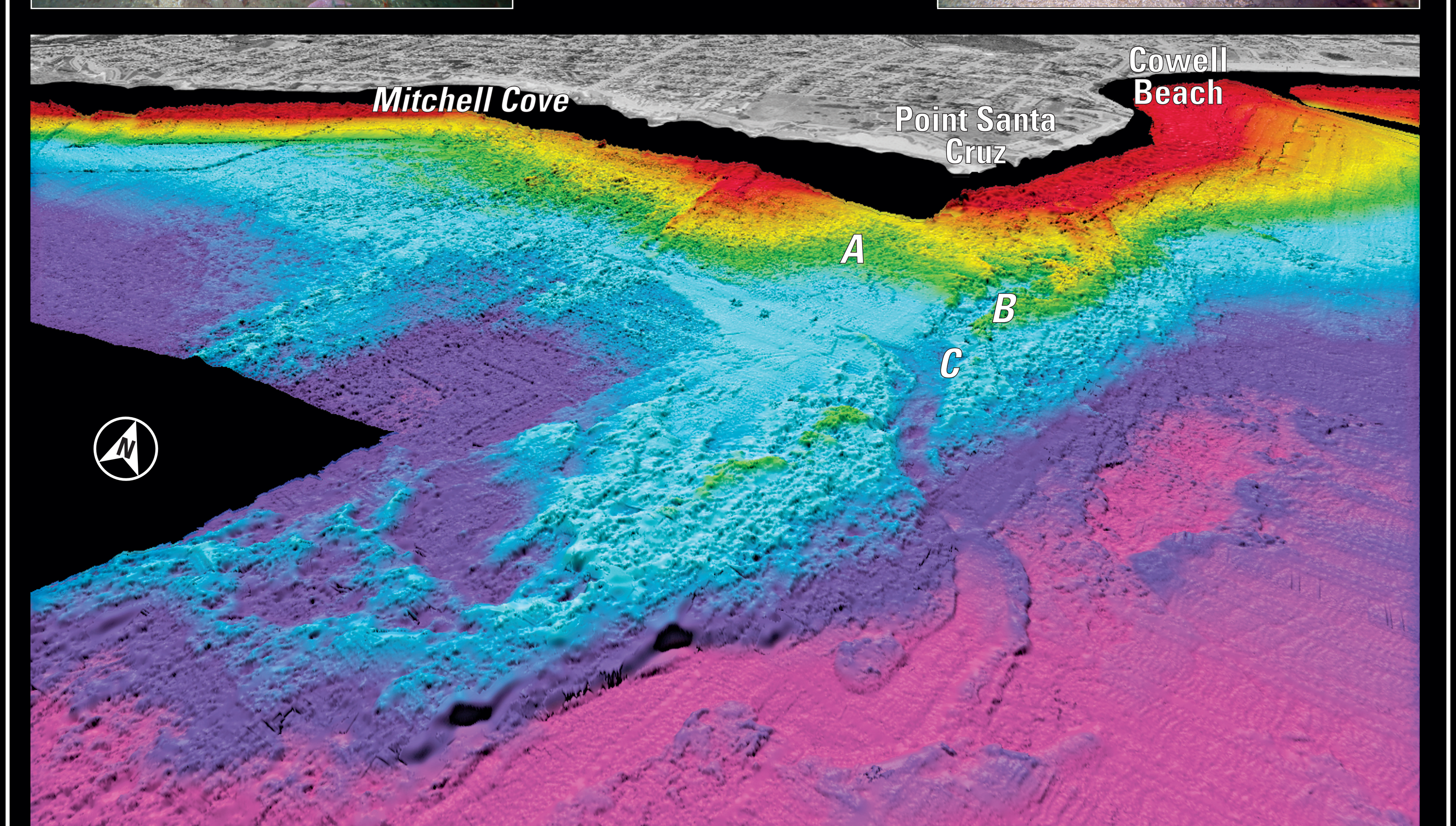


Figure 2. Oblique view to the northwest toward Point Santa Cruz. The southwest-trending bedrock ridge is composed of sandstone of the Purisima Formation, which crops out in Point Santa Cruz. The ridge runs more than 4 km (2.4 mi) offshore and forms reefs that focus the waves that break southeast of Point Santa Cruz at Steamer Lane. The irregular pattern of the shallow sea floor to the west of the bedrock ridge is a field of boulders hypothesized to be resistant bedrock concretions eroded from the Santa Cruz Mudstone that crops out west of Mitchell Cove. The sinuous channel that cuts across the bedrock ridge appears to have formed by erosion, possibly during a period of lower sea level; the abrupt change in water depth over this channel causes the gaps between Steamer Lane's second and third peaks. Letters denote locations of photographs shown above. See figure 1 for depth scale; the vertical exaggeration is 5x. Approximate distance across the bottom of the image is 1.0 km (0.6 mi).

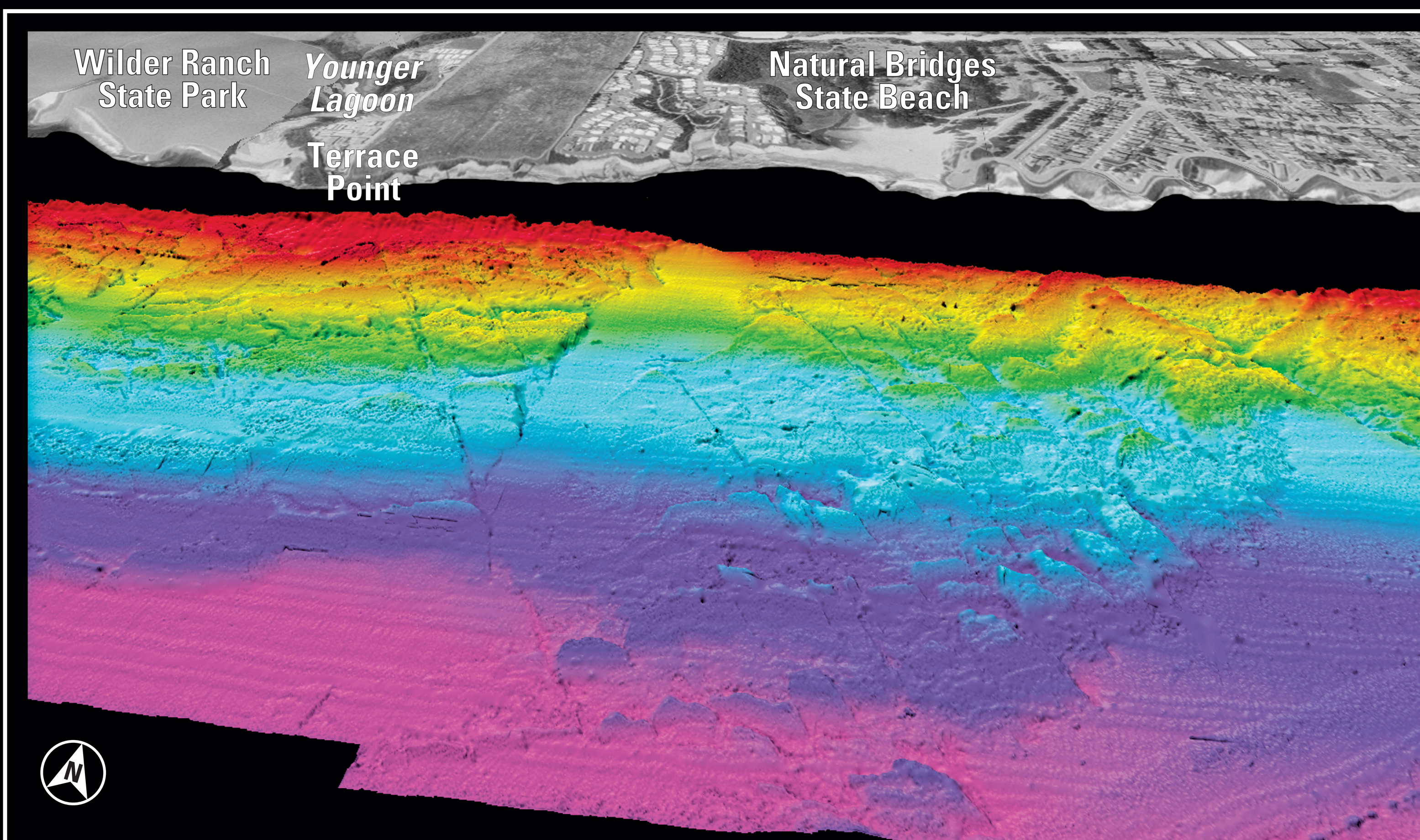
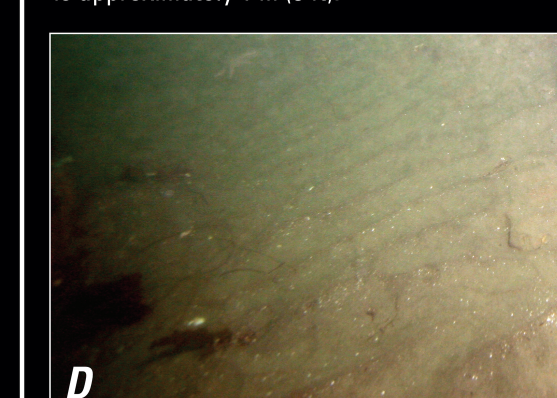
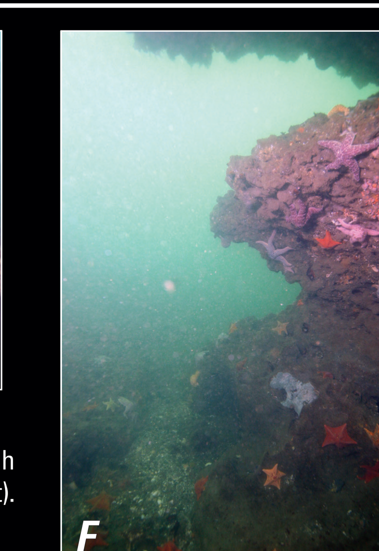


Figure 3. Oblique view to the northwest toward Terrace Point and Natural Bridges State Beach. The northwest-trending linear features are interpreted as faults offsetting the Santa Cruz Mudstone that crops out on the sea floor. The flat, shore-normal features that align with Natural Bridges State Beach and Younger Lagoon at Terrace Point are interpreted as old river channels that were incised into the sea floor during periods of lower sea level and later filled with sediment. The northeast-trending linear feature in the bottom right corner of the image is a line of boulders protecting the wastewater-treatment outfall pipe. See figure 1 for depth scale; the vertical exaggeration is 5x. Approximate distance across the bottom of the image is 2.2 km (1.4 mi).

D. Photograph of the sandy sea floor and drift kelp off Soquel Point. The sand here is finer grained than the material off Point Santa Cruz (see fig. 2*C*), presumably because of the lower wave energy at this location. The field of view is approximately 1 m (3 ft).



E. Photograph of resistant bedrock layers covered by numerous types of algae that support many fish species. The field of view is approximately 2 m (7 ft).



F. Photograph of resistant bedrock layers covered by numerous types of algae, cup corals, and sea stars. The field of view is approximately 2 m (7 ft).

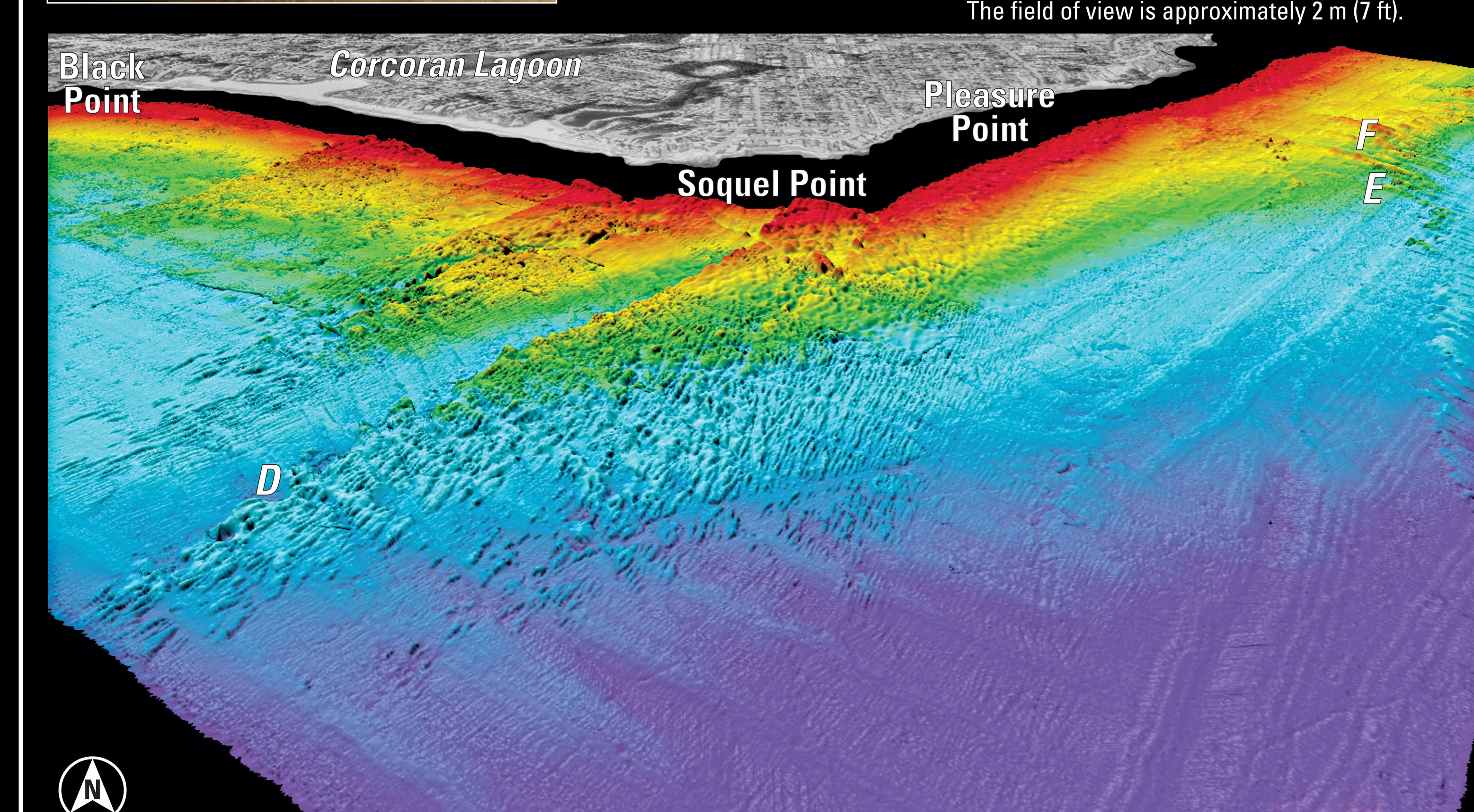


Figure 4. Oblique view to the north toward Soquel Point. The southwest-trending bedrock ridges, composed of southeast-dipping sandstone of the Purisima Formation, run more than 1.5 km (1 mi) offshore of the kelp beds that support many fish species. These bedrock ridges also form the reefs that focus the waves that break at 26th Avenue, Little Wind-n-Sea, Rockview, Sewers, and Pleasure Point. These bedrock ridges are highly fractured, probably because of movement along offshore faults. Letters denote locations of photographs shown above. See figure 1 for depth scale; the vertical exaggeration is 5x. Approximate distance across the bottom of the image is 1.2 km (0.7 mi).

Acknowledgments

This research was supported by the U.S. Geological Survey, the California Department of Boating and Waterways, the Santa Cruz County Redevelopment Agency, and the Santa Cruz County Department of Public Works. Gerry Hatcher and Mike Boyle (USGS) ran the bathymetric data acquisition systems while Jared Figurski, Randolf Skovan, and Jamie Grover (University of California at Santa Cruz) captained the R/V *Paragon*. Joshua Logan (USGS) helped collect the underwater photographs.

For more information on this study, go to http://walrus.wr.usgs.gov/

Files available at http://pubs.usgs.gov/sim/3007

For sale by U.S. Geological Survey, Information Services, Box 25286, Federal Center, Denver, CO 80225, 1-888-ASK-USGS

Manuscript approved for publication February 25, 2008

ISBN 978-1-4113-2092-5