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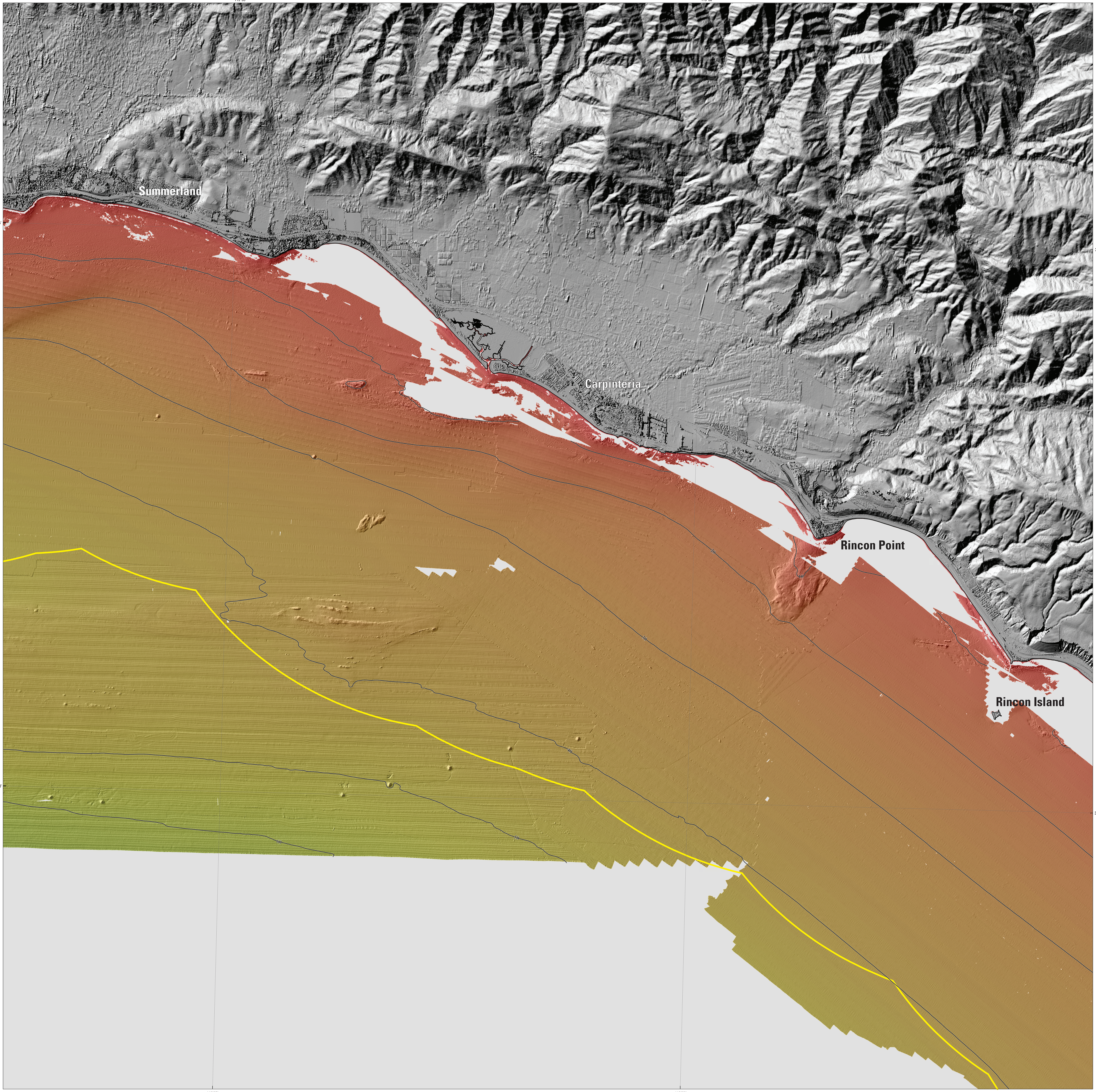
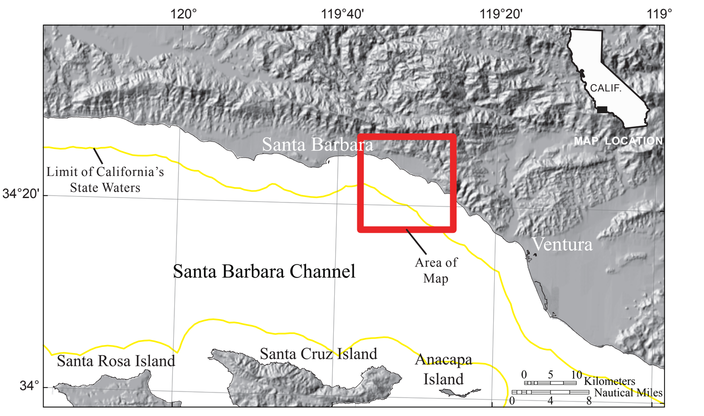
U.S. Department of the Interior
U.S. Geological Survey

Scientific Investigations Map 3261
Sheet 1 of 10
Pamphlet accompanies map





DISCUSSION

This colored shaded-relief bathymetry map of the Offshore of Carpinteria map area in southern California was generated from bathymetry data collected by California State University, Monterey Bay (CSUMB), by the U.S. Geological Survey (USGS), and by Fugro Pelagos for the U.S. Army Corps of Engineers (USACE) Joint Lidar Bathymetry Technical Center of Expertise (fig. 1). The southeastern nearshore and shelf areas, as well as the western midshelf area, were mapped by CSUMB in the summer of 2007, using a 244-kHz Reson 8101 multibeam echosounder. The western nearshore area, as well as the western outer shelf area, were mapped by the USGS in 2005 and 2006, using 117-kHz and 234.5-kHz SEA (AP) Ltd. SWATHplus-M phase-differencing sidescan sonars. The nearshore bathymetry and coastal topography were mapped for USACE by Fugro Pelagos in 2009, using the SHOALS-1000T bathymetric-lidar and Leica ALS60 topographic-lidar systems. All these mapping missions combined to collect bathymetry from the 0-m isobath to beyond the 3-nautical-mile limit of California's State Waters.

During the CSUMB mapping mission, an Applanix position and motion compensation system (POS/MV) was used to accurately position the vessel during data collection, and it also accounted for vessel motion such as heave, pitch, and roll (position accuracy, ±2 m; pitch, roll, and heading accuracy, ±0.02°; heave accuracy, ±5%, or 5 cm). NavCom 2050 GPS receiver (CNAV) data were used to account for tidal-cycle fluctuations, and sound-velocity profiles were collected with an Applied Microsystems (AM) SVPlus sound velocimeter. Soundings were corrected for vessel motion using the Applanix POS/MV data, for variations in water-column sound velocity using the AM SVPlus data, and for variations in water height (tides) using vertical-position data from the CNAV receiver. Final XYZ soundings and bathymetric-surface models were referenced to the World Geodetic System of 1984 (WGS 1984) relative to the North American Vertical Datum of 1988 (NAVD 1988).

During the USGS mapping missions, differential GPS (DGPS) data were combined with measurements of vessel motion (heave, pitch, and roll) in a CodaOctopus F180 attitude-and-position system to produce a high-precision vessel-attitude packet. This packet was transmitted to the acquisition software in real time and combined with instantaneous sound-velocity measurements at the transducer head before each ping. The returned samples were projected to the seafloor using a ray-tracing algorithm that works with previously measured sound-velocity profiles. Statistical filters were applied to the raw samples that discriminate the seafloor returns (soundings) from unintended targets in the water column. The original soundings were referenced to the WGS 1984 relative to the MLLW (Mean Lower Low Water) tidal datum, but, through postprocessing using National Oceanic and Atmospheric Administration's (NOAA's) VDatum tool, the soundings were transformed to the NAVD 1988. Finally, the soundings were converted into 2-m-resolution bathymetric-surface-model grids.

During the Fugro Pelagos mapping mission that was completed as part of the National Coastal Mapping Program of USACE, the Leica ALS60 topographic-lidar and the SHOALS-1000T bathymetric-lidar systems were mounted on an aircraft that flew survey lines at an altitude of 300 to 400 m (bathymetry) and 300 to 1,200 m (topography), at speeds of between 135 and 185 knots. The ALS60 system collected data at a maximum pulse rate of 200 kHz, and the SHOALS system collected data at 1 kHz. Information on aircraft position, velocity, and acceleration were collected using the Novatel and POS A/V 410 systems (SHOALS) and the onboard GPS/IMU system (ALS60). Aircraft-position data were processed using POSPac software, and the results were combined with the lidar data to produce 3-D positions for each lidar shot. Various commercial and proprietary software packages were used to clean the data, to convert all valid data from ellipsoid to orthometric heights, and to export the data as a series of topography and bathymetry ASCII files. Final grids were provided in geographic coordinates referenced to the NAVD 1988.

Once all the bathymetric-surface models were transformed to a common projection and datum, the files were merged into one overall 2-m-resolution bathymetric-surface model and clipped to the boundary of the map area. An illumination having an azimuth of 300° and from 45° above the horizon was then applied to the bathymetric surface to create the shaded-relief imagery. In addition, a modified "rainbow" color ramp was applied to the bathymetry data, using reds and oranges to represent shallower depths, and light greens to represent greater depths (note that the Offshore of Carpinteria map area requires only the shallower part of the full-rainbow color ramp used on some of the other maps in the California State Waters Map Series; see, for example, Kvitek and others, 2012). This colored bathymetry surface was draped over the shaded-relief imagery at 60-percent transparency to create this colored shaded-relief map. Bathymetric contours were generated from a modified 10-m-resolution bathymetric surface where a smooth arithmetic mean convolution function that assigns a weight of one-ninth to each cell in a 3-pixel by 3-pixel matrix was applied iteratively to the surface ten times.

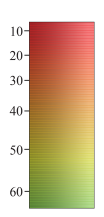
The onshore-area image was generated by applying the same illumination (azimuth of 300° and from 45° above the horizon) to the coastal airborne topographic-lidar data, as well as to publicly available, 3-m-resolution, interferometric synthetic aperture radar (ifSAR) data, available from NOAA Coastal Service Center's Digital Coast, at http://csc-s-mapsq.csc.noaa.gov/dataviewer/viewer.html (last accessed April 5, 2011).

REFERENCE CITED

Kvitek, R.G., Phillips, E.L., and Dartnell, P., 2012, Colored shaded-relief bathymetry, Hueneme Canyon and vicinity, California, *sheet 1 in* Johnson, S.Y., Dartnell, P., Cochrane, G.R., Golden, N.E., Phillips, E.L., Ritchie, A.C., Kvitek, R.G., Greene, H.G., Krigsman, L.M., Endris, C.A., Clahan, K.B., Sliter, R.W., Wong, F.L., Yoklavich, M.M., and Normark, W.R. (S.Y. Johnson, ed.), California State Waters Map Series—Hueneme Canyon and vicinity, California: U.S. Geological Survey Scientific Investigations Map 3225, pamphlet 41 p., 12 sheets, available at http://pubs.usgs.gov/sim/3225/.

EXPLANATION

Depth (in meters) and illumination (bright areas are illuminated, facing false sun; dark areas are in shadow, facing away from false sun)



Direction of illumination from false sun—Position of false sun is at 300° azimuth, 45° above horizon [arrow included in explanation for illustration purposes only; not shown on map]

Area of "no data"—Areas near shoreline not mapped owing to insufficient high-resolution seafloor mapping data; areas beyond 3-nautical-mile limit of California's State Waters were not mapped as part of California Seafloor Mapping Program

3-nautical-mile limit of California's State Waters

20 **Bathymetric contour (in meters)**—Derived from modified 10-m-resolution bathymetry grid. Contour interval: 10 m

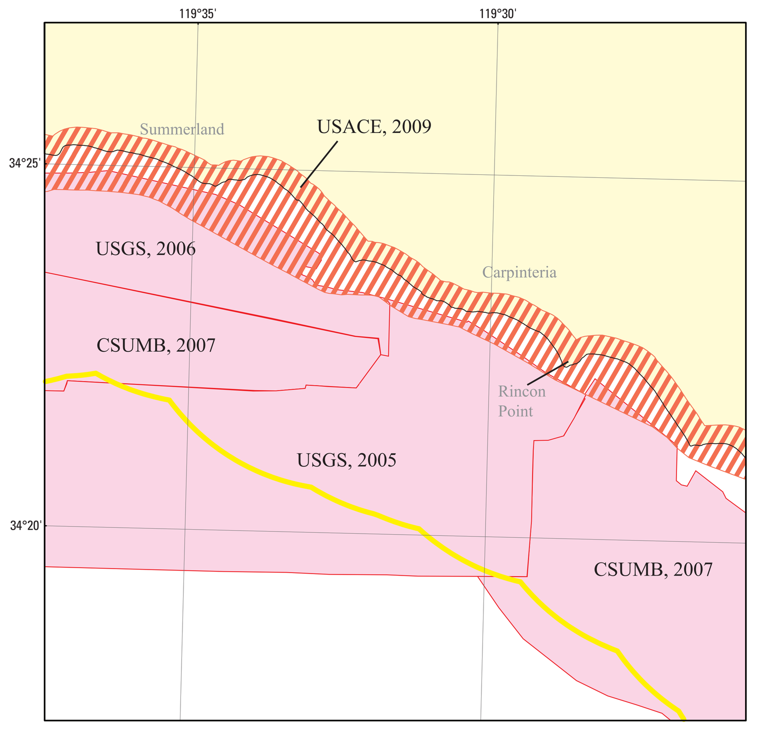


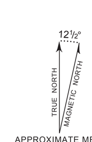
Figure 1. Map showing areas of multibeam-echosounder and bathymetric-sidescan surveys (pink shading), bathymetric and topographic-lidar surveys (orange diagonal lines), and publically available interferometric synthetic aperture radar (ifSAR) topography (yellow shading). Also shown are data-collecting agencies (CSUMB, California State University, Monterey Bay, Seafloor Mapping Lab; USACE, U.S. Army Corps of Engineers; USGS, U.S. Geological Survey) and dates of surveys if known.

Coastal Conservancy
CALIFORNIA OCEAN PROTECTION COUNCIL
NOAA
BOEM Bureau of Ocean Energy Management
US Army Corps of Engineers
Seafloor Mapping Lab CSU Monterey Bay

Onshore elevation data from NOAA Coastal Services Center (data collected by EarthData International in 2002-2003) and from U.S. Army Corps of Engineers (data collected by Fugro Pelagos in 2009). California's State Waters limit from NOAA Office of Coast Survey

Universal Transverse Mercator projection, Zone 11N

NOT INTENDED FOR NAVIGATIONAL USE



SCALE 1:24 000
1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER
BATHYMETRIC CONTOUR INTERVAL 10 METERS
ONE MILE = 0.869 NAUTICAL MILES

Shaded-relief bathymetry by Peter Dartnell, 2011 (data collected by U.S. Geological Survey in 2005 and 2006 and by California State University, Monterey Bay, Seafloor Mapping Lab in 2007). Bathymetric contours by Andrew C. Ritchie, 2011

GIS database and digital cartography by Nadine E. Golden and Eleyne L. Phillips

Edited by Taryn A. Lindquist

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Colored Shaded-Relief Bathymetry, Offshore of Carpinteria Map Area, California

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2013

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