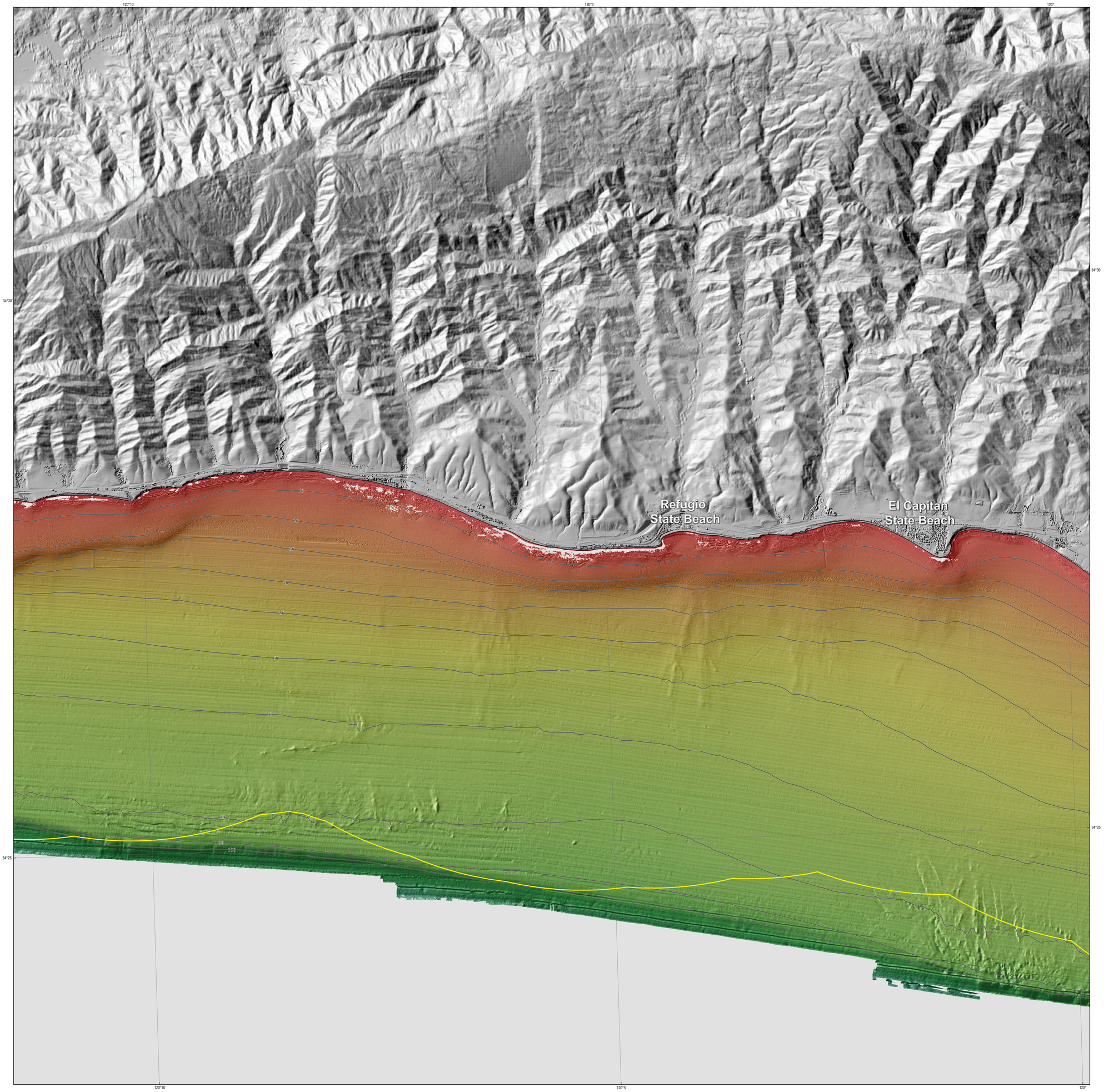
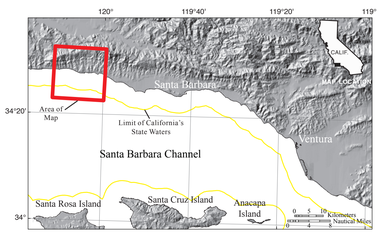
U.S. Department of the Interior
U.S. Geological Survey

Scientific Investigations Map 3319
Sheet 1 of 11
Pamphlet accompanies map





DISCUSSION

This colored shaded-relief bathymetry map of the Offshore of Refugio Beach map area in southern California was generated from bathymetry data collected 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 offshore region was mapped by the USGS in 2008, using a 234.5-kHz SEA (AP) Ltd. SWATHplus-M phase-differencing sidescan sonar. 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. 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 USGS mapping mission, GPS data with real-time-kinematic corrections 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 discriminate seafloor returns (soundings) from unintended targets in the water column. Finally, the soundings were converted into 2-m-resolution bathymetric-surface-model grids.

During the 2009 Fugro Pelagos coastal airborne-lidar 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.

Soundings from the different mapping missions were converted into individual 2-m-resolution bathymetric-surface-model-grids. The individual bathymetric-surface models were then merged into one overall 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 greens to represent greater depths (note that the Offshore of Refugio Beach 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. Following smoothing, contour lines were generated at 10-m intervals, from -10 to -100 m, then the contours were clipped to the boundary of the map area.

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 National Oceanic and Atmospheric Administration (NOAA) Coastal Service Center's Digital Coast, at http://csc-s-maps-q.csc.noaa.gov/dataviewer/viewer.html (last accessed November 2012).

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, M.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

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

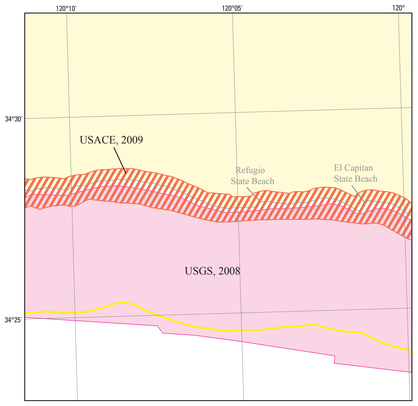


Figure 1. Map showing areas of bathymetric-sidescan surveys (pink shading), bathymetric- and topographic-lidar surveys (orange diagonal lines), and publicly available interferometric synthetic aperture radar (ifSAR) topography (yellow shading). Also shown are data-collecting agencies (USACE, U.S. Army Corps of Engineers; USGS, U.S. Geological Survey) and dates of surveys if known.

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 10N

NOT INTENDED FOR NAVIGATIONAL USE

SCALE 1:24 000

1 1/2 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

MAP LOCATION

Shaded-relief bathymetry by Peter Dartnell, 2012 (data collected by U.S. Geological Survey in 2008 and by U.S. Army Corps of Engineers in 2009). Bathymetric contours by Andrew C. Ritchie, 2011

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

Edited by Sarah E. Nagorsen

Manuscript approved for publication February 4, 2015

Colored Shaded-Relief Bathymetry, Offshore of Refugio Beach Map Area, California

By

Peter Dartnell, Eleyne L. Phillips, and David P. Finlayson

2015

Coastal Conservancy

CALIFORNIA OCEAN PROTECTION COUNCIL

NOAA

US Army Corps of Engineers

SEAFLOOR MAPPING LAB CSU MONTEREY BAY

This map was printed on an electronic plotter directly from digital files. Dimensional calibration may vary between electronic plotters and between X and Y directions on the same plotter, and paper may change size due to atmospheric conditions; therefore, scale and proportions may not be true on plots of this map.

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

Digital files available at http://pubs.usgs.gov/sim/3319/

Suggested Citation: Dartnell, P., Phillips, E.L., and Finlayson, D.P., 2015, Colored shaded-relief bathymetry, Offshore of Refugio Beach map area, California, *sheet 1 in* Johnson, S.Y., Dartnell, P., Cochrane, G.R., Golden, N.E., Phillips, E.L., Ritchie, A.C., Krigsman, L.M., Dieter, B.E., Conrad, J.E., Greene, H.G., Seitz, G.G., Endris, C.A., Sliter, R.W., Wong, F.L., Erdey, M.D., Gutierrez, C.I., Yoklavich, M.M., East, A.E., and Hart, P.E. (S.Y. Johnson and S.A. Cochran, eds.), California State Waters Map Series—Offshore of Refugio Beach, California: U.S. Geological Survey Scientific Investigations Map 3319, pamphlet 42 p., 11 sheets, scale 1:24,000, *http://dx.doi.org/10.3133/sim3319*

ISSN 2329-132X (online)
http://dx.doi.org/10.3133/sim3319