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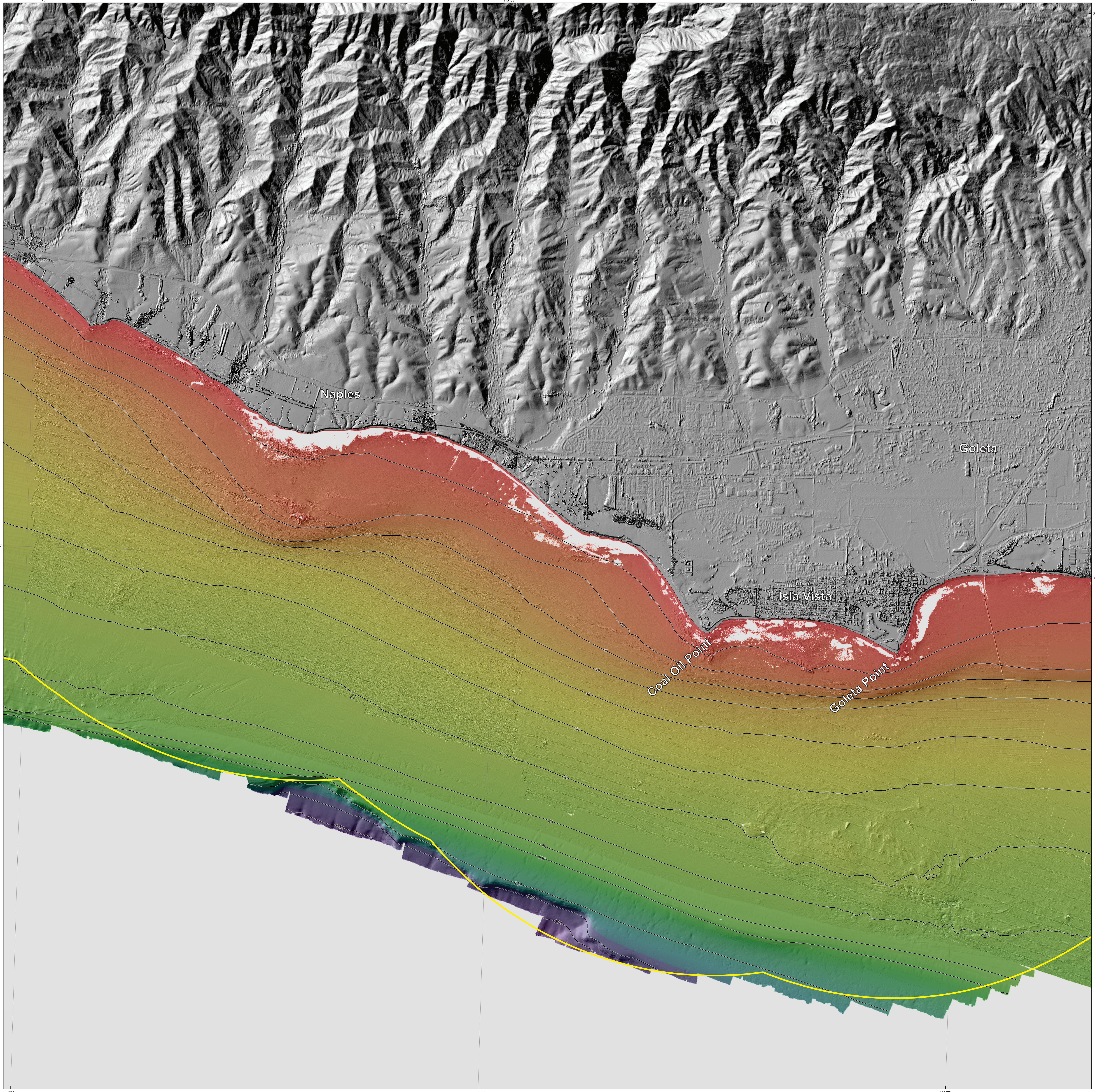
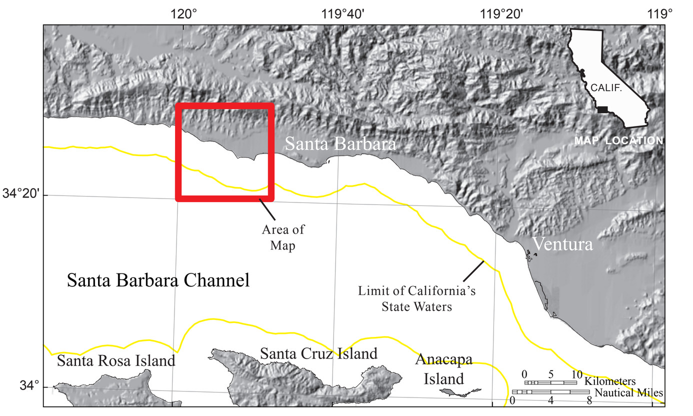
U.S. Department of the Interior
U.S. Geological Survey

Scientific Investigations Map 3302
Sheet 1 of 12
Pamphlet accompanies map





DISCUSSION

This colored shaded-relief bathymetry map of the Offshore of Coal Oil Point map area in southern California was generated from bathymetry data collected by the U.S. Geological Survey (USGS), by California State University, Monterey Bay (CSUMB), and by Fugro Pelagos (fig. 1). Most of the nearshore and shelf areas were mapped by the USGS in 2006, 2007, and 2008, using a combination of 117-kHz (2006, 2007) and 234.5-kHz (2008) SEA (AP) Ltd. SWATHplus-M phase-differencing sidescan sonars. A small area in the far-eastern nearshore and shelf was mapped by CSUMB in 2007, using a 244-kHz Reson 8101 multibeam echosounder. The outer shelf and slope were mapped by Fugro Pelagos in 2008, using a combination of 400-kHz Reson 7125, 240-kHz Reson 8101, and 100-kHz Reson 8111 multibeam echosounders. In addition, the nearshore bathymetry and coastal topography were mapped by Fugro Pelagos in 2009 for the U.S. Army Corps of Engineers (USACE) Joint Lidar Bathymetry Technical Center of Expertise, using the SHOALS-1000T bathymetric-lidar and the 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 missions, differential GPS (DGPS) data (2006, 2007) and GPS data with real-time kinematic corrections (2008) 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 both the CSUMB and the 2008 Fugro Pelagos multibeam mapping missions, an Applanix POS MV (Position and Orientation System for Marine Vessels) was used to accurately position the vessels 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). To account for tidal-cycle fluctuations, CSUMB used NavCom 2050 GPS receiver (CNAV) data, and Fugro Pelagos used KGPS data (GPS data with real-time kinematic corrections). In addition, 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 and also the KGPS data. Most soundings in the Offshore of Coal Oil Point map area were converted to 2-m-resolution bathymetric-surface-model grids; however, soundings along the outer shelf and slope in water depths greater than 80 m were converted to a 5-m-resolution bathymetric-surface-model grid because of lower sounding density.

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 bathymetric-surface-model grids: the 2-m-resolution surface models were merged into one overall 2-m-resolution bathymetric-surface model and clipped to the boundary of the map area; the 5-m-resolution bathymetric-surface model was processed as a separate grid. The overall 2-m-resolution grid and the 5-m-resolution grid were displayed together in a GIS to create this map. An illumination having an azimuth of 300° and from 45° above the horizon was then applied to the bathymetric surfaces 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 blues and purples to represent greater depths. This colored bathymetry surface was draped over the shaded-relief imagery at 60-percent transparency to create this colored shaded-relief map. Note that the ripple patterns and straight lines that are apparent within the map area are data-collection artifacts. In addition, lines at the borders of some surveys are the result of slight differences in depth, as measured by different mapping systems in different years. These various artifacts are made obvious by the hillshading process.

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, and at 50-m intervals, from -100 to -250 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 April 5, 2011).

EXPLANATION

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

20
40
60
80
100
200

Shallow

Deep

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

100 **Bathymetric contour (in meters)**—Derived from modified 10-m-resolution bathymetry grid. Contour intervals: 1–100 m water depth, 10 m; >100 m water depth, 50 m

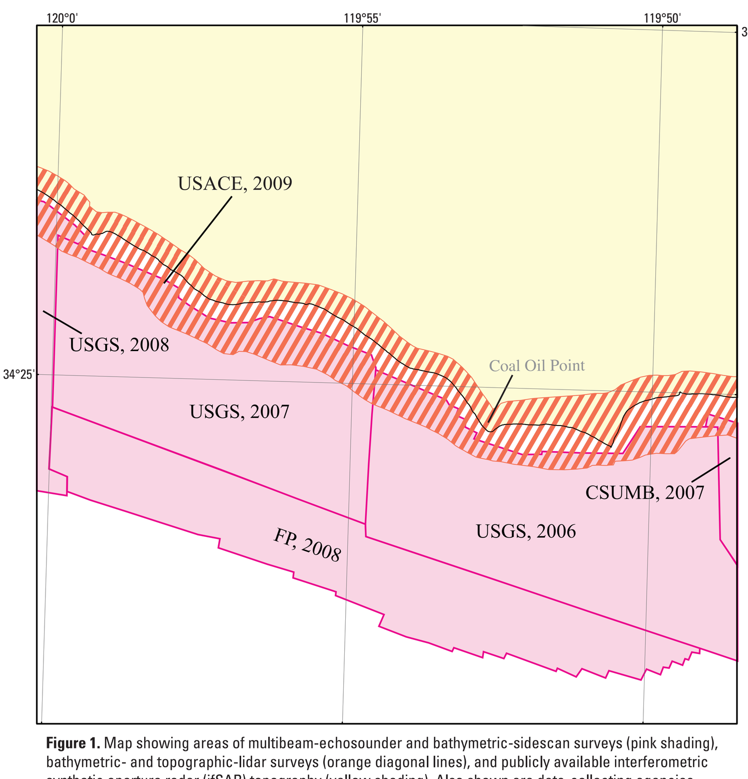


Figure 1. Map showing areas of multibeam-echosounder and bathymetric-sidescan surveys (pink shading), bathymetric- and topographic-lidar surveys (orange diagonal lines), and publicly available interferometric synthetic aperture radar (ifSAR) topography (yellow shading). Also shown are data-collecting agencies (CSUMB, California State University, Monterey Bay, Seafloor Mapping Lab; FP, Fugro Pelagos; 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 11N

NOT INTENDED FOR NAVIGATIONAL USE

12½°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2014

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 INTERVALS 10 AND 50 METERS

ONE MILE = 0.869 NAUTICAL MILES

Shaded-relief bathymetry by Peter Dartnell, 2012 (data collected by U.S. Geological Survey in 2006, 2007, and 2008; by California State University, Monterey Bay, Seafloor Mapping Lab in 2007; and by Fugro Pelagos in 2008 and 2009). 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 Coal Oil Point Map Area, California

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