

**DISCUSSION**

This colored shaded-relief bathymetry map of the Offshore of Bolinas map area in northern California was generated from bathymetry data collected by Fugro Pelagos, by California State University, Monterey Bay (CSUMB), and by Moss Landing Marine Laboratories (fig. 1). Mapping was completed between 2004 and 2010, using a combination of 200-kHz and 400-kHz Reson 7125, and 244-kHz Reson 5101 multibeam echosounders, as well as 408-kHz SEA SWATHplus and 250-kHz GeoSwath interferometric systems. The nearshore area from south of Bolinas Lagoon to Stinson Beach was mapped by Fugro Pelagos in 2009 for the National Oceanic and Atmospheric Administration (NOAA), and only bathymetry data were collected. These mapping missions combined to collect bathymetry data from about the 10-m isobath to beyond the 3-nautical-mile limit of California's State Waters.

During the 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); in addition, sound-velocity profiles were collected with an Applied Microsystems (AM) SVPlus sound velocimeter. To account for tidal-cycle fluctuations, CSUMB used NacCom 2050 GPS receiver (CNAV) data, and Fugro Pelagos used KGPS data (GPS data with real-time kinematic corrections). 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 KGPS receivers.

Processed soundings from the different mapping missions were exported from the acquisition or processing software as XYZ files and bathymetric surfaces. All the surfaces 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 greens to represent greater depths (note that the Offshore of Bolinas 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, Kvitck 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 at 10-m intervals from the merged 2-m-resolution bathymetric surface. The merged surface was smoothed using the Focal Mean tool in ArcGIS and a circular neighborhood that has a radius of between 20 and 30 m (depending on the location). The contours were generated from this smoothed surface using the Spatial Analyst Contour tool in ArcGIS. The most continuous contour segments were preserved; smaller segments and isolated island polygons were excluded from the final output. The contours were then 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 1-m-resolution topographic-lidar data collected by Earth Eye in 2010 for San Francisco State University and the U.S. Geological Survey (available at <http://ned.usgs.gov/>).

**REFERENCE CITED**

Kvitck, R.G., Phillips, E.L., and Dartnell, P., 2012, Colored shaded-relief bathymetry, Huacme Canyon and vicinity, California, sheet 7 in Johnson, S.Y., Dartnell, P., Cochrane, G.R., Golden, N.E., Phillips, E.L., Ritchie, A.C., Kvitck, R.G., Greene, H.G., Krugman, L.M., Lindis, C.A., Clahan, K.R., Sizer, R.W., Wong, F.L., Yoklavich, M.M., and Noemark, W.R. (S.Y. Johnson, ed.), California State Waters Map Series—Huacme 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)



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 2-m-resolution bathymetry grid. Contour interval: 10 m

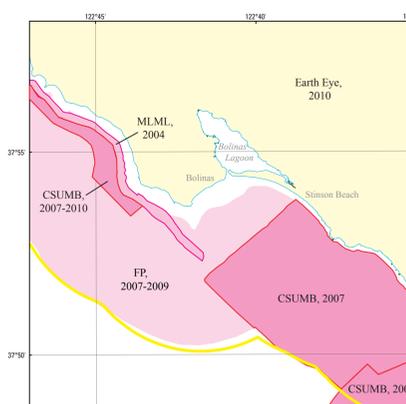
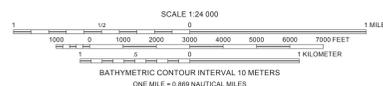


Figure 1. Map showing areas of multibeam-echosounder and interferometric surveys (pink shading) and onshore topographic-lidar surveys (yellow shading). Also shown are data-collecting agencies (CSUMB, California State University, Monterey Bay, Seafloor Mapping Lab; FP, Fugro Pelagos; MML, Moss Landing Marine Laboratories) and dates of surveys if known. Yellow line shows limit of California's State Waters.

Onshore elevation data collected by Earth Eye in 2010 for San Francisco State University and U.S. Geological Survey (available at <http://ned.usgs.gov/>). California's State Waters limit from NOAA Office of Coast Survey. Universal Transverse Mercator projection, Zone 10N. NOT INTENDED FOR NAVIGATIONAL USE

APPROXIMATE MEAN SEALEVEL DATUM, 1988



MAP LOCATION

Shaded-relief bathymetry by Peter Dartnell, 2012 (data collected by Moss Landing Marine Laboratories, 2004; by California State University, Monterey Bay, Seafloor Mapping Lab, 2004-2010; and by Fugro Pelagos, 2007-2009). Bathymetric contours by Mercedes D. Soley, 2012. GIS database and digital cartography by Nadine E. Golden. Manuscript approved for publication July 21, 2015.



**Colored Shaded-Relief Bathymetry, Offshore of Bolinas Map Area, California**

By  
Peter Dartnell,<sup>1</sup> Rikk G. Kvitck,<sup>2</sup> and Carrie K. Bretz<sup>2</sup>  
2015

<sup>1</sup>U.S. Geological Survey,  
<sup>2</sup>California State University, Monterey Bay, Seafloor Mapping Lab

Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government. This map was printed on an electronic platform directly from digital files. Dimensional calibration may vary between electronic platforms and between X and Y directions on the same platform, and paper may change size due to atmospheric conditions; therefore, scale and proportions may not be true on print of this map. For sale by U.S. Geological Survey, Information Services, Box 24206, Federal Center, Denver, CO 80224, 1-888-ASK-USGS. Digital files available at <http://dx.doi.org/10.3133/ofr20151135>. Suggested Citation: Dartnell, P., Kvitck, R.G., and Bretz, C.K., 2015, Colored shaded-relief bathymetry, Offshore of Bolinas map area, California, sheet 7 in Johnson, S.Y., Dartnell, P., Johnson, S.Y., Cochrane, G.R., Golden, N.E., Phillips, E.L., Ritchie, A.C., Kvitck, R.G., Greene, H.G., Krugman, L.M., Lindis, C.A., Clahan, K.R., Sizer, R.W., Wong, F.L., Yoklavich, M.M., and Noemark, W.R. (S.Y. Johnson, ed.), California State Waters Map Series—Huacme Canyon and vicinity, California: U.S. Geological Survey Open-File Report 2015-1135, pamphlet 41 p., 12 sheets, scale 1:24,000, <http://dx.doi.org/10.3133/ofr20151135>.