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

Scientific Investigations Map 3319
Sheet 4 of 11
*Pamphlet accompanies map*

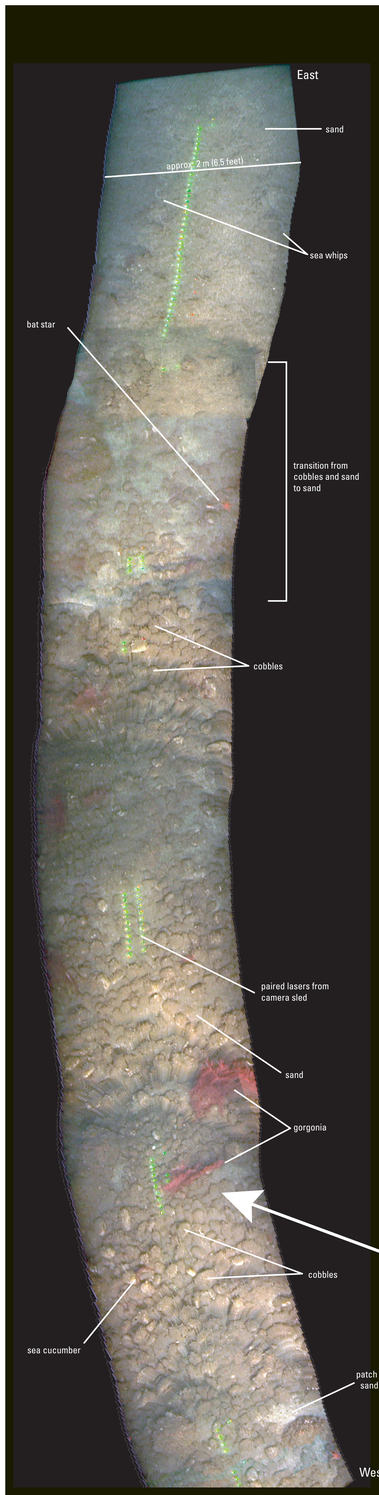



**Figure 3.** Video mosaic of outer shelf area south of Refugio State Beach (see fig. 4 for location), which reveals transition in seafloor environments from mixed seafloor (to west, at bottom of video mosaic), composed of cobbles and small patches of sand and shell material, to sandier seafloor (to east, at top of video mosaic). Gorgonia, sea cucumbers, and bat stars are present in mixed environment; sea whips protrude out of sand in sandier environment. Green dots are from camera-sled lasers used to scale features on seafloor. Transition from mixed to sandier seafloor in video-mosaic image corresponds to transition from higher to lower backscatter seen in figure 4. Video mosaic created using software developed by Dr. Yuri Rzhanov, Center for Coastal and Ocean Mapping, University of New Hampshire, through joint U.S. Geological Survey–University of New Hampshire cooperative agreement.

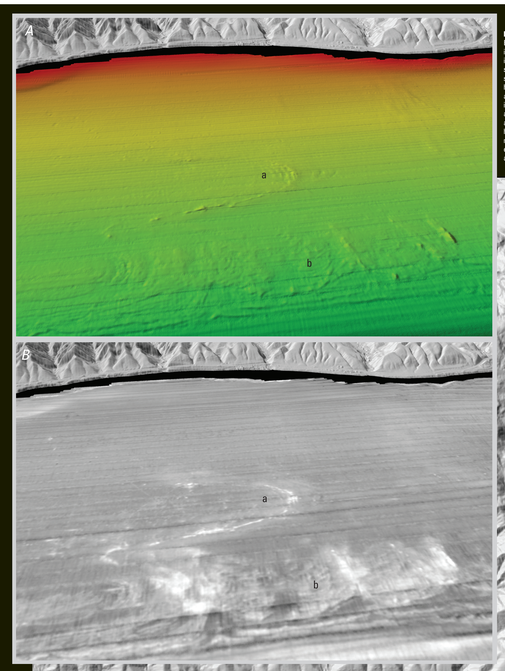



**Figure 1.** Perspective views to north over area southwest of Refugio State Beach, showing shaded-relief bathymetry (*A*) and acoustic-backscatter imagery (*B*). In backscatter imagery (see sheet 3 of this report), lighter tones indicate stronger backscatter intensity, suggesting rock or coarse-grained sediment, whereas darker tones indicate weaker backscatter intensity, suggesting more fine-grained sediment. Views highlight subtle horseshoe-shaped ridge (*a*) that has about 1 to 2 m of relief and high acoustic backscatter. Ridge is surface expression of east-plunging anticline in Molino gas field; seafloor outcrops consist mainly of the upper Moccasin and lower Pliocene Sisquoc Formation (Tennyson and Kropp, 1998; Forman and Redin, 2005). Toward bottom of images, area of rougher seafloor (*b*) also has moderate to high backscatter intensity; figure 4 reveals this as area of mixed seafloor consisting of bedrock, cobbles, and sand. Vertical exaggeration of perspective views, 2x; distance across bottom of image, about 2.5 km.

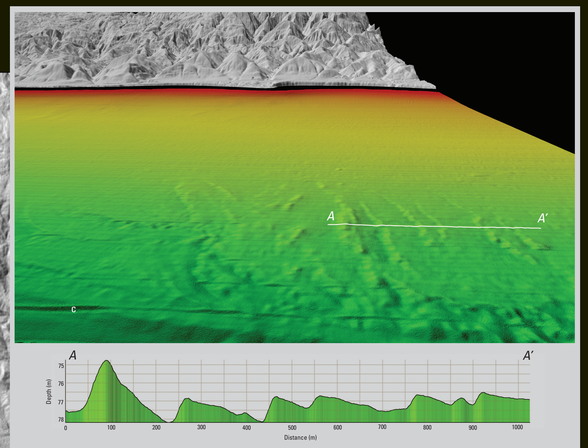
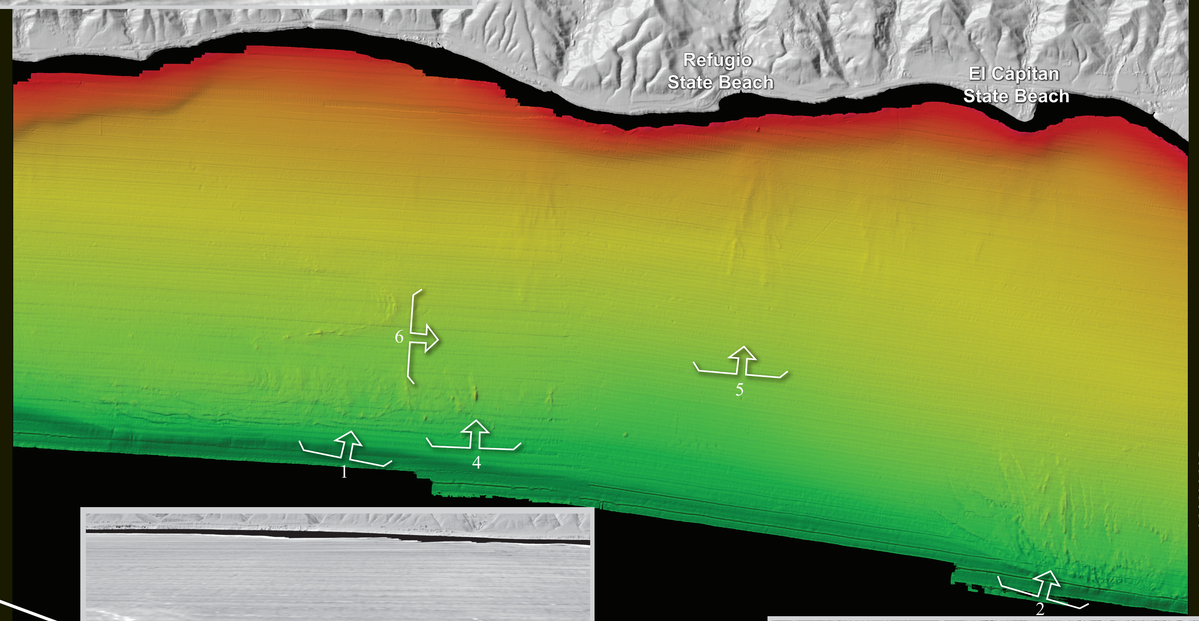



**Figure 2.** Perspective view to northeast and bathymetric profile over area of rougher seafloor along outer shelf south of El Capitan State Beach. Bathymetric profile *A*–*A*′ transects series of north-south-trending ridges that have 1 to 3 m of relief and appear to dip to east. Seafloor video and photographs collected in area reveal that ridges are underlain by resistant layers of bedrock locally covered by thin veneer of cobbles, pebbles, and sand, whereas intervening flat seafloor is composed of sand and rock. East-west-trending lines (*c*) are data-collection artifacts. Vertical exaggeration of perspective view, 2x; distance across bottom of image, about 3 km.




**Map view.** Colored shaded-relief bathymetry map of Offshore of Refugio Beach map area, generated from bathymetric-sidescan data. Colors show depth: reds and oranges indicate shallower areas; greens, deeper areas. Illumination azimuth is 300°, from 45° above horizon. Numbered arrows show viewing directions of perspective views shown on this sheet; numbers correspond to figure numbers of views.

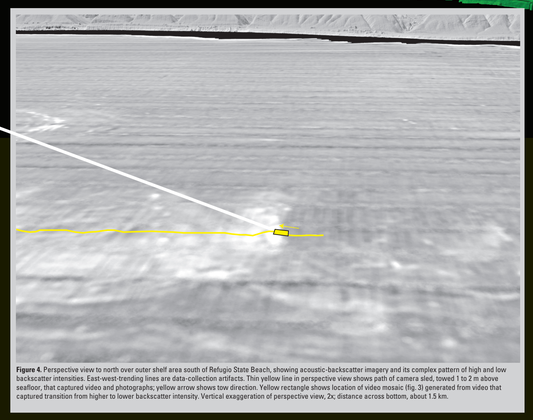


**Figure 4.** Perspective view to north over outer shelf area south of Refugio State Beach, showing acoustic-backscatter imagery and its complex pattern of high and low backscatter intensities. East-west-trending lines are data-collection artifacts. Thin yellow line in perspective view shows path of camera sled, towed 1 to 2 m above seafloor, that captured video and photographs; yellow arrow shows tow direction. Yellow rectangle shows location of video mosaic (fig. 3) generated from video that captured transition from higher to lower backscatter intensity. Vertical exaggeration of perspective view, 2x; distance across bottom, about 1.5 km.

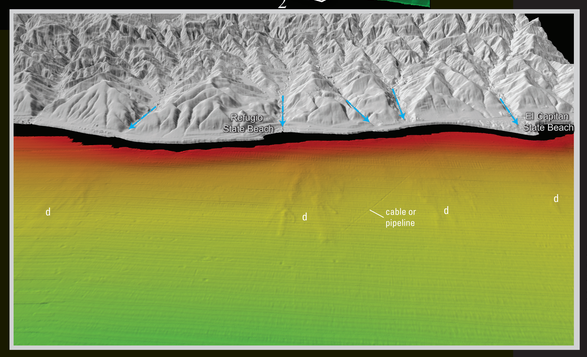



**Figure 5.** Perspective view to north over seafloor south of Refugio State Beach, showing four sediment fans (*d*) in nearshore that are characterized as having low (about 1 m) relief and moderate backscatter intensities (see sheet 3 of this report). Fans lie directly offshore of coastal watersheds (cyan dash-dot arrows), and their nearshore heads are about 750 to 1,000 m offshore, at depths of about 30 to 35 m. These sediment-transport features possibly could have been deposited as nearshore deltaic deposits during lower sea level, or they could be result of hyperpycnal gravity currents (Warrick and others, 2013). Similar fans have been mapped offshore of Santa Barbara, east of map area. Vertical exaggeration, 2x; distance across bottom, about 7 km.

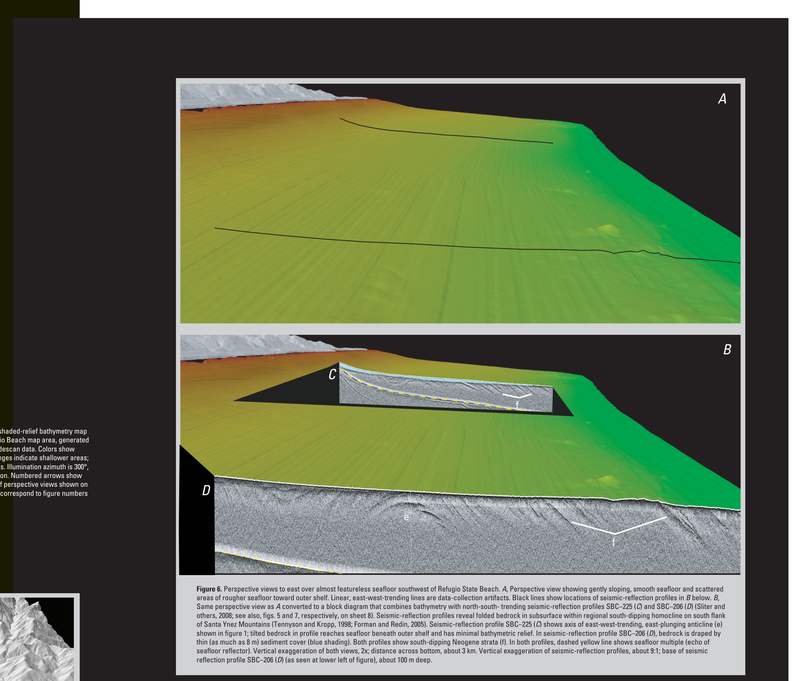



**Figure 6.** Perspective views to east over almost featureless seafloor southwest of Refugio State Beach. *A*, Perspective view showing gently sloping, smooth seafloor and scattered areas of rougher seafloor toward outer shelf. Linear, east-west-trending lines are data-collection artifacts. Black lines show locations of seismic-reflection profiles in *B* below. *B*, Same perspective view as *A* converted to a block diagram that combines bathymetry with north-south- trending seismic-reflection profiles SBC–225 (*C*) and SBC–206 (*D*) (Sliter and others, 2008; see also, figs. 5 and 7, respectively, on sheet 8). Seismic-reflection profiles reveal folded bedrock in subsurface within regional south-dipping homocline on south flank of Santa Ynez Mountains (Tennyson and Kropp, 1998; Forman and Redin, 2005). Seismic-reflection profile SBC–225 (*C*) shows axis of east-west-trending, east-plunging anticline (*e*) shown in figure 1; tilted bedrock in profile reaches seafloor beneath outer shelf and has minimal bathymetric relief. In seismic-reflection profile SBC–206 (*D*), bedrock is draped by thin (as much as 8 m) sediment cover (blue shading). Both profiles show south-dipping Neogene strata (*f*). In both profiles, dashed yellow line shows seafloor multiple (echo of seafloor reflector). Vertical exaggeration of both views, 2x; distance across bottom, about 3 km. Vertical exaggeration of seismic-reflection profiles, about 9:1; base of seismic reflection profile SBC–206 (*D*) (as seen at lower left of figure), about 100 m deep.

## DISCUSSION

Mapping California's State Waters has produced a vast amount of acoustic and visual data, including bathymetry, acoustic backscatter, seismic-reflection profiles, and seafloor video and photography. These data are used by researchers to develop maps, reports, and other tools to assist in the coastal and marine spatial-planning capability of coastal-zone managers and other stakeholders. Seafloor-character, habitat, and geologic maps may be used for fisheries management, for designation of Marine Protected Areas, for monitoring of environmental change such as sea-level-rise impacts, for prediction of sediment and contaminant budgets and transport, and for assessment of earthquake and tsunami hazards. To achieve these goals, it is helpful to integrate the different datasets and then view the results in three-dimensional representations such as those displayed on this data integration and visualization sheet for the Offshore of Refugio Beach map area.

The map view in the center of the sheet is similar to the colored shaded-relief bathymetry map of the Offshore of Refugio Beach map area (see sheet 1 of this report). Numbered arrows show viewing directions of the perspective views on this sheet (figs. 1, 2, 4, 5, 6); the numbers indicate the figure number of the perspective view.

The perspective views and bathymetric profiles in figures 1, 2, 4, 5, and 6 show the colored shaded-relief bathymetry of the Offshore of Refugio Beach map area, as viewed from different directions. These views highlight areas of relatively low-relief natural outcrop along the outer shelf, as well as sediment transport features within the nearshore area.

Draping the acoustic-backscatter imagery (see sheet 3 of this report) over the bathymetry data (figs. 1, 4) highlights the relations between the backscatter intensity and the seafloor morphology, as well as any anthropogenic influences on the seafloor (although none are visible in these views).

Video-mosaic images created from digital seafloor video (fig. 3) display the geologic (rock, sand, mud) and biologic complexity of the seafloor. Whereas photographs capture high-quality snapshots of a small area of the seafloor, video mosaics can capture larger areas and, thus, can show transitional zones between different seafloor environments.

Block diagrams (fig. 6), which combine the bathymetry with seismic-reflection-profile data (see sheet 8 of this report), help reveal the stratigraphic and structural relations between the surface and subsurface.

## REFERENCES CITED

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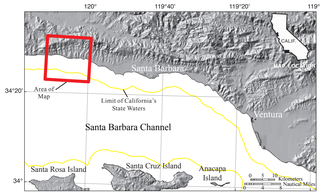
Warrick, J.A., Simms, A.R., Ritchie, A., Steel, E., Dartnell, P., Conrad, J.E., and Finlayson, D.P., 2013, Hyperpycnal plume-derived fans in the Santa Barbara Channel, California: Geophysical Research Letters, v. 40, p. 2,081–2,086.

## 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]




Coastal Conservancy

CALIFORNIA OCEAN PROTECTION COUNCIL

NOAA

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). Offshore shaded-relief bathymetry from map on sheet 1, this report
Universal Transverse Mercator projection, Zone 10N

**NOT INTENDED FOR NAVIGATIONAL USE**

APPROXIMATE MEAN DECLINATION, 2016

MAP LOCATION

Acoustic-backscatter imagery in figures 1 and 4 from map on sheet 3, this report. Bathymetric profile in figure 2, by Peter Dartnell, 2011. Video-mosaic image in figure 3 by Peter Dartnell, 2010, using software developed by Dr. Yuri Rzhanov, Center for Coastal and Ocean Mapping, University of New Hampshire, through joint U.S. Geological Survey–University of New Hampshire cooperative agreement. Seismic-reflection profile in figure 6 from sheet 8, this report

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

Edited by Sarah E. Nagorsen

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# Data Integration and Visualization, Offshore of Refugio Beach Map Area, California

By
Peter Dartnell

2015

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