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U.S. Departme nt of the Interior
U.S. Geological Survey

Open-File Report 2015–1135
Sheet 4 of 10
Pamphlet accompanies map

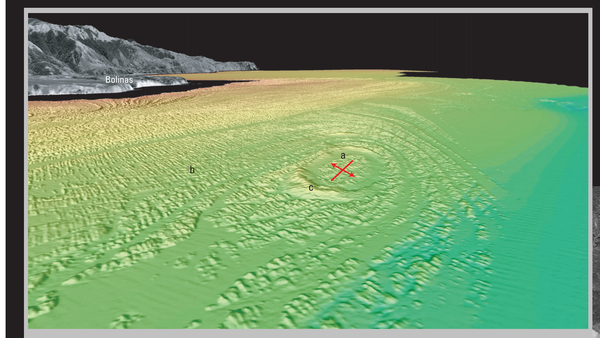


Figure 1. Perspective view to southeast past Bolinas, showing relatively low-relief rock outcrop in nearshore that has intervening sediment-filled fractures and channels. Elliptical structure in center of view (a) is surface expression of anticline mapped within upper Miocene and Pliocene Purisima Formation (unit Tp on sheet 10 of this report). Surrounding outcrop (b) has 1 to 2 m of relief, whereas outcrop near center of anticline (c) has 3 to 4 m of relief. Vertical exaggeration, 2x; distance across bottom of image, about 800 m.

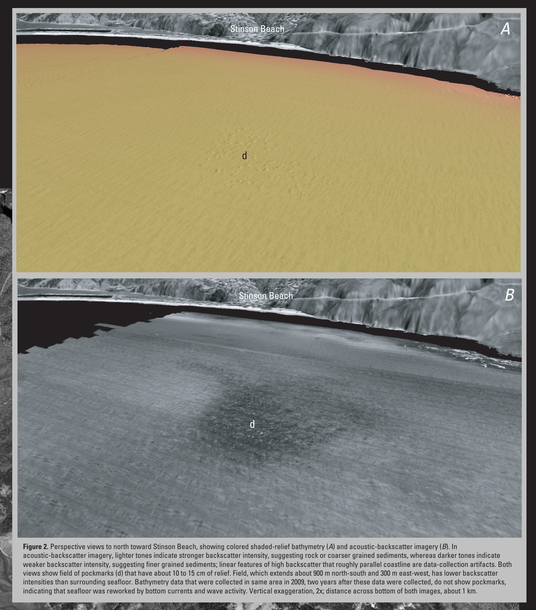


Figure 2. Perspective views to north toward Stinson Beach, showing colored shaded-relief bathymetry (*A*) and acoustic-backscatter imagery (*B*). In acoustic-backscatter imagery, lighter tones indicate stronger backscatter intensity, suggesting rock or coarser grained sediments, whereas darker tones indicate weaker backscatter intensity, suggesting finer grained sediments; linear features of high backscatter that roughly parallel coastline are data-collection artifacts. Both views show field of pockmarks (*d*) that have about 10 to 15 cm of relief. Field, which extends about 900 m north-south and 300 m east-west, has lower backscatter intensities than surrounding seafloor. Bathymetry data that were collected in same area in 2009, two years after these data were collected, do not show pockmarks, indicating that seafloor was reworked by bottom currents and wave activity. Vertical exaggeration, 2x; distance across bottom of both images, about 1 km.

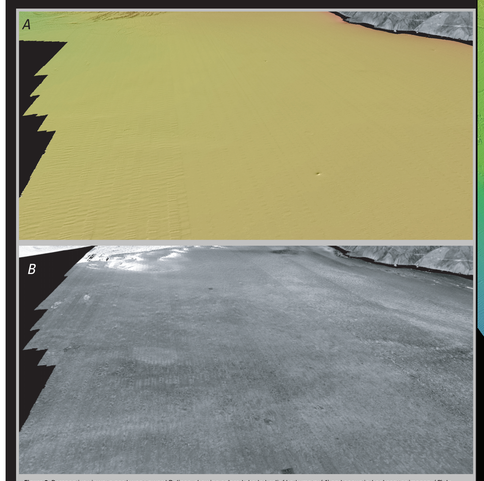


Figure 3. Perspective views to northwest toward Bolinas, showing colored shaded-relief bathymetry (*A*) and acoustic-backscatter imagery (*B*). In acoustic-backscatter imagery, lighter tones indicate stronger backscatter intensity, suggesting rock or coarser grained sediments, whereas darker tones indicate weaker backscatter intensity, suggesting finer grained sediments; linear features of high backscatter that roughly parallel coastline are data-collection artifacts. Colored shaded-relief bathymetry shows little to no seafloor relief; however, acoustic-backscatter imagery shows slight differences in backscatter intensities throughout shelf, suggesting that sediments that have different textures are being reworked by bottom currents and wave activity. Vertical exaggeration, 2x; distance across bottom of both images, about 2.5 km.

Map view. Colored shaded-relief bathymetry map of Offshore of Bolinas map area, generated from multibeam-echosounder data. Colors show depth: reds and oranges indicate shallower areas; blueish 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.

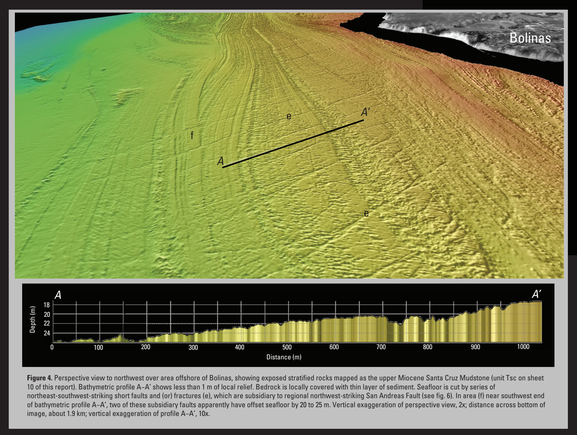


Figure 4. Perspective view to northwest over area offshore of Bolinas, showing exposed stratified rocks mapped as the upper Miocene Santa Cruz Mudstone (unit Tsc on sheet 10 of this report). Bathymetric profile A–A' shows less than 1 m of local relief. Bedrock is locally covered with thin layer of sediment. Seafloor is cut by series of northeast-southwest-striking short faults and (or) fractures (*e*), which are subsidiary to regional northwest-striking San Andreas Fault (see fig. 6). In area (f) near southwest end of bathymetric profile A–A', two of these subsidiary faults apparently have offset seafloor by 20 to 25 m. Vertical exaggeration of perspective view, 2x; distance across bottom of image, about 1.9 km; vertical exaggeration of profile A–A', 10x.

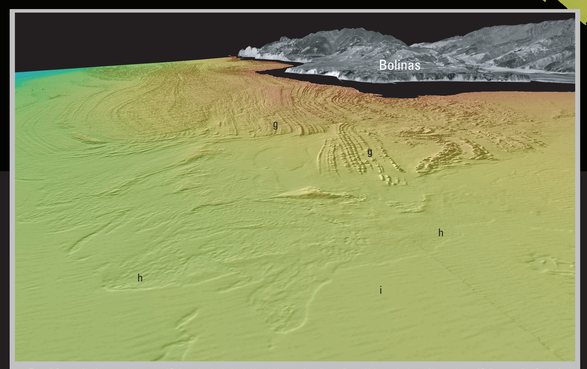


Figure 5. Perspective view to northwest toward Bolinas, showing bedrock ridges (g) in area of rougher seafloor, which extends about 4.5 km southeast of Bolinas coastline. South of ridges is complex pattern of less rough but still irregular seafloor (h) made up of lag deposits of gravel and sand (see sheet 10 of this report). Area of smoother seafloor (i) likely consists of finer grained sediment that is moving over coarser grained gravels and sands. Vertical exaggeration, 2x; distance across bottom of image, about 1.7 km.

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 Bolinas map area.

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

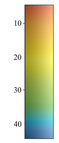
The perspective views and bathymetric profiles in figures 1 through 6 show the colored shaded-relief bathymetry of the Offshore of Bolinas map area, as viewed from different directions. These views highlight the diverse seafloor environments in this map area, which include areas of featureless, sedimented seafloor and extensive areas of folded and faulted bedrock.

Draping the acoustic-backscatter imagery (see sheet 3 of this report) over the bathymetry data (figs. 2, 3) highlights the relations between the backscatter intensity and the seafloor morphology, and it also aids in seafloor habitat and geology interpretations.

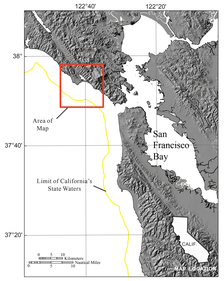
Block diagrams (fig. 6), which combine the bathymetry with seismic-reflection-profile data (see sheet 8 of this report), help reveal the stratigraphic and structural relations between the surface and subsurface.

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]



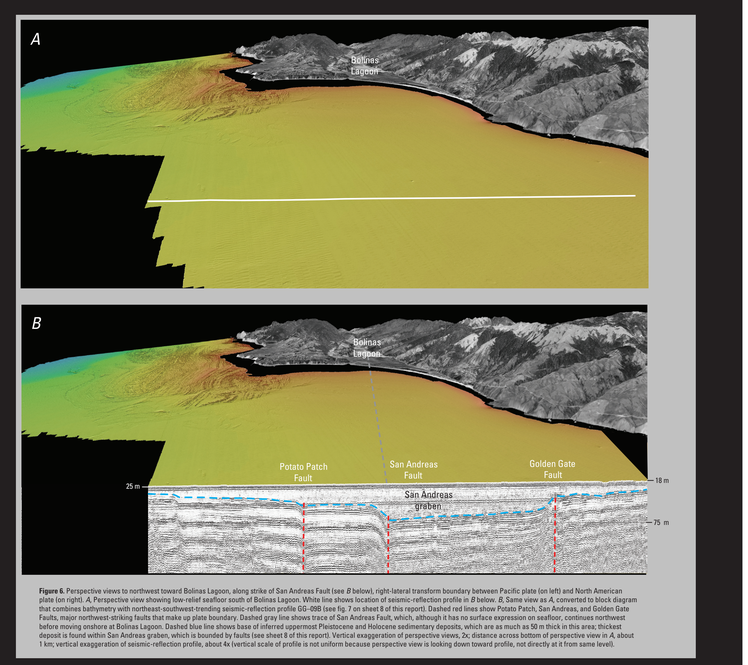


Figure 6. Perspective views to northwest toward Bolinas Lagoon, along strike of San Andreas Fault (see *B* below), right-lateral transform boundary between Pacific plate (on left) and North American plate (on right). *A*, Perspective view showing low-relief seafloor south of Bolinas Lagoon. White line shows location of seismic-reflection profile in *B* below. *B*, Same view as *A*, converted to block diagram that combines bathymetry with northeast-southwest-trending seismic-reflection profile GG–09B (see fig. 7 on sheet 8 of this report). Dashed red lines show Potato Patch, San Andreas, and Golden Gate Faults, major northwest-striking faults that make up plate boundary. Dashed gray line shows trace of San Andreas Fault, which, although it has no surface expression on seafloor, continues northwest before moving onshore at Bolinas Lagoon. Dashed blue line shows base of inferred uppermost Pleistocene and Holocene sedimentary deposits, which are as much as 50 m thick in this area; thickest deposit is found within San Andreas graben, which is bounded by faults (see sheet 8 of this report). Vertical exaggeration of perspective views, 2x; distance across bottom of perspective view in *A*, about 1 km; vertical exaggeration of seismic-reflection profile, about 4x (vertical scale of profile is not uniform because perspective view is looking down toward profile, not directly at it from same level).

Onshore elevation data collected by Earth Eye in 2010 for San Francisco State University and U.S. Geological Survey (available at http://eed.usgs.gov/). Offshore shaded-relief bathymetry from map on sheet 1, this report

Universal Transverse Mercator projection, Zone 10N

NOT INTENDED FOR NAVIGATIONAL USE

MAP LOCATION

Data Integration and Visualization, Offshore of Bolinas Map Area, California

By
Peter Dartnell

2015

Perspective views by Peter Dartnell, 2012. Acoustic-backscatter imagery in figures 2 and 3 from map on sheet 3, this report. Bathymetric profile in figure 4 by Peter Dartnell, 2012. Seismic-reflection profile in figure 6 from sheet 8, this report

GIS database and digital cartography by Nadine E. Golden

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