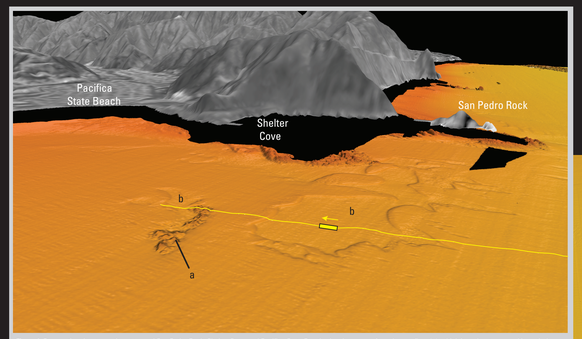


Figure 1. Perspective view to southeast toward San Pedro Rock, Shelter Cove, and Pacifica State Beach, showing areas of rougher seafloor (a), which is rock outcrop, and irregularly shaped features (b), which are scour depressions that have approximately 0.5 m of relief (see also, fig. 4). Thin yellow line shows path of camera sled, towed 1 to 2 m over seafloor, that captured video and photographs; yellow arrow shows tow direction. Yellow rectangle shows location of video mosaic (fig. 3) generated from video captured within depression. Vertical exaggeration, 2x; distance across bottom of image, about 700 m.

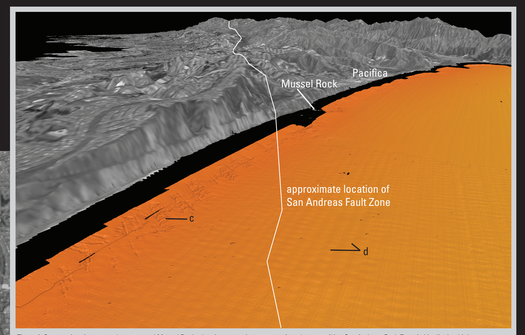


Figure 2. Perspective view to southeast toward Mussel Rock, showing approximate trace of northwest-striking San Andreas Fault Zone (white line), which moves offshore just north of Mussel Rock. Areas of rougher seafloor in nearshore (c) are mapped as upper Holocene coarse-grained marine nearshore deposits composed of coarse sand, gravel, and cobbles (see sheet 10 of this report); black lines parallel to shoreline are gaps in data. Rippled patterns offshore (d) likely are data-collection artifacts. Vertical exaggeration, 2x; distance across bottom of image, about 1.6 km.

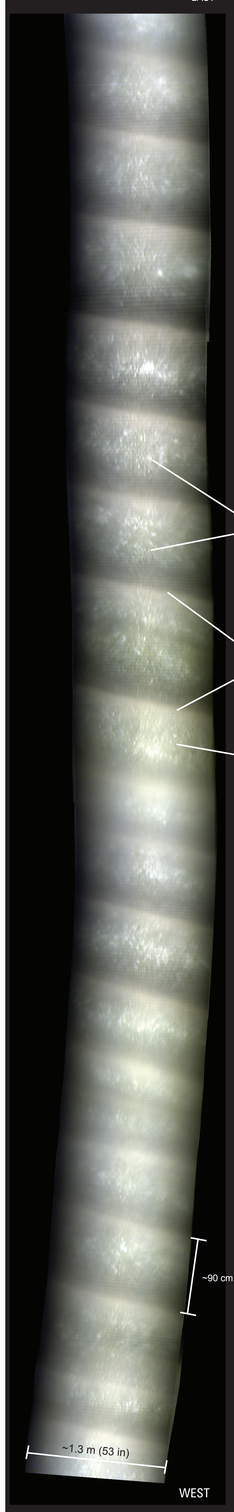


Figure 3. Video mosaic of area offshore of Pacifica (see fig. 1 for location), revealing sandy seafloor and symmetrical sand waves; shell material has gathered in sand-wave troughs. Sand waves have wavelength (crest to crest) of approximately 90 cm, too small to be mapped by multibeam bathymetry; however, seafloor character and composition (sand waves, sand, and shell material) does increase backscatter intensity (see fig. 4). Poor quality of mosaic is due to low seafloor visibility during camera-sled transect. 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.

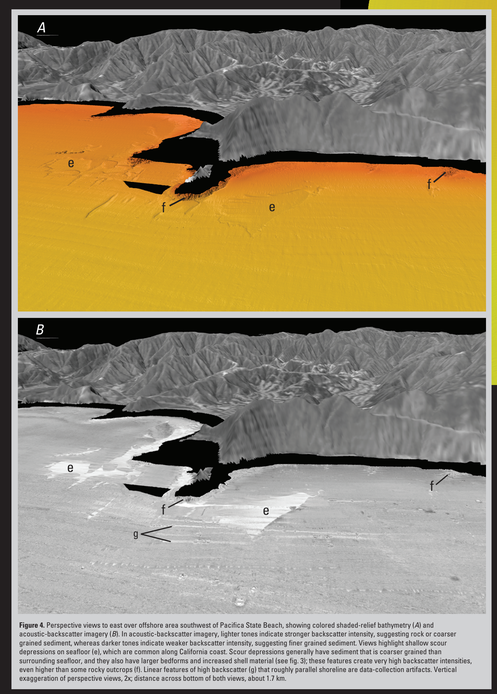


Figure 4. Perspective views to east over offshore area southwest of Pacifica State Beach, showing colored shaded-relief bathymetry (*A*) and acoustic-backscatter imagery (*B*). In acoustic-backscatter imagery, lighter tones indicate stronger backscatter intensity, suggesting rock or coarser grained sediment, whereas darker tones indicate weaker backscatter intensity, suggesting finer grained sediment. Views highlight shallow scour depressions on seafloor (*e*), which are common along California coast. Scour depressions generally have sediment that is coarser grained than surrounding seafloor, and they also have larger bedforms and increased shell material (see fig. 3); these features create very high backscatter intensities, even higher than some rocky outcrops (*f*). Linear features of high backscatter (*g*) that roughly parallel shoreline are data-collection artifacts. Vertical exaggeration of perspective views, 2x; distance across bottom of both views, about 1.7 km.

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

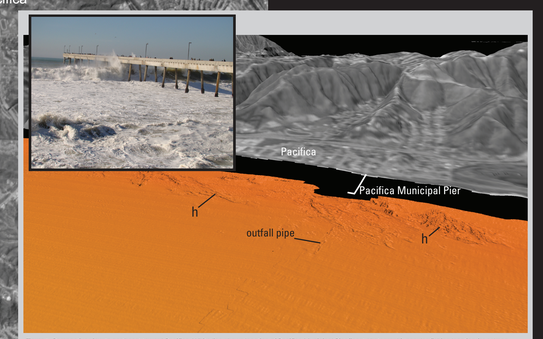


Figure 5. Perspective view to northeast toward Pacifica. White line shows location of Pacifica Municipal Pier (inset photograph), popular fishing location for salmon, western striped bass, and surfperch. Fish and other seafloor organisms may be attracted to area because of bedrock outcrops (h) that surround pier; bedrock is mapped as undivided Jurassic and Cretaceous Franciscan Complex (see sheet 10 of this report). Pacifica Municipal Pier was designed and built in 1973, in part, to serve as support structure for now-obsolete outfall pipes, which stretch from shoreline to short distance past pier; seafloor expression of outfall pipes can be seen in high-resolution bathymetry data (see sheets 1, 2 of this report). Vertical exaggeration, 2x; distance across bottom of image, about 1.2 km.

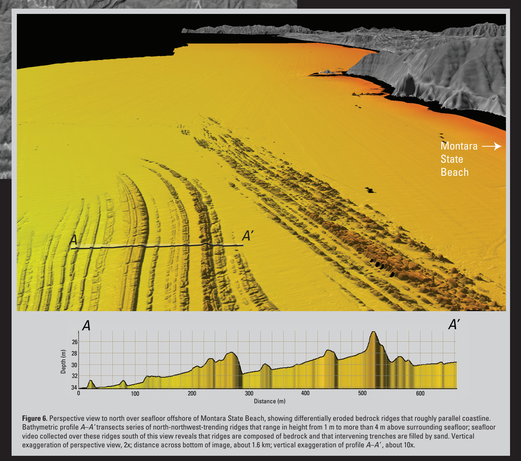


Figure 6. Perspective view to north over seafloor offshore of Montara State Beach, showing differentially eroded bedrock ridges that roughly parallel coastline. Bathymetric profile *A–A′* transects series of north-northwest-trending ridges that range in height from 1 m to more than 4 m above surrounding seafloor; seafloor video collected over these ridges south of this view reveals that ridges are composed of bedrock and that intervening trenches are filled by sand. Vertical exaggeration of perspective view, 2x; distance across bottom of image, about 1.6 km; vertical exaggeration of profile *A–A′*, about 10x.

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 Pacifica map area.

The map view in the center of the sheet is similar to the colored shaded-relief bathymetry map of the Offshore of Pacifica 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, 7); the numbers indicate the figure number of the perspective view.

The perspective views and bathymetric profiles in figures 1, 2, 4, 5, 6, and 7 show the colored shaded-relief bathymetry of the Offshore of Pacifica map area, as viewed from different directions. These views highlight the seafloor environments in the map area, which include large areas of featureless, sediment-covered seafloor interspersed with smaller, complex distributions of coarse-grained sediment and linear outcrops of differentially eroded bedrock.

Video-mosaic images created from seafloor digital 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.

Draping the acoustic-backscatter imagery (see sheet 3 of this report) over the bathymetry data (fig. 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). It also aids in seafloor habitat and geology interpretations.

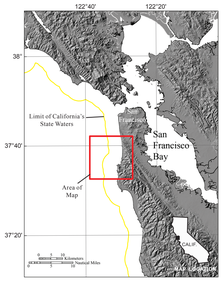
Block diagrams (fig. 7), which combine the bathymetry with seismic-reflection-profile data (see sheet 8 of this report), help reveal the stratigraphic and structural relations between the surface and subsurface.

EXPLANATION

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

Shallow
10
20
30
40
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]



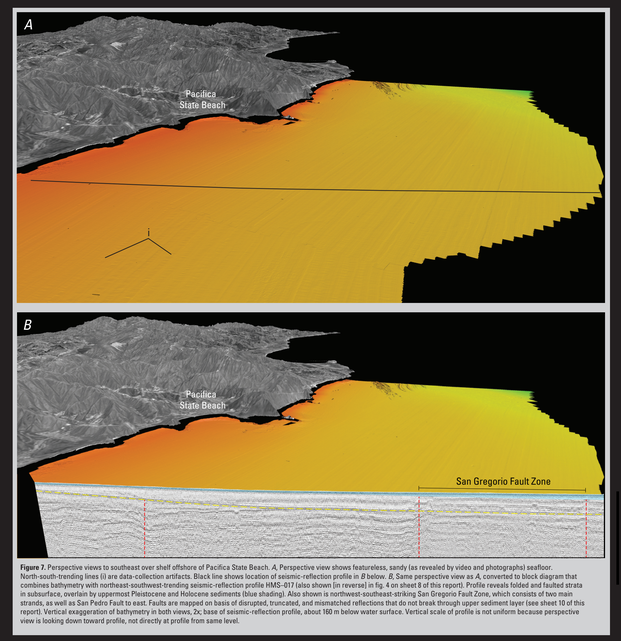


Figure 7. Perspective views to southeast over shelf offshore of Pacifica State Beach. *A*, Perspective view shows featureless, sandy (as revealed by video and photographs) seafloor. North-south-trending lines (*i*) are data-collection artifacts. Black line shows location of seismic-reflection profile in *B* below. *B*, Same perspective view as *A*, converted to block diagram that combines bathymetry with northeast-southwest-trending seismic-reflection profile HMS–017 (also shown [in reverse] in fig. 4 on sheet 8 of this report). Profile reveals folded and faulted strata in subsurface, overlain by uppermost Pleistocene and Holocene sediments (blue shading). Also shown is northwest-southeast-striking San Gregorio Fault Zone, which consists of two main strands, as well as San Pedro Fault to east. Faults are mapped on basis of disrupted, truncated, and mismatched reflections that do not break through upper sediment layer (see sheet 10 of this report). Vertical exaggeration of bathymetry in both views, 2x; base of seismic-reflection profile, about 160 m below water surface. Vertical scale of profile is not uniform because perspective view is looking down toward profile, not directly at profile from same level.

Onshore imagery from digital orthophotographs available at Cal-Atlas Geospatial Clearinghouse, http://atlas.ca.gov/ (last accessed January 2013). Offshore shaded-relief bathymetry from map on sheet 1, this report

Universal Transverse Mercator projection, Zone 10N

NOT INTENDED FOR NAVIGATIONAL USE

MAP LOCATION

Perspective views by Peter Dartnell, 2012. Video-mosaic image in figure 3 by Peter Dartnell, 2012, 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. Acoustic-backscatter imagery in figure 4 from map on sheet 3, this report. Bathymetric profile in figure 6 by Peter Dartnell, 2012. Seismic-reflection profile in figure 7 from sheet 8, this report.

GIS database and digital cartography by Nadine E. Golden and Florence L. Wong

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

By
Peter Dartnell

2014

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