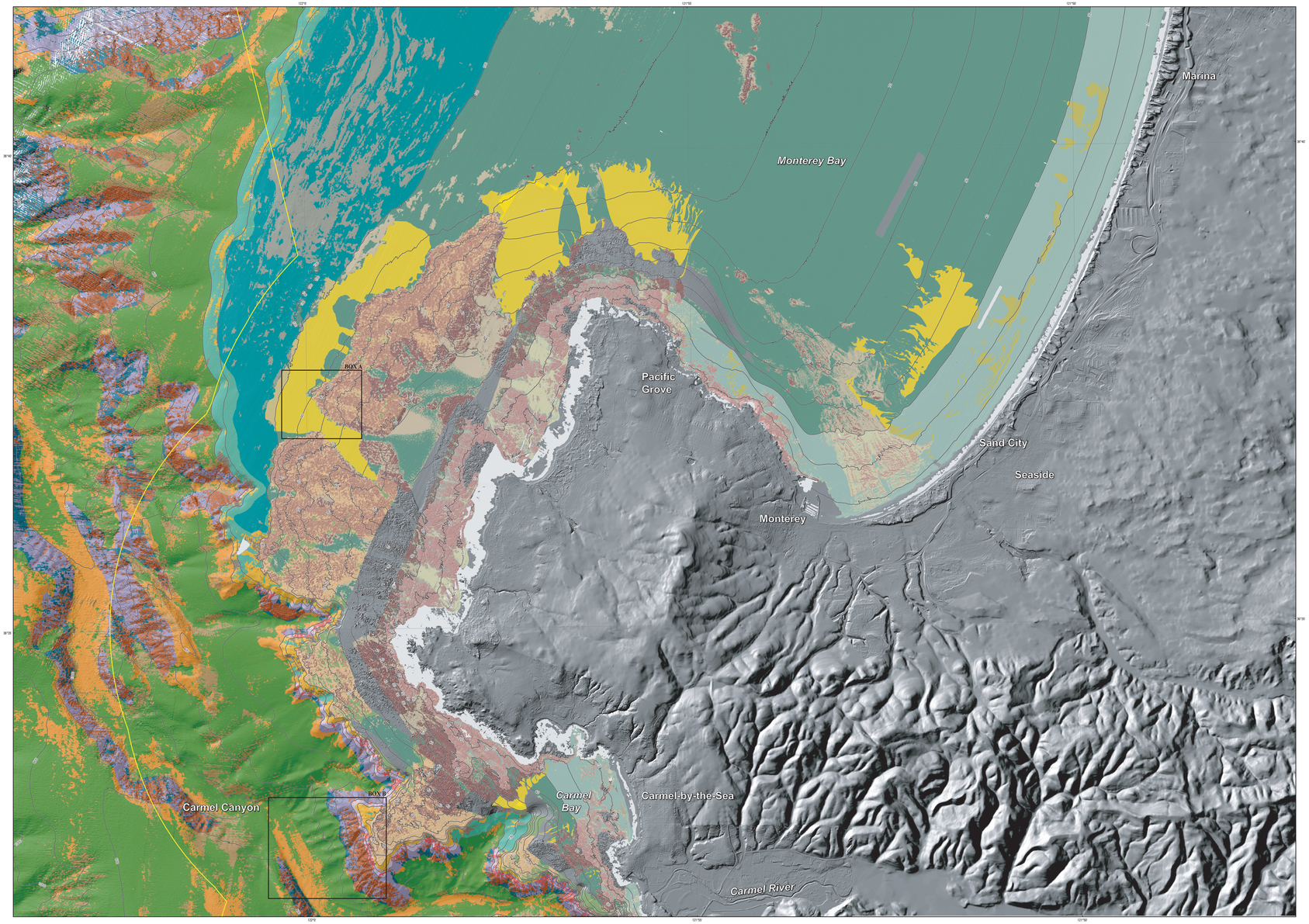
U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2016–1110
Sheet 5 of 10
Pamphlet accompanies map



Onshore elevation data from National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management's Digital Coast website at http://coast.noaa.gov/digitalcoast/data/topobathyelevation and from U.S. Geological Survey's National Elevation Dataset (available at http://ned.usgs.gov/). Offshore shaded-relief bathymetry from map on sheet 2, this report. California's State Waters limit from NOAA Office of Coast Survey

Universal Transverse Mercator projection, Zone 10N

NOT INTENDED FOR NAVIGATIONAL USE

APPROXIMATE MEAN DECLINATION, 2016

SCALE 1:24 000

BATHYMETRIC CONTOUR INTERVALS 10 METERS, 50 METERS, AND 200 METERS

ONE MILE = 0.869 NAUTICAL MILES

MAP LOCATION

Seafloor character mapped by Mercedes D. Erdey, 2015
Bathymetric contours by Peter Dartnell, 2015

GIS database and digital cartography by Mercedes D. Erdey

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Seafloor Character, Offshore of Monterey Map Area, California

By
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2016

DESCRIPTION OF MAP UNITS

DEPTH ZONE 2—INTERTIDAL TO 30 METERS WATER DEPTH

SLOPE CLASS 1—0 TO 5 DEGREES

Fine- to medium-grained smooth sediment—Low backscatter, low rugosity; typically mud to medium-grained sand, often rippled and (or) burrowed

Mixed smooth sediment and rock—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock

Rock and boulder, rugose—High backscatter, high rugosity; typically boulders and rugose bedrock

Medium- to coarse-grained sediment—Very high backscatter, low rugosity; typically medium- to coarse-grained sediment, with varying amounts of shell hash, in scour depressions

SLOPE CLASS 2—5 TO 30 DEGREES

Fine- to medium-grained smooth sediment—Low backscatter, low rugosity; typically mud to medium-grained sand, often rippled and (or) burrowed

Mixed smooth sediment and rock—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock

Rock and boulder, rugose—High backscatter, high rugosity; typically boulders and rugose bedrock

SLOPE CLASS 3—30 TO 60 DEGREES

Fixed smooth sediment and rock—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock

Rock and boulder, rugose—High backscatter, high rugosity; typically boulders and rugose bedrock

DEPTH ZONE 3—30 METERS TO 100 METERS WATER DEPTH

SLOPE CLASS 1—0 TO 5 DEGREES

Fine- to medium-grained smooth sediment—Low backscatter, low rugosity; typically mud to medium-grained sand, often rippled and (or) burrowed

Mixed smooth sediment and rock—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock

Rock and boulder, rugose—High backscatter, high rugosity; typically boulders and rugose bedrock

Medium- to coarse-grained sediment—Very high backscatter, low rugosity; typically medium- to coarse-grained sediment, with varying amounts of shell hash, in scour depressions

SLOPE CLASS 2—5 TO 30 DEGREES

Fine- to medium-grained smooth sediment—Low backscatter, low rugosity; typically mud to medium-grained sand, often rippled and (or) burrowed

Mixed smooth sediment and rock—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock

Rock and boulder, rugose—High backscatter, high rugosity; typically boulders and rugose bedrock

SLOPE CLASS 3—30 TO 60 DEGREES

Fine- to medium-grained smooth sediment—Low backscatter, low rugosity; typically mud to medium-grained sand, often rippled and (or) burrowed

Mixed smooth sediment and rock—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock

Rock and boulder, rugose—High backscatter, high rugosity; typically boulders and rugose bedrock

DEPTH ZONE 4—100 METERS TO 200 METERS WATER DEPTH

SLOPE CLASS 1—0 TO 5 DEGREES

Fine- to medium-grained smooth sediment—Low backscatter, low rugosity; typically mud to medium-grained sand, often rippled and (or) burrowed

Mixed smooth sediment and rock—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock

Medium- to coarse-grained sediment—Very high backscatter, low rugosity; typically medium- to coarse-grained sediment, with varying amounts of shell hash, in scour depressions

SLOPE CLASS 2—5 TO 30 DEGREES

Fine- to medium-grained smooth sediment—Low backscatter, low rugosity; typically mud to medium-grained sand, often rippled and (or) burrowed

Mixed smooth sediment and rock—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock

Rock and boulder, rugose—High backscatter, high rugosity; typically boulders and rugose bedrock

SLOPE CLASS 3—30 TO 60 DEGREES

Fine- to medium-grained smooth sediment—Low backscatter, low rugosity; typically mud to medium-grained sand, often rippled and (or) burrowed

Mixed smooth sediment and rock—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock

Rock and boulder, rugose—High backscatter, high rugosity; typically boulders and rugose bedrock

DEPTH ZONE 5—GREATER THAN 200 METERS WATER DEPTH

SLOPE CLASS 2—5 TO 30 DEGREES

Fine- to medium-grained smooth sediment—Low backscatter, low rugosity; typically mud to medium-grained sand, often rippled and (or) burrowed

Mixed smooth sediment and rock—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock

Rock and boulder, rugose—High backscatter, high rugosity; typically boulders and rugose bedrock

SLOPE CLASS 3—30 TO 60 DEGREES

Fine- to medium-grained smooth sediment—Low backscatter, low rugosity; typically mud to medium-grained sand, often rippled and (or) burrowed

Mixed smooth sediment and rock—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock

Rock and boulder, rugose—High backscatter, high rugosity; typically boulders and rugose bedrock

EXPLANATION OF MAP SYMBOLS

Area of "no data"—Areas near shoreline not mapped owing to insufficient high-resolution seafloor mapping data or gaps in data collection

Limit of California's State Waters

Bathymetric contour (in meters)—Derived from modified 2- and 5-m-resolution bathymetry grids. Contour intervals: 1–100 m water depth; 10 m; 100–200 m water depth; 50 m; >200 m water depth, 200 m

DISCUSSION

This seafloor-character map of the Offshore of Monterey map area in central California was produced using video-supervised, maximum-likelihood classification of the bathymetry and backscatter (intensity of return) signals from sonar systems (a summary of the video data collected for the purpose of supervising the classification is shown on sheet 6). Rugosity (a GIS-derived characterization of roughness) and backscatter intensity were used as variants in the classification. The interpreted classifications were then draped over shaded-relief bathymetry (see sheet 2).

The substrate classes mapped in this area have been divided into the following California Marine Life Protection Act depth zones: Depth Zone 2 (intertidal to 30 m); Depth Zone 3 (30 to 100 m); Depth Zone 4 (100 to 200 m); and Depth Zone 5 (greater than 200 m). In addition, the following slope classes are represented on this map (Coastal and Marine Ecological Classification Standard slope zones are shown in parentheses): Slope Class 1, 0° to 5° (flat); Slope Class 2, 5° to 30° (sloping); and Slope Class 3, 30° to 60° (steeply sloping). Depth Zone 1 (intertidal) and Slope Classes 4 and 5, greater than 60° (vertical to overhang), are not present in this map area.

Fine- to medium-grained smooth sediment (sand and mud) makes up 62.1 percent (160.8 km²) of the map area: 9.5 percent (24.6 km²) is in Depth Zone 2, 25.2 percent (65.4 km²) is in Depth Zone 3, 7.3 percent (19.0 km²) is in Depth Zone 4, and 20.0 percent (51.9 km²) is in Depth Zone 5. Mixed smooth sediment (sand and gravel) and rock (that is, sediment typically forming a veneer over bedrock, or rock outcrops having little to no relief) make up 17.2 percent (44.6 km²) of the map area: 1.4 percent (3.6 km²) is in Depth Zone 2, 4.7 percent (12.2 km²) is in Depth Zone 3, 3.3 percent (8.6 km²) is in Depth Zone 4, and 7.8 percent (20.2 km²) is in Depth Zone 5. Rock and boulder, rugose (rock and boulder outcrops having high surficial complexity) makes up 15.9 percent (41.2 km²) of the map area: 2.9 percent (7.5 km²) is in Depth Zone 2, 5.1 percent (13.3 km²) is in Depth Zone 3, 0.4 percent (1.0 km²) is in Depth Zone 4, and 7.5 percent (19.3 km²) is in Depth Zone 5. Medium- to coarse-grained sediment (in scour depressions consisting of material that is coarser than the surrounding seafloor) makes up 4.8 percent (12.5 km²) of the map area: 0.5 percent (1.2 km²) is in Depth Zone 2, 4.3 percent (11.0 km²) is in Depth Zone 3, and 0.1 percent (0.3 km²) is in Depth Zone 4 (table 1).

Table 1. Coverage of classified seafloor, in square kilometers (sq km) and percent of total area, broken into California Marine Life Protection Act Depth Zones 2, 3, 4, and 5.

	Total		Depth Zone 2 (water depth 0–30 m)		Depth Zone 3 (water depth 30–100 m)		Depth Zone 4 (water depth 100–200 m)		Depth Zone 5 (water depth >200 m)	
	percent	sq km	percent of total	sq km	percent of total	sq km	percent of total	sq km	percent of total	sq km
Fine- to medium-grained smooth sediment	62.1	160.8	9.5	24.6	25.2	65.4	7.3	19.0	20.0	51.9
Mixed smooth sediment and rock	17.2	44.6	1.4	3.6	4.7	12.2	3.3	8.6	7.8	20.2
Rock and boulder, rugose	15.9	41.2	2.9	7.5	5.1	13.3	0.4	1.0	7.5	19.3
Medium- to coarse-grained sediment	4.8	12.5	0.5	1.2	4.3	11.0	0.1	0.3	0.0	0.0

BOX A

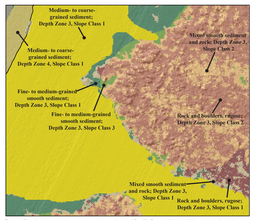

Figure 1. Detailed view of substrate classes mapped west of Pacific Grove, offshore of Monterey peninsula (see Box A, on map, for location). Depth Zones 3 and 4 (30 to 200 m), and Slope Classes 1, 2, and 3 (0°–60°). Fine- to medium-grained smooth sediment is shown in shades of green; mixed smooth sediment and rock is shown in shades of tan; rock is shown in shades of red and brown; and medium- to coarse-grained sediment is shown in shades of yellow. Bathymetric contour (100 m) shown for depth reference.

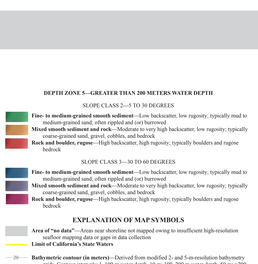

Figure 2. Acoustic-backscatter image (see sheet 3) draped over shaded-relief bathymetry (see sheet 2) for same area as figure 1 (Box A on map). Brighter areas indicate coarse-grained, rough, or hard seafloor; darker areas indicate unconsolidated (loosely packed) sediment. Parallel light-gray lines are data-collection and -processing artifacts. Interpreted substrate classes from figure 1 included for comparison. Bathymetric contour (100 m) shown for depth reference.

Figure 3. Rugosity (characterization of roughness derived from bathymetry) draped over shaded-relief bathymetry (see sheet 2) for same area as figure 1 (Box A on map). Rugosity values are displayed in muted "rainbow" color spectrum that ranges from purple (low rugosity) through green (medium rugosity) to red (high rugosity). Interpreted substrate classes from figure 1 included for comparison. Bathymetric contour (100 m) shown for depth reference.

BOX B

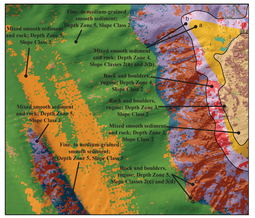

Figure 4. Detailed view of substrate classes mapped west of Carmel Bay, along continental shelf–canyon interface (see sheet 3 for location). Depth Zones 4 and 5 (100 to 200 m and greater than 200 m), and Slope Classes 2 and 3 (5°–60°). Fine- to medium-grained smooth sediment is shown in shades of green and blue; mixed smooth sediment and rock is shown in shades of tan, orange, and purple; and rock is shown in shades of red and brown. Bathymetric contours (100 and 200 m) shown for depth reference.

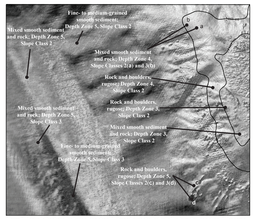

Figure 5. Acoustic-backscatter image (see sheet 3) draped over shaded-relief bathymetry (see sheet 2) for same area as figure 4 (Box B on map). Brighter areas indicate coarse-grained, rough, or hard seafloor; darker areas indicate unconsolidated (loosely packed) sediment. Interpreted substrate classes from figure 4 included for comparison. Bathymetric contours (100 and 200 m) shown for depth reference.

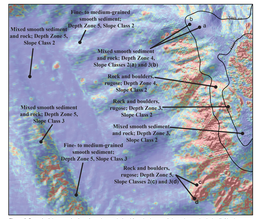

Figure 6. Rugosity (characterization of roughness derived from bathymetry) draped over shaded-relief bathymetry (see sheet 2) for same area as figure 4 (Box B on map). Rugosity values are displayed in muted "rainbow" color spectrum that ranges from purple (low rugosity) through green (medium rugosity) to red (high rugosity). Interpreted substrate classes from figure 4 included for comparison. Bathymetric contours (100 and 200 m) shown for depth reference.

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