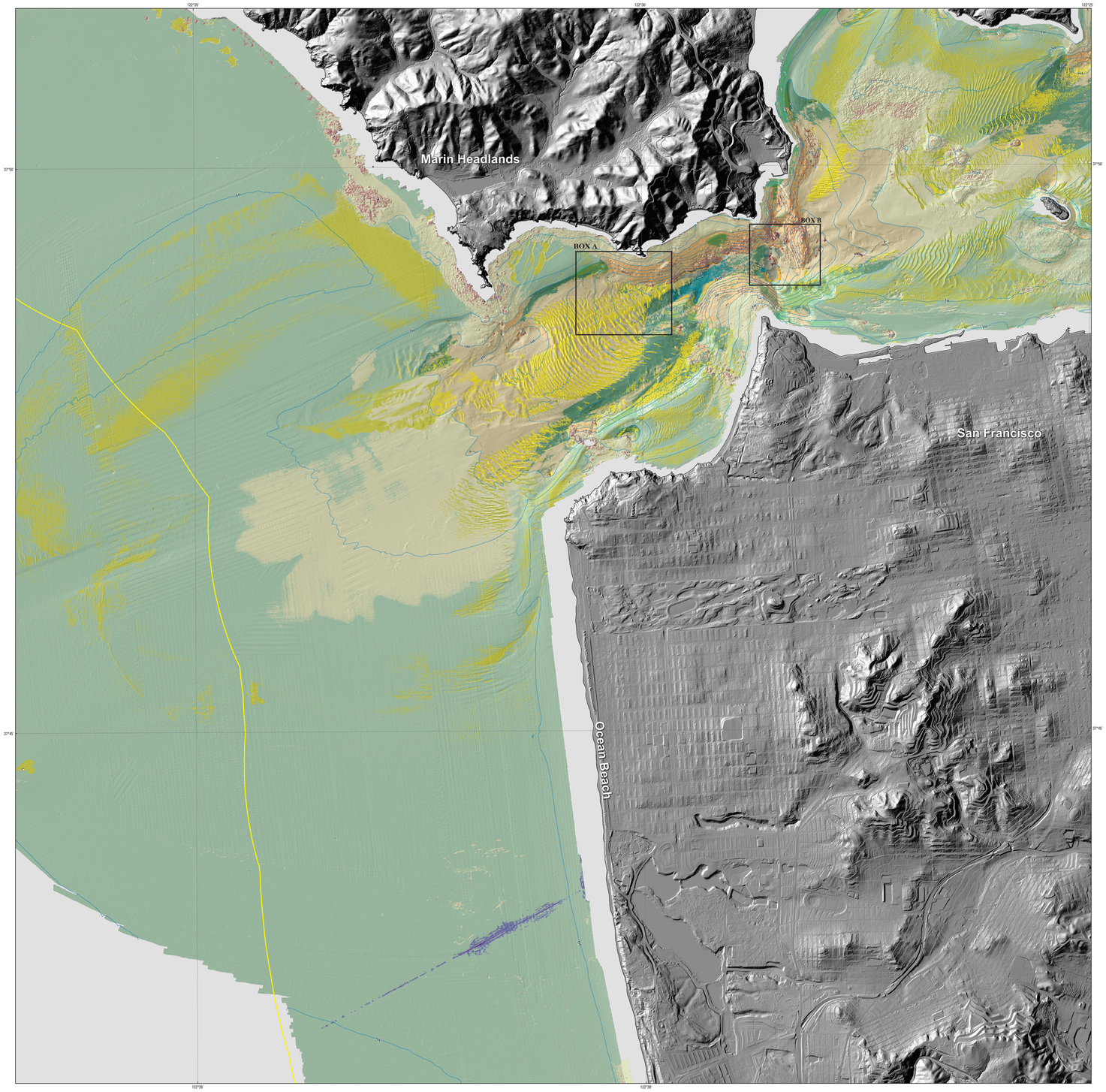
U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2015–1068
Sheet 5 of 10
Pamphlet accompanies map



Onshore elevation data collected by Earth Eye in 2010 for San Francisco State University and the U.S. Geological Survey. 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, 2015

SCALE 1:24 000

BATHYMETRIC CONTOUR INTERVAL 10 METERS

ONE MILE = 0.869 NAUTICAL MILES

MAP LOCATION

Bathymetric contours by Mercedes D. Erdey, 2012
GIS database and digital cartography by Mercedes D. Erdey
Manuscript approved for publication April 7, 2015

Seafloor Character, Offshore of San Francisco Map Area, California

By
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2015

DESCRIPTION OF MAP UNITS

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
Smooth, hard anthropogenic material—High backscatter, low rugosity; related to development by humans
Rugged anthropogenic material—High backscatter, high rugosity; related to development by humans

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

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

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

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

ZONE 4—100 METRES 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
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

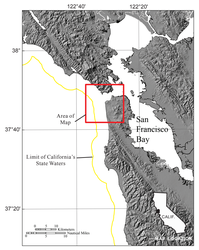
Medium- to coarse-grained sediment—Very high backscatter, low rugosity; typically medium- to coarse-grained sediment, with varying amounts of shell hash; in scour depressions

EXPLANATION OF MAP SYMBOLS

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

10 **Bathymetric contour (in meters)**—Derived from modified 2-m-resolution bathymetry grid. Contour interval: 10 m



DISCUSSION

This seafloor-character map of the Offshore of San Francisco map area in northern 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), and Depth Zone 4 (100 to 200 m). In addition, the following slope classes are represented on this map (Coastal and Marine Ecological Classification Standard slope zone is shown in parentheses): Slope Class 1, 0° to 5° (flat), and Slope Class 2, 5° to 30° (sloping). Depth Zone 1 (intertidal), Depth Zone 5 (greater than 200 m), and Slope Classes 3 to 5, greater than 30° (steeply sloping to overhang) are not present in this map area.

Fine- to medium-grained smooth sediment (sand and mud) makes up 70.5 percent of the map area (122.0 km^2): 117.8 km^2 is in Depth Zone 2, 3.9 km^2 is in Depth Zone 3, and 0.2. km^2 is in Depth Zone 4. Mixed smooth sediment (sand and gravel) and rock (sediment that typically forms a veneer over bedrock, or rock outcrops with little to no relief) make up 18.1 percent of the map area (31.3 km^2): 20.7 km^2 is in Depth Zone 2, 10.5 km^2 is in Depth Zone 3, and 0.2 km^2 is in Depth Zone 4. Rock and boulder, rugose (rock and boulder outcrops having high surficial complexity) makes up less than 0.8 percent (1.4 km^2) of the map area: 0.8 km^2 is in Depth Zone 2, 0.6 km^2 is in Depth Zone 3, and less than 0.1 km^2 in Depth Zone 4. Medium- to coarse-grained sediment makes up 10.5 percent (18.1 km^2) of the map area: 13.9 km^2 is in Depth Zone 2, 4.1 km^2 is in Depth Zone 3, and less than 0.1 km^2 is in Depth Zone 4. Anthropogenic material (a pipe and surrounding scours, hard substrate) is present only in Depth Zone 2. Smooth, hard anthropogenic material surrounding the pipe makes up 0.1 percent of the map area (0.2 km^2), and the pipe itself represents less than 0.1 percent of the map area (<0.1 km^2) (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, and 4.

	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)	
	percent	sq km	percent of total	sq km	percent of total	sq km	percent of total	sq km
Fine- to medium-grained smooth sediment	70.5	122.0	68.1	117.8	2.3	3.9	0.1	0.2
Mixed smooth sediment and rock	18.1	31.3	11.9	20.7	6.1	10.5	0.1	0.2
Rock and boulder, rugose	0.8	1.4	0.5	0.8	0.3	0.6	<0.1	<0.1
Medium- to coarse-grained sediment	10.5	18.1	8.1	13.9	2.4	4.1	<0.1	<0.1
Anthropogenic, smooth, hard (scours, coarse sediment)	0.1	0.2	0.1	0.2	0.0	0.0	0.0	0.0
Anthropogenic, rugged (pipe)	<0.1	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0

BOX A

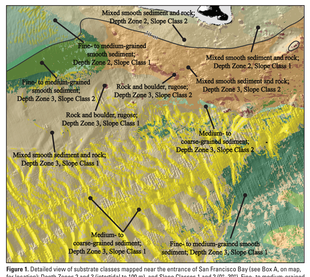


Figure 1. Detailed view of substrate classes mapped near the entrance of San Francisco Bay (see Box A, on map, for location): Depth Zones 2 and 3 (intertidal to 100 m), and Slope Classes 1 and 2 (0°–30°). Fine- to medium-grained smooth sediment is shown in shades of green; mixed smooth sediment and rock is shown in shades of tan and orange; rock is shown in shades of pink and brown; and medium- to coarse-grained sediment, including sandwaves and ripples, is shown in shades of yellow (on flats) and blue (on the slopes). Bathymetric contour (30 m) added for depth reference.

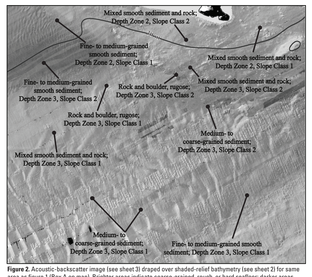


Figure 2. Acoustic-backscatter image (see sheet 3) draped over shaded-relief bathymetry (see sheet 2) for same area as figure 1 (Box A on map). Brighter areas indicate coarse-grained, rough, or hard seafloor; darker areas indicate unconsolidated (loosely packed) sediment. Interpreted substrate classes from figure 1 included for comparison. Bathymetric contour (30 m) added for depth reference.

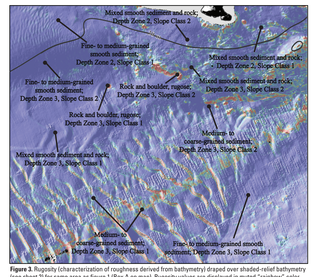


Figure 3. Rugosity (characterization of roughness derived from bathymetry) draped over shaded-relief bathymetry (see sheet 2) for same area as figure 1 (Box A on map). Rugosity values are displayed in muted "rainbow" color spectrum that ranges from purple (low rugosity) through green (medium rugosity) to red (high rugosity). Areas of high slope are indicated by high-rugosity values (red); areas of low slope, by medium- to low-rugosity values (green to purple). Interpreted substrate classes from figure 1 included for comparison. Bathymetric contour (30 m) added for depth reference.

BOX B

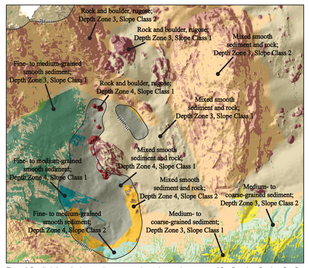


Figure 4. Detailed view of substrate classes mapped nearshore at the entrance of San Francisco Bay (see Box B, on map, for location): Depth Zones 2, 3, and 4 (intertidal to 200 m), and Slope Classes 1 and 2 (0°–30°). Fine- to medium-grained smooth sediment is shown in shades of green; mixed smooth sediment and rock is shown in shades of tan and orange; rock is shown in shades of pink and brown; and medium- to coarse-grained sediment, including sandwaves and ripples, is shown in shades of yellow (on flats) and blue (on the slopes). Bathymetric contour (30 m) added for depth reference.

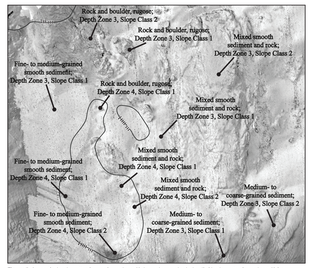


Figure 5. Acoustic-backscatter image (see sheet 3) draped over shaded-relief bathymetry (see sheet 2) for same area as figure 4 (Box B on map). Brighter areas indicate coarse-grained, rough, or hard seafloor; darker areas indicate unconsolidated (loosely packed) sediment. Interpreted substrate classes from figure 4 included for comparison. Bathymetric contours (30 m and 100 m) added for depth reference.

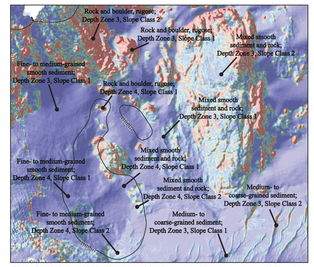


Figure 6. Rugosity (characterization of roughness derived from bathymetry) draped over shaded-relief bathymetry (see sheet 2) for same area as figure 4 (Box B on map). Rugosity values are displayed in muted "rainbow" color spectrum that ranges from purple (low rugosity) through green (medium rugosity) to red (high rugosity). Areas of high slope are indicated by high-rugosity values (red); areas of low slope, by medium- to low-rugosity values (green to purple). Interpreted substrate classes from figure 4 included for comparison. Bathymetric contours (30 m and 100 m) added for depth reference.

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