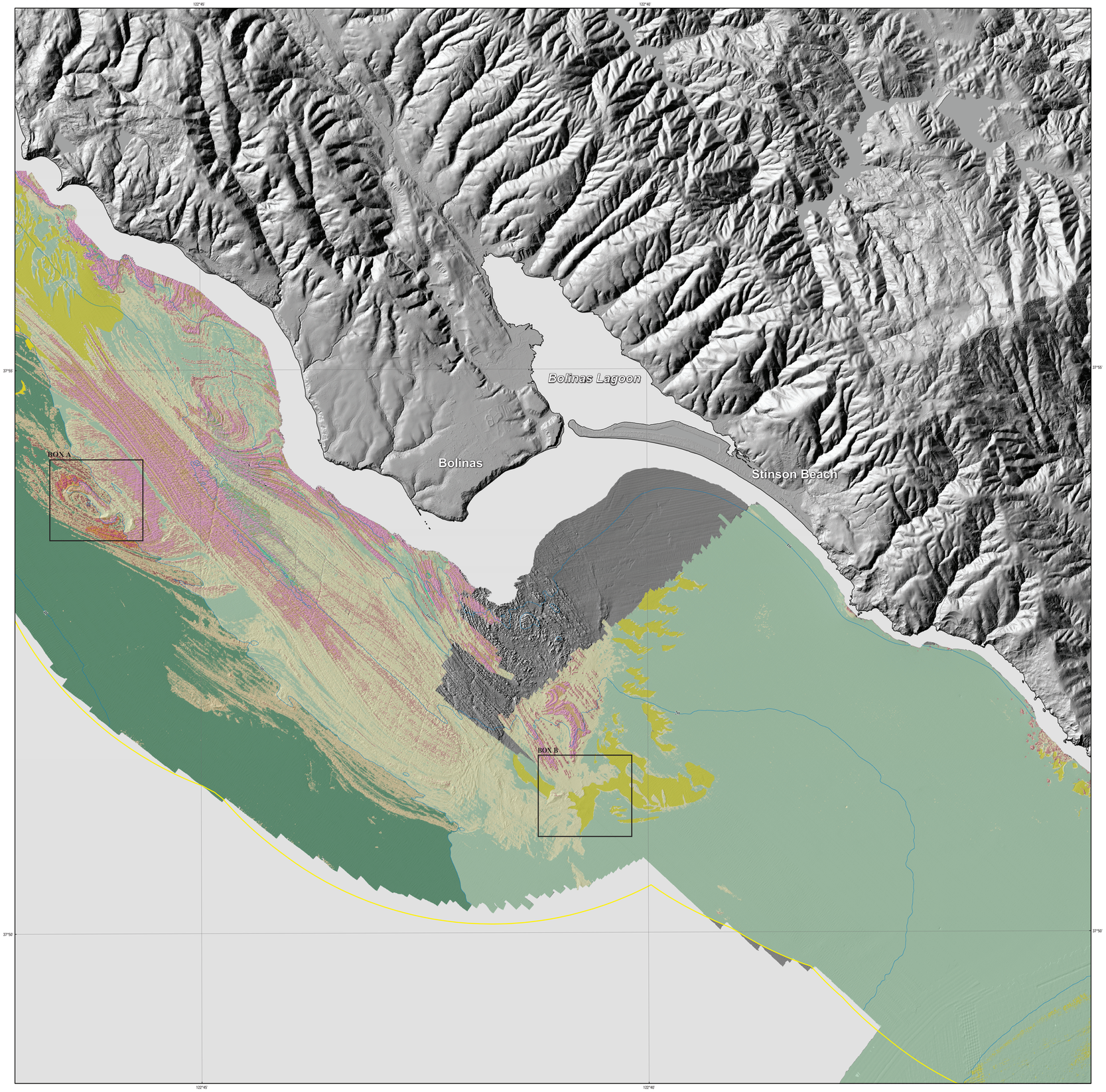
U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2015–1135
Sheet 5 of 10
Pamphlet accompanies map



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

14°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2015

SCALE 1:24 000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

BATHYMETRIC CONTOUR INTERVAL 10 METERS

ONE MILE = 0.869 NAUTICAL MILES

CALIF.
MAP LOCATION

Seafloor character mapped in 2013. Bathymetric contours by Mercedes D. Erdey, 2012

GIS database and digital cartography by Mercedes D. Erdey and Nadine E. Golden

Manuscript approved for publication July 21, 2015

Seafloor Character, Offshore of Bolinas Map Area, California

By
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2015

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

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

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

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 Bolinas 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). Note that no interpreted classifications were made south of Bolinas and Bolinas Lagoon, in the central part of the map area, owing to lack of backscatter data; in these areas, only shaded-relief bathymetry is shown.

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), and Depth Zone 3 (30 to 100 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); and Slope Class 2, 5° to 30° (sloping). Depth Zone 1 (intertidal), Depth Zones 4 and 5 (greater than 100 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 66.1 percent (72.7 km^2) of the map area: 56.1 km^2 is in Depth Zone 2, and 16.6 km^2 is in Depth Zone 3. 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 22.2 percent (24.5 km^2) of the map area: 20.8 km^2 is in Depth Zone 2, and 3.7 km^2 is in Depth Zone 3. Rock and boulder, rugose (rock outcrops and boulder fields having high surficial complexity) makes up 7.9 percent (8.7 km^2) of the map area: 8.3 km^2 is in Depth Zone 2, and 0.4 km^2 is in Depth Zone 3. Medium- to coarse-grained sediment (in scour depressions consisting of material that is coarser than the surrounding seafloor) makes up 3.8 percent (4.2 km^2) of the map area: 4.2 km^2 is in Depth Zone 2, and less than 0.1 km^2 is in Depth Zone 3 (table 1).

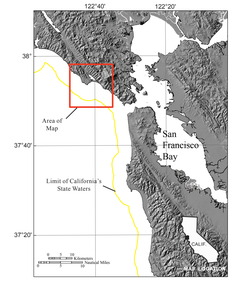

Table 1. Coverage of classified seafloor, in square kilometers (sq km) and percent of total area, broken into California Marine Life Protection Act Depth Zones 2 and 3.

	Total		Depth Zone 2 (water depth 0–30 m)		Depth Zone 3 (water depth 30–100 m)	
	percent	sq km	percent of total	sq km	percent of total	sq km
Fine- to medium-grained smooth sediment	66.1	72.7	51.0	56.1	15.1	16.6
Mixed smooth sediment and rock	22.2	24.5	18.8	20.8	3.4	3.7
Rock and boulder, rugose	7.9	8.7	7.5	8.3	0.4	0.4
Medium- to coarse-grained sediment	3.8	4.2	3.8	4.2	<0.1	<0.1

BOX A

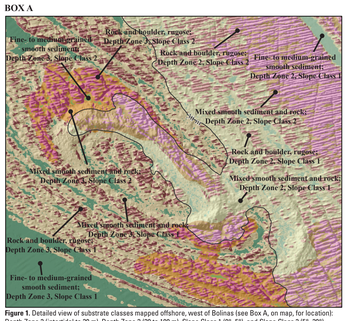

Figure 1. Detailed view of substrate classes mapped offshore, west of Bolinas (see Box A, on map, for location): Depth Zone 2 (intertidal to 30 m), Depth Zone 3 (30 to 100 m), Slope Class 1 (0°–5°), and Slope Class 2 (5°–30°). Fine- to medium-grained smooth sediment is shown in shades of green; mixed smooth sediment and rock is shown in shades of tan; and rock is shown in shades of pink. Bathymetric contour (30 m) added for depth reference.

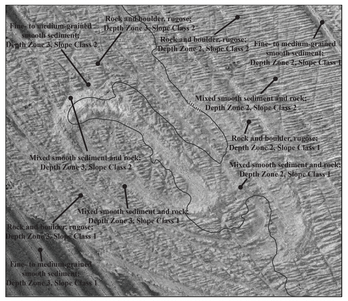

Figure 2. Acoustic-backscatter image (see sheet 3) draped over shaded-relief bathymetry (see sheet 2) for same area as figure 1 (Box A on map). Brighter areas indicate coarse-grained, rough, or hard seafloor; darker areas indicate unconsolidated (loosely packed) sediment. Northwest-southeast-trending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

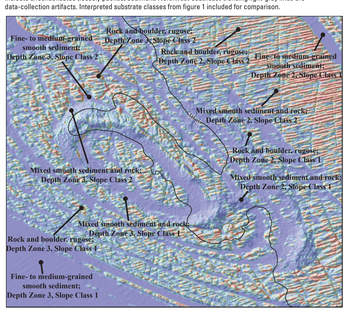

Figure 3. Rugosity (characterization of roughness derived from bathymetry) draped over shaded-relief bathymetry (see sheet 2) for same area as figure 1 (Box A on map). Rugosity values are displayed in muted "rainbow" color spectrum that ranges from purple (low rugosity) through green (medium rugosity)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

BOX B

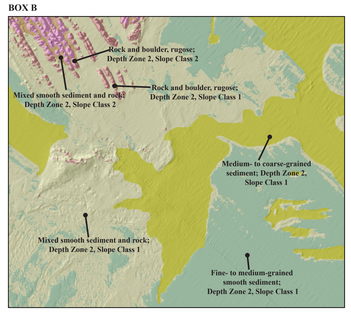

Figure 4. Detailed view of substrate classes mapped offshore of Stinson Beach (see Box B, on map, for location): Depth Zone 2 (intertidal to 30 m), Slope Class 1 (0°–5°), and Slope Class 2 (5°–30°). Fine- to medium-grained smooth sediment is shown in shades of green; mixed smooth sediment and rock is shown in shades of tan; rock is shown in shades of pink; and medium- to coarse-grained sediment is shown in shades of yellow.

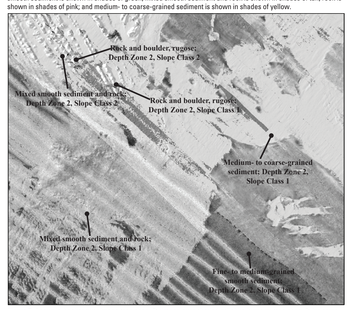

Figure 5. Acoustic-backscatter image (see sheet 3) draped over shaded-relief bathymetry (see sheet 2) for same area as figure 4 (Box B on map). Brighter areas indicate coarse-grained, rough, or hard seafloor; darker areas indicate unconsolidated (loosely packed) sediment. Northwest-southeast-trending light-gray lines are data-collection artifacts. Interpreted substrate classes from figure 4 included for comparison.

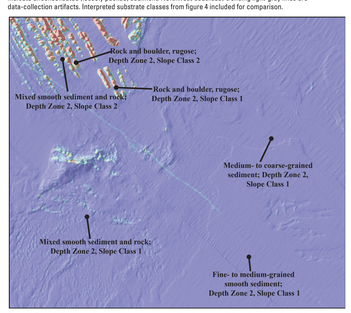

Figure 6. Rugosity (characterization of roughness derived from bathymetry) draped over shaded-relief bathymetry (see sheet 2) for same area as figure 4 (Box B on map). Rugosity values are displayed in muted "rainbow" color spectrum that ranges from purple (low rugosity) through green (medium rugosity)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

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