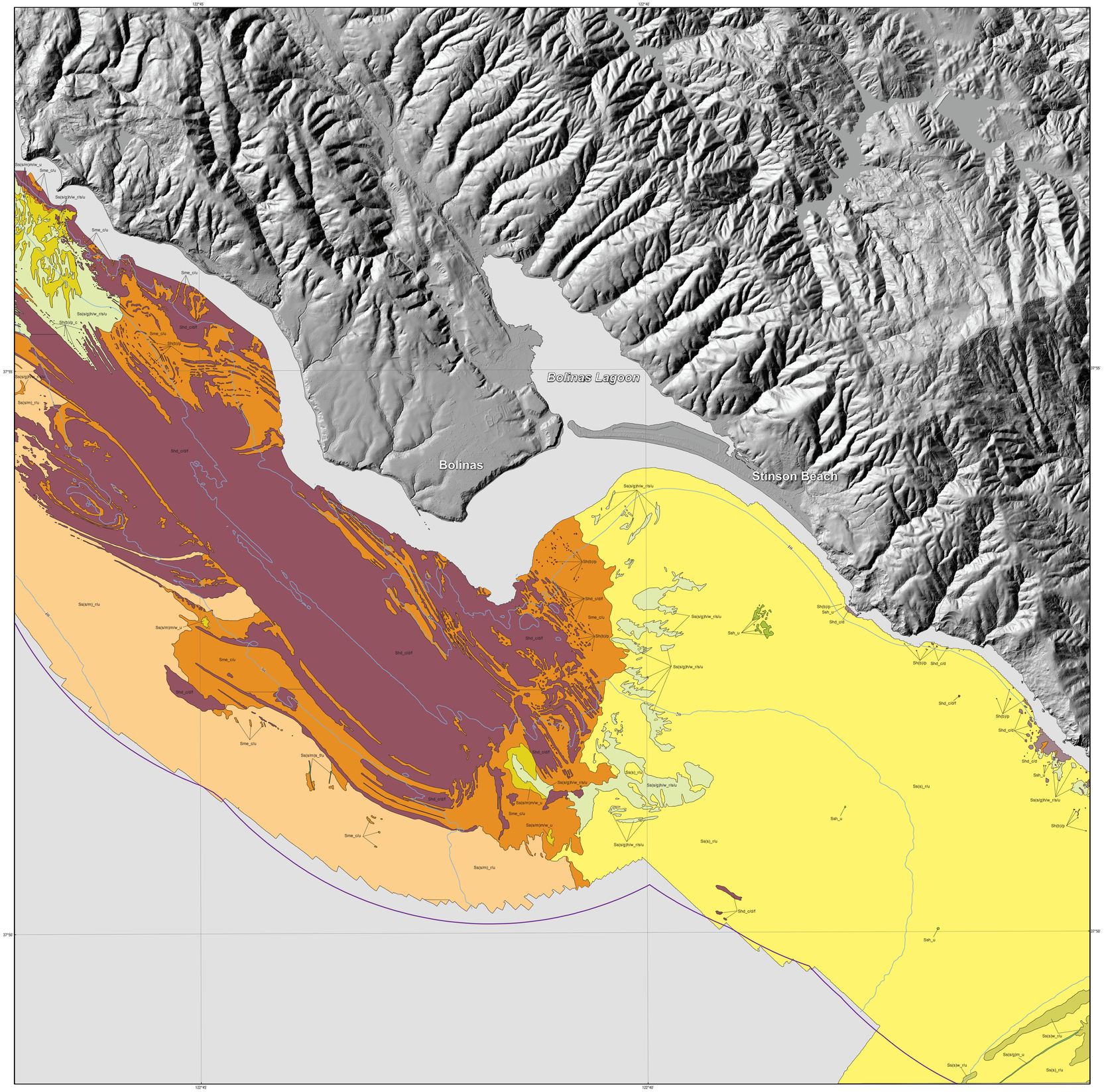
U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2015–1135
Sheet 7 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/). 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

1 1/2 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0 1 KILOMETER

BATHYMETRIC CONTOUR INTERVAL 10 METERS

ONE MILE = 0.869 NAUTICAL MILES

MAP LOCATION

Potential marine benthic habitats mapped by H. Gary Greene, Charles A. Endris, and Bryan E. Dieter, 2012–2013. Bathymetric contours by Mercedes D. Erdey, 2012

GIS database and digital cartography by Charles A. Endris and Mercedes D. Erdey

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## DESCRIPTION OF MAP UNITS

### UNCONSOLIDATED CONTINENTAL SHELF SEDIMENTS

- Ss(s)_r/u — Soft, unconsolidated sediment (sand), predominantly rippled
- Ss(s/m)_r/u — Soft, unconsolidated sediment (sand and mud), predominantly rippled
- Ss(s)w_r/u — Sediment waves in soft, unconsolidated, rippled sediment (sand)
- Ss(s/m)m/w_u — Soft, unconsolidated dynamic mound of sediment (sand and mud)
- Ss(s/m)s_f/u — Scarp of soft, unconsolidated sediment (sand and mud), indicating fault expression
- Ss(s/g)m_u — Linear ridge of soft, unconsolidated sediment (sand and gravel)
- Ss(s/g)h/w_r/s/u — Soft, mobile sediment window with unconsolidated and rippled sediment waves overlying scoured lag pavement of sand and gravel (sorted bedforms)
- Ssh_u — Depression in soft, unconsolidated sediment

### MIXED SUBSTRATE ON CONTINENTAL SHELF

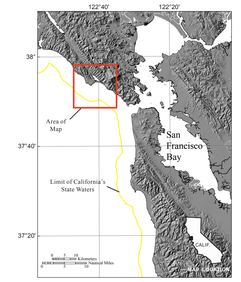
- Sme_c/u — Mixed habitat of soft, unconsolidated sediment, locally overlying hard, consolidated sedimentary bedrock

### HARD SUBSTRATE ON CONTINENTAL SHELF

- Shd_c/d — Hard, deformed, and differentially eroded sedimentary-bedrock outcrop
- Shd_c/d/f — Hard, faulted, fractured, deformed, and differentially eroded sedimentary bedrock
- Sh(b)/p — Hard boulder, boulder field, or pinnacle
- Sh(b)/p_c — Boulder or pinnacle of hard, consolidated sedimentary bedrock

## EXPLANATION OF MAP SYMBOLS

- **Contact**
- **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 map shows "potential" marine benthic habitats in the Offshore of Bolinas map area. Marine benthic habitats represent a particular type of substrate, geomorphology, seafloor process, or any other attribute that may provide a habitat for a specific species or an assemblage of organisms. Such maps are based largely on seafloor geology, and this map integrates seafloor geology (sheet 10) with information depicted on several other thematic maps in the Offshore of Bolinas map area: high-resolution bathymetry (sheet 1); shaded-relief imagery (sheet 2); backscatter (sheet 3); seafloor character (sheet 5); and ground-truth information (sheet 6). This map also uses information from the usSEABED bottom-sampling compilation by Reid and others (2006). The combination of remotely observed data (for example, multibeam bathymetry and backscatter, seismic-reflection profiles) and directly observed data (for example, camera transects, sediment samples) translates to higher confidence in the ability to interpret broad areas of the seafloor (fig. 1).

To avoid any possible misunderstanding of the term "habitat," the term "potential habitat" (as defined by Greene and others, 2005) is used herein to describe a set of distinct seafloor conditions that in the future may qualify as an "actual habitat." Once habitat associations of a species are determined, they can be used to create maps that depict actual habitats, which then need to be confirmed by "ground-truth" surveying using in situ observations, video, and (or) photographic documentation.

Marine benthic habitats are classified using the Benthic Marine Potential Habitat Classification Scheme, a mapping-attribute code developed by Greene and others (1999, 2007). In this map series, habitat-classification codes are based on the deepwater habitat-characterization scheme developed by Greene and others (1999), which was created to not only easily distinguish marine benthic habitats but also to facilitate ease of use and queries within GIS and database programs. The code, which is summarized in chapter 6 in the accompanying pamphlet, is derived from several categories of the Benthic Marine Potential Habitat Classification Scheme (Greene and others, 1999, 2007), and it can be subdivided on the basis of the spatial scale of the data.

High-resolution, multibeam-sonar data, converted to bathymetric depth grids (seafloor digital elevation models; sheet 1), are essential to development of the habitat map, as is shaded-relief imagery (sheet 2), which allows for visualization of seafloor terrain and provides a foundation for interpretation of submarine landforms. Areas of seafloor bedrock exposures are identified by their common sharp edges and high relative relief; these may be contiguous outcrops, isolated parts of outcrop protruding through sediment cover (pinnacles or knobs), or isolated boulders.

Backscatter maps (sheet 3) also are essential for developing potential benthic habitat maps. High backscatter is further indication of "hard" bottom, consistent with interpretation as rock or coarse sediment. In many locations, areas within or around a rocky feature appear to be covered by a thin veneer of sediment, identified on the habitat map as "mixed" induration (in other words, containing both rock and sediment). Broad, generally smooth areas of the seafloor that lack sharp and angular edge characteristics are mapped as "sediment" and are further defined by various sedimentary features such as erosional scours and depressions, as well as depositional features such as dunes, mounds, or sand waves. Low backscatter, indicative of a "soft" bottom, also significantly aids identification and classification of sedimentary habitats.

Delineated in the Offshore of Bolinas map area are 13 potential marine benthic habitat types, all of which are located on the continental shelf ("Shelf" megahabitat). These include rippled, unconsolidated sediment; dynamic features such as sediment waves; "mixed" hard-soft habitats; deformed and differentially eroded sedimentary-bedrock outcrops; and boulders and pinnacles. Backscatter data show that most of the map area is underlain by soft, unconsolidated sediment, consistent with the interpretation that unconsolidated sediments are the primary habitat in the map area, with the well-exposed, deformed and differentially eroded sedimentary bedrock being the next most prominent habitat type.

Sediment transport is primarily to the southeast, and sedimentary processes, which are quite active in the map area, produce mobile sand sheets. In addition, erosion through shelf sediments down to a coarser lag has produced sediment-filled scour depressions that resemble "ripple scour depressions" of Cacchione and others (1984) and Phillips and others (2007), found mainly on the shelf in the northwestern part of the map area.

Of the 119.24 km$^2$ in the map area, 75.3 km$^2$ (63.2 percent) is soft, unconsolidated sediment, 14.69 km$^2$ (12.3 percent) is mixed substrate (soft sediment over hard substrate), and 29.26 km$^2$ (24.5 percent) is hard substrate.

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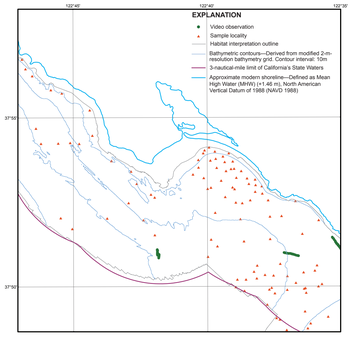


**Figure 1.** Map showing video-observation locations and sample localities for Offshore of Bolinas map area.

# Potential Marine Benthic Habitats, Offshore of Bolinas Map Area, California

By

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