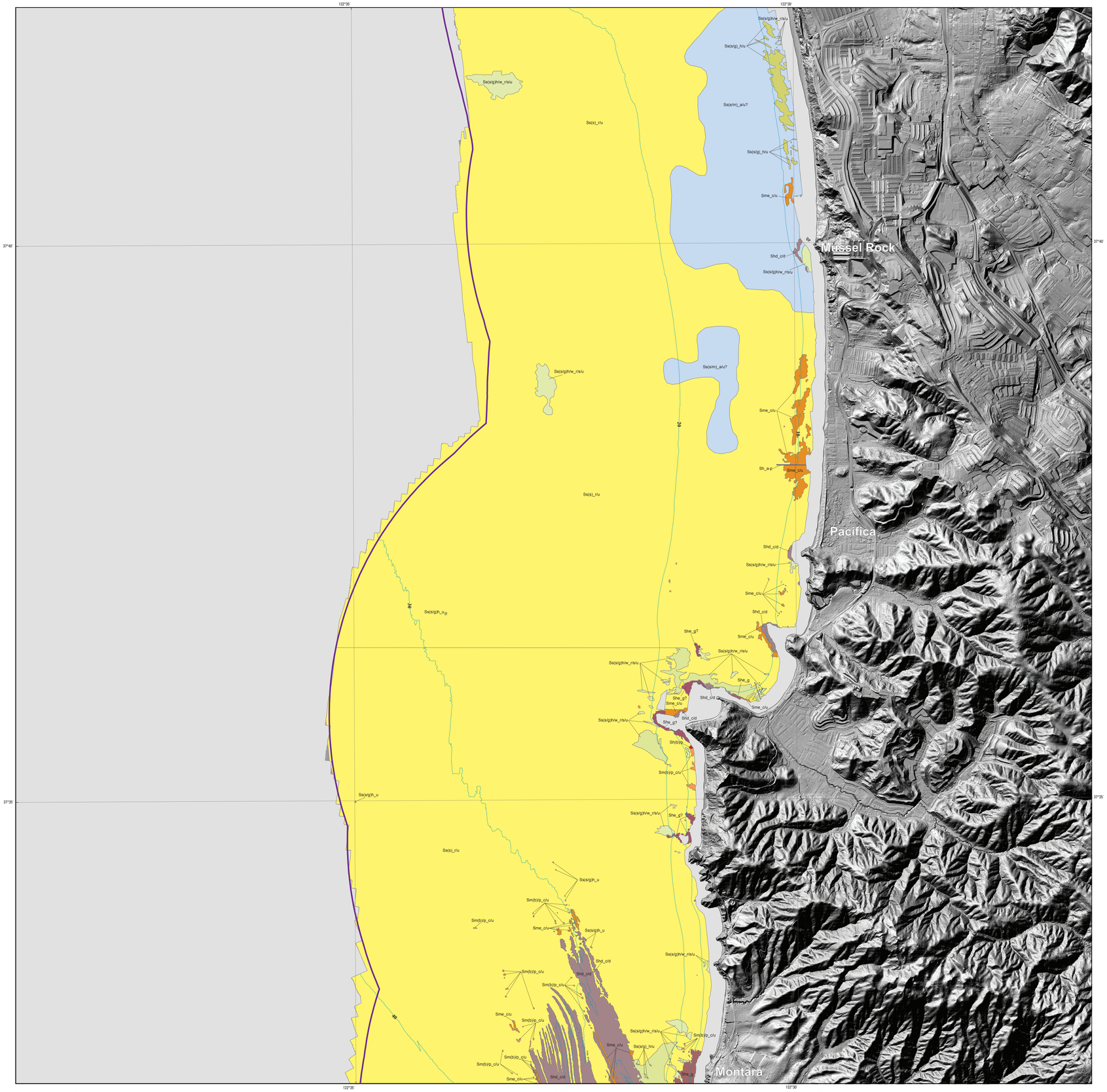
U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2014–1260
Sheet 7 of 10
Pamphlet accompanies map



Onshore elevation data collected by Photoscience in 2005 for U.S. Geological Survey and County of San Mateo. 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°
APPROXIMATE MEAN DECLINATION, 2014

SCALE 1:24 000

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

BATHYMETRIC CONTOUR INTERVAL 10 METERS
ONE MILE = 0.869 NAUTICAL MILES

CALIF.
MAP LOCATION

Potential marine benthic habitats mapped by Charles A. Endris, Bryan E. Dieter, and H. Gary Greene, 2011. Bathymetric contours by Carrie K. Bretz, 2008

GIS database and digital cartography by Nadine E. Golden, Mercedes D. Erdey, and Charles A. Endris

Manuscript approved for publication December 22, 2014

Potential Marine Benthic Habitats, Offshore of Pacifica Map Area, California

By
Charles A. Endris,[1] H. Gary Greene,[1] Bryan E. Dieter,[1] Mercedes D. Erdey,[2] Nadine E. Golden,[2] and Brian D. Edwards[2]
2014

[1]Moss Landing Marine Laboratories, Center for Habitat Studies;
[2]U.S. Geological Survey

DESCRIPTION OF MAP UNITS

UNCONSOLIDATED CONTINENTAL SHELF SEDIMENTS

- **Ss(s)_r/u** — Soft, unconsolidated sediment (sand), predominantly rippled
- **Ss(s/g)_h/u** — Soft, unconsolidated, hummocky sediment (sand and gravel)
- **Ss(s/g)h/w_r/s/u** — Soft, mobile sediment window that has unconsolidated and rippled sediment waves, overlying scoured lag pavement of sand and gravel (sorted bedforms)
- **Ss(s/g)h_u** — Depression that contains soft, unconsolidated sediment (sand and gravel)

MIXED SUBSTRATE ON CONTINENTAL SHELF

- **Sm(b)/p_c/u** — Mixed habitat of boulders or pinnacles and cobbles with soft, unconsolidated sediment
- **Sme_c/u** — Mixed habitat of soft, unconsolidated sediment, locally overlying hard, consolidated sedimentary bedrock

HARD SUBSTRATE ON CONTINENTAL SHELF

- **Sh(b)/p** — Hard boulder, boulder field, or pinnacle
- **Shd_c/d** — Hard, deformed, and differentially eroded sedimentary–bedrock outcrop
- **She_g** — Hard, granitic-rock exposure; may contain unconsolidated sediment (sand) in crevices and cracks
- **She_g?** — Hard, granitic-rock exposure; may contain unconsolidated sediment (sand) in crevices and cracks; inferred

ANTHROPOGENIC FEATURES

- **Ss(s/m)_a/u?** — Unconsolidated sediment (sand and mud) with anthropogenic features; inferred
- **Sh_a-p** — Hard anthropogenic feature (pipeline; boulders placed over and around pipe)

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 Pacifica 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 of the Offshore of Pacifica 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 usSEARBED 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 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.

The Offshore of Pacifica map area covers a flat continental shelf that is composed primarily of soft, unconsolidated sediment. Delineated on the map are 12 potential marine benthic habitat types, all of which are located on the continental shelf ("Shelf" megahabitat). The meso- and macrohabitats include "hard" deformed sedimentary-rock outcrops and rugose granitic-rock outcrops; "mixed" flat, hard bedrock exposures and (or) boulders and pinnacles that are covered locally with soft, unconsolidated sediment; and dynamic features such as mobile sand sheets and associated scour depressions. Backscatter data show that the map area is dominated by "soft" sediment, with scattered seafloor bedrock exposures in the nearshore and adjacent to points of land.

Although the map area is located on the relatively flat, eroded continental shelf, the differentially eroded bedrock areas form the local relief and rugosity that make promising potential habitats for rockfish (*Sebastes* spp.), especially in the southern part of the map area and near Point San Pedro. Sediment transport is primarily to the southeast, and sedimentary processes, which are quite active in the map area, produce the dynamic bedforms that may be habitats for forage fish such as Pacific sand lance (*Ammodytes hexapterus*). 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 and near points of land.

Unusual areas of hummocky sediment, possibly containing boulders and artifacts, were mapped in the nearshore in the northern part of the map area; these areas are classified as anthropogenic on the basis of their irregular acoustic returns.

Of the 107.92 km^2 in the map area, only 2.0 km^2 (1.9 percent) is exposed hard bedrock, and 0.66 km^2 (0.6 percent) consists of sediment-covered bedrock, which is of the mixed hard-soft induration class. Soft, unconsolidated sediment covers a total of 96.5 km^2 (89.4 percent). Possibly anthropogenic and hummocky sediment covers 8.75 km^2 (8.1 percent) of the map area.

REFERENCES CITED

Cacchione, D.A., Drake, D.E., Grant, W.D., and Tate, G.B., 1984, Rippled scour depressions of the inner continental shelf off central California: Journal of Sedimentary Petrology, v. 54, p. 1,280–1,291.

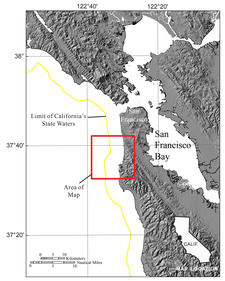
Greene, H.G., Bizzarro, J.J., O'Connell, V.M., and Brylinsky, C.K., 2007, Construction of digital potential marine benthic habitat maps using a coded classification scheme and its application, *in* Todd, B.J., and Greene, H.G., eds., Mapping the seafloor for habitat characterization: Geological Association of Canada Special Paper 47, p. 141–155.

Greene, H.G., Bizzarro, J.J., Tilden, J.E., Lopez, H.L., and Erdey, M.D., 2005, The benefits and pitfalls of geographic information systems in marine benthic habitat mapping, *in* Wright, D.J., and Scholz, A.J., eds., Place matters: Portland, Oregon State University Press, p. 34–46.

Greene, H.G., Yoklavich, M.M., Starr, R.M., O'Connell, V.M., Wakefield, W.W., Sullivan, D.E., McRea, J.E., and Cailliet, G.M., 1999, A classification scheme for deep seafloor habitats: Oceanologica Acta, v. 22, p. 663–678.

Phillips, E.L., Storlazzi, C.D., Dartnell, P., and Edwards, B.D., 2007, Exploring rippled scour depressions offshore Huntington Beach, CA: Coastal Sediments 2007, v. 3, p. 1,851–1,864.

Reid, J.A., Reid, J.M., Jenkins, C.J., Zimmerman, M., Williams, S.J., and Field, M.E., 2006, usSEABED—Pacific Coast (California, Oregon, Washington) offshore surficial-sediment data release: U.S. Geological Survey Data Series 182, available at http://pubs.usgs.gov/ds/2006/182/.



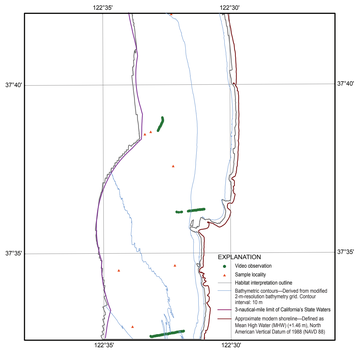


Figure 1. Map showing video-observation locations and sample localities for Offshore of Pacifica map area.

Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government

This map was printed on an electronic plotter directly from digital files. Dimensional calibration may vary between electronic plotters and between X and Y directions on the same plotter, and paper may change size due to atmospheric conditions; therefore, scale and proportions may not be true on plots of this map.

For sale by U.S. Geological Survey, Information Services, Box 25286, Federal Center, Denver, CO 80225, 1–888–ASK–USGS

Digital files available at http://pubs.usgs.gov/of/2014/1260/

Suggested Citation: Endris, C.A., Greene, H.G., Dieter, B.E., Erdey, M.D., Golden, N.E., and Edwards, B.D., 2014, Potential marine benthic habitats, Offshore of Pacifica map area, California, *sheet 7 in* Edwards, B.D., Phillips, E.L., Dartnell, P., Greene, H.G., Bretz, C.K., Kvitek, R.G., Hartwell, S.R., Johnson, S.Y., Cochrane, G.R., Dieter, B.E., Sliter, R.W., Ross, S.L., Golden, N.E., Watt, J.T., Chin, J.L., Erdey, M.D., Krissman, L.M., Manson, M.W., and Endris, C.A. (S.A. Cochran and B.D. Edwards, eds.), California State Waters Map Series—Offshore of Pacifica, California: U.S. Geological Survey Open-File Report 2014–1260, pamphlet 38 p., 10 sheets, scale 1:24,000, *http://dx.doi.org/10.3133/ofr20141260*

ISSN 2331-1258 (online)
http://dx.doi.org/10.3133/ofr20141260