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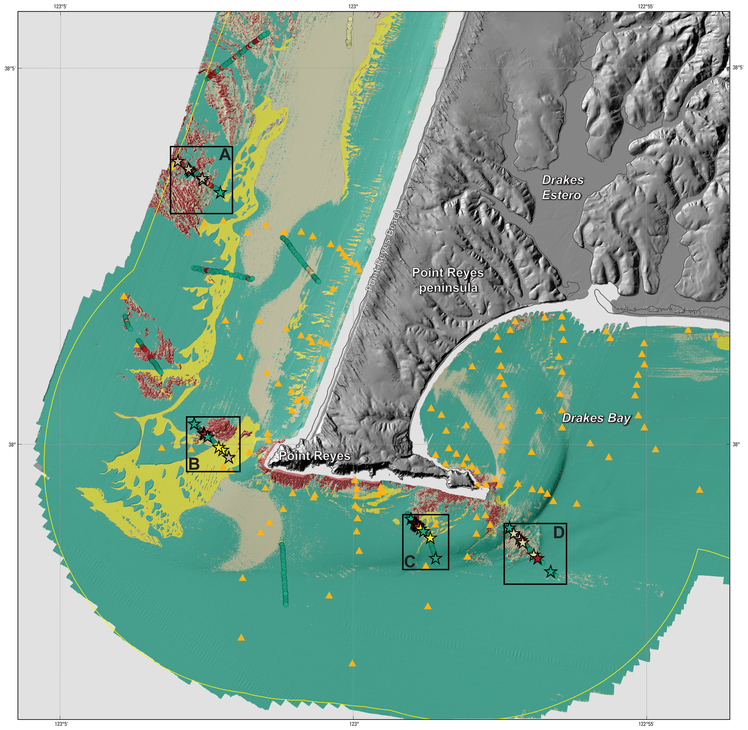
U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2015–1114
Sheet 6 of 10
Pamphlet accompanies map



Onshore elevation data from NOAA Coastal Service Center's Digital Coast (available at http://coast.noaa.gov/digitalcoast/) and from U.S. Geological Survey 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

SCALE 1:50 000

2 MILES
7000 3500 0 7000 FEET
0.5 0 1 KILOMETER
ONE MILE = 0.869 NAUTICAL MILES

APPROXIMATE MEAN DECLINATION, 2015

Seafloor-character map simplified from map on sheet 5, this report. Video observations recorded and digital still photographs taken in 2007 and 2008. Sample localities from usSEABED (Reid and others, 2006)

GIS database and digital cartography by Nadine E. Golden and Elayne L. Phillips

Manuscript approved for publication June 8, 2015

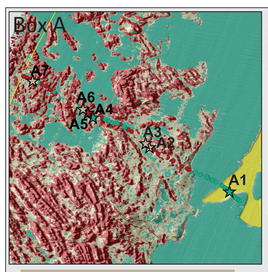


Figure 1A. Detailed view of seafloor character mapped west of Point Reyes Beach, approximately 4 km offshore (see Box A, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 1B through 1H) from camera line CAM61, cruise L–9–08–NC.

Figure 1B. Digital still photograph no. A1 (see fig. 1A for location). Sandy mud and burrows (water depth, 59 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes Dungeness crab, *Cancer magister* (c). Distance between lasers (red dots) is 15 cm.

Figure 1C. Digital still photograph no. A2 (see fig. 1A for location). Mixed gravel and sand (water depth, 57 m). Abiotic complexity is low, biotic complexity is absent, and biocover is high. Biocover includes blue rockfish, *Sebastes mystinus* (rf); cup corals (cc); and sea cucumbers (sc). Distance between lasers (green dots) is 15 cm.

Figure 1D. Digital still photograph no. A3 (see fig. 1A for location). Low-relief fractured rock (water depth, 57 m). Abiotic complexity is low, biotic complexity is absent, and biocover is high. Biocover includes sea cucumbers (sc), brittle star (bs), and cup corals (cc). Distance between lasers (red dots) is 15 cm.

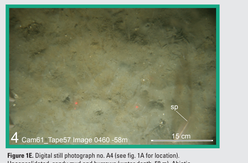


Figure 1E. Digital still photograph no. A4 (see fig. 1A for location). Unconsolidated, sandy mud and burrows (water depth, 58 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes sea pen (sp). Distance between lasers (red dots) is 15 cm.

Figure 1F. Digital still photograph no. A5 (see fig. 1A for location). Interface between sandy mud and fractured rock (water depth, 59 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is moderate. Biocover includes sea cumumbers (sc) , bryozoans (bry), and sponge (spo). Distance between lasers (green dots) is 15 cm.

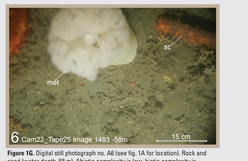


Figure 1G. Digital still photograph no. A6 (see fig. 1A for location). Rock and sand (water depth, 58 m). Abiotic complexity is low, biotic complexity is present, and biocover is present. Biocover includes white-plumed anemone, *Metridium* spp. (mst); and California sea cucumber, *Parastichopus californicus* (sc). Distance between lasers (red dots) is 15 cm.

Figure 1H. Digital still photograph no. A7 (see fig. 1A for location). Unconsolidated sand and gravel (water depth, 58 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes red sea star, *Mediaster aequalis* (sst). Distance between lasers (green dots) is 15 cm.

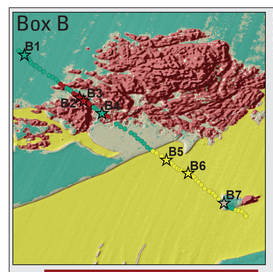


Figure 2A. Detailed view of seafloor character mapped west of Point Reyes headland, approximately 1 km offshore (see Box B, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 2B through 2H) from camera line CAM41, cruise F–3–07–NC.

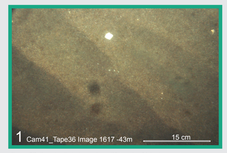


Figure 2B. Digital still photograph no. B1 (see fig. 2A for location). Unconsolidated sand with oscillatory ripples (water depth, 43 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (green dots are just out of view in this image but are visible in previous video frame) is 15 cm.

Figure 2C. Digital still photograph no. B2 (see fig. 2A for location). Massive rock (water depth, 38 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes strawberry anemones, *Corynactis californica* (sta); zoanthids (zoa); encrusting sponge (spo); and scallops (scl). Distance between lasers (green dots are just out of view in this image but are visible in previous video frame) is 15 cm.

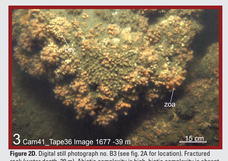


Figure 2D. Digital still photograph no. B3 (see fig. 2A for location). Fractured rock (water depth, 39 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes zoanthids (zoa) and bryozoans (bry). Distance between lasers (green dots are just out of view in this image but are visible in previous video frame) is 15 cm.

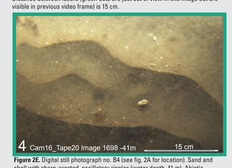


Figure 2E. Digital still photograph no. B4 (see fig. 2A for location). Sand and shell with sharp-crested, oscillatory ripples (water depth, 41 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (green dots are just out of view in this image but are visible in previous video frame) is 15 cm.

Figure 2F. Digital still photograph no. B5 (see fig. 2A for location). Sand, gravel, and shell fragments with ripples (water depth, 40 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (green dots are just out of view in this image but are visible in previous video frame) is 15 cm.

Figure 2G. Digital still photograph no. B6 (see fig. 2A for location). Sand, gravel, and shell fragments with ripples (water depth, 40 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (green dots are just out of view in this image but are visible in previous video frame) is 15 cm.

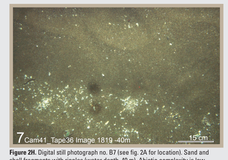


Figure 2H. Digital still photograph no. B7 (see fig. 2A for location). Sand and shell fragments with ripples (water depth, 40 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (green dots) is 15 cm.

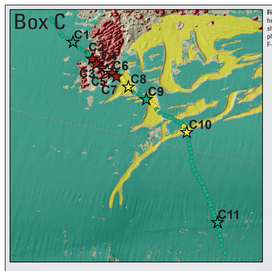


Figure 3A. Detailed view of seafloor character mapped south of Point Reyes headland, approximately 1 km offshore (see Box C, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 3B through 3J) from camera line CAM38, cruise F–3–07–NC.

Figure 3B. Digital still photograph no. C1 (see fig. 3A for location). Sand and shell fragments with ripples (water depth, 23 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

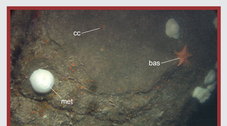


Figure 3C. Digital still photograph no. C2 (see fig. 3A for location). Massive rock (water depth, 24 m). Abiotic complexity is high, biotic complexity is present, and biocover is moderate. Biocover includes white-plumed anemones, *Metridium* spp. (met); bat stars, *Asterina miniata* (bas); and cup corals (cc). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

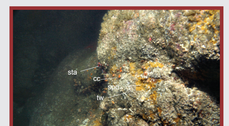


Figure 3D Digital still photograph no. C3 (see fig. 3A for location). Massive rock (water depth, 24 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes strawberry anemones, *Corynactis californica* (sta); cup corals (cc); encrusting sponges (spo); and tubeworms (tw). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

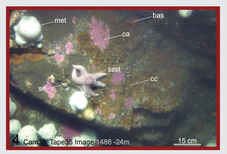


Figure 3E. Digital still photograph no. C4 (see fig. 3A for location). Fractured rock (water depth, 24 m). Abiotic complexity is high, biotic complexity is present, and biocover is high. Biocover includes white-plumed anemones, *Metridium* spp. (met); short-spined sea star, *Pisaster brevispinus* (sasl); bat star, *Asterina miniata* (bas); cup coral (cc); snails (sn); and encrusting coralline algae (ca). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

Figure 3F. Digital still photograph no. C5 (see fig. 3A for location). Low-relief rock (water depth, 24 m). Abiotic complexity is low, biotic complexity is absent, and biocover is moderate. Biocover includes bat stars, *Asterina miniata* (bas); cup corals (cc); snail (sn); and drifting algae (a). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

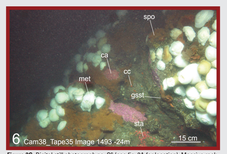


Figure 3G. Digital still photograph no. C6 (see fig. 3A for location). Massive rock (water depth, 24 m). Abiotic complexity is high, biotic complexity is present, and biocover is high. Biocover includes white-plumed anemones, *Metridium* spp. (met); strawberry anemones, *Corynactis californica* (sta); giant-spined sea star, *Pisaster giganteus* (gsst); encrusting coralline algae (ca); encrusting sponge (spo); and cup coral (cc). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

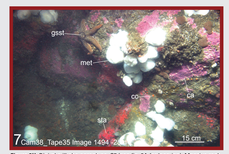


Figure 3H. Digital still photograph no. C7 (see fig. 3A for location). Massive rock (water depth, 25 m). Abiotic complexity high, biotic complexity is present, and biocover is high. Biocover includes white-plumed anemones, *Metridium* spp. (met); strawberry anemones, *Corynactis californica* (sta); giant-spined sea star, *Pisaster giganteus* (gsst); encrusting coralline algae (ca); and cup coral (cc). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

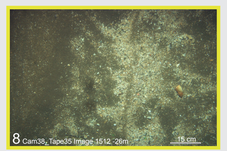


Figure 3I. Digital still photograph no. C8 (see fig. 3A for location). Unconsolidated sand and shell fragments with ripples (water depth, 26 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

Figure 3J. Digital still photograph no. C9 (see fig. 3A for location). Sand and shell fragments with oscillatory ripples (water depth, 27 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes drifting algae (a); and olive snails, *Olivella biplicata* (sn). Distance between lasers (green dots) is 15 cm.

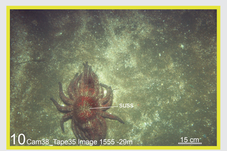


Figure 3K. Digital still photograph no. C10 (see fig. 3A for location). Unconsolidated sand and shell fragments with ripples (water depth, 29 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes sunflower sea star, *Pycnopodia helianthoides* (suss). Distance between lasers (red dots) is 15 cm.

Figure 3L. Digital still photograph no. C11 (see fig. 3A for location). Unconsolidated, muddy sand (water depth, 48 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes small crabs (c). Distance between lasers (red dots) is 15 cm.

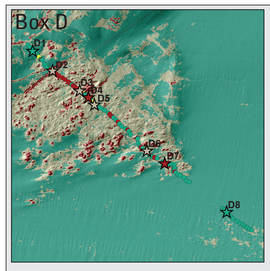


Figure 4A. Detailed view of seafloor character mapped southeast of Point Reyes headland, approximately 1.5 km offshore (see Box D, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 4B through 4I) from camera line CAM34, cruise F–3–07–NC.

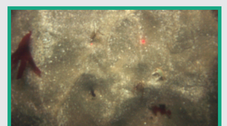


Figure 4B. Digital still photograph no. D1 (see fig. 4A for location). Unconsolidated sand and shell fragments with confused ripples (water depth, 24 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

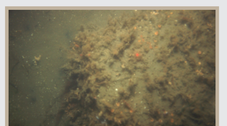


Figure 4C. Digital still photograph no. D2 (see fig. 4A for location). Interface between low-relief rock and area of sand and shell fragments (water depth, 31 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is moderate. Distance between lasers (red dots) is 15 cm.

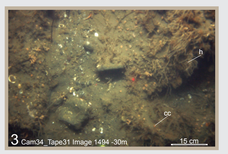


Figure 4D. Digital still photograph no. D3 (see fig. 4A for location). Cobbles, sand, and shell fragments (water depth, 30 m). Abiotic complexity is low, biotic complexity is absent, and biocover is moderate. Biocover includes cup corals (cc) and hydroids (h). Distance between lasers (red dots) is 15 cm.

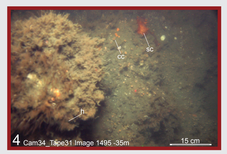


Figure 4E. Digital still photograph no. D4 (see fig. 4A for location). Layered rock (water depth, 35 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes sea cucumber (sc), cup corals (cc), and hydroids (h). Distance between lasers (red dots) is 15 cm.

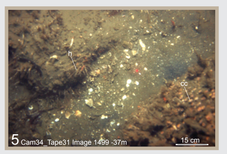


Figure 4F. Digital still photograph no. D5 (see fig. 4A for location). Fractured rock and, filling in sand channel, sand and shell fragments (water depth, 37 m). Abiotic complexity is low, biotic complexity is absent, and biocover is moderate. Biocover includes cup corals (cc) and hydroids (h). Distance between lasers (red dots) is 15 cm.

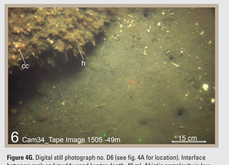


Figure 4G. Digital still photograph no. D6 (see fig. 4A for location). Interface between rock and muddy sand (water depth, 49 m). Abiotic complexity is low, biotic complexity is absent, and biocover is moderate. Biocover includes cup corals (cc) and hydroids (h). Distance between lasers (red and green dots) is 15 cm.

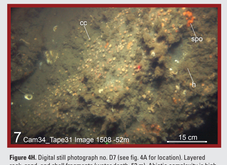


Figure 4H. Digital still photograph no. D7 (see fig. 4A for location). Layered rock, sand, and shell fragments (water depth, 52 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes cup corals (cc), encrusting sponge (spo), and hydroids (h). Distance between lasers (red dots) is 15 cm.

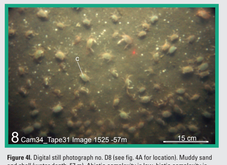


Figure 4I. Digital still photograph no. D8 (see fig. 4A for location). Muddy sand and shell (water depth, 57 m). Abiotic complexity is low, biotic complexity is absent, and biocover is high. Biocover includes small crabs (c). Distance between lasers (red dots) is 15 cm.

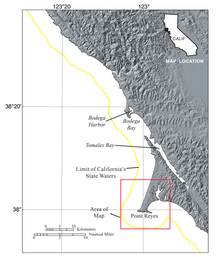
Ground-Truth Studies, Offshore of Point Reyes Map Area, California

By

Nadine E. Golden,[1] Guy R. Cochrane,[1] and Lisa M. Krigsman[2]

2015

[1]U.S. Geological Survey;
[2]National Oceanic and Atmospheric Administration, National Marine Fisheries Service



DISCUSSION

Between 2006 and 2007, the seafloor in the Offshore of Point Reyes map area in northern California was mapped by Fugro Pelagos and California State University, Monterey Bay (CSUMB), using both multibeam echosounders and bathymetric sidescan-sonar systems (see sheets 1, 2, 3). These mapping missions combined to collect bathymetry and acoustic-backscatter data from about the 10-m isobath to out beyond the 3-nautical-mile limit of California's State Waters. In order to characterize the bathymetry and acoustic-backscatter data into geologically and biologically useful information, the USGS ground-truth-surveyed the data by towing a camera sled (fig. 5) over specific locations throughout the map area.

The ground-truth surveys occurred on two separate cruises in 2007 and 2008. During the ground-truth-survey cruises, the camera sled was towed 1 to 2 m above the seafloor, at speeds of between 1 and 2 nautical miles/hour. The sled housed two standard-definition (640×480 pixel resolution) video cameras (one forward looking, the other downward looking), a high-definition (1,080×1,920 pixel resolution) video camera, and an 8-megapixel digital still camera, which captured a digital still photograph once every 30 seconds. The video was relayed in real time to the research vessel, where USGS and National Oceanic and Atmospheric Administration (NOAA) scientists recorded both the geologic and biologic character of the seafloor once every minute, using programmable keypads. The locations and directions of the camera-sled tracklines were chosen in order to visually inspect areas thought to represent the full range of bottom hardness and rugosity in the map area.

In the context of marine-fisheries management, benthic-habitat complexity can be divided into abiotic (geologic) and biotic (biologic) components. Benthic-habitat complexity refers to the visual classification of local abiotic and biotic vertical relief and structure that may provide potential refuge for both juvenile and adult forms of various species. Only abiotic attributes (primary- and secondary-substrate composition) were used in the production of the seafloor-character map on sheet 5. Classifications of primary and secondary substrate are based on the Wentworth (1922) scale of sediment grain-size categories, and the sand, cobble, and boulder sizes are classified as in Wentworth (1922). However, the difficulty in distinguishing the finest divisions in the Wentworth (1922) scale during video observations made it necessary to aggregate some grain-size classes: the granule and pebble sizes have been grouped together into a class called "gravel," and the clay and silt sizes have been grouped into a class called "mud." In addition, hard bottom and clasts larger than boulder size are classified as "rock." Primary and secondary substrate, by definition, constitute greater than 50 and 20 percent of the seafloor during an observation, respectively.

This sheet contains a smaller, simplified (depth-zone symbology has been removed) version of the seafloor-character map (sheet 5), on which the camera-sled tracklines used to ground-truth-survey the sonar data are indicated by aligned colored dots, each dot representing the location of a recorded observation. Primary- and secondary-substrate compositions are shown by differently colored dots. The map also shows the locations of the detailed views of seafloor character along some of the tracklines (Boxes A through D) that are highlighted on this sheet (figs. 1A, 2A, 3A, 4A). Also shown are locations of samples (triangles) from usSEABED (Reid and others, 2006) that were used to supplement the ground-truth surveys.

The seafloor-character map shows that, within the relatively sheltered Drakes Bay, the seafloor is dominated by sandy sediment. Nearshore areas around the Point Reyes headland consist of rocky habitat, which can be seen along the wave-exposed coastline west and south of the headland. In the northwestern part of the map area, west of Point Reyes Beach, large areas of rocky habitat that are present in deeper water are related to regional faulting (see sheet 10). Erosional scour depressions are found at all water depths, both adjacent to, and distant from, rocky areas. In these areas, moderately to poorly sorted coarse sand and gravel typically form shallow depressions relative to the adjacent sandy seafloor. Many depressions are characterized by large ripples and megaripples composed of coarse sand, fine gravel, and scattered shells (see, for example, figs. 2G, 3I). These features are characterized by low abiotic complexity, low biotic complexity, and low percent biocover.

Each detailed view (figs. 1A, 2A, 3A, 4A) shows the locations of camera-sled tracklines (aligned colored dots), as well as of the photographs (colored stars) taken along the tracklines. These photographs, which are representative of the seafloor, are displayed with a description of the observed seafloor characteristics recorded by USGS and NOAA scientists (figs. 1B through 1H; 2B through 2H; 3B through 3L, 4B through 4I). Only primary and secondary substrates are reported, although individual photographs may show more substrate types. Organisms, when present, are labeled on the photographs.

Ground-truth surveys in the Offshore of Point Reyes map area include approximately 18 trackline kilometers of video and 713 still photographs, in addition to 748 seafloor observations of abiotic and biotic attributes. A visual estimate of slope also was recorded.

GLOSSARY

Rugosity—A GIS-derived characterization of seafloor roughness, calculated as the ratio of the three-dimensional surface area of seafloor to the two-dimensional planar-base area, for each cell in the bathymetry grid.

Backscatter intensity—The amplitude of the reflected sonar signal (see sheet 3) used to infer the hardness of the bottom, determined after sonar-data processing has removed (as much as possible) the effects of water depth, angle of reflection, and bottom roughness.

Biocomplexity—The assessment of the presence or absence of biological structures that have the potential of providing shelter for fauna, determined by estimating the scale, the amount, and the morphology of biological relief (as described by Tissot and others, 2006).

Biocover—The visual estimate of the proportion of biologic cover by encrusting organisms: high, greater than 50 percent; moderate, between 50 percent and 10 percent; low, less than 10 percent.

REFERENCES CITED

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/.

Tissot, B.N., Yoklavich, M.M., Love, M.S., York, K., and Amend, M., 2006, Benthic invertebrates that form habitat on deep banks off southern California, with special reference to deep sea coral: Fishery Bulletin, v. 104, p. 167–181.

Wentworth, C.K., 1922, A scale of grade and class terms for clastic sediments: Journal of Geology, v. 30, p. 377–392.

EXPLANATION

Substrate class

- **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

Location of real-time video observation and interpreted substrate class of seafloor

- **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

Location of digital still photograph and interpreted substrate class of seafloor

- **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

Interpreted substrate class depicted in digital still photograph—Indicated by colored frame around photograph (not shown on map; shown in figures only)

- **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

Sample localities

- **From usSEABED (Reid and others, 2006)**

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

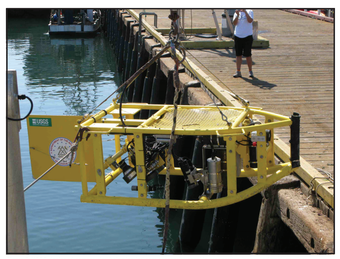


Figure 5. USGS-designed camera sled being loaded onto research vessel in preparation for ground-truth studies. Components onboard sled include four digital video camcorders, one 8-megapixel digital SLR camera, lasers for scale, and various strobe and video lights, as well as telemetry instrumentation that records depth, altitude, and compass heading.

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