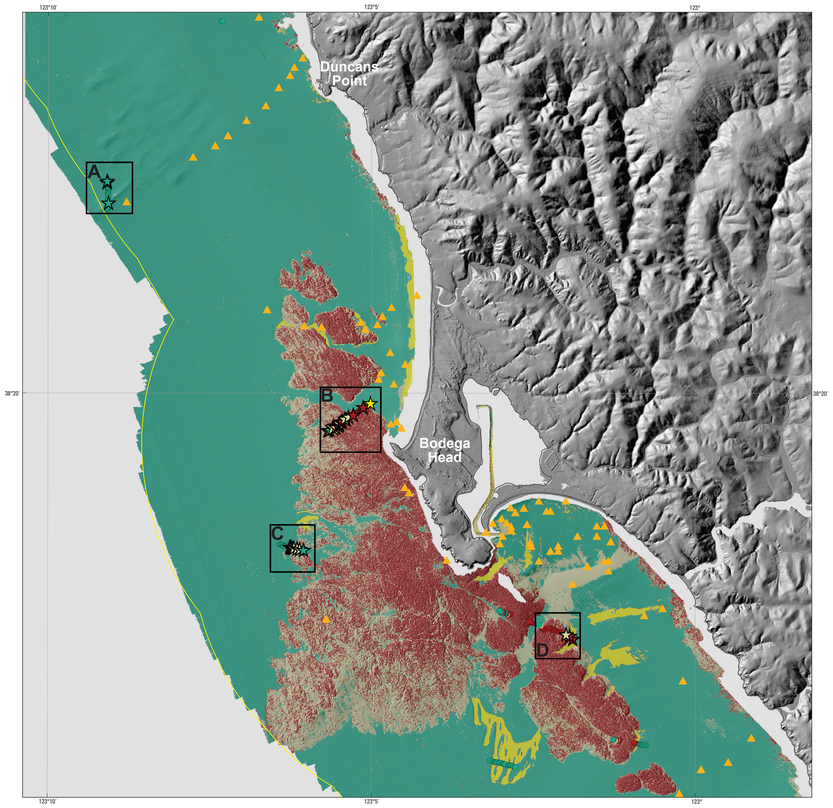
U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2015–1140
Sheet 6 of 10
Pamphlet accompanies map



Onshore elevation data from California Coastal Conservancy (available at http://www.csc.noaa.gov/digitalcoast/data/coastallidar/) and from U.S. Geological Survey's 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

APPROXIMATE MEAN DECLINATION, 2015

SCALE 1:50 000

ONE MILE = 0.869 NAUTICAL MILES

MAP LOCATION

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

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

Manuscript approved for publication July 31, 2015

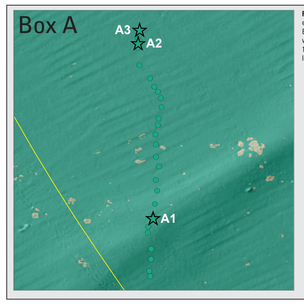


Figure 1A. Detailed view of seafloor character mapped east-southeast of Duncans Point, approximately 4.5 km offshore (see Box A, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 1B through 1D) from camera line CAM55, cruise L–9–08–NC. Yellow line shows limit of California's State Waters.

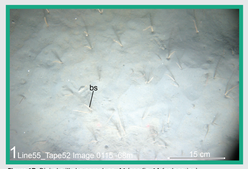


Figure 1B. Digital still photograph no. A1 (see fig. 1A for location). Unconsolidated, muddy sand with bioturbation (water depth, 68 m). Abiotic complexity is low, biotic complexity is absent, and biocover is moderate. Biocover includes brittle stars (bs). Distance between lasers (red dots) is 15 cm.

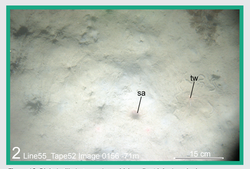


Figure 1C. Digital still photograph no. A2 (see fig. 1A for location). Unconsolidated, muddy sand with bioturbation (water depth, 71 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes tube-dwelling sea anemone (sa) and tubeworm (tw). Distance between lasers (red dots) is 15 cm.

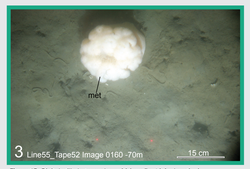


Figure 1D. Digital still photograph no. A3 (see fig. 1A for location). Unconsolidated, muddy sand with bioturbation (water depth, 70 m). Abiotic complexity is low, biotic complexity is present, and biocover is low. Biocover includes white-plumed anemone, *Metridium spp.* (met). Distance between lasers (red dots) is 15 cm.

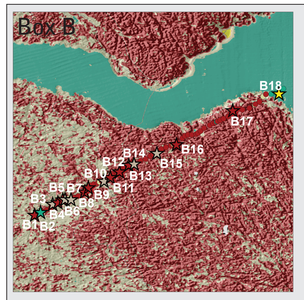


Figure 2A. Detailed view of seafloor character mapped approximately 1 km offshore of Bodega Head (see Box B, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 2B through 2S) from camera line CAM69, cruise L–9–08–NC.

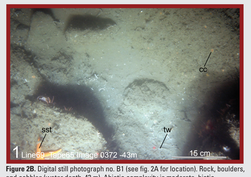


Figure 2B. Digital still photograph no. B1 (see fig. 2A for location). Rock, boulders, and cobbles (water depth, 43 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is low. Biocover includes cup corals (cc), sea star (sst), and tubeworm (tw). Distance between lasers (red dots) is 15 cm.

Figure 2C. Digital still photograph no. B2 (see fig. 2A for location). Unconsolidated, muddy sand and shells with bioturbation (water depth, 42 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

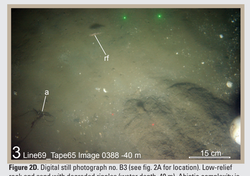


Figure 2D. Digital still photograph no. B3 (see fig. 2A for location). Low-relief rock and sand with degraded ripples (water depth, 40 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes halfbanded rockfish, *Sebastes semicinctus* (rf); and drifting algae (a). Distance between lasers (red and green dots) is 15 cm.

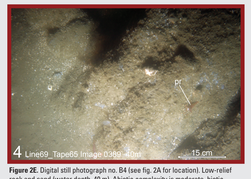


Figure 2E. Digital still photograph no. B4 (see fig. 2A for location). Low-relief rock and sand (water depth, 40 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is low. Biocover includes spot prawn, *Pandalus platyceros* (pr). Scale determined from lasers on synchronized video (scale lasers are not visible on photograph).

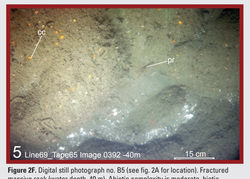


Figure 2F. Digital still photograph no. B5 (see fig. 2A for location). Fractured massive rock (water depth, 40 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is moderate. Biocover includes spot prawn, *Pandalus platyceros* (pr); and cup corals (cc). Distance between lasers (red dots) is 15 cm.

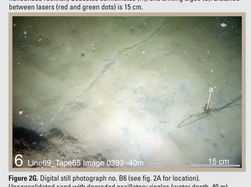


Figure 2G. Digital still photograph no. B6 (see fig. 2A for location). Unconsolidated sand with degraded oscillatory ripples (water depth, 40 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes drifting algae (a). Distance between lasers (red dots) is 15 cm.

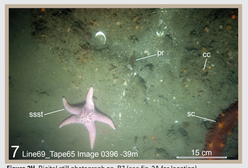


Figure 2H. Digital still photograph no. B7 (see fig. 2A for location). Unconsolidated sand and low-relief rock (water depth, 39 m). Abiotic complexity is low, biotic complexity is absent, and biocover is moderate. Biocover includes California sea cucumber, *Parastichopus californicus* (sc); short-spined sea star, *Pisaster brevispinus* (ssst); spot prawn, *Pandalus platyceros* (pr); and cup corals (cc). Distance between lasers (red dots) is 15 cm.

Figure 2I. Digital still photograph no. B8 (see fig. 2A for location). Fractured, massive rock (water depth, 36 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is high. Biocover includes cup corals (cc), hydroids (h), and crab (c). Distance between lasers (red dots) is 15 cm.

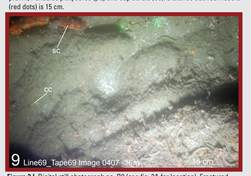


Figure 2J. Digital still photograph no. B9 (see fig. 2A for location). Fractured, massive rock (water depth, 36 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is moderate. Biocover includes California sea cucumber, *Parastichopus californicus* (sc); and cup corals (cc). Distance between lasers (red and green dots) is 15 cm.

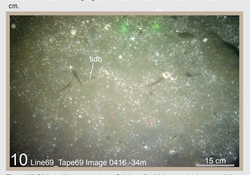


Figure 2K. Digital still photograph no. B10 (see fig. 2A for location). Low-relief rock, sand, and shells (water depth, 34 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes sanddab, *Citharichthys sordidus* (sdb). Distance between lasers (red and green dots) is 15 cm.

Figure 2L. Digital still photograph no. B11 (see fig. 2A for location). Fractured, massive rock (water depth, 32 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is moderate. Biocover includes cup corals (cc) and sea cucumber (sc). Distance between lasers (green dots) is 15 cm.

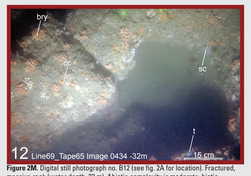


Figure 2M. Digital still photograph no. B12 (see fig. 2A for location). Fractured, massive rock (water depth, 32 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is high. Biocover includes bryozoans (bry), sea cucumbers (sc), cup corals (cc), and tunicate (t). Distance between lasers (green dots) is 15 cm.

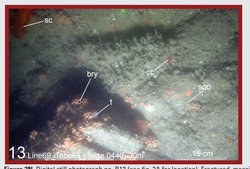


Figure 2N. Digital still photograph no. B13 (see fig. 2A for location). Fractured, massive rock (water depth, 30 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is high. Biocover includes California sea cucumber, *Parastichopus californicus* (sc); bryozoans (bry); encrusting sponge (spo); tunicate (t); and cup corals (cc). Distance between lasers (green dots) is 15 cm.

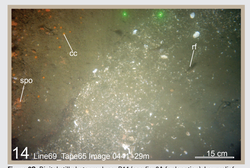


Figure 2O. Digital still photograph no. B14 (see fig. 2A for location). Low-relief rock, sand, and shells (water depth, 29 m). Abiotic complexity is low, biotic complexity is absent, and biocover is moderate. Biocover includes cup corals (cc), rockfish (rf), and encrusting sponge (spo). Distance between lasers (green dots) is 15 cm.

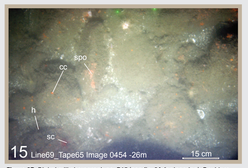


Figure 2P. Digital still photograph no. B15 (see fig. 2A for location). Boulders, cobbles, sand, and shells (water depth, 26 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is high. Biocover includes sea cucumbers (sc), encrusting sponge (spo), cup corals (cc), and hydroids (h). Distance between lasers (green dots) is 15 cm.

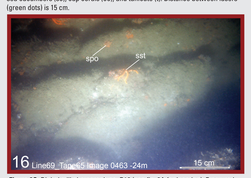


Figure 2Q. Digital still photograph no. B16 (see fig. 2A for location). Fractured, massive rock (water depth, 24 m). Abiotic complexity is high, biotic complexity is moderate, and biocover is moderate. Biocover includes sea stars (sst) and encrusting sponge (spo). Scale determined from lasers on synchronized video (scale lasers are not visible on photograph).

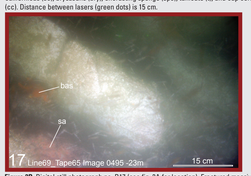


Figure 2R. Digital still photograph no. B17 (see fig. 2A for location). Fractured massive rock (water depth, 23 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is indiscernible. Biocover includes bat star, Asterina miniata (bas); and strawberry anemones, Corynactis californica (sta). Scale determined from lasers on synchronized video (scale lasers are not visible on photograph).

Figure 2S. Digital still photograph no. B18 (see fig. 2A for location). Sand, in area of sand waves (water depth, 20 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Scale determined from lasers on synchronized video (scale lasers are not visible on photograph).

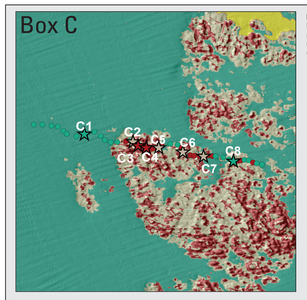


Figure 3A. Detailed view of seafloor character mapped west of Bodega Head, approximately 2.5 km offshore (see Box C, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 3B through 3I) from camera line CAM53, cruise L–9–08–NC.

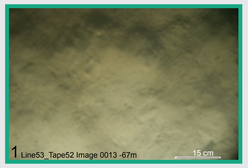


Figure 3B. Digital still photograph no. C1 (see fig. 3A for location). Unconsolidated sand (water depth, 67 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Scale determined from lasers on synchronized video (scale lasers are not visible on photograph).

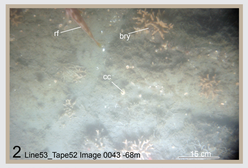


Figure 3C. Digital still photograph no. C2 (see fig. 3A for location). Fractured, low-relief rock (water depth, 68 m). Abiotic complexity is low, biotic complexity is absent, and biocover is moderate. Biocover includes rockfish (rf), cup corals (cc), and bryozoans (bry). Distance between lasers (red dots) is 15 cm.

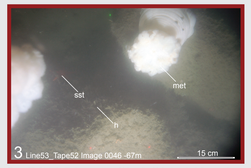


Figure 3D. Digital still photograph no. C3 (see fig. 3A for location). Fractured, massive rock (water depth, 67 m). Abiotic complexity is high, biotic complexity is present, and biocover is moderate. Biocover includes white-plumed anemones, *Metridium spp.* (met); hydroids (h); and sea star (sst). Distance between lasers (red dots) is 15 cm.

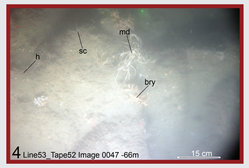


Figure 3E. Digital still photograph no. C4 (see fig. 3A for location). Fractured, massive rock (water depth, 66 m). Abiotic complexity is high, biotic complexity is absent, and biocover is moderate. Biocover includes hydroids (h), sea cucumbers (sc), and bryozoans (bry). Also labeled on photograph is marine debris (md). Scale determined from lasers on synchronized video (scale lasers are not visible on photograph).

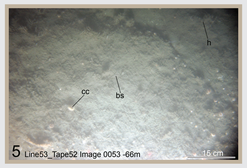


Figure 3F. Digital still photograph no. C5 (see fig. 3A for location). Low-relief rock (water depth, 66 m). Abiotic complexity is low, biotic complexity is absent, and biocover is moderate. Biocover includes cup corals (cc), brittle stars (bs), and hydroids (h). Distance between lasers (red dots) is 15 cm.

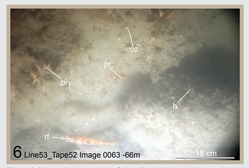


Figure 3G. Digital still photograph no. C6 (see fig. 3A for location). Low-relief rock, cobbles, and sand (water depth, 66 m). Abiotic complexity is low, biotic complexity is absent, and biocover is high. Biocover includes halfbanded rockfish, *Sebastes semicinctus* (rf); spot prawn, Pandalus platyceros (pr); bryozoans (bry); cup corals (cc); and hydroids (h). Scale determined from lasers on synchronized video (scale lasers are not visible on photograph).

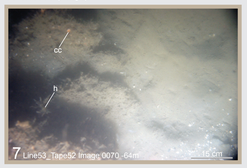


Figure 3H. Digital still photograph no. C7 (see fig. 3A for location). Low-relief rock, sand, and shells (water depth, 64 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is low. Biocover includes cup coral (cc) and hydroids (hh). Scale determined from lasers on synchronized video (scale lasers are not visible on photograph).

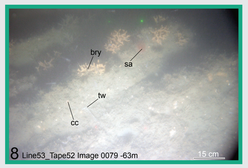


Figure 3I. Digital still photograph no. C8 (see fig. 3A for location). Fractured, massive rock (water depth, 63 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes bryozoans (bry), sea anemone (sa), cup corals (cc), and tubeworm (tw). Distance between lasers (green dots) is 15 cm.

Figure 4A. Detailed view of seafloor character mapped southeast of Bodega Head, 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 4D) from camera line CAM50, cruise L–9–08–NC.

Figure 4B. Digital still photograph no. D1 (see fig. 4A for location). Fractured, massive rock (water depth, 13 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes bat star, Asterina miniata (bas); and encrusting algae (a). Scale determined from lasers on synchronized video (scale lasers are not visible on photograph).

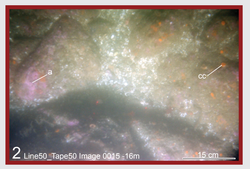


Figure 4C. Digital still photograph no. D2 (see fig. 4A for location). Fractured, massive rock, with gravel and shells (water depth, 16 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes cup coral (cc) and encrusting algae (a). Distance between lasers (red dots) is 15 cm.

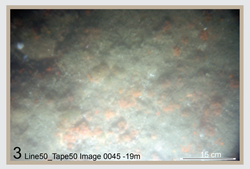
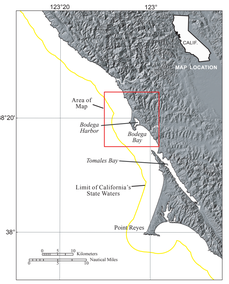


Figure 4D. Digital still photograph no. D3 (see fig. 4A for location). Fractured, low-relief rock (water depth, 19 m). Abiotic complexity is low, biotic complexity is absent, and biocover is high. Distance between lasers (red dots) is 15 cm.



DISCUSSION

Between 2006 and 2007, the seafloor in the Offshore of Bodega Head 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 in 2008.

During the ground-truth-survey cruise, 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 the seafloor in the central and southern parts of the Offshore of Bodega Head map area is underlain by a large area of massive granitic bedrock (see, for example, figs. 2M, 3D, 4B; see also, geologic map on sheet 10), which is continuous with rocks exposed onland at Bodega Head. The rocky granitic outcrops extend from the shoreline to as far as the limit of California's State Waters. North of Bodega Head, granitic seafloor outcrops are onlapped by sediment (sand and mud), resulting in smooth seafloor (see figs. 2, 3 on sheet 8 of this report). Smooth seafloor south and east of the granitic seafloor outcrops is primarily sand, and it includes a large transverse bar that formed on the more wave-protected east flank of Bodega Head.

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 1D; 2B through 2S; 3B through 3I; 4B through 4D). 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 Bodega Head map area include approximately 6 trackline kilometers of video and 381 still photographs, in addition to 351 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.

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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

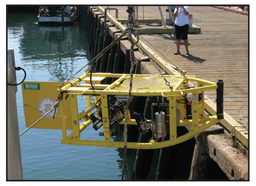

Figure 5. USGS-designed camera sled being loaded onto a research vessel in preparation for ground truth studies. Components onboard sled include four digital video camcorders, one 8-megapixel digital SLR camera, lasers for scale, and various strobe and video lights, as well as telemetry instrumentation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

Ground-Truth Studies, Offshore of Bodega Head Map Area, California

By
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2015

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