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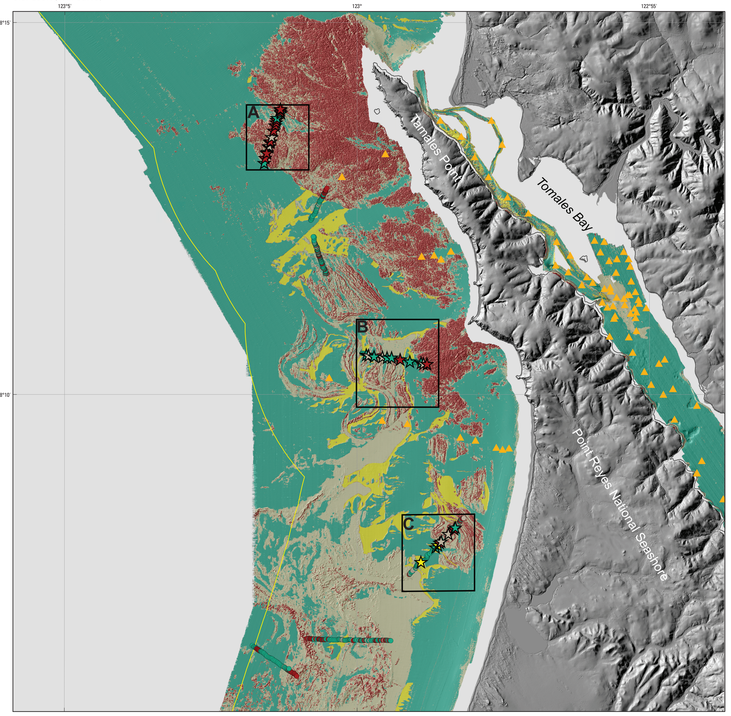
U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2015–1088
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, National Elevation Dataset, 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 1:50 000

2 1 0 2 MILES
7000 3500 0 7000 FEET
2.5 0 2.5 5 KILOMETER
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 May 4, 2015

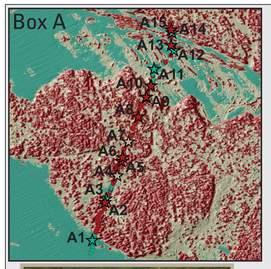


Figure 1A. Detailed view of seafloor character mapped approximately 2.5 km offshore of Tomales Point (see Box A, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 1B through 1P) from camera line CAM68, cruise L-9-08-NC.

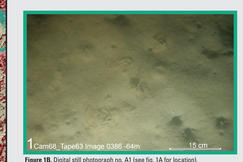


Figure 1B. Digital still photograph no. A1 (see fig. 1A for location). Unconsolidated muddy sand with burrows (water depth, 64 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

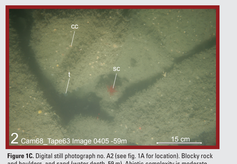


Figure 1C. Digital still photograph no. A2 (see fig. 1A for location). Blocky rock and boulders, and sand (water depth, 59 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is high. Biocover includes a sea cucumber (sc), tunicates (t), and cup corals (cc). Distance between lasers (red dots) is 15 cm.

Figure 1D. Digital still photograph no. A3 (see fig. 1A for location). Unconsolidated muddy sand (water depth, 59 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes vermillion rockfish (rf, *Sebastes miniatus*) and unidentifiable sculpin (slp). Distance between lasers (red dots) is 15 cm.

Figure 1E. Digital still photograph no. A4 (see fig. 1A for location). Fractured low-relief rock and cobble (water depth, 56 m). Abiotic complexity is low, biotic complexity is absent, and biocover is moderate. Biocover includes red sea star (sst, *Mediaster aequalis*), sea cucumber (sc), brittle stars (bs), and cup corals (cc). Distance between lasers (red dots) is 15 cm.

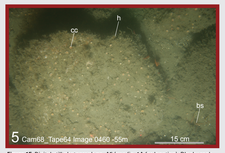


Figure 1F. Digital still photograph no. A5 (see fig. 1A for location). Blocky rock and boulder (water depth, 55 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is high. Biocover includes cup corals (cc), brittle stars (bs), and hydroids (h). Distance between lasers (red dots) is 15 cm.

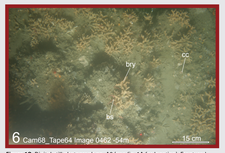


Figure 1G. Digital still photograph no. A6 (see fig. 1A for location). Fractured low-relief rock (water depth, 54 m). Abiotic complexity is low, biotic complexity is absent, and biocover is high. Biocover includes bryozoans (bry), brittle stars (bs), and cup corals (cc). Distance between lasers (red dots) is 15 cm.

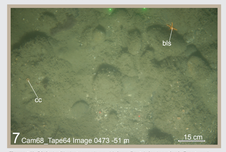


Figure 1H. Digital still photograph no. A7 (see fig. 1A for location). Fractured low-relief rock, cobbles, and gravel (water depth, 51 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes blood star (bls, *Henricia leviuscula*) and cup corals (cc). Distance between lasers (red dots) is 15 cm.

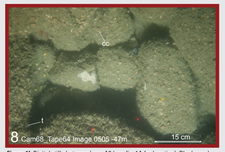


Figure 1I. Digital still photograph no. A8 (see fig. 1A for location). Blocky rock and boulders, and sand (water depth, 47 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes cup corals (cc) and tunicates (t). Distance between lasers (red dots) is 15 cm.

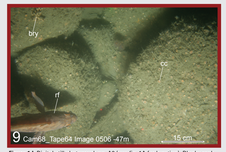


Figure 1J. Digital still photograph no. A9 (see fig. 1A for location). Blocky rock and boulders, and sand (water depth, 47 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes brown rockfish (rf, *Sebastes auriculatus*), cup corals (cc), and bryozoans (bry). Distance between lasers (red dots) is 15 cm.

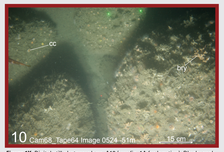


Figure 1K. Digital still photograph no. A10 (see fig. 1A for location). Blocky rock and boulders, and sand (water depth, 51 m). Abiotic complexity is low, biotic complexity is absent, and biocover is high. Biocover includes bryozoans (bry) and cup corals (cc). Distance between lasers (green dots) is 15 cm.

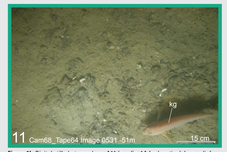


Figure 1L. Digital still photograph no. A11 (see fig. 1A for location). Low-relief rock, sand and gravel (water depth, 51 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes kelp greenling (kg, *Hexagrammos decagrammus*). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

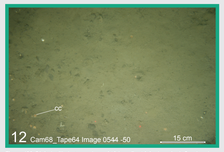


Figure 1M. Digital still photograph no. A12 (see fig. 1A for location). Sand and gravel (water depth, 50 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes cup corals (cc). Distance between lasers (red dots) is 15 cm.

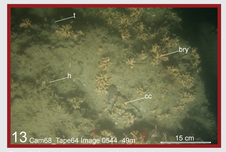


Figure 1N. Digital still photograph no. A13 (see fig. 1A for location). Massive rock (water depth, 49 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes bryozoans (bry), cup corals (cc), tunicates (t), and hydroids (h). Distance between lasers (red dots) is 15 cm.

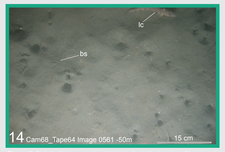


Figure 1O. Digital still photograph no. A14 (see fig. 1A for location). Bioturbated sand (water depth, 50 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes brittle stars (bs), and lingcod (lc, *Ophiodon elongatus*). Distance between lasers (red dots) is 15 cm.

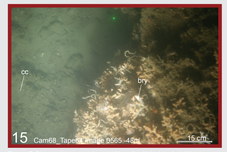


Figure 1P. Digital still photograph no. A15 (see fig. 1A for location). Massive rock, cobbles, and sand (water depth, 48 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes bryozoans (bry) and cup corals (cc). Distance between lasers (green dots are just out of view in this image but are visible in previous video frame) is 15 cm.

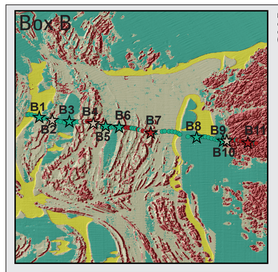


Figure 2A. Detailed view of seafloor character mapped approximately 2 km offshore from Tomales Bay (see Box C, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 2B through 2L) from camera line CAM65, cruise L-9-08-NC.

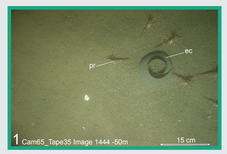


Figure 2B. Digital still photograph no. B1 (see fig. 2A for location). Unconsolidated sand and shell (water depth, 50 m). Abiotic complexity is low, biotic complexity is absent, and biocover is moderate. Biocover includes moon snail egg case (ec) and spot prawns (pr, *Pandalus platyceros*). Distance between lasers (red dots) is 15 cm.

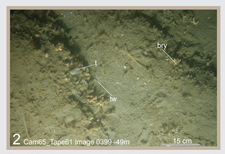


Figure 2C. Digital still photograph no. B2 (see fig. 2A for location). Low-relief rock (water depth, 49 m). Abiotic complexity is low, biotic complexity is absent, and biocover is high. Biocover includes bryozoans (bry), tunicate (t), and tubeworm (tw). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

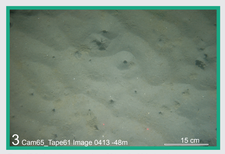


Figure 2D. Digital still photograph no. B3 (see fig. 2A for location). Unconsolidated sand and shell with confused ripple pattern and bioturbation (water depth, 48 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

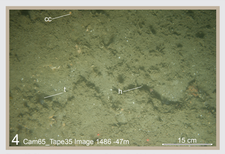


Figure 2E. Digital still photograph no. B4 (see fig. 2A for location). Low-relief rock (water depth, 47 m). Abiotic complexity is low, biotic complexity is absent, and biocover is moderate. Biocover includes tunicate (t), hydroids (h), and cup corals (cc). Distance between lasers (red dots) is 15 cm.

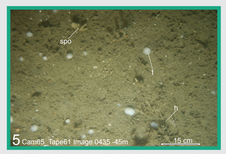


Figure 2F Digital still photograph no. B5 (see fig. 2A for location). Low relief rock (water depth, 45 m). Abiotic complexity is low, biotic complexity is absent, and biocover is moderate. Biocover includes tunicates (t), sponges (spo), and hydroids (h). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

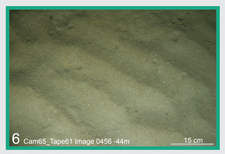


Figure 2G. Digital still photograph no. B6 (see fig. 2A for location). Unconsolidated sand with degraded oscillatory ripples (water depth, 44 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

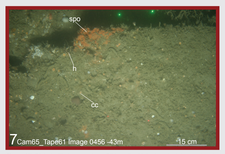


Figure 2H. Digital still photograph no. B7 (see fig. 2A for location). Layered rock (water depth, 43 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is high. Biocover includes encrusting sponge (spo), hydroids (h), and cup corals (cc). Distance between lasers (red and green dots) is 15 cm.

Figure 2I. Digital still photograph no. B8 (see fig. 2A for location). Unconsolidated sand with degraded oscillatory ripples (water depth, 41 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes lingcod (lc, *Ophiodon elongatus*). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

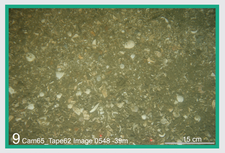


Figure 2J. Digital still photograph no. B9 (see fig. 2A for location). Unconsolidated gravel, sand, and shell (water depth, 39 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

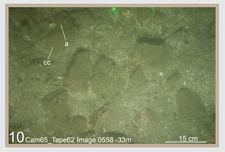


Figure 2K. Digital still photograph no. B10 (see fig. 2A for location). Sand and angular cobble (water depth, 33 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes cup corals (cc), and drifting algae (a). Distance between lasers (red and green dots) is 15 cm.

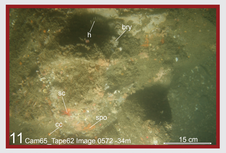


Figure 2L. Digital still photograph no. B11 (see fig. 2A for location). Massive rock (water depth, 34 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is high. Biocover includes encrusting sponge (spo), bryozoans (bry), sea cucumber (sc), cup corals (cc), and hydroids (h). Distance between lasers (red dots) is 15 cm.

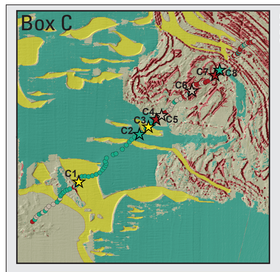


Figure 3A. Detailed view of seafloor character mapped approximately 1.5 km offshore of Point Reyes National Seashore (see Box C, on map, for location), showing the locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 3B through 3I) from camera line CAM64, cruise L-9-08-NC.

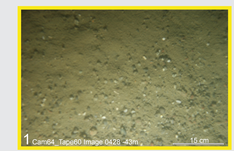


Figure 3B. Digital still photograph no. C1 (see fig. 3A for location). Unconsolidated sand and gravel in area with ripples (water depth, 43 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

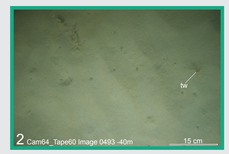


Figure 3C. Digital still photograph no. C2 (see fig. 3A for location). Unconsolidated sand with degraded oscillatory ripples and bioturbation (water depth, 40 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes tubeworms (tw). Distance between lasers (red dots) is 15 cm.

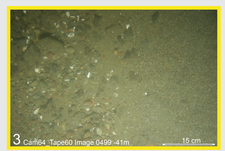


Figure 3D. Digital still photograph no. C3 (see fig. 3A for location). Unconsolidated sand and gravel in area with ripples (water depth, 41 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

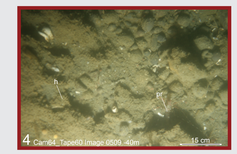


Figure 3E. Digital still photograph no. C4 (see fig. 3A for location). Low relief rock and cobble (water depth, 40 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes spot prawn (pr, *Pandalus platyceros*) and hydroids (h). Distance between lasers (red dots) is 15 cm.

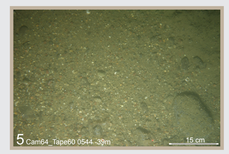


Figure 3F. Digital still photograph no. C5 (see fig. 3A for location). Unconsolidated gravel, sand, and cobble (water depth, 39 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

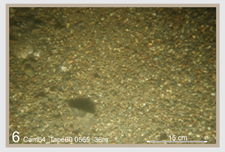


Figure 3G. Digital still photograph no. C6 (see fig. 3A for location). Unconsolidated gravel and cobble (water depth, 36 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

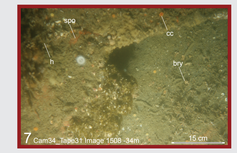


Figure 3H. Digital still photograph no. C7 (see fig. 3A for location). Layered sedimentary rock and sand (water depth, 34 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes hydroids (h), cup corals (cc), encrusting sponge (spo), and bryozoans (bry). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

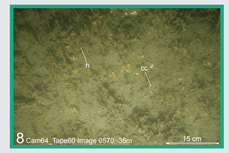
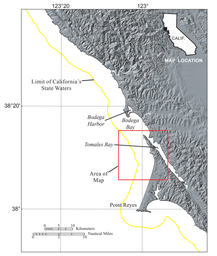


Figure 3I. Digital still photograph no. C8 (see fig. 3A for location). Low-relief rock (water depth, 35 m). Abiotic complexity is low, biotic complexity is absent, and biocover is high. Biocover includes hydroids (h) and cup corals (cc). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.



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
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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
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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
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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

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.

DISCUSSION

Between 2006 and 2007, the seafloor in the Offshore of Tomales Point 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 units (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 U.S. Geological Survey (USGS) ground-truth-surveyed the data by towing camera sleds (fig. 4) over specific locations throughout the map area.

The ground-truth survey occurred in 2008. The camera sleds were towed 1 to 2 m above the seafloor, at speeds of between 1 and 2 nautical miles/hour. During the ground-truth cruise, a USGS camera sled was used that 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 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 C) that are highlighted on this sheet (figs. 1A through 3A, respectively). 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 this area is characterized by patchy distributions of sandy sediment and exposed rock. Nearshore areas of rocky habitat can be seen along wave-exposed coast of Tomales Point in the northern half of the map area. Rocks exposed in this area are massive granitic rocks uplifted along the San Andreas Fault (see sheet 10 of this report). To the south the rocks exposed are layered sedimentary rock, are in deeper water, and are of lower relief (consisting of both Class II and Class III habitat types; see sheet 5 of this report) indicating they are more easily eroded. The patchy combination of different geologic units across the spectrum of depths makes this a diverse habitat area.

Each detailed view (figs. 1A through 3A) 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 1P; 2B through 2L, 3B through 3I). Only primary and secondary substrate 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 Tomales Point map area include approximately 11 trackline kilometers of video and 547 still photographs, in addition to 731 seafloor observations of abiotic and biotic attributes. A visual estimate of slope also was recorded.

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Figure 4. 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.

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

By

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