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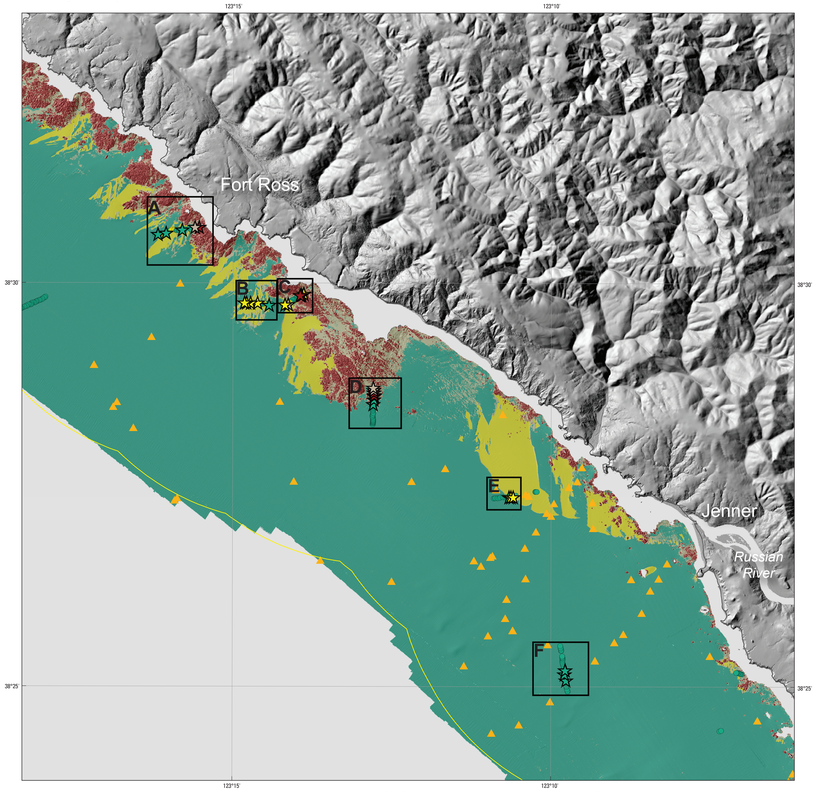
U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2015–1211
Sheet 6 of 10
Pamphlet accompanies map



Onshore elevation data from National Oceanic and Atmospheric Administration's (NOAA's) Digital Coast (available at http://coast.noaa.gov/digitalcoast/data/coastallidar), from OpenTopography (available at http://www.opentopography.org/), 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

14°

APPROXIMATE MEAN GEOLINATION, 2015

SCALE 1:50 000

2 1 0 2 MILES
7000 3500 0 7000 FEET
1 0.5 0 1 KILOMETER
1 CM=0.5 KM
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 and 2008. Sample localities from usSEABED (Reid and others, 2006)

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

Manuscript approved for publication November 5, 2015

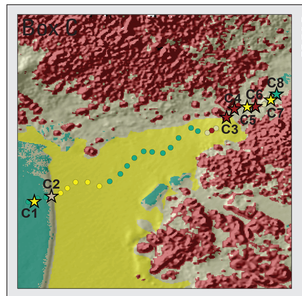


Figure 3A. Detailed view of seafloor character mapped southeast of Fort Ross, approximately 0.2 km offshore (see Box C, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 3B through 3I) from camera line CAM71, cruise L–9–08–NC.

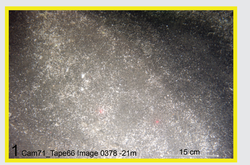


Figure 3B. Digital still photograph no. C1 (see fig. 3A for location). Coarse sand, gravel, and shells with ripples (water depth, 21 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

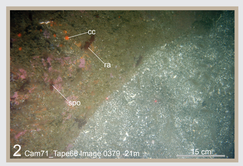


Figure 3C. Digital still photograph no. C2 (see fig. 3A for location). Massive rock, as well as coarse sand and shells with ripples (water depth, 21 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is moderate. Biocover includes encrusting sponge (spo), red algae (ra), and cup corals (cc). Distance between lasers (red dots) is 15 cm.

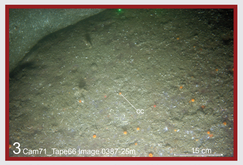


Figure 3D. Digital still photograph no. C3 (see fig. 3A for location). Massive rock, as well as coarse sand and shells (water depth, 25 m). Abiotic complexity is high, biotic complexity is absent, and biocover is low. Biocover includes cup corals (cc). Distance between lasers (red dots) is 15 cm.

Figure 3E. Digital still photograph no. C4 (see fig. 3A for location). Massive rock, as well as coarse sand and shells (water depth, 25 m). Abiotic complexity is high, biotic complexity is present, and biocover is high. Biocover includes short-spined sea stars, *Pisaster brevispinus* (ssst); sea anemone (sa); and cup corals (cc). Distance between lasers (red dots) is 15 cm.

Figure 3F. Digital still photograph no. C5 (see fig. 3A for location). Coarse sand and shells (water depth, 27 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is low. Biocover includes blue rockfish, *Sebastes mystinus* (rf). Distance between lasers (red dots) is 15 cm.

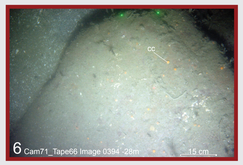


Figure 3G. Digital still photograph no. C6 (see fig. 3A for location). Massive rock, as well as coarse sand (water depth, 28 m). Abiotic complexity is high, biotic complexity is absent, and biocover is low. Biocover includes cup corals (cc). Distance between lasers (red and green dots) is 15 cm.

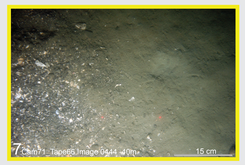


Figure 3H. Digital still photograph no. C7 (see fig. 3A for location). Unconsolidated sand, gravel, and shells with degraded ripples (water depth, 40 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

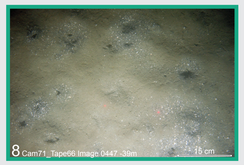


Figure 3I. Digital still photograph no. C8 (see fig. 3A for location). Sand and shells with bioturbation (water depth, 39 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

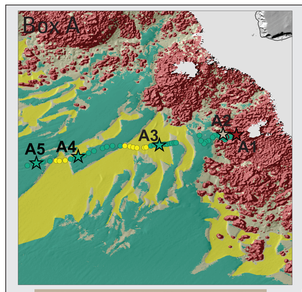


Figure 1A. Detailed view of seafloor character mapped just offshore of Fort Ross (see Box A, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 1B through 1F) from camera line CAM73, cruise L–9–08–NC.

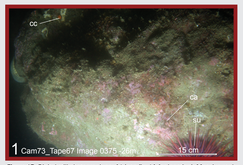


Figure 1B. Digital still photograph no. A1 (see fig. 1A for location). Massive rock (water depth, 26 m). Abiotic complexity is high, biotic complexity is absent, and biocover is moderate. Biocover includes sea urchin (su), encrusting coralline algae (ca), and cup coral (cc). Distance between lasers (red dots) is 15 cm.

Figure 1C. Digital still photograph no. A2 (see fig. 1A for location). Low-relief, massive rock, with gravel and sand (water depth, 33 m). Abiotic complexity is low, biotic complexity is moderate, and biocover is moderate. Biocover includes short-spined sea star, *Pisaster brevispinus* (ssst); cup corals (cc); and drifting algae (a). Distance between lasers (red and green dots) is 15 cm.

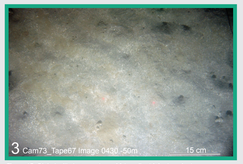


Figure 1D. Digital still photograph no. A3 (see fig. 1A for location). Unconsolidated sand with bioturbation (water depth, 50 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

Figure 1E. Digital still photograph no. A4 (see fig. 1A for location). Unconsolidated sand and shells with bioturbation (water depth, 47 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes lingcod, *Ophiodon elongatus* (lc); and Dungeness crab, *Cancer magister* (c). Distance between lasers (red dots) is 15 cm.

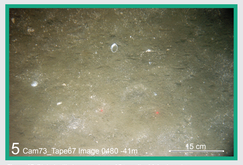


Figure 1F. Digital still photograph no. A5 (see fig. 1A for location). Unconsolidated sand and shells with bioturbation (water depth, 41 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

Figure 2A. Detailed view of seafloor character mapped south of Fort Ross, approximately 0.75 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 2F) from camera line CAM72, cruise L–9–08–NC.

Figure 2B. Digital still photograph no. B1 (see fig. 2A for location). Coarse sand and shells with degraded ripples (water depth, 40 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.

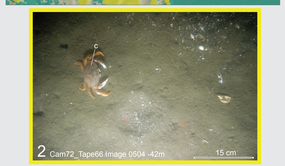


Figure 2C. Digital still photograph no. B2 (see fig. 2A for location). Unconsolidated sand, gravel, and shells with bioturbation and degraded ripples (water depth, 42 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes Dungeness crab, *Cancer magister* (c). Distance between lasers (red dots) is 15 cm.

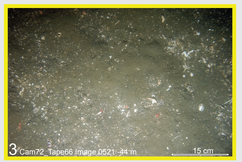


Figure 2D. Digital still photograph no. B3 (see fig. 2A for location). Unconsolidated sand, gravel, and shells with degraded ripples (water depth, 44 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

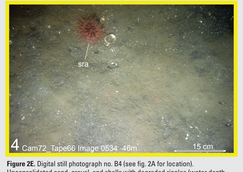


Figure 2E. Digital still photograph no. B4 (see fig. 2A for location). Unconsolidated sand, gravel, and shells with degraded ripples (water depth, 46 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes sand-rose anemone, *Urticina columbiana* (sra). Distance between lasers (red dots) is 15 cm.

Figure 2F. Digital still photograph no. B5 (see fig. 2A for location). Unconsolidated sand and shells with bioturbation (water depth, 46 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes brittle stars (bs). Distance between lasers (red dots) is 15 cm.

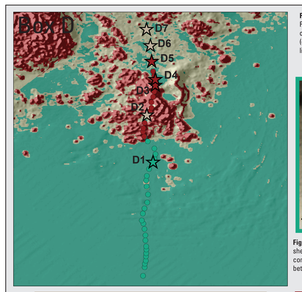


Figure 4A. Detailed view of seafloor character mapped about halfway between Fort Ross and mouth of Russian River, approximately 1.5 km offshore (see Box D, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 4B through 4H) from camera line CAM59, cruise L–9–08–NC.

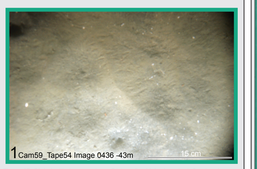


Figure 4B. Digital still photograph no. D1 (see fig. 4A for location). Sand and shells with asymmetric ripples and bioturbation (water depth, 43 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

Figure 4C. Digital still photograph no. D2 (see fig. 4A for location). Low-relief rock and sand and shells (water depth, 33 m). Abiotic complexity is low, biotic complexity is absent, and biocover is moderate. Biocover includes sea cucumber (sc), cup corals (cc), and bryozoan (bry). Distance between lasers (red dots) is 15 cm.

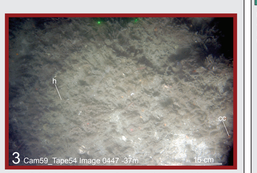


Figure 4D. Digital still photograph no. D3 (see fig. 4A for location). Massive rock (water depth, 37 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes hydroids (h) and cup corals (cc). Distance between lasers (red and green dots) is 15 cm.

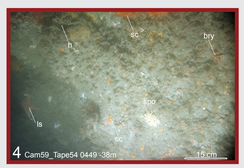


Figure 4E. Digital still photograph no. D4 (see fig. 4A for location). Massive rock (water depth, 38 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes leather star, *Dermasterias imbricata* (ls); cup corals (cc); sea cucumber (sc); hydroids (h); sponges (spo); and bryozoans (bry). Distance between lasers (red dots) is 15 cm.

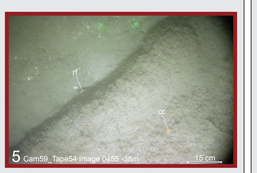


Figure 4F. Digital still photograph no. D5 (see fig. 4A for location). Massive rock, as well as sand, gravel, and shells (water depth, 38 m). Abiotic complexity is high, biotic complexity is absent, and biocover is low. Biocover includes cup corals (cc) and rockfish (rf). Distance between lasers (green dots) is 15 cm.

Figure 4G. Digital still photograph no. D6 (see fig. 4A for location). Gravel and shells (water depth, 38 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.

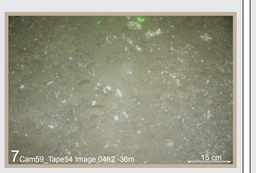


Figure 4H. Digital still photograph no. D7 (see fig. 4A for location). Gravel, sand, and shells (water depth, 36 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red and green dots) is 15 cm.

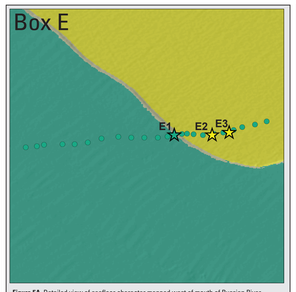


Figure 5A. Detailed view of seafloor character mapped west of mouth of Russian River, approximately 1.5 km offshore (see Box E, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 5B through 5D) from camera line CAM58, cruise L–9–08–NC.

Figure 5B. Digital still photograph no. E1 (see fig. 5A for location). Sand and shells with sharp-crested, oscillatory ripples (water depth, 33 m). Abiotic complexity is moderate, 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.

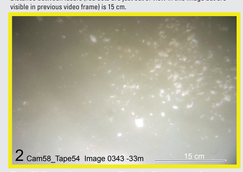


Figure 5C. Digital still photograph no. E2 (see fig. 5A for location). Sand, gravel, and shells with degraded ripples (water depth, 33 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is low. Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

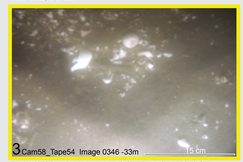


Figure 5D. Digital still photograph no. E3 (see fig. 5A for location). Sand, gravel, and shells with degraded ripples (water depth, 33 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is low. Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

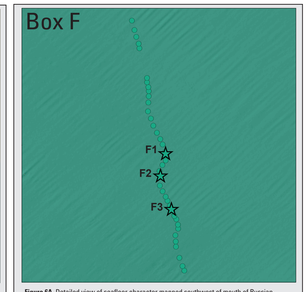


Figure 6A. Detailed view of seafloor character mapped southwest of mouth of Russian River, approximately 3 km offshore (see Box F, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 6B through 6D) from camera line CAM57, cruise L–9–08–NC.

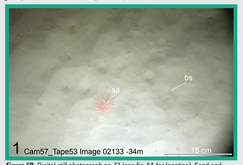


Figure 6B. Digital still photograph no. F1 (see fig. 6A for location). Sand and shells (water depth, 34 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes sea anemone (sa) and brittle stars (bs). Distance between lasers (red dots) is 15 cm.

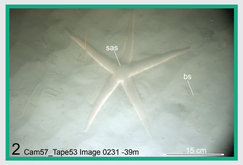
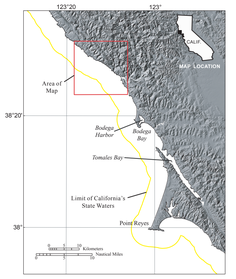


Figure 6C. Digital still photograph no. F2 (see fig. 6A for location). Sand with asymmetric ripples and bioturbation (water depth, 39 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes sand star, *Luidia foliolata* (sas); and brittle stars (bs). Distance between lasers (red dots) is 15 cm.

Figure 6D. Digital still photograph no. F3 (see fig. 6A for location). Sand and shells with ripples in confused pattern and bioturbation (water depth, 44 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes hermit crab (hc). Distance between lasers (red dots) is 15 cm.



DISCUSSION

Between 2006 and 2007, the seafloor in the Offshore of Fort Ross 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. 7) 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 F) that are highlighted on this sheet (figs. 1A, 2A, 3A, 4A, 5A, 6A). 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 Offshore of Fort Ross map area is dominated by unconsolidated sand and mud but also contains extensive bedrock outcrops in the nearshore. The outcrops are associated with uplift along the San Andreas Fault Zone, which crosses the shelf within the map area before passing onshore southeast of Fort Ross. Rocks exposed in this area are massive plutonic rocks (see figs. 1B, 4E), similar to rocks of the Sierra Nevada that have been displaced to the north by regional faulting (see sheet 10). Rocky habitat can be seen along the entire wave-exposed coast, extending out approximately 2 to 3 km in the central part of the map area. Extensive areas of coarse-grained sediments (fig. 4G) and scour depressions (figs. 3B, 5C), which are generated by localized, strong bottom currents, extend off the rocky outcrops. Deeper areas are dominated by rippled sand (fig. 6D, 4B) and mud.

Each detailed view (figs. 1A, 2A, 3A, 4A, 5A, 6A) 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 1F; 2B through 2F; 3B through 3I; 4B through 4H; 5B through 5D; 6B through 6D). 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 Fort Ross map area include approximately 6 trackline kilometers of video and 524 still photographs, in addition to 346 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 smooth 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 smooth 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 smooth 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 smooth 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 7. 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 Fort Ross Map Area, California

By

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