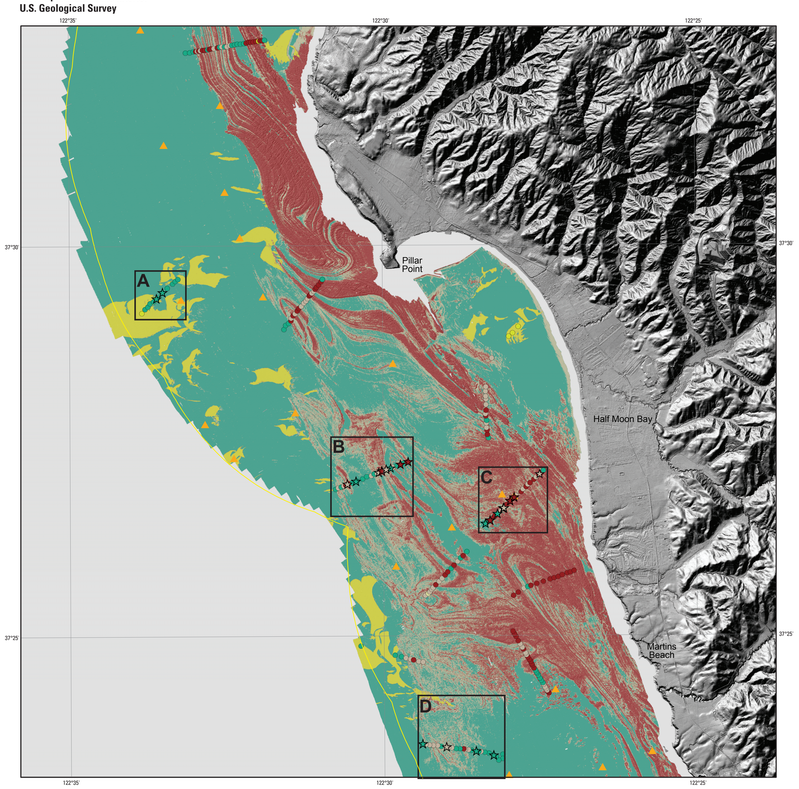
U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2014–1214
Sheet 6 of 10
Pamphlet accompanies map



Onshore elevation data collected by Photoscience in 2005 for U.S. Geological Survey and County of San Mateo. Offshore shaded-relief bathymetry from map on sheet 2, this report. California's State Waters limit from NOAA Office of Coast Survey

Universal Transverse Mercator projection, Zone 10N

NOT INTENDED FOR NAVIGATIONAL USE

APPROXIMATE MEAN DECLINATION, 2014

SCALE 1:50 000

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

CALIF.
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 Elwyne L. Phillips

Manuscript approved for publication October 2, 2014

Figure 1A. Detailed view of seafloor character mapped west of Pillar Point, approximately 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 1E) from camera line CAM22, cruise F–3–07–NC.

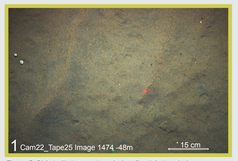


Figure 1B. Digital still photograph no. A1 (see fig. 1A for location). Unconsolidated, medium- to coarse-grained sand with oscillatory ripples (water depth, 48 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

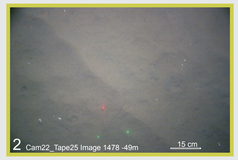


Figure 1C. Digital still photograph no. A2 (see fig. 1A for location). Unconsolidated, medium- to coarse-grained sand with oscillatory ripples (water depth, 49 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

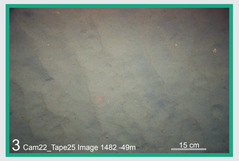


Figure 1D. Digital still photograph no. A3 (see fig. 1A for location). Unconsolidated, fine- to medium-grained sand with oscillatory ripples (water depth, 49 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

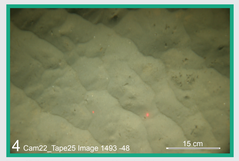


Figure 1E. Digital still photograph no. A4 (see fig. 1A for location). Unconsolidated, fine- to medium-grained sand with sharp-crested oscillatory ripples (water depth, 48 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

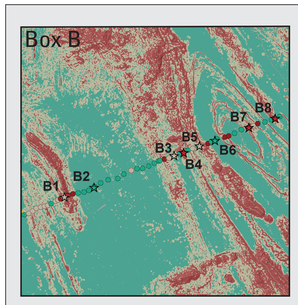


Figure 2A. Detailed view of seafloor character mapped west of city of Half Moon Bay, approximately 4.5 km offshore (see Box B, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 2B through 2I) from camera line CAM16, cruise F–3–07–NC.

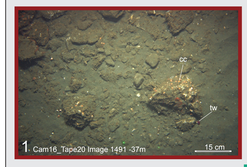


Figure 2B. Digital still photograph no. B1 (see fig. 2A for location). Mixed boulders and cobbles with sand and scattered shells (water depth, 37 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is moderate. Biocover includes cup corals (cc) and tubeworm (tw). Distance between lasers (green dots) is 15 cm.

Figure 2C. Digital still photograph no. B2 (see fig. 2A for location). Unconsolidated, fine- to medium-grained sand with sharp-crested, oscillatory ripples in confused pattern (water depth, 38 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes sea pen (sp), octopus (o), and brachiopod (bra). Distance between lasers (red dots) is 15 cm.

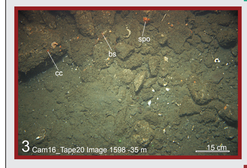


Figure 2D. Digital still photograph no. B3 (see fig. 2A for location). Mixed boulders and cobbles with sand and scattered shells (water depth, 35 m). Abiotic complexity is low, biotic complexity is absent, and biocover is moderate. Biocover includes cup corals (cc), brittle star arms (bs), and encrusting sponge (spo). Distance between lasers (green dots) is 15 cm.

Figure 2E. Digital still photograph no. B4 (see fig. 2A for location). Mixed rounded to subrounded boulders and cobbles overlying rock (water depth, 34 m). Abiotic complexity is moderate to high, biotic complexity is absent, and biocover is high. Biocover includes bat star (bas), cup corals (cc), and encrusting sponges (spo). Distance between lasers (green dots) is 15 cm.

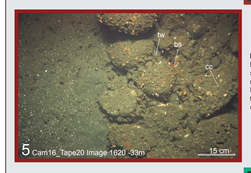


Figure 2F. Digital still photograph no. B5 (see fig. 2A for location). Interface between mixed boulders with cobbles and sand with shell hash (water depth, 33 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is high. Biocover includes cup corals (cc), brittle star arms (bs), and tubeworms (tw). Distance between lasers (green dots) is 15 cm.

Figure 2G. Digital still photograph no. B6 (see fig. 2A for location). Unconsolidated, fine- to medium-grained sand with sharp-crested, oscillatory ripples (water depth, 33 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (pairs of red and green dots) is 15 cm.

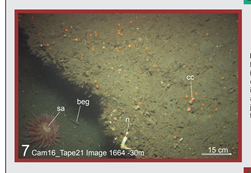


Figure 2H. Digital still photograph no. B7 (see fig. 2A for location). Interface between rock and sand with shell hash (water depth, 30 m). Abiotic complexity is high, biotic complexity is absent, and biocover is moderate. Biocover includes cup corals (cc), nudibranch (n), blackeye goby (beg), and sea anemone (sa). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

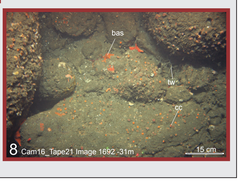


Figure 2I. Digital still photograph no. B8 (see fig. 2A for location). Mixed rounded to subrounded boulders and rugose rock outcrop (water depth, 31 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes bat stars (bas), cup corals (cc), and tubeworms (tw). Distance between lasers (green dots) is 15 cm.

Figure 3A. Detailed view of seafloor character mapped southwest of city of Half Moon Bay, approximately 1 km offshore (see Box C, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 3B through 3I) from camera line CAM18, cruise F–3–07–NC.

Figure 3B. Digital still photograph no. C1 (see fig. 3A for location). Unconsolidated, fine- to medium-grained sand with sharp-crested, oscillatory ripples and varying amounts of scattered shells (water depth, 26 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

Figure 3C. Digital still photograph no. C2 (see fig. 3A for location). Interface between rock and fine- to medium-grained sand with sharp-crested, oscillatory ripples (water depth, 25 m). Abiotic complexity is low, biotic complexity is absent, and biocover is high. Biocover includes bat star (bas) and algae (a). Distance between lasers (red dots) is 15 cm.

Figure 3D. Digital still photograph no. C3 (see fig. 3A for location). Unconsolidated, fine- to medium-grained sand with oscillatory ripples in confused pattern and varying amounts of scattered shells (water depth, 24 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

Figure 3E. Digital still photograph no. C4 (see fig. 3A for location). Rugose rock outcrop (water depth, 23 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is high. Biocover includes strawberry anemones (sta), encrusting sponges (spo), and 3-dimensional sponges (spo3D). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

Figure 3F. Digital still photograph no. C5 (see fig. 3A for location). Interface between rugose rock outcrop with shell hash and sand in intervening channel (water depth, 22 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is low. Distance between lasers (green dots) is 15 cm.

Figure 3G. Digital still photograph no. C6 (see fig. 3A for location). Rugose rock outcrop (water depth, 20 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes strawberry anemones (sta), sea urchin (su), encrusting coralline algae (ca), cup corals (cc), nudibranch (n), and young-of-the-year rockfish (rtf). Distance between lasers (green dots) is 15 cm.

Figure 3H. Digital still photograph no. C7 (see fig. 3A for location). Mixed rounded to subrounded boulders and rugose rock outcrop with sand and scattered shells (water depth, 19 m). Abiotic complexity is high, biotic complexity is absent, and biocover is low. Biocover includes encrusting sponges (spo). Distance between lasers (green dots) is 15 cm.

Figure 3I. Digital still photograph no. C8 (see fig. 3A for location). Mixed gravel, cobbles, and rugose rock outcrop with scattered shells (water depth, 9 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is high. Biocover includes encrusting sponges (spo), red algae (ra), cup coral (cc), and kelp greenling (kg). Distance between lasers (red dots) is 15 cm.

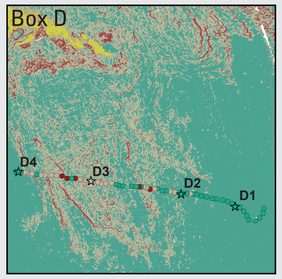


Figure 4A. Detailed view of seafloor character mapped southwest of Martins Beach, approximately 4 km offshore (see Box D, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 4B through 4E) from camera line CAM2, cruise F–3–07–NC.

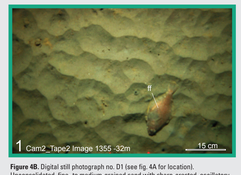


Figure 4B. Digital still photograph no. D1 (see fig. 4A for location). Unconsolidated, fine- to medium-grained sand with sharp-crested, oscillatory ripples in confused pattern (water depth, 32 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes flatfish (fl). Distance between lasers (red dots) is 15 cm.

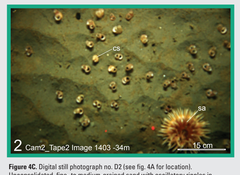


Figure 4C. Digital still photograph no. D2 (see fig. 4A for location). Unconsolidated, fine- to medium-grained sand with oscillatory ripples in confused pattern (water depth, 34 m). Abiotic complexity is low, biotic complexity is absent, and biocover is high. Biocover includes sea anemone (sa) and clam siphons (cs). Distance between lasers (red dots) is 15 cm.

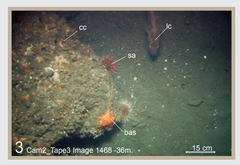


Figure 4D. Digital still photograph no. D3 (see fig. 4A for location). Mixed boulder with sand and scattered shells (water depth, 36 m). Abiotic complexity is moderate, biotic complexity is absent, and biocover is moderate. Biocover includes cup corals (cc), bat star (bas), sea anemones (sa), and lingcod (lc). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

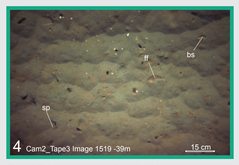
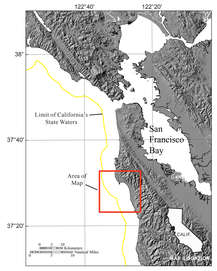


Figure 4E. Digital still photograph no. D4 (see fig. 4A for location). Unconsolidated, fine- to medium-grained sand with oscillatory ripples in confused pattern (water depth, 39 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Biocover includes flatfish (ff), brittle star arms (bs), and sea pen (sp). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.



DISCUSSION

Between 2006 and 2007, the seafloor in the Offshore of Half Moon Bay map area in northern California was mapped by Fugro Pelagos and California State University, Monterey Bay (CSUMB), using multibeam echosounders (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 2007.

During the ground-truth-survey cruise, the camera sled was towed 1 to 2 m over 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 location 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 this area is dominated by sedimentary-rock outcrops (see, for example, figs. 2E, 2I, 3G, 3H). At deeper depths in the northern part of the map area, the seafloor is covered predominantly by sandy sediment (see, for example, figs. 1B, 1C, 1D) that is characterized by sharp-crested, oscillatory ripple patterns (typical wavelengths, 5 to 15 cm). The general absence of burrows documents sparse populations of mega-infauna capable of bioturbating the sandy seafloor at a scale observable by our camera systems and (or) a dynamic environment of mobile sediment that degrades or destroys evidence of burrowing. The sandy-shelf areas are typified by low abiotic complexity, low biotic complexity, and low biocover.

Rocky outcrops and areas of moderately to poorly sorted, coarse sand and gravel are located along the entire length of the shallow areas and are the dominant substrate in the central part of the map area. These areas are characterized by moderate to high abiotic complexity created by steep rocky outcrops projecting dramatically above the adjacent sandy seafloor (see, for example, figs. 2D, 2F, 3I, 4D). Here, epifauna can be diverse, and urchins, starfish (asteroids), and schools of rockfish, as well as numerous attached fauna (for example, sponges, cup corals), provide moderate to high biocover.

Scour depressions are found at all water depths, and they are both adjacent to, and distant from, rocky areas. Moderately to poorly sorted, coarse sand and gravel located in these areas typically form shallow depressions relative to the adjacent sandy seafloor. Many of these depressions are characterized by large ripples and megaripples composed of coarse sand, fine gravel, and scattered shells (see, for example, figs. 1B, 1C). These features provide low abiotic complexity, low biotic complexity, and low biocover.

Each detailed view (figs. 1A, 2A, 3A, 4A) shows the locations of camera-sled tracklines (aligned colored dots), as well as of the photographs (colored stars) taken along the tracklines. These photographs, which are representative of the seafloor, are displayed with a description of the observed seafloor characteristics recorded by USGS and NOAA scientists (figs. 1B through 1E; 2B through 2I; 3B through 3I; 4B through 4E). 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 Half Moon Bay map area include approximately 23 trackline kilometers of video and 2,000 still photographs, in addition to 1,086 seafloor observations of abiotic and biotic attributes. A visual estimate of slope was also recorded.

GLOSSARY

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

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

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

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

REFERENCES CITED

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

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

EXPLANATION

Substrate class

- **Fine- to medium-grained smooth sediment**—Low backscatter, low rugosity; typically mud to medium-grained sand; often rippled and (or) burrowed
- **Mixed smooth sediment and rock**—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock
- **Rock and boulder, rugose**—High backscatter, high rugosity; typically boulders and rugose bedrock
- **Medium- to coarse-grained sediment**—Very high backscatter, low rugosity; typically medium- to coarse-grained sediment, with varying amounts of shell hash; in scour depressions

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

- **Fine- to medium-grained smooth sediment**—Low backscatter, low rugosity; typically mud to medium-grained sand; often rippled and (or) burrowed
- **Mixed smooth sediment and rock**—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock
- **Rock and boulder, rugose**—High backscatter, high rugosity; typically boulders and rugose bedrock
- **Medium- to coarse-grained sediment**—Very high backscatter, low rugosity; typically medium- to coarse-grained sediment, with varying amounts of shell hash; in scour depressions

Location of digital still photograph and interpreted substrate class of seafloor

- **Fine- to medium-grained smooth sediment**—Low backscatter, low rugosity; typically mud to medium-grained sand; often rippled and (or) burrowed
- **Mixed smooth sediment and rock**—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock
- **Rock and boulder, rugose**—High backscatter, high rugosity; typically boulders and rugose bedrock
- **Medium- to coarse-grained sediment**—Very high backscatter, low rugosity; typically medium- to coarse-grained sediment, with varying amounts of shell hash; in scour depressions

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

- **Fine- to medium-grained smooth sediment**—Low backscatter, low rugosity; typically mud to medium-grained sand; often rippled and (or) burrowed
- **Mixed smooth sediment and rock**—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock
- **Rock and boulder, rugose**—High backscatter, high rugosity; typically boulders and rugose bedrock
- **Medium- to coarse-grained sediment**—Very high backscatter, low rugosity; typically medium- to coarse-grained sediment, with varying amounts of shell hash; in scour depressions

Sample localities

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

Area of "no data"—Areas near shoreline not mapped owing to insufficient high-resolution seafloor mapping data; areas beyond 3-nautical-mile limit of California's State Waters were not mapped as part of California Seafloor Mapping Program

3-nautical-mile limit of California's State Waters

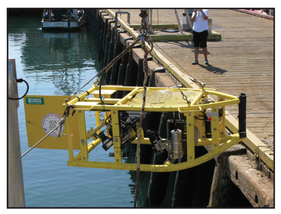

Figure 5. USGS-designed camera sled being loaded onto research vessel in preparation for ground-truth studies. Components onboard sled include four digital video camcorders, one 8-megapixel digital SLR camera, lasers for scale, and various strobe and video lights, as well as telemetry instrumentation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

Ground-Truth Studies, Offshore of Half Moon Bay Map Area, California

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

2014

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

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