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Scientific Investigations Map 2917

UNDER THE GOLDEN GATE BRIDGE —VIEWS OF THE SEA FLOOR NEAR THE ENTRANCE TO SAN FRANCISCO BAY, CALIFORNIA

By

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2006

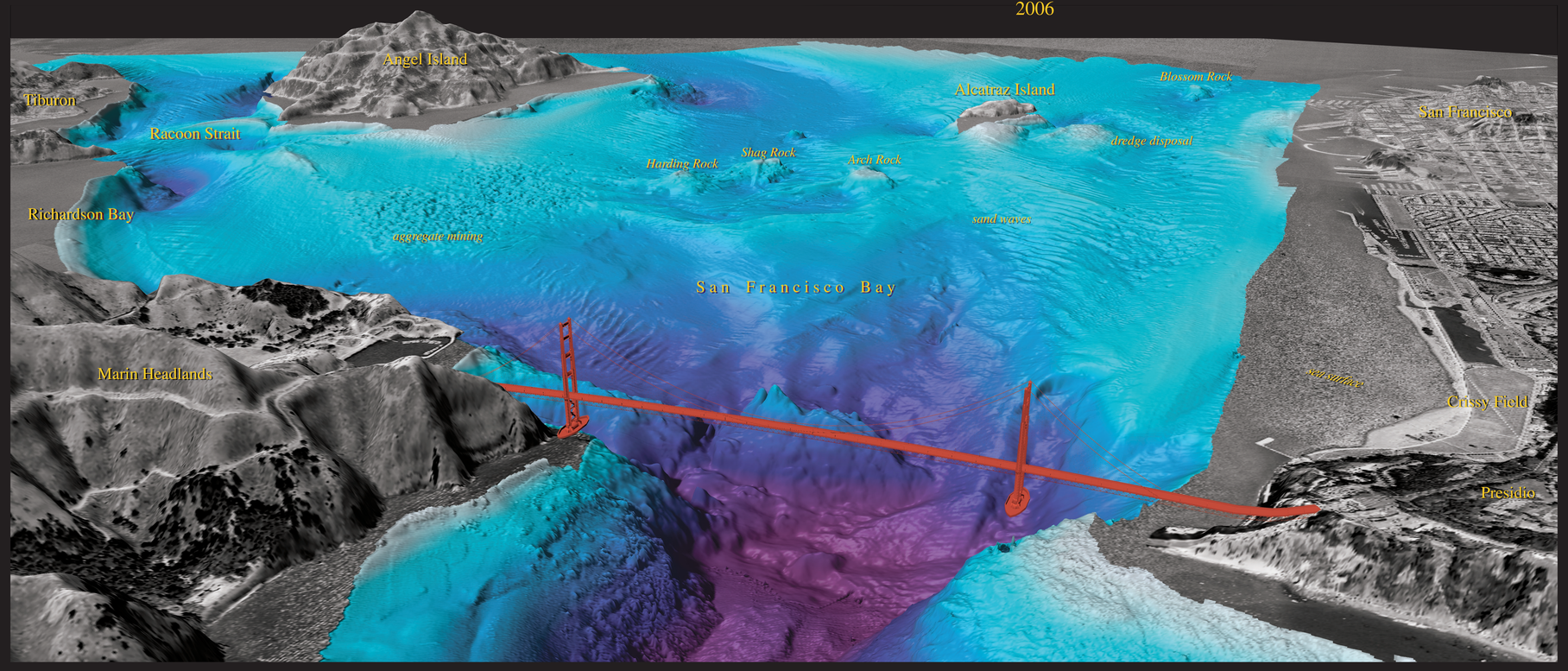
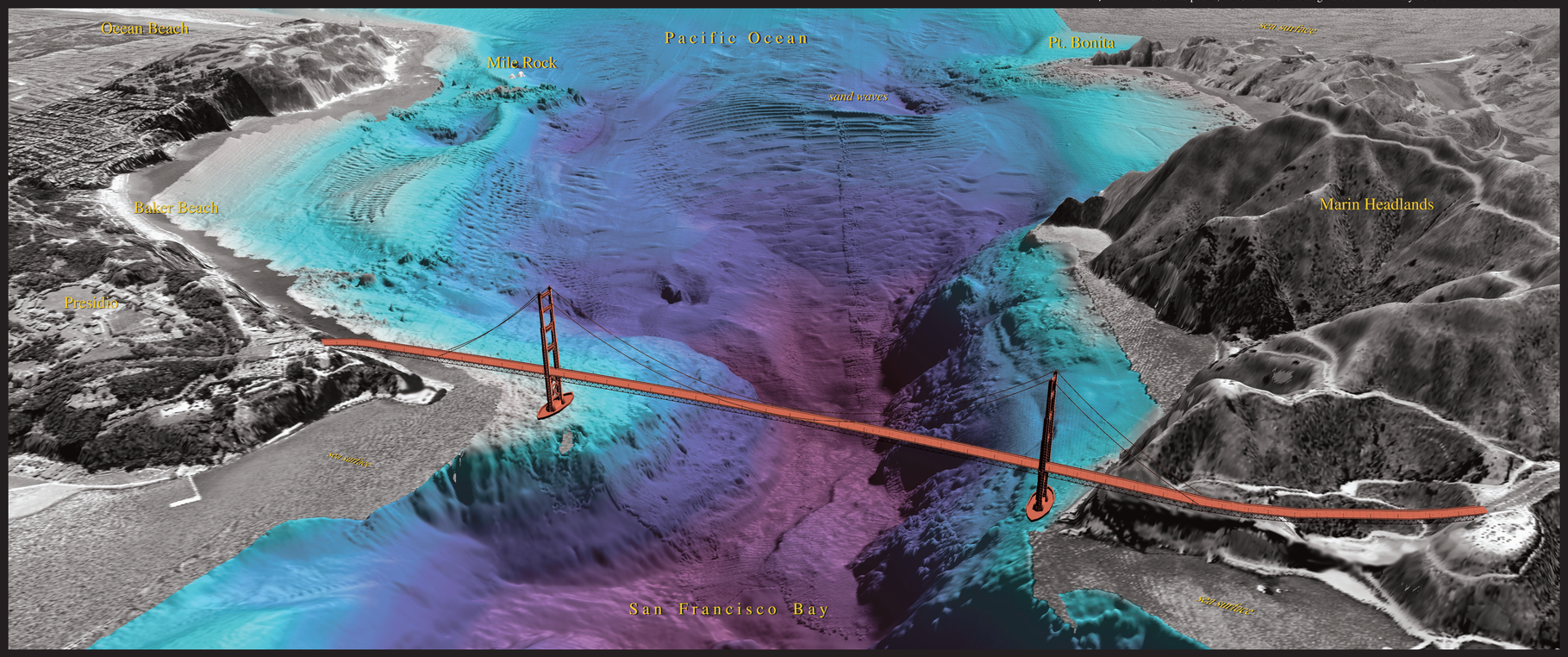


Figure 2. Perspective view looking northeast over the Golden Gate Bridge into west-central San Francisco Bay (Figure 1). The depth below the Golden Gate Bridge (purple shade) is 115 m (377 ft). Harding, Shag, and Arch rocks in the center of the Bay are shallower (11 m, 36 ft) than the bottom of large container and tanker ships (14 m, 46 ft) traveling in and out of San Francisco Bay. The potmarked sea floor west of Angel Island may be due to mining of aggregate for construction material. The mound south (right) of Alcatraz Island is sediment transported from dredging of harbors around the Bay. Sand waves between Alcatraz Island and the Golden Gate Bridge formed by strong tidal currents are as much as 4 m (13 ft) high and have wavelengths exceeding 100 m (328 ft). The distance across the bottom of the image is about 2.7 km (1.7 miles).

View Toward Bay

View Toward Ocean

Figure 3. Perspective view looking southwest over the Golden Gate Bridge toward the Pacific Ocean at the entrance to San Francisco Bay (Figure 1). The features on the sea floor in the center of the channel are a field of giant sand waves as much as 10 m (33 ft) high with wavelengths exceeding 200 m (656 ft). The sand waves are among the largest seen along the west coast. The lines running perpendicular through the sand waves are artifacts from the sea floor mapping process. See figure 6 for a different perspective view of these sand waves. The distance across the bottom of the image is about 3.0 km (1.9 miles). In all of the perspective views on this poster, the Golden Gate Bridge is shown with only its above-water structure.



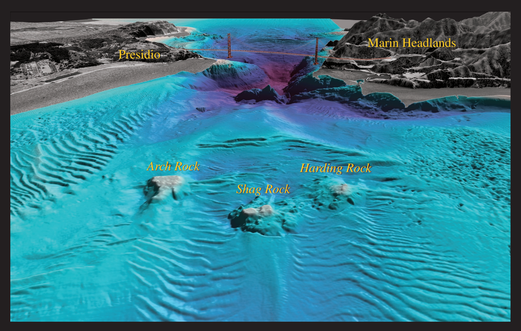


Figure 4. Perspective view of central San Francisco Bay looking southwest toward the Golden Gate Bridge (Figure 1). The Marin Headlands are to the right (north) of the Golden Gate Bridge and the Presidio is to the left (south). The foreground shows large sand waves that are about 2 m (6.5 ft) high with wavelengths as great as 125 m (410 ft). The tops of Harding, Shag, and Arch Rocks are as shallow as 11 m (36 ft) below sea level. The distance across the bottom of the image is about 1.7 km (1.1 miles).

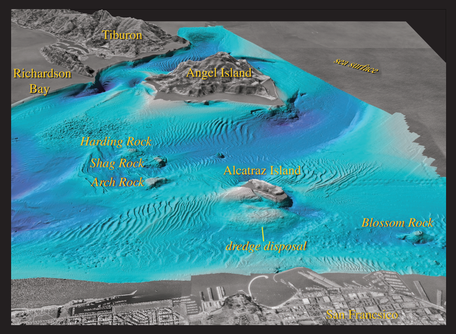


Figure 5. Perspective view looking north over west-central San Francisco Bay toward Alcatraz and Angel Islands (Figure 1). The mound just south of Alcatraz Island is material dredged and transported from container and tanker ship terminals around the Bay. The mound rises about 13 m (43 ft) above the surrounding sea floor to a depth of 11 m (36 ft) below sea level. The distance across the bottom of the image is about 5.0 km (3.1 miles).

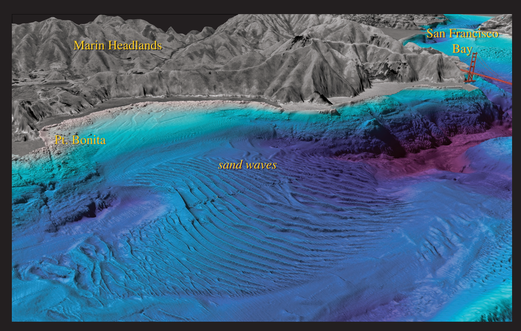
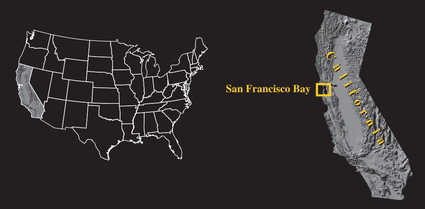


Figure 6. Perspective view looking northeast over the entrance to San Francisco Bay (Figure 1). The large sand waves in the center of the image are created by strong tidal currents flowing into and out of the Bay. The average height of the sand waves within this field is 6 m (20 ft) with a wavelength of 82 m (269 ft). The largest of the sand waves are 10 m (33 ft) high with wavelengths as great as 220 m (722 ft). The water depth over the sandwaves ranges from 30 to 100 m (98 to 328 ft). The distance across the bottom of the image is about 2.4 km (1.5 miles).

San Francisco Bay in northern California is one of the largest and most altered estuaries within the United States (Nichols and others, 1986). The sea floor within the bay as well as at its entrance is constantly changing due to strong tidal currents, aggregate mining, dredge disposal, and the creation of new land using artificial fill. Understanding this dynamic sea floor is critical for addressing local environmental issues, which include defining pollution transport pathways, deciphering tectonics, and identifying benthic habitats. Mapping commercial interests such as safe ship navigation and dredge disposal is also significantly aided by such understanding.

Over the past decade, the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), and California State University, Monterey Bay (CSUMB) in cooperation with the U.S. Army Corps of Engineers (USACOE) and the Center for Integrative Coastal Observation, Research and Education (CICORE) have partnered to map central San Francisco Bay and its entrance under the Golden Gate Bridge using multibeam echosounders. These sonar systems can continuously map to produce 100 percent coverage of the sea floor at meter-scale resolution and thus produce an unprecedented view of the floor of the bay.

This poster shows views of the sea floor in west-central San Francisco Bay around Alcatraz and Angel Islands, underneath the Golden Gate Bridge, and through its entrance from the Pacific Ocean. The sea floor is portrayed as a shaded relief surface generated from the multibeam data color-coded for depth from light blues for the shallowest values to purples for the deepest. The land regions are portrayed by USGS digital orthophotographs (DOQs) overlaid on USGS digital elevation models (DEMs). The water depths have a 4x vertical exaggeration while the land areas have a 2x vertical exaggeration.



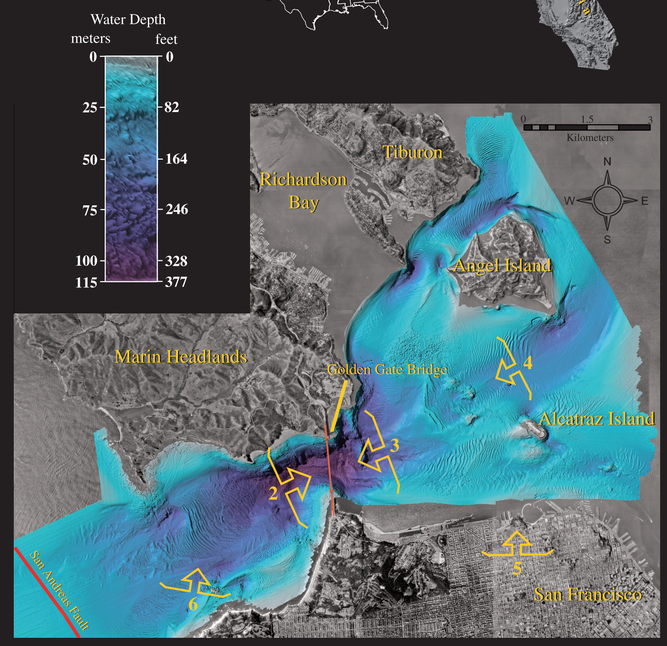


Figure 1. Map view of central San Francisco Bay and its entrance showing the extent of the sea floor mapping (in shades of blue and purple). Arrows indicate the viewing directions of the perspective views on this poster. The number next to the arrows corresponds to the figure number. The main strand of the San Andreas Fault Zone passes through the mapped area but is not apparent in the sea floor depth data.

Reference Cited

Nichols, Frederic H., Cloern, James E., Luoma, Samuel N., and Peterson, David H., 1986, The modification of an estuary: Science, v. 231, p. 567-573.

Selected References

Cacchione, David A., Carlson, Paul R., Chavez, Pat F., Jr., Chin, John L., Dartnell, Peter, Gardner, James V., Gibbons, Helen, Rubin, David M., Velasco, Miguel, and Wong, Florence L., 2003, Under San Francisco Bay - A new view of the sea floor of west-central San Francisco Bay: U.S. Geological Survey Open-File Report 01-90 [http://geopubs.wr.usgs.gov/open-file/of01-90/].

Chin, John, L., Wong, Florence L., and Carlson, Paul R., 2004, Shifting Shoals and Shattered Rocks-How Man Has Transformed the Floor of West-Central San Francisco Bay: U.S. Geological Survey Circular 1259 [http://pubs.usgs.gov/circ/2004/c1259/].

Dartnell, Peter, and Gardner, James V., 1999, Sea-Floor Images and Data from Multibeam Surveys in San Francisco Bay, Southern California, Hawaii, the Gulf of Mexico, and Lake Tahoe, California-Nevada: USGS Digital Data Series, DDS-55, CD-ROM, [http://wrgis.wr.usgs.gov/dds/dds-55/].

Gardner, James, V., Dartnell, Peter, Mayer, Larry A., Hughes Clarke, John E., and Stone, J. Christopher, 2000, Bathymetry and Selected Perspective Views of Central San Francisco Bay, California: USGS Water Resources Investigations Report 00-4164, 2 maps.

Karl, Herman A., Chin, John L., Ueber, Edward, Stauffer, Peter H., and Hendley, James W., II, 2002, Beyond the Golden Gate - Oceanography, Geology, Biology, and Environmental Issues in the Gulf of the Farallones: U.S. Geological Survey Circular 1198 [http://geopubs.wr.usgs/circular/c1198/].

Parsons, Tom, 2002, Post-1906 stress recovery of the San Andreas fault system from 3-D finite element analysis: Journal of Geophysical Research, v. 107, no. B8, p. ESE 3-1–3-13.

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US Army Corps of Engineers

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