

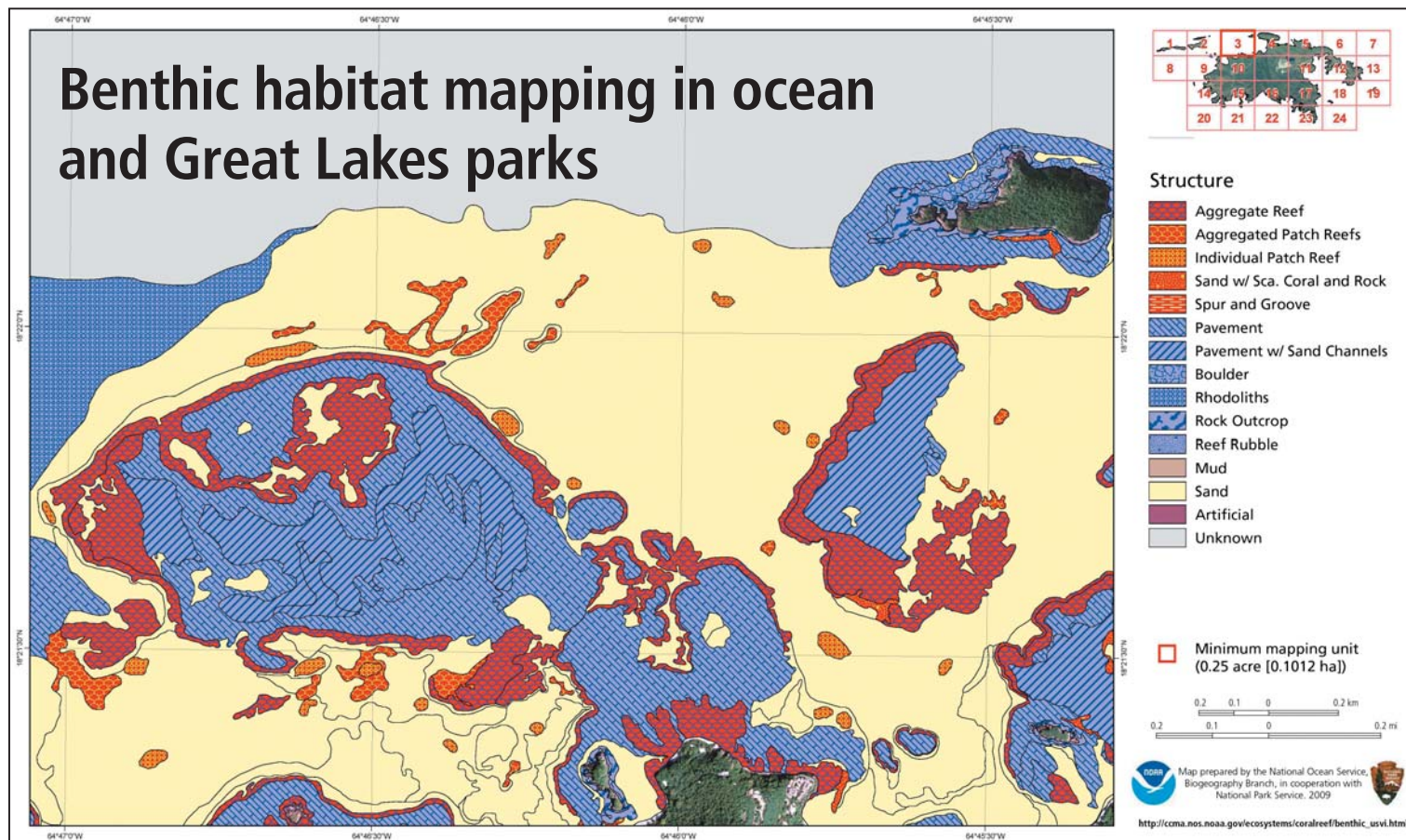


**Figure 1.** This benthic habitat map of Cinnamon Bay, Virgin Islands National Park, is based on aerial color photography and IKONOS satellite imagery. It was produced by the NOAA Center for Coastal Monitoring and Assessment (complete park map is available for downloading from [http://ccma.nos.noaa.gov/ecosystems/coralreef/benthic\\_usvi.html](http://ccma.nos.noaa.gov/ecosystems/coralreef/benthic_usvi.html)).

By Jeffrey N. Cross

**MANAGERS OF 80 OCEAN AND GREAT LAKES** units in the National Park System face increasing impacts from coastal development, land-based pollution, recreational use, nonnative species, and climate change. Park managers often have only general knowledge and a vague understanding of the nature, extent, and condition of submerged resources within their park's boundaries. Unlike their counterparts at terrestrial parks, managers of ocean and Great Lakes units cannot readily observe their resources. The most spectacular topography and habitat features are hidden from casual view and may only be detected by surveys that are technically complex, logistically difficult, and expensive, which is why submerged natural resources remain unmapped for the majority of our ocean and Great Lakes parks.

Spatial display and analysis is the most efficient and cost-effective way for park managers to use complex natural resource information. In 2008, the Natural Resource Program Center (NRPC) initiated a pro-

gram to produce digital, geographically referenced data that can be used in geographic information systems (GIS) to create high-quality habitat maps that support resource assessments and management planning. Funded by the NPS Inventory and Monitoring Program, the Natural Resource Program Center partnered with the U.S. Geologic Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), and several academic institutions to develop benthic habitat maps for six parks,<sup>1</sup> with several more under way or about to get started.<sup>2</sup> While the focus is on submerged natural resources, it can easily be extended to cultural resources. As Dave Conlin, director of the NPS Submerged Resources Center, says, "Submerged cultural resources are habitat for natural resources."

<sup>1</sup>Glacier Bay National Park and Preserve, Golden Gate National Recreation Area, Gulf Islands National Seashore, Sleeping Bear Dunes National Lakeshore, Virgin Islands Coral Reef National Monument, and Virgin Islands National Park

<sup>2</sup>Assateague Island and Point Reyes national seashores, Buck Island Reef National Monument, San Juan National Historic Site, and Salt River Bay National Historical Park and Ecological Preserve

# Science Notes

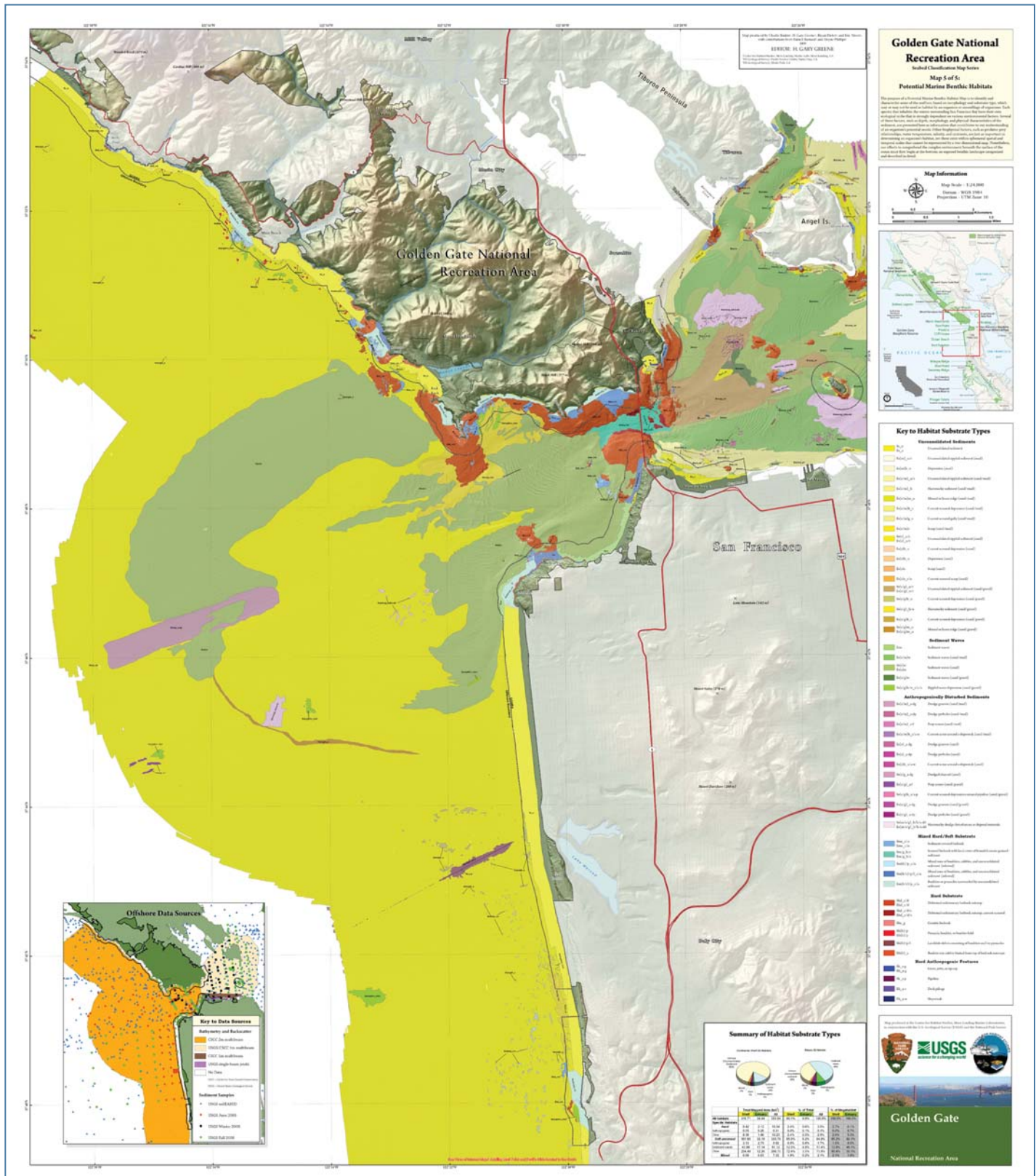


Figure 2. This benthic habitat map of Golden Gate National Recreation Area and vicinity is based on multibeam and side-scan acoustic data and sediment surveys. The map was produced by the U.S. Geological Survey and Moss Landing Marine Laboratories.

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### Mapping standards

Currently, no national standard for classifying ocean and coastal habitats is available for use. The primary challenge is to develop a classification standard that can support site-specific maps (high level of detail) and regional maps (lower level of detail). The Natural Resource Program Center is working with the NOAA Center for Coastal Monitoring and Science, NatureServe, and the Federal Geographic Data Committee to adopt a national classification, mapping, and validation standard based on the Coastal Marine Ecological Classification Standard developed by NOAA and NatureServe. A draft classification was submitted to the Federal Geographic Data Committee for review and consideration in early summer 2010.

### Producing the maps

The steps to produce benthic habitat maps include data mining and acquisition, interpretation and mapping, validation and accuracy assessment, and GIS products and reports. Data for mapping are usually acquired by remote sensing and include visible imagery, acoustic data, laser light data, and bottom visualization.<sup>3</sup>

Satellite and aerial imagery are useful for studying ocean and coastal features. Satellites with multi-spectral sensors, such as Landsat (30 m resolution) and IKONOS (4 m resolution), can be used to map submerged resources in shallow (<20 m), clear waters (fig. 1, page 21).

Sonar systems (side-scan and multibeam) use sound produced and recorded by an array of transducers to generate high-resolution, three-dimensional images of the ocean floor. Side-scan systems are effective in shallow water because they can image wide areas from a short distance above the bottom. Multibeam systems are useful in deep water because of the wide bottom swath, although resolution decreases with increasing depth (fig. 2, facing page). Acoustic surveys return a depth value in addition to a reflection coefficient that is correlated to bottom properties. Using reflectivity correlations, bottom types can be classified in terms of “hardness” (e.g., mud, sand, rock).

Light detection and ranging (lidar) can be used in clear, shallow waters (1–10 m resolution). The light waves from a green laser are reflected from the bottom and the travel time is used to calculate depth. Lidar systems can be used over land as well as in the water to map the topography across the coastal zone.

Direct images of the bottom are necessary to validate habitat maps based on remotely sensed data. Bottom visualization systems include scuba divers, towed and dropped cameras, remotely operated vehicles, and submersibles. Bottom visualization can be augmented by shipboard sampling (e.g., sediment grabs).

Benthic habitat maps establish baselines for monitoring. As sea level rises and barrier islands are eroded by storms, as ocean temperatures rise and flora and fauna redistribute themselves, benthic habitat maps can be used to track changing conditions. Mapping products can also guide park managers as they assess post-incident damage (e.g., storms, ship groundings, oil spills) and inform post-incident mitigation and management decisions.

### About the author

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<sup>3</sup>Moses, C. S., A. Nayegandhi, R. Beavers, and J. Brock. A Service-wide benthic mapping program for national parks. USGS Open File Report. U.S. Geological Survey, Reston, Virginia, in press.