Mapplets

Mapping the Seafloor

American Samoa

In the southwestern Pacific Ocean lies American Samoa, a small archipelago of five islands and two coral atolls that represent the only U.S. territory south of the equator. American Samoa is home to Fagatele (Fohng-ah-teh-leh) Bay National Marine Sanctuary (FBNMS), the smallest, most remote, and least explored of the 13 sites that make up the U.S. National Marine Sanctuary System and the only true tropical coral reef among those sites. Yet another treasure in the islands is the National Park of American Samoa, one of the few sites within the Department of Interior's National Park Service (NPS) that includes both land and ocean.

Until recently, both the sanctuary and the park were largely unexplored below depths of 30 meters, and no comprehensive documentation of their plants, animals, and submarine topography existed. Indeed, virtually nothing is known about the world's shelf-edge (50–120 meters deep) coral reef habitats and no global inventory of shelf-edge, benthic species exists.

In 1998, though, the Sustainable Seas Expeditions (SSE, http://sustainableseas.noaa.gov) launched a major initiative to remedy this situation. SSE has pioneered the use of new technologies, including the single-occupant submersible *Deep Worker,* to explore, document, and provide critical scientific data for marine sanctuaries, with the goal of developing a strategy for restoring and conserving these resources. SSE's mission plan includes three phases: photo-documenting sanctuary plants, animals, and habitats at depths as great as 600 meters; expanding the characterization of habitats, focusing on those of larger animals such as whales, sharks, rays, and turtles; and finally, analyzing and interpreting these data and conducting extensive public outreach and education.

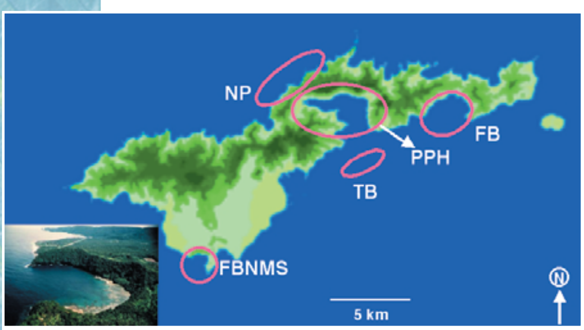

FIGURE 1 This map of American Samoa indicates areas surveyed (pink circles) in spring 2001. The inset photo is the marine sanctuary.

As part of phase one, I collaborated last spring with FBNMS Manager Nancy Daschbach, and University of South Florida (USF) scientists David Naar and Brian Donahue, to complete bathymetric surveys in both the marine sanctuary and the national park. I then began to integrate this and other baseline data into a GIS.

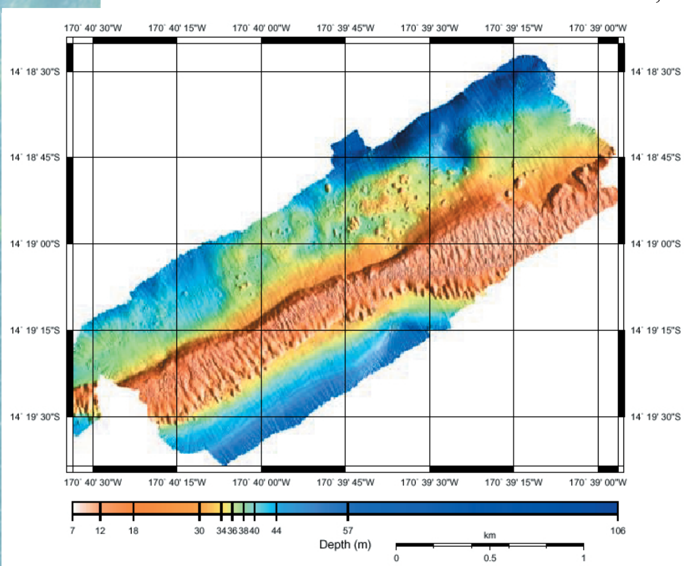

FIGURE 2 This histogram-equalized, shaded-relief bathymetric map reveals the Taema Bank, a drowned coral reef terrace 3 kilometers off the coast of Tutuila.

To map the area's underwater topography, we used a portable multibeam bathymetric mapping system, attached to the bow of a 30-foot survey boat. The sonar system operates at an acoustic frequency of 300 kHz, fanning out as many as 127 tiny beams at a maximum ping rate of 25 Hz and an angle of 130 degrees (1.5 × 1.5 degree beams are spaced 0.9 degree apart). This yields swaths as much as four times greater than the water depth. At normal survey speeds of 3–12 knots, the sonar can capture data at depths as great as 100 meters, with data gridded at spacings of 0.25–25 meters. Positions are recorded using GPS. With no differential corrections available at the time, we achieved a sounding accuracy of about 24 meters (points fell within a circle of radius 24 meters) and data were gridded at a 1-meter resolution.

In only two weeks, we obtained full bathymetric coverage around selected sites off the main island of Tutuila, including FBNMS, part of the National Park (NP), Pago Pago Harbor (PPH), Taema Bank (TB), and Faga'itua Bay (FB, see Figure 1). After the surveys, we cleaned the navigation data to eliminate erroneous positions and applied National Oceanic and Atmospheric Administration tidal corrections to the depth soundings. We then gridded ASCII-formatted *x,y,* and *z* depth data using a public-domain suite of software tools for processing and display of swath sonar data. Initial maps made from the grids revealed many important features, such as reef terraces, erosional remnants, volcanic edifices, and blocks of reef debris (see Figure 2). Mapping of Pago Pago harbor also captured in striking detail the wreckage of the *USS Chehalis,* a World War II–era oil and gas tanker that exploded and sank in the harbor in 1949, and may still be a source of water pollution (see Figure 3).

We then converted bathymetric grids to Arc format. These grids constituted the base layers for the new FBNMS GIS. The GIS also comprised an initial compilation of terrestrial data layers — including a 10-meter digital elevation model of Tutuila — various digital line graph and digital raster graphics files, shapefiles, coverages, and grids, all obtained from NPS, the U.S. Geological Survey, the Digital Chart of the World, and other sources.

To make all data sets in the FBNMS GIS accessible — not only to the sanctuary staff and their collaborators in American Samoa but also to parties throughout Oceania and the United States — we built a Web clearinghouse (see http://dusk.geo.orst.edu/djl/ samoa). The clearinghouse provides links to all of the GIS data and metadata, bathymetric grids in Generic Mapping Tools format for non-GIS users, maps, photographic images, and graphics. All GIS data are provided as export interchange files, which may be imported into GIS software.

Ground truthing. Ground truthing our bathymetric surveys with photography and videography is an ongoing endeavor. For example, the new bathymetry of the FBNMS helped to guide the location of a deep-diving mission to the sanctuary on May 16, 2001 (see Figure 4). University of Hawaii researcher Richard Pyle used rebreather technology to work underwater for more than 3.5 hours (significantly longer than possible with traditional SCUBA), and collected videotape of coral reef biota and habitats as deep as 113 meters. Although the mission was cut short by poor weather, Pyle observed 12 completely new species of fish in the bay, 17 species that had never before been observed in American Samoa, and several species that were previously unknown to the waters of Fagatele Bay.

And in March 2002, SSE founder Dr. Sylvia Earle, a famed marine biologist and National Geographic Explorer-in-Residence, led a small diving, photography, fish count, and public outreach mission in the area. Earle, along with Kip Evans, Gale Mead, former National Marine Sanctuary Program Director Francesca Cava (all from SSE), Brian Donahue from USF, Laddie Akins of the Reef Environmental Education Foundation, and Nancy Daschbach, made 60 dives at the sanctuary and several other sites around Tutuila. They created an extensive collection of underwater video and still images, and observed and documented 30–50 species of corals, four different shark species, more than 200 fish species, and 20 invertebrate species.

Future stages in the unveiling of the seafloor will include the postprocessing and gridding of bathymetric data gathered on a 1-day circuit of the island, which we conducted aboard the *R/V Revelle* in March 2002. These data will enable us to characterize the volcanic flanks of Tutuila at depths greater than 100 meters.

In December, we plan to conduct additional shallow-water surveys. In addition to bathymetry, these surveys will include the gathering of backscatter imagery (representing the strength of the return signal rather than just the travel time), so that seafloor classification and habitat maps may be prepared and integrated with high-resolution satellite imagery. These maps will be the basis for ongoing studies in the sanctuary and the park that will include selecting sites for habitat class designation and protection (no-take zones), developing sanctuary program monitoring protocols, and obtaining a general understanding of species composition and abundance.

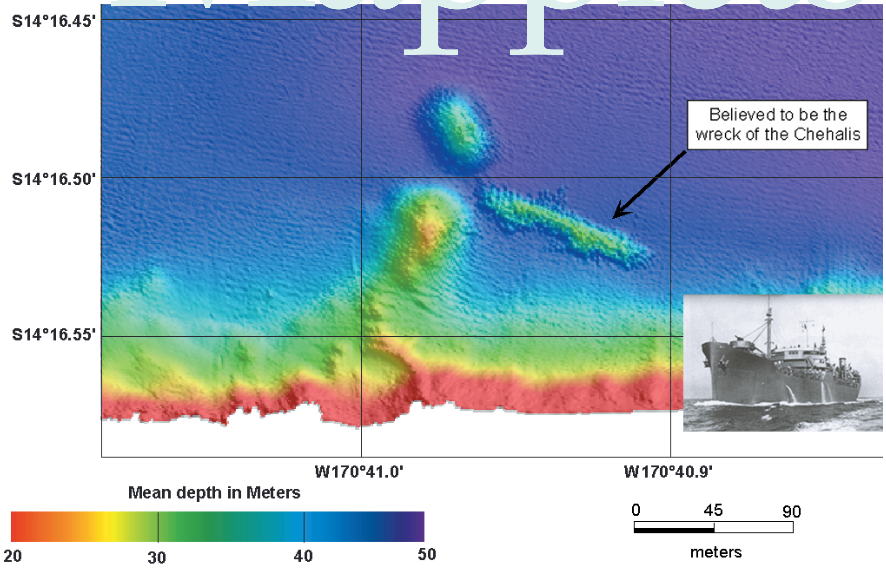

FIGURE 3 This color-shaded, sun-illuminated bathymetric map shows the wreck of the *USS Chehalis* in Pago Pago Harbor. The inset ship is the same class as the *Chehalis.*
Cartography by Brian Donahue, inset photo courtesy of nara.gov/publications/sl/navyships/auxil.html.

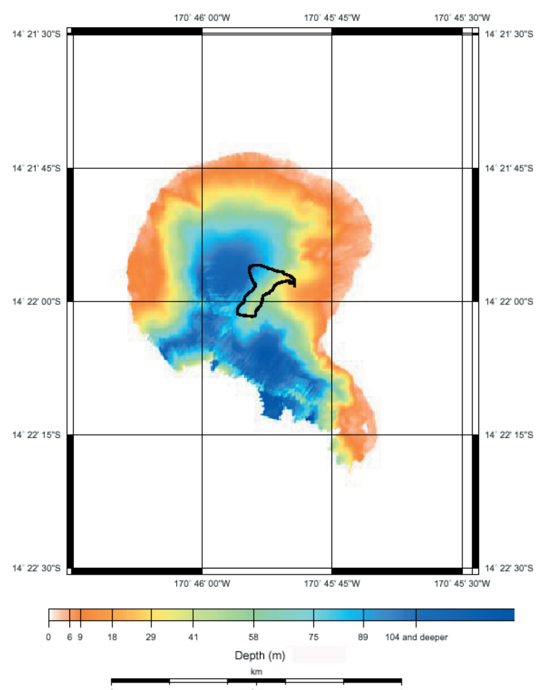

FIGURE 4 The solid line delineates the estimated dive track of a rebreather diving mission in the FBNMS immediately following our bathymetric survey.

The survey team logged and visualized bathymetric data with Kongsberg-Simrad's Merlin software (www.kongsberg-simrad.com), postprocessed with Kongsberg-Simrad's Neptune software, and gridded with MB System (www.ldeo.columbia.edu/MB-System/html/mbsystem_home.html). Initial maps were produced with GMT (http://gmt.soest.hawaii.edu) and converted to GIS format with ArcGMT (http://dusk.geo.orst.edu/ arcgmt). The FBNMS GIS was built using ESRI's (www.esri.com) ArcView 3.2 and ArcInfo 8.1.

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