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Research

Newly Discovered Fossil Sponges Share Scientific Secrets About Miami's Ancient Marine Environment

By Ann B. Tihansky and Kevin J. Cunningham

The urban bedrock of a low-relief landscape beneath a crowded city seems like an unusual place for a significant fossil discovery. However, a new fossil find at four sites amid the bustling expressways and vast expanses of homes and commercial buildings of metropolitan Miami, Florida, indicates that these sites were once a unique marine habitat. In a report published in the May 2007 issue of *Geology*, scientists from the U.S. Geological Survey (USGS), Brigham Young University, and Smith College describe the newly discovered fossils: large, dense aggregations of hefty vase- and barrel-shaped sponges as much as 2 m high and 1.8 m in diameter. The fossilized sponge communities occur as biostromes—extensive, blanket-like masses of rock built and composed mainly of sedentary organisms, in this case, sponges. More simply, the aggregations may be thought of as sponge reefs. Within the limestone bedrock at the discovery sites, the upright fossil sponges are commonly packed so closely that they resemble a dense forest of wide, stubby tree trunks. The sponges are part of the Miami Limestone, which formed in southeastern Florida during the last interglacial period, approximately 125,000 years ago, when sea level was somewhat higher than today. This geologic unit forms the foundation of the natural terrain in present-day Miami.

These fossil sponges belong to a class of sponge called the demosponge, which includes the familiar variety of natural sponge used for bathing. Relations between the newly discovered sponge reefs and surrounding rock types indicate that the sponges thrived mostly within tidal channels where seawater was cyclically

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Well-preserved new species of fossil demosponge, Miamiamplia vasiforma, *in growth position along the wall of a suburban canal in Miami.*

Sound Waves

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Research, continued

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exchanged at relatively high rates of flow between the ancient Atlantic Ocean and a landward shallow lagoon in an area that includes part of the present-day and predevelopment Everglades. The fossil sponge reefs appear to be constrained to ancestral tidal channels, with bends and straight stretches of their reef structures conforming to the courses of the original tidal channels. These ancient tidal channels cut northeast to southwest through a region of large submarine sand dunes that were several meters above the surrounding sea floor, creating a mosaic submarine landscape that separated the lagoonal waters from the open waters of the paleo-Atlantic Ocean. The largest of the sponge reefs follows the axis of one relict tidal channel for a distance of 3.5 kilometers.

USGS hydrogeologist **Kevin Cunningham** discovered the first two of four reefs during the summer of 2004. On a routine drive through suburban Miami, he noticed something unusual in the wall of one of the numerous drainage canals constructed throughout Miami more than 40 years ago. "I stopped and took a quick look at a few of the sponges. At first, it wasn't clear to me just what I'd found, but after more careful examination, I realized I'd lucked upon a real beauty of a sponge reef. Because researching the sponges was outside the normal scope of my responsibilities with the USGS, I sent off samples to fossil-sponge expert **Keith Rigby** at Brigham Young University, who verified that the sponges are a single species of demosponge." **Rigby** has identified the sponges as a new, extinct species, which he and **Cunningham** have named *Miamiamplia vasiforma* in a newly published paper on the sponge's taxonomy (see *Journal of Paleontology*, July 2007, URL **http://jpaleontol.geoscienceworld.org/cgi/content/extract/81/4/788**).

"Once I realized that I was on to something with potential substantial impact on the geologic community," continued **Cunningham**, "I began to work on the primary discovery site on weekends and even used vacation time." According to **Cunningham**, "These are the only sponge reefs currently known, within both the modern and fossil record, that were constructed within moderate- to high-energy tidal channels. Scientists have generally assumed that large barrel sponges live in rather low-energy submarine settings."

The new findings raise more questions: What contributed to the ability of these particular sponges to inhabit the ancient tidal channels with such robust individual sizes, and to form long, kilometer-scale reefs? Some of the sponges have clearly developed "holdfasts" that extend outward from the lower parts of the sponges and can look like the roots of a tree. These holdfasts may have played a role in keeping the sponges upright in the swift currents and shifting sand dunes within the tidal channels. **Cunningham** speculates that "high nutrient levels, flowing from a more northern part of the ancient flooded Floridan peninsula during the last interglacial period, gave the sponges an advantage over competing organisms in the stressed channel environments. This would allow

Florida region, showing study area and additional places mentioned in text.

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the sponges to virtually dominate some areas of the channel landscape."

Scientists use comparisons between the modern environment and the fossil record to improve our understanding of Earth history. The occurrence of the Florida fossil sponges in relict tidal channels provides a new example of an environmental niche where sponges can construct large-scale reefs. Today, similar large sponge reefs, produced by siliceous sponges, are known from a few places, notably off the west coast of British Columbia, but in cold, deep water. Calcified demosponges are the primary frame-building organisms within some modern coral reefs; however, they occur in the much deeper parts of the reefs, below the zone of active coral growth near the sea surface. **Cunningham** commented that "compared to these other types of modern deep-water sponge reefs, the geologically young Miami sponge reefs are unique. They are the only known large-scale sponge reefs I'm aware of that have formed in shallow-marine, tropical seas since many millions of years ago." But that doesn't mean there may not be others. Not far away to the east of Miami, on the Great Bahama Bank, modern examples of similar mosaics of tidal channels and submarine sand dunes are common. Like the ancient sand dunes where the fossil sponges were discovered, the sand dunes on the Great Bahama Bank consist largely of ooids: smooth, round grains formed by concentric layers of calcium carbonate precipitated around a nucleus. Ooids are primarily found where strong bottom currents exist. Not long ago, in the 1980s, geologists were amazed by the discovery of large, erect columns of algal-bound sediment called stromatolites growing in association with oolitic sand bodies in Bahamian tidal channels. Up to then, modern stromatolites were thought to be confined to hypersaline waters (for example, Hamelin Pool in Shark Bay, Australia). The discovery of numerous stromatolites growing in normal marine waters led to a revolution in how Earth scientists interpret the marine environments in which fossil stromatolites had formed.

*USGS scientists **Don Hickey** (left) and **Mark Stewart** coring one of four sponge biostromes recently discovered in Miami.*

After seeing the spectacular Miami sponge reefs, some of **Cunningham's** geologic colleagues interested in comparing modern and ancient limestone environments have begun to discuss exploring the tidal channels of the Great Bahama Bank in search of modern shallow-water sponge reefs. Perhaps one day a Bahamian tidal channel will be found to contain the modern counterpart to the fossil sponge reefs discovered by **Cunningham** in the Miami Limestone.

According to **Cunningham**, "It's amazing to me that no one had noticed the astonishing reefs before. The engineers and construction teams that built these canals must have known they were digging up something very unusual but obviously didn't realize what they were or their significance. Additionally, the Miami area has been mapped by a number of prestigious geologists who have left great legacies of understanding the geologic history of South Florida. Somehow these sponges have kept their existence secret until now."

Details about the newly discovered sponges are available in the recent articles in *Geology* and *Journal of Paleontology*:

Cunningham, K.J., Rigby, J.K., Wacker, M.A., and Curran, H.A., 2007, First documentation of tidal-channel sponge biostromes (upper Pleistocene, southeastern Florida): Geology, v. 35, no. 5, p. 475-478, doi:10.1130/G23402A.1 [URL **http://www.gsajournals.org/perlserv/?request=get-abstract&doi=10.1130%2FG23402A.1**].

Rigby, J.K., and Cunningham, K.J., 2007, A new, large, late Pleistocene demosponge from southeastern Florida: Journal of Paleontology, v. 81, no. 4, p. 788-793 [URL **http://jpaleontol.geoscienceworld.org/cgi/content/extract/81/4/788**.]

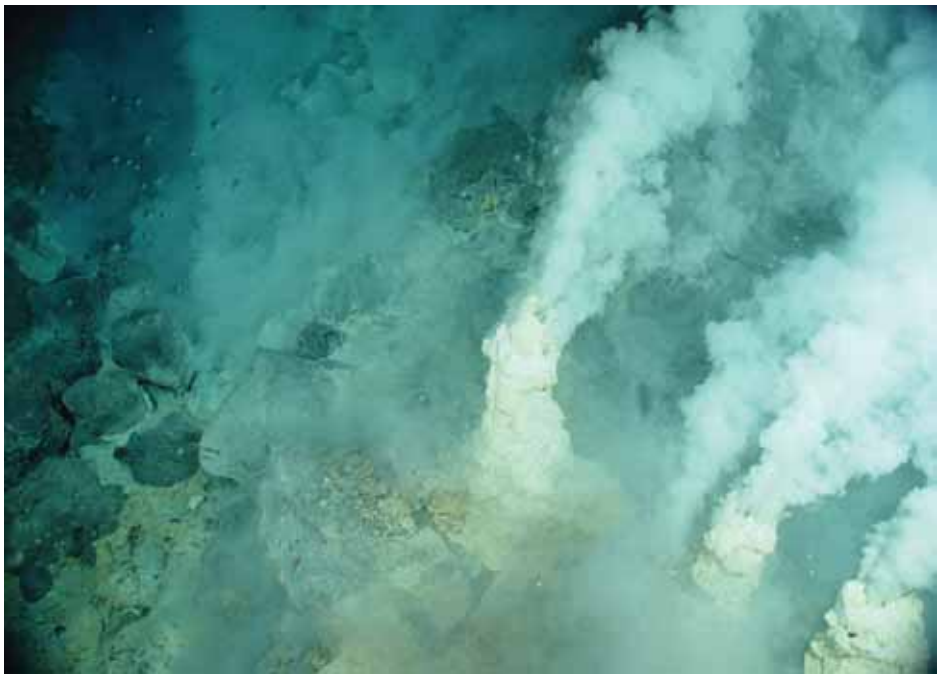
Photomosaic of part of a sponge biostrome along the wall of a canal in suburban Miami. Densely spaced upright sponges have a barrel- or vase-like shape and are overlain by oolitic limestone. These sponges thrived in a tidal-channel environment between ooid shoals during the last interglacial period, about 125,000 years ago.

Alchemy in the Abyss—USGS Public Lecture on Deep-Ocean Minerals

By Helen Gibbons

U.S. Geological Survey (USGS) marine geologist **James Hein** introduced listeners to the mysteries of deep-ocean minerals in a public lecture titled "Alchemy in the Abyss" on May 31 at the USGS center in Menlo Park, California. The demand for metals is increasing dramatically, especially in Asia, and nations are exploring to see whether mineral deposits in the deep ocean can help supply the new markets. **Jim** described the three main types of deep-ocean deposits:

- Polymetallic sulfide deposits forming rapidly at submarine hot springs, called hydrothermal vents, along volcanically active midocean ridges and island arcs,
- Slow-forming manganese nodules occurring over vast areas of the sediment-covered abyssal depths, and
- Cobalt-rich ferromanganese crusts forming extremely slowly on sediment-free tops and flanks of undersea mountains called seamounts. (See article in *Sound Waves*, May 2007, URL **http://soundwaves.usgs.gov/2007/05/research.html**, to learn about **Jim's** study of these crusts.)



White chimneys at Champagne vent site in the active Mariana Arc, western Pacific Ocean. Chimneys are approximately 20 cm (8 in) across and 50 cm (20 in) high, venting fluids at 103°C (217°F). Notice the unusual bubbles of liquid CO_2 in upper left. Photograph taken April 2004 during Pacific Ring of Fire 2004 Expedition conducted by the National Oceanic and Atmospheric Administration (NOAA) Office of Ocean Exploration; ***Bob Embley*** *(NOAA Pacific Marine Environmental Laboratory), chief scientist. (See related* Sound Waves *article at URL* ***http://soundwaves.usgs.gov/2004/07/****.)*

The audience was fascinated by **Jim's** tales of deep-sea exploration using manned submersibles and remotely operated vehicles (ROVs). The lecture incorporated videos taken during some of **Jim's** cruises, including footage shot from an ROV of the first deep-sea volcanic eruption to be caught on film. The scientists thought they were filming a sulfur-rich hydrothermal plume until they saw dark rock fragments being ejected. The ROV was quickly retrieved and, once back on deck, was seen to be spattered with blobs of elemental sulfur from the eruption ejecta. (Read more about this expedition in "Exciting New Discoveries in Submarine Hydrothermal Systems," *Sound Waves*, July 2004, at URL **http://soundwaves.usgs.gov/2004/07/**)

Nautilus Minerals, Inc., based in Canada and Australia, plans to begin mining polymetallic sulfides (for gold and copper) from extinct hydrothermal mounds in the Exclusive Economic Zone (sea floor within 200 nautical miles) of Papua New Guinea in 2009, a fact that sparked questions about possible environmental impacts. Not much is known about deep-ocean ecosystems outside those at active vent sites, but other deep-ocean ecosystems are beginning to receive increasing attention through major international cooperative programs.

The talk ended with a lively question-and-answer session, and many audience members lingered to speak to **Jim** afterwards. To see an archived video of the lecture, visit URL **http://online.wr.usgs.gov/calendar/2007.html** (scroll down).

USGS Draws Public with Hands-On Activities at Florida's Marine Quest 2007

By Ann Tihansky and Nancy DeWitt

In celebration of Earth Day, the State of Florida's Fish and Wildlife Conservation Commission hosted the 2007 Marine Quest on Saturday, April 21. Marine Quest is a public open house for the Fish and Wildlife Research Institute (FWRI) held annually at Bayboro Harbor in downtown St. Petersburg. Along with representing the many resource programs for the State of Florida, the FWRI invites outside scientific organizations to participate. The U.S. Geological Survey (USGS) was one of 23 additional research facilities represented at the event, which attracted more than 3,200 public visitors.

USGS scientific programs complement the myriad presentations and displays at Marine Quest. To take advantage of the

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opportunity to interact with the public, the USGS booth was designed to be "hands-on" and became a hubbub of activity. Along with a colorful array of take-home items, including bookmarks, pencils, buttons, posters, and information sheets about Web resources and scientific programs, the booth offered visitors several activities. Many tried their hand at the guessing game "What Kind of Water Is it?" This game teaches the importance of observation and raises awareness about how the appearance of water is not always the best indicator of whether it is potable. Some kids even returned with a new friend in tow to help them play the game more than once. Those who challenged themselves at this game won a USGS ruler and learned a lot about how looks can be deceiving when it comes to water quality.

Nancy DeWitt hosted a get-your-hands-wet activity called "Bathy Bottoms," which familiarized visitors with how scientists conduct bathymetric surveys with high-resolution sonar systems to map the sea floor. Although global-positioning-system (GPS) technology is an important part of bathymetric-survey techniques, the display focused on technology used to measure differences in water depth (and thus map sea-floor features). Booth visitors could manipulate a tiny "research vessel" equipped with real single-beam sonar sensors in a large tank of water to help a gang of pirates locate and map their sunken ship and treasure. The hands-on activity vividly conveyed a complicated concept. A new high-resolution map of Tampa Bay, created through the Tampa Bay Integrated Science Project (**http://gulfsci.usgs.gov/tampabay/**), was displayed behind the interactive tank. The map served as an example of the final products that can be created by using these kinds of technology (view the Tampa Bay map at URL **http://pubs.usgs.gov/of/2007/1051/**, and see related story, this issue). Both the treasure mapping and the examples of map products spurred interest and questions from visitors of all ages.

A collection of rocks from around the world sparked other conversations between the visiting public and the USGS volunteers about geology, the basic differences between rock types, and the origins of the rock samples. Volunteers included **Nancy DeWitt**, **Ann Tihansky** and her daughter **Anastasia**, **Marc Blouin** and his wife **Ava**, **Molly McLaughlin**, and **Kate Ciembronowicz**. The booth was busy all day, and everyone learned about the science around them!

*Observant youngsters work as a team to guess "What Kind of Water Is It?" at the USGS booth, hosted by the Florida Fish and Wildlife Research Institute during Marine Quest 2007. **Nancy DeWitt** is at left.*

*Using a new high-resolution map of Tampa Bay as an example, **Nancy DeWitt** discusses how sonar data are used to generate bathymetric maps.*

Enthusiastic visitors learn more as they gather USGS information and educational materials.

***Nancy DeWitt** uses real instruments deployed in a demonstration tank to show visitors how single-beam sonar technology works.*

***Molly McLaughlin** moves the "research vessel" while one of her "scientific team" watches the result on the display screen.*

Piedmont College Students Introduced to USGS Studies in the San Francisco Bay Region

By Helen Gibbons

A field trip to coastal cliffs and marine terraces, a demonstration of state-of-the-art laser scanning used for topographic surveys, and a video and discussion about San Francisco Bay ecosystem research were among the presentations offered by U.S. Geological Survey (USGS) scientists to a group of students from Piedmont College in northeastern Georgia. The 16 students were visiting California in a traveling class led by geology professor **Deborah Dooley** and psychology professor **Viviane Daigle**. During their week-and-a-half-long trip, which began in Los Angeles and ended in San Francisco, the group spent half their time exploring topics in environmental geology—focusing on how people interact with the natural environment—and the other half exploring topics in environmental psychology—how people interact with the built environment.

The Piedmont College group reached the San Francisco Bay region about halfway through their tour, and on Saturday, May 12, they were treated to a field-trip double-header: In the morning, geologist **Mike Rymer** of the USGS Earthquake Hazards team in Menlo Park showed them a landslide in the town of La Honda that has destroyed several homes and threatens more. **Mike**, who lives near the affected area and has coauthored publications about the landslide (see the latest at URL **http://pubs.usgs.gov/of/2006/1397/**), recounted the landslide's history and explained how various features of the still-active slide are related to local geology.

Monty Hampton, a USGS emeritus geologist with the Western Coastal and Marine Geology team in Santa Cruz and Menlo Park, accompanied the students on the landslide trip and then led them to Half Moon Bay, where he told them about the evolution of the bay, the adjacent coastal terraces, and the mountains farther inland. He also discussed the area's geologic hazards, including erosion, earthquakes, and tsunamis.

A few days later, on May 16, the students came to the USGS center in Menlo Park, where their visit began with a short tour of the campus. At the campus Map and Publication Sales office operated by the California Geological Survey (CGS), engineering geologist **Anne Rosinski** of CGS outlined the geologic hazards that affect the residents of California and described the many products that CGS produces to help mitigate hazards; USGS cartographer **Mitch Adelson** explained how the USGS makes the topographic maps that are a major draw at the sales office. Later that morning, the group met with research civil engineer **Brian Collins** of the Western Coastal and Marine Geology Team, who described his use of a high-resolution laser scanner to conduct detailed surveys of a landslide in Daly City. The results of that study were published quickly and used almost immediately by city officials (see article in *Sound Waves*, June 2007, URL **http://soundwaves.usgs.gov/2007/06/pubs.html**). The scanner, just back from a trip down the Grand Canyon to survey sensitive archeological sites, produced a sample scan of some of the group members.

After enjoying a sunny lunch at the café on campus, the group met with hydrologist **Brent Topping** of the USGS Water Resources Discipline, who had lined up several of his colleagues to describe their San Francisco Bay ecosystem studies. Biologist **Francis Parchaso**, hydrodynamic modeler **Lisa Lucas**, and **Brent** started the afternoon with "Delta Revival: Restoring a California Ecosystem," a 22-minute USGS video about how scientists from many disciplines are working together to guide the restoration of the Sacramento-San Joaquin Delta east of San Francisco

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*Students from Piedmont College and their professors **Deborah Dooley** (first row, second from left) and **Viviane Daigle** (middle row, fifth from left) pose for a group photograph on the USGS campus in Menlo Park, California.*

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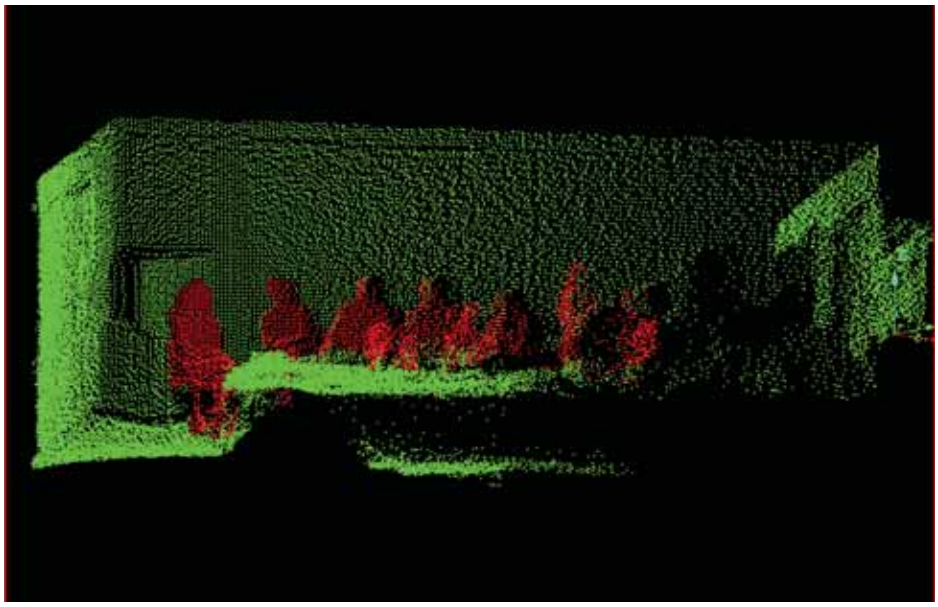
Bay. The fast-paced video, with many shots of boat-based fieldwork, sparked numerous questions for discussion. Next came visits to several laboratories: In one lab, biologist **Dan Cain** explained how he studies metal accumulations in insects as a tracer for environmental quality. He also took the students to a "cold lab," where they viewed aquatic snails and clams used in experiments on how quickly organisms take up metal from surrounding water and sediment. The final stop was the analytical laboratory of hydrologist **Tom Bullen**, who described his studies of chromium in ground water.

The afternoon passed quickly, and soon it was time for the visitors to board their buses back to San Francisco. The teachers expressed appreciation for the many USGS presentations and spoke of repeating the California trip in the future.



"Coarse scan" of some of the Piedmont College students, produced by the USGS laser scanner at its lowest-resolution setting. Each dot (some colored red to highlight the people) can be linked to geographic coordinates. The data can be rotated for viewing from virtually any angle.

Expert Panel Discusses Potential Impacts of Future Sea-Level Rise on U.S. Mid-Atlantic Coast

By Ben Gutierrez

Based on compelling observations, scientists around the world agree that the climate is changing because of human-induced warming. The predicted consequences are highly variable, but two that will greatly affect all coastal regions are sea-level rise and the potential for more frequent and energetic storms. To address the first of these topics, U.S. Geological Survey (USGS) scientists **S. Jeffress Williams, Rob Thieler**, and **Ben Gutierrez** convened a panel of coastal scientists to discuss the potential changes that could occur to the ocean shores of the U.S. mid-Atlantic coast as a result of sea-level rise over the next century. The 2-day workshop was held April 12-13 in Beltsville, Maryland, at the Beltsville Laboratory of the USGS Patuxent Wildlife Research Center. Meeting attendees discussed the important geologic, physical, and anthropogenic factors that contribute to shoreline changes in this region. In addition, they discussed the challenges involved in using predictive approaches to make long-term shoreline-change assessments.

The results of this meeting are being used to assist USGS participation in preparing the Climate Change Science Program (CCSP) Synthesis and Assessment Product 4.1 (SAP 4.1), titled "Coastal Elevations and Sensitivity to Sea-Level Rise." The USGS team, consisting of **Williams**, **Thieler**, and **Gutierrez** of the USGS Woods Hole Science Center, **Donald Cahoon** of the USGS Biological Resources Discipline at the Patuxent Wildlife Research Center, and **Eric Anderson** of the USGS National Mapping Discipline and the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center, are collaborating with scientists at the Environmental Protection Agency (EPA) and NOAA to assess potential impacts resulting from sea-level rise that can be expected by the year 2100. The goal of the CCSP product is to identify lands that could be affected by such sea-level rise. The prospectus for this report can be viewed at URL **http://www.climatescience.gov/Library/sap/sap4-1/SAP4-1prospectus-final.pdf**.

The panel convened for the Beltsville meeting consisted of coastal scientists and managers who have experience in basic research as well as coastal policy and management. Panel participants included **Mark Byrnes** (Applied Coastal Research and Engineering), **Jay Tanski** (New York Sea Grant), **Stewart Farrell** (Richard Stockton College of New Jersey), **Art Trembanis** (University of Delaware), **Randy McBride** (George Mason University), **Carl Hobbs** (Virginia Institute of Marine Science), **Jesse McNinch** (Virginia Institute of Marine Science), **Tony Rodriguez** (University of North Carolina), and **Paul Gayes** (Coastal Carolina University).

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The group discussed the nature of a regional assessment of sea-level-rise impacts that could occur over the next century. They agreed that there is a high degree of uncertainty in predicting long-term shoreline changes because of the range of factors involved and the complexity of their interaction. Principal unknowns identified by the panel include regional sediment budgets and anthropogenic influences (for example, erosion-mitigation efforts such as beach nourishment). The panel conducted a qualitative review of potential shoreline changes that could be expected over the next century under different sea-level-rise scenarios. The panel also discussed basic approaches that may work to parameterize future vulnerability to sea-level rise. The meeting results are being integrated into the USGS contribution to SAP 4.1, expected to be released by the CCSP in fall 2007.❁

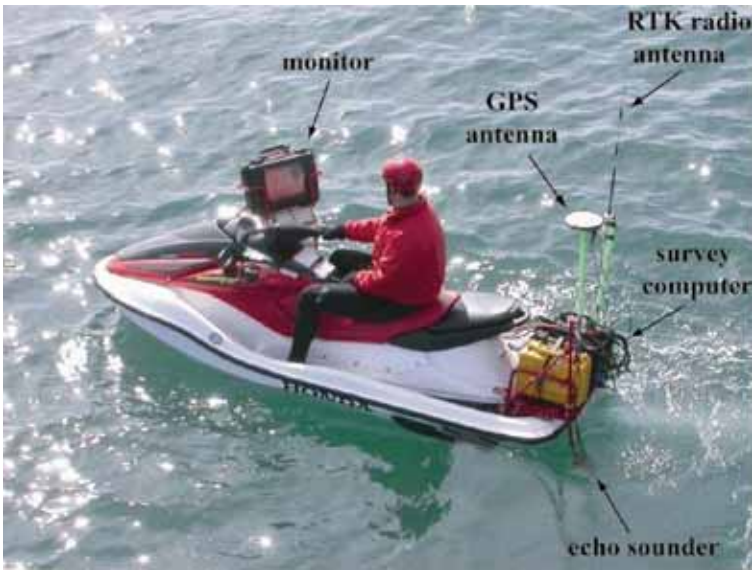
Left to right: ***Art Trembanis***, ***Ben Gutierrez***, ***Jay Tanski***, ***Paul Gayes***, ***Randy McBride***, ***Mark Byrnes***, *and* ***Stewart Farrell***. *Photograph by* ***Eric Anderson***.

Left to right: ***Tony Rodriguez***, ***Jesse McNinch***, ***Rob Thieler***, ***Don Cahoon*** *(partially covered)*, ***Jeff Williams***, *and* ***Carl Hobbs***. *Photograph by* ***Eric Anderson***.

USGS Hosts Onshore-Offshore Geologic Map Workshop

By Helen Gibbons and Guy Cochrane

The U.S. Geological Survey (USGS) and the California Geological Survey (CGS) cohosted a Coastal Map Development Workshop on May 2-3, 2007, in Menlo Park, California, to discuss the content and format of a prototype onshore-offshore geologic map. Typically, onshore geologic and topographic maps are separated from their offshore equivalents not only by an unmapped intertidal zone but also by differences in methods of data acquisition and interpretation. The USGS and the CGS are collaborating with other State and Federal agencies to develop a new type of coastal geologic map that will bridge this gap and serve as an important tool for addressing a broad range of coastal-zone management issues.



USGS scientists use instruments mounted on personal watercraft to conduct bathymetric surveys in shallow areas, such as the surf zone, where water depths can be less than 1 m. Abbreviations: GPS, global positioning system; RTK, real-time kinematics.

The workshop assembled producers and users of coastal maps to discuss the problems and benefits of merging onshore and offshore geospatial data. Attendees from the West Coast, Alaska, the Northeast, and the Gulf States represented numerous organizations, including the USGS, the CGS, the Minerals Management Service, the National Park Service, the National Oceanic and Atmospheric Administration, the U.S. Army Corps of Engineers, many State and local organizations, and private institutions.

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(Onshore-Offshore Map continued from page 8)

Organized by **Guy Cochrane** of the USGS Western Coastal and Marine Geology Team, the workshop was divided into sessions for presentations and discussions of bathymetry and topography, geology, habitat, and the needs of end users. An extended lunch period allowed people to lay out existing maps and discuss their merits and shortcomings. Participants and other interested persons will also have the opportunity to review the prototype map to be produced for the California Coast State Waters Mapping Project (URL **http://www.coastalconservancy.ca.gov/Programs/SeaFloorMapping/SeafloorMapping.htm**). This map will consist of seamless bathymetry/topography and geology at a scale of 1:24,000 for an area around Santa Barbara, California, where the USGS and California State agencies are already conducting sea-floor mapping and onshore geologic mapping (for example, see "Mapping the Sea Floor Off Santa Barbara, California" in *Sound Waves*, September 2006, URL **http://soundwaves.usgs.gov/2006/09/fieldwork2.html**).

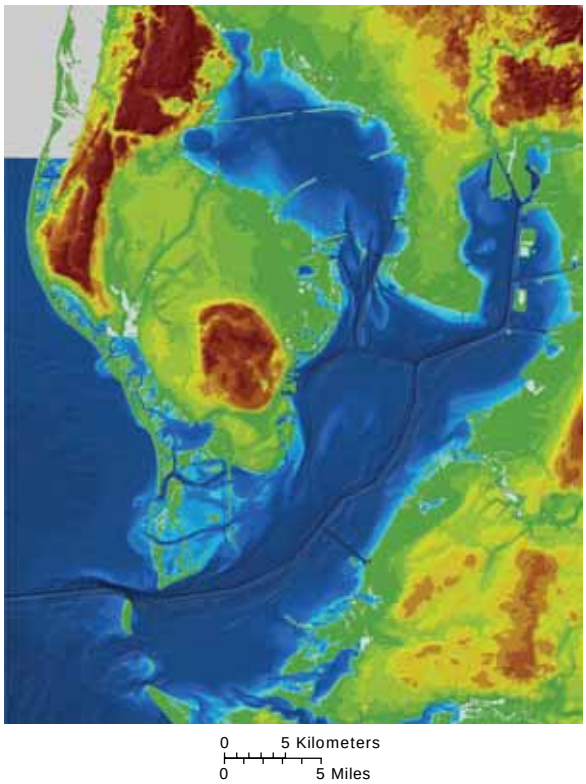
A goal of the recent workshop was to develop a plan for maximizing the utility of the prototype map, which will serve as a model for similar maps in other areas. It is expected that onshore-offshore geologic maps will be used by coastal-zone managers and the broad scientific community to address a host of important issues, including coastal erosion and sediment management, sediment and contaminant budgets and transport, onshore and offshore landslides, effects of dam removal, designation of marine protected areas, onshore and offshore infrastructure and development, potential earthquake sources, and potential offshore tsunami sources and tsunami-inundation modeling.

High-Resolution Map Merges Tampa Bay Bathymetry and Topography

By Dave Zawada

The multidisciplinary U.S. Geological Survey (USGS) Tampa Bay Study has released a new "topobathymetric" map that merges topographic (land elevation) and bathymetric (water depth) data into a high-resolution image of Florida's Tampa Bay and adjacent watersheds (URL **http://pubs.usgs.gov/of/2007/1051/**). With a spatial resolution of approximately 3 meters, this topobathymetric map is the highest resolution map of its type for this large estuarine system.

The map grew out of the acquisition of high-resolution bathymetric data from various sites in Tampa Bay to support the development of hydrodynamic and sediment-transport models. The map's first author, **Dean Tyler** of the USGS Center for Earth Resources Observation and Science (EROS), created the map by merging the disparate datasets. All of the topographic data come from the USGS National Elevation Dataset (NED) and much of the bathymetric data from NOAA's GEOphysical DAta System (GEODAS). For most of the nearshore areas around the bay, GEODAS data were replaced with higher-resolution bathymetric data acquired in 2003 and 2004 with the National Aeronautics and Space Administration (NASA) Experimental Advanced Airborne Research Lidar (EAARL).



Small version of the newly published topobathymetric map of Tampa Bay, Florida. Colors indicate elevation, with deepest blue representing water depths of -29.8 to -16.0 m and dark reddish brown representing elevations of +16.1 to +32.0 m. Areas where no data were collected are gray. For full-size map and additional information, see URL ***http://pubs.usgs.gov/of/2007/1051/****.*

Lidar, an acronym for light detection and ranging, is an optical technique for accurately and quickly measuring distance with lasers. The basic principle is to emit a short pulse of laser light and record the time it takes for the light to reflect off a distant object and return to the starting point. When installed in an airplane and pointed downward, lidar systems can be used to measure topography and nearshore bathymetry. Water clarity determines how deep the laser light can penetrate; under ideal conditions, the maximum water depth of EAARL data points is roughly 25 m. In the new Tampa Bay map, EAARL depth measurements extend down to approximately 3 m. The EAARL system is flown in a Cessna-type aircraft at a nominal altitude of 300 m. As the aircraft moves forward,

(Tampa Bay Map continued on page 10)

(Tampa Bay Map continued from page 9)

EAARL sweeps a series of laser pulses at 2-m intervals from left to right along a swath line 240 m long. Each pulse represents a unique distance measurement, and 25 swath lines are covered every second. The new map has unprecedented resolution in the areas where EAARL data have been collected. (To see a map of these areas, or to download the data, visit URL **http://gulfsci.usgs.gov/tampabay/data/1_lidar/**; for additional information about EAARL, see URL **http://coastal.er.usgs.gov/remote-sensing/advancedmethods/eaarl.html**.)

Tampa Bay is one of several areas in the United States for which the USGS EROS data center has merged topographic and bathymetric datasets. Visit URL **http://gisdata.usgs.net/website/TopoBathy/** to view and download merged datasets for parts of Puget Sound, Delaware Bay, and the San Francisco Bay region, as well as Tampa Bay.

Now in its final year, the Tampa Bay Study is a USGS-led 5-year effort conducted in partnership with other Federal, State, academic, and local partners (see URL **http://gulfsci.usgs.gov/tampabay/**). Participants used an integrated science approach to study relations between geologic, biologic, chemical, and hydrologic components of the Tampa Bay estuarine system. This technique provides scientists and managers with tools to measure the impacts of changes, both natural and anthropogenic, on all components of estuarine systems. Results from this research will enable scientists and resource managers to better assess management strategies and guide future policy.

The new topobathymetric map is the Tampa Bay Study's latest data product; its full citation is:

Tyler, Dean, Zawada, D.G., Nayegandhi, Amar, Brock, J.C., Crane, M.P., Yates, K.K., and Smith, K.E.L., 2007, Topobathymetric data for Tampa Bay, Florida: U.S. Geological Survey Open-File Report 2007-1051 [URL **http://pubs.usgs.gov/of/2007/1051/**].

USGS Analyzes 70 Years of Coastal Cliff Retreat in California

The U.S. Geological Survey (USGS) recently published a report analyzing coastal cliff retreat along more than 350 km of the California coast over a period of approximately 70 years. Released in May 2007, this study is the first comprehensive assessment of the State's historical coastal cliff retreat.

Findings indicate that the average annual coastal cliff retreat in California is 0.3 m/yr, with an average retreat of 17.7 m over the 70-yr period of the assessment (1930s to 1998 or 2002, depending on the stretch of coast). Cliff retreat tends to be focused in "erosion hotspots." The greatest amount of retreat in the State over the 70-yr period was 223 m at a large coastal landslide near Cape Vizcaino in northern California (the area from the California-Oregon border south to Point Reyes). The maximum amount of retreat in central California (south from Point Reyes to just north of Santa Barbara) was 211 m, measured just north of Pillar Point Harbor (this was also the second-highest value for retreat in the State over the 70-yr period). The highest amount of retreat in southern California, 115 m, occurred near Santa Monica at the site of the Big Rock Mesa landslide. All of the highest retreat rates occurred in areas characterized by large coastal landslides. Retreat rates were also found to be high in cliffs formed of weaker rock and at dominant headlands, such as Point Arena, Bodega Head, Point Reyes, Pillar Point, Point Sal, and Point Loma.

*Oblique aerial view of a coastal cliff in Aptos, California, northern Monterey Bay, from the recent USGS report on coastal cliff retreat. Photograph taken by **Cheryl Hapke** in February 1998, after a major storm had triggered debris slides that damaged several houses at the base of the cliff.*

"Coastal cliff retreat is a serious and chronic coastal hazard along California's coast," said **Cheryl Hapke** of the USGS and lead author of the report. Many analyses of cliff retreat have been conducted along the California coast, but they covered only small, specific areas and used different methods with varying accuracies, making it difficult to compare retreat hazards from one area to the next. The USGS study, the first comprehensive quantification of coastal cliff retreat in

(Coastal Cliff Retreat continued on page 11)

(Coastal Cliff Retreat continued from page 10)

California, included the development of repeatable methodologies that use both historical data and modern state-of-the-art lidar (light detection and ranging) data. The database is designed to be expandable as additional data become available in the future.

Produced as part of the National Assessment of Shoreline Change, the new report is titled "The National Assessment of Shoreline Change, Part 4: Historical Coastal Cliff Retreat along the California Coast" (USGS Open-File Report 2007-1133, URL **http://pubs.usgs.gov/of/2007/1133/**). A companion volume offers data that can be used in geographic-information-system (GIS) applications and is titled "The National Assessment of Shoreline Change: A GIS Compilation of Vector Cliff Edges and Associated Cliff Erosion Data for the California Coast" (USGS Open-File Report 2007-1112, URL **http://pubs.usgs.gov/of/2007/1112/**).

These reports will be used by State and local agencies for planning and regulatory applications and by the scientific community for coastal-hazard assessments.

A few days after these reports were published, **Hapke** spoke at the Coastal Sediments 07 conference (URL **http://www.asce.org/conferences/cs07/index.cfm)** in New Orleans, Louisiana (May 13-17), comparing the newly released coastal-cliff-retreat data with shoreline-change data from California's sandy shorelines, published in a USGS report last fall titled "Historical Shoreline Change and Associated Coastal Land Loss Along Sandy Shorelines of the California Coast" (USGS Open-File Report 2006-1219, URL **http://pubs.usgs.gov/of/2006/1219/**).

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