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Fieldwork

Mapping, Measuring, and Modeling to Understand Water-Quality Dynamics in Barnegat Bay-Little Egg Harbor Estuary, New Jersey

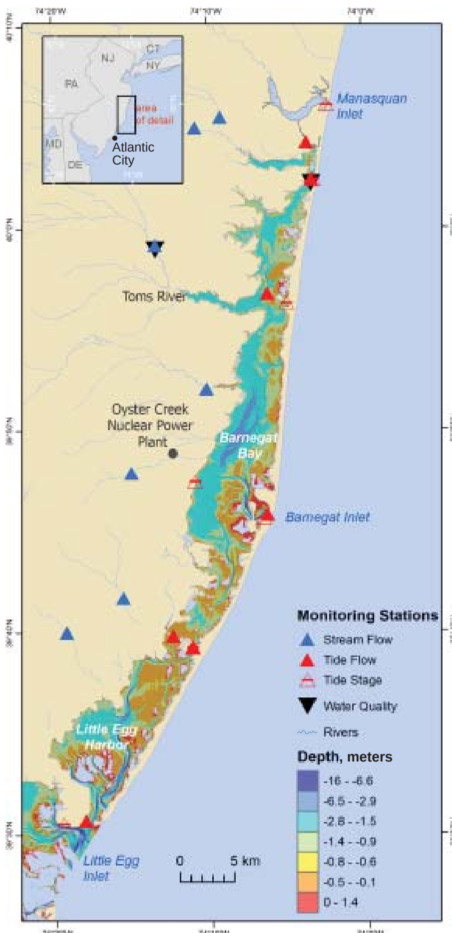
By Jennifer Miselis, Brian Andrews, Neil Ganju, Anthony Navoy, Robert Nicholson, and Zafer Defne

Water quality in the Barnegat Bay-Little Egg Harbor estuary along the New Jersey coast is the focus of a multidisciplinary research project begun in 2011 by the U.S. Geological Survey (USGS) in partnership with the New Jersey Department of Environmental Protection. The agencies began this collaboration in response to New Jersey Governor **Chris Christie's** plan to clean up Barnegat Bay, set into motion in December 2010 (**http://www.nj.gov/dep/barnegatbay/**). The ongoing study will also yield insights into the impacts of Hurricane Sandy, which made landfall southwest of the study area on October 29, 2012 (see "Hurricane Sandy Disrupts USGS Study...," this issue, **http://soundwaves.usgs.gov/2013/02/fieldwork2.html**).

The narrow estuary—71 kilometers (44 miles) long and a maximum of 6 kilometers (4 miles) wide—is bounded on the west by the mainland and on the east by barrier islands that constitute much of the Jersey Shore. The estuary covers approximately 340 square kilometers (130 square miles), with a mean depth of less than 1 meter (3 feet). This long body of water, flushed by just three inlets connecting it to the Atlantic Ocean, is experiencing degraded water quality, algal blooms, loss of seagrass, and increases in oxygen-depletion events, seaweed, stinging nettles, and brown tides. Added to these problems is uncertainty about how the planned removal of the Oyster Creek nuclear power plant, which discharges heated water into the estuary, will alter the estuary's thermal structure. The scale of the estuary and the scope of the problems within it necessitate a multidisciplinary approach that includes characterizing its physical characteristics (for example, depth, magnitude and direction of tidal currents, distribution of sediment on and beneath the seafloor) and modeling how the physical characteristics interact to affect the estuary's water quality.

Scientists from the USGS Coastal and Marine Geology Program offices in Woods Hole, Massachusetts, and St. Petersburg, Florida, began mapping the seafloor of the Barnegat Bay-Little Egg

(Water Quality continued on page 2)



Coast of New Jersey, showing Barnegat Bay-Little Egg Harbor estuary and its three inlets—(from north to south) Manasquan, Barnegat, and Little Egg—and locations of USGS hydrologic monitoring stations. Color-coded depths in estuary are gridded data from the National Oceanic and Atmospheric Administration (NOAA) Estuarine Data Set. Acquired in the 1930s, these are the latest comprehensive bathymetric data collected in the estuary before the current survey.

*USGS scientists **Bill Danforth** (standing, left) and **Chuck Worley** (crouching on deck) deploy a swath bathymetric sonar from the bow of the research vessel (R/V)* Raphael, *a boat from the USGS Woods Hole Coastal and Marine Science Center used for seafloor mapping and sediment sampling, docked at Dillon's Creek Marina in Island Heights, New Jersey. **Danforth** led a tour of the vessel and its scientific equipment for local news reporters and visitors from the New Jersey Department of Environmental Protection and the USGS New Jersey Water Science Center during the first survey in November 2011 (view video at **http://www.app.com/section/VIDEONETWORK?bctid=1255433327001**).*

Sound Waves

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Contents

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Deadline: The deadline for news items and publication lists for the May/June issue of *Sound Waves* is Wednesday, March 6, 2013.
Publications: When new publications or products are released, please notify the editor with a full reference and a bulleted summary or description.
Images: Please submit all images at publication size (column, 2-column, or page width). Resolution of 200 to 300 dpi (dots per inch) is best. Adobe Illustrator© files or EPS files work well with vector files (such as graphs or diagrams). TIFF and JPEG files work well with raster files (photographs or rasterized vector files).

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Can't find the answer to your question on the Web? Call 1-888-ASK-USGS

Want to e-mail your question to the USGS? Send it to this address: ask@usgs.gov

Fieldwork, continued

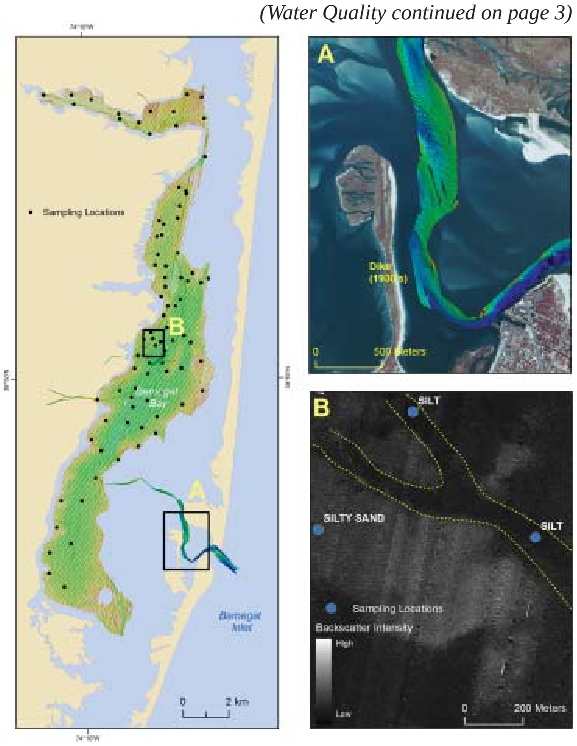
(Water Quality continued from page 1)

Harbor estuary in November 2011 and continued the mapping in March 2012. With funding from the New Jersey Department of Environmental Protection and logistical support from the USGS New Jersey Water Science Center, they collected data with a suite of geophysical tools, such as a swath bathymetric sonar for measuring seafloor depth, a sidescan sonar for collecting acoustic-backscatter data (which provides information about seafloor texture and sediment type), and a subbottom profiler for imaging sediment layers beneath the floor of the estuary. (View a short video about these instruments at **http://www.app.com/section/VIDEONETWORK?bctid=1255433327001**; for additional information, visit **http://woodshole.er.usgs.gov/operations/sfmapping/**.)

The resulting data provide the first comprehensive look at the estuary's morphology (shape of shore and seafloor) and geology (composition and geometry of seafloor and subseafloor materials). The mapping effort, to be completed in March 2013, is using marine and airborne sensors to collect high-resolution depth and elevation data, as well as data on seafloor and subseafloor composition. Together, these data will help reveal the geologic history of the estuary and provide a context for understanding modern processes that affect its water circulation. To date, the scientists have mapped approximately 85 square kilometers (33 square miles) of the estuary and have collected numerous samples and detailed photographs of the seafloor. Publication of the complete seafloor-mapping dataset is expected in late 2013. The data have already shown connections between the subseafloor geology and the modern distribution of sediments within the estuary, which may profoundly affect recruitment of shellfish, distribution of seagrasses, and persistence of pollutants.

Personnel from the USGS New Jersey Water Science Center are continuously measuring flow, stage (water level), and water quality at strategic sites with funding from the New Jersey Department of Environmental Protection and the USGS Cooperative Water Program (see map on page 1). Flow at the estuary's three ocean inlets and at three bridge crossings is measured by using acoustic Doppler velocity meters (ADVMs). Tidal stage is continuously monitored at seven sites within the bay. These measurements provide detailed information on movement of brackish wa-

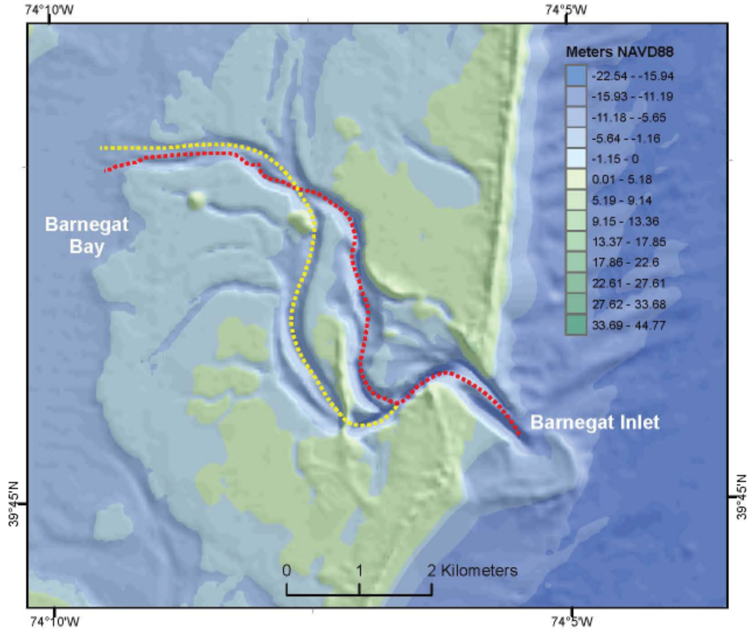
(Water Quality continued on page 3)



Shoreline of Barnegat Bay, showing color-coded USGS bathymetric data (deeper toward blue end of spectrum, shallower toward red end) collected in November 2011 and March 2012, and locations of bottom-sediment-sampling stations (black dots) visited in March 2012. Despite a survey-trackline spacing of 50 meters (55 yards), 100-percent bathymetric coverage of the estuary seafloor was impossible because of the estuary's shallow depths. Inset A, *Detailed bathymetry of channel leading out to Barnegat Inlet, with numerous bedforms, such as sand waves, lining channel floor. Inset* B, *Subset of the sidescan-sonar data, which achieved 100-percent coverage of the estuary seafloor. Analysis of sediment samples shows that lower backscatter (darker in this image) represents silt and higher backscatter (lighter) represents silty sand. Yellow dashed lines delineate zone of low backscatter that overlies relict tidal channels mapped beneath the estuary's seafloor, indicating a link between the geologic history of the estuary and modern sediment distribution.*

(Water Quality continued from page 2)

ter through the estuary. Streamflow-gaging stations at seven sites on the major tributary streams provide a continuous record of freshwater flow into the bay. Sixty-eight percent of the area contributing freshwater inflow and 100 percent of the tidal flux between the bay and the Atlantic Ocean are continuously monitored. USGS monitoring stations measure changes in various water-quality parameters, including nitrate concentrations in the largest tributary stream and concentrations of chlorophyll *a* (an indicator that relates to five algal species groupings: green algae, cyanobacteria, cryptophytes, diatoms, and dinoflagellates) at the northernmost bridge crossing the bay. Additionally, the New Jersey Department of Environmental Protection and other research partners are undertaking a multiyear, weekly water-quality-sampling program in the estuary and its freshwater tributaries.



Barnegat Inlet, showing changes in the inlet navigation channel and island morphology between the 1930s (yellow) and 2011 (red). North-south dike, shown here as a green ridge between the red and yellow lines (also shown in inset A *of previous figure), was added in the 1930s to create a straighter path for the channel.*

Seafloor-mapping data and hydrologic measurements provide the foundation to develop and calibrate models of the estuary, which predict how the water and sediment within it move in response to tides, storm currents, and other influences. The New Jersey Department of Environmental Protection, the USGS Cooperative Water Program, and the USGS Coastal and Marine Geology Program fund this effort. USGS scientists in Woods Hole are developing a three-dimensional hydrodynamic model of the estuary using the Coupled Ocean-Atmosphere-Wave-Sediment Transport (COAWST) modeling system (**http://woodshole.er.usgs.gov/operations/modeling/COAWST/**) to understand circulation and to provide input for a water-quality model being constructed by the USGS New Jersey Water Science Center. The modeling effort is strongly linked with the seafloor-mapping and hydrologic-measurement efforts on several levels. For example, preliminary modeling with historical bathymetry from the early 20th century revealed that tidal dynamics are strongly affected by inlet configuration and bathymetry. Once we updated the inlet configuration with modern aerial photography and bathymetry, the model properly simulated tidal amplitudes within the estuary. The model is updated as new bathymetric data become available, and the sediment-transport-modeling component will rely heavily on data that we collect about bottom sediment, such as its composition and grain size.

The hydrologic measurements being led by the USGS New Jersey Water Science Center provide a critical calibration dataset for the model. New Jersey Water Science Center scientists are using the Water-quality Analysis Simulation Program (WASP) to simulate estuarine water quality. Output from the COAWST hydrodynamic model will prescribe water velocity, tidal levels, temperature, and salinity for the water-quality model through a model linkage being developed as part of the study. Simulated estuarine conditions and processes include dissolved-oxygen concentrations and sediment oxygen consumption (uptake of oxygen by sediment-dwelling organisms), changes in nutrient distribution, changes in sediment nutrient composition, and phytoplankton growth.

The parallel application of mapping, measuring, and modeling ensures that all efforts are complementary and optimized for the widest possible use. Results from this integrated study will help guide efforts to manage and improve water quality in the estuary, as well as provide the framework for many new research projects being conducted by regional, State, and Federal agencies and universities. These projects will shed light on how past, present, and future water quality in the Barnegat Bay-Little Egg Harbor estuary will affect seagrass, benthic invertebrates, phytoplankton, zooplankton, harmful algae, and shellfish. Our initial endeavor, combining expertise in coastal geology, hydrologic science, and physics-based modeling, is a template for fruitful interdisciplinary science by the USGS. ❆

*USGS tidal-flow-monitoring station at Little Egg Inlet near Beach Haven Heights, New Jersey. Photograph courtesy of **Jason Shvanda**, USGS New Jersey Water Science Center.*

Hurricane Sandy Disrupts USGS Study of the Barnegat Bay-Little Egg Harbor Estuary in New Jersey, Provides Additional Research Opportunities

By Jennifer Miselis, Anthony Navoy, Zafer Defne, Brian Andrews, Neil Ganju, and Robert Nicholson

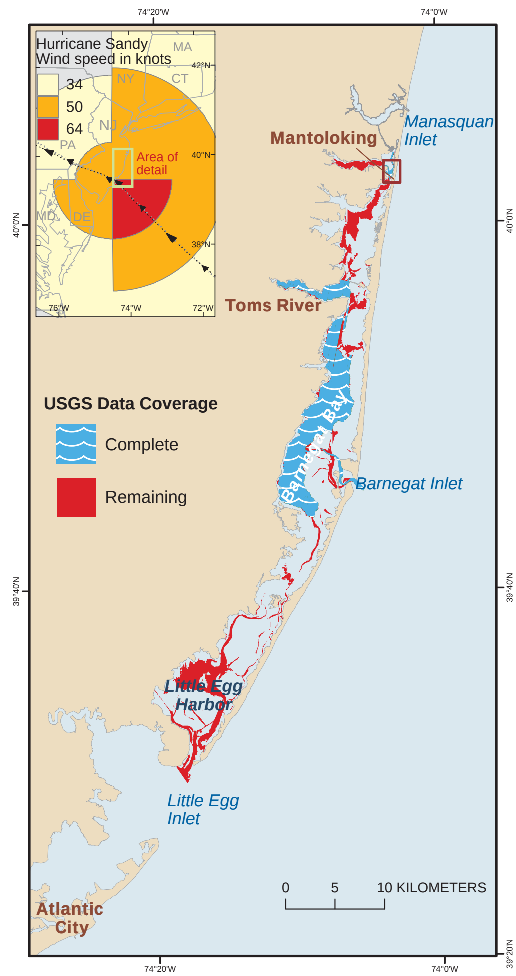
On October 29, 2012, Hurricane Sandy made landfall just south of Atlantic City, New Jersey, with wind speeds ranging from 50 to 64 knots (about 60 to 75 miles per hour). The storm had significant impacts on Barnegat Bay-Little Egg Harbor estuary, where the U.S. Geological Survey (USGS) and the New Jersey Department of Environmental Protection (DEP) are conducting a multiyear, multidisciplinary study (see "Mapping, Measuring, and Modeling to Understand Water-Quality Dynamics in Barnegat Bay-Little Egg Harbor Estuary, New Jersey," this issue, **http://soundwaves.usgs.gov/2013/02/**).

The arrival of Hurricane Sandy during the Barnegat Bay-Little Egg Harbor estuary study will allow scientists to investigate not only how various factors—shape of the shoreline and seafloor, patterns of water circulation, distribution of sediment—influence the estuary's water quality, but also how those factors respond to significant storm events. Multidisciplinary mapping and data collection conducted by USGS scientists before the storm, and a network of water-level and water-quality sensors throughout the study area (some deployed in anticipation of the hurricane's arrival), will provide a foundation for rigorous post-storm impact assessments.

During Hurricane Sandy, storm surge within Barnegat Bay raised water levels 2 meters (6 feet) above normal high-tide levels, flooding estuarine coastlines and damaging coastal infrastructure. Barrier-islands that form the estuary's eastern boundary were eroded and breached. Two of these breaches—near Mantoloking, New Jersey—are shown on page 5 in aerial photographs taken by the National Oceanic and Atmospheric Administration (NOAA). Airborne lidar (light detection and ranging) surveys flown before and after Sandy by the USGS Coastal and Marine Geology Program's lidar project also documented the breaches, and showed decreases in barrier-island beach and dune elevations of as much as 6 meters (20 feet). Such information is essential for focusing the response effort in the most heavily impacted areas and for identifying potential sediment resources for coastal-restoration projects.

As part of the Barnegat Bay-Little Egg Harbor estuary study, USGS scientists conducted seafloor mapping and related data collection in November 2011 and March 2012. A third seafloor survey had been scheduled for late November and early December of 2012 but had to be postponed because of Sandy's impact on the estuary, which was littered with storm debris—including houses, docks, and cars—that was still being cleaned up as of late January 2013. Rescheduled for March 2013, the post-storm mapping and data collection will enable an assessment of how the shape of the estuary floor and the characteristics of its sediment changed as a result of the storm (and the ensuing cleanup efforts), and how those changes might affect estuarine habitats. Model simulations of conditions during Sandy will focus the post-storm survey on areas most likely to have experienced dramatic changes. The instruments used for the March survey will also be helpful for identifying the location of submerged debris, which will facilitate continued post-storm clean up.

Because the Barnegat Bay-Little Egg Harbor estuary project includes modeling to predict how the water and sediment move in response to tides, storm currents, and other influences, a hydrodynamic model had already been constructed for the study area. This model proved extremely useful after Hurricane Sandy, helping scientists to assess the effects of barrier-island breaches on water quality and tidal water levels within the estuary. The residence time of estuarine water—the time needed to completely flush the estuary—is commonly used as an indicator of water quality. In general, the shorter the residence time, the better the water quality. To determine how the large breach near



*Barnegat Bay-Little Egg Harbor estuary, New Jersey, showing areas where USGS scientists have conducted seafloor-mapping and data-collection surveys (aqua and white) and areas where future surveys will be conducted (red). Brown box shows location of post-storm photographs on page 5. Inset shows path of Hurricane Sandy and wind speeds at time of landfall near Atlantic City. Data source for inset: National Oceanic and Atmospheric Administration (NOAA) National Weather Service, National Hurricane Center (**http://www.nhc.noaa.gov/gis/**).*

Mantoloking would affect the residence time of the water in the Barnegat Bay-Little Egg Harbor estuary, pre-breach and post-breach scenarios were simulated with the hydrodynamic model. Comparing the results of the model simulations showed a decrease in residence time of 10 days

(Sandy's Impacts continued on page 5)

(Sandy's Impacts continued from page 4)

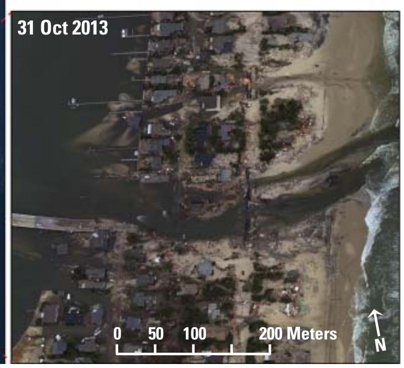
for the simulation that included the large breach. This finding indicates that there is potential for improved water quality in the estuary if the breach were to remain open. The simulation also indicates little to no increase in tidal water levels on the mainland shore as a result of the breach. Such information is critical for coastal-resource managers, who look to science to guide post-storm coastal management.

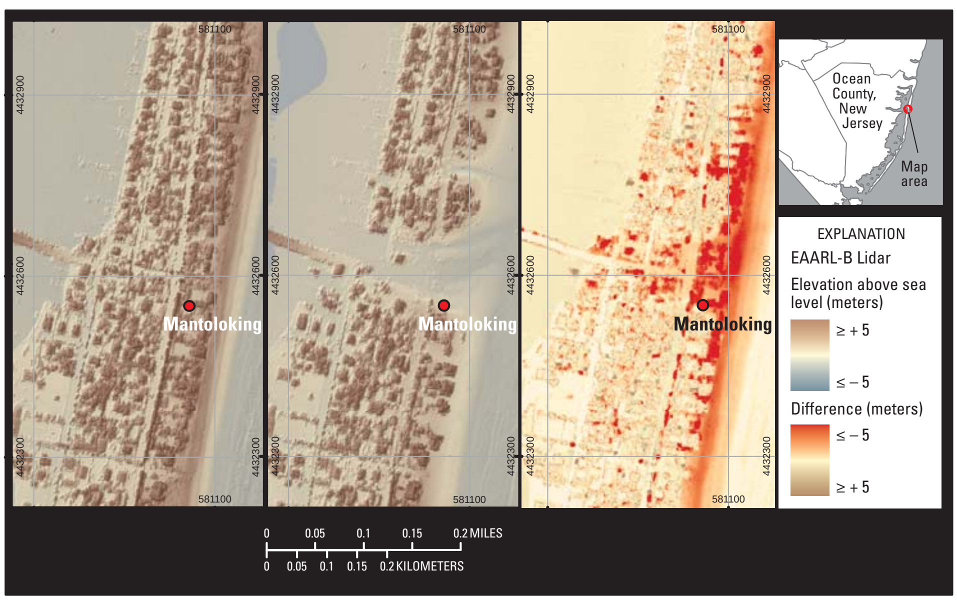
The well-established water-level and water-quality monitoring network within the estuary collected critical data about conditions during the storm despite the loss of a few sensors and related infrastructure. The network recorded maximum water levels around the bay during the storm, providing vital input data for hydrodynamic-model simulations. Of particular help was the water-quality monitoring station at Mantoloking, which remained operational throughout the storm even though the barrier island was breached adjacent to its location. The station recorded peak turbidity (sediment concentration in the water column) more than 40 times the normal range. Such data are invaluable to scientists trying to understand how barrier-island breaches alter the water quality of estuaries during and after storms. Observations of water levels and water quality from around the bay will continue to yield information for post-storm model simulations and for monitoring the impact of coastal-restoration projects.

The effects of tropical and extratropical storms on estuaries and coasts are multifaceted—they can change the shape of the coastline dramatically, thereby affecting coastal resources and ecosystems. A multidisciplinary approach, such as the study underway in Barnegat Bay-Little Egg Harbor estuary, is invaluable for providing data to quantify storm impacts and to guide future coastal restoration and rebuilding efforts.

(Read more about USGS responses to Hurricane Sandy at **http://soundwaves.usgs.gov/2012/12/**, **http://www.usgs.gov/blogs/features/usgs_top_story/sandy/**, and **http://www.usgs.gov/blogs/features/usgs_top_story/start-with-science-to-address-vulnerable-coastal-communities/**.)

*Post-storm aerial photographs acquired October 31, 2012, showing barrier-island breaches near Mantoloking, New Jersey (brown box on map, page 4). Source: National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey Hurricane SANDY Response Imagery Viewer (**http://storms.ngs.noaa.gov/storms/sandy/**).*





*Airborne lidar (light detection and ranging) surveys recorded coastal elevations before and after Hurricane Sandy and documented a large barrier-island breach near Mantoloking, New Jersey. Left: Pre-storm elevations acquired October 26, 2012. Center: Post-storm elevations acquired November 1, 2012. Right: "Difference map" showing elevation changes caused by the storm; red tones indicate elevation losses, which exceeded 5 meters (16 feet) in some places. Experimental Advanced Airborne Research Lidar-B (EAARL-B, **Wayne Wright**, principal investigator) surveys conducted by the USGS Coastal and Marine Geology Program lidar project. First-surface elevation data shown are preliminary. Red dot, USGS water-monitoring station. Figure by **Cindy Thatcher, USGS**; view detailed version at **http://soundwaves.usgs.gov/2013/02/Fieldwork2/morelettershere**.*

Scientists from Four USGS Science Centers Collaborate in Study of Coastal Groundwater Exchange in Hood Canal, Washington

By Peter Swarzenski, Kevin Kroeger, and Christopher G. Smith

Hood Canal is a fjord forming the western arm of Puget Sound in Washington State. Lynch Cove, located at the head of Hood Canal, was the site of a recent interdisciplinary study of complex processes related to coastal groundwater exchange. In July and August 2012, U.S. Geological Survey (USGS) scientists from across the country, representing three USGS Coastal and Marine Science Centers and the USGS Washington Water Science Center, conducted a field study in Lynch Cove addressing a suite of physical and biogeochemical processes associated with enhanced submarine groundwater discharge (SGD). This interdisciplinary approach, drawing on experts in geochemistry, hydrology, geology, and oceanography, is the central theme of the USGS Coastal Aquifer Project (CAPII), which was recently restructured by **Peter Swarzenski** (USGS Pacific Coastal and Marine Science Center), **Kevin Kroeger** (USGS Woods Hole Coastal and Marine Science Center), and **Christopher G. Smith** (USGS St. Petersburg Coastal and Marine Science Center) to align with current USGS science strategies and opportunities. CAPII currently seeks to address the response of coastal ecosystems to a host of environmental "stressors," including projected sea-level rise and the global trend toward increasing density of population and associated infrastructure in the coastal zone. These stressors negatively impact coastal ecosystems, both in the short and long terms, and can increase their vulnerability to future geohazards. (To learn more about CAPII, see **http://walrus.wr.usgs.gov/research/projects/CAPII.html**.)

Northwestern Washington, showing locations of Puget Sound, Hood Canal, and Lynch Cove. Boundaries of Olympic National Park are outlined in red.

Lynch Cove is a perfect setting in which to study the dramatic interplay between the terrestrial and marine processes that affect coastal groundwater exchange. The high annual rainfall—200 centimeters (80 inches) per year at the study site and 360 centimeters (140 inches) per year in neighboring Olympic National Park—maintains a shallow water table in the permeable glacial sediments surrounding the cove, and this shallow water table drives the discharge of fresh groundwater into the cove. In detail, however, submarine groundwater discharge at the study site is complicated by the extreme tidal range, typically 4 to 5 meters (13–16 feet). At low tide, the discharge of fresh groundwater is so vigorous that small geysers commonly erupt from the exposed beach face. At high tide, fresh groundwater moves seaward more slowly and mixes with saltwater that seeps through the now-submerged beach face. The battle between these terrestrial and marine "forcings" thus plays out dramatically at Lynch Cove, changing hour by hour but with submarine groundwater discharge generally prevailing. (To see a dramatic time-lapse video of the tidal range at the study site, please visit **http://gallery.usgs.gov/videos/569**.)

Submarine groundwater discharge benefits coastal ecosystems by conveying fresh water, nutrients, and other vital constituents into nearshore waters, where they contribute to ecosystem health, sustainability, and even resilience to external stressors. (SGD can also have adverse impacts if the groundwater contains contaminants or an excess of nutrients such as nitrogen.) A complete understanding of this physical control on coastal ecosystems, both today and into the future, is the overarching goal of CAPII.

(Hood Canal continued on page 7)

*High tide (left) and low tide (right) at study site in Lynch Cove, at the head of Hood Canal, Washington. Summer 2012 USGS fieldwork was made possible by **Dr. Bill Portuese** and his family, who graciously offered the use of their dock and beach for the USGS experiments. Photographs by **Peter Swarzenski**, USGS.*

(Hood Canal continued from page 6)

For the summer 2012 fieldwork, nine USGS Coastal and Marine Geology Program (CMGP) employees and contractors converged on Lynch Cove from the three CMGP science centers: **Peter Swarzenski**, **Leticia Diaz**, **Cordell Johnson**, and **Jeremy Merckling** from the Pacific Coastal and Marine Science Center (PCMSC) in Santa Cruz, California; **Kevin Kroeger**, **Sandy Baldwin**, and **Wally Brooks** from the Woods Hole Coastal and Marine Science Center (WHCMSC) in Woods Hole, Massachusetts; and **Christopher G. Smith** and **Marci Marot** from the St. Petersburg Coastal and Marine Science Center (SPCMSC) in St. Petersburg, Florida. Three scientists from the USGS Washington Water Science Center in Tacoma, Washington (**Matt Bachmann**, **Steve Cox**, and **Rich Sheibley**), provided hydrologic expertise and scuba-diving assistance.

*Some members of the USGS research team at the study site in Lynch Cove (left to right): **Peter Swarzenski, Wally Brooks, Christopher G. Smith, Sandy Baldwin, Marci Marot, Cordell Johnson,** and **Kevin Kroeger**. Photograph by **Leticia Diaz**, USGS.*

The group designed a suite of complementary experiments to examine large-scale, tidally driven sea-level fluctuations in relation to:

- the physics of groundwater and seawater mixing,
- geologic controls on the physical exchange of groundwater,
- biogeochemical cycles of nutrients, trace metals, and uranium-thorium series radionuclides (naturally occurring geochemical tracers), and
- submarine groundwater discharge and associated material fluxes (such as nutrients and contaminants) into coastal waters.

These individual research components included high-resolution, two-dimensional water sampling down to 10 meters (33 feet) below the sediment-water interface, concurrent time-series sampling at strategic sites throughout a tidal cycle and across the beach face, high-resolution temperature profiling, sediment coring, and geophysical surveys using ground-penetrating radar (to image subsurface earth materials) and multichannel electrical-resistivity methods (to characterize salinity).

Pete Dal Ferro, **Cordell Johnson**, **Jeremy Merckling**, and **Peter Swarzenski** (all at the PCMSC), along with **Christopher G. Smith** (SPCMSC), went to the field area early—in June 2012—to install temporary wells that would enable the team to characterize different groundwater masses and their response to tidal forcing. Four sets of "nested" wells (designed to sample different depth intervals) were installed between the high- and the low-tide lines and instrumented with pressure, electrical-resistivity, and temperature probes.

The most striking observation during the July and August fieldwork was that groundwater in wells at the low-tide line was fresher and had more stable salinity values than groundwater in wells at the high-tide line. Subsequent groundwater sampling across the entire intertidal zone and offshore using a piezometer (a hollow probe pushed down to the water table) confirmed that fresh groundwater persisted at the low-tide line regardless of the tidal stage. At the high-tide line, in contrast, encroaching seawater mixed with fresh groundwater twice a day during the high tides and then drained from the beach face during the intervening low tides.

How this dynamic exchange at the high-tide line and the persistent freshwater outwelling at the low-tide line affect the transport and transformation of dissolved nutrients, metals, and major cations and anions will be addressed by CMGP scientists. The CMGP team will also model the production, transport, and decay of dissolved and solid phases of radium and radon, two uranium-thorium

(Hood Canal continued on page 8)

*Well cluster installed in June 2012 to a depth of 10 meters (33 feet) below the beach face. Photograph taken at low tide; the white PVC extensions prevented the wells from being flooded during high tide (compare with photograph of research team standing on same dock, above). Photograph by **Peter Swarzenski**, USGS.*

(Hood Canal continued from page 7)

series radionuclides that are useful for tracing groundwater movement. (To learn more about these naturally occurring geochemical tracers, see **http://walrus.wr.usgs.gov/sgd/ra_quartet.html** and **http://walrus.wr.usgs.gov/sgd/radon.html**.)

To further study shallow exchange processes in the intertidal zone, custom-designed temperature rods with multiple thermistors (temperature sensors) were installed during different tidal stages. The temperature rods allowed for detailed examination of the vertical temperature structure and the influence of tides on groundwater temperature. These temperature data can provide an independent indicator of complex fluid exchange to corroborate the rates of submarine groundwater discharge derived from radon tracer studies.

Geophysical surveys using ground-penetrating radar and multichannel electrical-resistivity methods were also conducted across the beach face to evaluate possible geologic controls on submarine groundwater discharge to the sea and to better understand how tides affect the fresh water/saltwater interface.

Two six-thermistor temperature rods installed on the beach face to a depth of 1.3 meters (4.3 feet). Photograph by ***Peter Swarzenski****, USGS.*

Look for updates to this and related coastal-groundwater projects at **http://walrus.wr.usgs.gov/sgd/**, or contact **Peter Swarzenski** (**pswarzen@usgs.gov**), **Kevin Kroeger** (**kkroeger@usgs.gov**), or **Christopher G. Smith** (**cgsmith@usgs.gov**).

Related articles from the *Sound Waves* archives include:

- "Recent USGS Field Studies of Nearshore Hydrogeologic Exchange and Submarine Groundwater Discharge on U.S. West Coast and Hawaii," *Sound Waves*, November 2009, **http://soundwaves.usgs.gov/2009/11/fieldwork4.html**
- "Submarine Groundwater Discharge Along the West Florida Shelf: Is Groundwater an Important Nutrient Source for Florida's Red Tides?" *Sound Waves*, June/July 2009, **http://soundwaves.usgs.gov/2009/07/**
- "Scientists Go Deep to Track Algae-Feeding Nitrogen in Washington State's Hood Canal," *Sound Waves*, July 2006, **http://soundwaves.usgs.gov/2006/07/**

Research

Tracking Pacific Walrus: Expedition to the Shrinking Chukchi Sea Ice

By Catherine Puckett and Paul Laustsen

[Slightly modified from USGS Science Features : Top Story at **http://www.usgs.gov/blogs/features/usgs_top_story/tracking-pacific-walrus-expedition-to-the-shrinking-chukchi-sea-ice/**]

A U.S. Geological Survey (USGS) film released in November 2012 will take you on a journey along with USGS researchers tracking walruses going about their daily lives in the remote Chukchi Sea. The film, *Tracking Pacific Walrus: Expedition to the Shrinking Chukchi Sea Ice* (**http://www.youtube.com/watch?v=pF-aNYhCr8k**), follows scientists as they travel to the Chukchi Sea to examine how these mammals are faring in an Arctic environment with sparse summer sea ice and increasing human activity.

Female walruses and their young must haul out of the water to rest between foraging bouts. Photograph by ***Sarah Sonsthagen****, USGS, taken July 15, 2012, in the Chukchi Sea.*

The USGS-produced film contains exclusive footage of the large mammals in their natural habitat, documenting the lives of these huge animals as they raise their young, dive for clams and worms on the ocean floor, and congregate with other walruses.

(Tracking Pacific Walrus continued on page 9)

(Tracking Pacific Walrus continued from page 8)

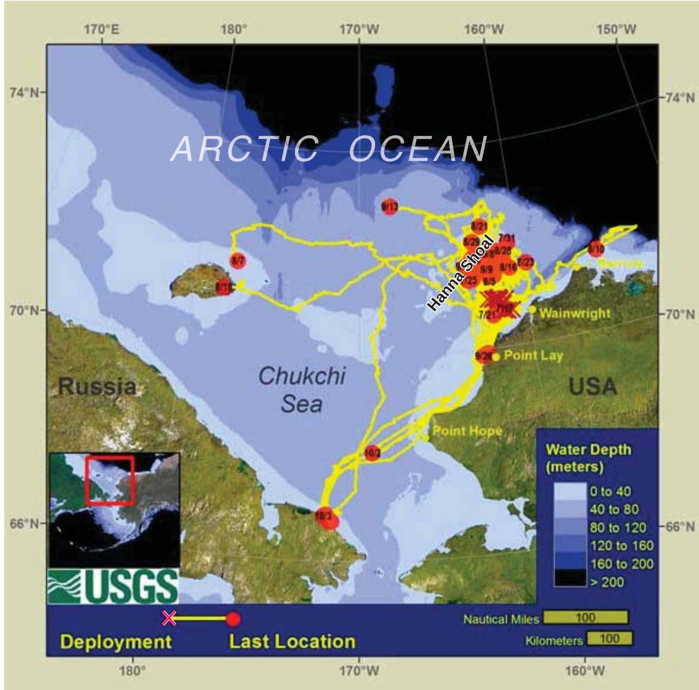
A Changing Arctic Climate Means Changing Arctic Ecosystems

Arctic sea ice is melting faster than originally forecasted: some researchers predict that the first ice-free summer could occur in the 2030s, and possibly as early as the 2020s (see "A sea ice free summer Arctic within 30 years…," by Wang and Overland, Geophysical Research Letters, v. 39, **http://dx.doi.org/10.1029/2012GL052868**). But warming temperatures are causing other changes as well—increasing coastal erosion, deteriorating permafrost, and major changes in the dynamics of freshwater flows. These changes influence biological communities and the ways in which human communities interact with them. For example, the longer open-water season in the Arctic is allowing an increase in shipping, tourism, energy production, and other human activities in this remote region.

As part of the USGS Changing Arctic Ecosystems initiative (**http://alaska.usgs.gov/science/interdisciplinary_science/cae/index.php**), USGS researchers are identifying and investigating the linkages among physical processes (such as sea ice melting at a faster rate), ecosystems, and wildlife populations. By understanding the degree to and manner in which wildlife species adapt to rapid environmental change, resource managers and policy makers will have a better foundation for making critical decisions now and in the future.

New Research on Pacific Walrus and Sea Ice

The information gained through tracking large marine mammals, such as polar bears (**http://alaska.usgs.gov/science/biology/polar_bears/tracking.html**) and walruses (**http://alaska.usgs.gov/science/biology/walrus/tracking.html**), is helping USGS scientists understand how disappearing Arctic sea ice is affecting the region's ecosystems and the species that inhabit these ecosystems. For example, a report published in *Marine Ecology Progress Series* in November 2012 (**http://dx.doi.org/10.3354/meps10057**) by USGS and Russian scientists revealed that diminishing summer sea ice in the Arctic over the past 5 years has caused behavioral changes in Pacific walruses. The population-level effects of these changes are unknown, and the subject is being actively investigated by the USGS.



Paths of walruses tracked in 2012. Slightly modified (labels added for Arctic Ocean and Hanna Shoal) from ***http://alaska.usgs.gov/science/biology/walrus/2012animation.html****; this webpage also features an animated map showing daily locations of tagged walruses and sea-ice distributions during the tracking period.*

Using a simple darting system, scientists attached radio-tracking tags to 251 walruses in the Chukchi Sea. The tags transmitted the animals' whereabouts and whether they were in the water and feeding. Using the tagging data gathered from 2008–2011, scientists created detailed maps of the walruses' seasonal movements and feeding patterns relative to the location and amount of sea ice. (See **http://alaska.usgs.gov/science/biology/walrus/2012animation.html**.)

(Tracking Pacific Walrus continued on page 10)

Adult female walrus on ice floe photographed shortly after receiving a behavior-monitoring satellite-linked radio tag from USGS researchers. Data acquired from such radio tags are providing insights into the distribution and behavior of Pacific walruses during a time when their summer sea-ice habitat is rapidly changing. Photograph by ***Sarah Sonsthagen****, USGS, taken July 15, 2012, in the Chukchi Sea.*

(Tracking Pacific Walrus continued from page 9)

When Chukchi Sea Ice Retreats North of the Continental-Shelf Edge, Walruses Haul Out

The study found that due to earlier melting of the ice in the summer, walruses arrived earlier in their northern feeding grounds on the broad continental shelf of the Chukchi Sea. When the sea ice over the shelf melted completely in the fall, however, they hauled out onshore in large aggregations and foraged for food closer to shore. (“Hauling out” refers to seals and walruses temporarily leaving the water for sites on land or ice.)

Sarah Sonsthagen *(left) drives a skiff as* ***Tony Fischbach*** *scans the ice for resting walruses to radio-tag. On an hourly basis, these instruments show whether the walrus is in the water, resting out of the water, or foraging at the seafloor. The radio tag will fall off after 3 to 12 weeks. Screenshot from video* Tracking Pacific Walrus: Expedition to the Shrinking Chukchi Sea Ice, ***https://www.youtube.com/watch?feature=player_embedded&v=pF-aNYhCr8k***.

The specific effects of these behavioral changes are not yet understood; however, scientists do know that while onshore, young walruses are susceptible to mortality from trampling. The USGS has recently published a study that examined the population effects of this type of mortality, finding that loss of young animals to haul-out mortality affects the population more than loss of adult females in the harvest. In light of this finding, the U.S. Fish and Wildlife Service is increasing its ongoing efforts to protect hauled-out walruses from disturbance. Additionally, hauling out onshore and using nearshore feeding areas may require more energy for animals that are used to simply diving off their sea-ice platforms for food at the bottom of the shallow Chukchi Sea.

Data from this study will provide resource managers with basic information on areas important for walruses, such as the Hanna Shoal region (in the Chukchi Sea, about 100 miles off the northwest coast of Alaska; see map on page 9), as human activities in the Arctic increase. The areas of walrus foraging observed in this study overlap with oil and gas lease blocks leased by the Bureau of Ocean Energy Management (BOEM).

The *Marine Ecology Progress Series* paper, published as the feature article in the November 2012 issue (**http://dx.doi.org/10.3354/meps10057**), is part of the USGS Changing Arctic Ecosystems initiative at the Alaska Science Center (**http://alaska.usgs.gov/science/interdisciplinary_science/cae/index.php**). ☸

Outreach

USGS Contributes to Success of St. Petersburg Science Festival in Florida

By Kate Bradshaw and Theresa Burress

For the second year in a row, U.S. Geological Survey (USGS) scientists and staff played an integral role in the annual St. Petersburg Science Festival in St. Petersburg, Florida. This year’s expanded program included more than 100 science activities and shows, as well as a handful of food trucks and other concessions. The event took place at the waterfront campus of the University of South Florida (USF) St. Petersburg on Saturday, October 27, 2012. The free festival was held in conjunction with MarineQuest, the annual open house for the Florida Fish and Wildlife Conservation Commission (FWC)’s Fish and Wildlife Research Institute. USF St. Petersburg officials estimated attendance this year at more than 12,000—better than double that of the inaugural festival held in 2011 (see article in *Sound Waves*, August 2011, **http://soundwaves.usgs.gov/2011/08/outreach.html**).

Heather Schreppel *(right) helps a visitor hold a caiman while* ***Becky Schwarz*** *(left) looks on. Photograph by* ***Kate Bradshaw***.

As awareness of the essential role of science in everyday life continues to grow, events celebrating science, technology, engineering, and mathematics (STEM) are attracting thousands to similar festivals throughout the Nation. These festivals cel-

(Science Festival continued on page 11)

(Science Festival continued from page 10)

*A festival visitor (far end of tank) makes a wave at the "Surf's Up!" exhibit. Photograph by **Kate Bradshaw**.*

ebrate the breadth of science disciplines, their impact on society, and how genuinely compelling and fun they can be. The St. Petersburg Science Festival set out to stoke curiosity about science in learners of all ages by way of hands-on activities showcasing the astonishing array of ways that science affects everyday life. Exhibitors came from a broad range of scientific and artistic disciplines and represented government agencies, academia, nonprofits, and businesses.

USGS scientists and staff played a key part in carrying out the festival mission by sharing science in an array of compelling exhibits and by participating in the planning process. **Theresa Burress** (Cherokee Nation Technology Solutions [CNTS] contractor to USGS) acted as Festival Co-Chair and Program Chair; **Kate Bradshaw** (CNTS communications contractor to USGS) served on the Marketing Committee.

Among the biggest hits was the exhibit "Surf's Up!", in which USGS oceanographer **Kara Doran** and **Kate Bradshaw** helped visitors generate waves to show the different ways in which major storms can drastically alter the beach profile. This exhibit included a long wave tank with a sandy beach. Doran said, "Visitors generated large and small waves and watched how the beach profile changed in response to the wave impact. Experiments like this one help the community understand how waves are generated and how they travel through the ocean. Visitors gained an understanding of how storms shape our beaches and how rip currents form."

The demonstration also aimed to help communities understand the impacts that storms of varying magnitudes can have on coastal landscapes that are generally taken for granted. The festival took place as Hurricane Sandy approached the Eastern Seaboard and as the USGS Hurricanes and Extreme Storms team worked on predictions about how the coast would change as a result of the storm (see "USGS Scientists Predict, Measure Sandy's Impacts on the Coastal Landscape," *Sound Waves*, November/December 2012, **http://soundwaves.usgs.gov/2012/12/**).

Another big draw was an exhibit in which U.S. Fish and Wildlife Service wildlife biologist **Todd Mecklenborg** teamed up with USGS research ecologist **Tom Smith**, CNTS contractor **Heather Schreppel**, and USGS student employee **Kira Barrera** to give attendees a rare chance to hold a baby alligator, caiman, or crocodile. They also taught visitors how to distinguish these related reptiles.

Information specialist **Rachel Pawlitz** of the USGS Ecological Science Center in Gainesville, Florida, intrigued visitors with "Where in The Wild? Tagging and Tracking Animals." This exhibit showcased how scientists monitor both native and nonnative animal species.

At the exhibit "Catch Climate Fever," USGS research geologist **Lisa Osterman** and geologists **Caitlin Reynolds** and **Katie Richwine** showed visitors how to look at shells of tiny organisms called foraminifera through a microscope. Because the chemistry of the protozoans' shells records the temperature of the waters in which they live, the Gulf of Mexico Climate and Environmental History project uses their fossil shells collected in seafloor sediment to create records of climate variability over the past 10,000 years.

"Diggin' the Past: The History Beneath Our Feet" provided a closeup look at tools that are essential to geologic field studies of marshes and wetlands. USGS scientists **Julie Bernier**, **Noreen Buster**, and **Kyle Kelso** gave lively descriptions of how and why they use sediment cores and vibracore rigs in their fieldwork. USGS watercraft safety program manager **Gary Hill** showed off a USGS airboat, which is used to help geologists collect cores in hard-to-reach marshes and wetlands.

Dick Poore, Director of the St. Petersburg Coastal and Marine Science Center, said, "USGS scientists engaged thousands

(Science Festival continued on page 12)

***Noreen Buster** discusses different examples of sediment cores. Photograph by **Kate Bradshaw**.*

(Science Festival continued from page 11)

of festival visitors in interactive science activities that demonstrated the coastal science and marine geology that are the cornerstone of our program and that are vital to our community and region."

The all-day event kicked off at Harbor Walk Circle with a grand procession and performance by the Mount Zion Progressive Missionary Baptist Church Drum Line. Festival Co-Chairs **Theresa Burress** (CNTS contractor to USGS) and **E. Howard Rutherford** (Pier Aquarium President and CEO) gave the opening address, and St. Petersburg City Council Member **Karl Nurse** read a proclamation from Mayor **Bill Foster** acknowledging the impact the festival has on the community. Nurse also spoke about the essential role that science plays in all aspects of life.

The entertainment roster included lively science shows by Aldebaran Robotics and Mad Science, a "Birds of Prey" demonstration, an "Under the Sea" puppet show, and musical performances by science rapper **Funky49** and electronic percussionist **Jono Magro**. Technical presentations on "Seafood Sustainability" and NASA's "Mars Rover Curiosity" were also a hit with festival visitors.

Other exhibits included Aldebaran Robotics' humanoid robot "NAO"; the Pier Aquarium's "Corals on Acid" exhibit, which demonstrated the process of ocean acidification through live experiments and a display of coral-reef fragments (an exhibit for which USGS research ecologist **Ilsa Kuffner** served as an advisor); and Boyd Hill Nature Preserve's "Wild Florida!", which showed the diverse wildlife living in the Tampa Bay area by bringing live animals for children to touch or observe.

***Rita Beckhorn** helps a festival visitor view foraminifera through a microscope. Photograph by **Kate Bradshaw**.*

The USF St. Petersburg campus is an ideal venue for such an event. Situated on the downtown St. Petersburg waterfront, the campus is one of 14 marine science-focused institutions that together constitute the St. Petersburg Ocean Team (**http://www.spoceanteam.org/**). These include the USGS St. Petersburg Coastal and Marine Science Center, the USF College of Marine Science, the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service Southeast Regional Office, the FWC, and others. The proximity of these science organizations has fostered a collaborative approach to marine science in the Tampa Bay area.

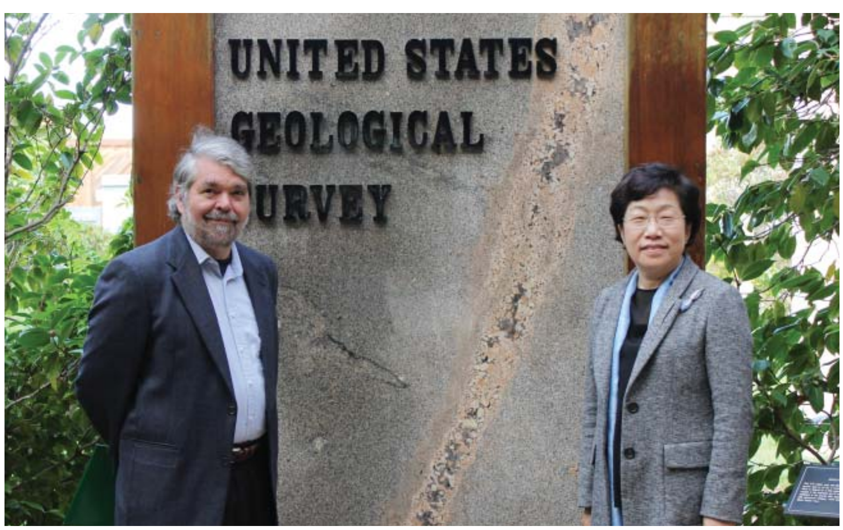
This collaborative approach to science was reflected in the planning and implementation of the festival, whose participants and sponsors included the USF College of Marine Science, USF St. Petersburg, Eckerd College, St. Petersburg College, Draper Laboratory, Progress Energy, Paramount Power, AAA The Auto Club Group, Bayfront Health System, the USGS, NOAA, the FWC, The Pier Aquarium, Secrets of the Sea Marine Exploration Center and Aquarium, the City of St. Petersburg, the Science Festival Alliance, yourmembership.com, and media sponsors WEDU, BayNews 9, and WMNF 88.5 FM Community Radio.☸

South Korean Geoscientists Visit the USGS in Menlo Park and Santa Cruz, California

By Helen Gibbons

U.S. Geological Survey (USGS) geologist **James Hein** arranged tours of the USGS facilities in Menlo Park and Santa Cruz, California, on December 6, 2012, for scientists from the Korea Institute of Geoscience and Mineral Resources (KIGAM; **http://www.kigam.re.kr/english/index.asp**). The visitors—KIGAM President **Dr. Hyo-Sook Lee**, Executive Director of KIGAM's International Cooperation Office **Dr. Yong-Je**

(KIGAM Visit continued on page 13)



*USGS emeritus geophysicist **Jonathan Childs** (left) and Korea Institute of Geoscience and Mineral Resources (KIGAM) President **Dr. Hyo-Sook Lee** at the USGS campus in Menlo Park, California. Photograph by **Mr. Dae-In Kim**, Senior Administrator of KIGAM's International Cooperation Office.*

(KIGAM Visit continued from page 12)

Kim, and Senior Administrator of KIGAM's International Cooperation Office **Mr. Dae-In Kim**—were in the area for the American Geophysical Union (AGU) Fall Meeting in San Francisco. Hosted by USGS emeritus geophysicist **Jonathan Childs** in Menlo Park and Hein in Santa Cruz, they were introduced to a range of USGS studies, including microbiology, radiometric dating, analytical labs, data-processing operations, the Global Seismographic Network, deep-sea mineral investigations, and more.

The Korean scientists had inquired about a visit during AGU week in hopes of learning more about the USGS and strengthening ties between the two agencies. Hein sent word of their interest to the office of USGS Director **Marcia McNutt**, who met with KIGAM President Dr. Lee on December 5 in San Francisco.

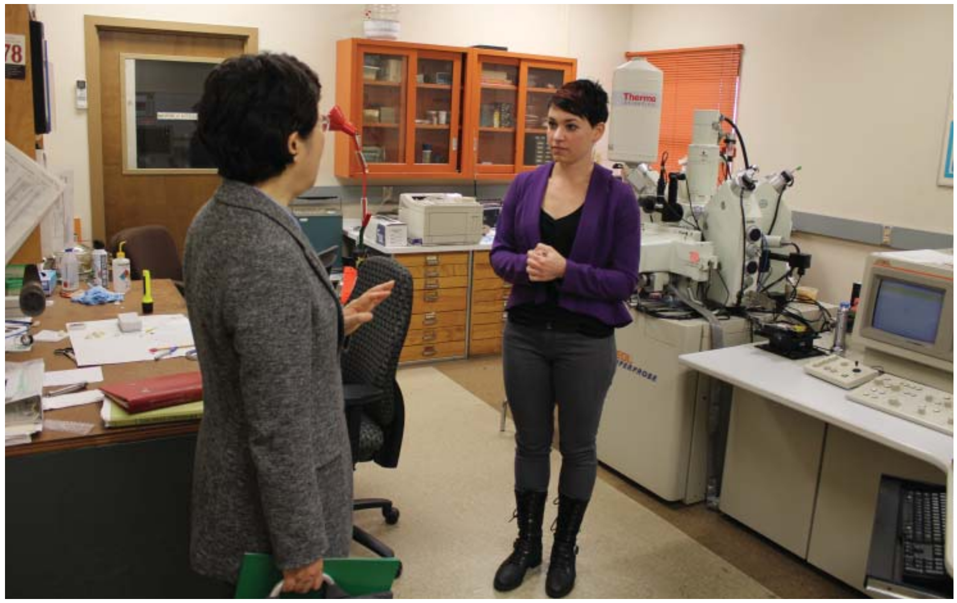
Many thanks to the following USGS personnel, who spent time explaining their work to the visiting scientists:

In Menlo Park:

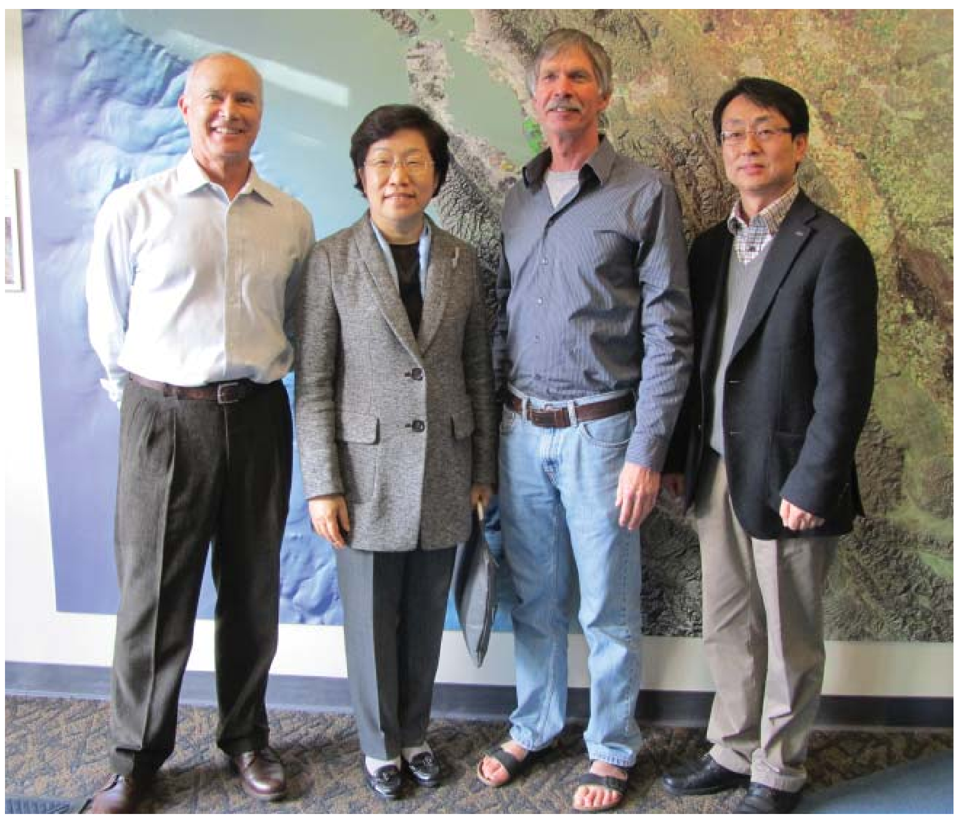
- **Joe Langdon**: USGS library
- **Larry Miller** and **Shelley Hoeft**: Microbiology laboratory
- **Mike Torresan**: Sediment Core and Multi Sensor Core Logger (MSCL) laboratories
- **Andy Calvert**: Argon geochronology ($^{40}Ar/^{39}Ar$) laboratory
- **Leslie Hayden**: Scanning-electronic-microscope (SEM) and microprobe laboratory
- **Jim Luetgert**: Northern California Seismic Network and NetQuakes (**http://earthquake.usgs.gov/monitoring/netquakes/**)

In Santa Cruz:

- **Bob Rosenbauer**: Pacific Coastal and Marine Science Center director
- **Jim Hein**: Marine minerals laboratory
- **Carolyn Degnan**: Infobank, data archiving
- **Peter Swarzenski**: Radiochemistry; submarine groundwater discharge
- **Renee Takesue**: Environmental geochemistry
- **Peter Dartnell**: Coastal mapping projects ❅



*KIGAM President **Dr. Hyo-Sook Lee** (left) talks with **Leslie Hayden** at the USGS scanning-electron-microscope (SEM) and microprobe laboratory in Menlo Park, California. Photograph by **Mr. Dae-In Kim**, Senior Administrator of KIGAM's International Cooperation Office.*



*Left to right, USGS geologist **James Hein**, Korea Institute of Geoscience and Mineral Resources (KIGAM) President **Dr. Hyo-Sook Lee**, USGS Pacific Coastal and Marine Science Center Director **Robert Rosenbauer**, and Executive Director of KIGAM's International Cooperation Office **Dr. Yong-Je Kim** at the USGS Pacific Coastal and Marine Science Center in Santa Cruz, California. Photograph by **Helen Gibbons**, USGS.*

Strategic IODP Planning Workshop for Ultra-Deep Drilling into Arc Crust

By Amy Draut

*Geologists **Erin Todd** (left) and **Amy Draut** represented the USGS at an IODP planning workshop on "Ultra-Deep Drilling into Arc Crust." Held in Hawai'i in September 2012, the workshop included a field trip to Kilauea Volcano, where this photograph was taken.*

Two U.S. Geological Survey (USGS) geologists—**Amy Draut** of the Pacific Coastal and Marine Science Center in Santa Cruz, California, and **Erin Todd** of the Alaska Science Center in Anchorage—were among 58 international scientists who gathered in Kona, Hawai'i, from September 17 to 21, 2012, for a planning workshop on "Ultra-Deep Drilling into Arc Crust" by the International Ocean Discovery Program (IODP, **http://www.iodp.org/new-program**; formerly the Integrated Ocean Drilling Program).

The participants were geophysicists, geologists, geochemists, and petrologists interested in the nature of oceanic-arc crust, how it is modified by collisions at subduction zones, and how it is incorporated and preserved in continental crust. These research problems are fundamental to the next decade of IODP science, one goal of which is to address "how… subduction zones initiate, cycle volatiles, and generate continental crust." (See Challenge 11 of the program's Science Plan for 2013–2023, posted at **http://www.iodp.org/science-plan-for-2013-2023**.)

Oceanic arcs are volcanic chains, such as the Mariana Islands, that form above subduction zones where one slab of thin oceanic crust is sliding beneath another. (In contrast, other subduction zones occur where thin, dense oceanic crust slides beneath thicker, less dense continental crust, forming a continental volcanic chain, such as the Andes Mountains.) Scientists have known for decades that oceanic crust is produced at seafloor-spreading ridges, but the production of continental crust—generally considered to begin in subduction zones—is not well understood. IODP investigation of oceanic-arc subduction zones will help elucidate the process of continental-crust formation.

The planning workshop included 3 days of talks and discussions; for a change of pace, the participants also took a 1-day field trip to nearby Kilauea Volcano, Hawai'i's most active volcano. Draut presented an invited talk at the workshop, summarizing the role of arc-continent collisions in producing and modifying continental crust.

Workshop scientists discussed the merits, methods, and implications of drilling more than 6 kilometers (4 miles) below the seafloor in the Izu-Bonin-Mariana arc offshore of Japan with the riser-equipped deep-sea drilling vessel (D/V) *Chikyu* (**http://www.jamstec.go.jp/e/about/equipment/ships/chikyu.html**). The proposed drilling is a unique opportunity to sample young continental-type crust, to observe the mid-crustal processes that produce the nuclei of new continental crust, and to examine the nature of juvenile continental crust as first generated at oceanic arcs.

As noted in the workshop report (posted at **http://www.jamstec.go.jp/ud2012/**), "For the first time in human history, ultra-deep drilling can reach juvenile continental crust that has never been re-processed" and thus shed new light on continental-crust formation. Scientists also hope that ultra-deep drilling will help them link processes active at specific levels in the arc crust with geophysical signals, and so enable the use of such signals to infer processes in other active arcs.

The IODP ultra-deep-drilling leg, which could take place as early as 2014, is sponsored jointly by JAMSTEC (Japan Agency for Marine-Earth Science and Technology, **http://www.jamstec.go.jp/e/**) and the National Science Foundation (**http://www.nsf.gov/**).

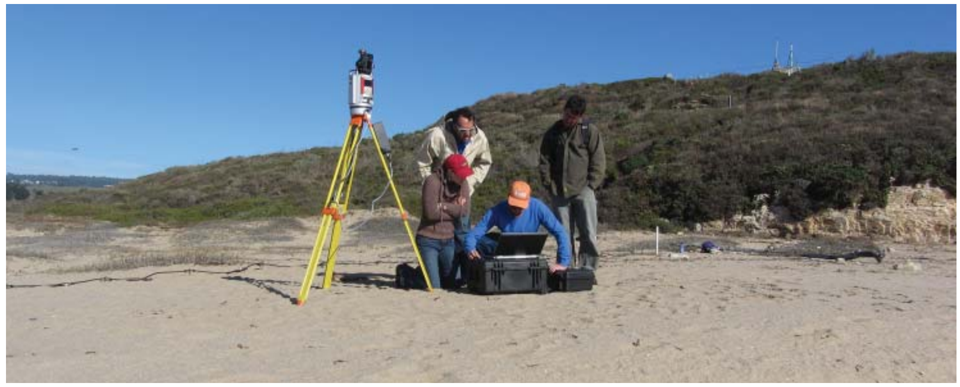
Training to Use New Lidar (Light Detection and Ranging) Scanner in Santa Cruz, California

By Helen Gibbons

A newly acquired terrestrial lidar (light detection and ranging) scanner was the focus of training at the U.S. Geological Survey (USGS) Pacific Coastal and Marine Science Center in Santa Cruz, California, in December 2012. USGS technicians and scientists learned how to operate the new instrument during a 4-day workshop organized by Deputy Center Director for Marine Operations **George Tate** and geographer **Joshua Logan**.

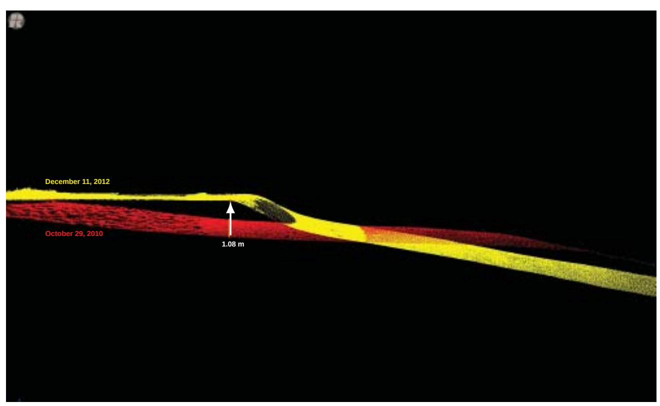
(Lidar Workshop continued on page 15)

(Lidar Workshop continued from page 14)



(Left to right) USGS geologist ***Amy Draut****, Riegl USA instructor* ***Bret Bienkowski****, USGS geographer* ***Josh Logan****, and USGS physical scientist* ***Jackson Currie*** *observe data collected by the new lidar scanner (to left of group) at Younger Lagoon in Santa Cruz, California. Photograph by* ***Tom Reiss****, USGS.*

Scan by the new lidar scanner at Younger Lagoon in Santa Cruz, California, on December 11, 2012. Shaded swath from left of center to lower right corresponds to swath of yellow data in image below. True colors (tans, greens, and so on) are created by combining lidar data with imagery from a high-resolution digital camera attached to the scanner. Image courtesy of ***Josh Logan****, USGS.*



Lidar data collected December 11, 2012 (yellow), in comparison with lidar data collected October 29, 2010 (red), showing change in beach profile. Spot marked by vertical arrow was 1.08 meters higher at time of 2012 survey than at time of 2010 survey. Such measurements are possible because the points in each lidar data set have precise x*,* y*, and* z *coordinates. Image courtesy of* ***Josh Logan****, USGS.*

Lidar scanners use laser light to measure distances, producing highly accurate three-dimensional maps and images of terrain. USGS scientists make extensive use of lidar to study landscape change, employing both airborne lidar scanners (for example, see lidar maps of coastal change caused by Hurricane Sandy, **http://coastal.er.usgs.gov/hurricanes/sandy/lidar/**) and ground-based lidar scanners (for a description of the use of ground-based lidar to track rapid coastal change, see USGS Fact Sheet 2006–3111, **http://pubs.usgs.gov/fs/2006/3111/**; for an example of ground-based lidar surveying to document the shape of the lower Elwha River, Washington, before removal of two large dams, see **http://soundwaves.usgs.gov/2012/04/pubs.html**).

The newly acquired scanner—a RIEGL VZ-1000—is a ground-based unit that can be mounted on a tripod for surveying coastal terrain from positions on land or mounted on a moving platform, such as a boat or car, for conducting surveys while underway.

Riegl USA representative **Bret Bienkowski** taught the December workshop, beginning with an introduction to the lidar scanner and its software. On the second day of the training, participants took the instrument into the field, scanning terrain at Younger Lagoon, about 1 mile southwest of the Pacific Coastal and Marine Science Center, for comparison with data from previous surveys. The rest of the workshop focused on post-processing, data flow, and data management.

The addition of the scanner to the Pacific Coastal and Marine Science Center instrument pool will complement existing lidar capabilities. The instrument will not only save the center considerable equipment-rental expenses in future work but also provide additional capabilities important to center scientists, such as:

- The ability to scan from a moving vessel, allowing center personnel to conduct topographic surveys concurrently with bathymetric surveys and thus collect co-registered elevation data from coastal land and adjacent seafloor. (Read about such mapping tested by the USGS in the Gulf of Mexico in July 2011, **http://soundwaves.usgs.gov/2011/10/fieldwork2.html**.)
- The ability to detect and record "multiple returns" for each laser pulse emitted. When the laser light reflects off multiple objects (for example, several pieces of vegetation and the ground behind it), the scanner can record the location of each object. Processing software can distinguish between these multiple returns, which can assist in filtering out vegetation data from ground-surface data.
- The ability to collect geographically registered data sets by using a Geographic Positioning System (GPS) interface, a built-in electronic compass, and an inclinometer.

The first scientific use of the new lidar scanner will likely be continued surveying along the Elwha River to document the changes caused by dam removal. Stay tuned! ☸

Remembering Asbury “Abby” Sallenger—Architect of the USGS Coastal Program

By USGS Staff

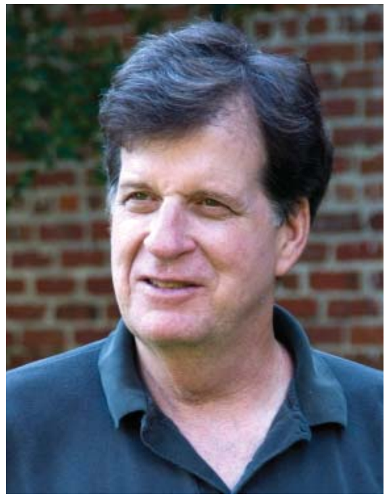
USGS scientist and renowned coastal-hazards expert **Asbury “Abby” Sallenger**, 63, died at home on the evening of February 5. He was a distinguished research scientist, a skilled communicator, and a mentor throughout his career. Seen as a leader in scientific response to coastal storms, Sallenger served as the voice of the USGS on hurricanes and coastal change since the USGS stood up its first scientific storm-response team in the mid-1990s.

“The untimely loss of any truly inspirational scientist is always a cause for mourning, but it is particularly difficult to lose this giant in coastal science just as he was advising on how to protect coastal communities in the post-Superstorm Sandy era,” said USGS Director **Marcia McNutt**. “I can think of no better way to honor his legacy than to use science to build more resilient coastal communities in the face of changing climate.”

Sallenger was a pioneer in recognizing the growing need for science to protect coastal communities from the hazards of coastal change. He envisioned a national coastal-research program that supported scientific excellence in response to societal needs.

“Abby’s contributions to the USGS, to the Coastal and Marine Program, and to many of us personally cannot be briefly captured. He was the architect of our coastal program,” said USGS scientist

***Abby Sallenger** (right) stands next to a street sign in Rodanthe, North Carolina, after Hurricane Dennis in 1999. Wave overwash covered the road with sand as much as 1 meter (3 feet) thick. Photograph by **Karen Morgan**, USGS, taken September 8, 1999.*



***Asbury “Abby” Sallenger**, 1949–2013. Photograph by **Karen Morgan**, USGS, taken October 15, 2008.*

John Haines. “At the heart of our response to hurricanes, you’ll find Abby’s vision, Abby’s science, and Abby’s leadership. He insisted that science comes first,” said Haines.

Sallenger built the USGS coastal program around these values, through a tireless dedication to research and a talent for explaining complex science and why it mattered. He garnered support among fellow scientists and leaders in the USGS, partners in research, administration officials, on Capitol Hill, and with the public. His work with extreme-storm impacts on coasts and his skill in explaining them made him a sought-after expert by many. He was regularly interviewed and quoted by national news-media outlets, such as the *New York Times*, CNN, and The Weather Channel.

He was one of the first to recognize the value of lidar (light detection and ranging) to quickly map coastlines (for example, see **http://coastal.er.usgs.gov/hurricanes/sandy/lidar/**). Baseline surveys of much of the U.S. coast were completed in large measure from Sallenger’s efforts and his ability to establish effective partnerships to share resources with other science agencies. He developed an experimental product to forecast coastal change prior to hurricane landfall, to inform the evacuation of barrier islands, emergency response, recovery, and future land management (see **http://coastal.er.usgs.gov/hurricanes/sandy/coastal-change/**).

Sallenger led the USGS National Assessment of Coastal Change Hazards (**http://coastal.er.usgs.gov/national-assessment/**), which investigates how coasts change over the long term and during extreme storms. His recent research focused on Louisiana’s barrier islands, where rapid land subsidence simulates the long-term sea-level rise that could impact the world’s coasts in the next century. Last summer, Sallenger published research that the rate of sea-level rise has increased three or four times faster along much of the U.S. East Coast than globally (see **http://soundwaves.usgs.gov/2012/10/research.html**). He was recently named as a lead author on the Fifth Assessment Report of the Intergovernmental Panel for Climate Change (**http://www.ipcc.ch/**), publication expected in 2014.

Having written scientific papers for many years, Sallenger tried his hand at creative writing. His book, *Island in a Storm*, published in 2009, recounts the effects of a severe hurricane that destroyed one of Louisiana’s barrier islands in the mid-1800s and tells the story of a young survivor.

Sallenger received many professional awards throughout his Federal career for his excellence in science, his communication skills, and his leadership.

***Abby Sallenger** surveys the remains of a home along the shore in Waveland, Mississippi. Storm surge and waves from Hurricane Katrina destroyed structures along the coast and left behind nothing but foundations. Photograph by **Laura Fauver**, USGS, taken October 25, 2005.*

Middlebury College Research Vessel Named for Retired USGS Scientist

By Deborah R. Hutchinson

Research vessel (R/V) David Folger.

In the marine research community, one of the greatest honors is to have a research vessel named for you. Such is the distinction bestowed on retired U.S. Geological Survey (USGS) scientist **Dave Folger**. The research vessel (R/V) *David Folger*, a 48-foot hydrofoil catamaran, is the newly dedicated research vessel for Middlebury College in Vermont. It will explore the waters of Lake Champlain while offering a state-of-the-art oceanographic platform for undergraduate students to learn the basics of marine research.

Dave Folger, who served on the faculty from 1969 to 1975, started the oceanographic research program at Middlebury by obtaining a 25-foot Coast Guard surf rescue boat, christened the R/V *Bruno Schmidt* after a distinguished and retired geology faculty member. With the help of students to maintain, operate, and conduct research from this old wooden vessel, Dave collected a comprehensive geologic and geophysical data set about sediment contamination in Lake Champlain from the International Paper Co. plant in Ticonderoga, New York. These data became the basis of many student senior theses and were part of two Supreme Court cases about pollution and restoration in the lake. (Learn more about the project at **http://blogs.middlebury.edu/researchvessel/about-david-folger/**, and about the court cases at **http://www.law.cornell.edu/supremecourt/text/417/270** and **http://www.law.cornell.edu/supremecourt/text/479/481**.)

Dave Folger *standing by the logo and name of the vessel.*

Dave subsequently joined the USGS in Woods Hole, Massachusetts, in 1975, pursuing an active research career that included early environmental studies off the Atlantic coast, a return to Enewetok Island in the western Pacific Ocean to understand the impact of the nuclear test explosion on the atoll's geology, and investigation of the impacts of changing lake levels in the Great Lakes of North America. He also served as Branch Chief for the Woods Hole office between 1977 and 1982. Dave retired from the USGS in 1997.

The R/V *David Folger* is the third research vessel operated by Middlebury College. When the original *Bruno Schmidt* was retired from research in 1985, the college obtained a 32-foot Maine lobster boat, the R/V *Brewster Baldwin*, named for another beloved geologist on the faculty. In 2010, Middlebury geology faculty **Pat** and **Tom Manley** developed a proposal for the newest of the platforms, which was funded by a combination of research grants and private grants. The *Folger* is fully equipped with multibeam-sonar, CHIRP subbtottom-profiling, and sidescan-sonar systems. A future grant will help obtain additional geologic, geophysical, and oceanographic equipment.

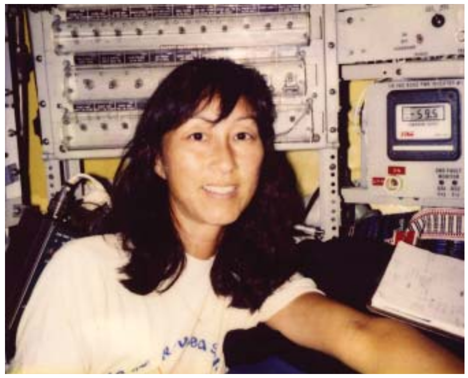
Attending the October 20, 2012, dedication ceremony for the R/V *David Folger* were Dave's entire immediate family and nine of his former students, including several, such as **Debbie Hutchinson** and **Dave Twichell**, who were hired at the USGS in the 1970s. A short cloudburst after the dedication ceremony produced a spectacular double rainbow over the newly christened vessel.

To read more about the construction and journey of the vessel from Washington State to Vermont, visit **http://blogs.middlebury.edu/researchvessel/**. For a summary of the dedication ceremony, see **http://blogs.middlebury.edu/middmag/2012/10/24/celebrating-the-flagship-rv-folger/**. To read more about Dave, visit **http://blogs.middlebury.edu/researchvessel/about-david-folger/**. ☸

Rainbow on the R/V David Folger. *Photograph by* ***Lee Gove***.

A Passion for Educational Outreach—Profile of USGS Geologist Carol Reiss

By Helen Gibbons and Carol Reiss



Carol's first tour of a submersible, the deep-submergence vehicle (DSV) Sea Cliff*, "sister ship" to the DSV* Turtle *and, like the* Turtle*, owned and operated by the U.S. Navy. Photograph taken in 1988 on the research vessel (R/V)* Laney Chouest*, from which the* Sea Cliff *was being used for a USGS investigation of the Gorda Ridge offshore of northern California. Photograph by U.S. Navy personnel.*

U.S. Geological Survey (USGS) geologist **Carol Reiss** of the USGS Pacific Coastal and Marine Science Center in Santa Cruz, California, gave her 99th educational-outreach presentation to a group of local fourth graders on December 17, 2012. Carol took the students on "geology field trips" around the facility's large conference room, where they saw rocks and fossils that Carol had collected from sites around the world, including Hawai'i, California, Mount St. Helens, Mount Everest, and the Juan de Fuca spreading ridge at the bottom of the North Pacific Ocean. Highlights included a model of an erupting volcano, a replica skull of *Smilodon californicus* (sabertoothed cat, California's State fossil), a woolly mammoth tooth, a giant ammonite, and a trilobite. The visitors learned about numerous rocks and minerals through hands-on activities, such as floating a piece of pumice, holding foam cups that had been shrunken by exposure to deep-sea pressures, and piloting a life-size mock submersible before watching a video of deep-sea hydrothermal vents.

Carol's geology career started at the USGS in 1975 with the Branch of Pacific and Arctic Marine Geology (a precursor to the Pacific Coastal and Marine Science Center) in Menlo Park, California. The branch began leasing the 180-foot-long research vessel *Sea Sounder* in 1976, and Carol soon became a participant on numerous research cruises. Working on a project with **Jan Morton**, she was a scientific observer on the deep-submergence vehicle (DSV) *Turtle* in 1992 and 1994 during dives to the Juan de Fuca Ridge offshore of Oregon.

Carol became interested in educational outreach while serving on the Ethnic Minority Advisory Committee (EMAC) from 1992 to 1996. During that time, she headed up the educational-outreach committee to promote science within local minority communities; the first group presentation was given in 1993. Since then, Carol has made presentations at numerous schools, fairs, and museums. She has organized USGS Open House displays and chaired USGS school-tour subcommittees (1997–2009). She organized the first USGS Earth Science Week celebration for school groups at the Menlo Park campus in 2001 (see **http://soundwaves.usgs.gov/2001/11/outreach.html**) and has been a major contributor to subsequent USGS Earth Science Days.

Carol has been invited to submit information about herself to the Extreme Science website (see **http://www.extremescience.com/carol-reiss.htm**); to the "People in Science/Careers" section of the textbook *McGraw-Hill Science 2002*; to two kids' books about careers in science, titled *What Do You Want to Be? Explore Earth Sciences* (Sally Ride Science, 2005) and *Cool Science Jobs* (Scholastic, 2003); and to a TV show highlighting science (Dragonfly TV; 2006; **http://pbskids.org/dragonflytv/scientists/scientist33.html**). She has been asked to attend numerous career days at local high schools and has given invited presentations to Earth science classes, to attendees at Sally Ride Science Festivals, and to members of the American Association of University Women. She helped her daughter—who shares Carol's excitement about education—set up a small science museum in her classroom in New Orleans.

In the past several years, Carol has been helping fellow scientists manage the data they collect, giving her new insights into natural processes affecting the coast and seafloor, including earthquakes and tsunamis, erosion, sediment movement, chemical interactions, nearshore ecology, and much more. With her enthusiasm and passion for science, she continually strives to share her knowledge and experiences with young minds, explaining scientific concepts and discoveries to capture the imagination and interest of potential future scientists. ❁

In the 99th educational-outreach presentation of her USGS career, geologist ***Carol Reiss*** *(kneeling at right) hosted an energetic group of fourth graders at the USGS Pacific Coastal and Marine Science Center on December 17, 2012. She introduced them to (among other things) a replica skull of* Smilodon californicus *(sabertoothed cat, center of table), a woolly mammoth tooth (left of* Smilodon *skull), and a megalodon tooth (held by student in red). Photograph by* ***Tracey Conrad****, USGS.*

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(Publications Submitted continued on page 22)

(Publications Submitted continued from page 21)

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(Publications Submitted continued on page 23)

(Publications Submitted continued from page 22)

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