USGS

Sound Waves Coastal Science and Research News from Across the USGS

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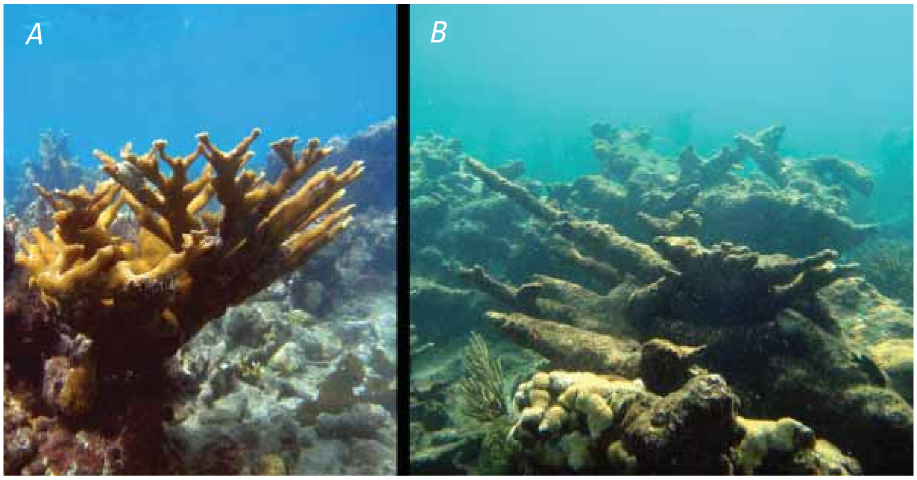
Fieldwork

Impacts of Ocean Acidification on Coral Growth: Historical Perspectives from Core-Based Studies

By Ryan P. Moyer



Corals and coral reefs are severely threatened by processes such as ocean acidification: A*, "Healthy" coral reef with living* Acropora palmata *and good water quality.* B*, Degraded coral reef with dead* A. palmata *and poor water quality. Processes such as ocean acidification are rapidly transforming healthy reefs into degraded reefs in Puerto Rico and other Caribbean and western tropical Atlantic Ocean regions. Photographs by* ***Ryan Moyer****.*

Coral reefs are uniquely complex ecosystems in that they are defined by the underlying geologic structures ("reefs") that are constructed primarily by calcifying organisms (mostly coral and algae). Coral-reef habitats are one of the most important ecosystems on Earth. They harbor the highest biodiversity of any known marine ecosystem and provide critical habitat for many fish and invertebrate species that are of global commercial importance. Coral reefs also provide numerous important economic benefits that help sustain a large and ever-growing coastal human population. However, a recent increase in anthropogenic and climatic stresses has resulted in degradation and near collapse of many coral communities worldwide. Recent reports have identified ocean acidification as a potential major stressor to coral reefs and the various calcifying organisms that build them. Improved understanding and information are needed to guide policies and best-management practices effectively in order to preserve and restore coral-reef resources for future generations.

As atmospheric carbon dioxide (CO_2) continues to increase, primarily as a result of anthropogenic activities, complex changes to the carbon cycle take place on land and in the oceans. Oceans are the ultimate sink for most of the additional CO_2, which has significant impacts on seawater chemistry. As the amount of CO_2 dissolved in seawater increases, pH decreases (hence the term "ocean acidification"), which in turn decreases the availability of carbonate ions (CO_3^{2-}). The decrease in carbonate ions lowers the saturation state with respect to aragonite, which is an important mineral for shell and skeleton formation in calcifying marine organisms. Estimates indicate that ocean surface waters may have already undergone a reduction of 0.1 pH units since the beginning of industrial times. As a result, complex interactions between seawater, calcifying organisms, and surrounding carbonate sediments are expected to occur in coastal-marine ecosystems.

Calcification rates are expected to decrease in response to decreasing pH for several major groups of calcifying marine organisms in coastal and open-ocean environments. Numerous predictions based on both in situ experiments and computer-model simulations indicate that large decreases (as much as 50 percent) in calcification and an associated loss of coral-reef ecosystems could occur within the next few decades to centuries. In contrast, some researchers have concluded that, despite a decrease in ocean pH and aragonite saturation, calcification in corals may increase, owing to an increased metabolic response driven by warming associated with increased anthropogenic CO_2. Although such findings remain controversial, they emphasize the fact that critical gaps exist in our knowledge of how coastal tropical-marine ecosystems, such as coral reefs, will respond to global changes brought about by increased atmospheric CO_2.

Currently, U.S. Geological Survey (USGS) scientist **Ryan Moyer** is trying to understand the effects of ocean acidification on coral growth and calcification by measuring growth and geochemical variations in coral cores collected in the western Atlantic and Caribbean Sea region. **Moyer** is a Mendenhall Postdoctoral Research Fellow at the USGS science center in St. Petersburg, Florida. His current research builds on his earlier Ph.D. work, which focused on using geochemical

(Coral Coring continued on page 2)

Sound Waves

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Contents

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Deadline: The deadline for news items and publication lists for the January/February issue of *Sound Waves* is Tuesday, November 24.
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

(Coral Coring continued from page 1)

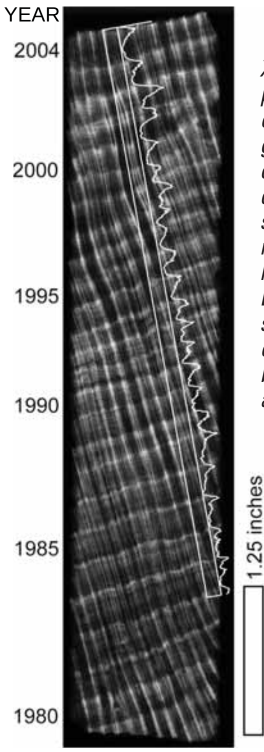
tracers in coral skeletons to understand local carbon cycling in tropical mountainous watersheds and how processes on land affect the biogeochemistry of the tropical coastal ocean and coral reefs.

Corals are excellent recorders of environmental change: they deposit calcium carbonate (aragonite) skeletons in distinct couplets of annual bands and can grow for several hundred years. Cyclic variations in skeletal density within the growth record of corals are evident on X-radiographs and can be combined with isotope and (or) trace-metal geochemistry of the skeleton to serve as proxies for a host of paleoenvironmental events and conditions. Several of these proxies have direct relevance to research addressing the question of coral response to ocean acidification. Variations in the ratio of stable isotopes of boron ($\delta^{11}B$) record changes in seawater pH, and skeletal density as inferred from X-radiographs records relative changes in growth and calcification over the lifespan of the coral. Thus, **Moyer** hypothesizes that the information recorded in skeletons of modern corals that have grown over the past century (or longer) should provide critical information on how corals have responded in terms of growth and calcification to seawater pH changes that are already known to have occurred since preindustrial times, owing to excess anthropogenic CO_2. Coral-based paleo-pH records have been successfully produced by using a *Porites* coral from the Great Barrier Reef; the authors of that study concluded that "Additional paleo-pH records are required from a range of coral reef ecosystems to improve our understanding of the physical and biological controls on reef-water pH, and the long-term impacts of future ocean acidification." (From "Preindustrial to Modern Interdecadal Variability in Coral Reef pH" by **Carles Pelejero** and others, published 2005 in *Science*, v. 309, p. 2204-2207 [**http://dx.doi.org/10.1126/science.1113692**].)

In July 2009, **Moyer**, **Nate Smiley**, and **Chris DuFore** (all USGS, St. Petersburg) traveled to Puerto Rico to collect cores from corals growing on the reefs off La Parguera. Coral coring is a labor-intensive process that involves the use of a surface-supplied hydraulic drill by a trained team of scientific divers. The drill is fitted with a 4-inch-diameter diamond-bit core barrel that is used to drill into the coral skeleton.

(Coral Coring continued on page 3)

*USGS scientists **Nate Smiley** (left) and **Ryan Moyer** use a submersible hydraulic drill to extract a coral core from a large colony of* Montastraea faveolata *off Puerto Rico. Photograph by **Chris DuFore**.*



*X-radiograph positive of a coral skeleton. A graphical overlay of relative skeletal density (white line) shows the alternating high- and low-density bands. Each couplet corresponds to 1 year of coral growth. Image by **Kevin Helmle** and **Ryan Moyer**.*

(Coral Coring continued from page 2)

Extension bars allow the team to collect cores as long as 3 m, which could correspond to 300-plus years of coral growth. The USGS team collected eight cores from large colonies of three species: *Montastraea faveolata*, *Diploria strigosa*, and *Siderastrea siderea*. After each colony was cored, the borehole was filled with loose reef rubble, fitted with a cement cap, and sealed with an underwater epoxy. This "plug" creates a surface for the surrounding coral tissue to grow over. Monitoring studies have shown that complete coral recovery is possible within a few years after coring.

A preliminary assessment of the Puerto Rico cores indicates that they include at least two 100-year-plus records of coral growth. Further processing of the cores is currently being conducted by **Moyer** and collaborators **Kevin Helmle** of the National Oceanic and Atmospheric Administration (NOAA) and **Richard Dodge** of the National Coral Reef Institute (NCRI). The cores will be cut longitudinally, planed into parallel-sided slabs, and X-radiographed to reveal an accurate coral-growth history. **Moyer** and his collaborators will then use the X-radiographs to determine

Ryan Moyer *applies a cement-and-epoxy cap to the core hole in a large colony of* Montastraea faveolata*. The cap will allow coral tissue to grow over the affected area. Photograph by* ***Nate Smiley****.*

changes in growth rate and calcification over the lifespan of the coral. **Moyer** will also make measurements of $\delta^{11}B$ within the skeleton in cooperation with **Bärbel Hönisch** at the Lamont-Doherty Earth Observatory. The growth and calcification data will then be combined with the $\delta^{11}B$ paleo-pH proxy data to determine how coral growth and calcification have responded to changes in surface-ocean pH since the beginning of industrial times. This work is also being conducted on coral cores collected off Florida and Tobago, whereby **Moyer** hopes to better understand the natural variability and local- to regional-scale impacts of ocean acidification on coral growth in the Caribbean and western tropical Atlantic Ocean regions.

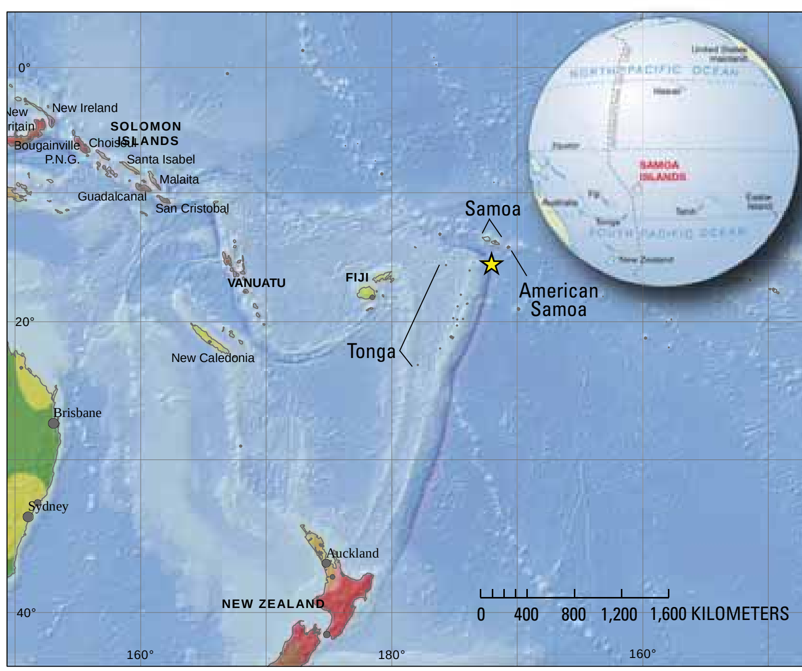
Moyer joined the USGS after completing his Ph.D. in geological sciences at the Ohio State University's School of Earth Sciences under the direction of **Andréa Grottoli**. **Moyer** also holds a B.S. in marine science from Kutztown University of Pennsylvania and an M.S. in marine biology from Nova Southeastern University Oceanographic Center. For more information about his study of the impacts of ocean acidification on coral growth and calcification, contact **Ryan P. Moyer**, U.S. Geological Survey, 600 Fourth Street South, St. Petersburg, FL 33701, phone (727) 803-8747 (ext. 3030), fax (727) 803-2032, e-mail **rmoyer@usgs.gov.**❆

USGS Scientists Respond to Deadly Samoa Tsunami

By Helen Gibbons

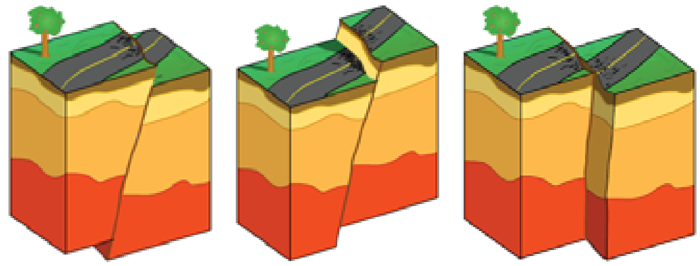
U.S. Geological Survey (USGS) tsunami scientists responded quickly after a magnitude 8.0 submarine earthquake occurred at 6:48 a.m. Samoa Standard Time on September 29, 2009, approximately 190 km (120 mi) south of Samoa. The earthquake triggered a tsunami that caused deaths and widespread damage in Samoa, American Samoa, and Tonga.

(Samoa Tsunami continued on page 4)



The region of the South Pacific where a magnitude 8.0 earthquake (epicenter marked by star) triggered a tsunami on September 29, 2009, which caused more than 150 deaths and widespread destruction in Samoa, American Samoa, and Tonga. Land areas are color-coded according to shaking hazard, with areas toward the red end of the spectrum subject to greater hazard from earthquake shaking. Map modified from USGS poster at ***http://earthquake.usgs.gov/earthquakes/eqarchives/poster/2009/20090929.php****. Inset globe courtesy of National Park Service.*

(Samoa Tsunami continued from page 3)



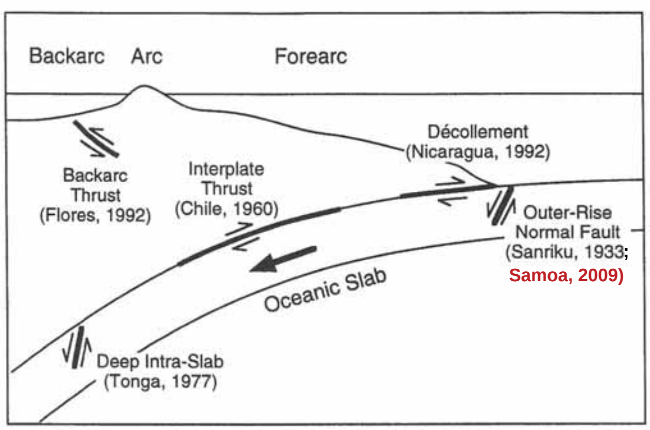
Three basic fault types. A thrust fault (not shown here) is a reverse fault that dips less than 45° from horizontal. Most tsunamis are triggered by thrust faulting, reverse faulting, or (less commonly) normal faulting. Strike-slip faults, such as the San Andreas fault in California, are much less likely to trigger a tsunami but can do so if their movement shifts topographic highs relative to topographic lows or causes a submarine landslide. Diagrams excerpted from animations in entries for "dip slip" and "strike slip" in the USGS Earthquake Glossary, ***http://earthquake.usgs.gov/learning/glossary.php****.*

Eyewitnesses reported three to seven tsunami waves; the largest were higher than 5 m and reached more than 500 m inland. Thanks to educational efforts, residents of the affected islands evacuated to high ground after the earthquake. Had they not, the death toll would have been in the thousands. Nevertheless, some people were overtaken by the tsunami waves, which traveled very quickly through the deep water between the epicenter and the nearest islands—a circumstance that one USGS scientist called "heart-wrenching." The death toll was 148 on Samoa, 34 in American Samoa, and 9 in Tonga.

The earthquake occurred near the boundary between the Pacific and Australian tectonic plates, one of the most active earthquake regions in the world. At the latitude of the earthquake, the Pacific plate is subducting westward beneath the Australian plate. The earthquake was centered near the north end of a 3,000-km-long segment of the Pacific/Australia plate boundary that trends north-northeast and is marked by the Tonga trench. On the basis of currently available information, USGS seismologists infer that the September 29 earthquake occurred as a normal-fault rupture within the outer rise of the subducting Pacific plate, where the plate bends downward toward the Earth's mantle (see subduction-zone diagram, below left). Most fault ruptures in subduction zones occur on thrust or reverse faults between the two plates, where compression pushes rock on one side of the fault up and over rock on the other side (see diagram of fault types, above). The earthquake that triggered the 2004 Indian Ocean tsunami was a thrust-fault rupture. Normal-fault ruptures, in which rock on one side of the fault slips down and away from rock on the other side, are less common in subduction zones but do occur in such places as the outer rise, where bending of the subducting plate exerts extensional forces on the rock.

Thrust faulting, reverse faulting, and normal faulting all produce vertical displacement of the seafloor, which in

(Samoa Tsunami continued on page 5)



Generalized diagram of a subduction zone, showing types of fault ruptures that have triggered tsunamis. Thick lines, fault segments that ruptured; arrows, relative directions of rock movement on either side of fault. Examples of tsunamis generated by each type of fault rupture are listed in parentheses (place that tsunami struck, year of tsunami). Modified from "Local tsunamis and earthquake source parameters" by ***E.L. Geist****, 1999, Advances in Geophysics, v. 39, p. 117-209.*

The first tsunami wave receding toward Pago Pago Harbor, American Samoa; red arrow points to man sitting beneath roof at lower left. Photograph taken by National Oceanic and Atmospheric Administration fisheries biologist ***Gordon Yamasaki*** *from his second-floor office in Pago Plaza.* ***Yamasaki*** *estimated that the first wave was about 3 m high at the site of his office more than 100 m from the shore. The wave was much larger at many locations in American Samoa. See more photographs by* ***Yamasaki*** *at* ***http://picasaweb.google.com/qrkpub/SamoaTsunami#****.*

(Samoa Tsunami continued from page 4)

turn displaces water above, giving rise to the tsunami (learn more at **http://walrus.wr.usgs.gov/tsunami/basics.html**). Relative to many subduction-zone earthquakes, the September 29 earthquake was "shallow"—it occurred only about 12 km (7 mi) below the seafloor—and so most of its energy reached the seafloor and was transferred to the overlying water. What's more, the September 29 earthquake occurred beneath relatively deep water, currently estimated at about 5 to 7 km (scientists are still analyzing data to determine more precisely where the fault rupture occurred). The deeper the water above the earthquake, the more the tsunami amplifies when it travels into shallow water. Finally, the speed of a tsunami is related to the depth of the water through which it travels: the deeper the water, the faster the tsunami. The deep water between the earthquake epicenter and the islands in the Samoa region allowed the tsunami waves to speed toward the islands at about 500 mph in the open ocean, or as fast as a 747 jumbo jet. Thus the first tsunami wave reached some coasts facing the epicenter as soon as 14 minutes after the earthquake. Shallow water close to the islands slowed the tsunami to approximately 30 mph by the time it hit the shore, but even at that speed the huge mass of moving water exerted tremendous force.

As news of the earthquake and tsunami broke, private citizens as well as numerous reporters from news agencies and radio and television stations contacted the USGS for additional information. Among the scientists who answered their questions were tsunami experts **Eric Geist**, a geophysicist who models the generation and propagation of tsunami waves; **Bruce Jaffe**, an oceanographer who studies sediment deposited by tsunamis for clues to tsunami history; and **Uri ten Brink**, a geophysicist who studies tsunami and earthquake hazards in the Caribbean region.

Plans were soon set in motion for a USGS rapid-response team from Menlo Park and Santa Cruz, California, to travel to American Samoa to collect geologic data expected to be quickly degraded or

*Debris in the parking lot of Pago Plaza, American Samoa. Photograph by **Gordon Yamasaki**.*

destroyed by recovery activities and natural processes. **Jaffe** arrived in Pago Pago, on the island of Tutuila, American Samoa, on October 4 and began working with an International Tsunami Survey Team. He was joined later by USGS colleagues **Bruce Richmond**, **Mark Buckley**, **Guy Gelfenbaum**, **Steve Watt**, and **Alex Apotsos**, as well as oceanographer **Walter Dudley** of the University of Hawai‘i, Hilo, and geologist **Brian McAdoo** of Vassar College. The researchers collected time-sensitive data to help them determine the height of tsunami waves at various sites, flow directions, and the distances the waves traveled inland. They also studied the transport of sediment and other debris, looked for evidence of subsidence or uplift caused by the earthquake, documented erosion caused by the tsunami waves, and made other observations critical to the better understanding of tsunami impacts and processes. For news and photographs from this team, visit **http://walrus.wr.usgs.gov/news/samoareports.html**.

A second USGS team—**Dan McNamara** and **Jeff Fox** of the USGS National Earthquake Information Center in Golden, Colorado—deployed six seismic stations in American Samoa to detect aftershocks and collect data for determining ground-motion attenuation, a key parameter for assessing seismic hazard.

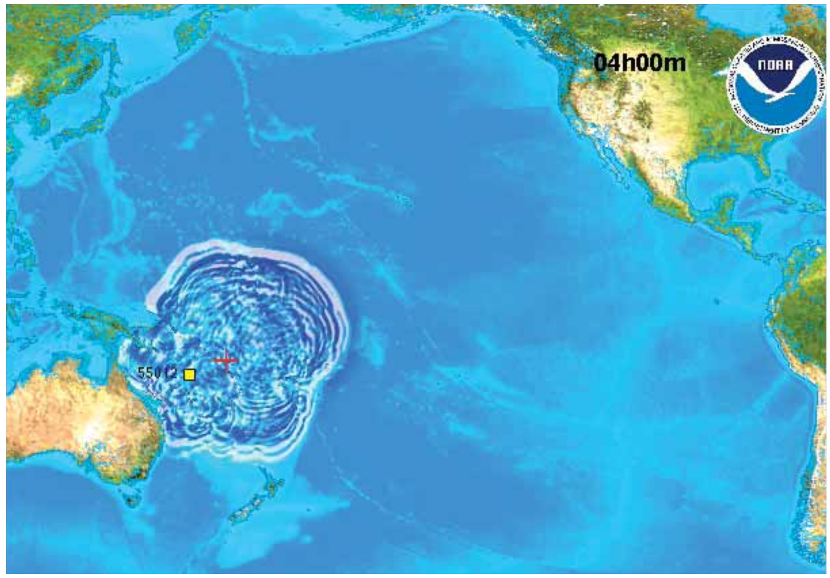
Both teams coordinated with other Federal and local agencies to ensure that scientific activities did not interfere with rescue and recovery activities.

After their fieldwork on American Samoa, **Richmond**, **Buckley**, **Dudley**, and **McAdoo** traveled to Apia on the island of Upolu, Samoa, to join an international rapid-response effort to map tsunami impacts in Samoa. For **Richmond's** reports on this effort, visit **http://walrus.wr.usgs.gov/news/samoareports.html**. ☸

*The tsunami swept away virtually all but the foundation of this house in Fagasa, American Samoa. Photograph by **Bruce Jaffe** on October 5, 2009. View additional photographs by USGS tsunami scientists at **http://walrus.wr.usgs.gov/news/samoareports.html**.*

USGS Scientist in American Samoa Helps Calm Fresh Tsunami Fears

By Helen Gibbons



*Tsunami waves generated by two earthquakes near Vanuatu in the southwestern Pacific Ocean on October 7, 2009, spread across the entire Pacific basin, but initial information indicates amplitudes of less than 1 m on most of the shores they struck. Excerpt from tsunami-propagation animation at NOAA Pacific Marine Environmental Laboratory's Web page for the October 7 event (**http://nctr.pmel.noaa.gov/vanuatu20091007/**).*

Residents of American Samoa were still dealing with the aftermath of the September 29, 2009, tsunami that caused severe damage and 191 deaths in the region when the Pacific Tsunami Warning Center (National Weather Service) issued another tsunami warning on October 7. This warning was prompted by two submarine earthquakes, of magnitude 7.6 and 7.8, that struck within minutes of one another near Vanuatu, about 2,500 km (1,600 mi) west of American Samoa.

U.S. Geological Survey (USGS) scientist **Bruce Jaffe** was in American Samoa to study the impacts of the September 29 tsunami and was able to help with the response to the new tsunami warning. In a report to managers and scientists at the USGS, **Jaffe** wrote: "…people were in a state of panic, and many of the roads were nearly gridlocked as people tried to get to their homes. I went to the command center, told them that the event did not likely generate a tsunami that would be large in American Samoa, and led them through the data I used to come to that conclusion." **Jaffe** also called a radio station to let people know that the consensus of the group of tsunami scientists in American Samoa to study the September 29 event was that it was unlikely that the islands would be hit by a large tsunami from the new earthquakes. He also urged people to remain calm and to listen for emergency announcements as more information became available. The warning was called off about 1 hour before the arrival of the tsunami, just a few centimeters high, in Pago Pago.

The first of a USGS rapid-response team to arrive in American Samoa, **Jaffe** was working with an International Tsunami Survey Team on the island of Tutuila to collect data on various physical characteristics of the September 29 tsunami waves—such as water height, flow directions, and distance traveled inland. It is hoped that their observations, and those made by other teams in the region, will help decrease losses in future tsunamis in American Samoa and elsewhere. ☸

Recent USGS Field Studies of Nearshore Hydrogeologic Exchange and Submarine Groundwater Discharge on U.S. West Coast and Hawai'i

By Peter W. Swarzenski and Helen Gibbons

One is hard-pressed to find three study sites whose groundwater systems are more diverse than a tropical bay next to Honolulu, Oahu, Hawai'i (Maunalua Bay), a famous beach just up the coast from Los Angeles, California (Surfrider Beach, Malibu), and a high-energy delta system in southern Puget Sound that is poised for large-scale ecological restoration (Nisqually River delta, Washington). In each of these three contrasting sites, the exchange of surface water and groundwater and the associated transport of chemical constituents (for example, nutrients, metals, organic compounds) in nearshore coastal waters can play an important, even defining role in the health of the sites' ecosystems.

Scientists with the U.S. Geological Survey (USGS) Geology Discipline—**Peter Swarzenski**, **Eric Grossman**, and **Leticia Diaz** (Santa Cruz, California); **Robert Rosenbauer** (Menlo Park, California); and **Chris Reich** (St. Petersburg, Florida)—joined forces with scientists with the USGS Water Resources Discipline—**Gordon Tribble** and **Sarah Rosa** (Honolulu, Hawai'i); **John Izbicki**, **Carmen Burton**, **Nick Teague**, **Dave O'Leary**, and **Dara Goldrath** (San Diego, California); **Jacob Fleck** (Sacramento, California); and **Rick Dinicola** and **Steve Cox** (Tacoma, Washington)—to investigate the exchange of water and associated constituents between groundwater and coastal surface water using a suite of geochemical (radionuclides, trace elements, and nutrients) and geophysical

(Submarine Groundwater continued on page 7)

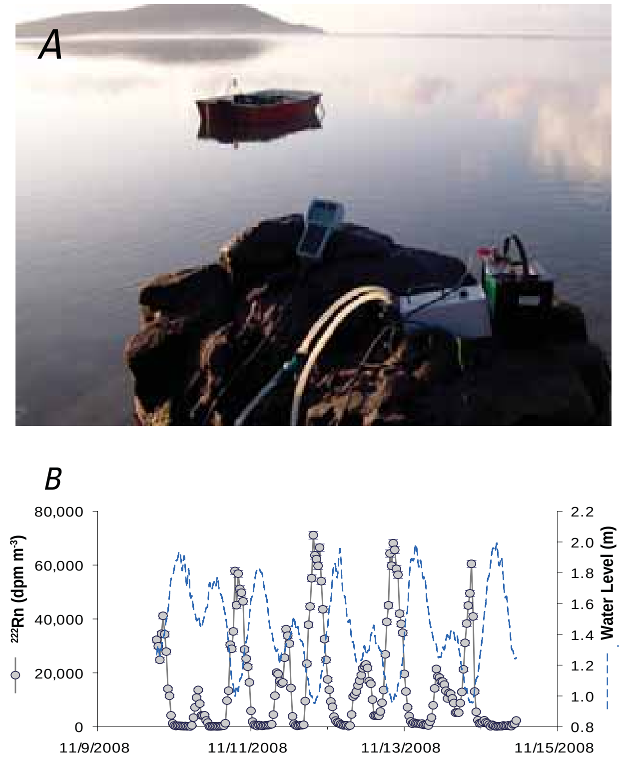
(Submarine Groundwater continued from page 6)

(electromagnetic seepmeters, electrical resistivity) tools.

Ample evidence now exists to confirm that the persistent discharge of coastal groundwater can significantly affect the chemistry of nearshore waters. For example, groundwater commonly contains land-derived nutrients, such as nitrogen and phosphorus, in higher concentrations than surface water. When elevated amounts of these nutrients are delivered to coastal waters by submarine groundwater discharge, they can fuel algal blooms and contribute to coastal eutrophication—a process in which decomposition of excessive algae depletes oxygen dissolved in the water, leading to increased stress and even death for fish and shellfish. Submarine groundwater discharge may also transport microorganisms into nearshore waters.

Among the objectives of our studies were to systematically characterize the dynamics of submarine groundwater discharge and the associated flux of terrestrial material and to evaluate how the three ecosystems are responding to natural and man-made environmental stressors. Such results contribute to ongoing USGS ecosystem studies, including the Coastal Habitats in Puget Sound (CHIPS) Project and the Coral Reefs Project, which aim to improve our understanding of ecosystem responses to climate change and land use, including restoration.

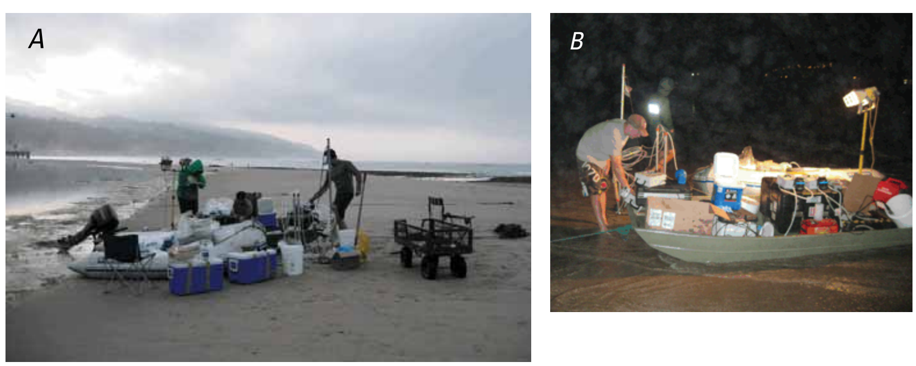
Maunalua Bay is on the south side of the island of Oahu and forms part of the eastern shoreline of Honolulu. Over the past 50 years, increased sedimentation and pollution from the land have affected the bay ecosystems. Nonnative plants and animals have invaded the bay, the diversity and abundance of coral-reef species have diminished, and populations of reef fishes have declined. We began an investigation to determine whether submarine groundwater discharge might be affecting ecosystem health. In parts of Maunalua Bay, we identified and quantified widespread groundwater discharge of nearly fresh water using time-series measurements of radon (^{222}Rn), a naturally occurring noble gas. As a radioisotope, ^{222}Rn has a short half-life (3.8 days) and is much more concentrated in groundwater than in surface water, making it an excellent tracer for groundwater discharge. Analysis of these and additional data will help us identify the impacts of submarine groundwater discharge on the bay.



Study sites in Maunalua Bay, Oahu, Hawai'i. A, *Niu study site. On rock in foreground are (right to left) a battery, a pump, and a water-quality probe for measuring water temperature, salinity, pH, and dissolved oxygen. The boat contained additional water-quality probes, plus instruments for making continuous measurements of ^{222}Rn, a tracer for submarine groundwater discharge.* B, *A time series of ^{222}Rn (half-life = 3.8 days) over 4-plus days at the Black Point study site shows clear maxima just after each low tide and can be used to calculate a submarine-groundwater-discharge rate at this site (approximately 33 cm per day). dpm, disintegrations per minute.*

Surfrider Beach in Malibu, California, about 15 km up the coast from Los Angeles, is one of several Southern California beaches where bacterial contamination has caused frequent beach closures. We have begun an investigation here to study the relation between submarine groundwater discharge and nearshore water quality. Preliminary results indicate that the sandy, permeable beach berm at Surfrider Beach in Malibu provides a leaky but effective filter for many microorganisms as the water from Malibu Lagoon is tidally pumped through the permeable sand. Additional data and analyses will help us better understand the role of submarine groundwater discharge in the delivery of land-derived contaminants to coastal waters. Interestingly, a great white shark about as long as our research boat

(Submarine Groundwater continued on page 8)



The beach at Malibu Lagoon becomes a temporary lab from which to study how the tides move water and microorganisms through the permeable berm sand. A, *early morning, low tide; lagoon to left, Pacific Ocean to right.* B, *midnight, high tide; lagoon to right.*

(Submarine Groundwater continued from page 7)

Low tide at a coastal spring near the Nisqually River delta. Continuous measurements of ^{222}Rn, a tracer for submarine groundwater discharge, were being made by instruments on the boat and in the spring vent (foreground) to quantify discharge rates.

was observed near the Malibu Pier while we were conducting offshore surveys. To view video footage of the shark and get a general look at our study area, visit **http://www.myfoxla.com/dpp/news/local/Great_White_Shark_Sighting_in_Malibu_20090723**.

Dikes constructed to drain wetlands for agricultural use more than a century ago are gradually being removed in the Nisqually River delta as part of a project to restore some of Puget Sound's richest estuarine habitat (see **http://www.nisquallydeltarestoration.org/**). At Nisqually, we focused our nearshore-exchange study on a large coastal spring, where tides with ranges greater than 5 m surge into and out of the hydrologically transmissive glacial terrain, thereby modulating spring discharge and associated material transport. Further studies will help us understand how the changes associated with restoration affect the patterns of submarine groundwater discharge.

Preliminary results confirm the utility of the techniques we used to better understand land/sea exchange processes, including submarine groundwater discharge and the flux of associated constituents. This research benefited tremendously from the help of local citizens, including **Alyssa Miller** and **Carol Wilcox** (Malama Maunalua; **http://malamamaunalua.org/**), **Barbara Cameron** (City of Malibu), and **Daniel Hull** (Nisqually Reach Nature Center; **http://www.nisquallyestuary.org/**).

For more details about submarine groundwater discharge, visit the USGS Submarine Groundwater Discharge Web site at **http://coastal.er.usgs.gov/sgd/**. For more information about the projects described in this article, please contact **Peter Swarzenski**, U.S. Geological Survey, 400 Natural Bridges Drive, Santa Cruz, CA 95060, phone 831-427-4729, e-mail **pswarzen@usgs.gov**. ☸

Staff and Center News

Summer Student Fellows Assist USGS Scientists Investigating Gas Hydrates and Carolina Coastal Change Processes

By Bill Winters, Marinna Martini, and John Warner

Julie Bing *(right) and* ***Dave Mason*** *examining some of the electronics used to record sensor information from the Instrumented Pressure Testing Chamber. Photograph by* ***Bill Winters****. Inset photograph of* ***J. Carlos Santamarina*** *inspecting the IPTC provided by Georgia Institute of Technology.*

Julie Bing and **Jordan Landers**, both members of the Woods Hole Oceanographic Institution (WHOI) Summer Student Fellowship program, assisted the U.S. Geological Survey (USGS) Gas Hydrates and Carolina Coastal Change Processes projects in Woods Hole, Massachusetts, in summer 2009. **Bing** and **Landers** were among 28 students selected from 212 applicants at 147 national and international undergraduate institutions. As the USGS representative on the selection committee, **Kathy Scanlon** reviewed applicants' records and helped match selected students with mentors and projects. **Michelle McCafferty** is the WHOI coordinator of the program.

Bing, who recently completed a bachelor's degree in mechanical engineering at Ohio Northern University, is continuing graduate engineering studies at the Ohio State University. She worked with the Gas Hydrates group on modifications of the Instrumented Pressure Testing Chamber (IPTC), which was originally developed and built by **J. Carlos Santamarina** of the Georgia Institute of Technology

(Summer Fellows continued on page 9)

(Summer Fellows continued from page 8)

(Georgia Tech). Gas hydrate, an ice-like form of methane and water, is stable over a specific range of low-temperature and moderate-pressure conditions. Special "pressure cores" are used to sample sediments containing gas hydrate and to hold them at in situ fluid pressures to prevent gas-hydrate dissociation after the cores are brought to the surface. The IPTC is used to make acoustic, electrical conductivity, and strength measurements and to conduct small-scale methane-production tests on such cores. In the future, the IPTC will be managed by the USGS Gas Hydrates Project and jointly run by the USGS and Georgia Tech to support measurements on hydrate-bearing sediment cores obtained by U.S. and international coring programs in deep marine and permafrost environments. **Bing** worked with **Bill Winters**, **Dave Mason**, student intern **Russel Wilcox-Cline**, and electronics consultant **Richard Nowak** to improve the mechanical systems and data-acquisition capabilities of the IPTC. She also performed index-property measurements to characterize sediments being used to calibrate the sensors.

***Jordan Landers** with a display of a typical sonar image of bottom ripples recorded in winter off Cape Hatteras, North Carolina. Photograph by **John C. Warner**.*

*A barbecue was held to mark the end of the 2009 WHOI Summer Student Fellowship program. Some of the USGS program attendees and invited guests included (left to right): **Chris Polloni**, **Dave Mason**, **Bill Waite**, **Russel Wilcox-Cline**, **Ben Gutierrez**, **Claudia Flores**, **Marisa Rydzy** (Colorado School of Mines), **Peter Bratton**, **Bill Winters**, **Richie Williams**, and **Julie Bing**. Photograph by **John Crusius**.*

Landers, who graduated this year with a bachelor's degree in mathematics from Williams College, analyzed physical oceanographic data for **John Warner** and **Marinna Martini**. **Landers** got the first look at a dataset of measurements recently recovered from tripods deployed on the seafloor through the winter off Cape Hatteras, North Carolina. These data are part of a larger study to understand sediment-transport processes and the impacts of storms on a coastal system, focusing on the Outer Banks of North Carolina. **Landers** processed sonar data and interpreted images of seafloor ripples and other bedforms taken at regular intervals. She then related the observed seafloor-bedform response to variations in winds, waves, and ocean currents in order to infer sediment-transport processes. **Landers** found that bedforms changed shape during storms and that ripple orientation did not always indicate mean sediment-transport direction.❅

Frank Shipley Is New Western Regional Chief Scientist

By Anne Kinsinger, USGS Western Regional Director

In September 2009, **Frank Shipley** became the new Regional Chief Scientist for the U.S. Geological Survey (USGS) Western Region. **Frank** has worked for the USGS since 1995 in a variety of scientific and leadership roles. Most recently he has served as the Regional Science Coordinator for Biology in the Western Region, where he will continue to lead strategic development of ecosystem-scale and climate-change science and cross-discipline, cross-bureau collaborations while a permanent replacement is sought. **Frank's** career passion is the development of ecosystem- and landscape-scale science to support natural-resource conservation in the public trust.

Frank's early career as a scientist involved teaching and research at Kansas State University; Del Mar College in Corpus Christi, Texas; and the University of Houston. He is the author of more than 50 publications on topics ranging from impacts of floodwaters on aquatic systems to reproductive patterns in avian populations. From 1989 to 1995, **Frank** established and directed the Galveston Bay Estuary Program, where he led ecosystem research and creation of a management plan to guide the activities of multiple resource agencies. After joining the USGS in the fall of 1995, **Frank** served for 8 years as

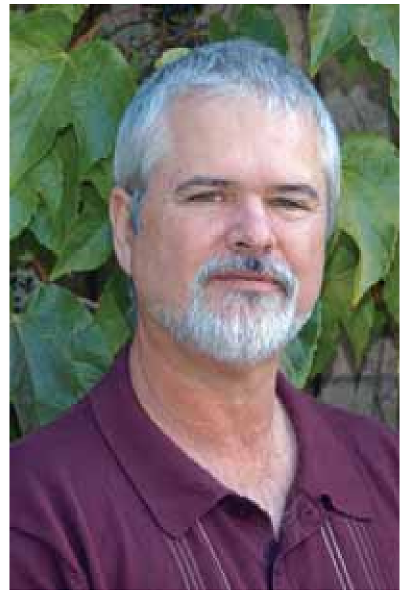
(New Chief Scientist continued on page 10)

(New Chief Scientist continued from page 9)

the Director of the USGS Western Fisheries Research Center. After 3 years as the Deputy Regional Biologist, **Frank** completed several senior executive details for the USGS, including acting as the Northwest Area Regional Executive, the Deputy Regional Director of the Western Region, and the Western Regional Biologist. He is currently a member of the USGS Carbon Committee, serves as cochair of the National Technical Advisory Team for Strategic Habitat Conservation, and is on the Puget Sound Partnership Science Panel. **Frank** has a B.S. in wildlife biology from Colorado State University (1974) and M.S. (1976) and Ph.D. (1980) degrees in biology from Kansas State University, with an emphasis in evolutionary ecology. He and his wife **Theresa** live on Vashon Island, Washington.

Frank began duties as the Regional Chief Scientist in mid-September and is eager to delve into the full breadth of USGS science, learn more about the work of all the disciplines, and develop new and powerful ways to foster interdisciplinary science. I would like to thank **Susan Benjamin** for an outstanding job leading the Regional Science Office during her tenure as acting Regional Chief Scientist from June to September 2009. **Susan** will continue in the other half of her double acting role as the Geography Coordinator for the Western Region.

Frank's scientific experience, programmatic and executive leadership skills, and extensive record of relationship building among USGS partners and scientists provide a powerful foundation for his new role within the USGS. I am confident that he will continue to advance the role of the Regional Science Office in support of all discipline and interdisciplinary science in the region. Please join me in welcoming **Frank**! ☸



***Frank Shipley**. Photograph by **Mike Diggles**, USGS*

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