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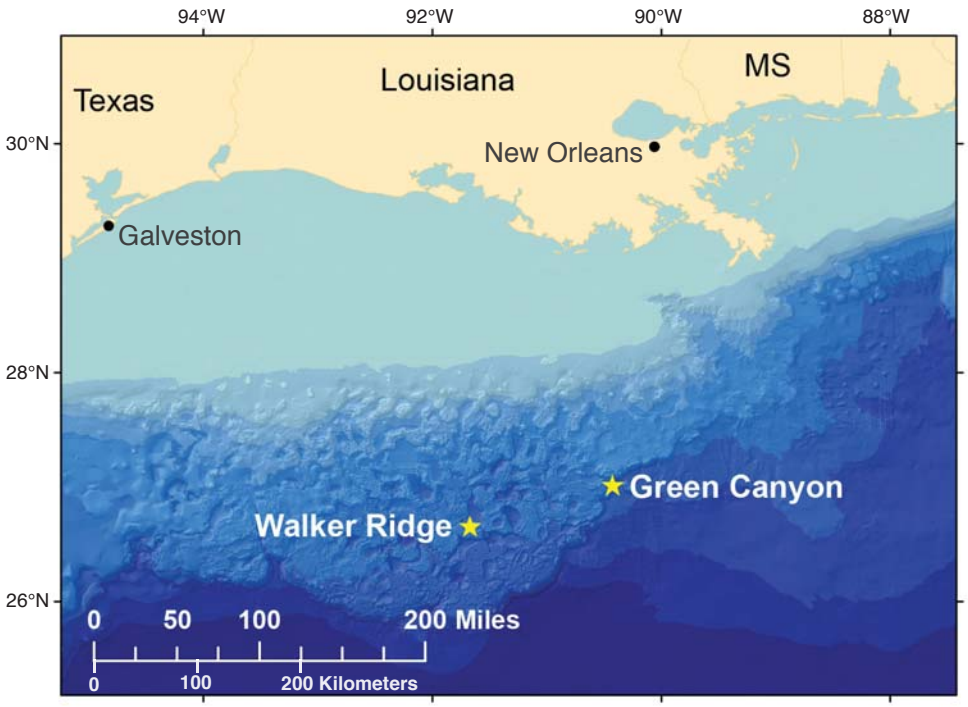
Fieldwork

Seismic-Imaging Research Cruise Investigates Deepwater Gas Hydrate Deposits in the Gulf of Mexico

By Patrick E. Hart, Seth Haines, and Carolyn Ruppel

Interest is mounting in the possibility that gas hydrate—a naturally occurring ice-like substance that contains vast quantities of methane—might be a viable source of natural gas. A research cruise by the U.S. Geological Survey (USGS) Gas Hydrates Project in the northern Gulf of Mexico in spring 2013 shed new light on that possibility. The 15-day cruise was conducted by USGS scientists and technicians with partial financial support from the U.S. Department of Energy (DOE) and the U.S. Bureau of Ocean Energy Management (BOEM). The scientific surveys focused on sites in the deepwater Gulf where 2009 drilling had revealed thick sections of gas-hydrate-rich reservoir rocks (**http://soundwaves.usgs.gov/2009/07/fieldwork2.html**). The 2013 cruise imaged sediments deep beneath the seafloor in and around two of the drilled areas, Green Canyon and Walker Ridge (see map). The primary objectives were to constrain the saturation of gas hydrate (the percentage of available pore space in the sediment that is filled by gas hydrate) and to produce high-quality imagery of faults, sediment layers, and gas-related features in the sediments above the gas hydrate deposits. The new high-resolution imaging will enable the most detailed interpretation to date of the distribution, saturation, and geologic setting of gas hydrate and associated free gas at these sites.



Stars show the sites of seismic surveys conducted on the research vessel Pelican *in April and May 2013 to image previously identified deepwater gas hydrate deposits in the northern Gulf of Mexico.*

Gas hydrate is a naturally occurring ice-like compound that forms in sediment when water and certain gases combine at the pressure and temperature conditions common at ocean depths greater than approximately 500 meters (1,600 feet) and in areas of continuous permafrost. Methane, popularly known as natural gas, is the gas most often trapped in gas hydrate deposits. Gas hydrate concentrates large amounts of methane into compact crystals and globally sequesters far more methane than exists in proven natural-gas reserves. There is substantial interest in gas hydrate as a potential energy resource—Japan produced methane from deepwater gas hydrate deposits for the first time in March 2013 (**http://soundwaves.usgs.gov/2013/04/research.html**). The USGS Gas Hydrates Project (**http://woodshole.er.usgs.gov/project-pages/hydrates/**) studies energy-resource issues, as well as the interaction of gas hydrates and the climate system (for example, see **http://soundwaves.usgs.gov/2012/06/**) and the potential contribution of gas hydrates to seafloor destabilization. Ongoing studies characterize and quantify gas hydrate deposits beneath many of the world's continental margins and in permafrost areas.

To image deep gas hydrate-rich sediments during the 2013 cruise, scientists used a high-resolution multichannel seismic (MCS) reflection system and ocean bottom seismometers (OBS). Both systems make use of acoustic (sound) energy. For the MCS reflection surveys, seismic sources were towed behind the vessel to produce low-energy sound waves that traveled to and beneath the seafloor, reflecting off surfaces with contrasting

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Fieldwork, continued

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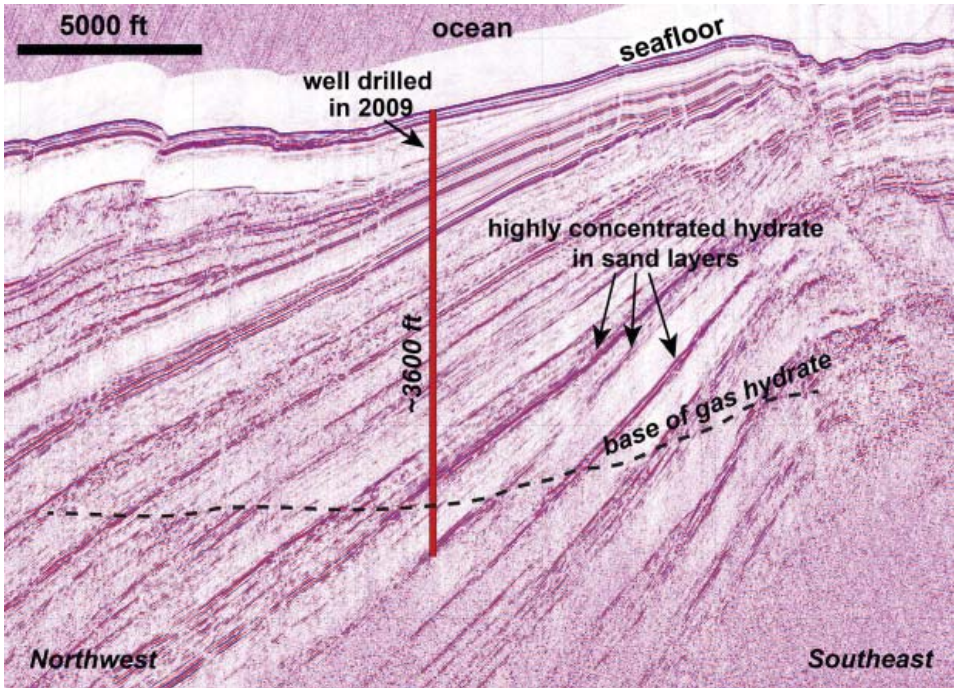

High-resolution seismic-reflection image collected during a research cruise to study sites with high saturations of gas hydrate in the northern Gulf of Mexico in April and May 2013. The data were collected at Walker Ridge, where a well drilled in 2009 (red) revealed the distribution of gas hydrates and methane gas in the sediments. Water depth at the well is approximately 2,000 meters (6,500 feet). Magenta and (much thinner) blue lines correspond to sediment layers, which mostly dip westward. Sand layers with high concentrations of gas hydrate are marked, but hydrate also occurs elsewhere in this sedimentary section. (Dips appear steeper than they actually are, owing to a vertical exaggeration of nearly 3 to 1.)

physical properties, particularly different densities. The returning sound energy was received by 72 hydrophones (underwater microphones) arrayed in a 450-meter (1,500 foot) digital streamer that is owned by the USGS. The data were recorded on shipboard computers and then processed to yield a cross-section, or side view, of sediment layers beneath the seafloor (see example above).

An OBS is an instrument that is deployed on the seafloor, where it records the seafloor motion produced either by earthquakes or by artificial sound sources (**http://woodshole.er.usgs.gov/operations/obs/whatobs.html**). The 25 OBS used during the 2013 cruise are partially managed by the USGS and were supplied by the Woods Hole Oceanographic Institution (WHOI). These OBS recorded signals and tiny seafloor vibrations caused by the same sound sources as used by the MCS system. Each OBS employed a hydrophone like those in the MCS system to record energy waves transmitted through the water and a geophone to record energy waves transmitted through the seafloor. The geophone recorded vertical seafloor motion and two directions (at right angles to one another) of horizontal seafloor motion. Thus each OBS collected what are referred to as "four-component" data—one component from the hydrophone and three components (three directions) from the geophone. Because much of the energy recorded by the OBS traveled paths at a wide angle from vertical, the OBS data are also called "wide-angle."

Sound energy travels through the water as compressional waves (P-waves, like compression waves in a slinky; see **http://web.ics.purdue.edu/~braile/edumod/waves/Pwave.htm**), but in sediment layers beneath the seafloor, part of the energy is converted into shear waves (S-waves, like waves in a rope; see **http://web.ics.purdue.edu/~braile/edumod/waves/Swave.htm**). Shear waves cannot travel through fluid and so are not recorded

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by hydrophones. The OBS geophones, however, can record shear waves as well as compressional waves, thus providing information not available from the MCS system. This information yields clues about the composition of sediment layers, including whether or not the pores contain gas hydrate and free gas.

The 2013 seismic cruise continues a long tradition of interagency cooperation and coordination among the USGS, DOE, and BOEM to advance national research and development objectives related to determining the viability of gas hydrates as a potential energy resource. These groups collaborated with a Chevron-led industry consortium to conduct the 2009 gas hydrate-drilling program in the Gulf of Mexico (**http://soundwaves.usgs.gov/2009/07/fieldwork2.html**). The USGS Gas Hydrates Project (**http://woodshole.er.usgs.gov/project-pages/hydrates/**), the DOE National Methane Hydrates R&D Program (**http://www.netl.doe.gov/technologies/oil-gas/futuresupply/methanehydrates/maincontent.htm**), and BOEM (**http://www.boem.gov/**) jointly funded the 2013 seismic program, which was conducted by the USGS during around-the-clock operations from April 18 to May 3 aboard the research vessel (R/V) *Pelican*.

***Tim Kane** (left) and **Peter Lemmond** (Woods Hole Oceanographic Institution) deploying an ocean bottom seismometer (OBS) from the research vessel* Pelican *to study gas hydrates in the deepwater Gulf of Mexico. The OBS will free-fall to the seafloor and record data that provide information about the geometry and composition of sub-seafloor sediment layers. To recover the OBS, an acoustic (sound) signal sent from the ship will trigger the release of the anchor (the flat metal plate suspended below the yellow housing), and the OBS will float to the surface. USGS photograph taken in April 2013 by **Patrick Hart**.*

The 35-meter (115 foot) R/V *Pelican* (**http://www.lumcon.edu/pelican/**) is a University-National Oceanic Laboratory System (UNOLS) vessel operated by the Louisiana Universities Marine Consortium (LUMCON) and home-ported in Cocodrie, Louisiana. **Seth Haines**, of the USGS Energy Resources Program (ERP, **http://energy.usgs.gov/**), Denver, Colorado, and **Patrick Hart**, of the Coastal and Marine Geology Program (CMGP, **http://marine.usgs.gov/**), Santa Cruz, California, were co-chief scientists on the cruise. Additional science crew included **Thomas O'Brien**, **Wayne Baldwin**, and **Eric Moore** (CMGP, Woods Hole, Massachusetts) and **Ray Sliter**, **Jenny White**, **Pete Dal Ferro**, and **Rob Wyland** (CMGP, Santa Cruz). **Tim Kane** and **Peter Lemmond** (WHOI) ran the OBS shipboard operations.

The seismic data-acquisition equipment was installed on the *Pelican* over a 3-day period beginning April 16. After a 20-hour transit during the night of April 18 to the first study site in the Green Canyon area, work began with deployment of a pattern of 21 OBS in water approximately 2,000 meters (6,500 feet) deep. Once these OBS were in place, MCS data acquisition commenced. The 72-channel digital hydrophone streamer was deployed along with three depth-controller "birds" to maintain the 450-meter (1,500 foot) streamer at a constant 3-meter (10 foot) depth below the sea surface. A pair of generator-injector (GI) air guns was used as a low-energy sound source to provide the signal recorded by the digital streamer and the OBS. Lamont-Doherty Earth Observatory loaned these GI air guns to the USGS for use on this project. Air-gun operations were conducted under guidelines in an Incidental Harassment Authorization (IHA) issued to the USGS by the National Marine Fisheries Service (**http://woodshole.er.usgs.gov/project-pages/environmental_compliance/**). Two contracted Protected Species Visual Observers were onboard during the cruise to ensure compliance with the IHA.

*USGS technicians (left to right) **Tom O'Brien**, **Eric Moore**, and **Wayne Baldwin** deploy the seismic streamer from the stern of the research vessel* Pelican *to collect data on gas hydrates in the deepwater Gulf of Mexico. USGS photograph taken in May 2013 by **Robert Wyland**.*

*USGS technicians **Eric Moore** (left) and **Jenny White** deploy air guns (silver cylinders), compressor hose (black), and orange buoys at the start of a seismic survey to explore gas hydrates in the deepwater Gulf of Mexico. USGS photograph taken in May 2013 by **Patrick Hart**.*

A closely-spaced grid of 65 two-dimensional (2D) seismic-reflection profiles and longer OBS-appropriate seismic lines

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totaling 397 kilometers (nearly 250 miles) were recorded at the Green Canyon site, centered on the 2009 gas hydrate drilling locations. The OBS were recovered after completion of the MCS acquisition, and the *Pelican* transited to the Walker Ridge site, where the OBS and MCS operations were repeated. Twenty-five OBS were deployed, and 450 kilometers (about 280 miles) of 2D data along 43 profiles were acquired at Walker Ridge. Data acquisition was completed on May 2, and the *Pelican* was back at LUMCON in Cocodrie on May 3. (Additional information about the cruise, including maps of the ship's track, is posted at **http://walrus.wr.usgs.gov/infobank/p/p0113la/html/p-01-13-la.meta.html**.)

Preliminary processing of the MCS data was completed at sea soon after the acquisition of each line. This onboard processing provided continuous quality control and enabled underway adjustments to be made to the pre-planned program. The preliminary MCS seismic images show dramatic improvements in vertical resolution in comparison with available private-sector data at the two study sites. Increased resolution is critical for the interpretation of these gas hydrate deposits, which the 2009 logging-while-drilling data (data collected during drilling by instruments positioned behind the drill bit) have shown to be considerably thinner than the resolution possible with the previously available seismic-reflection data. The seismic-reflection image on page 2 shows an example of the new MCS data from the Walker Ridge site.

Final processing of the MCS and OBS data is currently underway. OBS data-processing efforts are focusing on:

- Determining the velocities of both P- (compressional) and S- (shear) waves through the imaged layers, which yield information about the composition of the layers, including whether they contain gas hydrate, and
- Creation of images based on the reflection of P-waves from boundaries between sediment layers (like the images produced by the MCS system) and images based on the conversion of P-waves to S-waves at boundaries between layers (which yield different information not available to the MCS system).

On the basis of the quality and volume of seismic data acquired, the USGS 2013 Gulf of Mexico gas hydrate research cruise was highly successful. The data processing and interpretation phases are just beginning, but the outlook is promising for a much more detailed understanding of gas hydrates in the Gulf of Mexico.

Seismic equipment is craned off the research vessel Pelican *at the dock in Cocodrie, Louisiana, after a 15-day expedition to explore gas hydrates in the deepwater Gulf of Mexico. USGS photograph taken May 2013 by* ***Patrick Hart****.*

Deep-Sea Instrument Tripod Passes Test in Monterey Bay, California—Next Stop is South China Sea

By Helen Gibbons, George Tate, and Jingping Xu

A deepwater tripod system designed by the U.S. Geological Survey (USGS) will be the first of its kind to be deployed on the bottom of the South China Sea at depths approaching 3,000 meters (10,000 feet). Instruments mounted on the tripod will gather data to help scientists better understand how and where deep-seafloor sediment moves and accumulates. Such knowledge can be applied in deep waters adjacent to the United States as well, to determine where contaminated sediment is likely to accumulate, for example, or to choose favorable sites for undersea cables and other infrastructure.

The free-ascending tripod, or FAT, was designed by **George Tate**, head of the Marine Facility (MarFac) of the USGS Pacific Coastal and Marine Science Center in Santa Cruz, California. Tate and engineering technician **Peter Harkins** built the tripod at MarFac, and on February 6, 2013, a team from the science center—Tate, Harkins, **Hank Chezar**, **Joanne Ferreira**, **Kurt Rosenberger**, and **Jingping Xu**—tested the new system at the Santa Cruz

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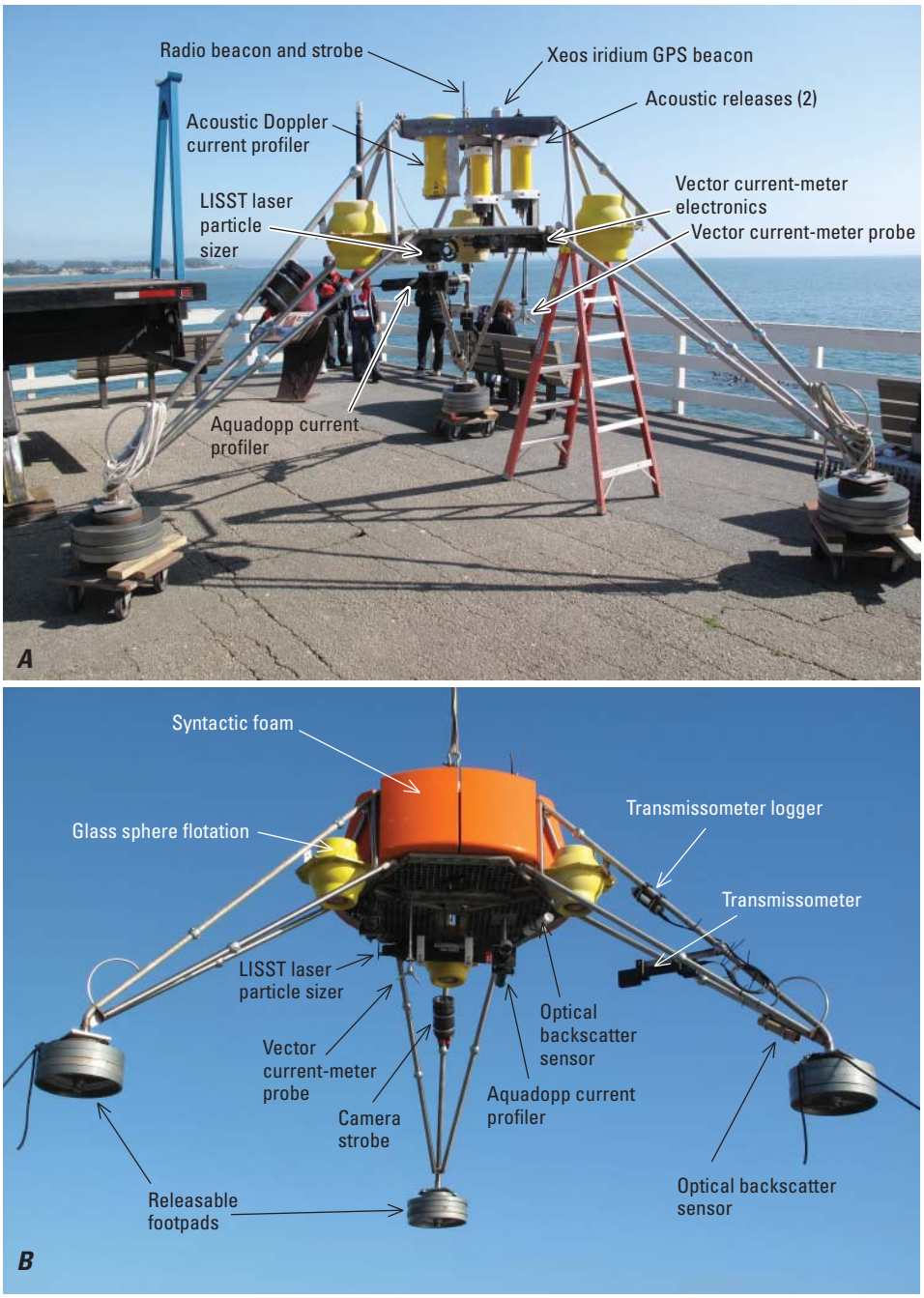
Municipal Wharf. The tripod passed with flying colors, clearing it for use later this year in the project "In-Situ Observation of Bottom Currents and Sediment Transport in the Northeastern South China Sea," a study co-sponsored by the USGS and Tongji University (**http://www.tongji.edu.cn/english/**; see related *Sound Waves* story at **http://soundwaves.usgs.gov/2012/06/staff.html**). The project is funded by the National Natural Science Foundation of China (NSFC, **http://www.nsfc.gov.cn/e_nsfc/desktop/zn/0101.htm**). USGS participation is headed by **Jingping Xu**.



*New USGS deepwater tripod, called the free-ascending tripod, or FAT. **A**, Sitting on the Santa Cruz Municipal Wharf in Santa Cruz, California, and **B**, suspended from a crane before being lowered into water. Some of the instruments mounted on the tripod have been labeled. USGS photographs taken February 6, 2013, by George Tate.*

Project scientists working in the South China Sea will collect current and sediment data in the layer of water just above the seafloor—called the "bottom boundary layer"—at depths of 2,000 meters (6,500 feet) to 3,000 meters (10,000 feet). In the bottom boundary layer, sediment and biological particles on the seafloor interact with the near-bed currents, a process that determines why and how these particles are resuspended into the water column or deposited and accumulated on the seafloor. The scientists aim to better understand (1) bottom-boundary-layer processes and (2) the circulation of near-bed currents in the deep basin of the region. These currents are thought to hold the keys to understanding the source, transport, and deposition of the deep-sea sediment and the evolution of the basin-scale

*USGS personnel adding pieces of syntactic foam (composed of glass microspheres embedded in resin) that will provide buoyancy to raise the tripod to the surface for recovery. Left to right: **Jingping Xu**, **Hank Chezar**, **Kurt Rosenberger**, and **Peter Harkins**. USGS photograph taken February 6, 2013, by **George Tate**.*

sediment deposits. Using a platform that sits on the bottom, like the new deepwater tripod, is the most efficient way to collect near-seabed data continuously for a long period of time.

The new tripod is a stainless-steel frame approximately 2 meters (6.5 feet) tall, with a triangular base about 4 meters (13 feet) on a side. It weighs approximately 900 kilograms (nearly 2,000 pounds) in air and

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has a deployed buoyant weight of about 110 kilograms (240 pounds). The tripod carries a suite of acoustic (sound-based) and optical (light-based) instruments for measuring current velocity, temperature, and sediment concentration in the bottom boundary layer. Many of the instruments make simultaneous measurements at different heights above the seafloor, creating vertical "profiles" of the properties being measured. A high-definition camera system takes photographs of the ocean floor to record variations over time in seafloor morphology (shape) and bioturbation (mixing of seafloor sediment by burrowing organisms).

What makes the new tripod unusual is the mechanism for raising it from the deep seafloor to the surface so that the data it has collected can be recovered. Similar tripods used to collect bottom-boundary-layer data in relatively shallow water on the continental shelf are fitted with buoys attached to a coiled recovery line. An acoustic (sound) signal sent from a vessel at the sea surface triggers the release of the buoys, which rise to the surface pulling one end of the recovery line with them. Scientists can then motor to the buoys, attach the recovery line to a winch cable, and pull the tripod off the bottom and onto the deck. Such release systems are limited to a maximum depth of approximately 200 meters (650 feet). Because of this limitation, current measurements in the deep ocean are typically collected by instruments attached to a long mooring—a line with a large flotation package at the surface and a heavy anchor at the seabed. The heavy anchor makes unobstructed near-bed flow measurements extremely difficult. Tripods permit more open flow near the seabed, and so the USGS team developed a system for recovering a tripod from the deep seafloor.

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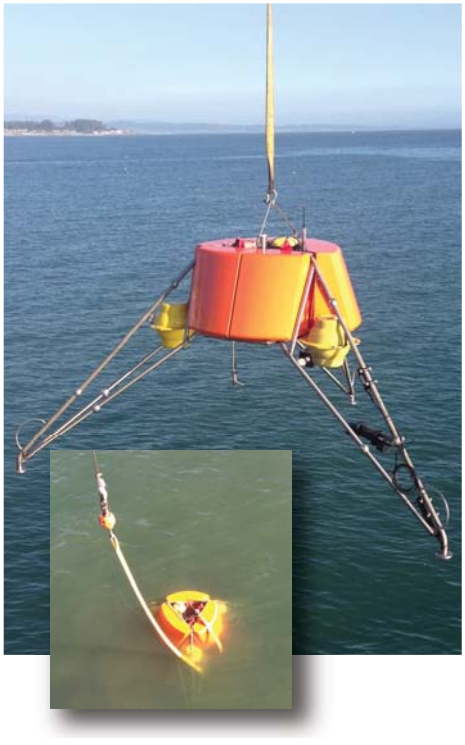
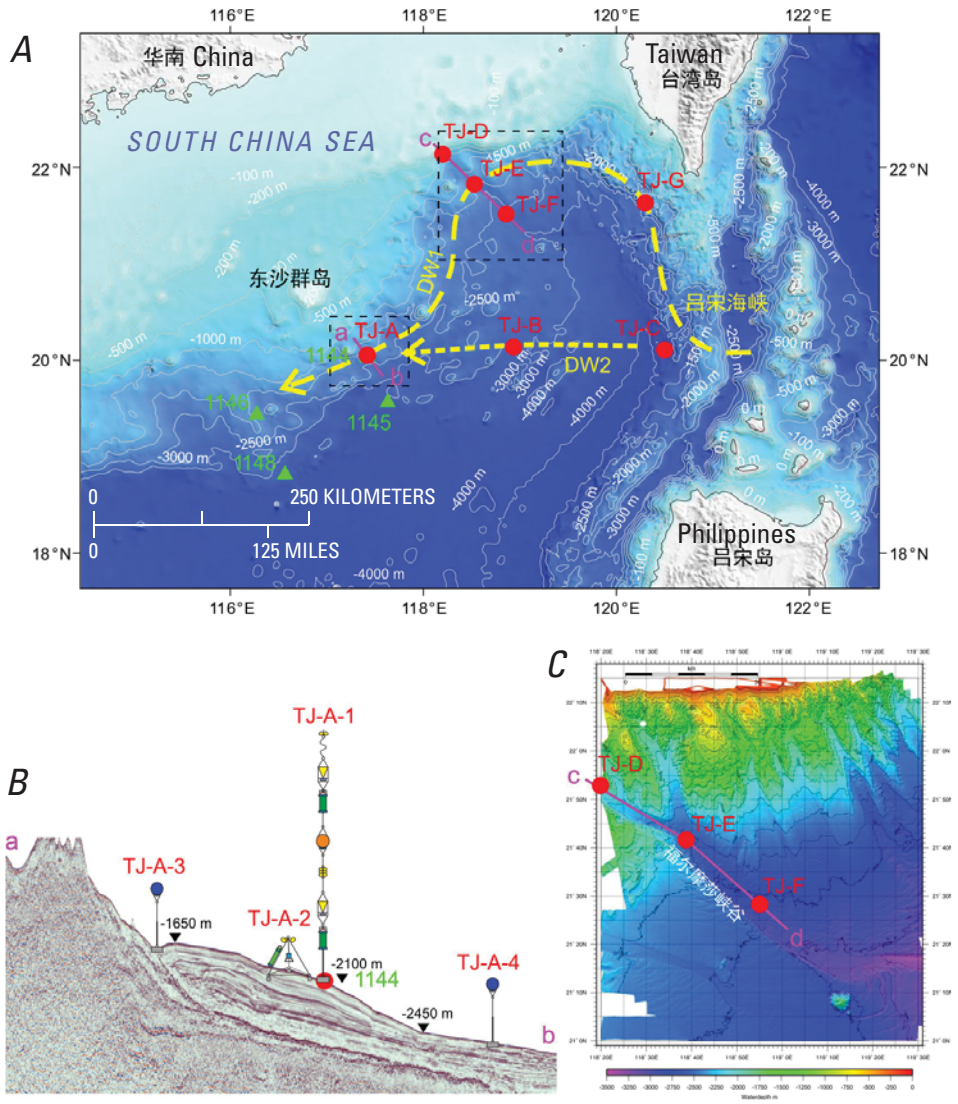


Success! The tripod, now lacking its footpads, has been lifted out of the water after rising by itself to the surface (note slack winch line in inset photograph). USGS photographs taken February 6, 2013, by ***Jingping Xu****.*



A*, Sites in South China Sea where the USGS deepwater tripod and about a dozen moorings will collect data to shed light on sediment movement and accumulation on the seafloor. Red dots, sites of instrumented platforms. Green triangles, sites of Ocean Drilling Program (ODP;* ***http://www-odp.tamu.edu/****) boreholes. Long-dashed yellow line, hypothesized route of deep contour-following current entering from the Pacific Ocean. Short-dashed yellow line, hypothesized alternative route of deep current from the Pacific.* ***B****, Seismic-reflection profile along line a–b on map, showing sediment layers in an apparent contourite (deposited by contour currents). Simplified drawings indicate where scientists intend to place the tripod (TJ-A-2) and several moorings (TJ-A-1, TJ-A-3, TJ-A-4).* ***C****, Enlarged map of line c–d, showing sites (red dots) where groups of moorings will be placed along the axis of a submarine canyon (Formosa Canyon).*

(Deep-Sea Tripod continued from page 6)

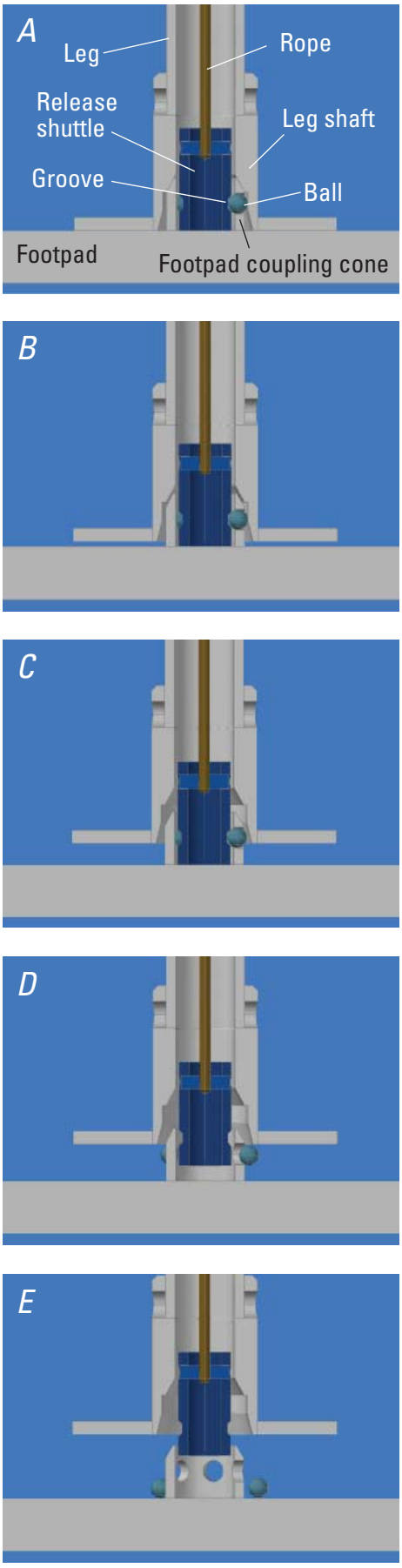
Rather than buoys that pull a recovery line to the surface, the new USGS tripod is fitted with buoyant material that raises the entire tripod to the surface—hence the name free-ascending tripod. The tripod's recovery buoyancy is provided by hydrodynamic pieces of syntactic foam (a moldable material made of glass microspheres embedded in resin) that surround the instrument bay in the upper section of the tripod. The anchor weight is provided by the three low-profile lead-and-stainless-steel footpads at the ends of the legs. The footpads are attached by high-strength fiber rope to a pair of redundant acoustic releases in the instrument bay. (Ideally, both of these devices will respond to a release command sent from the vessel, but the tripod will be freed for ascent even if only one of them works.) The rope supplies tension to a locking mechanism at the end of each leg that keeps the footpad firmly attached to the leg. When an acoustic command is sent from a vessel at the surface, the tension on the rope slackens, the locking mechanism releases, and the tripod detaches from the footpads, which remain at the seafloor. The syntactic foam provides nearly 300 kilograms (about 650 pounds) of buoyancy, which raises the tripod to the surface for recovery. The release coupling employs an innovative, simplified design developed specifically for the new tripod (see diagram at right).

When deployed, the USGS deepwater tripod will join a dozen or so moorings to form the largest field campaign ever conducted for deep-sea sediment-transport research in the South China Sea. The results are expected to improve understanding of factors that influence sedimentation in the region, including:

- distribution of near-bottom ocean currents in the study area,
- turbidity currents and the mechanisms that trigger them,
- processes that determine whether particles in the bottom boundary layer remain suspended in the water or settle on the seafloor, and
- sources and pathways of the bottom sediment that has accumulated in the study area.

Knowledge gained from the research can be applied in practical ways; examples include siting of deep-sea cables and other infrastructure; assessment of hazards related to submarine landslides, including tsunamis; and determination of whether and where polluted sediments are likely to accumulate on the deep seafloor.

For more information, contact **Jingping Xu**, **jpx@usgs.gov,** or **George Tate**, **gtate@usgs.gov**.



*Ball-lock release sequence for releasing tripod leg from footpad. **A**, Five stainless-steel balls (greenish blue in this diagram) fit into holes in the footpad coupling cone (gray), which is welded to the footpad. In the locked position, these balls are trapped between the groove in the release shuttle (blue) and the wall of the leg shaft (gray). Tension in the high-strength fiber rope (brown) attached to the release shuttle keeps the footpad coupling cone and attached footpad from separating from the tripod leg. **B**, An acoustic signal from the surface activates a transponder that releases tension in the rope, allowing the tripod legs to begin to rise via lift provided by the syntactic foam on the upper frame of the tripod. Slack in the rope allows the release shuttle to rest on the footpad while the leg shaft rises. The footpad coupling cone holds the balls in place between the release shuttle groove and the leg shaft as they slide along the interior surface of the leg shaft. **C**, As the tripod leg continues to rise, the balls reach the level of the enlarged radius at the base of the leg shaft, allowing for sideways movement. **D**, When there is no more slack in the rope, the release shuttle rises with the leg and the balls are pushed outward by the slanted groove in the shuttle. **E**, The balls have fallen out of the holes in the footpad coupling cone. Free of the heavy footpads, the tripod will continue rising until it reaches the surface.*

Predicting Hurricane-Induced Coastal Change—USGS Publications Will Help Community Planners, Emergency Managers

By Vic Hines, Hilary Stockdon, and Hannah Hamilton

The probability of hurricane-induced coastal change on sandy beaches from Florida to New York has been assessed for the first time in two U.S. Geological Survey (USGS) studies released on July 1, 2013.

The two reports—one assessing the coastline from Florida to North Carolina, the other from Virginia to New York—can function as part of a "virtual toolkit" for U.S. Atlantic coast community planners and emergency managers as they make decisions on how to best address coastline vulnerabilities. The new publications complement a 2012 report on the hurricane vulnerability of the U.S. Gulf of Mexico coast (**http://soundwaves.usgs.gov/2012/10/research4.html**).

The new reports show that during even the weakest hurricane, a category 1 with winds between 74 and 95 miles per hour, 89 percent of the dune-backed beaches from Florida to New York are very likely (probability exceeds 90 percent) to experience dune erosion during a direct landfall. But scientists involved say the strength of the studies is in their ability to predict coastal change in specific areas.

An associated online mapping tool (**http://coastal.er.usgs.gov/hurricanes/erosionhazards/**), based on a USGS state-of-the-art model, will allow community planners and emergency managers to focus on a specific storm category and see the predicted coastal change in their area. The tool incorporates findings from the two new reports on the Atlantic coast as well as the 2012 report on the Gulf of Mexico coast. The information it provides can help planners and managers with decisions ranging from changing building codes and choosing locations for new construction to determining the best evacuation routes for future storms.

"The USGS has been working on identifying storm-driven coastal-change hazards for more than a decade," said **Hilary Stockdon**, co-author of the studies and research oceanographer with the USGS St. Petersburg Coastal and Marine Science Center in St. Petersburg, Florida. "The data collected and modeling capabilities developed during that period are what's enabled us to complete these regional assessments of predicted coastal change, providing key information to decision makers working to build more resilient communities and take actions to protect lives and property before storms hit."

*Parking areas, septic systems, and foundations in South Nags Head, North Carolina, collapsed when the underlying dune was eroded during the September 1999 landfall of Hurricane Dennis. Figure 1 from USGS Open-File Report 2013–1130, <**http://pubs.usgs.gov/of/2013/1130/**>.*

For the entire Atlantic coast study area, the modeling also shows that during a category 1 hurricane, storm waves are expected to increase water levels at the shoreline by approximately 150 percent above storm-surge levels. For example, in a category 1 storm with a surge of 2 meters (about 6 feet), waves would raise water levels at the shoreline by an additional 3 meters (10 feet), for a total water elevation of 5 meters (16 feet). Results show that waves play a significant role in elevating water levels during lower category storms, whereas storm surge is the major contributor to high water levels in stronger storms.

In an assessment of Atlantic coast dune heights from Florida to New York, the researchers found the southeast coasts, because of their lower dune elevations, more likely to experience overwash, or the landward movement of beach sand, than coastlines farther north. Dune heights from Delaware to New York are 1.4 meters (4.6 feet) higher, on average, than the dunes from Maryland south to Florida. Of the beaches studied, those on the South Carolina coast, where average dune elevations are only 2.9 meters (9.5 feet), are the most vulnerable to overwash. Ninety-six percent of coastal locations in the State are likely to undergo overwash if a category 1 hurricane makes landfall there.

Before Hurricane Sandy, dunes on New York's south shore were among the highest on the Atlantic coast, and so during a category 1 storm, only 9 percent of these coastal areas were likely to experience overwash. Still, these high dunes were vulnerable to extreme erosion during a category 1 hurricane, with 76 percent of the dunes very likely to be eroded. Such erosion was observed during Hurricane Sandy, which made landfall as an extratropical cyclone but pounded the beach with hurricane-strength waves and surge. The protective sand dunes along barrier islands in New Jersey and New York were completely eroded in places, increasing

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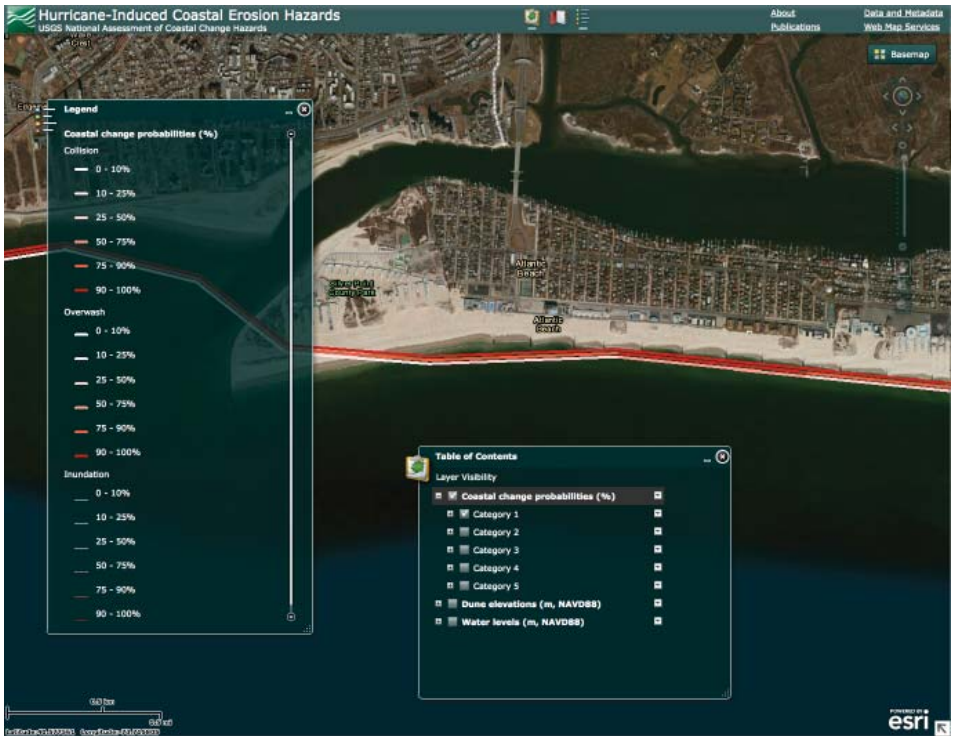
vulnerability to more extreme erosion during future storms.

But vulnerability doesn't just come down to dune height; scientists credit the continuity of the dunes as being one of the key reasons coastal vulnerabilities vary greatly along the coast.

"Large areas of the South Carolina coast are very likely to erode during hurricanes due to long, continuous stretches of low dunes. In other areas, such as Delaware and New York, the mix of high and low dune elevations creates a more complex picture of vulnerabilities, where relatively safe areas are adjacent to areas that are likely to be inundated," said Stockdon.

"Inundation" is a process by which an entire beach system is submerged and, in extreme cases, can result in island breaching. Only 9 percent of the entire Atlantic coast study area is very likely to be inundated in a category 1 storm, although the percent is significantly higher in some regions. If a category 1 storm makes landfall on the South Carolina coast, for example, 34 percent of the beaches and dunes there are very likely to be inundated.

Beaches serve as a natural buffer between the ocean and inland communities, ecosystems, and natural resources. However, these dynamic environments move and change in response to winds, waves, and currents. During extreme storms, changes to beaches can be large, and the results are sometimes catastrophic. Lives may be lost, communities destroyed, and millions of dollars spent on rebuilding.



*Closeup view of Atlantic Beach on Long Island, New York, in USGS Hurricane-Induced Coastal Erosion Hazards online interactive tool, <**http://coastal.er.usgs.gov/hurricanes/erosionhazards/**>. Screenshot shows probabilities of (a) collision, in which dune toe is eroded by waves and surge (line closest to shore, 90–100 percent in stretch directly in front of "Atlantic Beach" label near center of image), (b) overwash, in which sand is transported landward over beach and dune (middle line, 75–90 percent in same stretch), and (c) inundation, in which beach and dune are completely and continuously submerged (line farthest from shore, 25–50 percent in same stretch) during a category 1 storm. Other layers can be chosen to display dune elevations (at crest and toe) and predicted water levels (mean water levels and extreme water levels) for selected storm categories.*

*Waves and surge during Hurricane Sandy (October 2012) left an overwash deposit covering roads, parking areas, and homes in Mantoloking, New Jersey. Yellow arrows point to the same features in each photograph. Figure 2 from USGS Open-File Report 2013–1131, <**http://pubs.usgs.gov/of/2013/1131/**>.*

These reports and the online mapping tool can serve as an important resource for coastal planners and emergency managers as they work to protect their communities from future storms.

The 2013 Atlantic coast publications, the 2012 Gulf of Mexico publication, and Internet mapping services are available online. Their full citations are:

Doran, K.S., Stockdon, H.F., Sopkin, K.L., Thompson, D.M., and Plant, N.G., 2013, National assessment of hurricane-induced coastal erosion hazards—Mid-Atlantic coast: U.S. Geological Survey Open-File Report 2013–1131, 28 p. <**http://pubs.usgs.gov/of/2013/1131/**>.

Stockdon, H.F., Doran, K.J., Thompson, D.M., Sopkin, K.L., and Plant, N.G., 2013, National assessment of hurricane-induced coastal erosion hazards—Southeast Atlantic coast: U.S. Geological Survey Open-File Report 2013–1130, 28 p. <**http://pubs.usgs.gov/of/2013/1130/**>.

Stockdon, H.F., Doran, K.J., Thompson, D.M., Sopkin, K.L., Plant, N.G., and Sallenger, A.H., 2012, National assessment of hurricane-induced coastal erosion hazards—Gulf of Mexico: U.S. Geological Survey Open-File Report 2012–1084, 51 p. <**http://pubs.usgs.gov/of/2012/1084/**>.

U.S. Geological Survey St. Petersburg Coastal and Marine Science Center, 2013, National assessment of hurricane-induced coastal erosion: U.S. Geological Survey website, <**http://coastal.er.usgs.gov/hurricanes/erosionhazards/**>.

Weight-Based Approach to Measuring Coral Growth Offers Valuable Tool for Reef Researchers and Managers

New Technique Reveals Surprising Growth Patterns in the Florida Keys

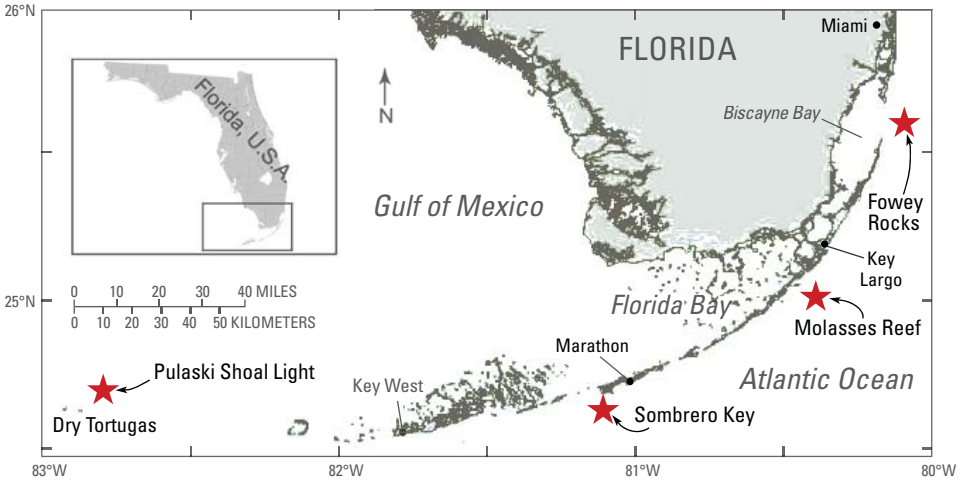
By Ilsa Kuffner, Ann Tihansky, Hannah Hamilton, and Helen Gibbons

An innovative weight-based approach to monitoring coral growth in the wild has been developed by U.S. Geological Survey (USGS) researchers and is expected to lead to more definitive answers about the status of coral reefs.

Corals and other marine organisms build their skeletons and shells through calcification, the biological process of secreting calcium carbonate obtained from seawater. The new weight-based approach to measuring coral calcification rates can provide finer scale resolution than traditional linear measurements of coral growth. It is a valuable tool for researchers and managers seeking to understand the global decline in coral reefs.

Using the weight-based approach, USGS scientists established a new calcification-monitoring network in 2009 to study coral growth in the Florida Keys. They published their results in June 2013 in the journal *Coral Reefs*, and their article is available for free download at <**http://dx.doi.org/10.1007/s00338-013-1047-8**>.

The researchers measured growth rates of the reef-building coral *Siderastrea siderea* (massive starlet coral) at four sites in the Florida Keys Reef Tract (see map). (Early stages of this study are described in "Coral Calcification Rates in South Florida During Times of Changing Ocean Conditions," *Sound Waves*, October/November 2010, <**http://soundwaves.usgs.gov/2010/11/fieldwork2.html**>.) At each of the four sites, the researchers securely fastened 10 concrete blocks to the seafloor. For each block, a sample of massive starlet coral collected near the study site was epoxied to a plastic disc fitted with a 10-centimeter (4 inch)-long stainless-steel threaded bolt. The researchers slid the bolt through a hole drilled into the concrete block and fastened it with a wing nut. Thus the disk and the coral sample epoxied to it were firmly attached to the block. Every 6 months, the corals-plus-disks were detached from the concrete blocks, transported by boat (while submerged in seawater), buoyantly weighed on land, and returned to their blocks later that day. Staining the outer layer of the samples at the start of the experiment and at springtime site visits allowed the researchers also to measure linear growth of the corals—the traditional way to monitor coral growth. Comparison of the weight data and linear-growth data confirmed their expectation that weight measurement would prove a more precise and efficient way to calculate calcification rates.



Florida Keys, showing four sites (red stars) where calcification rates were monitored by USGS researchers who recently reported their findings in Coral Reefs, <***http://dx.doi.org/10.1007/s00338-013-1047-8***>. *The sites are named for adjacent National Data Buoy Center stations: Pulaski Shoal Light, Sombrero Key, Molasses Reef, and Fowey Rocks. Modified from USGS Coral Reef Ecosystem Studies (CREST) project webpage "Research: Monitoring Coral Reef Growth" at* <***http://coastal.er.usgs.gov/crest/research-themes/calcification.html***>.

"A coral may grow two millimeters in height on the left side of the colony and five millimeters on the right, so linear measurements are inherently variable and require sampling hundreds of corals to detect changes in growth over time…our method requires only 10 corals per site," said **Ilsa Kuffner**, USGS scientist and lead author of the study.

Using the weight-based approach, Kuffner's team has provided important baseline information on spatial and seasonal variability in calcification rates of reef-building corals in the Florida Keys. For example, they found that colonies of the massive starlet coral calcified about 50 percent faster in summer than in winter. They also discovered that, during the study period, the coral grew about 50 percent faster in the remote Dry Tortugas National Park than at three other outer-reef tract sites offshore of Miami, Key Largo, and Marathon, Florida (see map). The reasons behind this surprising pattern are not clear, leaving a mystery sure to pique the interest of many reef managers.

SCUBA diver working on a calcification station at Fowey Rocks, Biscayne National Park, Florida. Photograph by ***Carlie Williams****, USGS.*

(Measuring Coral Growth continued on page 11)

(Measuring Coral Growth continued from page 10)

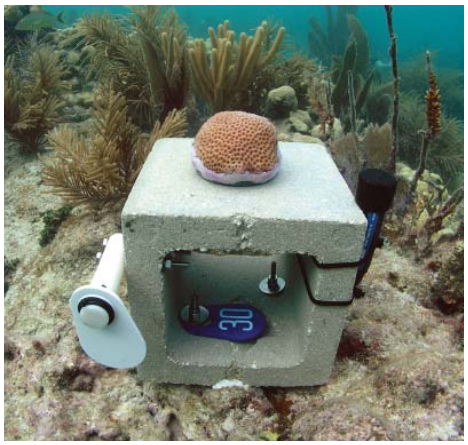
The new approach could be highly useful to managers because it can detect small changes in growth rate over space and time due to its high level of precision. Measuring changes in growth is becoming increasingly important as corals face challenges from ocean acidification (decreasing pH caused by increasing atmospheric CO_2) and other climate-change and land-use impacts. Additionally, the method uses inexpensive and easy-to-find materials, and no corals are harmed in the process.

"This tool provides the kind of scientific information needed to manage coral reefs at the ecosystem scale by looking at the relationships between coral health, climate change, and water quality. It provides partners and reef managers with better, more sensitive metrics to assess coral growth, identify the most important variables, and prioritize strategies to protect and preserve these valuable ecosystems," said Acting USGS Director **Suzette Kimball**. "It is also one of the ways USGS science is advancing the National Ocean Policy by supporting a number of on-the-ground priority actions."

A next step in understanding declines in coral growth is discerning the different components of water quality that are driving calcification rates, and this can only be achieved through the cooperation of reef managers and scientists around the world. The real power in the new approach will be realized if it is applied across many reefs that naturally have different temperature regimes, water quality, and pH conditions.

"The study results suggest that we should pay more attention to different aspects of water quality if we hope to understand and predict what will happen to coral reefs as oceans continue to change," said Kuffner.

According to Kuffner, managers already know that coral reefs are in decline, but they want to know why. They need a linkage between cause and effect that explains why reefs are not growing like they used to or are not recovering from disease or die-off events. Correlating finely measured coral growth rates with water quality and other environmental information is an important step toward making these linkages so they can inform management decisions.



Underwater photograph of a calcification station (1 of 40). Attached are a colony of the reef-building coral Siderastrea siderea *(top), a temperature logger (black, on right), and an "accretion tile" (white, on left) for collecting crustose coralline algae, calcifying organisms that help cement reefs and provide reef-building coral larvae a place to settle. The growth rates of these important calcifiers were also monitored during the study. Figure 2 from "Calcification rates of the massive coral* Siderastrea siderea *and crustose coralline algae along the Florida Keys (USA) outer-reef tract" in* Coral Reefs, <***http://dx.doi.org/10.1007/s00338-013-1047-8***>.

Coral reefs are in decline globally, with the National Oceanic and Atmospheric Administration currently proposing to list 66 reef-building coral species under the Endangered Species Act (**http://www.nmfs.noaa.gov/pr/species/invertebrates/corals.htm**). Identifying the cause of the decline is not straightforward. Oceanographic instruments have confirmed that the ocean is warming, acidifying, and changing in other aspects of water quality. Warming and acidification are results of altered carbon distribution due to burning of fossil fuels; other changes in water quality stem largely from land-use changes. Laboratory studies demonstrate that all three of these environmental stressors can hinder coral growth, but linking the causative agents to reef decline in the natural environment requires dependable, precise methods to detect change over time.

This study is part of a larger USGS Coral Reef Ecosystem Studies (CREST) project aimed at understanding the status, construction, and resilience of shallow-water reef environments around Florida and U.S. Caribbean islands, and forecasting future change to inform reef-management strategies. Current areas of research include the Dry Tortugas, U.S. Virgin Islands and Biscayne National Parks, and selected areas of the Florida Keys National Marine Sanctuary.

To learn more about the CREST project, please visit the website at <**http://coastal.er.usgs.gov/crest/**>.

To learn about USGS coral reef studies in the Pacific region, visit the USGS Pacific Coral Reefs Website, <**http://coralreefs.wr.usgs.gov/**>.

Massive starlet coral, Siderastrea siderea. *Photograph by* ***Ilsa B. Kuffner****, USGS.*

To learn more about the methods used during the coral-growth study, read "Methods for Monitoring Corals and Crustose Coralline Algae to Quantify In-Situ Calcification Rates," USGS Open-File Report 2013–1159, posted at <**http://pubs.usgs.gov/of/2013/1159**/>.

The full citation for the recent article in *Coral Reefs* is:

Kuffner, I.B., Hickey, T.D., and Morrison, J.M., 2013, Calcification rates of the massive coral *Siderastrea siderea* and crustose coralline algae along the Florida Keys (USA) outer-reef tract: Coral Reefs, published online June 8, 2013, doi:10.1007/s00338-013-1047-8 <**http://dx.doi.org/10.1007/s00338-013-1047-8**>.

(The coral-growth study was conducted under scientific permits from the Florida Keys National Marine Sanctuary and the National Park Service. The USGS Coastal and Marine Geology Program funded the majority of the study, and the U.S. Department of the Interior [DOI] Southeast Climate Science Center provided supplementary funds.)

On California's Beaches, Mallard Ducks Have Learned to Surf for Food

By Ben Young Landis

*Slightly modified from "WERC from the Field" story at <**http://www.werc.usgs.gov/outreach.aspx?RecordID=186**>*

Mallards (*Anas platyrhynchos*)—that familiar duck species ubiquitous to park ponds with males parading their emerald-green heads—have picked up a new feeding habit along the beaches of Santa Barbara.

These ducks have learned to surf. For sand crabs.

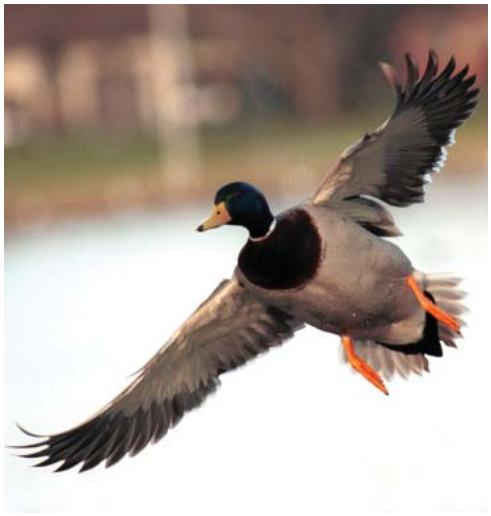
U.S. Geological Survey (USGS) Western Ecological Research Center scientist **Kevin Lafferty** and **John McLaughlin** and **Jenifer Dugan** of the University of California, Santa Barbara, reported this newly observed feeding behavior in the June 2013 issue of *The Wilson Journal of Ornithology*, <**http://dx.doi.org/10.1676/12-141.1**>.

"We watched as a swash (the part of a broken wave that washes up a beach) approached a Mallard (*Anas platyrhynchos*) from behind, lifted it, and deposited it down the beach; the bird then stuck its bill in the sand, swept it from side to side, dug, captured a Pacific sand crab (*Emerita analoga*) and swallowed it; this occurred again and again."

The scientists described the surfing behavior further: "Unlike foraging shorebirds, Mallards do not avoid incoming swashes. Instead, the incoming swash lifts and deposits them down the beach."

Lafferty and colleagues first observed this behavior at Coal Oil Point Reserve (**http://coaloilpoint.ucnrs.org/**) near the UC Santa Barbara campus in 2011. The behavior continues to be observed in Santa Barbara Mallards, and is now also known from Mallards in Ventura and San Diego County, as well as Coos Bay in Oregon.

Sand crabs are quick burrowers adept at escaping human fingers and hungry predators, as any surf angler or curious child knows. The only other ducks known to feed on them are scoters (genus *Melanitta*), which are specialized for sea diving. Black Brants (*Branta bericla nigricans*) have also been seen to feed in the surf zone on sand crabs.



A male Mallard in flight. Photograph courtesy of the U.S. Fish and Wildlife Service.

But Mallards are a freshwater species that mostly "dabbles" at the water surface for food bits. How did they learn to surf and dig for little sand crabs? Is this a case of duck-see, duck-do?

The scientists speculate:

"It is possible that this behavior is a recent by-product of adaptation to human-dominated landscapes. Mallards commonly occur at wetlands and parks near sandy beaches and are tolerant to human activities. Continual exposure to novel feeding opportunities in these areas might have eventually predisposed some Mallards to mimic shorebirds feeding in the swash zone. In any case, Mallards can now be considered a part of the sandy beach food web along the west coast."

The full citation for the recent report is:

Lafferty, K.D., McLaughlin, J.P., and Dugan, J.E., 2013, Novel foraging in the swash zone on Pacific sand crabs (*Emerita analoga*, Hippidae) by Mallards: The Wilson Journal of Ornithology, v. 125, no. 2, p. 423–426, doi:10.1676/12-141.1 <**http://dx.doi.org/10.1676/12-141.1**>.

*Screenshot from a video of surf-feeding behavior at William Randolph Hearst Memorial State Beach in San Simeon, California, January 2013. Watch the video, by "WERC from the Field" reader **Joanne Aasen**, at <**http://www.flickr.com/photos/cambriabird/8354888665/**>.*

*Mallards observed feeding in the surf. Photograph courtesy of **Dave Hubbard**, University of California, Santa Barbara.*

A sand crab or mole crab. Photograph courtesy of the California Academy of Sciences.

Inspiring Girls To Pursue Careers in STEM

By Rex Sanders

How can we inspire girls to pursue careers in science, technology, engineering, and mathematics (STEM)? An informal group of scientists at the U.S. Geological Survey (USGS) Pacific Coastal and Marine Science Center (PCMSC) decided to help. On Earth Day, April 22, 2013, five women scientists from the science center gave presentations and answered questions for girls and parents at Gateway School in Santa Cruz, California.

Although girls perform as well as or better than boys on many indicators of educational achievement, women lag behind men in STEM careers. A report published in 2011 by the Department of Commerce (**http://www.esa.doc.gov/Reports/women-stem-gender-gap-innovation**) contains these statistics:

- 24 percent – Scientists and engineers who are women
- 28 percent – Tenure-track STEM faculty who are women
- 41 percent – Ph.D.s in STEM fields earned by women

(For the record, approximately 40 percent of STEM jobs at the USGS Pacific Coastal and Marine Science Center are held by women.)

The gap between women and men starts early. Whereas girls and boys perform at similar levels in mathematics and science in elementary school, girls show less-positive attitudes toward science and have fewer out-of-school science experiences than boys. According to a report by the Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development (**http://www.nsf.gov/publications/pub_summ.jsp?ods_key=cawmset0409**), by eighth grade, only half as many girls as boys show an interest in STEM careers.

Scientists at the PCMSC, many of them parents, started discussing how they could inspire girls to pursue STEM careers. For the presentation at Gateway School, they set up a panel of very accomplished USGS women in STEM to discuss their exciting and fulfilling careers and inspire girls to pursue similar paths. The women shared their experiences, answered questions about what they do and how they got there, and described some of their successes and struggles. The panel members were: **Amy Draut**, Ph.D., geologist; **Andrea O'Neill**, M.S., meteorologist-oceanographer; **Li Erikson**, Ph.D., engineer; **Nadine Golden**, M.A., geographer; and **Nancy Prouty**, Ph.D., geochemist. **Curt Storlazzi**, Ph.D., a geologist whose daughter attends Gateway School, promoted the program.

*USGS scientists inspiring girls, left to right: **Amy Draut**, **Nadine Golden**, **Li Erikson**, **Andrea O'Neill**, and **Nancy Prouty**, with students from Gateway School, Santa Cruz, California.*

"If we're going to out-innovate and out-educate the rest of the world, we've got to open doors for everyone. We need all hands on deck, and that means clearing hurdles for women and girls as they navigate careers in science, technology, engineering and math."

*—**First Lady Michelle Obama**, September 26, 2011*

"I enjoyed the experience," said O'Neill. "It's good to know there are engaged parents and eager girls out there who are just starting to figure out their path in life and want to learn about the varied courses ahead of them."

Golden said, "An interesting aspect that I did not anticipate was the level of personal honesty that we were all able to share during the discussion about barriers girls face to STEM careers. Some barriers are well-known, documented, and observed, but there are many more that are subtle and difficult to define."

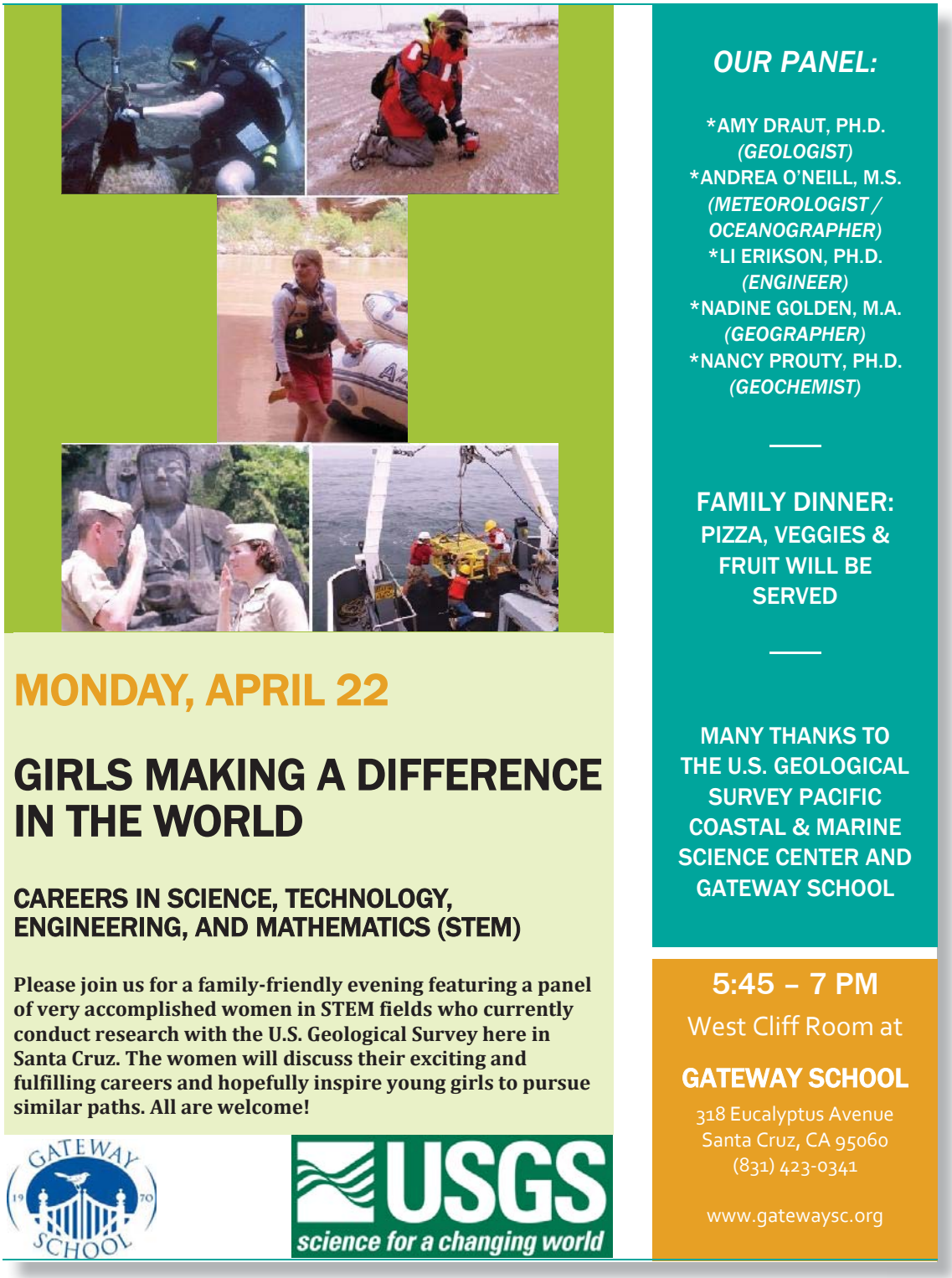
One girl said she was excited to learn that so many women could do such fun and interesting things outdoors for their jobs. A parent said her daughter was happy to learn that she could make maps for

(STEM continued on page 14)

(STEM continued from page 13)

a career. Eight girls attended with their parents around dinnertime. Storlazzi said, "I hope next time we get a time slot during school hours."

The informal USGS group plans to refine the format on the basis of feedback from educators, parents, and girls; expand to other schools in the area; repeat their presentation as girls move through school; and involve the approximately 30 other women in STEM at the PCMSC.❁



Flyer announcing the April 22, 2013, STEM night at Gateway School, Santa Cruz, California.

Meeting to Coordinate USGS Data Management to Support Ocean Planning

By the USGS Blueprint Team for Ocean Planning

Americans use their coastal ocean in many ways: fishing for food; drilling for oil; shipping fuels and manufactured goods; fishing, boating, and diving for enjoyment; U.S. Navy activities; and more. As we increase our use of the ocean, these activities are coming into conflict with each other. To resolve these conflicts, those who care about how we use the sea, and how we keep it clean and productive, can participate in a process called "ocean planning," which is part of the 2013 *National Ocean Policy Implementation Plan* (**http://www.whitehouse.gov/administration/eop/oceans/implementationplan**). Successful ocean planning will require a regional public process that considers all parties and all ocean uses, and it will also require trustworthy scientific data addressing ocean ecosystems and resources, the changing ocean environment, and the effects of both human activities and natural events. The U.S. Geological Survey (USGS) is one of the Federal agencies that will provide these data.

Providing scientific data to support ocean planning is not trivial. The data must provide answers to the right questions; it must have documentation so that it can be found and used; it must be in a format that allows it to be compared and combined with other kinds of data from other agencies; and its quality must be undeniable. The USGS already has established "best practices" for data management (for more information, see **http://www.usgs.gov/datamanagement/**) and Fundamental Science Practices that ensure the quality of our scientific products (for more information, see **http://www.usgs.gov/fsp/**). The current challenge for USGS data managers is to apply what they know to meet the needs of the National Ocean Policy.

To launch this effort, the USGS Blueprint Team for Ocean Planning convened a meeting to coordinate data-management activities to support ocean planning, February 20–21, 2013, at USGS Headquarters in Reston, Virginia. The intention of the meeting sponsors was to develop a flexible process that could be implemented throughout the USGS in support of many national initiatives in addition to ocean planning. A pilot

(Ocean Planning continued on page 16)

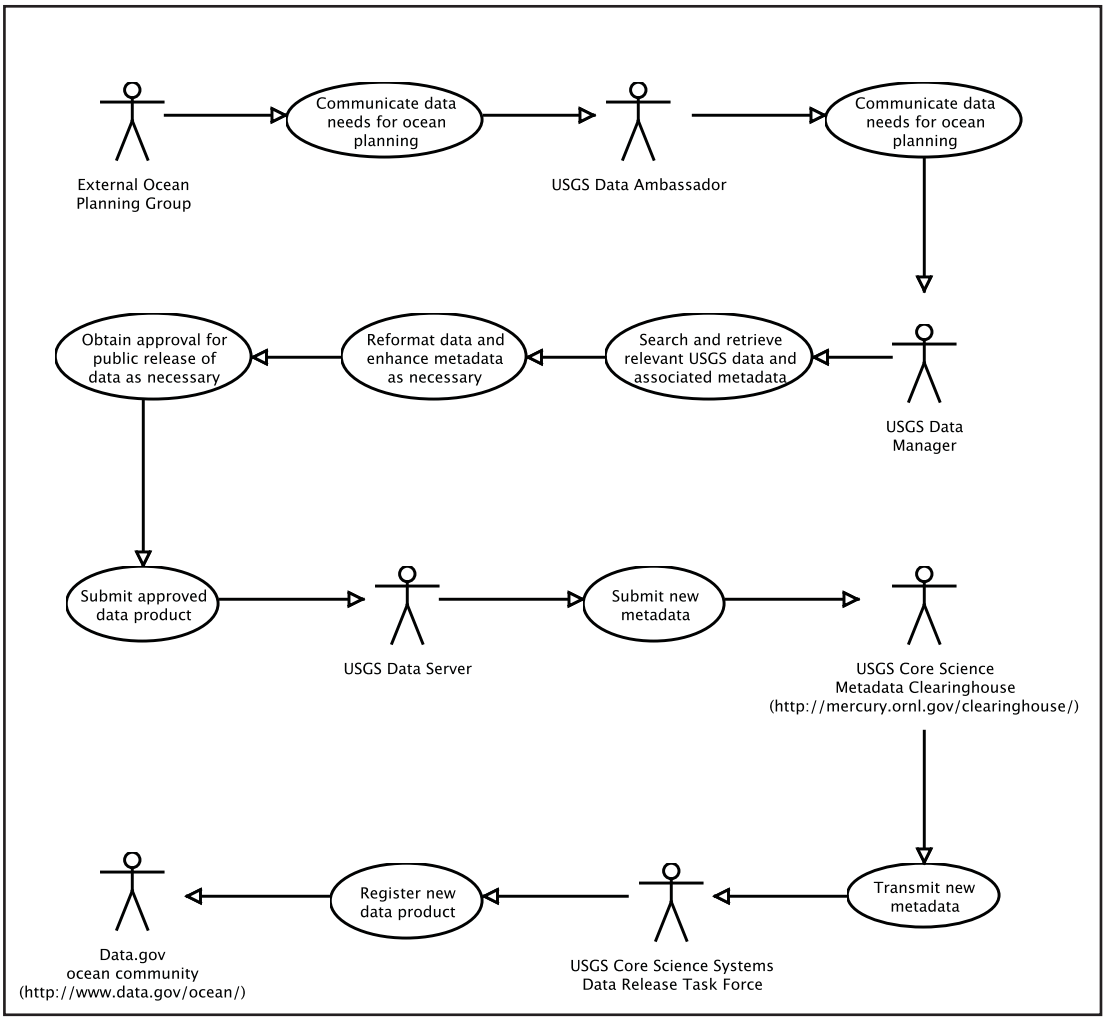


*Diagram illustrating the proposed process for coordinating USGS data management to support ocean planning. "Actors" in the process (stick figures) are the humans, organizations, and computers responsible for specific actions (ovals). Arrows indicate the general flow of events, beginning with communication of the data needs of external ocean-planning groups and ending with registration of relevant USGS data and associated metadata ("data about data") with the Data.gov ocean community (**http://www.data.gov/ocean/**). The envisioned process can be applied to support other national initiatives in addition to ocean planning.*

(Ocean Planning continued from page 15)

project focusing on data from the Coastal and Marine Geology Program (**http://marine.usgs.gov/**) will be used to refine this cooperative process for identifying appropriate datasets, evaluating their quality and usefulness, making necessary improvements, submitting them to online data-delivery services, and registering their metadata ("data about data") with online data catalogs such as the National Ocean Council portal on Data.gov (**http://www.data.gov/ocean/**). Meeting participants also identified essential areas of cooperation between the Coastal and Marine Geology Program, the Core Science Systems mission area (**http://www.usgs.gov/core_science_systems/**), and the Office of Science Quality and Integrity (**http://www.usgs.gov/quality_integrity/**) in developing the process. In the future, the process will expand to include additional USGS science programs with the help of the Science Data Coordinator Network (**http://www.usgs.gov/datamanagement/partners/SDCN.php**) and the Community for Data Integration (**http://www.usgs.gov/datamanagement/partners/CDI.php**).

Key aspects of managing USGS data to support ocean planning are:

- Development of the role of "data ambassador" to communicate with external planning groups that need scientific data and to convey their requirements to USGS data managers.
- Assignment of responsibility to Core Science Systems for maintaining the "pipeline" for registering USGS data products with Data.gov and its specialized communities (for more information on Data.gov communities, see **http://www.data.gov/communities**).
- Clarification of USGS standards and policies for data and metadata to ensure that USGS data products meet requirements for quality and interoperability.
- Use of standards-based online data-delivery services and data catalogs (for more information on these standards see **http://www.opengeospatial.org/standards**).

Meeting participants from across the USGS included **Fran Lightsom**, **Alan Allwardt**, **Kristy Guy**, **VeeAnn Cross**, **Carolyn Degnan**, **Greg Miller**, **Susan Russell-Robinson**, and **Rich Signell** from the Coastal and Marine Geology Program; **Andrea Ostroff**, **Mark Fornwall**, **Lisa Zolly**, **Viv Hutchison**, and **Mike McDermott** from Core Science Analytics and Synthesis; **Peter Schweitzer** from the Mineral Resources Program; **Barbara Poore** and **Doug Nebert** from the National Geospatial Program; **Steve Char** from the National Water-Quality Assessment Program; **Heather Henkel** from Priority Ecosystems Science; and **Keith Kirk** from the Office of Science Quality and Integrity. The charge to the meeting was presented by **Kevin Gallagher**, Associate Director for Core Science Systems, and **John Haines**, Program Coordinator for the Coastal and Marine Geology Program.

For more information on the USGS Blueprint Team for Ocean Planning, please contact **Fran Lightsom** (**flightsom@usgs.gov**) or **Andrea Ostroff** (**aostroff@usgs.gov**).

Mike Field Receives Department of the Interior's Distinguished Service Award

U.S. Geological Survey (USGS) emeritus geologist **Michael E. Field** has been awarded the highest merit award of the Department of the Interior, the Distinguished Service Award, in recognition of his outstanding scientific contributions to the study of coastal and marine geology and his exemplary leadership within the USGS and the scientific community. The honor was announced at a Pacific Coastal and Marine Science Center awards ceremony in Santa Cruz, California, on June 19, 2013. The citation letter, signed by Interior Secretary **Sally Jewell** on May 2, 2013, describes Mike's many achievements:

"Dr. Field's four-decade career as a geologist for the U.S. Government encompasses complex research that spans the globe from deep-sea fans to shallow coral reef environments. Dr. Field is a world leader in the study of coastal and marine sedimentology using a range of cutting-edge methods. As a pioneer of the first U.S. effort to systematically map the U.S. Exclusive Economic Zone (EEZ) in the Pacific Ocean, he conceptualized, led, and conducted creative studies of the morphology and sedimentology of continental shelf systems. These efforts spurred his interest in marine stratification in response to changes in sediment input, sea level, and climate change, about which he is now an acknowledged international expert. During the 1990s, Dr. Field served as the USGS Pacific Marine Geology Branch Chief. While leading the Branch, he guided the evolution of a national program for USGS Coastal and Marine studies and defined major new research directions that included important marine geologic hazard and environmental issues. As part of this transition, he conceptualized and spearheaded the USGS Coastal and Marine Geology Program's efforts to study the Nation's coral reefs. This effort, continuing for more than a decade, has solidified the role of the USGS Coastal and Marine Geology Program as a world leader in mapping, measuring, and modeling terrestrial sediment impacts to coral reefs, garnering numerous awards and accolades from the USGS and international coral reef community. Dr. Field's expertise and vision for the future led him to establish the USGS Pacific Science Center

(Distinguished Service continued on page 17)

(Distinguished Service continued from page 16)

and made it a founding member of the Monterey Bay Research Crescent Ocean Research Consortium, which comprises 26 organizations and is the largest concentration of marine science educational and research institutions in the world. Dr. Field has been active in several professional societies, serving as Treasurer of the National Society for Sedimentary Geology and on the editorial boards of *Marine Geology* and the *Journal of Sedimentary Research*. He is a superb leader who has inspired and motivated many young and senior scientists.

"For his outstanding scientific contributions to the study of coastal and marine sedimentology, and for his leadership to the USGS and the scientific community at large, Dr. Michael E. Field is granted the highest honor of the Department of the Interior, the Distinguished Service Award."❁

USGS emeritus geologist ***Michael E. Field*** *(left) receives the Department of the Interior's highest honor, the Distinguished Service Award, from USGS Pacific Coastal and Marine Science Center Director* ***Bob Rosenbauer****. USGS photograph by* ***Helen Gibbons****.*

Gene Shinn Writes *Bootstrap Geologist—My Life in Science*

By Helen Gibbons

On a May evening in Pittsburgh, Pennsylvania, at the 2013 convention of the American Association of Petroleum Geologists, retired U.S. Geological Survey (USGS) geologist **Gene Shinn** sat at a table signing copies of his new book, *Bootstrap Geologist—My Life in Science*. Gene was greeted with pleasure by numerous colleagues—from the oil industry, where he began his career; from the USGS, where he spent the greater part of it; and from academia, a world he recently joined as a courtesy professor at the University of South Florida.

Gene's new book details experiences and discoveries from each of these worlds, amassed over a career that has spanned nearly five decades.

Gene began as a lab assistant with Shell Development Company's Coral Gables Carbonate Research group. One of his Shell supervisors, **Marlan Downey**, cites Gene's energy, open mind, extraordinary level of curiosity, and powers of observation as the qualities that propelled him from lab assistant to senior geologist at Shell. Those same qualities, aided by his boating and scuba skills, led Gene to discoveries that were controversial for the time, such as his realization while diving in the Persian Gulf that limestone cement can form in saltwater, not just in freshwater.

After a varied and rewarding 15 years with Shell, Gene joined the USGS in 1974, taking a job that he writes "would lead to the most productive thirty-one years of my life." His curiosity unabated, Gene kept his eye on topics that had interested him at Shell, such as submarine cementation (**http://soundwaves.usgs.gov/2000/05/awards2.html**), and he branched out into many new areas of research, such as measuring rates of coral

(Bootstrap Geologist *continued on page 18)*

Gene Shinn *signs copies of his book,* Bootstrap Geologist—My Life in Science*, at the American Association of Petroleum Geologists Annual Convention in Pittsburgh, Pennsylvania, May 2013.*

(Bootstrap Geologist *continued from page 17)*

growth as a clue to coral health (**http://soundwaves.usgs.gov/2011/04/research.html**) and investigating the ecologic effects of African dust carried by winds to the Caribbean (**http://soundwaves.usgs.gov/2002/09/research2.html**).

Still going strong after retiring from the USGS in 2006 (**http://soundwaves.usgs.gov/2006/02/staff2.html**), Gene received the Twenhofel Medal, the highest award given by the Society for Sedimentary Geology, in 2009 (**http://soundwaves.usgs.gov/2008/12/awards.html**). He continues doing science and service work from his office at the University of South Florida's College of Marine Science, where he also penned the new book. ❁

*Not just an innovative researcher, but also an innovative communicator, **Gene Shinn** uses his "flushable toilet" model to demonstrate how sewage flushed or injected into shallow disposal wells flows through porous limestone underlying the Florida Keys. (He received the 2002 USGS Shoemaker Award for Distinguished Achievement in Communications, <**http://soundwaves.usgs.gov/2003/03/awards.html**>.)*

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