USGS
Sound Waves
Coastal and Marine Research News from Across the USGS
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Cover Story

Before-and-After Photos: SE Beach Dunes Lost to Hurricane Matthew

By Joseph Long and Heather Dewar

Hurricane Matthew's storm surge and waves overwashed 177 miles of beach dunes in four states—about 11% of the sand dunes on Florida's Atlantic Coast, 30% along Georgia's coastline, 58% of dunes on South Carolina's sandy beaches, and 9% of North Carolina's dunes as the powerful storm brushed past the southeastern states October 6–9, 2016. These figures are derived from USGS experts' preliminary review of USGS low-altitude before-and-after images along the coast and NOAA photographs collected after the storm.

"The hurricane's impact on southeastern shorelines was less extensive than a pre-storm prediction, which called for 24% of Florida's Atlantic Coast to be overwashed by the storm surge," said USGS research oceanographer **Joseph Long**. "That forecast was based on a worst-case scenario, the maximum waves forecast by the National Hurricane Center striking the coast simultaneously with the maximum storm surge."

Low-altitude oblique photography taken before Hurricane Matthew (Sept. 6, 2014) and after (Oct. 13, 2016) shows the storm cut a new inlet between the Atlantic Ocean and the Matanzas River near St. Augustine, Florida, stripping away a 3.7 meter (12-foot) dune and carrying sand into the estuary.

Low-altitude oblique photography taken before Hurricane Matthew (Sept. 6, 2014) and after (Oct. 13, 2016) in Flagler Beach, Florida, shows that waves washed away part of Highway A1A and obliterated a 5.2-meter-high (17-foot) dune.

Long and his fellow scientists on the USGS National Assessment of Coastal Change Hazards storm team, headed by research oceanographer **Hilary Stockdon**, are working on a detailed assessment of Matthew's effects on the region's vulnerable shorelines. They are now comparing low-altitude, oblique aerial photos taken in September 2014 to photos collected October 13–15, about a week after the storm.

"High-altitude images give us a big-picture view of the coastline, and that's very useful to identify large areas of overwash, but we can't see the dunes in those images," Long said. "These low-altitude photos give us a clear view of the dune itself. We can see whether the storm surge altered or eliminated that protective barrier, and what happened to the houses and boardwalks and seawalls behind it."

When a storm is about to strike the U.S. Atlantic Coast, the team predicts the likelihood of coastal erosion and other changes, using a computer model that incorporates the National Hurricane Center's storm-surge predictions and NOAA wave forecasts. The USGS model adds information about the beach slope and dune height to predict how high waves and surge will move up the beach.

(Beach Dunes Lost continued on page 2)

Low-altitude oblique photography before Hurricane Matthew (Sept. 24, 2011) and after (Oct. 14, 2016) at Pritchards Island, South Carolina, shows that in the five years between photographs, the line of vegetation has moved landward as trees exposed to saltwater have died. The lack of vegetation allowed further erosion and overwash during Hurricane Matthew. The yellow arrows in each image point to the same features in both photos.

Sound Waves

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Deadline: The deadline for news items and publication lists for the 166th issue of *Sound Waves* is Friday, January 13, 2017.

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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U.S. Geological Survey
Earth Science Information Sources:

Need to find natural-science data or information? Visit the USGS Frequently Asked Questions (FAQ's) at URL https://www2.usgs.gov/faq/

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

Cover Story, continued

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The model forecasts three types of storm impact to the dunes that protect coastal communities: erosion, overtopping, and inundation, or flooding that reaches over and behind the dunes. After a storm has passed, the researchers test the model's accuracy using information about the state of the dunes from before-and-after photographs and other data.

In Florida, the state that had the closest brush with Matthew, an estimated 64 kilometers (40 miles) worth of dunes and other coastal structures were overtopped. A preliminary review found 52 kilometers (32 miles) worth of shoreline in Georgia and 121 kilometers (75 miles) in South Carolina were overwashed, mostly in lightly populated areas. In North Carolina, the hurricane's impacts were dominated by heavy rainfall that led to inland flooding, but storm tides also overtopped about 48 kilometers (30 miles) of dunes, according to the team's preliminary analysis.

The images clearly capture the damage at Florida's Vilano Beach, north of St. Augustine, where the storm surge and wave runup washed away a five-meter-high (16-foot) sand dune, destroying boardwalks and decks of oceanfront homes. South of St. Augustine, the storm surge opened up a new inlet between the Atlantic Ocean and the Matanzas River, stripping away a 3.7-meter-high (12-foot) dune and carrying most of its sand into the estuary. And farther south in the town of Flagler Beach, the powerful waves washed away a portion of Highway A1A, closing the beachfront highway indefinitely, and obliterated a 5.2-meter-high (17-foot) dune.

The U.S. Army Corps of Engineers, in collaboration with the USGS, is conducting a month-long series of data collection flights along the southeastern U.S. coast using airborne lidar, a technology that bounces beams of laser light at the ground to produce detailed elevation information about the surface below. Using that information, the USGS researchers can estimate the volume of sand that Hurricane Matthew moved off of southeastern beaches, measure the height and breadth of the remaining dunes, and be ready to forecast the erosion potential of the next storm.

See more before-and-after-Hurricane Matthew photos from Florida through North Carolina at **http://coastal.er.usgs.gov/hurricanes/matthew/**, and learn more about the USGS coastal change hazard team's hurricane research at **http://coastal.er.usgs.gov/hurricanes/**. ❁

Low-altitude oblique photography before Hurricane Matthew (Sept. 6, 2014) and after (Oct. 14, 2016) at Vilano Beach, Florida, shows storm surge and wave runup washed away a 5-meter-high (16-foot) sand dune, destroying boardwalks and decks and exposing an old seawall.

Low-altitude oblique photography before Hurricane Matthew (Feb. 19, 2016) and after (Oct. 15, 2016) shows storm surge and wave runup eroded dunes and exposed State Road 12 to wave attack, undercutting the roadway at Kitty Hawk, North Carolina. The yellow arrows in each image point to the same features in both photos.

Sound Waves News Briefs

Edited by Rex Sanders

▸ USGS, NASA Study Finds Widespread Coastal Land Losses from Gulf Oil Spill

November 17—A pattern of dramatic, widespread shoreline loss along Louisiana's coast caused by the 2010 BP *Deepwater Horizon* oil spill has been revealed in a new study by the USGS and NASA. Researchers used NASA's annual mapping to analyze shoreline loss across most of upper Barataria Bay, located on the western side of the Mississippi River Delta. The study looked at shoreline imagery taken a year before the oil spill and then at images taken during a 2.5-year span after the spill. Scientists also compared shoreline losses from storm-induced erosion with losses linked to shoreline oiling. For more information, see **https://www.usgs.gov/news/usgs-nasa-study-finds-widespread-coastal-land-losses-gulf-oil-spill**.

▸ CBS *This Morning* Features USGS Scientists Studying Link Between Earthquake Faults Near San Francisco, California

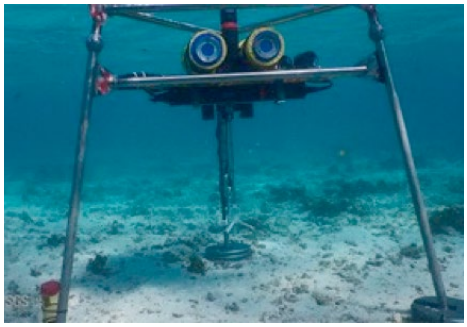
November 10—A camera crew from CBS *This Morning* visited the USGS Pacific Coastal and Marine Science Center on November 10, 2016, to interview **Janet Watt** about her discovery of a connection between the Hayward and Rodgers Creek faults (**https://walrus.wr.usgs.gov/news/#oct16b**), two of the most hazardous earthquake faults in California's San Francisco Bay area. In addition to a sit-down interview, they filmed Watt and her team—**Mary McGann**, **Katie Maier**, and **Tom Lorenson**—processing sediment cores collected along the fault beneath San Pablo Bay (**https://walrus.wr.usgs.gov/news/#nov16**). CBS News correspondent **Mireya Villareal** asked about what led to the discovery, what it means for Bay Area earthquake hazards, and how the team plans to use microfossils from the cores to date movement on the newly discovered fault strand. View the segment, which aired November 18, at **http://www.cbsnews.com/videos/california-prepares-for-next-big-earthquake/**.

Related:

Coring the Hayward-Rodgers Creek Fault Zone in San Pablo Bay, California, to Unravel the History of Faulting Beneath the Bay • **https://marine.usgs.gov/news/archive.php?#1022**

Link Between Two Earthquake Faults Near San Francisco, California, Revealed by Detailed Sub-Seafloor Mapping • **https://marine.usgs.gov/news/archive.php?#1011**.

▸ New Video Highlights Major Coral Reef Study by USGS and Australian Scientists



November 9—A new video, "Breaking Down Reefs, Building Up Beaches," (**https://walrus.wr.usgs.gov/coralreefs/ReefsToBeaches.html**) follows coral reef experts from the USGS and the University of Western Australia as they conduct the largest-ever hydrodynamic study of how coral reefs shape coasts. The scientists spent two weeks in May 2016 (**https://walrus.wr.usgs.gov/news/#may16a**) installing instruments to measure currents and sediment movement in and around Australia's largest fringing reef, in the Ningaloo Coast UNESCO World Heritage Site, Western Australia. Over the following two months, the instruments collected massive amounts of data that will give scientists great insight into the protective role of reefs and will help the USGS forecast what could happen to U.S. fringing reefs in the face of climate change and sea-level rise.

▸ Visualizing Sea-Level Rise in Santa Monica, California

November 7—Visitors to the Santa Monica Pier in Southern California can now see what the beach might look like when future storms and sea-level rise raise water levels. Two virtual-reality viewers, named "Owls" for their distinctive appearance, show the projected extent of flooding by a big storm at high tide (**http://mobileowl.co/samo/#description1**), by sea-level rise, and by both together. The projections come from the USGS Coastal Storm Modeling System (CoSMoS, **https://walrus.wr.usgs.gov/coastal_processes/cosmos/**). The viewers also show how communities can adapt to sea-level rise through nature-based coastal-planning projects, such as enhanced dunes. The City of Santa Monica developed the Owls (one ADA-accessible) in partnership with the USGS, Owlized, and the USC Sea Grant program. The Owls will operate from November 7, 2016, to January 7, 2017; a public celebration was held November 16 to coincide with "King" high tides. View more photographs

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on our Facebook page: USGS Coastal and Ocean Science (**https://www.facebook.com/pg/coastalandoceanscience/photos/?tab=album&album_id=1153735268054453**).

▸ TV News Features USGS Use of Historical Photos to Measure Cliff Erosion in San Francisco

October 28—USGS geologist **Jonathan Warrick** appeared in a TV newscast about his use of historical photos to measure cliff erosion at Fort Funston in San Francisco, California. On October 28, 2016, Warrick met **Andria Borba** of KPIX 5, a CBS affiliate, at Fort Funston. He showed her how easily the cliff crumbles, explained how overlapping photos enabled his team to measure erosion rates, and noted that the results can help scientists forecast future erosion. "Geologists Get 3-D Pictures Of Beach Erosion On California Coast," aired that night and on the web (**http://sanfrancisco.cbslocal.com/2016/10/29/geologists-get-3-d-pictures-of-beach-erosion-on-california-coast/**).

Related:

New Techniques for Measuring Cliff Change from Historical Photographs • **https://marine.usgs.gov/news/archive.php?#1020**

New Maps from Old Photos: Measuring Coastal Erosion • **https://www.usgs.gov/news/new-maps-old-photos-measuring-coastal-erosion**.

Hurricane Matthew News Briefs

In October 2016, Hurricane Matthew devastated the U.S. Atlantic Coast from central Florida through Virginia and beyond. The wind, storm surge, rain, and flooding caused more than $5 billion in damage and took 49 lives.

Before, during, and after the hurricane, USGS scientists and technicians worked to inform the public and emergency responders about potential and actual impacts. Our teams also collected data vital to responding to future hurricanes. Here are a few stories about the USGS response to Hurricane Matthew.

For complete coverage, visit the USGS Hurricane Matthew page (**https://www.usgs.gov/special-topic/hurricane-matthew**).

▸ After the Storm—Hurricane Matthew and the Floods

October 14—In the aftermath of Hurricane Matthew, USGS crews have been collecting the record number of storm-tide sensors deployed prior to the storm and are now determining high-water marks, collecting water-quality samples, and assessing the impacts of storm surge on southeastern beaches caused by erosion, overwash and inundation. Although the storm is over, the flooding continues, as does the flood work of the USGS. In North Carolina, at least 24 record peaks were set on local rivers, as heavy rain during Hurricane Matthew fell on ground already saturated just weeks earlier by Tropical Storm Julia. For more information: **https://www.usgs.gov/news/after-storm-hurricane-matthew-and-floods**.

▸ Severe Flooding in North Carolina Breaks More Than a Dozen USGS Peak Records

October 12—Just days after Hurricane Matthew made its approach up the East Coast, North Carolina is still feeling impacts from the storm as severe flooding has hit much of the central and eastern parts of the state. The heavy rains brought by Hurricane Matthew caused flooding that has been intensified due to rain events prior to Matthew that had many rivers across the central and eastern parts of the state already running at above normal stream-flow levels. For instance, the community of Spring Lake witnessed a period of record flooding in late September, only to have that peak broken again this week. "We've seen peak stream-flow records broken for at least 14 sites in North Carolina," said **Jeanne Robbins**, USGS hydrologist. "But, it is important for people to understand the waters are still rising in some areas, and we could see more records broken." For more information: **https://www.usgs.gov/news/severe-flooding-nc-breaks-more-a-dozen-usgs-peak-records**.

▸ Record Number of USGS Sensors Deployed for Hurricane Matthew

October 8—The USGS deployed a record number of sensors prior to Hurricane Matthew's move up the southeast coast. More than 70 USGS staff were out from Florida to Virginia installing 393 sensors at 290 locations. These sensors were a combination of 190 storm-tide

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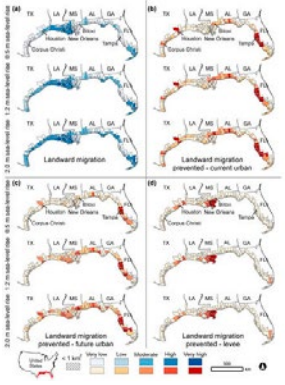
sensors, 92 barometric pressure sensors, 79 Wave Sensors, and 32 Rapid Deployment Gauges, which were put in place to collect information about the hurricane's effects on the Atlantic Coast. For more information: **https://www.usgs.gov/news/record-number-usgs-sensors-deployed-hurricane-matthew**.

▸ Florida, Georgia, and South Carolina Beaches Face 80-95 Percent Chance of Erosion from Hurricane Matthew

October 6—As the East Coast prepares for Hurricane Matthew's arrival, the USGS uses advanced models to forecast the coastal impacts Matthew could bring. "What's important for people to understand with this storm is that it's large and very powerful," said **Hilary Stockdon**, USGS research oceanographer and the lead developer of a series of coastal change forecasting tools. "Strong winds will create dangerous waves and surge over a large stretch of the coastline, leading to extensive beach and dune erosion." For more information: **https://www.usgs.gov/news/fl-ga-sc-beaches-face-80-95-percent-chance-erosion-hurricane-matthew**.

▸ Rising Sea Levels, Coastal Development's Effect on Gulf Coast Wetlands



October 3—Tidal saline wetlands along the U.S. Gulf of Mexico coast, such as mangrove forests, salt marshes, and salt flats, face survival challenges as sea levels rise rapidly and development along coastlines continues to grow. But, a recently published USGS study shows there is hope for some of these at-risk Gulf Coast wetlands. In the study, which was conducted from 2012 to 2015, the authors considered the potential for landward movement of coastal wetlands under different sea-level rise scenarios. They also considered the impact of barriers to wetland migration due to current and future urbanization and examined how existing conservation lands, such as parks and refuges, might accommodate expected landward migration. For more information: **https://www.usgs.gov/news/rising-sea-levels-coastal-development-s-effect-gulf-coast-wetlands**.

▸ More Headlines

- **November 21:** Looking for Causes of Underwater Landslides near Santa Barbara • **https://marine.usgs.gov/news/archive.php?#1028**
- **November 18:** Safeguarding Our Cultural Past from Future Climate Change—Stories from Cape Lookout National Seashore • **https://www.usgs.gov/news/safeguarding-our-cultural-past-future-climate-change-stories-cape-lookout-national-seashore**
- **November 17:** USGS Researchers to Host Hurricane Matthew Webinar for Congressional Staffers • **https://marine.usgs.gov/news/archive.php?#1027**
- **November 17:** USGS a Silver Sponsor of the 6th Annual St. Petersburg Science Festival • **https://marine.usgs.gov/news/archive.php?#1026**
- **November 17:** Location Matters—Hurricane Sandy's Tides Hit Some Parts of the New Jersey Coast Harder Than Others • **https://www.usgs.gov/news/location-matters-sandy-s-tides-hit-some-parts-new-jersey-coast-harder-others**
- **November 15:** San Francisco Bay-Delta Conference—Science for Solutions • **https://www.usgs.gov/news/sf-bay-delta-conference-science-solutions**
- **October 28:** EarthView—Hurricane Matthew Exacts Heavy Toll on Haiti • **https://www.usgs.gov/news/earthview-hurricane-matthew-exacts-heavy-toll-haiti**
- **October 21:** Post Hurricane Matthew—USGS Continues Efforts to Document How High Floodwaters Reached • **https://www.usgs.gov/news/post-hurricane-matthew-usgs-continues-efforts-document-how-high-floodwaters-reached**
- **October 9:** USGS Crews Measure Flooding in North Carolina, South Carolina, Georgia, and Florida • **https://www.usgs.gov/news/usgs-crews-measure-flooding-nc-sc-ga-and-fl**
- **October 6:** Into the Storm—Hurricane Matthew • **https://www.usgs.gov/news/storm-hurricane-matthew**
- **October 5:** USGS Center Director Interviewed on Syndicated Radio Program About Potential Impacts of Hurricane Matthew • **https://marine.usgs.gov/news/archive.php?#1015**

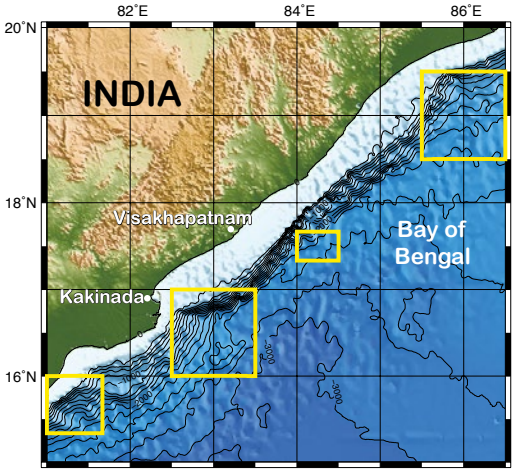
For all USGS Coastal and Marine Geology Program news, see: **https://marine.usgs.gov/news/**.

For all USGS news, see: **https://www.usgs.gov/news**. ❁

USGS Scientists Participate in Indian Ocean Gas Hydrates Drilling

By William Waite

During the summer of 2015, USGS Coastal and Marine Geology Program personnel participated in the Indian Government's National Gas Hydrates Program (NGHP-02) drilling expedition offshore from eastern India (see map). NGHP-02 is one component of a long-term study of the potential for India's marine gas hydrates to be an energy resource. Earlier this year, the program's sponsor, India's Directorate General of Hydrocarbons (DGH), and management agency, India's Oil and Natural Gas Company (ONGC), made their initial public announcement about the results (**http://tinyurl.com/gv7r8qk**). A recent *Sound Waves* story provides additional expedition highlights (**https://soundwaves.usgs.gov/2016/09/**).



NGHP-02 study areas (yellow boxes, left) in the Bay of Bengal offshore from eastern India. The D/V Chikyu, *which hosted the NGHP-02 field operations. Figure credit: USGS.*

What are gas hydrates?

Gas hydrates are a solid form of water and gas, stable at low temperature and elevated pressure. On Earth, the most abundant gas hydrate hosts methane, which is stable at the pressures and temperatures found in marine environments in the shallow subsurface, generally below ~350–400 meters of water (**http://woodshole.er.usgs.gov/project-pages/hydrates/primer.html**).

When brought to standard temperature and pressure, a given volume of methane hydrate will break down, or dissociate, releasing up to 164 times its volume in methane. The United States is among several countries engaged in testing the viability of extracting methane from gas hydrate as an energy resource.

Unprecedented scope of NGHP-02

Methane hydrate concentrated in the pore space of sands has the greatest potential as an energy resource. The NGHP-02 program extends the 2006 NGHP-01 project by specifically targeting sand-rich hydrate-bearing formations near the base of the continental slope.

The 2015 NGHP-02 drilling expedition was an ambitious, multi-component field study aboard the Japanese research-drilling vessel D/V *Chikyu*. From March 4 to April 27, 25 sites were logged while drilling, which generated high-resolution digital geophysical data that provided information about the sediments surrounding the borehole. Based on the logging-while-drilling results, gas hydrate-bearing sediment was identified across a range of depositional environments and sediment types. From April 28 to July 25, 10 priority sites were revisited for a combination of conventional and pressure coring, wireline logging, and vertical seismic profiling. During NGHP-02, approximately 6600 meters of subsurface were logged while drilling, and over 2200 meters of core material were collected.

The NGHP-02 expedition acquired 104 pressure cores, more than any gas hydrates drilling program completed over the past two decades. Unlike conventional cores, in which sediment is allowed to come to atmospheric pressure as the core is recovered, pressure cores use special technology to preserve sediments at the pressure they experienced in the seafloor. This is critical for maintaining gas hydrate within its stability field through the entire recovery process. Pressure cores are quickly cooled once on shipboard and can be stored for months or years at refrigerator temperatures prior to analysis without the hydrate breaking down.

The USGS Energy Resources Program and the Coastal and Marine Geology Program have participated in both of the Indian Government's National Gas Hydrates Program expeditions. **Timothy Collett** (USGS Energy Resources Program) was the expedition chief scientist for both cruises. The USGS Coastal and Marine Geology Program supported coring components of NGHP-01 and NGHP-02 with geochemical and geophysical sampling and measurements. For NGHP-02, **John Pohlman**, **Pamela Swarzenski**, and **Thomas Lorenson** sailed in support of geochemical studies focused on determining the source of methane, the overall gas generation potential across the study region, and the downhole hydrate saturation. **William Waite** assisted in geophysical studies to support the reservoir modeling and borehole engineering required for effectively extracting methane as an energy resource.

Sample collection for USGS Coastal and Marine Geology Program post-cruise studies

Aboard the D/V *Chikyu*, USGS scientists collected samples from conventional and pressure cores for several post-cruise geotechnical and geochemical studies. Sediments from the conventional cores were sampled for index property measurements. These measurements provide insight into several processes that must be understood to safely and effectively extract methane from hydrate as an energy resource, such as how fluids and gas will flow in response to extracting methane from hydrates, and how much the sediment is likely to settle around a production well.

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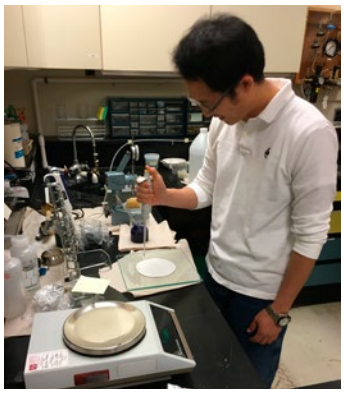
To measure how the presence of hydrate changes the sediment properties, assess the distribution and concentration of gas hydrate, and identify gasses contained within the hydrate, samples were also collected from pressure cores. Prior to sampling aboard the drillship, pressure cores were scanned to obtain initial X-ray, seismic velocity, and density profiles that were used to determine the distribution and saturation of gas hydrate in the sediments contained within the core and guide the subsampling locations for shipboard and post-cruise studies. Based on those initial scans, certain pressure-core subsections were depressurized in a controlled fashion to collect gas specimens for gas composition and origin studies, and to quantify the *in-situ* gas hydrate content. Twenty-five pressure-core sections were then stored for extensive post-cruise analysis by Japan's National Institute of Advanced Industrial Science and Technology in Sapporo, Japan, and by the USGS at the Woods Hole Coastal and Marine Science Center. William Waite and **Junbong Jang** travelled to Sapporo in winter and spring 2016 to assist with the planning and execution of the NGHP-02 pressure-core analysis at Japan's National Institute of Advanced Industrial Science and Technology.



Pamela Swarzenski *(left) from the USGS Pacific Coastal and Marine Science Center sampling gas released by gas hydrate breakdown during a quantitative degassing aboard the D/V* Chikyu *during NGHP-02.* **Junbong Jang** *(right) measures index properties on NGHP-02 sediment transferred to the USGS Woods Hole Coastal and Marine Science Center. Photo credit: USGS.*

Pressure-core analysis at the USGS Woods Hole Coastal and Marine Science Center

Five of the NGHP-02 pressure cores are earmarked for analyses by the USGS Gas Hydrates Project at a new facility being constructed at the Woods Hole Coastal and Marine Science Center with support from the U.S. Department of Energy. The facility is being built in a specially outfitted 40-foot refrigerated van set up adjacent to the Woods Hole Coastal and Marine Science Center core storage facility.

The new USGS pressure-core facility will house a suite of pressure-core characterization tools (PCCTs) originally built by **J. Carlos Santamarina** at Georgia Tech with U.S. Department of Energy support and now managed by the USGS Gas Hydrates Project on behalf of the U.S. hydrates community. The PCCTs make it possible to manipulate and measure properties of hydrate-bearing pressure core while continuously maintaining the pressure required to keep hydrate stable. Georgia Tech deployed the PCCTs during a collaboration with USGS and the National Institute of Advanced Industrial Science and Technology in Sapporo, Japan, in January, 2013 (see **http://soundwaves.usgs.gov/2013/04/research.html**). The USGS is now modifying the tools in preparation for commencing analyses on the NGHP-02 pressure cores in autumn 2016. Researchers at the Woods Hole Coastal and Marine Science Center will use the PCCTs to measure geophysical, geotechnical, and hydraulic properties of the NGHP-02 pressure cores. The resulting data will inform reservoir modeling and borehole engineering plans currently underway as part of preparations for an eventual methane production test at the NGHP-02 sites (**http://www.netl.doe.gov/file%20library/research/oil-gas/methane%20hydrates/MHNews_2016_Spring.pdf**).

Significance of NGHP-02 for Gas Hydrate Project goals

The broad scope of NGHP-02, covering multiple depositional environments and recovering hydrate-bearing sediment from a range of lithologies, is providing the USGS with an extensive collection of gas, water, and sediment samples. Post-cruise studies at the Woods Hole Coastal and Marine Science Center and Pacific Coastal and Marine Science Center are not only increasing our understanding of how the deposition of organic matter and sediment control the distribution and concentration of gas hydrates, but are also dramatically expanding our database linking chemical, mechanical, and transport properties to *in-situ* hydrate saturations. Together, these advances further refine our understanding of the geologic controls on the formation and properties of gas hydrate deposits, particularly those of potentially high energy-resource value (see **http://woodshole.er.usgs.gov/project-pages/hydrates/energy.html),** while providing data for improving reservoir and borehole engineering models needed for effectively extracting methane from hydrate as an energy resource. NGHP-02 has provided the USGS with opportunities to significantly advance our understanding of hydrates in nature and further refine our sampling and measurement strategies ahead of domestic field projects being planned for the Alaskan North Slope and Gulf of Mexico.

USGS Gas Hydrates Project

The USGS Gas Hydrates Project (**http://woodshole.er.usgs.gov/project-pages/hydrates/**) is a globally recognized research effort focusing on energy, climate, and geohazard issues associated with natural-gas hydrates, and is jointly supported by the USGS Coastal and Marine Geology Program and Energy Resources Program. The Project's research activities take place in the northern Gulf of Mexico, U.S. Arctic Ocean, the Alaskan North Slope, the U.S. Atlantic margin, and offshore Japan, India, and Korea (**http://energy.usgs.gov/OilGas/UnconventionalOilGas/GasHydrates.aspx**). ❁

Recent Fieldwork, October and November 2016

Rex Sanders

USGS scientists visited more than 20 locations in October and November 2016, studying Hurricane Matthew effects, coral growth, earthquake history, and much more. Here's a quick review of some coastal and offshore fieldwork by our researchers.

- **Monterey Canyon, California:** Recovered data from oceanographic moorings and redeployed a few days later, as part of the Coordinated Canyon Experiment, October 3–7, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-670-FA**

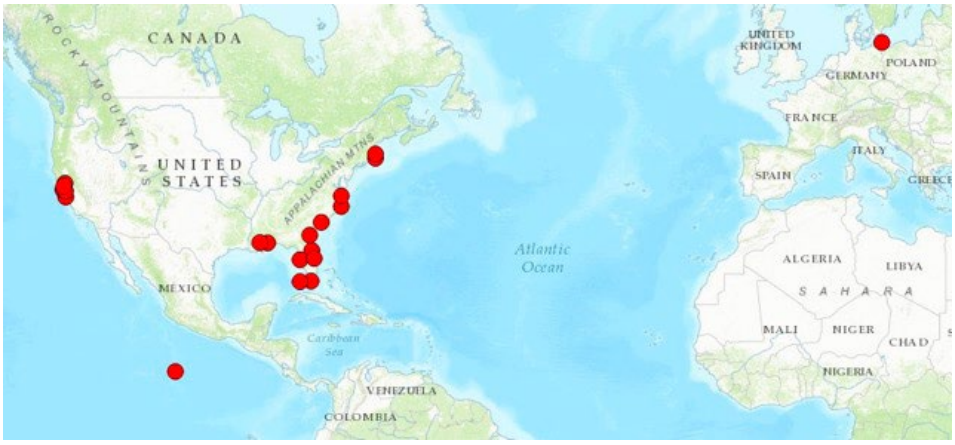
- **Monterey Canyon, California:** Recovered equipment measuring oceanography, grain size, and microfossils, October 10–12, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-679-FA**

- **San Francisco, California:** Monitored changes in Ocean Beach and undersea sand volume and distribution, October 13 and November 14, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-680-FA**

  https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-683-FA

- **Sacramento–San Joaquin Delta, California:** Collected time-series measurements of suspended sediment, tides, and waves for habitat restoration, August 8–October 14, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-662-FA**

- **Matanzas Inlet to Canaveral National Seashore, Florida:** Investigated overwash deposits from Hurricane Matthew: collected beach profiles, mapped overwash deposits, photographed impacts, collected sediment samples and cores, October 13–15, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-359-FA**



Above: *Approximate locations of some recent USGS coastal and offshore fieldwork in October and November 2016.*

- **Cape Cod, Massachusetts:** Collected surface-water samples, time-series water-quality and flow data to examine estuary health, October 18 and November 1, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-048-FA**

  https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-049-FA

  https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-015-FA

- **Florida–Georgia–South Carolina–North Carolina:** Post-Hurricane Matthew coastal air photography, October 12–18, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-360-FA**

- **San Francisco Bay, California:** Collected detailed bathymetry in Alviso Slough, October 12–20, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-678-FA**

- **San Pablo Bay, California:** Collected sediment cores to investigate the Hayward-Rodgers Creek fault zone, October 17–21, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-671-FA**

- **Baltic Sea:** Participated in greenhouse gas calibration, October 15–22, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-042-FA**

- **Grand Bay, Alabama—Mississippi:** Evaluated sediment dynamics and sediment fluxes in the estuary, October 18–25, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-046-FA**

- **Grand Bay, Mississippi:** Deployed sediment tracers and sediment traps at erosion monitoring sites in marshes, October 18–25, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-358-FA**

- **Stellwagen Bank National Marine Sanctuary, Massachusetts:** Collected seabed sediment samples for geological mapping, October 21–28 and November 4-18 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-039-FA**

  https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-040-FA

- **East Pacific Rise:** Collected metal sulfide minerals, and metal sulfide particles in high-temperature fluids, October 6–28, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-672-FA**

(Recent Fieldwork continued on page 9)

Fieldwork, continued

(Recent Fieldwork continued from page 8)

- **Pinellas County, Florida:** Measured water level, temperature, and salinity in monitoring wells offshore from Indian Rocks Beach, November 3, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-366-FA**

- **Florida Keys:** Measured coral and algae growth rates and collected temperature data, October 24–November 10, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-357-FA**

- **Florida–Georgia–South Carolina–North Carolina–Virginia:** Post-Hurricane Matthew: set up GPS ground-control points for LIDAR, mapped overwash areas, measured overwash thickness, sampled sediments, took notes and photographs, October 31–November 11, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-047-FA**

  https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-365-FA

- **Dry Tortugas, Florida:** Downloaded oceanographic data from Ocean Carbon System and collected validation samples, November 5–15, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-361-FA**

- **Indian River Lagoon, Florida:** Evaluated the spatial variability of groundwater discharge in the surface waters, November 13–18, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-362-FA**

- **Stennis Space Center, Mississippi:** Studied motion and transport of sand and oil clumps at the Naval Research Laboratory, November 14–18, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-364-DD**

- **Cape Cod, Massachusetts:** Examined the environmental geochemistry and health of 11 estuaries, April 11–November 30, 2016. Details at **https://cmgds.marine.usgs.gov/fan_info.php?fan=2016-016-FA**

For a complete list of USGS Coastal and Marine Geology program fieldwork, see: **https://cmgds.marine.usgs.gov/data_search.php**. ❁

Research

New Maps from Old Photos: Measuring Coastal Erosion in California

By Helen Gibbons and Jonathan Warrick

USGS scientists and their coauthors from the California Coastal Records Project have found a way to use historical aerial photographs not just to see evidence of coastal erosion, but to accurately measure how much has occurred over time. Applying a low-cost technique called "structure-from-motion" to five sets of oblique aerial photos spanning the years 2002 to 2010, the scientists measured the volume of material eroded from coastal cliffs at Fort Funston, on the westernmost edge of San Francisco.

Quantifying coastal change is essential for calculating trends in erosion, evaluating processes that shape coastal landscapes, and predicting how the coast will respond to future storms and sea-level rise, all critical for communities along the California coast.

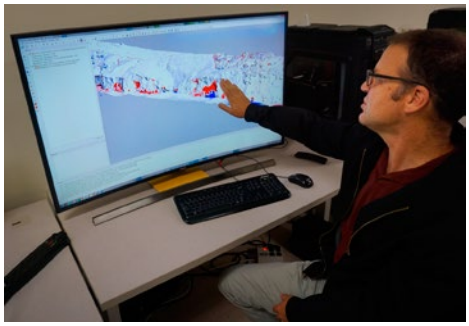
Kenneth and **Gabrielle Adelman** of the California Coastal Records Project photograph the California coast every few years and make the imagery publicly available online (**http://www.californiacoastline.org/**). "These photos

Gabrielle *and* ***Kenneth Adelman****, about to depart for Point Reyes, California. Gabrielle pilots the helicopter while Kenneth takes oblique photographs of the coast. Photo credit: California Coastal Records Project (****http://www.californiacoastline.org/****).*

are not only great for looking at the changing shoreline," said USGS geologist and lead author **Jon Warrick**, "but, as we've now shown, they can also be used to build 3D maps of beaches and cliffs. And these maps enable us to measure coastal change."

To measure coastal change in central California, Warrick and his USGS team began shooting structure-from-motion photographs from a chartered airplane. They wondered if they could apply the technique to existing, older photos to extend measurements back in time. They gave it a try with California Coastal Records Project photographs of cliffs along a half-mile stretch in Fort Funston (**https://www.nps.gov/goga/planyourvisit/fortfunston.htm**), a part of

(New Maps continued on page 10)



Jon Warrick *explains a "difference map" constructed from structure-in-motion data. Red areas indicate loss of material (erosion); blue areas show addition of material (deposition). Photo credit:* ***Amy West****, USGS.*

(New Maps continued from page 9)

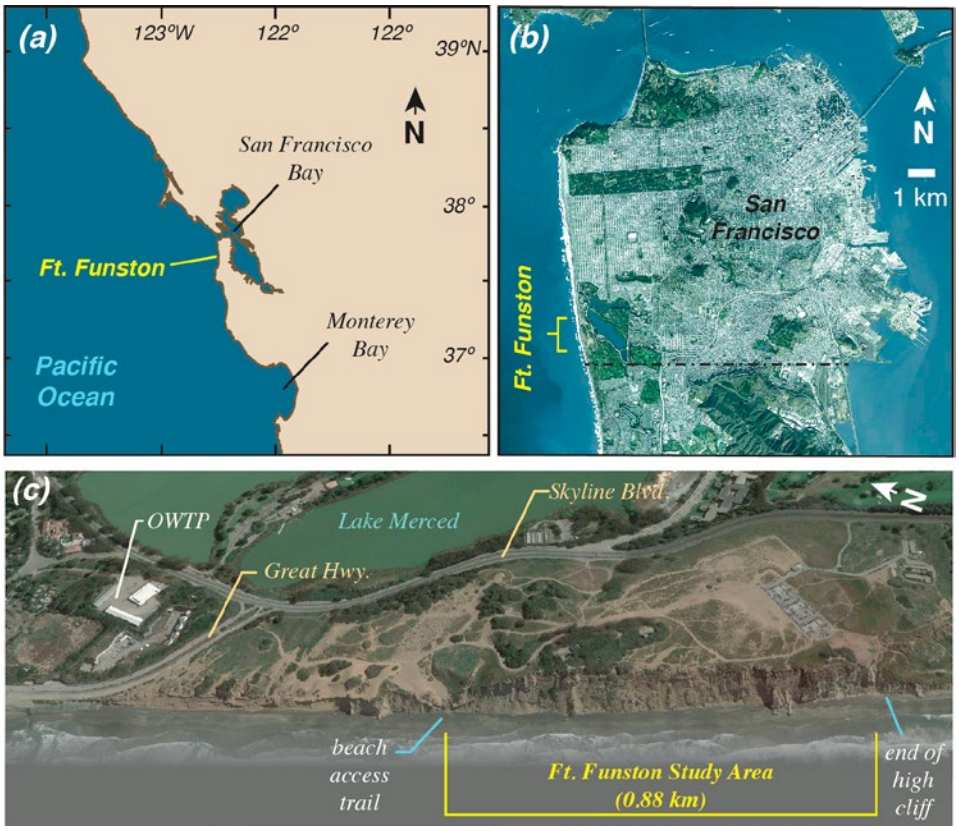
the Golden Gate National Recreation Area known to have relatively high erosion rates. The effort succeeded, yielding many details about the timing and magnitude of changes over the 2002–2010 study period, including landslides, rock falls, and the buildup and erosion of landslide debris on the beach.

"We are thrilled about this new use of our photos," said Gabrielle Adelman, who flies a helicopter along the coast while her husband Kenneth shoots photos. "The photos are a lot of work to take, and we are glad that they are so useful in so many ways. I trained as a scientist, and it's good that so much useful data have come of them."

The California Coastal Records Project is "an exceedingly valuable resource," said **Gary Griggs**, an authority on California coastal change and director of the Institute of Marine Sciences at the University of California, Santa Cruz (**http://ims.ucsc.edu/**). Griggs has worked with the Adelmans and helped facilitate their collaboration with Warrick. He said, "I'm really excited that Jon was able to connect [with Kenneth and Gabrielle] and make this analysis of historical photographs work out as a new tool that I hope others use as well."

Because helicopter time is expensive, **Kenneth Adelman** takes photos that overlap, so that if one is flawed, adjacent photos can provide much or all of the missing data. Such overlap is essential for structure-from-motion analysis, a relatively new technique for using two-dimensional images to create 3D maps. The structure-from-motion software picks points that can be identified on two or more overlapping photos—the corner of a building, for example, or the tip of a distinctive rock—and uses triangulation to measure their relative positions in space. Combining points from numerous photos produces a 3D image, sometimes called a "point cloud." By surveying some points with GPS or a Global Positioning System,

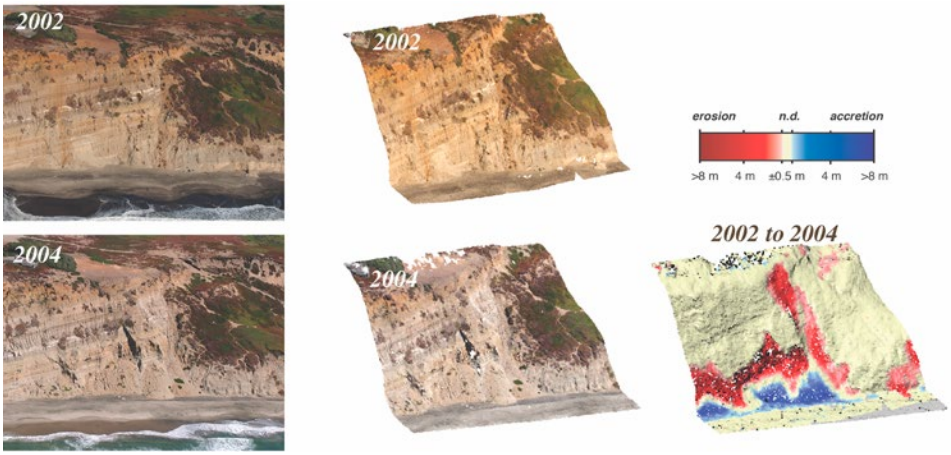
(New Maps continued on page 11)



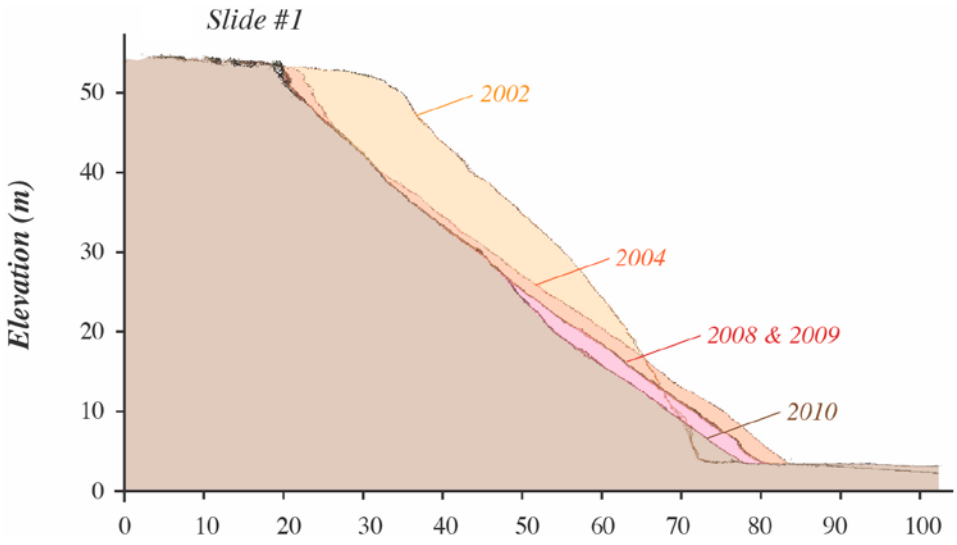
Maps of the Fort Funston, California, study area, including (a) regional perspective and (b) local plan view. (c) Oblique shaded-relief map of Fort Funston study area showing the half-mile length of cliffs between beach access trail in the north and end of high cliff in the south. Also shown is the Oceanside Wastewater Treatment Plant (OWTP). Imagery from (b) NASA and (c) Google Earth.

*Oblique aerial photographs of Fort Funston, California, in October 2009, from the California Coastal Records Project (**http://www.californiacoastline.org/**). Dashed lines show the approximate overlap between the photos; triangles at tops and bottoms of photos indicate photo midpoints.*

(New Maps continued from page 10)



Topographic changes caused by the second-largest landslide (Slide #2) in the Fort Funston study area between 2002 and 2004, as measured with structure-from-motion analysis. Original California Coastal Records Project photographs at left, topographic point clouds from structure-from-motion analysis in center, and difference map between years 2002 and 2004 on right.



Profile of topographic changes caused by the largest landslide in the study area (Slide #1) from 2002 to 2010, as measured with structure-from-motion analysis. Note that the greatest change occurred between 2002 and 2004.

Before-and-after photos of the largest landslide (Slide #1, right) that occurred in the study area between 2002 (photo on top) and 2010 (photo on bottom). During that period, as calculated in the new study, the slide caused a net erosion of nearly 15,000 cubic yards of material. Cropped from images in the California Coastal Records Project.

the mapper can assign a geographic position to each point, making the 3D image a 3D map.

Warrick said, "We can produce about 20 to 150 mapped points per square yard from the California Coastal Records photos," which added up to millions of points across the study area. Processing so much data requires considerable computing power, one reason the structure-from-motion technique has only lately come into wider use.

To test the accuracy of the Fort Funston structure-from-motion maps, the scientists compared them with maps produced by airborne lidar (light detection and ranging), an established technique that uses a laser scanner to measure distance from the instrument to various points on the ground. The structure-from-motion maps were found to have accuracy similar to that of the lidar maps, and they had the added benefit of imaging vertical and overhanging sections of cliff that could not be "seen" by airborne lidar. Because structure-from-motion relies on digital cameras rather than a laser scanner, it is much less expensive than lidar. Applying it to existing aerial photos makes it even more cost-effective.

"The success of our study shows that imagery originally obtained to provide qualitative assessments of our coasts can now be used in quantitative assessments of coastal change," said Warrick. The techniques reported in the new paper might be broadly applicable to photo sets of coasts throughout the world.

The results were published October 21, 2016, in the *Journal of Coastal Research* (**http://www.jcronline.org/doi/pdf/10.2112/JCOASTRES-D-16-00095.1**). ☸

In Search of a Solid Footing for Offshore Wind Turbines

By Fran Lightsom

The ocean is an attractive place to build wind turbines to generate electricity, because ocean winds are strong and relatively consistent in direction, and because a large coastal population is nearby to use the electricity. Of course, building offshore wind farms also brings special challenges: underwater construction is difficult, and the wind turbine towers must be built to withstand storm waves, hurricanes, ice floes, and salt corrosion. Before construction even begins, however, it is essential to identify areas of the sea floor that will provide a stable foundation for the towers over the long term. Knowledge of seafloor geology plays an important role in making this determination.

*At the USGS Woods Hole Data Library, librarian **Linda McCarthy** mends paper seismic records so that they can be safely digitized. Photo credit: **Alan Allwardt**.*

The Bureau of Ocean Energy Management, a sister agency of the USGS within the Department of the Interior, recently leased acreage along the New Jersey outer continental shelf (OCS) for potential wind-energy development. The leaseholder arranged for Fugro Marine GeoServices, Inc., to evaluate existing data about the underwater geology of the site in order to guide future wind-energy development.

On September 16, 2016, Fugro's **Sean Sullivan** contacted **Linda McCarthy**, the data librarian at the USGS Woods Hole Coastal and Marine Science Center. Sullivan wrote, "The seismic data collected during cruise 80-1 aboard the R/V *Whitefoot* in 1980 will assist Fugro in understanding the Tertiary–Quaternary shallow stratigraphic sequence and structural geology in order to help plan a future site investigation along the New Jersey OCS." Sullivan was referring to seismic-reflection techniques (**http://woodshole.er.usgs.gov/operations/sfmapping/seismic.htm**) used by the Woods Hole Coastal and Marine Science Center to reveal the layers of unconsolidated sediment and sedimentary rock underlying the sea floor in the lease area. He had previously consulted the online USGS Coastal and Marine Geoscience Data System (CMGDS, **https://cmgds.marine.usgs.gov/**) and discovered a USGS research cruise undertaken in 1980 for a different purpose, to look for geological hazards that might affect a proposed petroleum pipeline. McCarthy checked the data library holdings and sent Sullivan a list of large paper seismic profiles that could be scanned and made available. Sullivan compared the list to navigation data online at CMGDS and chose 22 track lines that would be useful to Fugro. By October 13, the scanning was completed, with the digital data and accompanying metadata totaling 24 GB, which was copied to an external hard drive supplied by Fugro.

*At the USGS Woods Hole Data Library, librarian **Linda McCarthy** feeds paper seismic records through the scanner to digitize them. Photo credit: **Alan Allwardt**.*

In the future, when wind turbines offshore of New Jersey provide electricity for New York City, 36-year-old USGS data will have helped make that possible. ❁

Woods Hole Coastal and Marine Science Center Participates in the 2nd Annual Woods Hole Science Stroll

By Andrea Toran

Water Street in Woods Hole, Massachusetts, was host to the second annual Woods Hole Science Stroll on August 6, 2016, offering participants a variety of opportunities to explore interactive displays, tour a research vessel, take part in science demonstrations, and engage with local scientists from 12 science centers, institutions, and organizations.

The USGS Woods Hole Coastal and Marine Science Center's Gas Hydrates, Sediment Transport, and Sea-Floor Mapping groups provided hands-on demonstrations under the USGS tent at the Science Stroll. The Gas Hydrates Project staff had samples of methane hydrate (an ice-like solid composed of methane and water molecules) and a laser-based gas analyzer for measuring greenhouse gas emissions from methane and other sources. Methane hydrate is thought to account for up to 50% of the world's mobile carbon, and the global abundance of methane hydrate has led to ongoing research by the USGS and others into the role of methane hydrate as a potential energy resource and as a component of environmental change. In spite of its natural

(Science Stroll continued on page 13)

(Science Stroll continued from page 12)

abundance, methane hydrate is only stable at moderately high pressure and low temperature, so few people have seen or handled it. At the Science Stroll, participants handled methane hydrate made by **Laura Stern** (USGS, Menlo Park) and preserved in liquid nitrogen. Participants watched as a laser-based gas analyzer measured carbon content of methane gas produced from a sample of degrading methane hydrate as well as from carbon dioxide in their breath. **John Pohlman** and **Michael Casso** built the USGS gas analyzer in Woods Hole. Along with **Lee-Gray Boze**, they discussed deployments of the tool in the Arctic and Atlantic Oceans and the North Sea and how they're using the data collected to determine if warming oceans are stimulating more or less greenhouse gas emissions to the atmosphere.

The Sediment Transport group, staffed by **Tarandeep Kalra**, had computer-generated simulations from the three-dimensional COAWST (Coupled Ocean Atmosphere Wave Sediment Transport) modeling system. Results from the COAWST modeling system show efficacy in capturing the processes that cause ocean circulation, sediment transport, and coastal erosion. Tarandeep answered questions and demonstrated how the modeling system works to predict hurricanes.

In addition to the popular and well-attended displays by the Gas Hydrates and Sediment Transport groups, the SEABOSS (SEABed Observation and Sampling System) display, courtesy of the Sea-Floor Mapping Group, was quite a crowd pleaser! The SEABOSS was designed by Woods Hole staff for rapid, inexpensive, and effective collection of seabed images and sediment samples in coastal and inner-continental shelf regions. The SEABOSS has video and still cameras, depth sensors, light sources, and a sediment sampler, all attached to a stainless steel frame that is deployed through an A-frame using a power winch. **Seth Ackerman**, Sea-Floor Mapping Group geologist and SEABOSS navigation specialist, provided a live, interactive demonstration of underwater video capabilities in the shallow waters off the seawall in front of the USGS display tent. USGS Principal Investigator and marine geologist **Laura Brothers** was also on hand to share information about how sediment sampling, photography, and video of the seafloor are critical components of the group's operations, and how they use the data from a variety of sources like the SEABOSS to conduct research.

Woods Hole Coastal and Marine Science Center information specialist **Andrea Toran** greeted the public, provided general information resources and handouts about the Center's research projects, and distributed copies of the recently published Circular titled "Coastal landforms and processes at the Cape Cod National Seashore—A primer." This book is about local beaches, bluffs, spits, dunes, barrier beaches, estuaries, and salt marshes, and quickly became a hot commodity to Science Stroll participants.

***William Waite**, Gas Hydrates Group Research Geophysicist, discussing methane gas hydrates with prospective scientists under the USGS tent at the Science Stroll. Photo credit: **Andrea Toran**.*

In addition to the Woods Hole Coastal and Marine Science Center, participating organizations included the Buzzards Bay Coalition, Marine Biological Laboratory, NOAA Fisheries, NOAA Office of Marine and Aviation Operations, Sea Education Association, United States Coast Guard, WCAI (Cape and Islands NPR station), Woods Hole Film Festival, Woods Hole Historical Museum, Woods Hole Research Center, Woods Hole Oceanographic Institution, and Zephyr Marine. ❁

***Tarandeep Kalra**, Sediment Transport Group Scientific Programmer, setting up computer-generated simulations from the three-dimensional modeling system. Photo credit: **Tom Kleindinst**, NOAA Northeast Fisheries Science Center.*

***Seth Ackerman,** Sea-Floor Mapping Group Geologist, answering questions about Woods Hole Coastal and Marine Science Center's underwater video capabilities and data collection tools. Photo credit: **Tom Kleindinst**, NOAA Northeast Fisheries Science Center.*

Coastal and Marine Scientists Talk About the AGU Fall Meeting

By Rex Sanders

USGS scientists are preparing for the 2016 American Geophysical Union (AGU, **https://fallmeeting.agu.org/2016/**) Fall Meeting—the largest gathering of Earth scientists in the world. Researchers from the USGS plan to give more than 400 presentations to 24,000 colleagues over five long days in San Francisco. Here are excerpts from interviews with USGS coastal and marine scientists at last year's meeting.

Why do you go to AGU?

***Rob Witter**, research geologist, Alaska Science Center.*

"AGU provides an incredible opportunity to meet with so many different people at the same place over a series of days. It's a huge cost savings. [I also evaluate] student presentations. It keeps me up-to-date on the latest science that's happening at universities."

***Janet Watt**, research geophysicist, Pacific Coastal and Marine Science Center.*

"I like to go to sessions in areas where I'm not an expert. It gives me a different perspective on the areas where I'm working. At AGU, you can get feedback from anyone who walks by, especially for a poster. It's another way of getting peer review, but from a much broader audience."

***Peter Haeussler**, research geologist, Alaska Science Center.*

"Going to AGU gives us a venue to share what we've learned with other scientists around the world."

***Bruce Richmond**, research geologist, Pacific Coastal and Marine Science Center.*

[I'm always saying] "Wow, that's something that I didn't know about," or "That's something that would be useful."

Describe a typical day at AGU.

Rob Witter: I had breakfast by myself because I wanted to see the first presentation [at my 8:00 session]. I sat through that entire session until my presentation and I enjoyed the session thoroughly. Then I met with two colleagues to discuss ongoing collaboration related to work along the Aleutian Islands, and paleotsunami and paleoseismology research. I [attended] a couple of more talks, then went to the poster session and had several nice encounters.

That evening we had dinner at a nearby restaurant. I got seven people together talking about a new project on the Fairweather fault in southeast Alaska. Some of the people on my team had never met before. It was also a chance for everyone to meet [retired USGS geologist] **George Plafker**. There was an opportunity to transfer knowledge from someone who's been working on [Alaskan faults] for decades.

*The Moscone Convention Center in San Francisco has been the home of the American Geophysical Union Fall Meeting for many years. Photo credit: **Rex Sanders**, USGS.*

Describe some of the other meetings you have at AGU.

Janet Watt: I have lunches and dinners booked for business, trying to set up new collaborations.

Bruce Richmond: One of the great things about AGU, it's the same time and same place every year. We've got dinner plans for 18 to 20 people, an international group that we worked with on a number of [tsunami] sites.

With so many online collaboration tools, why meet face-to-face?

Janet Watt: I think people are more likely to share data and work on collaborations when they can meet face-to-face and connect on a human level. You can get a better feel for people and whether it would be good to collaborate with them.

Rob Witter: Face-to-face meetings, so much more gets done, and relationships get built. The challenge is fitting it all in. I was just inviting people for yet another lunch meeting, and my buddy **Peter Haeussler** said, "Monday works, it's actually the only lunch I have left."

The leading experts in the field were there presenting their work. This stuff hasn't really seen the light of day yet. I could read a bunch of papers, but I wouldn't be able to ask authors right in front of me, ask simple questions because I'm not familiar with the method.

(Story continued on page 15)

(Story continued from page 14)

One small part of the AGU Fall Meeting's 6-acre (2.4 hectare) poster hall. Photo credit: ***Rex Sanders****, USGS.*

What have you learned from previous meetings?

Janet Watt: I always come out of AGU with more ideas for new projects, or connections with folks outside the USGS. I'll go into a session and find out something that blows my mind.

Rob Witter: In 2012, I presented new findings where we found this amazing record of large tsunamis from a site near Dutch Harbor, Alaska. Right there was another colleague, **Rhett Butler** [from the University of Hawaii], who had written a paper about this. He came at it from a tsunami-modeling angle, and said "What if there was a big earthquake in the eastern Aleutians? Where would it have to be to really have high impact on Hawaii?" He pointed to this area in the region of Dutch Harbor. That was where they generated an earthquake scenario that would produce a tsunami, which they felt had a great threat to Hawaii. Since then, Hawaii has taken steps to increase their tsunami evacuation zones. It's exciting.

Any last thoughts?

Rob Witter: [The AGU Fall Meeting has] allowed me to maintain my relationships with other scientists that I value greatly. I feel really privileged to be able to go to that meeting. It's a valuable way continue to learn. ❁

A Spotlight on the Enigmatic Atlantic Canyons

By Amy West

Gathering together a few hundred people devoted to studying coral in the darker, inaccessible regions of the oceans, can lead to some illuminating moments. USGS "gene-hunter" **Katharine Coykendall** discussed her unexpected genetic results she called "bananas" during a break at the 6th International Symposium on Deep-Sea Corals (**http://deepseacoral.org/**). Coykendall uses forensic science techniques to determine how closely related the *same* coral species are between deepwater canyons in the Atlantic Ocean; how far do the juveniles migrate from the parent corals? What she discovered in her informal conversation with a colleague was that the species of *Paragorgia* coral (commonly known as the bubblegum coral) she tested from a canyon off Ireland was in fact *not* the same species from those tested in other canyons! When Coykendall presented her talk the next day, she garnered many chuckles as she wryly slid in her new discovery about why such genetic outliers occur.

USGS scientist ***Katharine Coykendall*** *presents at the 6th International Symposium of Deep Sea Corals in Boston, Massachusetts. Photo credit:* ***Amy West****, USGS.*

"Keep your friends close, but keep your taxonomists and geneticists closer!" joked USGS microbiologist **Christina Kellogg** during her own presentation.

Kellogg and Coykendall were two of the six USGS scientists presenting at the conference, along with **Amanda Demopoulos**, **Cheryl Morrison**, **Jill Bourque**, and **Nancy Prouty**. This all-female force hailed from USGS centers in West Virginia, California, and Florida.

6th International Symposium of Deep Sea Corals opens in Boston, Massachusetts. Photo credit: ***Amy West****, USGS.*

This symposium occurs every four years, and less than 200 attendees gathered this time in Boston—with about half from outside the U.S. With no concurrent talks, one could easily spot common trends and identify possible partnerships. Geneticists, chemists, ecologists, and microbiologists

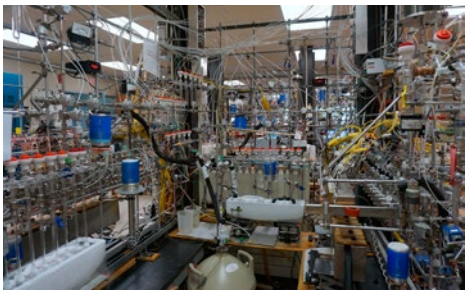
(Atlantic Canyons continued on page 16)

(Atlantic Canyons continued from page 15)

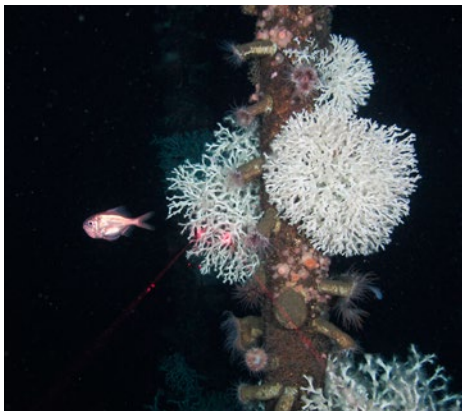
Left to right: ***Jill Bourque***, ***Cheryl Morrison***, ***Nancy Prouty***, ***Katharine Coykendall***, ***Amanda Demopoulos***, ***Christina Kellogg***. *Photo credit:* ***Amy West***, *USGS.*

received the entire deep-sea picture of new results, which covered such issues as the Gulf of Mexico oil spill, trawling effects, toxic plumes from deep-sea mining, ocean acidification and climate change, plus the challenges to protecting deep-sea coral. Amassing these experts from all corners of the globe can increase the spread of knowledge faster than publishing a scientific paper, as it gave researchers a chance to pose questions to the collective coral brain: what do these results mean, have you seen this aberration, how do you approach this problem, and where can one find more samples? Case in point, five researchers offered Coykendall new samples.

USGS science covered the gamut of topics. Morrison spoke about a contentious issue in the deep-sea coral world: should the coral poster child for the deep-sea—*Lophelia,* a colonial reef-building coral—merge with *Desmophyllum*, a solitary coral, now that genetics indicates they are similar? Morrison questioned combining these genera because the key-defining characteristic



During the symposium, participants could tour the facilities at Woods Hole Oceanographic Institution, such as this radiocarbon lab. Here scientists analyze the amount of radiocarbon in such material as coral or wood to help determine their age. Photo credit: ***Amy West****, USGS.*



Large Lophelia *colonies and numerous anemones at a depth of about 1,500 feet in Mississippi Canyon. Red laser beams, projected from a remotely operated vehicle, represent a separation of 10 centimeters (about 4 inches). A western roughy is seen to the left of the structure. Photo credit:* Lophelia II *2012 Expedition, NOAA-OER/BOEM/USGS.*

A close-up of the Paramuricea *polyps when open. Photo credit: NOAA-OER/BOEM/USGS.*

for corals divides those living alone from those living in a colony. Many also worry that the confusion generated by merging the genera may hamper conservation efforts for *Lophelia*.

Demopoulos studied deepwater canyons situated just 70 nautical miles apart, but found that their seafloor communities differed greatly. After assembling a small army to analyze the 2,000 samples, she discovered that a canyon's shape influenced access to food, and thus the structure of the deep-sea community residing there.

Bourque dove into seafloor sediments to explain why a completely different community of animals inhabits the sediment next to *Lophelia* compared with other corals. Apparently *Lophelia's* complex shape creates a physically different habitat, right down to the size of sediment grains. This coral also has more food available to support the animals. She emphasized that deep-sea corals

A massive colony of Paragorgia *(bubble gum coral) with squat lobster hiding among the polyps. Photo credit: NOAA-OER/BOEM/USGS.*

actually have an influence beyond the reef; they foster a higher diversity of microscopic critters in the surrounding seafloor.

Kellogg focused in even closer: the microbes residing within these deep corals. The bacterial community in most corals was completely unknown. These microbes help cycle nutrients, and can both protect against and indicate disease; they are one way a coral adapts to its environment. She found only one bacterial group shared by all of them, and that the coral itself controlled which bacteria lived there. Having this basic knowledge is critical in the face of change during a climate change, or an oil spill.

Prouty looked within the coral matrix to show that its iodine levels could reveal the age of one of the oldest organisms on earth: the long-lived black coral (see **http://www.livescience.com/13598-black-sea-corals-aged.html**). This coral may live up to 4,000 years; iodine makes up about a quarter of its skeleton (see **https://www.llnl.gov/news/deep-sea-corals-may-be-oldest-living-marine-organism**). It's a novel and inexpensive approach to carbon dating, which can be miscalculated for deepwater corals. That's because corals may be influenced by seawater that has flowed deep below the surface for some time, and not reset its carbon clock to reflect the current carbon-dioxide levels at the surface.

The growing volume of knowledge used to conserve and manage these deeper ocean realms comes from many at this symposium. It was thus, an apt and rewarding surprise that the last day began with the announcement that President Obama decided to protect a patch of deep sea in the Atlantic—a first for this ocean (see **https://www.whitehouse.gov/the-**

(Atlantic Canyons continued on page 17)

(Atlantic Canyons continued from page 16)

press-office/2016/09/15/presidential-proclamation-northeast-canyons-and-seamounts-marine). Many in the room had contributed the scientific support during the past 20 years for this "monumental" decision, which created the Northeast Canyons and Seamounts Marine National Monument. It would prohibit fishing and any other activities extracting the region's resources. The announcement seemed to get at the heart of the week's presentations by the USGS: the diversity of life in the Atlantic Ocean canyons provides a record of how our climate has been changing, and warrants protection (**http://www.nytimes.com/2016/09/16/us/politics/obama-to-create-atlantic-oceans-first-marine-monument.html?_r=0**).

The USGS co-sponsored the symposium with the Bureau of Ocean Energy Management (BOEM), the National Oceanic and Atmospheric Administration (NOAA), Woods Hole Oceanographic Institution (WHOI), and Temple University College of Science and Technology. Some of those sponsors have worked jointly on prior deep-sea coral projects. NOAA, USGS, and BOEM and other non-federal partners won three awards (see **https://soundwaves.usgs.gov/2014/02/awards.html**) recognizing their collaboration in *Lophelia II* (**https://soundwaves.usgs.gov/2012/12/awards.html**) and *Pathways to the Abyss (***https://soundwaves.usgs.gov/2016/03/awards.html***)*. This federal trio and their partners will likely be in the running for yet another award for their new study in the Atlantic Ocean that began with a cruise to look at deep-sea environments off the coast of Virginia and the Carolinas in the fall of 2016 (see **http://oceanexplorer.noaa.gov/explorations/16carolina/background/plan/plan.html**).

A cluster of the solitary coral, Desmophyllum. *Photo credit:* ***Art Howard,*** *Deepwater Canyons 2012 Expedition, NOAA-OER/BOEM.*

The backdrop for the next symposium in 2019 will be tropical Cartagena, Columbia, which won out over Scotland. Considering the environmental hurdles facing deepwater corals, and that impacts to them extend beyond just the reef, that conference promises to showcase a melting pot of revelations. ❁

USGS Participates in SACNAS National Conference

By Jennifer A. Flannery

The Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS, **https://sacnas.org/**) has been the leading multicultural and multidisciplinary science, technology, engineering, and mathematics (STEM) diversity organization in the United States for over 40 years. The annual SACNAS conference is three days of elite science, mentoring, training, and cultural activities for all levels of students and scientists of all minority backgrounds and their allies. The combination of science, culture, and diversity celebrates all STEM fields. This year the annual conference was held in Long Beach, California, from October 13–15, 2016.

Jennifer Flannery (Chemist, St. Petersburg Coastal and Marine Science Center) and **Christopher Smith** (Research Geologist, St. Petersburg Coastal and Marine Science Center) were invited to speak about their research in a USGS-sponsored session entitled "Clocks in the Rocks, Coral, and Wood: Dating Techniques That Keep Time For Earth History and Ecosystem Change" along with **Thomas Doyle** (Deputy Director, Wetland Aquatic Research Center, Lafayette, Louisiana) and **Debra Willard** (Coordinator, Climate and Land Use Change Research and Development Program, Reston, Virginia). Flannery, Smith, and Doyle served as judges for several undergraduate and graduate student poster and oral presentations in the fields of geology and marine science. Flannery and Doyle participated in a "Conversation with Scientists" mentoring/guidance event to speak with undergraduate and graduate students, post-docs, and early-career scientists looking at careers with the USGS. All representatives from the USGS spent time at the USGS exhibit booth talking to people with various scientific backgrounds and academic levels about the cutting-edge research performed by various groups within the USGS. ❁

Jennifer Flannery *at the USGS exhibitor booth.*

Presenters in the USGS-sponsored session "Clocks in the Rocks, Coral, and Wood: Dating Techniques That Keep Time For Earth History and Ecosystem Change." From left: ***Thomas Doyle, Jennifer Flannery, Christopher Smith,*** *and* ***Debra Willard****.*

James Hein Wins Prestigious Moore Medal Award from the International Marine Minerals Society

By Kira Mizell

The International Marine Minerals Society (IMMS, **http://www.immsoc.org/**) has awarded its highest honor, the Moore Medal, to **James Hein** of the USGS Pacific Coastal and Marine Science Center, in recognition of his 43-year scientific career dedicated to the study of marine minerals with the USGS.

The IMMS is a professional society whose members share a common interest in marine minerals as a resource for study and sound application to meet world demands for strategic minerals. Founded in 1987, the IMMS includes a worldwide membership of individuals from industry, government agencies, and research institutions. The Moore Medal is given to members of the society who exhibit distinction in the field of marine minerals and contribute notably to the objectives and initiatives of the society. The award was presented to Hein on October 11, 2016, during the banquet dinner of the 45th annual Underwater Mining Conference in Songdo-Incheon, South Korea, hosted by the IMMS, the Korea Institute of Ocean Science and Technology, and the University of Hawai'i.

***James Hein** accepts the Moore Medal award.*

Hein has been a member of the IMMS for 30 years, 18 of which have been spent as a member of the society's Executive Board, including two terms as president. Hein has authored and co-authored more than 500 papers and abstracts investigating all types of marine mineral deposits (**https://walrus.wr.usgs.gov/research/projects/pac_eez_minerals.html**), and he has served as an unbiased academic consultant to numerous studies conducted by researchers, industries, and governments. In addition, Hein has mentored many students and professionals who now also hold important positions in oceanographic institutes and marine mineral programs throughout the world.

***James Hein** after receiving the Moore Medal, with Ph.D. student and USGS colleague **Kira Mizell** (right) and collaborating Fullbright scholar **Natalia Konstantinova** (left).*

The IMMS esteems Dr. Hein as a cornerstone scientist in the field of marine minerals, whose contributions are far-reaching and will have a permanent impact on its continued development, thus making him a clear choice for the 2016 Moore Medal. ❁

International Recognition for Historic Elwha River Restoration

By Jonathan Warrick

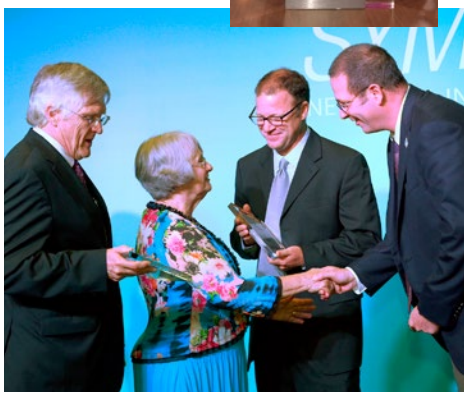
The collaborative work of the U.S. Department of the Interior and the Lower Elwha Klallam Tribe to restore the Elwha River of Washington, USA, was recognized as a world-renowned restoration project during the awarding of the 2016 Thiess International Riverprize.

Riverprize is an annual award given by the International River Foundation to recognize and support premier examples of river restoration management. The 2016 award was presented during an award ceremony at the 19th International River Symposium September 14, 2016, in New Delhi, India.

The Elwha River was recognized as one of three Riverprize finalists for its unprecedented approach to restoring salmon populations through the largest orchestrated dam removal project in history (**https://www.nps.gov/olym/learn/nature/elwha-ecosystem-restoration.htm**). The USGS has been a major partner in the project, providing scientific monitoring and analyses of the fish, waters, and sediment before, during, and after dam removal (**http://walrus.wr.usgs.gov/elwha/**). The Elwha River Restoration Project encompasses numerous restoration elements, including fisheries management, reseeding and replanting, water management and treatment, sediment management, and

(Riverprize continued on page 19)

*USGS scientists **Jonathan Warrick** and **Jeff Duda** receiving Riverprize recognition in New Delhi, India. Above: plaque recognizing the Elwha River Restoration Project as one of three finalists for the 2016 Thiess International Riverprize. Photo credit: International River Foundation.*



(Riverprize continued from page 18)

educational activities. These coordinated activities came after decades of debate, planning, and collaboration.

"The Elwha River Restoration is a shining example of what can happen when diverse groups work together to recognize rivers for their many contributions to our culture, economy, and environment," said U.S. Secretary of the Interior **Sally Jewell**. "It was powerful to witness the largest dam removal and ecosystem restoration project in history, and to see endangered salmon, trout, and other fish once again regain access to their historic migration and spawning habitat along the Elwha River."

Two large dams on the Elwha River were removed between 2011 and 2014, resulting in the release of millions of cubic meters of sediment downstream and the reopening of fish passage upstream, past former dam sites into protected habitats of Olympic National Park. The project now serves as a living laboratory of cultural and ecosystem restoration as the salmon return to the river.

"Elwha River Restoration is a historic achievement for the Department of the Interior and the Tribe that could not have been accomplished without the help of our many partners, and we are very honored to have been chosen as a finalist for the Thiess International Riverprize," said Olympic National Park Acting Superintendent **Rachel Spector**.

Personal watercraft fitted with sonar and GPS were among the tools used by USGS scientists to map the bottom of shallow coastal waters near the mouth of the Elwha River. This shot was taken August 25, 2011, during a survey conducted just a few weeks before dam removal began.

Webcam photo taken February 7, 2012, during deconstruction of the Glines Canyon Dam by a process called "notching down." The dam was built in 1927 in Olympic National Park. Photo credit: National Park Service.

Glines Canyon Dam removal showing notching and spillway. Site of the Elwha River Restoration project.

***Amy East** poses with a salmon carcass, found several miles upstream upstream of the former Glines Canyon Dam site on the Elwha River in Washington State.*

"In completing this project, we are able to give a gift of renewed salmon populations to this great river and to future generations," stated **Robert Elofson**, River Restoration Director for the Lower Elwha Klallam Tribe. "We are honored to be recognized as world leaders in river restoration."

Revegetation in the river valley at the Elwha River restoration site.

Revegetation planting day at former Lake Mills reservoir as Glines Canyon Dam is removed.

Visitors at Glines Canyon East Abutment in Olympic National Park, the location of the Elwha River Restoration project.

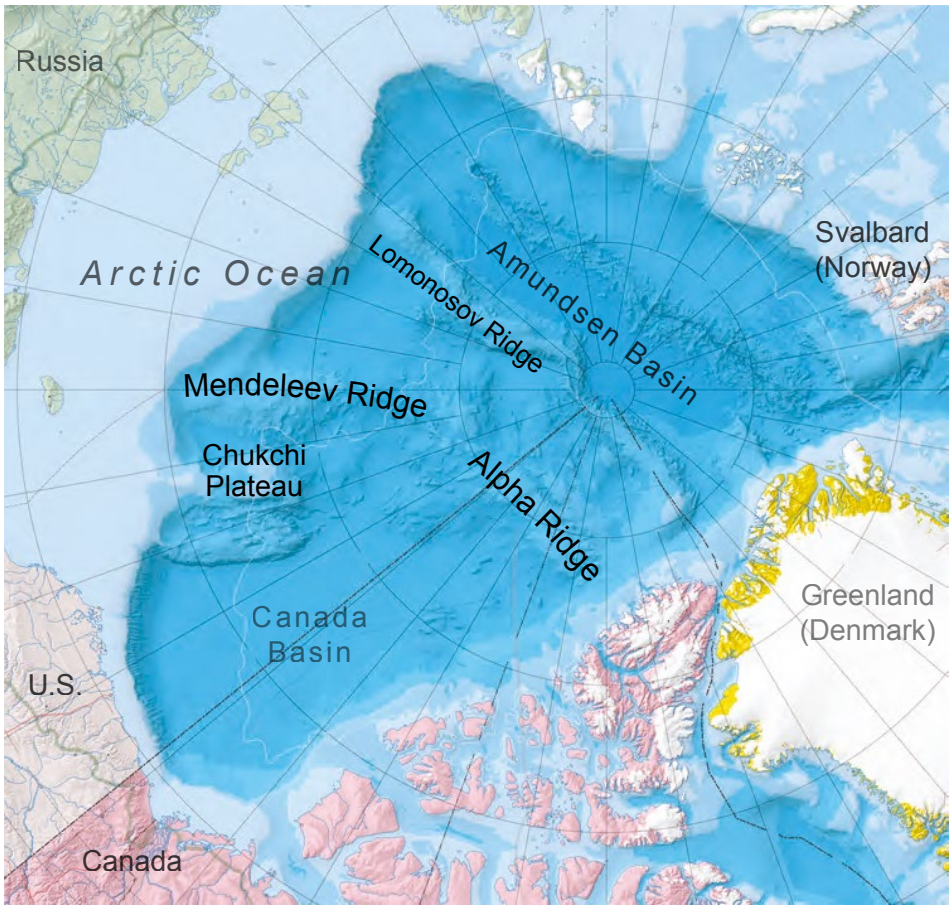
The three finalists for the 2016 Riverprize included the Segura River of Spain, and the Niagara and Elwha Rivers of the USA (**http://riverfoundation.org.au/2016/09/niagara-river-team-wins-2016-thiess-international-riverprize/**). The Buffalo Niagara Riverkeeper project was awarded the Riverprize. ❁

Visiting Russian Scholar Studying Ferromanganese Crusts and Nodules from the Arctic Ocean

By Mariah Mikesell

Natalia Konstantinova has joined the USGS Pacific Coastal Marine Science Center in Santa Cruz, California, as a visiting scholar. Konstantinova is currently a Ph.D. student at the Institute of Earth Sciences at Saint Petersburg State University in Russia (**http://earth.spbu.ru/en/**), where she received a bachelor's degree in 2010 and a master's degree in 2012. She investigates marine mineral deposits, particularly ferromanganese crusts—iron- and manganese-rich deposits that precipitate extremely slowly from cold seawater onto hard rock surfaces. Ferromanganese crusts form on seamounts, ridges, and plateaus throughout the global ocean.

Konstantinova's academic advisor is **Georgy Cherkashov**, professor at Saint Petersburg State University, and her thesis advisor is **James Hein**, research geologist at the USGS Pacific Coastal and Marine Science Center in Santa Cruz, California. After receiving her master's degree, Konstantinova was invited by Cherkashov to work at the I.S. Gramberg Institute for Geology and Mineral Resources of the Ocean (**http://en.vniio.ru**), where she gained further experience in geological and oceanographic research. Konstantinova is now able to work part-time at the I.S. Gramberg Institute while pursuing a Ph.D.



*Arctic Ocean. Base map from North Circumpolar Region (2008), Atlas of Canada, Natural Resources Canada (**http://www.nrcan.gc.ca/earth-sciences/geography/atlas-canada/selected-thematic-maps/16886**).*

***Natalia Konstantinova** on Bennett Island during a 2014 scientific expedition in the East Siberian Sea.*

Konstantinova is currently studying ferromanganese crusts from the Mendeleev Ridge in the western Arctic Ocean to better understand the nature and origin of these deposits. Konstantinova's work at the USGS is funded through a nine-month Fulbright Fellowship with Hein, who is a world expert on marine ferromanganese deposits. Together, they will determine how the complex and unique characteristics of the Arctic Ocean produce crusts and nodules that are unlike any others formed throughout the global ocean. Konstantinova and Hein will also compare samples obtained from the Mendeleev Ridge during a 2012 Russian Arctic cruise with samples recovered from the Chukchi Plateau and Alpha Ridge during extended U.S. Continental Shelf (**https://www.continentalshelf.gov**) cruises in 2008, 2009, and 2012. ❁

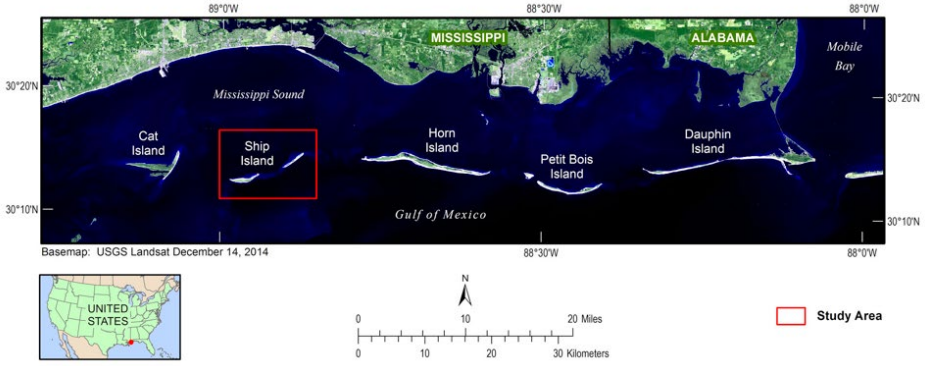
Structured Decision Making in Barrier Island Restoration: Study Demonstrates the Potential for Informing Management Decisions and Guiding the Focus of Scientific Research

By Soupy Dalyander

A new study, "Use of structured decision-making to explicitly incorporate environmental process understanding in management of coastal restoration projects: Case study on barrier islands of the northern Gulf of Mexico," demonstrates the use of a decision-analysis tool to inform management of coastal restoration projects and identify high-priority research gaps.

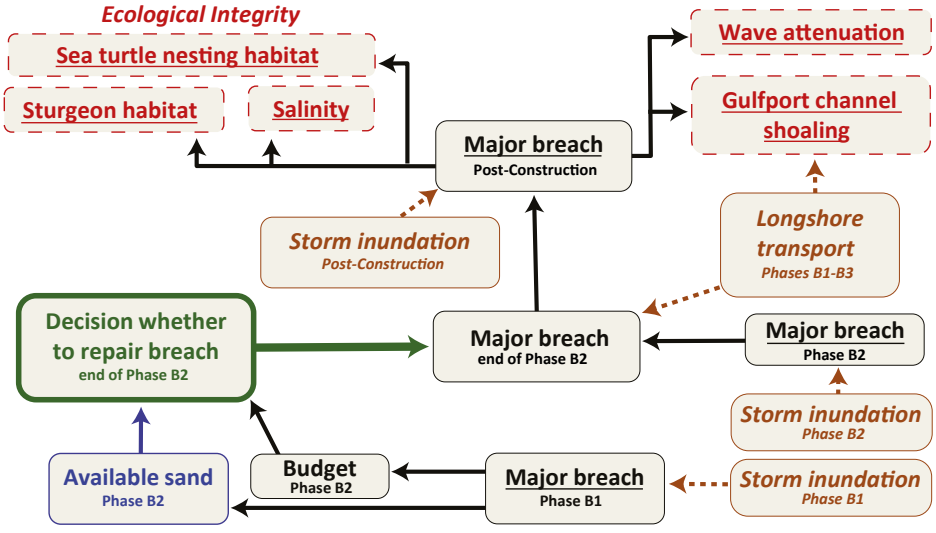
The focus of the study is the planned restoration of Ship Island, Mississippi, a once-contiguous barrier island in the northern Gulf of Mexico that has been split in two since Hurricane Camille (1967). As part of the Mississippi Coastal Improvements Program, the U.S. Army Corps of Engineers plans to use approximately 22 million cubic yards of sand to close the gap between East and West Ship Islands and nourish the eastern end to enhance the supply of sand via longshore transport.

The project will take place in five phases over approximately three years. If a tropical storm occurs during construction and damages the project, management decisions will have to be made regarding if and when (i.e., which construction phase) repairs should be made to maximize the likelihood that the project will achieve its objectives of habitat restoration and protecting the mainland from waves.



Map showing the location of Ship Island, Mississippi. The focus of the study is the planned restoration of Ship Island, Mississippi, a once-contiguous barrier island in the northern Gulf of Mexico that has been split in two since Hurricane Camille (1967).

In this study, structured decision-making (SDM) was evaluated as a tool for incorporating data and environmental process knowledge directly into coastal restoration management decisions. The transparent SDM process included soliciting input from stakeholders on project objectives and relative importance, and from scientists and engineers on the physical drivers and response of the system. This input was incorporated into a probabilistic framework that linked storm inundation data, the physical response of the island, repair decisions, and sand and budget constraints to the quantitative impacts on project objectives. If the project incurs damage during construction, this framework will be used to inform decisions made in response. For example, the analysis indicated that it is more cost effective to repair major damage immediately despite the additional cost of moving equipment, rather than wait until a subsequent construction phase and risk additional damage to the weakened project.



Example of a simplified influence diagram developed in building a structured decision-making framework at Ship Island, in this case representing a single decision on whether or not to repair a major breach in Phase B2. Influence diagrams conceptually link system drivers and response, budget and sand constraints, management decisions, and the objectives of the project. A Bayesian (probabilistic) network was developed to statistically evaluate the quantitative impact of possible damage and response decisions on project objectives.

In addition to providing a framework for analyzing decisions at Ship Island, this effort identified several key gaps in scientific understanding of barrier island dynamics that limit the ability to robustly manage coastal restoration projects. For example, there is relatively high uncertainty in predicting the relation between island width and storm resilience, and in quantifying the potential benefits of upstream sand nourishment on project longevity.

This study demonstrates the potential for structured decision-making to directly incorporate scientific and engineering

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knowledge into a framework that can both improve coastal restoration management and identify priority gaps in data, predicting model capability, and process understanding that can be filled with targeted scientific research.

This effort included collaborators from the USGS, U.S. Army Corps of Engineers, University of Natural Resources and Life Sciences Institute of Silviculture, Applied Coastal Research and Engineering, the National Park Service, and the Louisiana Coastal Protection and Restoration Authority. Funding was provided by the Department of the Interior Southeast Climate Science Center.

The full citation for the article is:

- Dalyander, P.S., Meyers, M., Mattsson, B.J., Steyer, G., Godsey, E., McDonald, J., Byrnes, M., and Ford, M., 2016, Use of structured decision-making to explicitly incorporate environment process understanding in management of coastal restoration projects: Case study on barrier islands of the northern Gulf of Mexico: Journal of Environmental Management, **https://doi.org/10.1016/j.jenvman.2016.08.078.** ❁

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