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Fieldwork

Arctic Expedition Reaches 88.5 Degrees North Latitude—Fourth Joint U.S.-Canada Survey for Purpose of Delineating Extended Continental Shelf

By Deborah Hutchinson and Lisa Robbins

The United States and Canada joined forces once again in August and September 2011 to survey the seafloor in remote and ice-covered regions of the Arctic Ocean. The two-icebreaker expedition was the last of four joint cruises designed to collect data that each country will use to define its "extended continental shelf"—the area beyond 200 nautical miles (nm) from shore where a nation has sovereign rights over resources on and beneath the seafloor according to the Law of the Sea Convention. (Visit **http://www.un.org/Depts/los/** to learn more.)

The criteria for delimiting extended continental shelf as set forth in the convention require detailed information about the shape ("morphology") of the seafloor and the thickness of sediment beneath the seafloor. To map seafloor morphology, scientists used a multibeam bathymetric-mapping system aboard the U.S. Coast Guard Cutter *Healy*. To acquire information about sediment thickness, they used a multichannel seismic-reflection system on the Canadian Coast Guard Ship *Louis S. St-Laurent* (the *Louis*).

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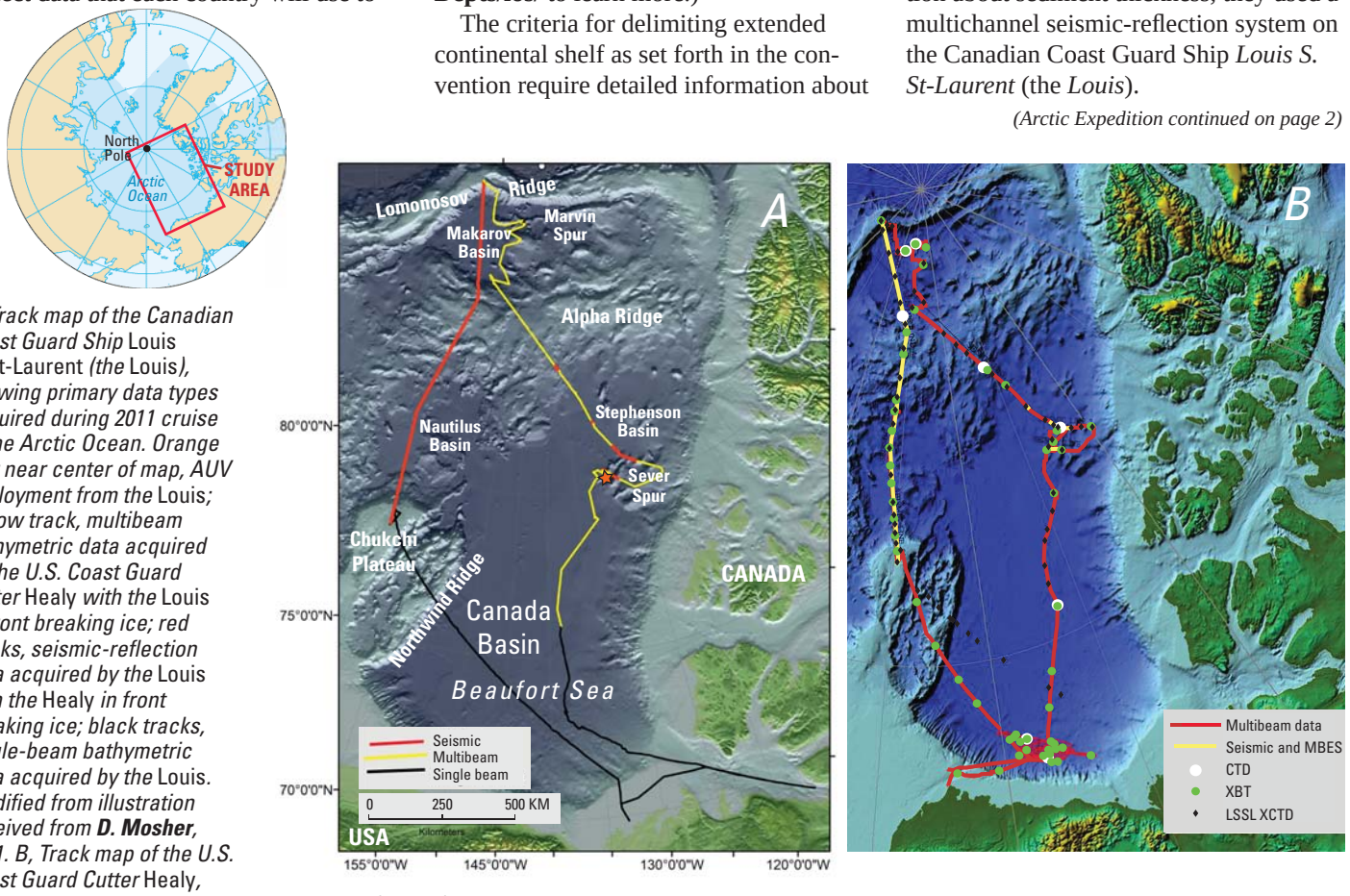

A, Track map of the Canadian Coast Guard Ship Louis S. St-Laurent *(the* Louis*), showing primary data types acquired during 2011 cruise in the Arctic Ocean. Orange star near center of map, AUV deployment from the* Louis*; yellow track, multibeam bathymetric data acquired by the U.S. Coast Guard Cutter* Healy *with the* Louis *in front breaking ice; red tracks, seismic-reflection data acquired by the* Louis *with the* Healy *in front breaking ice; black tracks, single-beam bathymetric data acquired by the* Louis*. Modified from illustration received from* ***D. Mosher****, 2011. B, Track map of the U.S. Coast Guard Cutter* Healy*, showing seismic-reflection-data acquisition (yellow) when the* Healy *broke ice in front of the* Louis*. Multibeam bathymetric soundings were collected on all* Healy *tracks (red). CTD, conductivity-temperature-depth; LSSL,* Louis S. St-Laurent*; MBES, EM-122 Multibeam Echosounder; XBT, expendable bathythermograph (device that measures temperature and depth while falling through the water); XCTD, expendable conductivity/temperature/depth profiler. Modified from Mayer and Armstrong, 2011, Cruise Report (visit* ***http://www.ccom-jhc.unh.edu/publications/*** *and scroll down to link "Mayer_2011_cruise_report_HEALY1102.pdf"). (Different map projections give maps A and B different shapes.)*

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Fieldwork, continued

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The *Healy* and *Louis* worked together to collect data between lat 78° and 88° N. along some of the most poorly mapped ridges and basins of the Arctic Ocean. The 2011 work started with a 1,200-km seismic-reflection transect northward from the Chukchi Plateau, across Alpha Ridge and the Makarov Basin, to Lomonosov Ridge (see map on previous page). Along the return tracks southward, the expedition acquired primarily multibeam bathymetric data, although four additional short seismic-reflection lines were collected in the Stephenson Basin and on Sever Spur. Before joining the *Louis* for the two-icebreaker work, the *Healy* collected approximately 25,000 km^2 of multibeam bathymetric soundings in deep water of the Alaskan margin east-northeast of Barrow (map *B*).

Each summer since 2008, the two icebreakers *Healy* and *Louis* have worked together to enable scientists to collect morphologic and sediment-thickness data in the Arctic, primarily beyond 200 nm from shore. In 2008 the fieldwork was conducted mainly in the southern and central Canada Basin, and in 2009 primarily in the central and northern Canada Basin. The 2010 fieldwork was conducted along both the Alaskan and Canadian Beaufort margins, with additional lines along Northwind Ridge and the Stephenson Basin. Profiling conducted in 2011 expanded the previous surveys northward.

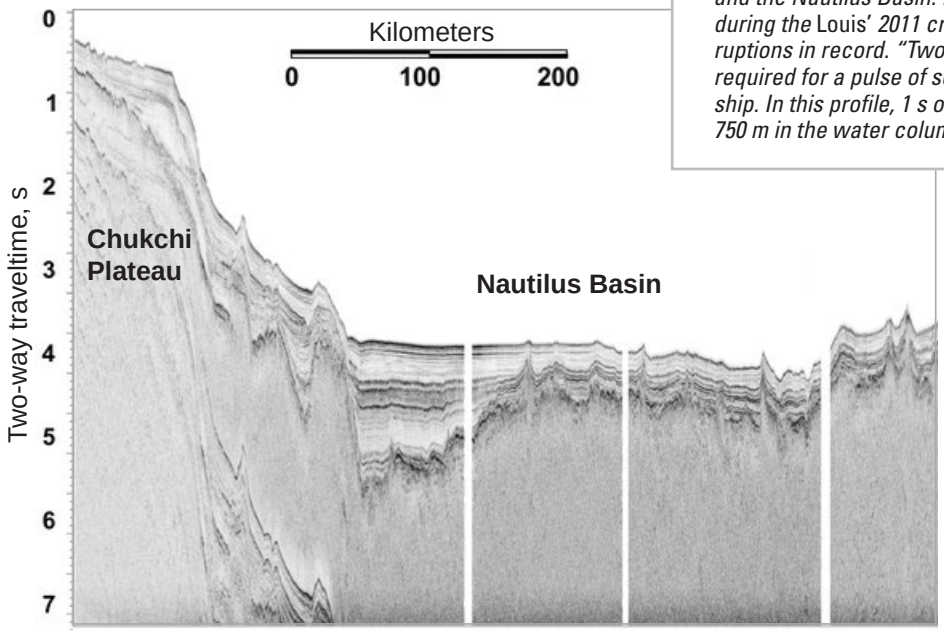
Throughout the 4 years of joint icebreaker work, the primary U.S. and Canadian focus was on collecting multichannel seismic-reflection data, with the *Healy* breaking ice in front of the *Louis*. Canada and the United States also had bathymetric objectives, and where those objectives were a priority, the *Louis* broke ice ahead of the *Healy*. Together, the joint surveys have added approximately 15,000 km of high-quality multichannel seismic-reflection data, many thousands of kilometers of multibeam bathymetric data, and more than 120 sonobuoy seismic-refraction lines in parts of the Arctic where surface ships have rarely been able to operate. (Seismic-refraction data, commonly collected by deploying an instrument called a sonobuoy, are required for correct calculation of sub-seafloor sediment thickness from the seismic-reflection data; they also provide information about sediment composition.) The multichannel seismic-reflection profile acquired from the Chukchi Plateau northward to Lomonosov Ridge is the first continuous seismic-reflection profile collected in this part of the Arctic Ocean, providing some of the first images across Alpha Ridge and the Makarov Basin that show clear sedimentary stratigraphy and basement morphology. ("Basement" is the hard rock beneath the sediment, into which the sound waves used to collect sediment data typically do not penetrate.)

Chief scientists for the 2011 cruises were **David Mosher** (Geological Survey of Canada) on the *Louis* and **Larry Mayer** (University of New Hampshire) and **Andy Armstrong** (National Oceanic and At-

(Arctic Expedition continued on page 3)

The Healy *breaking ice in front of the* Louis *during multichannel seismic-reflection data acquisition. Photograph by* ***Hans Böggild****, who wrote a blog from the* Louis *(****http://blogs.science.gc.ca/arctic-arctique/2011/****).*

(Arctic Expedition continued from page 2)



Multichannel seismic-reflection profile, showing the Chukchi Plateau and the Nautilus Basin. Profile was preliminary stack-processed during the Louis' *2011 cruise. Data gaps are indicated by white interruptions in record. "Two-way traveltime" refers to time (in seconds) required for a pulse of sound to travel to depth shown and back to ship. In this profile, 1 s of two-way traveltime corresponds to about 750 m in the water column and about 1,500 m in the sediment.*

mospheric Administration) on the *Healy*. For the third year, **Deborah Hutchinson** (U.S. Geological Survey [USGS] Woods Hole Coastal and Marine Science Center, Woods Hole, Massachusetts) was the U.S. liaison on the *Louis*. Aboard the *Healy*, **Lisa Robbins** (USGS St. Petersburg Coastal and Marine Science Center, St. Petersburg, Florida) led a group of scientists—**Paul Knorr** and **Brian Buczkowski** of the USGS and **Jonathan Wynne** of the University of South Florida—in a "science of opportunity" study of ocean acidification in the Arctic Ocean. Gravity data were collected on both ships, monitored by **Hutchinson** on the *Louis* and **Buczkowski** on the *Healy*.

The ocean-acidification measurements taken from the *Healy*, which expand the region sampled in the 2010 joint icebreaker cruise, represent the first continuous sample transect taken near the North Pole from surface ships (see "USGS Arctic Ocean Research: A Polar Ocean Acidification Study," published before the cruise in *Sound Waves*, August 2011, **http://soundwaves.usgs.gov/2011/08/**). More than 9,000 continuous samples (collected from seawater flowing through a shipboard system) were analyzed, as well as 515 discrete surface samples collected for pH measurement and 350 discrete surface samples collected for measurement of carbonate concentration. At eight

Alice Orlich *(middle), from University of Alaska, Fairbanks, prepares to take an ice core. Photograph by* ***Don Glencross****, Defense Research and Development Canada.*

sites, water samples were collected from selected water-column depths during deployment of a "CTD"—an assembly of instruments that measure conductivity (related to salinity), temperature, and depth while being lowered through the water. The CTD frame holds a ring, or "rosette," of water-sampling bottles triggered to collect water at selected depths as the assembly is raised back toward the surface. Ice samples were taken at three sites. The 2011 measurements provide a rich dataset for comparing CO_2

Autonomous underwater vehicle (AUV) being deployed from the Louis, *with the* Healy *in background. Photograph by* ***Deborah Hutchinson****, USGS.*

saturations and fluxes among the Canada, Nautilus, Makarov, and Stephenson Basins, as well as understanding how the carbon values relate to other physical and biological parameters. A blog and additional information about the ocean-acidification studies is posted at **http://coastal.er.usgs.gov/ocean-acidification/arcticcruise2011/**.

Several "firsts" took place aboard the *Louis* during the 2011 trip. For the first time, an autonomous underwater vehicle (AUV) was deployed in the ice and completed a successful 20-hour mission acquiring multibeam bathymetric data from a height of approximately 100 m above the seafloor along the ice-covered Canadian margin. Although recovery of the vehicle was challenging in the ice, the successful mission demonstrated the potential for using AUVs in remote and difficult environments, such as the

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A, Launching a Raven UAV from the Louis. *B, Infrared image of* Louis *from the UAV (white indicates warmer temperatures), also showing melt pools around the* Louis *that were otherwise obscured by snow cover. Photograph by* ***Deborah Hutchinson****, USGS.*

ice-covered Arctic, where movement of surface ships is restricted. Another first was the use of a drone unmanned aerial vehicle (UAV) for scientific purposes in the Arctic. U.S. Air Force Captain **Steve Wackowski** flew nine missions using cameras aboard Raven UAVs to image ice conditions and search for marine mammals. An ozone buoy (O-buoy) was deployed on the ice near lat 88° N. to collect air-quality measurements integrated with physical-environment data and hourly camera images in this remote part of the Arctic (visit **http://obuoy.datatransport.org/** and click on "OBuoy #4"). Finally, near the northernmost extent of the expedition, samples from throughout the water column were taken with CTD rosettes to add to a limited number of observations of full-depth physical oceanography and water-mass interactions in the area.

The *Healy* and *Louis* rafted together twice during the expedition, once at the beginning of the cruise for the *Louis* to take on fuel from the *Healy* after high winds prevented the *Louis* from refueling from a barge off Tuktoyaktuk, Northwest Territories, Canada, and again at the end of the cruise, for the third year of joint-operations celebration. (Logistical complexities prevented a celebration raft-up in 2010.) This year's end-of-cruise raft-up included nautical-skills competitions (the *Healy* excelled), musical entertainment (the *Louis* excelled), and a feast of amazing treats (everyone excelled). A set of blogs about life aboard Louis is posted at **http://blogs.science.gc.ca/arctic-arctique/?lang=en**. Finally, a USGS flag flown on the *Louis* to the northernmost point of the journey was given to the captain and crew of the *Louis* in appreciation of the 4 years of successful joint operations with the USGS.

The Extended Continental Shelf Project is operated through the U.S. Extended Continental Shelf Task Force, an interagency body chaired by the Department of State with co-vice chairs from the Department of the Interior and the National Oceanic and Atmospheric Administration. The task force, which reports to the National Ocean Council, includes representatives from the USGS, the Executive Office of the President, the Joint Chiefs of Staff, the U.S. Navy, the U.S. Coast Guard, the U.S. Department of Energy, the National Science Foundation, the U.S. Environmental Protection Agency, the Bureau of Ocean Energy Management, and the U.S. Arctic Research Commission. Additional information on the joint U.S.-Canadian Extended Continental Shelf cruise is posted at **http://continentalshelf.gov/** and **http://ess.nrcan.gc.ca/scient_e.php**. ☸

Ozone buoy (O-buoy) deployed in the ice, with the Louis *in background. Learn more about the buoy at* ***http://obuoy.datatransport.org/*** *(click "OBuoy #4"). Photograph by* ***Don Glencross****, Defense Research and Development Canada.*

Canadian flag (right) and USGS flag (left) flying from the Louis' *masthead, near lat 88° N. Photograph by* ***Deborah Hutchinson****, USGS.*

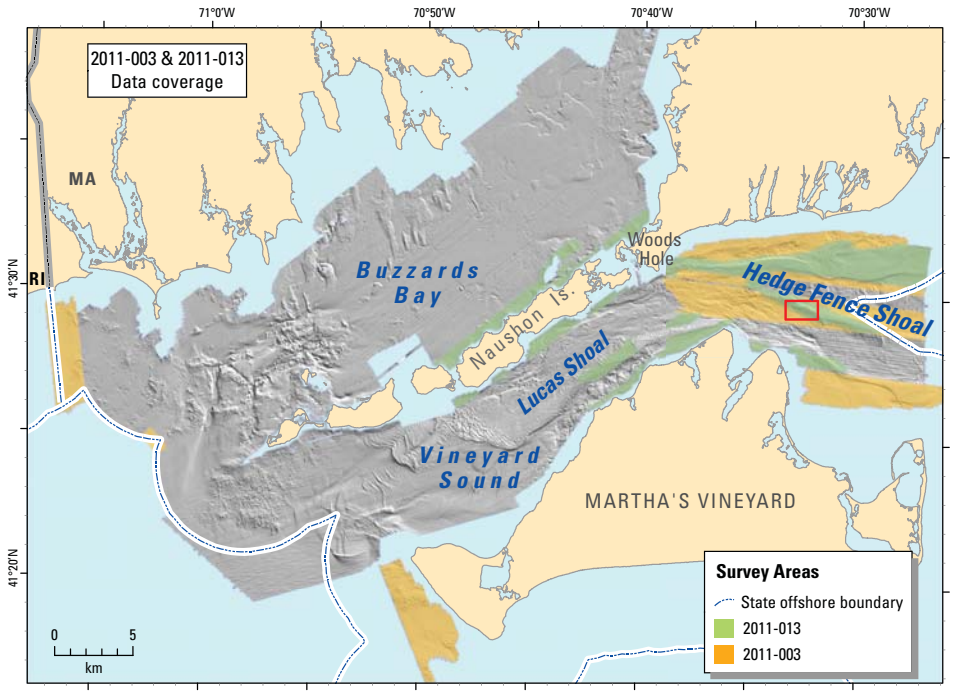
Collaborative Seafloor-Mapping Program Completes Final Mapping Surveys off Massachusetts

By Brian Andrews and David Foster

Two seafloor-mapping surveys off the coast of Massachusetts in spring and summer 2011 wrapped up fieldwork for the mapping phase of the investigation by the Massachusetts Seafloor Mapping Cooperative (**http://woodshole.er.usgs.gov/project-pages/coastal_mass/**), a collaboration between the U.S. Geological Survey (USGS) Woods Hole Coastal and Marine Science Center (WHSC) and the Massachusetts Office of Coastal Zone Management (CZM). The long-term objectives of this program are to provide a framework for scientific research and to develop geologic information to assist the management of coastal and marine resources. High-resolution spatial data and detailed maps of seafloor geology build a foundation for protecting fish habitat, delineating marine resources, and assessing environmental changes caused by natural or human impacts. Initiated in 2003, this collaborative program has produced five USGS Open-File Reports containing spatial data and geologic interpretations of the seafloor within state waters. A regional seabed characterization map will be produced as a final product of the mapping phase, along with derivative reports on the Quaternary geology of the region.

The 40-m-long by 10-m-wide M/V Scarlett Isabella*, used during WHSC Field Activity 2011-003-FA in May 2011. Photograph by* **Dann Blackwood***, USGS.*

In May 2011, USGS researchers conducted a 2-week survey aboard the 40-m-long motor vessel (M/V) *Scarlett Isabella* that filled data gaps in Buzzards Bay and Vineyard Sound from previous surveys (see related article in *Sound Waves*, December 2010, **http://soundwaves.usgs.gov/2010/12/fieldwork3.html**). USGS crew participating in this survey included **Dave Foster** (principal investigator), **Bill Danforth**, **Chuck Worley**, **Emile Bergeron**, **Eric Moore**, **Seth Ackerman**, and **Aaron Turecek**. The spacious working deck and accommodations of the *Scarlett Isabella* provided ample room for USGS vans and gear. During 11 days of 24-hour operations, a total of 101 km^2 was mapped with a SEA SWATHplus 234-kHz interferometric sonar (to measure seafloor depths and backscatter of sound energy, which provides information about seafloor roughness and composition), a Klein 3000 dual-frequency sonar (to measure backscatter), and an EdgeTech 512i Chirp seismic profiler (to image subbottom sediment layers). Data collected during this survey (WHSC Field Activity 2011-003-FA) will be combined with data from two previous surveys (WHSC Field Activities 2009-002-FA and 2010-004-FA) and published in two USGS Open-File Reports, one covering Buzzards Bay and the other covering Vineyard Sound.



Areas mapped during WHSC Field Activities 2011-003-FA (gold) and 2011-013-FA (green). Areas displayed as gray-scale shaded relief were mapped during previous USGS/CZM surveys. Red rectangle outlines area of perspective view of Hedge Fence Shoal, next page.

The second survey (WHSC Field Activity 2011-013-FA), which focused on shallow areas (less than 10-m water depth), was conducted in August 2011 aboard the 8-m-long research vessel (R/V) *Rafael* during 19 days of daylight operations. The *Rafael* was hauled out of the

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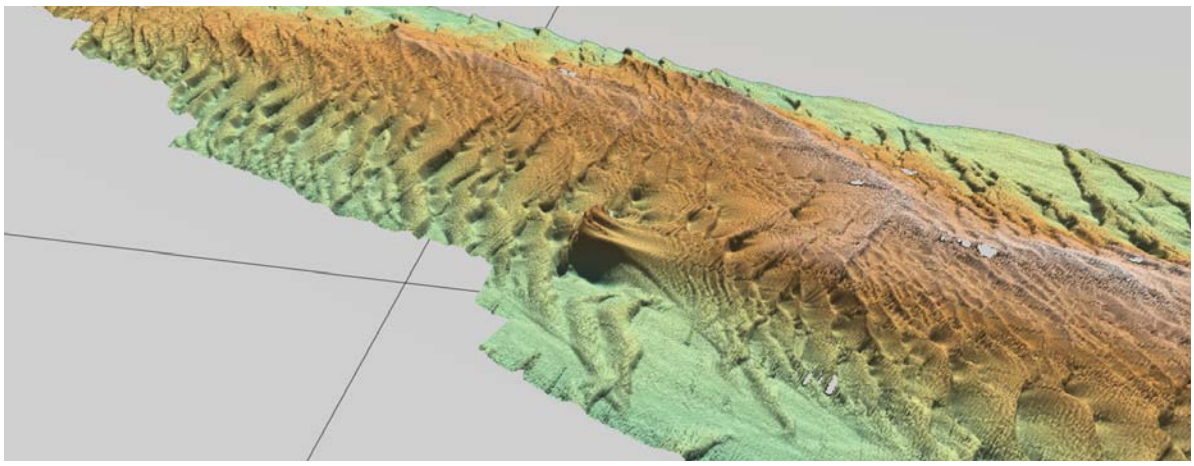
water in anticipation of Hurricane Irene, providing a 4-day break midway through the survey. Survey crew from the WHSC Seafloor Mapping Group included **Dave Foster** (principal investigator), **Barry Irwin**, **Chuck Worley**, **Bill Danforth**, **Eric Moore**, **Brian Andrews**, and **Aaron Turecek**. The purpose of this survey was to collect geophysical data in the shallow areas that larger, deeper-draft survey vessels could not safely navigate. The *Rafael* survey area covered approximately 66 km^2 in areas as shallow as 2 m over Hedge Fence and Lucas Shoals (see detailed view of Hedge Fence Shoal, below). Data were collected by using the SWATHplus 234-kHz sonar (depth and backscatter), the Klein 3000 dual frequency sonar (backscatter), and a Knudsen Chirp 3200 (3.5 kHz) subbottom profiler. Data collected during this survey will be published later this year.❁

The 8-m-long R/V Rafael*, used during WHSC Field Activity 2011-013-FA in August 2011. Photograph by* **David Foster***, USGS.*



Three-dimensional perspective view of high-resolution bathymetry (2-m resolution) collected by the R/V Rafael *on Hedge Fence Shoal (outlined in red on map, previous page) during August cruise, showing some of the large (3-m relief) bedforms in this high-energy environment.*

State and Federal Agencies Partner for Seafloor-Sampling Survey off Massachusetts

By Seth Ackerman

In September 2011, U.S. Geological Survey (USGS) researchers and their partners collected seafloor photographs and sediment samples off Massachusetts to identify bottom types (such as bedrock, gravel, sand, or mud) and organisms living on the seafloor and in the sediment. This multiagency sampling survey was a component of the Massachusetts Seafloor Mapping Cooperative project (**http://woodshole.er.usgs.gov/project-pages/coastal_mass/**), begun in 2003. The mapping phase of the project—a survey of the seafloor geology inside the 3-mile limit of Massachusetts state waters—has been largely completed (see "Collaborative Seafloor-Mapping Program Completes Final Mapping Surveys off Massachusetts," this issue, **http://soundwaves.usgs.gov/2012/02/fieldwork2.html**). The September cruise was part of the followup phase, in which researchers are sampling the seafloor to better understand biological communities and habitat, as well as to refine the mapping-phase products.

Brian Andrews, **Kate McMullen**, **Chuck Worley**, and **Seth Ackerman**, all from the USGS Woods Hole Coastal and Marine Science Center (WHSC) in Woods Hole, Massachusetts, joined scientists and staff from the U.S. Environmental Protection Agency (EPA), the Massachusetts Office of Coastal Zone Management (CZM), and the Massachusetts Division of Marine Fisheries (DMF) for the 8-day survey (September 9-16, 2011) in the coastal waters of Massachusetts. Working aboard the ocean survey vessel (OSV) *Bold* (**http://www.epa.gov/bold/**), a 224-ft ocean and coastal monitoring vessel operated by the EPA, they collected samples in Cape Cod Bay, Buzzards Bay, and Vineyard Sound and offshore of Martha's Vineyard and Nantucket.

The research team used the SEABed Observation and Sampling System (SEABOSS) to survey approximately 320 sites chosen by the CZM, DMF, and USGS.

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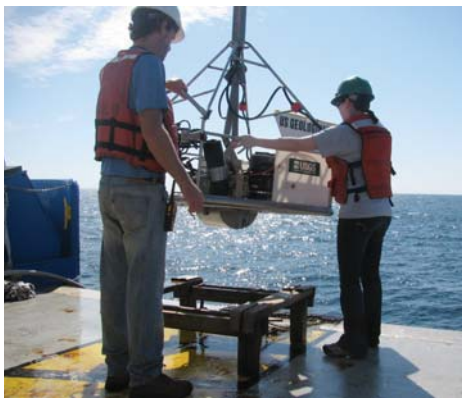
U.S. Environmental Protection Agency's ocean survey vessel (OSV) Bold. *Photograph by* ***Kathryn Ford****, Massachusetts Division of Marine Fisheries.*

Kate McMullen *(USGS) at the SEABed Observation and Sampling System (SEABOSS) control center, monitoring the realtime video feed from the SEABOSS, keeping the survey log, and triggering the high-resolution digital still camera. Photograph by* ***Dave Turin****, U.S. Environmental Protection Agency.*

Developed at the USGS, the SEABOSS incorporates high-resolution digital still and video cameras with a modified Van Veen sediment grab sampler (see **http://woodshole.er.usgs.gov/operations/sfmapping/seaboss.htm**) to allow scientists to view the seafloor in realtime aboard the ship, manually trigger the still camera, and collect sediment grab samples. After a few minutes of drifting over the seabed, the SEABOSS is lowered to the seafloor, and a sediment sample is taken. (Sample grabs are not attempted in rocky areas.) Forward- and downward-looking video is recorded to DVD and digital tape during each deployment. Upon retrieval of the SEABOSS on deck, a sediment grab subsample is collected and stored for postcruise analysis at the WHSC sediment lab. On the OSV *Bold* cruise, additional subsamples were collected from the grab sampler at 214 sites to be postprocessed for benthic-fauna analyses by the CZM. On several days of calm seas, DMF researchers set off from the *Bold* aboard the ship's small boat, a 23-ft Parker, to collect photographs and video of the seafloor at 116 sites that were too shallow (less than 10-m water depth) for the *Bold* to reach.

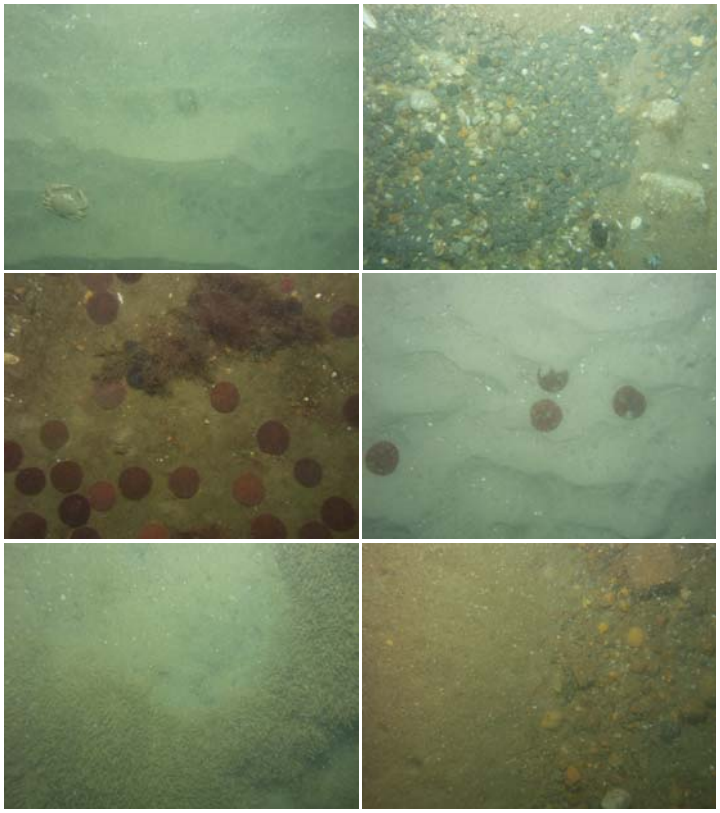
USGS researchers worked on the *Bold* with **Bob Boeri**, **Emily Huntley**, **Dan Sampson**, **Chris Garby**, **Dave Janik**, and **Todd Callaghan** (all from the CZM); **Kathryn Ford** and **John Logan** (both from the DMF); **Marcel Belaval**, **Katie Connors**, **Mary Garren**, and **Dave Turin** (all from the EPA); and volunteers **Alex Boeri** and **Kate Douglas**. **Dann Blackwood** and **Emile Bergeron** (both USGS) were a tremendous help during the pre-cruise mobilization in Woods Hole. We also owe a great debt of gratitude to the ship's crew, who kept survey operations running smoothly and made sure we were safe, dry, and well fed during the cruise.

The successful sampling survey was a great opportunity for state and federal agencies to work cooperatively toward understanding the marine environment of coastal Massachusetts. Results from this research cruise will be used to create and refine maps showing the characteristics of the seafloor, identify coastal and marine resources, and assist agencies in siting and permitting coastal-zone projects.



The USGS' SEABOSS being retrieved on the deck of the OSV Bold *by* ***Todd Callaghan*** *(left; Massachusetts Office of Coastal Zone Management [CZM]) and* ***Katie Connors****, U.S. Environmental Protection Agency (EPA). Photograph by* ***Bob Boeri****, CZM.*

This work will contribute to the goals established in the 2009 Massachusetts Ocean Management Plan (**http://www.mass.gov/eea/ocean-coastal-management/mass-ocean-plan/final-massachusetts-ocean-management-plan.html**) by providing data for efficient and comprehensive coastal and marine spatial planning and ecosystem-based management of the coastal ocean.



Several (of more than a thousand) seafloor photographs taken by the SEABOSS during the September 2011 survey aboard the OSV Bold.

Coral Reef Disease Hits Kāne'ohe Bay, Hawai'i

By Thierry Work and Jessica Robertson

Scientists have discovered an outbreak of coral disease called Montipora white syndrome in Kāne'ohe Bay, O'ahu. The affected corals are of the species *Montipora capitata*, also known as rice coral.

Rice corals provide valuable habitat, shelter, and foraging grounds for a variety of tropical marine fish and invertebrates and provide the fundamental structure of coral reefs. Rice corals are especially important to Hawai'i's marine ecosystems because they are one of the more abundant coral reef species in the region. (See related article "Tracking Coral Larvae to Understand Hawai'i Reef Health," *Sound Waves*, August/September 2010, **http://soundwaves.usgs.gov/2010/08/fieldwork3.html**.)

Loss of corals can have negative effects on many other reef-associated organisms. In fact, losing a coral reef is similar to losing a rainforest, with many species reliant on that ecosystem for survival.

In addition, coral reefs in Hawai'i are an important source of tourism and other economic income (fisheries). For example, Kāne'ohe Bay, where this outbreak is concentrated, is a popular spot frequented by snorkelers, bathers, divers, boaters, and fishermen.

Although this particular disease outbreak seems limited to south Kāne'ohe Bay, coral diseases have the potential to be widespread, affecting large geographic regions. A prime example is the Western Atlantic and Caribbean, where large tracts of coral reefs have either declined or disappeared owing to diseases.

Science Helping Protect the Reefs

The investigation of this recent outbreak has been led by the University of Hawai'i's Hawai'i Institute of Marine Biology in collaboration with University of Hawai'i, West O'ahu, and the U.S. Geological Survey (USGS) National Wildlife Health Center Honolulu Field Station.

Current efforts are focused on determining the extent of the outbreak and collecting samples for laboratory analysis.

(Coral Reef Disease continued on page 9)

Corals affected by Montipora white syndrome. Note the large swaths of white skeleton tissue surrounded by normal (brown) corals. Photographs taken in Kāne'ohe Bay, O'ahu, Hawai'i, on January 6, 2012, by ***Thierry Work****, USGS National Wildlife Health Center's Honolulu Field Station.*

(Coral Reef Disease continued from page 8)

On a longer-term scale, all three partner organizations are trying to devise better methods to detect coral diseases and determine their causes.

For the most part, the causes of coral diseases are unknown. The current lack of knowledge about precisely what is killing corals has complicated management of coral-reef diseases. Scientists are investigating many possible causes, including host immunity, host physiology, potential infectious agents like bacteria or parasites, and environmental variables such as increased seawater temperatures associated with climate change or land-based sources of pollution.

The USGS is one of the few organizations globally that has applied biomedical tools to investigate animal diseases to coral reefs (yes, corals are animals too). The USGS' focus in this particular outbreak is to characterize the changes seen in sick corals by looking at the whole coral (what we see with the naked eye) as well as at the cellular level (under the microscope). The USGS is also developing other laboratory tools to help enhance our understanding of coral diseases with the eventual goal of pinpointing the causes of such important diseases.

What Is Montipora White Syndrome?

Corals are basically modified anemones, which are a group of predatory—and often strikingly pretty—marine organisms related to jellyfish. Corals secrete a calcium carbonate skeleton that forms the foundation of coral reefs. The skeleton is covered by a thin layer of tissues. Montipora white syndrome affects the rice coral and involves loss of tissues from the coral until the underlying white skeleton is revealed, hence the name "white syndrome."

History of Outbreak and Future Risks

On the basis of surveys done since 2006 by the University of Hawai'i and the USGS, Montipora white syndrome has historically been documented in coral reefs in Kāne'ohe Bay, albeit at low levels with scattered, isolated colonies affected. Large-scale outbreaks involving multiple coral colonies over a larger geographic area have been documented only in March 2010 and in this recent event.

The reasons for this increase in outbreaks are presently unknown. Tissue-loss diseases like white syndrome are particularly insidious in that they result in immediate loss of coral cover. Often, dead corals are then overgrown by algae, leading to permanent reduction in coral reefs and a change in the ecosystem from a coral-dominated to an algae-dominated reef. Whether this will be the case here remains to be seen.

USGS and partner scientists are actively involved in trying to better understand Montipora white syndrome and other coral diseases. This will allow managers to also determine the environmental drivers of those causes, leading to better intervention and strategies to protect coral reefs.

For more information on this topic and other wildlife health related issues, visit the USGS Honolulu Field Station Web site at **http://www.nwhc.usgs.gov/hfs/**.

(Reprinted from **http://www.usgs.gov/blogs/features/usgs_science_pick/coral-reef-disease-hits-kane%CA%BFohe-bay-hawai%E2%80%98i/**; visit this site to view additional USGS Science Features.)❁

Flash Forward 100 Years: Climate Change Scenarios in California's Bay-Delta

By Jessica Robertson and James Cloern

U.S. Geological Survey (USGS) scientists and academic colleagues investigated how California's interconnected San Francisco Bay and Sacramento-San Joaquin Delta (the Bay-Delta system) is expected to change from 2010 to 2099 in response to both fast and moderate climate-warming scenarios. Their results, published September 2011 in the journal *PLoS ONE* (**http://dx.doi.org/10.1371/journal.pone.0024465**), indicate that this area will be affected by global climate change in the 21st century, with shifts in its biological communities, rising sea level, and modified water supplies.

"The protection of California's Bay-Delta system will continue to be a top priority for maintaining the state's agricultural economy, water security for tens of millions of users, and habitat essential to a valuable ecosystem," said USGS Director **Marcia McNutt**. "This new USGS research complements ongoing initiatives to conserve the Bay-Delta by providing sound scientific understanding for managing this valuable system such that it continues to provide the services we need in the face of climate uncertainty."

This study provides the first integrated assessment of how the Bay-Delta system will respond to climate change. Results show that the combined effects of increasing water temperature and salinity could reduce habitat quality for native species, such as the endangered Delta smelt and winter-run Chinook salmon, and intensify the challenge of sustaining their populations. The study indicates that water-resource planners will need to develop adaptation strategies to address potentially longer dry seasons, diminishing snowpacks, and earlier snowmelt leaving less water for runoff in the summer. The study also describes risk from flooding as sea-level rise accelerates and extreme water levels become increasingly common. Increased intensity and frequency of winter flooding could also occur as results of earlier snowmelt and a shift from snow to rain.

The Delta provides drinking water to 25 million people and irrigation water to farmland producing crops valued at $36 billion per year. Intensive efforts are underway among the USGS, the Bureau of Reclamation, the Fish and Wildlife Service, the National Oceanic and Atmospheric Administration (NOAA), and the state of California to address what will be increasingly difficult decisions regarding allocations of water for human consumption and biological needs. The report's findings provide new information that can inform planning of next steps

(Climate Change continued on page 10)

(Climate Change continued from page 9)

in collaborative initiatives, such as the Bay Delta Conservation Plan (**http://baydeltaconservationplan.com/**), and contribute to the scientific foundation underlying the Delta Stewardship Council's Delta Plan (**http://deltacouncil.ca.gov/**).

"As we plan for the future, it is important to consider more than just global warming," said USGS scientist and the study's lead author **James Cloern**. "We also have to consider other drivers, such as land-use changes and population growth. A comprehensive assessment of the future looks at responses to global warming in the context of all factors that will change the resources we value."

In addition to providing future visions of the Bay-Delta system, this research provides general lessons to guide development of adaptation strategies for coping with climate change in other coastal landscapes. Anticipation, flexibility, and adaptability will be the keys to the success of those strategies.

The article about this study, titled "Projected Evolution of California's San Francisco Bay-Delta-River System in a Century of Climate Change," is posted at **http://dx.doi.org/10.1371/journal.pone.0024465**.

Landsat Thematic Mapper (TM) satellite imagery of study area (red rectangle in index map) draped over digital elevation models. Modified from ***http://www.sfbayquakes.org/mapview.html****.*

A small slough in Suisun Bay, California. Photograph by ***Francis Parchaso****, USGS.*

"Hurricane" 3D Movie and TV Series to Feature USGS Coastal Change Hazards Scientists

By Matthew Cimitile

Discovery Channel and Paramount Pictures are shooting a full-length 3D film and three-part TV series titled "Hurricane," which features the U.S. Geological Survey (USGS) Coastal Change Hazards group in St. Petersburg, Florida (**http://coastal.er.usgs.gov/hurricanes/**), as they forecast and document the effects of August 2011's Hurricane Irene. A state-of-the-art 3D-camera documentary crew filmed USGS scientists forecasting erosion and inundation potential for the U.S Atlantic coastline from South Carolina to Delaware and taking post-storm aerial photographs of Hurricane Irene's impacts.

The film crew flew aboard an oblique-photography mission with scientists **Karen Morgan** and **Dennis Krohn** as they acquired images showing the extensive changes wrought by Hurricane Irene on the Outer Banks in North Carolina. (Read more about this mission in "Aerial Photographs of Outer Banks Show Coastal Damage from Hurricane Irene," *Sound Waves*, September/October 2011, **http://soundwaves.usgs.gov/2011/10/fieldwork4.html**.) Photographs show large volumes of sand pushed inland by the storm and several breaches that cut through the barrier islands and severed a state highway. Images obtained from the survey were georeferenced so that photograph locations could be easily plotted on a map and quickly uploaded to the Web to assist damage assessments in the immediate aftermath of the storm.

The film crew also interviewed USGS oceanographer **Asbury "Abby" Sallenger** on the impacts of Hurricane Irene, storm-impact modeling of the coastline before landfall, and collection of data before and after a hurricane. **Sallenger** discussed the opening of five breaches—three of them major—along

(Hurricane Movie continued on page 11)

(Hurricane Movie continued from page 10)

Using a 3D camera, Cyril Barbançon of Saint Thomas Productions films the coastline of North Carolina 4 days after Hurricane Irene made landfall near Cape Lookout.

the Outer Banks between Cape Hatteras and Oregon Inlet. He also talked about the variability of coastal changes caused by Hurricane Irene as the storm traveled northward along the Atlantic Seaboard from North Carolina to New York.

"Hurricane," which is being shot by Saint Thomas Productions, will follow extreme storms from their earliest beginnings with the light winds of the African Sahel to their landfall on the Atlantic and Gulf of Mexico coastlines. The production team said they would film tropical storms and hurricanes across the Caribbean and Gulf of Mexico to showcase hurricane-induced coastal changes affecting various ecosystems, including coral reefs, mangrove-fringed estuaries and coastlines, and forests. During the anticipated 3 years of filming, they will investigate operations and work closely with scientists undertaking state-of-the-art research at the USGS, the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), and the National Hurricane Center.

*Four days after Hurricane Irene made landfall on North Carolina's Outer Banks on August 27, 2011, **Karen L. M. Morgan** of the USGS takes photographs during the August 31, 2011, Post-Irene Oblique Photographic Survey. Data collected within days of landfall allow researchers to assess the storm's impacts and commonly give managers and property owners their first look at damage caused by the storm.*

Abby Sallenger answers questions pertaining to Hurricane Irene and coastal changes during his interview for the "Hurricane" 3D film and TV series at Albert Whitted Airport in St. Petersburg, Florida.

Public Forum On Seafloor Mapping at the Ocean Explorium in New Bedford, Massachusetts

By Chris Polloni

A public forum titled "The Seafloor Revealed: What Lies Beneath the Massachusetts Coastal Ocean" was held at the Ocean Explorium in New Bedford, Massachusetts, on July 11, 2011. The forum was planned and presented as part of a partnership between the U.S. Geological Survey (USGS) Woods Hole Coastal and Marine Science Center (WHSC), the Massachusetts Office of Coastal Zone Management (CZM), and the Massachusetts Division of Marine Fisheries (DMF). Its purpose was to demonstrate to the public examples of USGS marine-geology and sediment-transport research being conducted in and around Massachusetts state waters, with particular emphasis on the long-term WHSC-CZM marine-geologic-mapping cooperative (see related articles in this issue: "Collaborative Seafloor-Mapping Program Completes Final Surveys off Massachusetts," **http://soundwaves.usgs.gov/2012/02/fieldwork2.html**, and "State and Federal Agencies Partner for Seafloor Sampling Survey off Massachusetts, **http://soundwaves.usgs.gov/2012/02/fieldwork3.html**). The goal of the multimillion-dollar cooperative effort, begun in 2003, is to produce high-resolution maps of the seabed and spatial data for use in a geographic information system (GIS) that will serve the needs of research, management, and the public (**http://woodshole.er.usgs.gov/project-pages/coastal_mass/**).

Project lead **Bill Schwab** provided an overview of the history of the project, the USGS research and mapping efforts, and the geophysical and sampling tools used to characterize the seafloor. Next came presentations from **Todd Callaghan**

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(CZM) and **Kathryn Ford** (DMF), who showed how the maps and data are being used by the state and why they are important for management of the state's marine and coastal resources. Specific examples included planning activities related to the development of offshore liquefied-natural-gas facilities and pipelines, assessing the impacts of laying communication and power cables and developing offshore wind-turbine farms, fisheries management, and environmental monitoring. **Schwab** wrapped up the presentations by pointing out that the evolution of techniques we use to map the seabed and shallow subsurface has exponentially improved our ability to visualize seafloor characteristics at a level of detail we wouldn't have dreamed of a decade ago. After the presentations, the public was free to roam among examples of our mapping efforts and derivative products.

Part of the exhibit area.

A team of 11 USGS scientists and technologists attended the event, where they presented posters, animations, and the Geowall, a stereo-projection system used to illustrate spatial data in 3D. The team included **Bill Schwab**, **Jane Denny**, **Seth Ackerman**, **Brian Andrews**, **Walter Barnhardt**, **Brad Butman**, **Soupy Dalyander**, **Bill Danforth**, **Dave Foster**, **Jeff Obelcz**, **Chris Polloni**, and **Page Valentine**. **Butman** and **Dalyander** described work to develop indices of "seafloor mobility" (how frequently seafloor sediment moves) across the U.S. continental shelf, including Massachusetts coastal waters, based on the stress caused by currents and waves. These indices are useful for interpreting the seafloor geology and habitat, and for coastal and marine spatial planning (**http://www.whitehouse.gov/administration/eop/oceans/cmsp**). **Butman** and **Dalyander** also presented "Bottom Stress in Action: Massachusetts Bay," showing animations of sediment movement caused by northeast storms, and data and time-lapse movies of the seafloor obtained from instrumented tripods to better understand the processes that move sediment. **Valentine** presented his extensive work on habitat mapping on the banks and ledges in the Gulf of Maine, focusing on the Stellwagen Bank National Marine Sanctuary. WHSC Sea Floor Mapping Group members **Denny**, **Ackerman**, **Andrews**, **Danforth**, **Foster**, **Obelcz**, and **Polloni** used visualization software (including the GeoWall 3D system) to provide interactive displays of offshore areas, giving visitors a hands-on immersive experience with the data. The entire forum, which was set up in 1 hour and taken down in 30 minutes for return to the WHSC, was the first in what is likely to be several similar forums to be presented in the coming year in Boston and Provincetown.

Moving Toward a World Wide Web for Scientific Data—Working Sessions on Use Cases for Semantic-Web Development

By Fran Lightsom

Imagine a dozen U.S. Geological Survey (USGS) employees surrounded by projection screens, marker boards, and flip charts. They are drawing "activity diagrams" with hangman-like stick figures and arguing over the meaning of words.

Online shopping and social networking have made great strides in recent years, largely through use of "semantic web" methods that allow computers to automatically interpret information, rather than simply displaying it. The USGS Coastal and Marine Geology Program (CMGP) is learning to use these semantic-web methods to increase the value of online scientific data. Scientific use of the semantic web is especially appropriate because these methods automatically integrate data from diverse sources.

The USGS recognizes that scientific progress and sound management of the nation's resources increasingly depend on integration of data from diverse projects, not only from within the USGS but also from other agencies and research organizations. The semantic-web approach will allow the integration of CMGP databases, without significant modification to individual datasets, and facilitate integration of these CMGP databases with information systems being produced by the National Science Foundation (NSF), the USGS Council on Data Integration, the Interagency Working Group on Ocean and Coastal Mapping (formed in response to the Ocean and Coastal Mapping Integration Act of 2009), the National Ocean Council, and state and regional organizations engaged in coastal and marine spatial planning (**http://www.whitehouse.gov/administration/eop/oceans/cmsp**). In a broader context,

(Semantic Web continued on page 13)

(Semantic Web continued from page 12)

this CMGP effort is consistent with the government-wide commitment to the semantic web (**http://www.data.gov/semantic**).

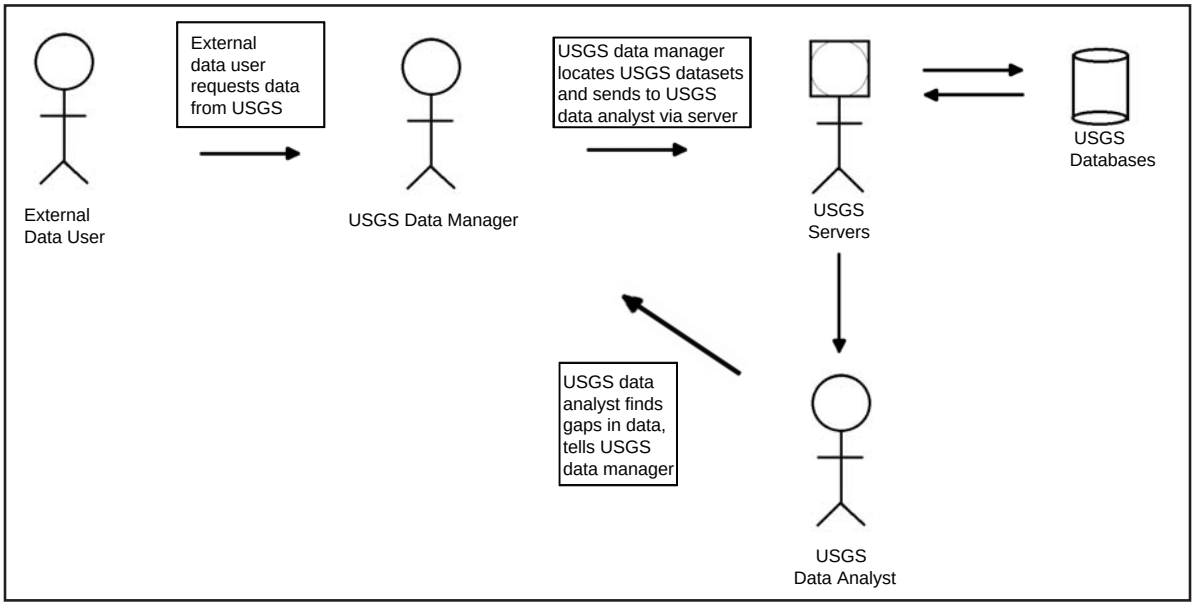
In September 2011 and January 2012, USGS employees met with experts from Rensselaer Polytechnic Institute (RPI) and Woods Hole Oceanographic Institution (WHOI) to learn about semantic-web development and begin implementing the semantic-web-development methodology employed at RPI and WHOI. The foundation of both meetings was a lecture by RPI professor **Peter Fox** on the RPI methodology for semantic-web development. Central to this methodology is a "use case," which identifies a user's goal and describes the steps or actions between a user and a software system required to achieve this goal. Analysis of the information and activities necessary to meet each use-case goal leads to development of an information model. The concepts and the relations between them that are expressed in the information model allow a system to be designed to meet many similar goals. Analysis of several use cases serves to identify the full requirements of the system. The RPI process is iterative, with rapid software prototyping, expert reviews, and ongoing communication among subject-matter experts, modelers, and software engineers. This methodology is being used to develop innovative scientific information systems by such organizations as WHOI, the National Aeronautics and Space Administration (NASA), and the NSF. The NSF-funded Virtual Solar Terrestrial Observatory (VSTO) is one early success story for RPI methodology (**http://www.vsto.org/**; see also **http://tw.rpi.edu/web/project/VSTO**).

Participants in the St. Petersburg, Florida meeting, January 2012. Standing (left to right): ***Seth Ackermann, Fran Lightsom, Joe Futrelle, Rob Wertz, Andy Maffei, Kristy Guy, Rex Sanders, Karen Morgan, Alan Allwardt, Brendan Dwyer, Brian Andrews, Shawn Dadisman, Bryan McCloskey, Peter Fox,*** *and* ***Greg Miller****. Sitting (left to right):* ***Emily Himmelstoss, VeeAnn Cross, Jamie Cormier, Heather Schreppel, Theresa Burress,*** *and* ***Carolyn Degnan****. Photograph by* ***Betsy Boynton****, USGS.*

After the September lecture, participants applied the use-case methodology to their own goals for USGS information systems. Discussion of these first use cases, and comments provided by **Professor Fox**, clarified the types of description and level of detail that are needed for a use case to serve as the basis for an information model and for implementation by software engineers.

During the final stage of the September meeting and most of the January meeting, participants were divided into teams to work on specific use cases identified as especially important for the CMGP. These use cases describe specific, hypothetical scenarios in which given users

(Semantic Web continued on page 14)



Excerpt from an activity diagram illustrating one of the use cases developed in the September 2011 and January 2012 meetings. Round-headed "actors" represent people; block-headed actors represent computers; cylinders represent databases. Complete diagram includes many more steps, leading to delivery of final data product to external data user.

(Semantic Web continued from page 13)

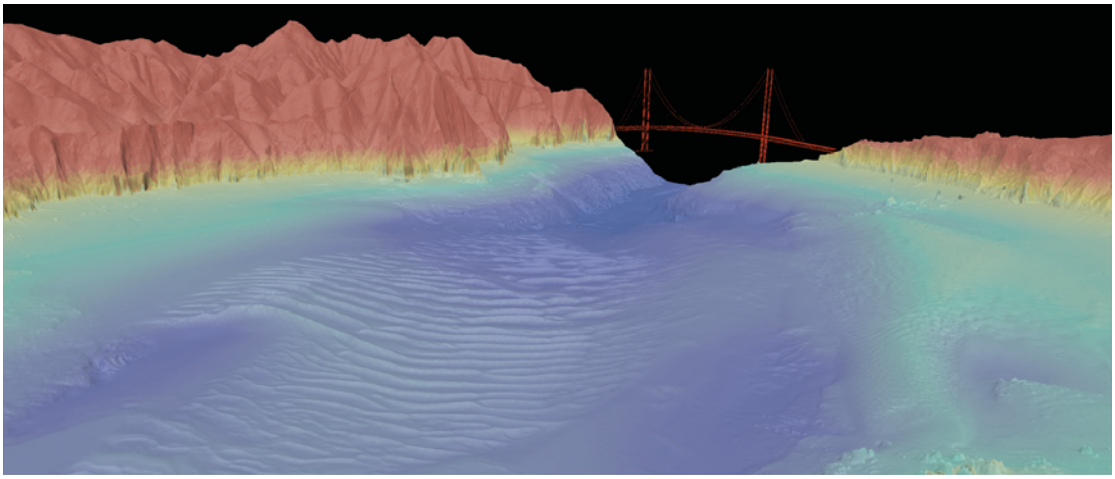
achieve their information-seeking goals: for instance, a Massachusetts coastal-zone analyst seeking and obtaining integrated CMGP seafloor data, with the ultimate goal of characterizing benthic habitats. A few carefully selected use cases of this type, which, taken together, represent a wide range of users, information needs, and information-seeking behavior, can be used to guide information-system development.

The workshop teams were formed to include a mix of skills and roles. In addition to subject-matter experts who know about CMGP data acquisition, analysis, and publication, each team included a knowledge modeler, a software engineer, a facilitator, and a scribe. Through an iterative process, each team discussed and clarified the elements of the use case: goal, actors, preconditions, triggering events, postconditions, normal and alternate flow of events, and resources required. The teams also drew diagrams to summarize the interactions between people and the information system, and they developed models to show the relations among essential information concepts. Team members agreed to work on refining two use cases and implementing prototype systems to test them.

The working meetings were held at the USGS Woods Hole Coastal and Marine Science Center in Woods Hole, Massachusetts, September 21-23, 2011, and the USGS St. Petersburg Coastal and Marine Science Center in St. Petersburg, Florida, January 18-20, 2012. Leaders were **Peter Fox** (RPI and WHOI), **Andy Maffei** (WHOI), and **Joe Futrelle** (WHOI). Participants were **Emily Himmelstoss**, **Seth Ackerman**, **Fran Lightsom**, **VeeAnn Cross**, **Brian Andrews**, **Ellyn Montgomery**, **Guthrie Linck**, and **Brad Butman** of the USGS Woods Hole Coastal and Marine Science Center; **Rob Wertz**, **Shawn Dadisman**, **Jamie Cormier**, **Theresa Burress**, **Kristy Guy**, **Brendan Dwyer**, **Heather Schreppel**, **Bryan McCloskey**, **Greg Miller**, **Karen Morgan**, and **Jolene Gittens** of the USGS St. Petersburg Coastal and Marine Science Center; **Alan Allwardt**, **Carolyn Degnan**, and **Rex Sanders** of the USGS Pacific Coastal and Marine Science Center; **Janice Gordon** of the USGS Bioinformatics Program; **Dahlia Varanka** of the USGS Center for Excellence in GIS; and **Massimo DiStefano** of RPI and WHOI. **Peter Fox's** lectures were shared via WebEx with the CMGP's information-management community and the USGS Community for Data Integration.

Workshop on Fledermaus Software for Visualizing Mapping Data in 3D

By Nadine Golden



Oblique 3D view created using Fledermaus looks from the Pacific Ocean northeast toward the Golden Gate Bridge (San Francisco, California). Elevations in the scene are vertically exaggerated by 3 times. Image is part of a seamless, high-resolution coastal digital elevation model (DEM) of central California being prepared by USGS scientists ***Amy Foxgrover*** *and* ***Patrick Barnard****. Image courtesy of* ***Amy Foxgrover****.*

The U.S. Geological Survey (USGS) Pacific Coastal and Marine Science Center hosted a 2-day Fledermaus workshop December 1 and 2, 2011, in Santa Cruz, California. Fledermaus is a suite of software tools produced by Interactive Visualization Systems (IVS 3D) that aids the analysis and interpretation of massive sets of spatial data—such as seafloor-mapping data—by allowing scientists to visualize and manipulate the data in three dimensions. USGS geographers, geologists, and others, along with scientists from the National Oceanic and Atmospheric Administration (NOAA) National Marine Protected Areas Center and Southwest Fisheries Science Center, examined the Fledermaus suite of software in a course customized for this purpose by IVS 3D trainer **Erin Heffron** and USGS geographer **Nadine Golden**.

The first day of the course covered core information about Fledermaus Version 7 for new users and those in need of a refresher. The material included the core Fledermaus Module: working with imagery, using vertical curtains and draping (3D-visualization techniques), masking, cropping, colormaps, time data, fly-throughs, movies, and interpretation. The first day ended with an introduction to Fledermaus' new FMGIS, a tool in which USGS geographic-information-system (GIS) users are particularly interested because it integrates Fledermaus with ArcGIS, a widely used suite of GIS software.

(Fledermaus Workshop continued on page 15)

(Fledermaus Workshop continued from page 14)

The second day covered more specialized Fledermaus uses, including visualization of multibeam bathymetric and lidar (light detection and ranging) data, quality assurance (QA) and quality control (QC), PFMs (a type of three-dimensional graph), 3D editing, processing multibeam backscatter data (which can reveal information about the texture and composition of the seafloor), processing multibeam water-column data (which can image such phenomena as hydrocarbon-rich plumes rising from seafloor seeps), and the CUBE (Combined Uncertainty and Bathymetric Estimator) technique for processing multibeam bathymetric data.

*IVS 3D trainer **Erin Heffron** (left) discusses details of the newest version of Fledermaus software with USGS geologist and GIS analyst **Florence Wong**.*

Video Podcast Series Wins 2011 USGS Shoemaker Award

By Matthew Cimitile

The Coastal and Marine Geology Podcast Series produced at the U.S. Geological Survey (USGS) office in St. Petersburg, Florida, received the 2011 Shoemaker Award in the Audio/Visual Product category. Awarded by the USGS Office of Communications and Publishing, the Shoemaker Awards recognize extraordinary examples of communicating complex scientific concepts and discoveries that capture the interest and imagination of the American public or increase understanding among USGS employees about our mission.

The video podcast series highlights science conducted at the St. Petersburg Coastal and Marine Science Center. So far, seven videos have been produced, covering such topics as research on ocean acidification in the Arctic, measuring and forecasting the impacts of extreme storms on coastal environments, and the effects of African dust on coral-reef health. The series has benefited from the tremendous support and knowledge of scientists and staff at the center. Members of the podcast team include **Matthew Cimitile** (director, writer), **Betsy Boynton** (graphics, video editing), and **Ann Tihansky** (editor, producer). In making the announcement, **Christina Nyquist** (USGS Internal and Web Communications) commended the team for their submission, their dedication to communicating USGS science, and their contribution to communication excellence. Shoemaker Award winners were recognized at the annual USGS Awards Ceremony held October 25, 2011, at the USGS National Center in Reston.

To view the award-winning podcast series, visit **http://coastal.er.usgs.gov/podcast/**.

*USGS Director **Marcia McNutt** (far left) and U.S. Department of the Interior Deputy Assistant Secretary for Water and Science **Lori Caramanian** (far right) present the 2011 Shoemaker Award in the Audio/Visual Product category to (left to right) **Betsy Boynton**, **Matthew Cimitile**, and **Ann Tihansky**.*

Sedimentologist Arnold H. Bouma Passes Away

*Renowned researcher and educator **Arnold H. Bouma**, who worked as a marine geologist with the U.S. Geological Survey (USGS) from 1975 to 1981, passed away December 16, 2011. Many members of the USGS Coastal and Marine Geology Program remember with pleasure working and sailing with **Arnold**. The following obituary was provided by Aria Cremation Service and Funeral Home (**http://hosting-24300.tributes.com/show/Arnold-H.-Bouma-92942200**):*

Dr. Arnold H. Bouma, "A truly caring man who put his family and students first, who truly impacted thousands of lives."

Surrounded by his family, **Arnold H. Bouma** passed away the evening of December 16th, 2011, at the age of 79. He is survived by his best friend and wife for over five decades, **Lieneke**; their three sons and their families: **Mark A. Bouma** and wife, **Elizabeth** and children, **Tamara Bouma**, **Logan Bouma**, and **Kelsey Bouma**; **Bobby Bouma** and wife, **Gina** and children, **Colt Webb** and **Sydney Bouma**; **Lars Bouma** and wife, **Vicki** and children, **Harrison Bouma** and **Carleigh Bouma**.

He was known internationally in the geological world as "an extraordinary geoscientist, a prolific author and editor, an educator committed to the highest standard of teaching, and a researcher who advanced the geocommunities' knowledge through his innovation, creativity, and tireless contributions to deep-water sedimentology and stratigraphy."

Arnold Bouma was born in 1932 in Groningen, Netherlands. His professional education started at the State University at Utrecht, Netherlands, where he earned a Masters of Science in Geology, Sedimentology, and Paleontology in 1959 and a Ph.D. in Sedimentary Geology in 1961. **Arnold Bouma's** 1962 research findings identified a sequence for dividing deep-water turbidites into intervals—which later became known as "the Bouma sequence"; it has been cited as being "a geological milestone of the 20th century." In 1966, **Arnold** and his family emigrated to the United States, where he accepted a professorship in oceanography at Texas A&M University. From 1975 to 1981, he was a marine geologist with the U.S. Geological Survey. Between 1981 and 1986, he was a senior scientist, manager, and acting vice president for Gulf Oil Research and Development Co. In 1986, he became a senior research associate at the Chevron Research and Development branch in La Habra, California. He left Chevron in 1988 to become the Charles T. McCord chaired professor at Louisiana State University (LSU) in Baton Rouge, where he taught for many years. In 2005, he and his wife returned to College Station, Texas, where he held a position as adjunct professor with a bold plan to establish a Shale Studies Center at Texas A&M.

***Arnold H. Bouma**, 1932-2011*

Arnold was the winner of LSU's 2003 Distinguished Research Master Award and a distinguished lecturer and leader for the American Association of Petroleum Geologists (AAPG) and the Society for Sedimentary Geology (SEPM). His numerous awards include the Francis P. Shepard Award from the SEPM in 1982 and the Outstanding Education Award from the Gulf Coast Association of Geological Societies in 1992. In 2007, he was the recipient of the Sidney Powers Memorial Award, the AAPG's highest honor (learn more about **Arnold's** scientific achievements in an article written for this occasion: **http://www.aapg.org/explorer/2007/03mar/bouma.cfm**); and in 2010, **Arnold** received the Doris M. Curtis medal for scientific excellence.

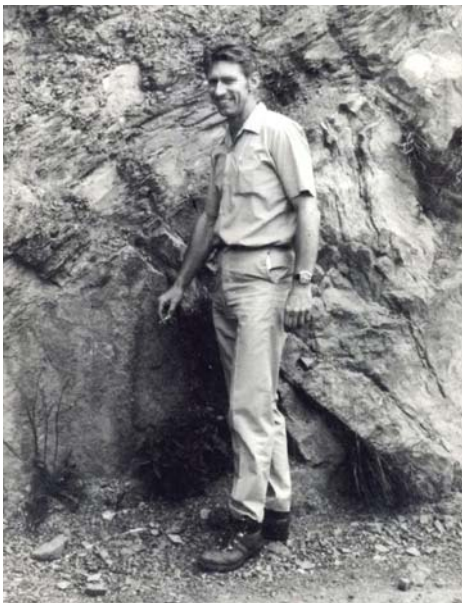
A memorial service was held December 21, 2011, at Aria Memorial Chapel. Memorials may be sent in honor of **Arnold Bouma** to the SEPM Foundation endowment fund (**http://www.sepm.org**) to help support future graduate studies. Please send family condolences and sign the online register book at **http://www.ariacremation.com**.

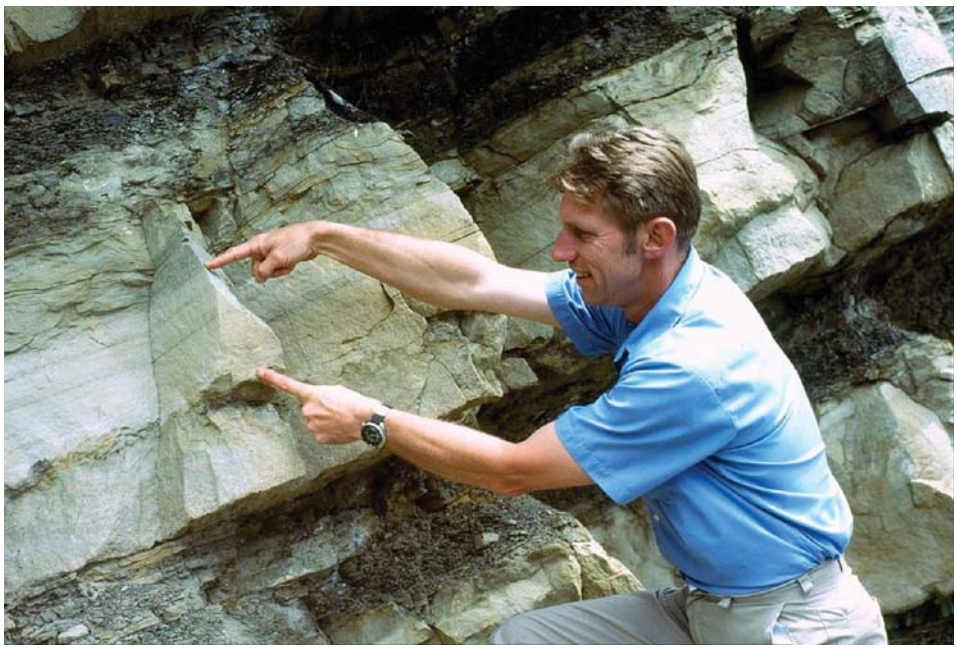
(Arnold Bouma continued on page 17)

***Arnold** with former USGS employee **Bob Orlando** at the 2007 American Association of Petroleum Geologists (AAPG) Convention in Long Beach, California, where **Arnold** received the Sidney Powers Memorial Award, the AAPG's highest honor. Photograph courtesy of **Bob Orlando**.*

(Arnold Bouma continued from page 16)

"There are still discoveries to be made, but it won't be the computer that tells us what it all means; for that, we always have to go back to the rock." —Arnold H. Bouma





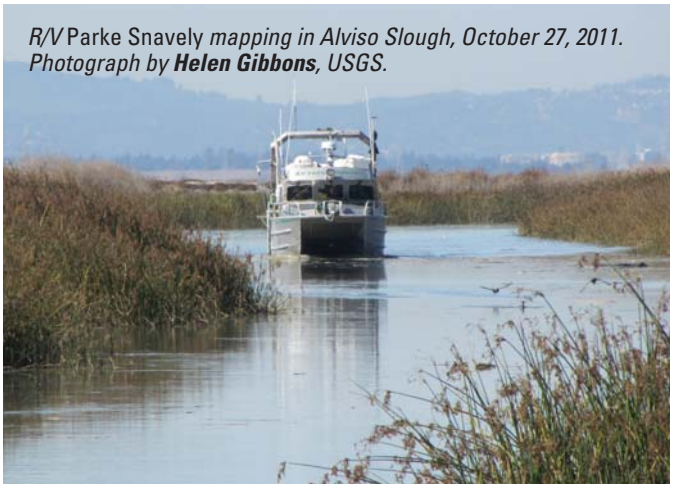
***Arnold** in his field area in the 1970s. Photographs from collection at Aria Cremation Service and Funeral Home (**http://hosting-24300.tributes.com/show/Arnold-H.-Bouma-92942200**).*

Views of South San Francisco Bay Before Salt-Pond Restoration

By Helen Gibbons

The largest tidal-wetland-restoration project on the U.S. west coast is underway in south San Francisco Bay, California, where more than 15,000 acres of industrial salt ponds are being restored to intertidal habitats. The U.S. Geological Survey (USGS) is a major player in the South Bay Salt Pond Restoration Project (**http://www.southbayrestoration.org/**), a joint effort by federal, state, and nonprofit organizations. Among its many contributions, the USGS is making maps of the bay floor before and after the breaching of levees to restore natural tidal flows. The first of those maps—the "before" set—were recently released in USGS Open-File Report 2011-1315, "2010 Bathymetry and Digital Elevation Model of Coyote Creek and Alviso Slough, South San Francisco Bay, California" (**http://pubs.usgs.gov/of/2011/1315/**).

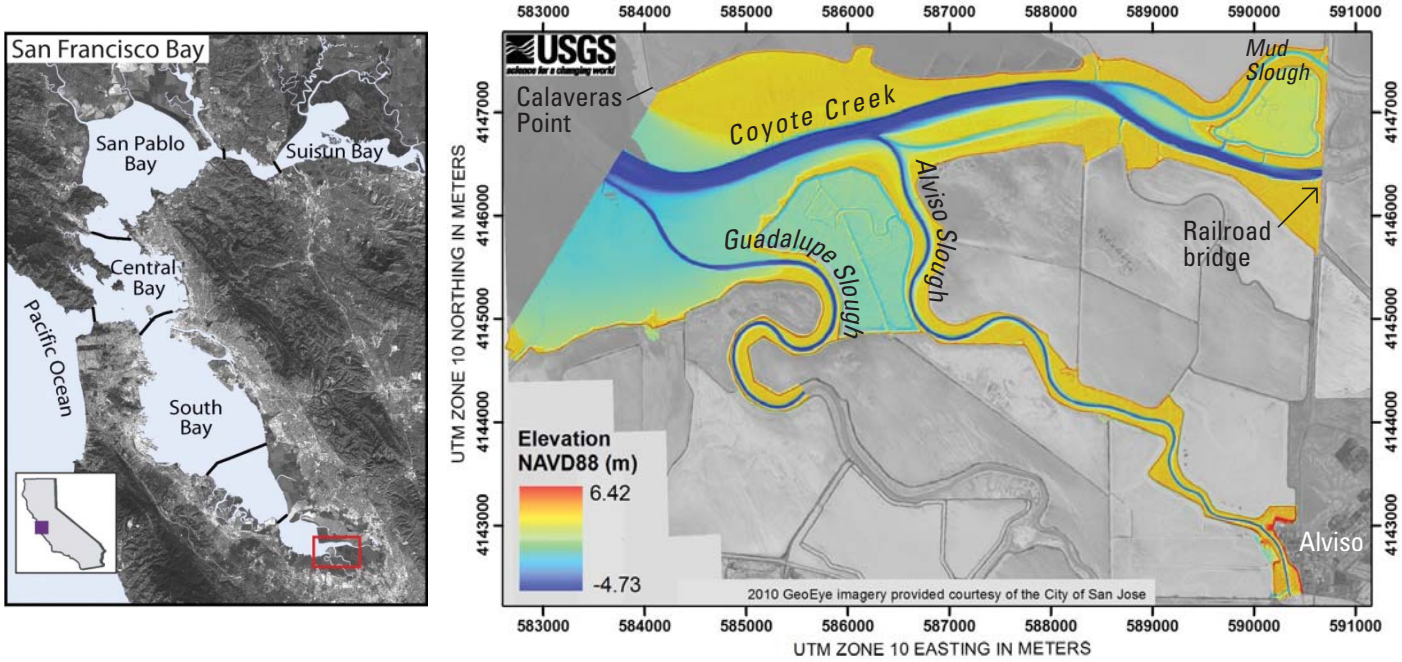
The "before" mapping took place in 2010, when USGS scientists conducted three cruises—in January, September, and early December—to map the bathymetry of channels and shallow intertidal mudflats in the southernmost part of south San Francisco Bay. Data from the three surveys were merged to generate comprehensive maps of Coyote Creek (from Calaveras Point east to the railroad bridge) and Alviso Slough (from San Francisco Bay to the town of Alviso) to establish



R/V Parke Snavely *mapping in Alviso Slough, October 27, 2011. Photograph by **Helen Gibbons**, USGS.*

(Before Restoration continued on page 18)

(Before Restoration continued from page 17)



San Francisco Bay, California. Red rectangle in map on left outlines area of image on right: a seamless bathymetric/topographic digital elevation model (DEM) of region surrounding Coyote Creek and Alviso Slough in south San Francisco Bay.

baseline bathymetry before the breaching of levees adjacent to Alviso Slough as part of the restoration project.

The bathymetric surveys were done by the research vessel (R/V) *Parke Snavely* outfitted with an interferometric sidescan sonar for swath mapping (bathymetric mapping of overlapping swaths of seafloor) in extremely shallow water. These surveys yielded high-resolution bathymetric data that are presented in the new Open-File Report. Additionally, the authors merged the bathymetric data with aerial lidar (light detection and ranging) data collected for the USGS during the same time period. The result, also presented in the new report, is a seamless, high-resolution digital elevation model (DEM) of the study area—a view of the ground surface as it would look if both water and vegetation were removed.

On December 10, 2010, the South Bay Salt Pond Restoration Project breached a levee beside Alviso Slough and used that breach and a series of water-control structures to begin circulating water throughout a network of ponds that had not had natural tidal flows for decades. (See photographs at **http://www.werc.usgs.gov/outreach.aspx?RecordID=24**.) USGS scientists are monitoring how both the physical environment and the ecology respond to the changes in the tidal regime. The USGS conducted a followup bathymetric survey in October 2011 to see how the bay floor had changed over the 11 months after the initial levee breaches of December 2010. Plans are in place to survey the same area three more times in 2012 to monitor change as restoration progresses.❁

Updated USGS Video "What Lies Beneath: Using Mangrove Peat to Study Ancient Coastal Environments and Sea-Level Rise"

*Ecologist **William C. Vervaeke** (left) and research ecologist **Karen L. McKee** collecting a mangrove peat core on Twin Cays off the coast of Belize. Screenshot from USGS video at **http://www.youtube.com/watch?v=1o4nz0hbR8U&feature=youtube_gdata**.*

The U.S. Geological Survey (USGS) recently updated a 9-minute video describing how scientists study past changes in sea level and coastal environments by analyzing deep deposits of peat (organic soil) beneath mangrove islands off the coast of Belize. Produced by the USGS National Wetlands Research Center in 2009 and updated in 2011, the video features research ecologist **Karen L. McKee** and ecologist **William C. Vervaeke** collecting peat cores on Twin Cays, about 10 mi off the coast of Belize. The thick peat deposits underlying the mangrove islands retain a valuable record of past sea level, vegetation, and climate. By studying past changes in sea level and how intertidal ecosystems, such as mangroves, have responded to these

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changes, scientists can better predict what will happen in the future as sea levels increase. The information generated by such research is critical to modeling efforts, as well as to management and conservation of coastal ecosystems.

View the updated video, titled "What Lies Beneath: Using Mangrove Peat to Study Ancient Coastal Environments and Sea-Level Rise," at **http://www.youtube.com/watch?v=1o4nz0hbR8U&feature=youtube_gdata**.

Additional information is available in the article "Belize Fieldwork Shows How Oceanic Mangrove Islands Kept Up With Sea-Level Rise for 8,000 Years," *Sound Waves*, December 2009 (**http://soundwaves.usgs.gov/2009/12/fieldwork4.html**).

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