USGS

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Research

Landmark Study Demonstrates How Methylmercury, Known to Contaminate Seafood, Forms in the Ocean

Mercury found in large marine fish, such as tuna, may enter the food chain via an ocean mercury cycle proposed by a USGS scientist and his colleagues.

By David Krabbenhoft

A team of scientists from the U.S. Geological Survey (USGS) and several universities has documented for the first time the process by which increased mercury emissions from human sources across the globe, and in particular from Asia, make their way into the North Pacific Ocean and lead to the formation of methylmercury, the form of mercury found in tuna and other seafood. Mercury levels measured in 2006 were approximately 30 percent higher than those measured in the mid-1990s. Because much of the mercury that enters the North Pacific comes from the atmosphere, the scientists predict an additional 50-percent increase in mercury in the Pacific by 2050 if mercury emission rates continue as projected.

This study documents for the first time the formation of methylmercury, a highly toxic form of mercury, in the waters of the North Pacific Ocean. Previously, scientists had hypothesized that methylmercury in the open ocean was geologic in origin and associated with deep-sea spreading centers. The recent study, however, supports methylmercury formation from atmospheric mercury that is deposited on the ocean surface and absorbed by algae living in sunlit waters near the surface. After the algae die, they "rain" downward to greater water depths. At depths of about 200 to 700 m, the settling algae are decomposed by bacteria, and this decomposition process in the presence of mercury results in the formation of methylmercury. Methylmercury rapidly accumulates in the food chain to levels that can cause serious health concerns for those who consume the seafood.

*Scientists **Cliff Buck** (left) and **Lauren Kaupp** prepare to lower a "rosette" of 12 Niskin bottles from the research vessel* Thomas G. Thompson. *The device collects samples in the ocean by remote triggering of each bottle at different depths. Extreme care was taken to ensure that the rosette did not contaminate the samples. Photograph by **William Landing**, Florida State University.*

The team collected samples of Pacific Ocean water during a hydrographic survey of the eastern North Pacific Ocean in March 2006 on the research vessel *Thomas G. Thompson* (P16N Leg-2). The cruise followed a north-south transect at approximately 152°W between Honolulu, Hawaii, and Kodiak, Alaska. A total of 41 stations were occupied, and samples for mercury analysis were collected at 16 stations. Vertical profiles (sets of water samples from

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Sound Waves

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Submission Guidelines

Deadline: The deadline for news items and publication lists for the October issue of *Sound Waves* is Wednesday, August 12.
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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Want to e-mail your question to the USGS? Send it to this address: ask@usgs.gov

Research, continued

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various depths) down to 1,000 m were obtained at 6 stations and surface samples (from less than 20-m depth) were collected at 10 stations. All mercury and methylmercury analyses were performed at the USGS Mercury Research Laboratory in Middleton, Wisconsin. Additionally, the scientists constructed a computer simulation that links atmospheric emissions, transport and deposition of mercury, and an ocean-circulation model. Their results were reported last May in the journal *Global Biogeochemical Cycles*.

One unexpected finding from this study is the significance of long-range transport of mercury in the ocean. USGS scientist and coauthor **David Krabbenhoft** stated: "Mercury researchers typically look skyward to find a mercury source from the atmosphere due to emissions from land-based combustion facilities. In this study, however, the pathway of the mercury was a little different. It appears that the recent mercury enrichment of the sampled Pacific Ocean waters originated from fallout of atmospheric mercury near the Asian coasts. The mercury-enriched waters then enter a long-range eastward transport by large ocean-circulation currents."

Scientists have known for some time that mercury deposited from the atmosphere to freshwater ecosystems can be transformed (methylated) into methylmercury, but identifying the analogous cycles in marine systems has remained elusive. As a result of this study we now know more about the process that leads to the transformation of mercury into methylmercury.

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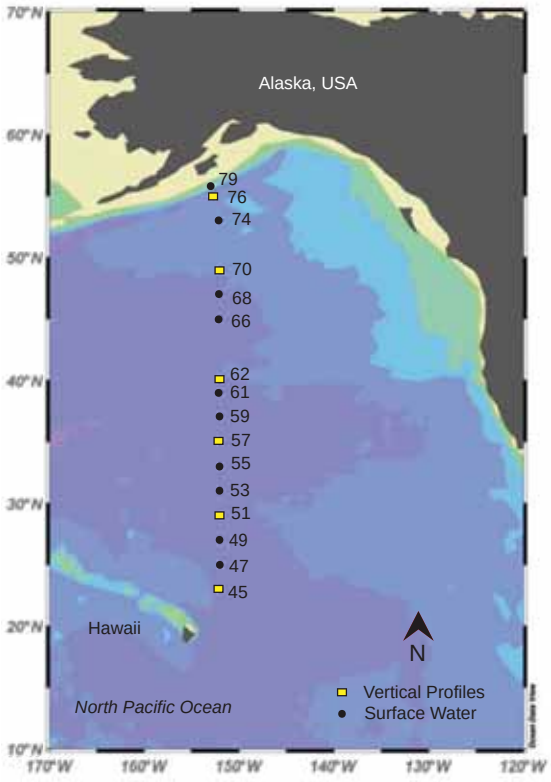
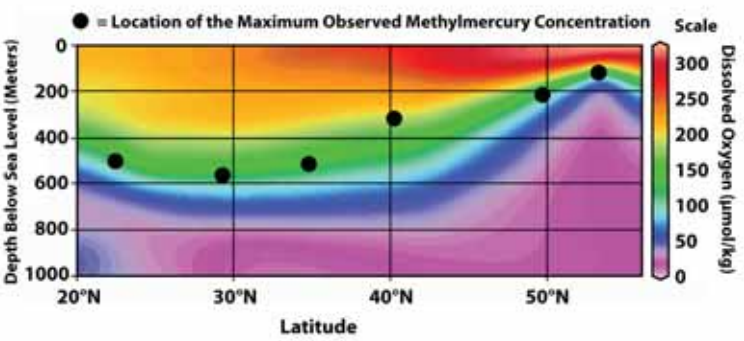


Locations of hydrographic stations sampled for mercury along the P16N Leg-2 cruise track from Honolulu, Hawaii, to Kodiak, Alaska, March 10-30, 2006.

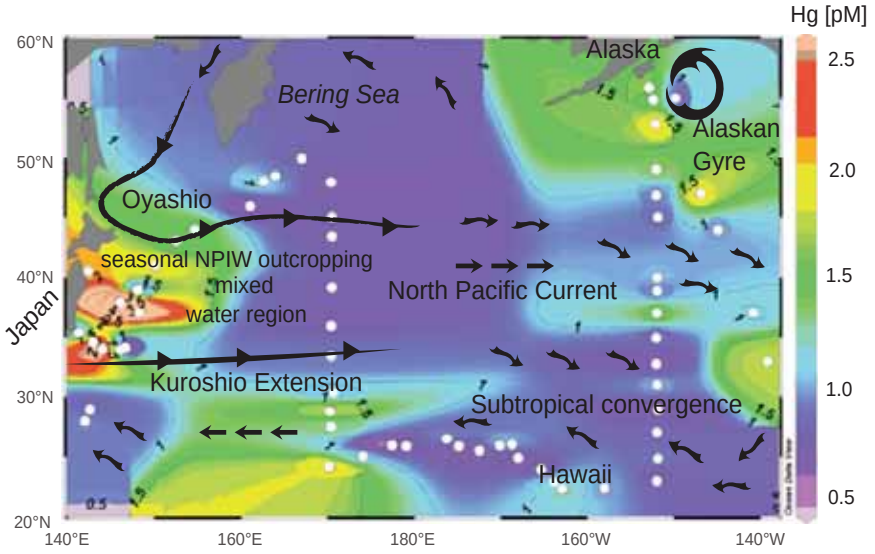


The location of the maximum methylmercury concentration at depth in the Pacific Ocean was the first evidence noted by the researchers pointing to the newly documented methylation cycle. Graph shows sampling depth on the left (in meters), and oxygen concentration by color (scale on right in micromoles per kilogram of seawater [µmol/kg]) along a north-south transect in the eastern North Pacific Ocean. The maximum methylmercury concentration (black dots) was consistently found at the ocean depth where the most rapid loss of oxygen was also observed. The process linking these two observations is microbial decomposition of "ocean rain"—settling algae produced near the surface of the ocean. The decomposition process consumes oxygen from the water and leads to methylmercury production.

(Methylmercury continued from page 2)

Krabbenhoft said, "National and international groups are seeking the most effective ways to minimize human exposure to methylmercury, and this paper presents the first evidence likely linking modern atmospheric mercury deposition to methylmercury in Pacific Ocean fish."

In the United States, about 40 percent of all human exposure to mercury is from tuna harvested in the Pacific Ocean, according to **Elsie Sunderland**, a coauthor of the study. Pregnant women who consume mercury can pass on life-long developmental effects to their children. That's why in 2004 the U.S. Environmental Protection Agency (EPA) and the U.S. Food and Drug Administration (FDA) issued the landmark Joint Guidance on the Consumption of Fish specifically targeted toward pregnant women and nursing mothers. Previous studies show that 75 percent of human exposure worldwide to mercury is from the consumption of marine fish and shellfish.



Mercury concentrations in surface water (less than 20-m depth) interpolated from data collected during cruises in 2006 (P16N Leg-2), 2002 (Intergovernmental Oceanographic Commission), and 1987 (Vertical Transport and Exchange Survey) on the North Pacific Ocean. Note high mercury concentrations near the coast of Asia. Surface circulation adapted from Pickard and Emery's Descriptive Physical Oceanography *(1990, 5th ed., Woburn, Mass., Elsevier Sci., 320 p.). White dots, sites of observational data; Hg, mercury; pM, picomolar; NPIW, North Pacific Intermediate Water.*

The paper, "Mercury Sources, Distribution and Bioavailability in the North Pacific Ocean: Insights from Data and Models," appeared on May 1, 2009, in volume 23 of *Global Biogeochemical Cycles*, which is published by the American Geophysical Union. In addition to USGS mercury expert **David Krabbenhoft**, the authors include **Elsie Sunderland**, Harvard University; **John Moreau**, University of Melbourne, Australia (until recently a USGS, National Research Council Postdoctoral Fellow); **William Landing**, Florida State University; and **Sarah Strode**, Harvard University.

The paper is posted online at **http://dx.doi.org/10.1029/2008GB003425**. Additional information about USGS mercury research is posted at **http://toxics.usgs.gov/investigations/mercury.html**.

Spring 2009 Nutrient Delivery to the Gulf of Mexico Above 30-Year Average

By Brent Aulenbach and Jennifer LaVista

Nutrient delivery to the northern Gulf of Mexico during spring 2009 was among the highest measured by the U.S. Geological Survey (USGS) in 30 years.

An abundance of nutrients, which are essential for plant growth, is not necessarily a good thing. Excessive nutrients can decrease the amount of oxygen in the water, a phenomenon known as hypoxia. This oxygen depletion can result in an area called a hypoxic zone, or "dead zone," where organisms living on or near the bottom experience stress or even death.

Hypoxia, along with overfishing, habitat loss, and toxic contamination, can adversely affect the Gulf of Mexico coastal region, an important fishing ground that provides the Nation with about 1.2 billion pounds of fresh seafood every year.

The amount of nutrients transported from the Mississippi River Basin to the Gulf during the spring is a major factor controlling the size of the hypoxic zone. The northern Gulf of Mexico hypoxic zone is the second largest in the world (the largest is in the Baltic Sea) and threatens the economic and ecological health of one of the Nation's largest and most productive fisheries.

Nutrients can come from many sources, such as fertilizers applied to agricultural fields, golf courses, and suburban lawns; atmospheric contributions; erosion of soils; and discharge from sewage-treatment plants.

In early June each year, the USGS releases estimates of nutrients delivered to the Gulf of Mexico from the Mississippi and Atchafalaya Rivers (**http://toxics.usgs.gov/hypoxia/mississippi/oct_jun/**). These estimates are used by the National Oceanic and Atmospheric Administration (NOAA), the Louisiana Universities Marine Consortium, and other researchers to predict the areal extent of the hypoxic zone.

Predictions of the size of the 2009 hypoxic zone, released June 18 (see NOAA press release at **http://www.noaanews.noaa.gov/stories2009/20090618_deadzone.html**), reflect USGS estimates of about 295,000 metric tons of nitrogen (in the form of nitrate) delivered in April and

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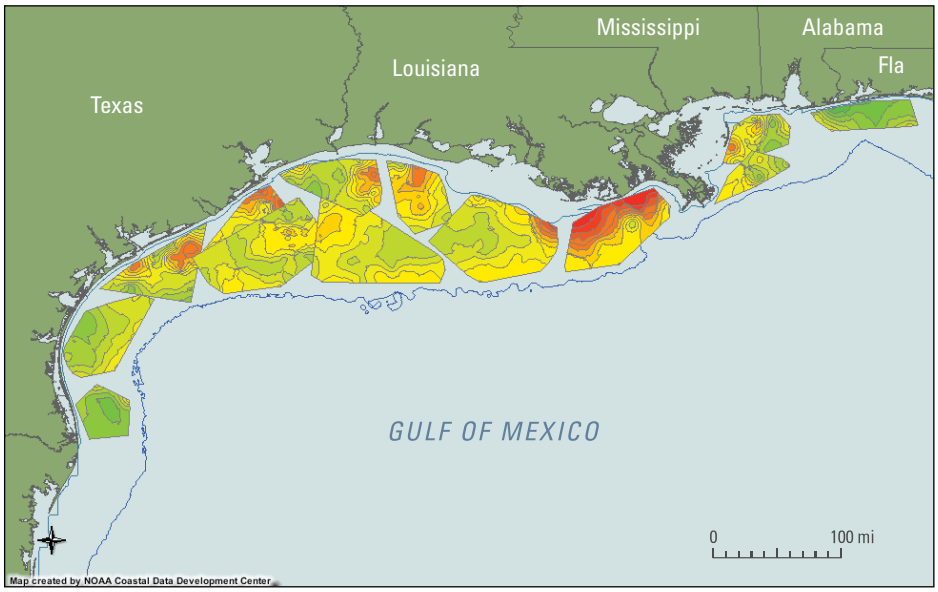
May 2009 to the northern Gulf. In 2008, the hypoxic zone exceeded 20,000 km^2, an area similar in size to the State of New Jersey. Spring delivery of nitrogen in 2009 was about 23 percent lower than that measured in 2008, but still about 11 percent above the average from 1979 to 2009.

The amount of nutrients delivered to the Gulf each spring depends in large part on precipitation and the resulting amounts of nutrient runoff and streamflow in the Mississippi-Atchafalaya River Basin. Streamflows in spring 2009 were about 17 percent above the past 30-year average. Streamflows in spring 2008 were even higher, contributing to that year's higher nutrient levels (see graphs at **http://toxics.usgs.gov/hypoxia/mississippi/oct_jun/graphics.html**).

State and Federal partners serving on the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (**http://www.epa.gov/msbasin/**) are trying to reduce nutrients transported to the Gulf in order to reduce the 5-year-running-average areal extent of the Gulf of Mexico hypoxic zone to less than 5,000 km^2 by the year 2015. (The 5-year running average is the average of areal extents measured in 5 consecutive years, used to smooth the effect of an anomalously large or small hypoxic zone in any given year.) Tracking nutrient levels every year is important to determine if partners are on target for that goal.



Dissolved oxygen in bottom waters, measured from June 8 through July 17, 2009, during the annual summer Gulf of Mexico Southeast Area Monitoring and Assessment Program (SEAMAP) cruise in the northern Gulf of Mexico. Orange and red colors indicate lower dissolved oxygen concentrations. Data were received from the NOAA ship Oregon II *twice weekly and assimilated into a geospatially enabled database; more information and maps from previous years are available on NOAA's Gulf of Mexico Hypoxia Watch Web site at* ***http://ecowatch.ncddc.noaa.gov/hypoxia****.*

The USGS has monitored streamflow and water quality in the Mississippi River Basin for decades; to access more information, visit **http://toxics.usgs.gov/hypoxia/mississippi/flux_ests/**.

For more than 125 years, the USGS has served as the Nation's water-monitoring agency, collecting data on streamflow and water quality in selected streams and rivers across the United States. Access data from more than 7,400 streamgages, many of which provide real-time data in 15-min increments, at the USGS WaterWatch site, **http://waterwatch.usgs.gov/**.

For an even greater variety of USGS data, including data on groundwater as well as surface water, visit the National Water Information System's Web Interface (**http://waterdata.usgs.gov/nwis/**), which provides access to water-resources data collected at approximately 1.5 million sites in all 50 States, the District of Columbia, and Puerto Rico.

Submarine Landslides as Potential Triggers of Tsunamis That Could Strike the U.S. East Coast

First results from systematic sea-floor mapping of the continental slope from Cape Hatteras to Georges Bank

By Uri ten Brink

A recent assessment of tsunami hazard along the U.S. east coast, carried out by the U.S. Geological Survey (USGS) and funded by the U.S. Nuclear Regulatory Commission, has identified submarine landslides along the submerged continental margin as the primary potential source of dangerous tsunamis to this coast. The seriousness of this hazard was demonstrated by the 1929 Grand Banks submarine landslide, which produced a tsunami 3 to 8 m high that killed 28 people along the sparsely populated Newfoundland coast.

Most submarine landslides on the continental margin occur on the continental slope and upper rise; a lack of detailed maps for parts of this region has ham-

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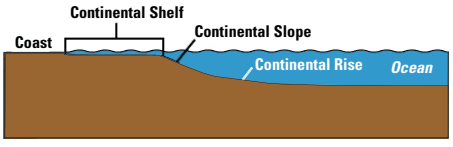

*General shape of continental shelf, slope, and rise. Modified from U.S. Office of Naval Research (****http://www.onr.navy.mil/Focus/ocean/regions/oceanfloor2.htm****).*

(Submarine Landslides continued from page 4)

pered efforts to produce a quantitative assessment of tsunami hazard. During May 11-25, 2009, a team of scientists conducted a 15-day survey aboard the National Oceanic and Atmospheric Administration (NOAA) ship *Ronald H. Brown* to provide a complete sea-floor map of the continental slope and upper rise from Cape Hatteras in the south to the eastern end of Georges Bank in the north, a distance of 1,200 km (750 mi). **Uri ten Brink**, **David Twichell**, **Bill Danforth**, and **Elizabeth Pendleton** from the USGS Woods Hole Science Center; **LTjg. Lindsey Waller** from NOAA's Pacific Marine Environmental Laboratory; and **Leslie Sautter**, **Brian Kennedy**, **Emily Allen**, **Shannon Hoy**, and **Will Sautter** from the College of Charleston used the *Ronald H. Brown's* hull-mounted SeaBeam 2112 multibeam echosounder to carry out the mapping. Before the survey, **Jason Chaytor** (USGS Woods Hole Science Center) compiled available multibeam bathymetric data to help focus new data collection on areas that were lacking coverage, particularly along the southern New England and Georges Bank margins. With the newly collected bathymetric data, more than 99 percent of the sea floor deeper than 400 m (and some areas to depths as shallow as 150 m) has now been mapped with a multibeam echosounder, allowing us to draw accurate maps of submarine canyons and the remains of past landslides along the entire U.S. east coast continental margin.

These new data provide the first detailed understanding of the morphology of the source areas for many of the largest landslides. Bathymetric data were collected along nearly 5,500 km of survey tracklines, and these data show that the largest landslides have occurred

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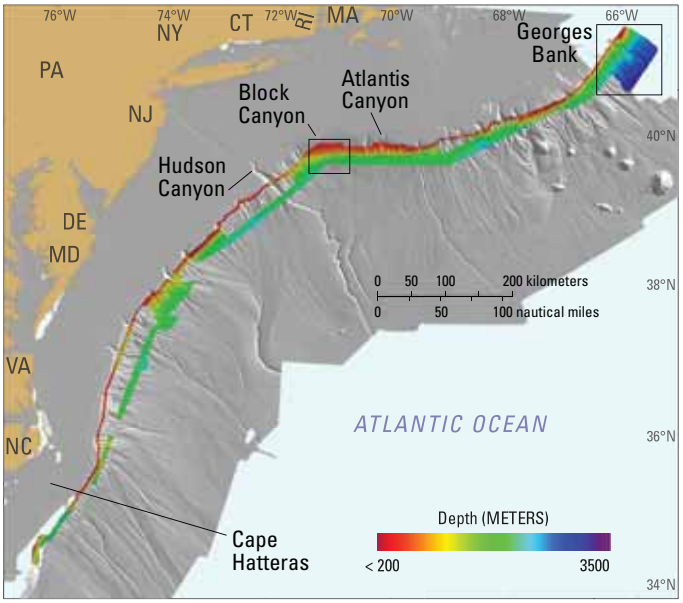
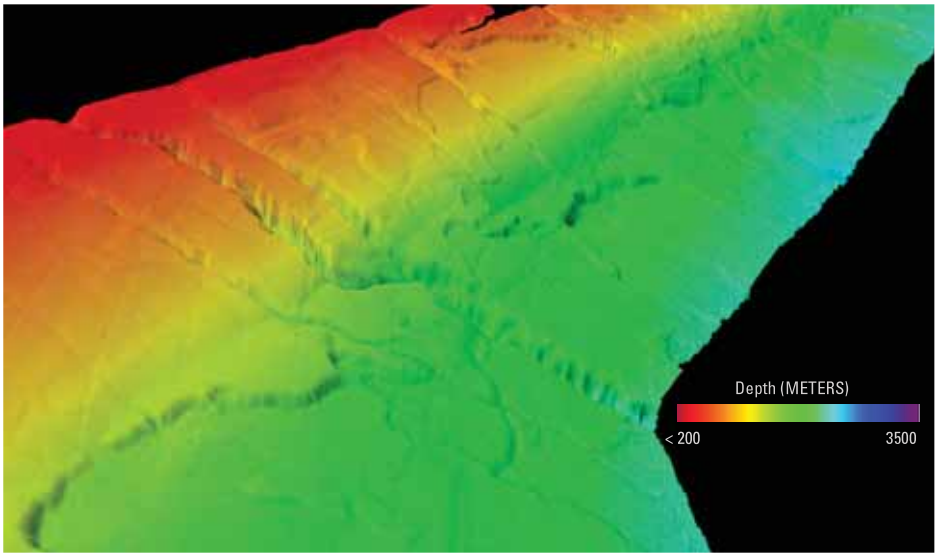
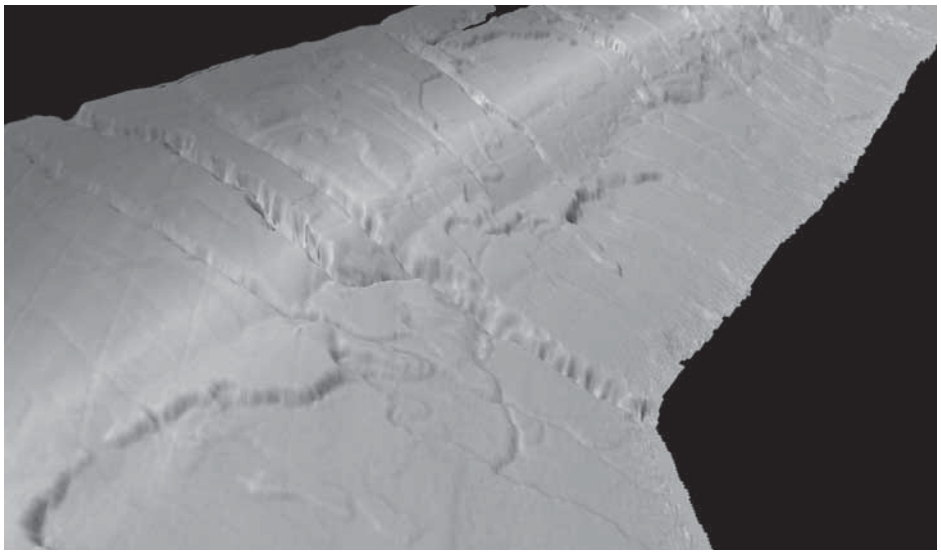
Shaded-relief map of U.S. Atlantic margin (gray), gridded from single-beam bathymetric soundings, and new bathymetric data (color-coded for depth) collected with a multibeam echosounder during the May 2009 cruise. Rectangles outline approximate areas of oblique views accompanying this article (below and next page).







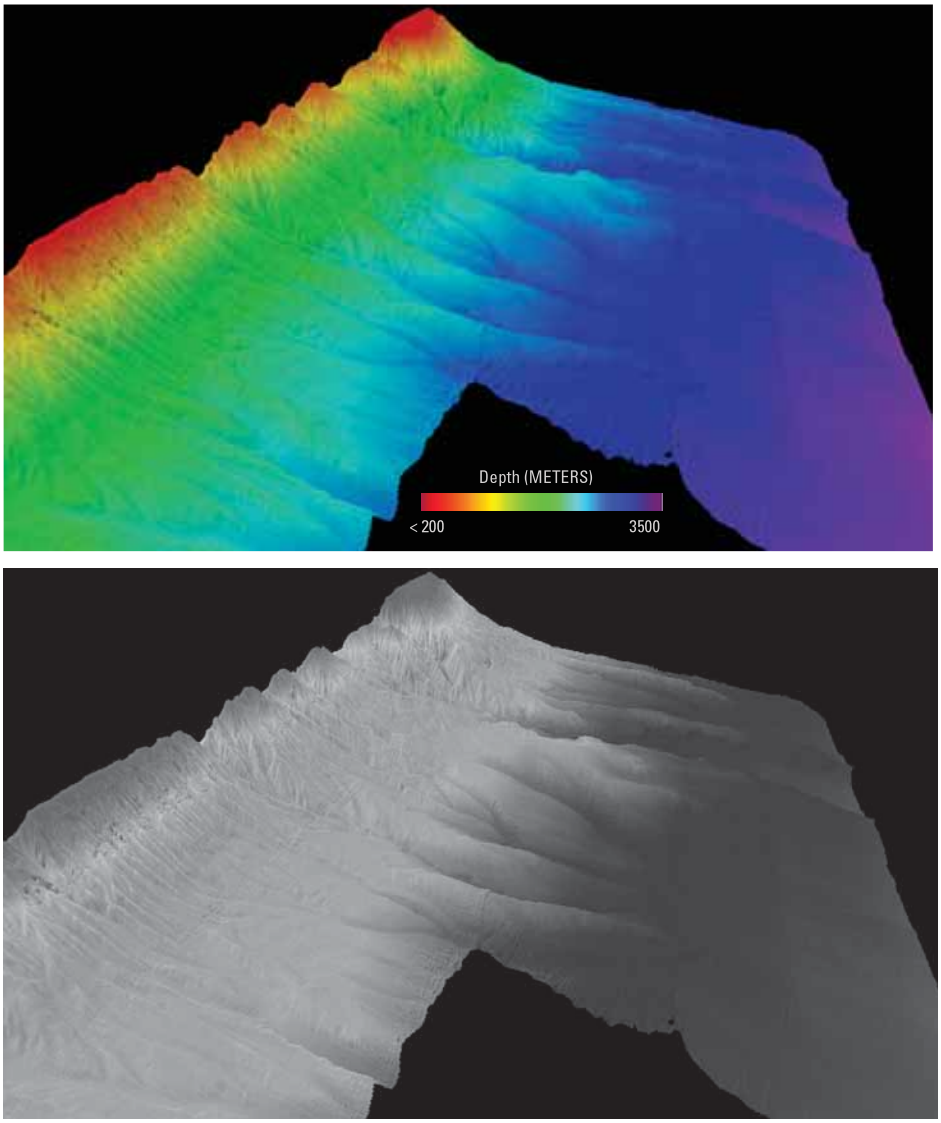
► *Oblique view of the continental slope of southern New England, showing a convex profile and numerous landslide scarps (see rectangle near center of accompanying map for approximate location). Most deeply incised canyon in this view is the meandering Block Canyon. Image in color (top) shows depth, and image in gray tones (bottom) shows details of topography.*

(Submarine Landslides continued from page 5)

along the southern New England continental slope and upper rise between Hudson Canyon and Atlantis Canyon. This section of the continental slope is characterized by numerous steep cliffs, some of them exceeding 100 m in relief. These cliffs are the headwall scarps of landslides—the surfaces that remain after the landslide material has fallen away. Some of the headwall scarps can be traced along the slope for 15-22 km, indicating that huge volumes of sediment were removed during single events. The height of a tsunami generated from a submarine landslide is highly dependent on the landslide volume, so the evidence for high-volume offshore landslides suggests that the southern New England coast may be prone to landslide-generated tsunamis. Farther east, offshore of Georges Bank, the continental slope is incised by numerous submarine canyons, and the headwall scarps of past landslides there are smaller and more widely spaced.

The newly collected multibeam echosounder data, coupled with available seismic-reflection data, fill a key gap in our information on submarine-landslide source areas. This new information is central to refining our assessment of tsunami hazard along the densely populated U.S. Atlantic coast.

Additional photographs showing life at sea and the rich marine life encountered during the survey of the continental margin can be found at **http://oceanica.cofc.edu/Multibeam/CruiseGallery-Tsunami/**.



Oblique view of the continental slope of Georges Bank, showing numerous canyons incising the slope and relatively few landslide scarps (see rectangle at upper right of map on previous page for approximate location). Image in color (top) shows depth, and image in gray tones (bottom) shows details of topography.

Photographic Overflight of New England and Mid-Atlantic Coast Provides Baseline for Change Assessments

By Cheryl J. Hapke, Emily A. Himmelstoss, and Karen L.M. Morgan

Continued demand to maintain permanent infrastructure along the coast is especially prevalent along the New England and mid-Atlantic U.S. coastline. This dynamic interface is the site of dense residential and commercial development in many areas, even though it is frequently subjected to a range of natural hazards that can include storm surge, flooding, coastal erosion, and tsunami inundation. Rising sea levels and an expected increase in storm intensities over the next century and beyond will make coastal regions increasingly vulnerable to shoreline erosion and coastal flooding.

The U.S. Geological Survey (USGS) National Assessment of Coastal Change Hazards project (**http://coastal.er.usgs.gov/national-assessment/**) includes ongoing efforts to better understand historical patterns of coastal change and to assess impacts from severe storms. The

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current focus of the historical-shoreline-change analysis is on New England and the mid-Atlantic States (Maine through Virginia). Previous historical assessments have been completed for the Gulf of Mexico (**http://pubs.usgs.gov/of/2004/1043/**), the U.S. Southeast Atlantic coast (**http://pubs.usgs.gov/of/2005/1401/**), and California (**http://pubs.usgs.gov/of/2006/1219/**). In order to interpret and analyze regional-scale shoreline-change data associated with these assessments, a detailed perspective on the varied coastal geomorphology and the location of coastal-protection structures is essential.

During the week of May 18-22, 2009, USGS personnel **Cheryl Hapke**, **Emily Himmelstoss**, and **Karen Morgan** conducted an aerial photographic mission along the New England and mid-Atlantic coast, from Cape Elizabeth, Maine, to the border between Virginia and North Carolina. The overflight was conducted with a Cessna 207 single-engine plane piloted by

Personnel from the USGS and Penobscot Island Air loading gear and setting up equipment on the tarmac of Knox County Regional Airport in Owls Head, Maine.

Brud Folger of Penobscot Island Air. Geolocated digital photographs were taken out of an open window of the plane, which flew 500 ft above the water and approximately 1,000 ft offshore. The camera system included a high-resolution digital still camera and a laptop computer with real-time position-tracking software. Wired to the camera was a dedicated Global Positioning System (GPS) unit that added geographic coordinates to the header of each photograph as it was taken. Nearly 10,000 oblique images were collected.

These new images will be used to interpret trends and along-coast variations in shoreline change in the assessment report for the New England and mid-Atlantic States. In addition, they can be qualitatively compared to a similar dataset that was collected in 2000 to look at short-term changes to the coast. Finally, they will provide a modern baseline for assessing the impacts of extreme storms, such as hurricanes and nor'easters, should this region be affected in the near future.

A humpback whale and her calf, spotted off the northeast tip of Cape Cod during the overflight, provided a momentary distraction from taking coastal photographs.

Approximate stretch of New England and mid-Atlantic coast that was photographed during the 2009 overflight and will be covered by the National Assessment of Shoreline Change Hazards analysis.

Striking changes occurred in the 9-yr period between coastal overflights on Cape Cod, Massachusetts. This location, at Nauset Beach near Chatham, is the site of a breach in the barrier island that formed during the April 15-17, 2007, "Patriots' Day" nor'easter. Several houses were destroyed (left of red arrow), and the beach was significantly eroded.

Climate Past, Climate Future: A Story of Aquatic Plants

By Beth A. Middleton

U.S. Geological Survey (USGS) scientists with extensive knowledge of coastal processes occasionally apply their expertise to scientific problems in inland areas. One of these scientists, ***Beth Middleton*** *of the USGS National Wetlands Research Center in Lafayette, Louisiana, was recently asked to look at the impact of droughts on wetland vegetation in Keoladeo National Park in northern India. This is her story about that work.—Ed.*

A gathering of the Keoladeo Naturalists Society, a group of naturalists and rickshaw pullers working in the Keoladeo National Park. Some of the members of this group worked on ecosystem studies with USGS research ecologist ***Beth Middleton*** *during the 1980s as part of her Ph.D. dissertation work with Iowa State University.*

The biodiversity of some of the world's best national parks may be threatened by water shortages, and predicted climate change could accelerate this problem in the future. The aquatic plant species of national parks in India may be particularly threatened by any future water shortages. According to forecasts for India by the National Centre for Medium Range Forecast (NCMRF, **http://www.ncmrwf.gov.in**), even though there may be 10 percent more rain in the future, temperatures may be 3-5°C hotter, so that water may become less available. The NCMRF also predicts more extreme storm activity. Monsoons—seasonal winds that bring rainfall to the region—are already becoming less predictable. If longer periods of drought occur in northern India in the future, national parks may need to prepare for biodiversity changes, particularly in aquatic plant species.

Local observers have noted the shrinking of habitat for aquatic plant species in the Keoladeo National Park in Bharatpur, Rajasthan, northern India, after a number of years of drought and upstream water abstraction. The Keoladeo Naturalists Society invited U.S. Geological Survey (USGS) research ecologist **Beth Middleton** to visit the park to make observations of aquatic species of concern (Technical Assistance Agreement T-09-763b). The Keoladeo Naturalists Society (a.k.a. "The Barefoot Naturalists") is a group of local nature guides and rickshaw pullers. **Middleton** is a researcher who studies the impact of climate change, drought, and hurricanes on coastal wetlands; because of this expertise, she was asked to look at the impact of droughts on the Keoladeo National Park wetlands. **Middleton** did her Ph.D. research in India 20 years previously, so she was familiar with the park under conditions of more normal flooding. Upon her return in April 2009, the park looked very different after several years of drought. The aquatic areas of the park appeared to be smaller than during the 1980s; however, at least one positive observation is that park managers have enlisted local villagers to remove the invasive mesquite plant, *Prosopis juliflora*, within upland savanna habitats .

*Villagers have been cutting the invasive mesquite (*Prosopis juliflora*) from savanna forest and digging the stumps out by the root. Managers at the Keoladeo National Park hope that eventually this invasive species can be controlled in the park. Native species such as* Salvadora oleiodes *and* Vetiveria zizaniodes *survived under the mesquite and are available to revegetate the savanna. In the 1980s, many savanna portions of the park were completely infested with* Prosopis juliflora.

Water shortages and drought are predicted for many places in the future as a consequence of climate change, and this story of potential biodiversity loss related to drought in the Keoladeo National Park is instructive for those of us who work to prevent the loss of native species. The Keoladeo Naturalists were concerned that after several years of drought, some aquatic species might now be lost from the park. The 2008 monsoon rains were more nearly normal, so that some of the aquatic

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*Savanna forest after invasive mesquite (*Prosopis juliflora*) removal. Large tree to left is a kadam,* Mitragyna parvifolia.

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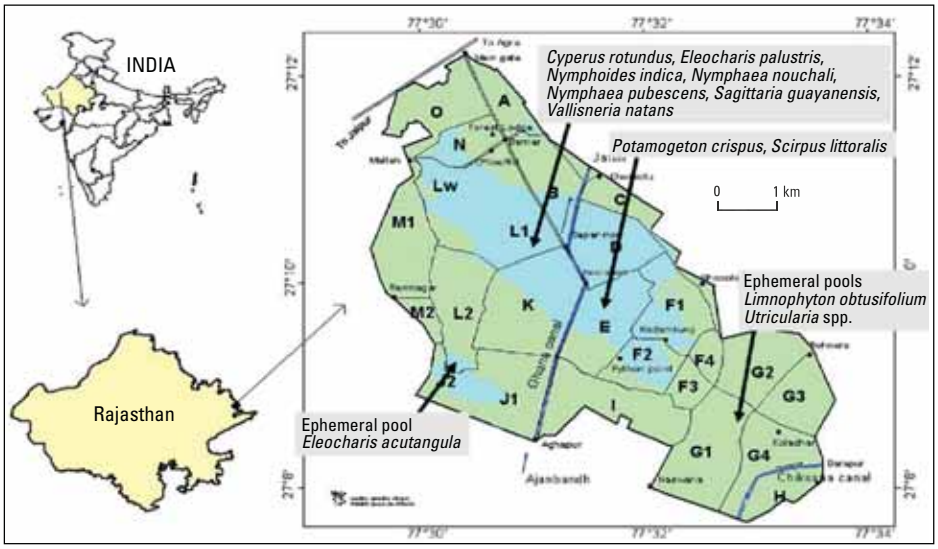
habitats filled with water. Accepting the invitation to return to India after 20 years, **Middleton** spent several days searching drying ponds for aquatic species in April 2009. April is a time of the year during which ponds normally become dry. During a "normal" year in this part of northern India, wetlands dry during the very dry and hot summer (March-June), then fill with water (July-October), and stay wet during a cold winter (November-February).

Members of the Keoladeo Naturalists Society and **Middleton** searched the park for aquatic species of concern, but not without some trepidation. Although aquatic species of monsoonal wetlands are adapted to drought, the question arises after many years of continuous drought: how long can aquatic species maintain themselves without water? **Middleton** suggested that areas of the park be checked where these species of concern had been found as seeds in seed banks (natural accumulations of viable seeds in the soil) studied during the 1980s. By following this strategy, the team found a number of the aquatic species of concern, albeit in restricted abundance on the edges of the drying ponds. The team found species such as *Cyperus rotundus*, *Nymphoides indica*, *Paspalum distichum*, *Potamogeton pectinatus*, *Scirpus tuberosus*, and *Vallisneria natans*.



Keoladeo National Park, India, showing sites (arrows) checked in April 2009 for aquatic plant species of concern, based on the presence of these species (listed in shaded boxes) in seed banks at the sites in the 1980s. Lettered zones are bounded by roads and levees. Blue areas, wetlands; green areas, savanna.

It was good news to discover that many of the aquatic species were still growing in the national park, but questions remain regarding the mechanisms underlying the drying of the park. Factors other than water abstraction, monsoon fluctuation, and climate drying might be contributing to this phenomenon. For example, could the wetland become drier because accumulation of plant matter is raising the ground elevation? **Middleton's** graduate studies at Iowa State University in the 1980s on the relationships between plant production and decomposition yielded some information regarding the controls of ground elevation in wetlands. Such baseline data are critical to understanding whether current rates of organic filling of wetlands may have changed from 20 years ago, and surface elevation table (SET) elevation analyses are suggested as future studies.

(Aquatic Plants continued on page 10)

Examples of aquatic species in Keoladeo National Park: left, Nymphoides cristata *(floating heart); right,* Nymphoides indica *(water snowflake).*

(Aquatic Plants continued from page 9)

The observations made in April 2009 by **Middleton** were a pilot study to determine the extent of the problem for aquatic plant species related to drought. Plans are underway for a more extensive vegetation survey in October 2009 to determine if the abundances of these species of concern have changed in the past 20 years. But this analysis can only occur if the monsoon of 2009 cooperates and fills the temporary ponds of the Keoladeo National Park.❁

Drying pool in Keoladeo National Park, India, March 12, 2008, with wintering bar-headed geese, migrant sandpipers, and possibly-breeding egrets. The park is highly prized for its populations of water birds, including migratory waterfowl and resident nesting birds. From ***http://whc.unesco.org/download.cfm?id_document=100720*** *(2.2 MB PDF file).*

USGS Scientist Leads SCUBAnauts to Capitol Hill During Ocean Week

By Chris Moses

Marine geologist **Chris Moses**, one of several leaders of the local SCUBAnauts International Program in west-central Florida, took a group of 22 SCUBAnauts to Capitol Hill in Washington, D.C., June 9-11, during Ocean Week. **Moses** is a contractor with Jacobs Technology at the U.S. Geological Survey (USGS) office in St. Petersburg, Florida, where he is developing a protocol to map sea-floor habitats. The SCUBAnaut International Program is a 501(c)(3) nonprofit organization that trains students ranging in age from 12 to 18 to become stewards of the ocean environment and explorers of tomorrow. The rapidly growing SCUBAnauts International Program now has three chapters in Florida—in Tampa, Tarpon Springs, and Key West.

SCUBAnauts from west-central Florida pose with ***Robert Ballard*** *(National Geographic Explorer in Residence; middle row, center) and* ***Billy Causey*** *(NOAA Superintendent of Southeast Region National Marine Sanctuaries; bottom row, center) and* ***Judge George Hanks*** *(nominee for National Marine Sanctuary Volunteer of the Year; bottom row, second from right).* ***Chris Moses*** *is at far left in second row from front. The SCUBAnauts were recognized for leadership and outreach in ocean stewardship at the National Marine Sanctuary Foundation Leadership Awards Dinner.*

On June 9, in conjunction with Ocean Week, the National Marine Sanctuary Foundation held its annual Leadership Awards Dinner, where the SCUBAnaut program was recognized for its efforts in education and ocean stewardship. The students ("nauts") met with National Oceanic and Atmospheric Administration (NOAA) officials such as **Dan Basta** (NOAA Director of National Marine Sanctuaries), as well as with Congressmen such as Representative **Gene Taylor** (D-Miss). The students were thrilled to be able to interact with famous ocean explorers such as **Robert Ballard** and **Sylvia Earle** (National Geographic Explorers in Residence). They also learned more about current marine research and ocean-conservation issues by participating in Capitol Hill Ocean Week scientific seminars.

For more information about Capitol Hill Ocean Week 2009, visit **http://nmsfocean.org/capitol-hill-ocean-week-2009.** For more information about SCUBAnauts International, visit **http://www.scubanautsintl.org/**.❁

USGS Scientist Participates in Panel Discussion after Film on Ocean Acidification

By Ann Tihansky

U.S. Geological Survey (USGS) scientist **Ilsa Kuffner** joined SRI International Research Engineer **Lori Adornato** and Ocean Conservancy Southeast Atlantic and Gulf of Mexico Regional Director **David White** in a panel discussion on June 8, 2009, after a public screening of the movie *A Sea Change: Imagine a World Without Fish*. The film was hosted by the International Ocean Institute and was shown at the Florida Fish and Wildlife Research Institute's auditorium coincident with World Oceans Day 2009. **Bill Hogarth**, Dean of the University of South Florida's College of Marine Science, introduced the event.

The film A Sea Change *raises issues about ocean acidification, chemistry, uncertainty in science, and public perceptions and concerns about current and future policy directions. Three panelists led the post-film discussion and answered questions from the audience (left to right):* ***Ilsa Kuffner****, USGS;* ***Lori Adornato****, SRI International; and* ***David White****, Ocean Conservancy.*

The film follows a grandfather seeking to better understand the relations between atmospheric carbon and ocean chemistry in simple language and examples so that he can relay messages to future generations, including his own grandson. (More information about the movie, including a trailer, is posted at **http://www.aseachange.net/**.)

The panel discussion reiterated that changes in ocean chemistry are measurable and well documented. Research ecologist **Kuffner** said, "We have well-documented data indicating that ocean pH has been decreasing for 20 years. There is very little uncertainty about the trends." Translating this information and putting it into a context that reaches the public is likely the largest challenge. Getting the public interested in a subject like ocean chemistry seems to be the next step. "Once the public understands this issue and the implications on a global scale, it is very likely we can pull together and address these changes. Look what we did with DDT and with the hole in the ozone," said **David White**.

The film, which is not yet publically available, is geared for general audiences to raise awareness about global effects from changes in ocean chemistry. **Mara Hendrix** of the International Ocean Institute organized the screening and is looking for more ways to share the film and its message with the general public.

New England Lidar Workshop

By Emily Klipp

Demand for high-quality elevation data has increased significantly, driven by local, State, and Federal government agencies as well as by the community and industry. Lidar (light detection and ranging) and other acquisition technologies are also developing at a rapid rate. In May 2009, the U.S. Geological Survey (USGS)

(Lidar Workshop continued on page 12)

(Clockwise, beginning with people on couch): ***Bill Schwab*** *(USGS Woods Hole Science Center),* ***John Brock*** *(USGS Woods Hole Science Center),* ***Amar Nayegandhi*** *(Jacobs Technology/USGS),* ***Dean Gesch*** *(USGS Earth Resources Observation and Science [EROS] Center), and* ***Stephen White*** *(National Oceanic and Atmospheric Administration's National Geodetic Survey) discuss possible collaboration efforts.*

(Lidar Workshop continued from page 11)

Coastal and Marine Geology Program's Decision Support for Coastal Science and Management project (**http://ngom.usgs.gov/dsp/**) and the Northeast Regional Ocean Council (NROC, **http://community.csc.noaa.gov/nroc/**) hosted a workshop to provide an overview of the current state of lidar data-acquisition technologies and to discuss applications and availability of high-resolution topographic data for meeting local and regional coastal needs in New England. Other objectives of this workshop, held at the USGS Woods Hole Science Center in Woods Hole, Massachusetts, were to understand the different statutory responsibilities of Federal agencies for collecting and disseminating lidar data, to discuss the needs of resource agencies for high-resolution elevation data, to explore ideas and options for a coordinated New England lidar program, to outline steps that can be taken over the next 18 months to build a coordinated network, and to learn about current applications of lidar technology to coastal science and resource issues.

The first workshop day gave participants an opportunity to discuss the needs for high-resolution elevation data and the status of existing data and their sources, as well as current and needed tools for data dissemination and interest in seamless datasets. Representatives from State agencies, nongovernmental organizations (NGOs), and universities presented first, followed by representatives from several Federal agencies. After the presentations, four breakout groups were formed, and each was asked to discuss a realistic scenario requiring a coordinated effort to collect, store, and disseminate high-resolution elevation data.

On the following day, participants discussed coordination efforts and what it would take to synchronize lidar activities in coastal New England. The afternoon discussion focused on current applications of lidar technology, including lidar bathymetric mapping, the use of lidar to determine the shoreline, barrier-island geomorphology derived from lidar, floodplain hydrologic modeling, terrestrial-vegetation mapping, and surveying with ground-based lidar.

The workshop ended with an optional third day to discuss the capabilities and applications of the Experimental Advanced Airborne Research Lidar (EAARL), an airborne lidar system that provides unique capabilities to survey coral reefs, nearshore benthic habitats, coastal vegetation, and sandy beaches. Operating in the blue-green portion of the electromagnetic spectrum, the EAARL is specifically designed to measure submerged topography and adjacent coastal land elevations seamlessly in a single scan of transmitted laser pulses. (More information about EAARL is posted at **http://ngom.usgs.gov/dsp/tech/eaarl/**.)

USGS and NROC Federal and State collaborators will continue to foster communication and coordinate planning to ensure that high-resolution elevation data will be available for coastal managers and decision makers entrusted with the well-being of human and ecological communities in coastal areas.

USGS Scientist Jeff Williams Receives 2009 Coastal Zone Foundation Career Award

At an award ceremony on June 2, 2009, **S. Jeffress Williams** of the U.S. Geological Survey (USGS) Woods Hole Science Center was given the 2009 Coastal Zone Foundation Award for career achievement. The award was presented by Foundation President **Orville T. Magoon** at the triennial American Society of Civil Engineers/Canadian Society of Civil Engineers/Institution of Civil Engineers (ASCE-CSCE-ICE) conference on climate change and its effects on coasts worldwide. The conference, titled "Coastal Engineering: Future Challenges and Risks," was held in St. John's, Newfoundland, Canada, where **Williams** gave an invited lecture on "Sea-Level Rise and Storm Effects on Coasts under Changing Global Climate."

A booklet handed out at the award ceremony describes **Williams'** career:

"**S. Jeffress Williams**, a senior research coastal marine geologist with the USGS Woods Hole Science Center, Woods Hole, MA, has focused his research career on the geologic history and processes of coastal, estuarine, wetland, and inner continental shelf regions. He has over 35 years' research experience investigating topics such as the geologic origins and development of marine coastal and estuarine as well as Great Lakes coastal systems, Holocene sea-level history, climate change effects on coasts, and the geologic origins and character of marine sand bodies and their importance to coastal sediment budgets. **Williams** has led or

(Career Award continued on page 13)

*The morning after a big storm in April 2007, **Jeff Williams** was at the shore to observe its effects. The storm deposited gravel on this bike path in Falmouth, Massachusetts, and caused considerable erosion in other areas. View southward, toward Nobska Point. Photograph by **Chris Polloni**, USGS.*

(Career Award continued from page 12)

participated in more than 80 field studies on shorelines around the world in complex field projects.

"He has authored over 300 research papers and has participated on committees of the National Academy of Sciences, National Ocean Partnership Program, 1998 National Oceans Conference, Coral Reef Task Force, Louisiana Wetlands Restoration Task Force, and the Louisiana Sand Task Force. Most recently he was a lead author for the U.S. Climate Change Science Program on an assessment of sea-level rise effects on coasts. He is a recognized expert on coastal-hazard and sea-level rise topics.

"Prior to taking his current research position, **Williams** directed the USGS Coastal and Marine Geology Program from 1996 to 2000 in Reston, VA. This involved managing and directing 250 staff carrying out more than 100 research projects at USGS research centers in Woods Hole, MA; St. Petersburg, FL, and Menlo Park/Santa Cruz, CA. Prior to joining the USGS in 1983, **Williams** was a research marine geologist with the US Army Corps of Engineers. He earned degrees in geology and oceanography from Allegheny College and Lehigh University."

Congratulations, **Jeff**!

USGS Scientist Receives Best Student Poster Award at GSA 2008 Meeting

By Brigid Moran

Paul Knorr, a graduate student in the Student Career Experience Program (SCEP) and geologist with the U.S. Geological Survey (USGS), received Best Student Poster Award from the Geological Society of America (GSA) on October 6, 2008. The Sedimentary Geology Division of GSA presented the award. **Knorr's** poster, "Effects of Increased pCO_2 on Aragonite Crystal Morphology in *Halimeda* spp.," was coauthored by his USGS supervisor and co-advisor **Lisa Robbins** and University of South Florida advisor **Peter Harries**. This research highlighted some of **Knorr's** dissertation work on a species of the calcifying green alga *Halimeda*—an important producer of carbonate sediment in tropical, shallow-water, carbonate settings—and the alga's reaction to differing levels of CO_2.

With higher levels of atmospheric CO_2 being absorbed by the world oceans, there have been decreases in the pH and calcium-carbonate-saturation state of seawater. Understanding how organisms will respond to decreasing pH in seawater is a major research aspect for understanding global change. The main goal of the experiment was to determine how the alga *Halimeda* responds to lower pH levels associated with rising CO_2. It is believed that continued decreases in pH will affect the rate and biogeochemical processes of calcification and carbonate-sediment production. (For example, see "Coral-Reef Builders Vulnerable to Ocean Acidification" in *Sound Waves*, March 2008, **http://soundwaves.usgs.gov/2008/03/research.html**.)

*USGS scientist and doctoral student **Paul Knorr** holds the "Best Student Poster Award" he received from the Geological Society of America in October 2008. Behind **Knorr** is the award-winning poster about his doctoral research on how the calcifying alga* Halimeda *responds to decreasing levels of seawater pH associated with rising levels of atmospheric CO_2.*

Using an automatic CO_2-injector system, **Knorr** was able to regulate the amount of CO_2 in an aquarium containing two species of *Halimeda*. The AquaController 3 controller/monitor (AC3) was programmed to keep the pH level at 7.5. Once sizeable specimens had been grown, the aragonite crystals within the algae were analyzed under a scanning electron microscope (SEM).

As presented in the award-winning poster, **Knorr** observed that the *Halimeda opuntia* grown in pH 7.5 water showed crystal growth about 55 percent smaller than normal, and *Halimeda tuna* showed crystals 19 percent smaller than those in the same species grown at pH 8.1, the current global average pH of ocean water. These data confirm the original hypothesis that lower pH levels will alter the carbonate production in these organisms. This research was initiated because of crystal trends seen in archived samples. Different species of *Halimeda* from the 1960s to the present also show trends of decreased crystal widths and increased abundance, as reported by **Robbins**, **Knorr**, and **Pamela Hallock** (University of South Florida) in a paper titled "Response of *Halimeda* to Ocean Acidification: Field and Laboratory Evidence," which will be published in the journal *Biogeosciences Discussions.*

Currently a doctoral student, **Knorr** followed an unusual path to the field of geology. While living in Munich, he took a geology class at the University of Maryland, Munich Campus, which included several field trips to both the Bavarian Kalkalpen (Northern Limestone Alps) and to Plitvice, Yugoslavia (now Croatia) that spurred his initial interest. He admits that, never having met a geologist, he didn't think geology was a practical choice for a career. Instead, he pursued a life in the U.S. Army.

Knorr, who grew up as an Army brat, spent 4 years as an infantry machine gunner and radio operator. During his first 2-year post as a paratrooper with the 82nd Airborne Division, he parachuted into

(Best Poster continued on page 14)

(Best Poster continued from page 13)

Panama for Operation Just Cause. After another 18 months near the South Korean Demilitarized Zone, he left the Army to finish a degree in geology at the University of Florida. After college, **Knorr**, who was commissioned through ROTC, continued a career in the military and was stationed as an Army Lieutenant with the U.S. Army Corps of Engineers in Fort Lewis, Washington. There he applied the cartographic and topographic knowledge he had learned in his geology studies and at a Defense Mapping Agency (now the National Geospatial-Intelligence Agency) officer's course, but still believed his interests in geology were simply a side hobby.

After spending another 3 years in combat engineer units working with explosives and mines, **Knorr** decided that geology could be a more practical, happy, and perhaps safer career choice. He worked as a hydrogeologist for an environmental consultant for several years before attending the University of South Florida, where he received a Master's degree in geology. He is now working with **Robbins** and **Harries** on a doctoral dissertation focused on ocean acidification.

Knorr's general interest lies in understanding global change and how the Earth has responded to changes over geologic time. Specifically, he is interested in contributing to understanding ocean acidification, realizing that this phenomenon may have immediate and near-term effects on environmental change and the Florida ecosystem as a whole.

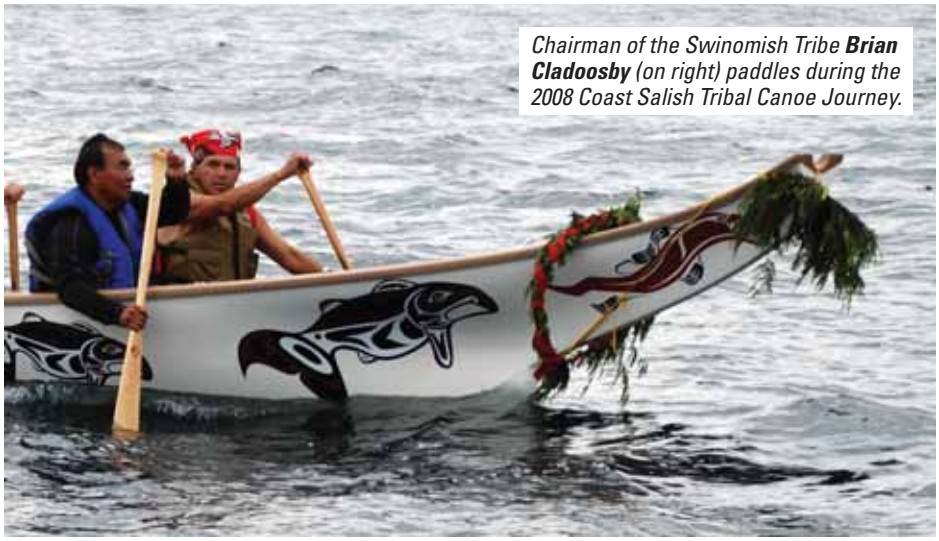
So what's next in **Knorr's** investigation of pH and CO_2 levels? In an interview at the lab where the research was conducted, **Knorr** stated that the next steps would include looking at the effects of lower pH levels on different types of carbonate-producing organisms and sediments—specifically benthic foraminifera—and measuring how both are affected by ocean acidification.

Department of the Interior Award Recognizes Coast Salish Tribal Journey Partnership

Participants in the Coast Salish-U.S. Geological Survey (USGS) Tribal Journey Water Quality Project were recognized recently with the U.S. Department of the Interior (DOI) Partners in Conservation Award for their studies to help restore nearshore marine habitats and ecosystem functions across the Salish Sea.

The award recognizes the strength of collaborative activities, such as the USGS partnership with the Coast Salish Western Washington Tribes and British Columbia First Nations. This cooperative effort combined traditional Tribal ecological knowledge and USGS science during the 2008 Tribal Canoe Journey to research resources undergoing decline in the Salish Sea, which includes Puget Sound, the Strait of Georgia, and the Strait of Juan de Fuca.

"The Salish Sea Ecosystem sustains our indigenous life way as People of the Salmon and Shoreline," said Chairman of the Swinomish Tribe **Brian Cladoosby**. "We say in our Lands, 'When the Tide is out, the Table is set.' Our way of life depends upon a healthy ecosystem that stretches from the mountains to the tidelands. Through the partnerships and project, we have a stronger science and policy capacity to protect the human health of our people, our culture, and aboriginal and treaty rights of our Nations."



*Chairman of the Swinomish Tribe **Brian Cladoosby** (on right) paddles during the 2008 Coast Salish Tribal Canoe Journey.*

During the 2008 Tribal Journey, members of Western Washington Tribes and British Columbia First Nations traveled in more than 100 canoes from locations throughout Washington and British Columbia to Cowichan First Nation in Duncan, British Columbia. Five of those canoes were very special; each towed a state-of-the-art water-quality probe and carried a global positioning system (GPS) unit. From north of the Strait of Georgia to southern Puget Sound, canoe families played a very big part in recording the health of the Salish Sea. In all, participants mapped more than 607 mi of the Salish Sea and collected more than 45,000 measurements of specific water-quality components, including surface-water temperature, salinity, pH, dissolved oxygen, total dissolved solids, and turbidity. Canoes are ideal for such data collection because they are slow moving and do not add toxins to the environment. USGS scientist **Eric Grossman** and Swinomish scientist **Sarah Akin** collaborated with USGS scientist **Paul Schuster** to develop

(Tribal Journey continued on page 15)

(Tribal Journey continued from page 14)

this marine-based data-gathering project and to provide technical expertise in planning and conducting the study and analyzing the data.

The Coast Salish are the trans-boundary indigenous and aboriginal group in a region that stretches from north of Powell River in British Columbia through all of Puget Sound and down the Washington coast. In February 2008, elders, chiefs, and representatives from more than 50 Tribes and First Nations formally adopted a mission and action agenda at the Third Annual Coast Salish Gathering in Tulalip, Washington, with a goal of developing policy and supporting sound science for the restoration and protection of coastal ecosystems of the Salish Sea.

The Director of the Yukon River Inter-Tribal Watershed Council, **Jon Waterhouse**, brought the Coast Salish Gathering Leaders the experience of conducting water-quality studies during a 1,200-mi-long canoe trip down the Yukon River in summer 2007. "The Yukon River Healing Journey was developed to check the pulse of the river, and it was up to our team to find a way," said **Director Waterhouse**. The Council's biologist **Bryan Maracle** and **Schuster** developed the concept of "marrying culture and science" by dropping a water-quality probe over the side of a canoe along the Yukon River Healing Journey, which started from Moosehide, Yukon Territory, Canada, and landed in Russian Mission, Alaska.

The Yukon River Healing Journey and the Salish Sea Tribal Canoe Journey share a common purpose of blending culture and science through water-quality testing and testimony from indigenous communities about environmental changes and issues within the water systems.

*USGS scientist **Eric Grossman** demonstrates a water-quality probe during an interview with KOMO-TV (ABC, Seattle) at the Swinomish Tribal Community Center before the start of the 2008 Tribal Canoe Journey.*

The Coast Salish and the USGS collaborated again during their second Tribal Canoe Journey together on July 20-August 3, 2009. During the 2008 canoe journey, areas of poor water-quality conditions had been identified along the travel routes. This year's journey included additional activities to identify the extent and causes of declines in water quality related to changes in land use and climate—information that is crucial to making informed decisions about balancing the needs of coastal ecosystems and human livelihood.

To learn more, visit the Tribal Journeys Information Site at **http://tribaljourneys.wordpress.com/2009-canoe-routes/** and the USGS Coast Salish Water Quality Project Web site at **http://www.usgs.gov/features/coastsalish/**.

Names and affiliations of the Partners in Conservation Award recipients are listed in a DOI news release at **http://www.doi.gov/news/09_News_Releases/050809d.html**.

New USGS Mendenhall Postdoctoral Research Fellows Include Three Who Will Research Coastal and Marine Topics

In October 2009, the U.S. Geological Survey (USGS) will welcome 18 new Mendenhall Postdoctoral Research Fellows for fiscal year 2010 (October 1, 2009, through September 30, 2010). These postdoctoral researchers will be the tenth group hired for 2-year appointments under the Mendenhall Postdoctoral Research Fellowship Program, created by the USGS in October 2000 in honor of the agency's fifth director, **Walter C. Mendenhall**. Each year since the program was established, more than 15 postdoctoral Fellows have been provided an opportunity to conduct in-depth research with selected USGS staff.

Of the 18 new Fellows, 3 will be conducting research on coastal or marine topics; their mentors, project titles, and duty stations are listed below:

- **Daniel Brothers** (Ph.D. from Scripps Institution of Oceanography, University of California, San Diego) will work with USGS scientists **Uri ten Brink**, **Eric Geist**, and **Homa Lee** on "Quantitative Evaluation of Tsunami Hazard to the Gulf of Mexico and Atlantic Coasts." **Brothers** will join the USGS Woods Hole Science Center, Woods Hole, Massachusetts.
- **Christopher Moy** (Stanford University) will work with **John Crusius** (USGS), **Dorothy Peteet** (Lamont-Doherty Earth Observatory of Columbia University), and **Tim Eglinton** (Woods Hole Oceanographic Institution) on "Exploring the Relationship Between Past Atmospheric Dust Composition, Climate, and Biological Productivity in the Northern Pacific Ocean." **Moy** will be with the USGS Woods Hole Science Center, Woods Hole, Massachusetts.

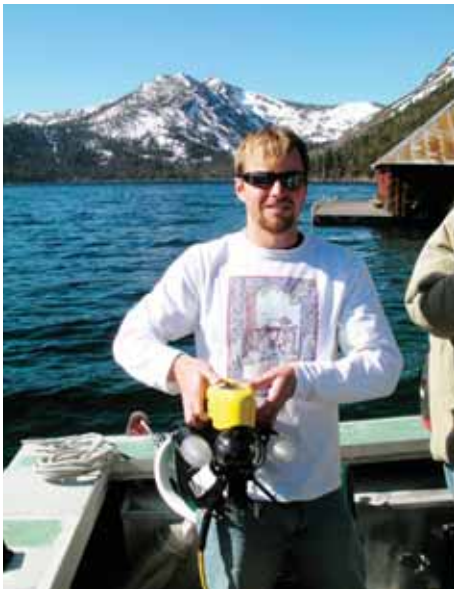
(Mendenhall Fellows continued on page 16)

(Mendenhall Fellows continued from page 15)

- **Joseph Long** (Oregon State University) will work with USGS scientists **Nathaniel Plant**, **Abby Sallenger**, **Peter Howd**, and **Hilary Stockdon** on "Prediction of Coastal Response to Extreme Storms Using High-Resolution Modeling and Data Assimilation." **Long** will be with the Florida Integrated Science Center, St. Petersburg, Florida.

The new Mendenhall Postdoctoral Research Fellows were announced in May 2009 by USGS Acting Director **Suzette Kimball**, who noted that the USGS Mendenhall Program continues to attract some of the best new Ph.D. graduates from leading universities to address a broad range of science topics. She praised the enthusiasm and productivity of past Mendenhall Fellows and stated, "The influx of postdoctoral talent continues to be a vital resource for the future of our science."

Visit the Mendenhall Program Web site at **http://geology.usgs.gov/postdoc/** for brief descriptions of the research being conducted, contact information, and products.



Danny Brothers *preparing to deploy a VideoRay remotely operated vehicle (ROV) to study ancient trees on the bottom of Fallen Leaf Lake, California, in May 2009.* ***Brothers*** *and his collaborators believe the trees record a medieval megadrought that occurred in the Lake Tahoe Basin.*

Chris Moy *prepares a 40-ft piston core for deployment in Lago Fagnano, Tierra del Fuego (Argentina), while University of Geneva graduate student* ***Nicholas Waldmann*** *looks on. One component of* ***Moy's*** *dissertation work involved participation in a study conducted by scientists and graduate students from Stanford University, the University of Texas, and the University of Geneva with the primary goal of understanding Holocene climate and tectonic evolution in southernmost South America. Photograph by* ***Rob Dunbar****, Stanford University, March 2006.*

Joe Long *at an open house at the College of Oceanic and Atmospheric Sciences at Oregon State University in July 2009.* ***Long*** *gave a talk about beach-surveying techniques and was photographed beside the* Argo, *an all-terrain vehicle (ATV) equipped with global positioning system (GPS) instrumentation used to survey areas of the beach exposed at low tide.*

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(Recently Published continued from page 16)

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