USGS

Sound Waves

Coastal Science and Research News from Across the USGS

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Fieldwork

Second Tsunami Causes Damage in Indonesia—USGS Scientists Post Observations on the World Wide Web

By Helen Gibbons

U.S. Geological Survey (USGS) scientists were in Jakarta, Indonesia, on March 28, 2005, when a magnitude 8.7 earthquake occurred off the northwest coast of Indonesia's island of Sumatra, less than 200 km southeast of the epicenter of the magnitude 9.0 earthquake that shook the region on December 26, 2004. The scientists were preparing for followup studies of the devastating tsunami generated by the December 26 earthquake, and they quickly revised their plans to include investigation of the smaller tsunami generated by the March 28 earthquake. (See "Why Wasn't There a Larger Tsunami?", this issue.) Throughout the month of April, USGS scientists measuring the impacts of both tsunamis in Indonesia have been posting photographs and accounts of their work on the Web at URL **http://walrus.wr.usgs.gov/news/reports.html**.

The USGS scientists are part of the West Sumatra International Tsunami Survey Team, formed in cooperation with the Indonesian government to conduct indepth studies of the impacts of the December 26, 2004, tsunami. This effort, funded in part by the U.S. Agency for International Development (USAID)'s Office of Foreign Disaster Assistance, will complement and expand on the findings of a survey conducted earlier this year (see "Astonishing Wave Heights Among the Findings of an International Tsunami Survey Team on Sumatra," *Sound Waves*, March 2005, at URL **http://soundwaves.usgs.gov/2005/03/**).

Although the March 28 earthquake did not generate a tsunami as large as the one that lashed countries around the Indian Ocean on December 26, the survey team soon learned that a local tsunami with

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The West Sumatra International Tsunami Survey Team visited offshore islands and sites along Sumatra's west coast. (Map modified from The World Factbook, *CIA, URL* ***http://www.odci.gov/cia/publications/factbook/****.)*

House destroyed by March 28, 2005, tsunami at Sorake Beach on Lagundri Bay, Nias Island, Indonesia. Photograph by ***Bob Peters****, USGS.*

Sound Waves

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Submission Guidelines

Deadline: The deadline for news items and publication lists for the June 2005 issue of *Sound Waves* is Thursday, May 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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reported wave heights of 2 to 4 m had hit coastal areas near the epicenter of the March earthquake—including Simeulue Island, Nias Island, and the Singkil district on mainland Sumatra. Computer models indicated that even larger waves might have struck the Banyak Islands. The team added all these areas to their itinerary of field stops along Sumatra's west coast.

Nias Island was the first of these areas to be visited by the scientists. Their report dated April 2, 2005, notes: "The 28 March tsunami was large and destructive at Lagundri Bay in southwest Nias Island. The team measured tsunami runup of 3 to 4 m and inundation distances of 400 to 500 m. Although there were few buildings in this location because it is a surf camp, more than 12 buildings were destroyed by the 28 March tsunami." People ran inland and uphill as soon as the earthquake shaking stopped; they were out of harm's way when the tsunami came ashore as one loud wave 5 to 15 minutes after the earthquake. The March 28 tsunami was larger at Lagundri Bay than the December 26 tsunami, which did no damage at this site. To read additional observations and reports from other sites, please visit URL **http://walrus.wr.usgs.gov/news/reports.html**.

The survey team consists of 5 Indonesian scientists and 12 U.S. scientists, including 6 from the USGS: **Bruce Jaffe** and **Bob Peters** (both stationed in Santa Cruz, CA), **Guy Gelfenbaum** and **Peter Ruggiero** (both stationed in Menlo Park, CA), **Bob Morton** (St. Petersburg, FL), and **Etienne Kingsley** (contractor stationed in Olympia, WA). The team conducted fieldwork from March 30 to April 26 in order to:

- Determine how large a tsunami was generated by the March 28 earthquake
- Fill gaps in measurements of wave heights, inundation distances, and runup heights of the December tsunami between Lhoknga in northern Sumatra and Padang on the central west coast
- Study sediment deposited by the December and March tsunamis and by older tsunamis
- Collect nearshore bathymetric data for improved tsunami-propagation modeling
- Investigate the effectiveness of previous education and mitigation strategies
- Measure earthquake-induced subsidence and uplift along the coast
- Measure ground-water salinity in coastal aquifers

Because the December tsunami had washed out many coastal roads, the survey team chartered a boat—the 61-ft-long merchant vessel *Seimoa*, which ordinarily runs surfing charters—to transport them to field sites along the coast. The team departed from Padang at about 9:30 a.m. on March 30 (Western Indonesia Standard Time), and at the time of this writing they had visited the Batu Islands, Simuk Island, Nias Island, and Sarangbaung Island.

Visit the Web site at URL **http://walrus.wr.usgs.gov/news/reports.html** to read updated and archived accounts of the West Sumatra International Tsunami Survey Team's fieldwork, view photographs from the field, and see maps of study-site locations. Background information about the survey and survey-team members is posted at URL **http://walrus.wr.usgs.gov/news/field.html**. ☸

Sarangbaung, a small island about 20 km north of Nias Island, subsided about 1.7 m during the March 28 earthquake. USGS contractor ***Etienne Kingsley*** *(left) and Indonesian scientist* ***Gegar Prasetya*** *are standing at what was the high-tide line before the March 28 earthquake. The team's boat, the* Seimoa, *is in the background. Photograph by* ***Widjokongko****, Indonesian Tsunami Research Center/Coastal Dynamic Research Center—BPPT.*

Why Wasn't There a Larger Tsunami from the Magnitude 8.7 March 28, 2005, Sumatra Earthquake?

By Eric L. Geist

The question many people asked after the magnitude 8.7 March 28, 2005, earthquake was "Why wasn't there a tsunami?" To start with, there was a tsunami generated by this earthquake, which is clearly evident from most tide-gauge stations throughout the Indian Ocean (see compilation at University of Hawai'i Sea Level Center, URL **http://ilikai.soest.hawaii.edu/uhslc/**). For example, a tide gauge at Malé in the Republic of Maldives, south of India, recorded a tsunami about 20 cm high (from crest to trough) after the March 28 earthquake; the same site recorded a tsunami about 2 m high after the December 26, 2004, earthquake.

A damaging local tsunami was also produced by the March 28 earthquake, as indicated by reports from coastal areas near its epicenter and data collected by an international tsunami survey team that includes U.S. Geological Survey scientists (see related article, this issue, and reports from the field at URL **http://walrus.wr.usgs.gov/news/reports.html**). At the time of this writing, the exact intensity of the local tsunami generated by the March earthquake had not been determined. Gathering data to assist in that determination was one of the goals of the survey team, which spent most of April conducting fieldwork along Sumatra's west coast.

So, a more appropriate question would be "Why was the March tsunami smaller than the December tsunami?" We are learning more and more details about both the magnitude 9.0 December earthquake and the magnitude 8.7 March earthquake that will help us answer this question. Rather than thinking of fault slip during an earthquake as starting from the hypocenter—the point within the Earth where the rock begins to break—and proceeding uniformly along the fault, earthquake rupture commonly is strongly heterogeneous, with some patches of the fault rupturing more than others. A rough schematic of high-slip patches for the December (gray) and March (yellow stripes) earthquakes is shown on the map accompanying this article. The epicenters for both earthquakes are shown by stars. At present, there appear to be four primary factors about the triggering earthquakes that help explain the differences between the two tsunamis:

Regional map of the area affected by the December and March earthquakes and tsunamis. Stars indicate epicenters for both earthquakes. Ovals indicate approximate areas of energy concentration (high slip) for the two earthquakes (gray, December; yellow stripes, March). Large arrows indicate approximate directions of tsunami-wave focusing for the two events. Thick red line shows sea-floor trace of the interplate thrust fault at the Sumatra-Andaman subduction zone.

- The first factor, obviously, is that the March earthquake was smaller in magnitude than the December earthquake. The magnitude of an earthquake is a function of the rupture area and the average amount of slip throughout the rupture. The December earthquake had a higher average amount of slip and ruptured a longer segment of the interplate thrust fault than the March earthquake.
- The primary-slip patch for the December earthquake (nearest to the epicenter) occurred beneath water depths of approximately 2 to 4 km, in contrast to the primary-slip patch for the March earthquake (nearest to the epicenter), which occurred beneath the island shelf at water depths of less than 1 km. This difference in water depth over areas of greatest energy release produced a difference in amplification as the tsunami traveled from the source region toward the shore.
- In addition, the primary-slip patch for the December earthquake was closer to the sea floor ("updip" along the ruptured fault) than the primary-slip patch for the March earthquake. This factor, along with the difference in magnitude, resulted in greater vertical movement of the sea floor in December. As indicated by the finite fault models on the USGS National Earthquake Information Center's event pages for the two earth-

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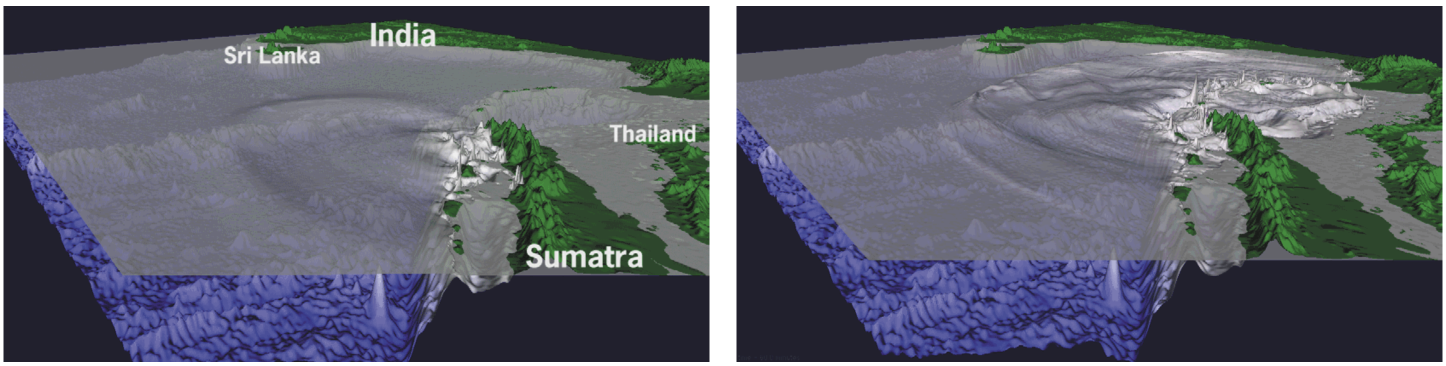
quakes (at URLs **http://earthquake.usgs.gov/eqinthenews/2004/usslav/** and **http://earthquake.usgs.gov/recenteqsww/Quakes/usweax.htm**), the peak vertical displacements of the sea floor were approximately 5 m for the December earthquake and 3 m for the March earthquake.

- Finally, there is a significant difference between the two events in the primary direction of tsunami-wave focusing, which affects the distant or "far field" impact of the tsunami. In December, the tsunami energy was focused to the west, toward Sri Lanka and India, and to the east, toward Thailand. In March, the tsunami energy was focused to the southwest, away from any nearby landmasses (excluding Sumatra itself). The island of Sumatra blocked significant wave activity toward Thailand and Malaysia (see map).

Knowledge gained from these important earthquakes will help us to provide more detailed tsunami-propagation simulations. Furthermore, analysis of these two earthquakes and comparison with historical earthquakes of similar magnitude (M>8.5) will allow us to better forecast future variations in tsunami runup. This improved understanding will greatly aid global efforts to provide accurate tsunami warnings and hazard assessments. The ultimate goal is to save lives and reduce property damage from future tsunami disasters.



Snapshots of computer animations of the March 28 tsunami (left) and the December 26 tsunami (right) 60 minutes after the earthquakes that generated them. Views northwestward. In the March 28 snapshot, Nias is the farthest visible island to the north. The Banyak Islands and Simeulue, north and northwest of Nias, respectively, are hidden by the waves. Both topography and wave heights are vertically exaggerated (at different scales).

Assessing Tsunami Impacts in the Republic of Maldives

By Bruce Richmond and Helen Gibbons

U.S. Geological Survey (USGS) scientist **Bruce Richmond** returned in early March from a two-week trip to examine the impacts of the December 26 tsunami on the low-lying atolls of the Republic of Maldives in the Indian Ocean. The country consists of 1,190 islands grouped in 26 atolls that stretch more than 800 km from north to south, crossing the equator at their south end. Although the archipelago is about 2,500 km from the epicenter of the earthquake that triggered the tsunami, its average elevation of only 1.5 m left it exposed to the tsunami waves, which swept completely across many of the islands. The Maldives was the only country where the effects of the tsunami were felt across the entire country, rather than in certain parts or regions. Total damage estimates are about $470 million. Approximately 100,000 people, or a third of the popula-

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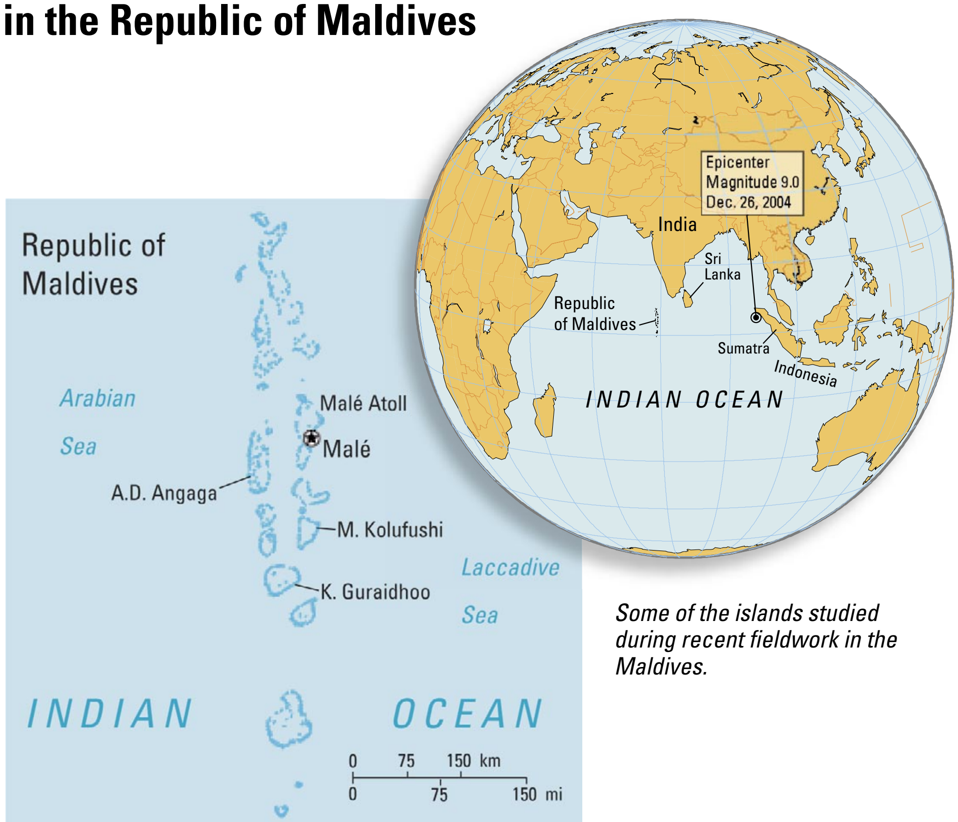

Some of the islands studied during recent fieldwork in the Maldives.

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tion of nearly 300,000, have been severely affected, with approximately 12,000 displaced and 8,500 in temporary shelters. About a quarter of the nearly 200 inhabited islands in the archipelago were severely damaged, and 10 percent were made uninhabitable. At the time of this writing, more than 80 people have been reported dead, and 26 are missing. The tsunami occurred during daylight hours near low tide, two factors that probably helped keep the death toll relatively low.

The recent field study was undertaken at the request of the Maldive government's Ministry of Environment and Construction (MEC) and funded by the U.S. Agency for International Development (USAID)'s Office of Foreign Disaster Assistance. **Richmond**, a coastal geologist from the USGS Pacific Science Center in Santa Cruz, CA, was part of a United Nations Environment Programme (UNEP) Rapid Assessment Team that included experts in waste management, ground water, soils, biodiversity, sanitation, construction, and agriculture. The outside experts were joined by local counterparts from various Maldive government ministries who assisted with data collection and interpretation. The team visited 17 islands on 7 atolls over a 10-day period.

Assessment-team members representing the United Nations Environment Programme (UNEP), the Maldive government's Ministry of Environment and Construction (MEC), the Maldives Water and Sanitation Authority (MWSA), and the USGS pose for a group photo at Angaga Island Resort. Left to right, ***Lubna Moosa*** *(MEC),* ***Ahmed Shain Haleem*** *(MEC),* ***Mijke Hertoghs*** *(UNEP),* ***Dennis Bruhn*** *(UNEP),* ***Ewald Spitaler*** *(UNEP),* ***Mohamed Musthafa*** *(MWSA),* ***Bruce Richmond*** *(USGS),* ***Nick Brown*** *(UNEP),* ***Hussain Neesham*** *(MEC),* ***Jon Godson*** *(UNEP), and* ***Mohamed Zuhair*** *(MEC).*

The islands of the Maldives are Holocene features that began forming 3,000 to 5,500 years ago. They are composed primarily of carbonate sediment derived from coral reefs and deposited by waves and currents. The submerged mountain chain on which the coral reefs are built has been in existence for millions of years, whereas the islands are some of the youngest land surfaces on Earth. Because they are largely unconsolidated, the islands should be considered ephemeral features over geologic time scales, and their low elevation makes them particularly vulnerable to storms and changes in sea level.

Tsunami water levels measured by the assessment team reached a maximum of 3.25 m; most measurements ranged from 2.0 to 2.6 m. The tsunami wave heights typically decreased from east to west as the waves traveled across the islands. Eyewitnesses on many islands reported tsunami waves approaching from the west. This phenomenon is believed to be a result of the tsunami refracting around the ends of the individual islands. The tsunami's extent ranged from complete island overwash to inundation around island margins. Wave effects were most pronounced on eastern shores, but flooding was widespread among the islands.

Remains of a house on M. Kolufushi. Unreinforced structures were heavily damaged during passage of the tsunami.

Alteration of coastal landforms by the tsunami was greatest among islands situated close to the eastern reef rim facing the direction of tsunami approach. Beach erosion was widespread and characterized by the formation of erosional scarps, typically 0.3 to 0.5 m high. Where the eastern beaches consist of mostly gravel-size reef debris, material was deposited as sheets, 10 to 20 m wide and 10 to 20 cm deep, landward of the berm. On islands that were overwashed, prominent scarps formed along western sandy shorelines, and the eroded sediment was deposited westward into adjacent reef-flat and lagoon areas. Changes to island interiors were generally limited to local scour around obstacles, such as buildings, and thin, patchy sediment deposits.

Parameters that appear to be controlling factors in local variations in the tsunami's impacts include the following:

1. Width of the reef flat: wider reef flats dissipated more wave energy and therefore offered more protection to the coast.

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2. Height of the beach berm: higher berms provided a physical barrier to overtopping by tsunami waves; berms in the Maldives commonly range from 1 to 2 m in height.
3. Orientation to tsunami approach: islands parallel to the approaching wave fronts suffered more damage.

Although offshore bathymetry appears to have influenced the characteristics of the tsunami as it approached land, bathymetric information from the Maldives is so scanty that its effects are difficult to quantify.

The tsunami was described by many eyewitnesses as multiple waves (generally three) about 20 seconds to minutes apart. Each succeeding wave was higher than the previous wave, with insufficient time for water to recede before the next wave hit. Tidal records, however, show that the main tsunami waves were about 20 minutes apart. What the eyewitnesses were observing was the evolution of a single wave into multiple bores, called undulatory bores and (or) solitons, as the tsunami passed from deep water to shallow water over the reefs.

There were many reports of freshwater flowing out of wells and from the ground immediately before the tsunami's arrival. In many places, house floors were buckled upward by the pressure. These occurrences suggest high permeability of the subsurface and a direct connection between ground water and the surrounding seawater.

Some eyewitnesses took photographs of water spouts occurring exactly at the same time as the tsunami struck. This phenomenon is unusual because water spouts typically do not occur near the equator.

As in other countries hit hard by the tsunami, human activities made some of the tsunami's impacts more severe. For example, dredging of sand and gravel from reef areas—a widespread practice in the Maldives that supplies needed construction materials—appears to have caused long-term erosion at the north end of the Maldive island of K. Guraidhoo. The tsunami accelerated this erosion, resulting in the undermining and collapse of several coastal structures. The assessment team observed at numerous sites that natural shorelines and land surfaces, either on uninhabited islands or in natural areas of inhabited islands, were much less damaged than developed areas.

The impact of the tsunami serves as an indicator of the vulnerability of the Maldives to external forces of nature. The tsunami provides an opportunity to better educate the people, to establish guidelines for human activities—such as dredging and construction—near the shoreline, and to develop plans for future disaster mitigation. ☸

Women on the lagoon-side reef flat of M. Kolufushi, an island that was severely affected by the tsunami. Trees and appliances (in the background) were washed from the island to the reefs.

Oblique aerial view of Malé, the capital of the Maldives. The island city, struck by the tsunami about 3 hours and 18 minutes after the earthquake, escaped serious wave damage and was primarily affected by widespread flooding.

Making Waves and Ripples in a Giant Flume in Japan

By Jessie Lacy

Sand on the sea floor is rarely flat, particularly close to the shore. Currents and waves interact with bed sediment to produce bedforms: ripples, dunes, and more complex structures. The type and shape of bedforms strongly influence the processes that cause sediment to be resuspended, or lifted from the sea floor. For this reason, prediction of bedform morphology is an important component of modeling the transport of sediment by water currents.

Bedform morphology (size, type, and orientation) is influenced by grain size, current speed, wave energy, and the angle between waves and currents. Whereas bedforms produced by currents or waves alone are fairly well understood from field and laboratory observations, bedforms produced by a combination of waves and currents have proved more difficult to study. Laboratory studies of combined waves and currents have dealt almost exclusively with waves and currents traveling in the same direction, because of the difficulty of generating waves transverse to the current flowing down a laboratory flume. In contrast, a wide range of angles between waves and currents occurs in nature—for example, waves close to shore are typically almost perpendicular to the longshore current.

In January, U.S. Geological Survey (USGS) scientists **Dave Rubin** and **Jessie Lacy** traveled to Japan to investigate ripples produced by a combination of waves and currents at varying angles in a giant flume at the University of Tsukuba, about 60 km northeast of Tokyo. The research in Japan, which is part of the USGS Coastal Evolution Modeling project, is supported by a grant from the Office of Naval Research to **Dan Hanes** and **Dave** to investigate ripple morphology and evolution (see *Sound Waves* article “Ripples for Everyone! Investigating How Sediment Moves on the Sea Floor” at URL **http://soundwaves.usgs.gov/2005/01/fieldwork5.html**).

(Left to right) ***Ikeda-san***, ***Yuhora-san***, *and* ***Mokudai-san*** *supporting a temporary barrier around the tray to prevent erosion of the sand on the tray while the flume is filling.*

Dave *and* ***Ikeda-san*** *outside the giant flume.*

To produce combined flows of waves and currents at varying angles, we planned to propel a large (2-m diameter) sand-covered tray back and forth across the floor of a wide flume, under water. Movement of the tray back and forth produces flow relative to the sand bed that mimics wave motion. By varying the current speed, the period and length of the tray oscillations, and the angle of the oscillations relative to the direction of the current down the flume, we could create a wide range of wave-current combinations. We designed a frame attached to the tray to hold instruments to measure water velocities above the sand bed and to monitor the evolution of bedforms. This approach requires a flume that is wide enough for the tray to move side-to-side at realistic wave velocities. At 160 m long by 4 m wide, the giant flume in Tsukuba is one of the few flumes in the world large enough for our experiment.

Kevin O’Toole manufactured the oscillating tray at the USGS Marine Facility (MarFac) in Redwood City, CA. He mounted the 2-m-diameter circular tray on 20 rollerblade wheels and designed and assembled a motor system to drive it. Not only did the system have to move the tray loaded with 10 cm of sand through water over a rough bottom, but it had to do so at various angles to the flow. The motor speed was controlled by a laptop computer; our code allowed us to specify the period and length of the oscillations, so that we could simulate a range of wave conditions. We conducted initial testing and debugging at MarFac and then shipped the tray, motor, and drive system to Japan.

Our host in Japan was **Dave’s** longtime collaborator **Hiroshi Ikeda**, professor of fluvial geomorphology at the University of Tsukuba. **Ikeda**, his research associate **Kuniyasu Mokudai**, and technicians **Hideo Iijima** and **Kazuhiro Yuhora** worked with us throughout our three weeks in Tsukuba; their participation was critical to the success of the project.

The first task in Tsukuba was to install the oscillating tray system in the flume and

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(Left to right) ***Iijima-san***, ***Mokudai-san***, ***Yuhora-san***, *and* ***Jessie*** *preparing for the next experiment.*

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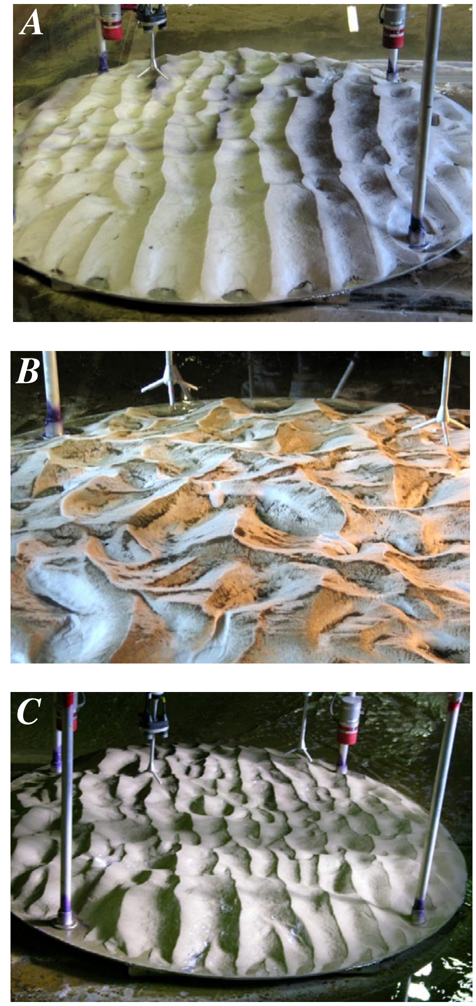
complete testing of the computer code. Since each experiment would consist of several hundred oscillations, the position of the tray had to be controlled quite precisely to prevent it from migrating toward (and crashing into) the side of the flume. We were dismayed to find that the floor of the flume was not smooth steel but was pitted with rust and embedded gravel, which made the tray motion quite bumpy. On the positive side, the tray and motor system worked beautifully. After a few initial crashes, more than a few code modifications, and a couple of sessions scraping the floor of the flume, we were ready to start the experiments.

We completed 18 experiments with different combinations of waves and currents at angles of 90°, 60°, and 45°. During the experiments, two rotating imaging sonars mounted on the instrument frame recorded bedform evolution. Acoustic Doppler velocimeters measured water speed and direction at two heights above the bed, and an acoustic backscatter sensor measured vertical profiles of suspended-sediment concentration. After each experiment, we drained the flume to measure the wavelength, height, and orientation of the bedforms and to take photographs. The experiments produced a wide range of bedforms, from linear wave ripples to more chaotic patterns, with ripple heights from 1 to 5 cm and wavelengths from 6 cm to more than 25 cm.

Fortunately, our long hours in the lab left us some time to appreciate Japan. In the evenings, **Jessie**, **Dave**, and **Dave's** wife **Michelle Rubin** sampled delicious and varied cuisine, after negotiating menus in Japanese with a combination of pointing and a smattering of phrasebook Japanese and the help of very patient waiters. Each Saturday, **Ikeda** took us on an excursion to see the lakes, rivers, coast, and geology of the region, as well as local villages and temples. Every day we enjoyed the company of our Japanese colleagues, who served us green tea, answered our questions about Japanese language and culture, and always made us feel welcome. ❆

Seafood ramen in Tsukuba.



*Bedforms produced by three experiments. A video clip of the experiment that produced the bedforms shown in the third photograph, labeled "C," is available at URL **http://soundwaves.usgs.gov/2005/04/research.html**.*

Recovery from Wildfire Is Slow for Point Reyes Mountain Beaver

By Gary M. Fellers, David Pratt, and Jennifer L. Griffin

In October 1995, a 12,000-acre wildlands fire on the Point Reyes peninsula in northern California burned 40 percent of the known range of the Point Reyes mountain beaver *(Aplodontia rufa phaea)*, including most of what was believed to be prime habitat. The fire burned through thickets and revealed thousands of mountain-beaver burrow openings. This exposure enabled researchers to assess the pre-fire distribution and population size of mountain beavers within the burned area and to evaluate their survival and recovery. U.S. Geological Survey (USGS) scientist **Gary M. Fellers** and collaborators

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*Plume of smoke over Inverness Ridge (Point Reyes National Seashore) the day a 12,000-acre wildlands fire broke out, October 3, 1995. That day, 45 homes burned, and the fire moved into Point Reyes National Seashore, where it destroyed extensive mountain-beaver habitat. Photograph by **Gary Fellers**.*

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David Pratt (National Park Service) and **Jennifer L. Griffin** (consultant) recently published their findings about the fire's effects on mountain beavers in the *Journal of Wildlife Management.*

Mountain beavers are not true beavers but rather muskrat-size animals that live in underground burrows dug in forest openings and dense thickets. Sedentary, primitive rodents with a 5- to 6-year lifespan, mountain beavers mature in their second year and then produce two to three young each spring. Because they have primitive, inefficient kidneys, their water requirements are unusually high: they must drink a third of their body weight daily. Mountain beavers feed on various plants, including nettles, blackberry, poison oak, and coyote brush. In California, two small, geographically isolated, distinct subspecies live along the coast: the Point Reyes population and the endangered Point Arena population. More extensive populations live in the Sierra Nevada and in the Pacific Northwest.

Systematic surveys of mountain-beaver habitat at Point Reyes National Seashore had been conducted before the 1995 fire, from 1984 to 1994, and the presence of mountain beavers had been confirmed, but population size could not be determined because dense vegetation hid the burrow openings.

In the first six months after the 1995 fire, researchers surveyed burned coastal scrub to count and map burrow openings. They estimated that 5,000 mountain beavers had occupied the areas before the fire. The presence of fresh dirt outside burrow openings and photographs from remotely triggered cameras documented 19 mountain beavers that had survived the fire and the immediate post-fire period. This number represented less than 2 percent of the original population. Activity was monitored for 5 years at eight sites where mountain beavers had survived the fire and at three sites where there were no survivors. The researchers found recovery at some of the eight sites and found migration into only one of the three sites where fire had eliminated the original population. They estimate that recovery may take 15 to 20 years.

In their recent article in the *Journal of Wildlife Management* (v. 68, no. 3, p. 503-508), the researchers suggest that the slow recovery may be caused by shifts in plant-species composition and in the physical structure of thickets. Limited dispersal of mountain beavers between suitable sites may also retard recovery. As the vegetation becomes more suitable, an increase in mountain beavers likely will occur as a result of population growth and immigration from outside the burned area.

The scientists' findings have several implications for the management of mountain beaver habitat:

- Intense fires have a strong negative impact on mountain beavers and can cause local extirpations; small, isolated populations are especially vulnerable.
- Recovery can be slowed by unfavorable shifts in plant-species composition, the physical structure of thickets, and low rate of immigration by mountain beavers.
- Although periodic small fires allow for normal changes in mountain-beaver habitat, large fires should not be allowed to burn substantial parts of areas known to be occupied by mountain beavers.

*Mountain beaver captured on video (clip can be viewed at URL **http://www.werc.usgs.gov/pt-reyes/movies/**). Scientists will use the video footage, obtained with cameras triggered by infrared sensors, to learn more about the behavior of this nocturnal creature, which is almost never seen.*

*Mountain-beaver burrows are about 4 inches in diameter. Each burrow system is occupied by a single individual and has 6 to 12 openings at the surface. Photograph by **Gary Fellers**.*

The full citation of the researchers' paper is:

Fellers, G.M., Pratt, David, and Griffin, J.L., 2004, Fire effects on the Point Reyes mountain beaver (*Aplodontia rufa phaea*) at Point Reyes National Seashore: Journal of Wildlife Management, v. 68, no. 3, p. 503–508.❁

Outreach

USGS Researcher Shares Coral-Reef Expertise with National Park Service

By Ann B. Tihansky

On February 23, **Robert Halley** of the U.S. Geological Survey (USGS) Center for Coastal and Watershed Studies in St. Petersburg, FL, was invited to present his talk "Causes of Coral-Reef Ecosystem Decline: Hurricanes, Land-Based Pollutants, and Climate Change" to the staff of Biscayne National Park in Miami, FL. Park Superintendent **Linda Canzanelli** had heard **Bob's** talk (geared to a broad audience, not just scientists) at the U.S. Coral Reef Task Force meeting in Miami earlier this year and requested that he make a presentation to her staff. The presentation was open to the public and videotaped by the National Park Service. Approximately 40 people attended.❁

Growing Oyster Habitat in Tampa Bay

By Ann B. Tihansky

The U.S. Geological Survey (USGS) participated in oyster-habitat restoration in Tampa Bay, FL, on March 4 and 5. The nonprofit group Tampa Bay Watch organized the event in cooperation with the U.S. Fish and Wildlife Service. More than 30 volunteers worked each day along with folks from Tampa Bay Watch, the U.S. Fish and Wildlife Service, and the USGS. The project targeted restoration efforts along the north end of Tarpon Key, an island that is part of Pinellas National Wildlife Refuge—one of several refuges that encompass islands in the bay.

More than 17 tons of fossilized shell material was bagged into individual mesh bags weighing about 30 lb apiece. The bags were then transported to the intertidal zone, where they were placed to serve as substrate for the upcoming oyster-spawning season. In addition to providing substrate for new oyster colonies, the shell material will help stabilize sediment and provide additional habitat for many other marine species.

An invaluable asset to the project was the USGS platform barge, one of two USGS boats designed to provide wide, stable, shallow-draft working platforms for many uses, including drilling wells for lithologic and hydrologic sampling in offshore areas. It was the perfect vessel for hauling large amounts of shell, moving it into shallow marine areas, and providing easy access for the “bucket brigade” that transferred shell bags from boat to shore. Because the barge was so well suited for this work, the USGS will probably participate in similar future events. Participants from the USGS Center for Coastal and Watershed Studies in St. Petersburg, FL, included boat captains **Gary Hill**, **Keith Ludwig**, and **Nancy Dewitt**, as well as the all-important shell baggers and movers: **Martha Loyd**, **Jolene Shirley**, **Molly McLaughlin**, and **Ann Tihansky**. ☸

***Nancy Dewitt** loads mesh bags of shell material onto the barge for transport to the island.*

The barge transports a full load, more than 75 shell bags weighing approximately 30 lb each, with an eager crowd of shell-bag movers.

*Shell is shoveled into a section of polyvinyl chloride (PVC) pipe that funnels shell material into a plastic mesh bag. **Jolene Shirley** holds a pipe and mesh bag in place while **Molly McLaughlin** shovels the shell material. (See video clip at URL **http://soundwaves.usgs.gov/2005/04/outreach.html**.)*

The shell bags are unloaded by a bucket brigade and placed in shallow water at the north end of Tarpon Key in Tampa Bay.

USGS Participates in CORE's National Ocean Sciences "Spoonbill" Bowl

By Ann B. Tihansky

USGS participants (standing, left to right) ***Lauren Yeager*****,** ***Jack Kindinger*****,** ***Wayne Baldwin*****,** ***Justin Krebs*****,** ***Jim Flocks*****,** ***Don Hickey*****,** ***Marci Marot****, and (kneeling, left to right)* ***Noreen Buster*** *and* ***Ann Tihansky*** *served as science judges, science experts, runners, timekeepers, and scorekeepers at this year's Spoonbill Bowl.*

The Spoonbill Bowl is a regional-level competition challenging high-school students to compete against other schools, using their knowledge of ocean science. It is part of the National Ocean Sciences Bowl®, created by the Consortium for Oceanographic Research and Education (CORE) to raise students' awareness and understanding of the Earth's ocean systems (see URL **http://www.nosb.org/** and related article in Staff and Center News, this issue). This year is the first time this academic competition has been held in St. Petersburg, FL. The local Spoonbill Bowl was held at the University of South Florida (USF)'s College of Marine Science and the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute in St. Petersburg. Local sponsors included the USF College of Marine Science, the Florida Fish and Wildlife Conservation Commission, the U.S. Geological Survey (USGS), the Florida Aquarium, the Pier Aquarium, and Mote Marine Laboratory. All of these sponsors donated educational materials, facilities, and volunteers to staff the event.

Edith Widder, a researcher with Harbor Branch Oceanographic Institution, kicked off the event on February 12 with a keynote address—a visually exciting talk about bioluminescence and her latest research in identifying and quantifying bioluminescent organisms in our oceans. Her program included incredible video footage of deep-marine organisms using bioluminescence to attract mates, sound alarms, and identify one another in the dark, deep ocean.

The 11 teams from various parts of Florida challenged each other's knowledge of ocean science with questions spanning a range of scientific fields, including biology, geology, chemistry, and physical oceanography. Nine USGS participants—**Lauren Yeager**, **Jack Kindinger**, **Wayne Baldwin**, **Justin Krebs**, **Jim Flocks**, **Don Hickey**, **Marci Marot**, **Noreen Buster**, and **Ann Tihansky**—served in this event as science judges, science experts, runners, timekeepers, and scorekeepers. The final four teams were Lake Brantley High School of Altamonte Springs, Durant High School of Plant City, Mitchell High School of New Port Richey, and Seminole High School of Seminole. Lake Brantley and Durant competed for third place, with Lake Brantley winning. Seminole and Mitchell went head to head for first and second places. It was a close match, with Mitchell ahead 48 to 45 in the last few seconds when a contested Seminole team answer for four points was judged favorably by USGS science expert **Don Hickey**, putting Seminole ahead for the win by one point (48 to 49). It was a very exciting day. Seminole High School will advance to Biloxi, MS, for the final national championship competition in April.

CORE's 2005 National Ocean Sciences Bowl® (NOSB®) nationwide competition is supported by U.S. Government agencies through the National Oceanographic Partnership Program (NOPP); these sponsors include the National Science Foundation (NSF), the U.S. Navy Office of Naval Research (ONR), the National Aeronautics and Space Administration (NASA), the USGS, the U.S. Minerals Management Service (MMS), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy (DOE), the National Oceanic and Atmospheric Administration (NOAA), and the Oceanographer of the Navy. Several nongovernmental organizations also sponsor the NOSB®, including the Ocean Conservancy, the Sea Education Association, the Marine Technology Society, the Wrigley Institute for Environmental Studies at the University of South Carolina, the National Marine Educators Association, the Bermuda Biological Station for Research, Inc., the Oceanic Engineering Society, Dolphin Quest, and the Hilton Waikoloa Village. ☸

Students from Lake Brantley High School of Altamonte Springs (team on left) consult with one another during their match against Durant High School of Plant City (team on right).

USGS Researcher Interviewed About Upcoming 2005 Hurricane Predictions

By Ann B. Tihansky

Brian Bossak, a Mendenhall Postdoctoral Research Fellow at the U.S. Geological Survey (USGS) Center for Coastal and Watershed Studies in St. Petersburg, FL, was interviewed by the *Palm Beach Post* in response to his article in the December 14, 2004, issue of *Eos* (*Transactions of the American Geophysical Union*) (see "USGS Scientist Studies Causes of Anomalous U.S. Hurricane Landfall Count in 2004" in *Sound Waves*, February 2005, at URL **http://soundwaves.usgs.gov/2005/02/research4.html**).

Brian's article analyzed 2004 North Atlantic hurricane activity and related the high count of hurricane landfalls along the southeast U.S. coastline to climate features that influence the track and intensification of Atlantic hurricanes. The *Post* interviewed **Brian** regarding the extremely active 2004 Atlantic hurricane season and implications for what the upcoming 2005 hurricane season will bring to Florida.

"Even 2004 was nothing special in the number of hurricanes spawned," said **Brian**. "What was strange was that so many of the storms were major—and, of course, that so many came whirling our way. You have to have so many conditions to be perfect to see another season like last year's. Even if one condition was conducive to a repeat, everything else might not be."

The *Post* article was published on February 21, 2005, and is available for a fee from URL **http://www.palmbeachpost.com/archives/content/archives/**. The article that **Brian** sent to *Eos* can be downloaded from URL **http://soundwaves.usgs.gov/2005/04/outreach3.html**.

In addition to preparing publications relating Atlantic hurricanes and climate features, **Brian** continues research on the development of the Coastal Impact Assessment Tool (CIAT). The CIAT is planned for use in hindcasting of historical storm impacts and experimental prediction of future impacts from coastal storms. ❁

Meetings

Integrating Science and the Scientific Community at the Tampa Bay Study's 4th Annual Science Conference

By Ann B. Tihansky

The U.S. Geological Survey (USGS) Tampa Bay Study, part of the USGS Gulf of Mexico Integrated Science project and a template for other integrated research studies in coastal ecosystems around the Nation, hosted its fourth annual science conference in Gulfport, FL, on February 8 and 9. Major topics included modeling plans and baseline mapping, water and sediment quality and quantity, ecology, model products and data management, and products and end-user examples. The sessions alternated between formal presentations and interactive poster sessions.

Participants had opportunities to meet with colleagues and discuss their work one on one. ***Victor Levesque*** *(left) of the USGS Florida Integrated Science Center speaks with* ***Roger Johansson*** *(right) of the City of Tampa's Bay Study Group.*

Integrating science also means integrating participants. The conference included USGS attendees from all four of the agency's disciplines—Geography, Biology, Water Resources, and Geology—as well as participants from other Federal agencies, including the U.S. Environmental Protection Agency, the National Oceanic and Atmospheric Administration, the National Park Service, and the Tampa Bay National Estuary Program and its partners. Additionally, participants came from State governmental agencies, including the Fish and Wildlife Research Institute, the Florida Department of Environmental Protection, and the Southwest Florida Water Management District. Various other participants represented academic institutions and local county and city governments and consulting firms, including the Hillsborough County Environmental Protection Commission, the University of South Florida (Biology Department, Geology Department, and College of Marine Science), the University of Louisiana at Lafayette, Eckerd College, the University of New Hampshire, the City of Tampa's Bay Study Group, the Pinellas County Department of Environmental Management, the Pinellas County Health Department, Mote Marine Laboratory, Pickett & Associates, Inc., WL Delft Hydraulics, Applied Science Associates, Inc., Johnson Controls, Inc., and DHI Water & Environment. This year the conference was attended by an outside review committee that included **Fred Short** (University of New Hampshire), **Chris Mooers** (University of Miami's Rosenstiel School of Marine and Atmospheric Science), and **Jim Cloern** (USGS National Research Program, Menlo Park, CA). More information about the study and the conference is posted at URL **http://gulfsci.usgs.gov/tampabay/**. ❁

Coral-Reef Researcher Wins Prestigious Award

By Ann B. Tihansky

U.S. Geological Survey (USGS) scientist **Caroline S. Rogers** received a U.S. Coral Reef Task Force Award for Outstanding Scientific Advancement of Knowledge on Coral Reefs. The award reflects her significant contributions to coral-reef science, the National Park Service, the USGS, and the broader community of coral-reef scientists and managers.

Caroline's work has led to the development of monitoring protocols used on coral reefs around the world. Her research and monitoring efforts and her collaboration with others in academia as well as in Federal and territorial agencies have improved the management of Virgin Islands National Park and Buck Island Reef National Monument and given these parks some of the longest and most comprehensive data sets on coral reefs, reef fishes, and water quality in the western Atlantic.

The award was presented in Washington, DC, on March 3 at the 13th meeting of the U.S. Coral Reef Task Force. **Caroline** was surprised by the honor and readily shared it with her colleagues. "Thank you so very much for selecting me for this award. What a wonderful surprise! It really is for several people, not just one. During the course of my career, I have been very fortunate to work with many incredibly dedicated people who share my passion for coral reefs. This award recognizes the work of many people, including colleagues at the University of Hawai'i and the University of the Virgin Islands, as well as those from other Federal agencies, such as the National Park Service and the National Oceanic and Atmospheric Administration."

***Caroline Rogers** took this photograph of a white-spotted filefish surrounded by sea fans near Waterlemon Cay in Virgin Islands National Park, one of the areas that has benefited from her coral-reef research.*

New Nematode Named After USGS Scientist

What's in a name? In 1991, **Robert N. Fisher**, now a research zoologist with the U.S. Geological Survey (USGS), visited the Palau Islands, Republic of Palau, as a graduate student conducting his Ph.D. research in population biology. During a routine examination for parasites in Palau wrinkled ground frogs (*Platymantis pelewensis*), a species endemic to the islands, he found an intestinal parasite new to science. He has been recognized in the naming of the new parasitic worm—*Spinicauda fisheri*—by colleagues **Charles R. Bursey** from the Pennsylvania State University and **Stephen R. Goldberg** from Whittier College, who described the new species in a recent issue of the *Journal of Parasitology* (v. 90, no. 6, p. 1428–1433).

S. fisheri is the 12th species in the *Spinicauda* genus of nematodes, and the first from Oceania. *Spinicauda* means "spiny tailed." Nematodes in this genus have a tail that ends in a filament with tiny paired hairlike bristles. *S. fisheri* has five such spiny pairings, which distinguish it from the nearest species, with 12 pairs.

*Palau wrinkled ground frog (*Platymantis pelewensis*), host of a new species of nematode,* Spinicauda fisheri*, named for USGS research zoologist **Robert N. Fisher**, who discovered the nematode when he was a graduate student at the University of California, Davis. Photograph copyright © 2004 **Chris Austin**; used with permission. (View this and other frog photos on AmphibiaWeb, at URL **http://www.amphibiaweb.org/**.)*

Fisher joined the USGS in 1998 at the Western Ecological Research Center (WERC)'s San Diego Field Station. He traveled to the Palau Islands as part of his ongoing study of the historical biogeography of the Pacific Basin islands, how different species were able to move to these islands, and the role the first humans to the region had in moving these species around. On November 10-11, 2004, **Fisher** and USGS scientist **Stacie Hathaway** (also from WERC) participated in an international workshop held at the University of the South Pacific in Fiji to help develop a comprehensive conservation plan for Fiji's native iguanas. For additional information about **Fisher** and his research, visit URL **http://www.werc.usgs.gov/sandiego/fisher.asp.**

USGS Biologist Recognized by National Park Service

U.S. Geological Survey (USGS) research biologist **Gary M. Fellers** of the Western Ecological Research Center is the recipient of the 2004 Natural Resource Research Award from the Pacific West Region (PWR) of the National Park Service (NPS). NPS PWR regional director **Jonathan B. Jarvis** announced the winners of the 2004 PWR Natural Resource Stewardship and Science Awards on February 22, 2005. Recipients of these awards are recognized for their significant contributions to improving management and knowledge of park resources.

Fellers is stationed at Point Reyes National Seashore, and his research efforts and assistance have helped managers at this and other national-park areas. **Fellers** is cited in his nomination as "one of the primary and preeminent researchers of NPS in the Pacific West Region over the past 20 years." Many of his studies in the 1980s and early 1990s "were seminal and form the foundation for subsequent work in the Inventory and Monitoring Program that is currently funded under the Natural Resource Challenge Initiative." The scope of his work at Point Reyes "covers a broad range of issues/conflicts, including cattle grazing; many threatened, endangered, and sensitive species; wildfire and prescribed fire; and many invasive non-indigenous plants and animals." **Fellers** was cited for consistently providing assistance to managers throughout a career spanning major organizational changes, during which he served first as a researcher in the NPS, then in the National Biological Service, and finally in the Biological Resources Discipline of the USGS.

Examples of how **Fellers'** research has significantly contributed to a better understanding of natural resources include his research of the Point Reyes mountain beaver, which formed the basis of a protection program at Point Reyes National Seashore after a 12,000-acre wildland fire in 1995 burned 40 percent of the known range of this isolated subspecies (see related article in Research section, this issue). His radio tracking of red-legged frogs at Point Reyes revealed that they travel overland from breeding ponds to streams, where they overwinter, bringing to light the importance of preserving stream habitats as well as ponds for these frogs. His amphibian work in collaboration with others has documented amphibian declines in the Sierra Nevada and the Cascade Range and has identified causes for these declines. Innovative methods for sampling, which he sought out or developed, have become standard in parks. One example is the detection of bats by their vocalizations rather than by the older method of mist-netting and handling individuals (visit URL **http://www.werc.usgs.gov/bats/batstudiesnorth.html** for more information about this technique and to hear sample vocalizations).

*USGS research biologist **Gary Fellers** conducting amphibian fieldwork in Yosemite National Park. Photograph by **Mark Crosse**,* Fresno Bee.

Additional information about **Fellers** and his research is posted at URL **http://www.werc.usgs.gov/pt-reyes/fellers.asp**. ❅

Staff and Center News

Getting to the CORE of Ocean Sciences—Admiral West Discusses Pew Oceans Commission Report at USGS Office in St. Petersburg, FL

By Ann B. Tihansky

Rear Admiral **Richard D. West**, U.S. Navy (retired), visited the U.S. Geological Survey (USGS) Center for Coastal and Watershed Studies in St. Petersburg, FL, on January 25. He is currently the president and chief executive officer of the Consortium for Oceanographic Research and Education (CORE). His seminar, titled "A View of the Oceans—the View from Washington, DC," discussed the importance of the Pew Oceans Commission report and its recommendations for future Federal investments in marine research, technology, and education. The report suggests a whole-ocean approach to marine policy, based on sound science and a strengthened scientific infrastructure, to sustain the oceans and their valuable resources for future generations. The Pew Oceans Commission report, "America's Living Oceans: Charting a Course for Sea Change" (available from URL **http://www.pewoceans.org/**), indicates that the health of the world's oceans and coastal regions is at risk. **Admiral West** highlighted efforts that CORE is making to raise awareness of how important the health of our oceans and coastal waters is to the future of our country. An example of these efforts is the National Ocean Sciences Bowl® (NOSB®), a national academic-competition program created by CORE to raise interest, understanding, and awareness in students about the Earth's ocean systems. As **Admiral West** said, "a scientifically literate and engaged public will be able to move forward with renewed vision for our oceans." On February 12, the USGS supported CORE and **Admiral West's** mission by participating in the Spoonbill Bowl, a regional-level competition within CORE's National Ocean Sciences Bowl® (see related story in Outreach section, this issue). ❅

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