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Coastal Science and Research News from Across the USGS

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Fieldwork

Storm Impact, Sea-Floor Change, and Barrier-Island Evolution: Scientists Map the Sea Floor and Stratigraphy Around Ship and Horn Islands, Northern Gulf of Mexico

By Jim Flocks and Emily Klipp

Gulf Islands National Seashore is a series of barrier islands that stretch from Florida to Louisiana. The white sandy beaches of the barrier-island chain make up the longest national seashore in the United States, and a unique variety of vegetation—including dune grasses, marshes, and forests—provides habitat for migratory birds and endangered mammals. More than 80 percent of the Gulf Islands National Seashore's resources are submerged; these include inlets, lagoons, and more than 20 km^2 of seagrass habitat. The seagrass beds are in a state of decline, and the islands' land areas have been severely affected over the past century by storms, sea-level rise, and human alteration. Heavy damage was inflicted in 2005 by Hurricane Katrina, which made landfall as a category 3 storm and battered the islands with winds of more than 160 km/h (100 mph) and a storm surge of 9 m (30 ft).

Gulf Islands National Seashore (GUIS), managed by the National Park Service (NPS), is a series of barrier islands that extend from the Florida panhandle to Mississippi. The U.S. Geological Survey (USGS) is collaborating with the NPS to map the islands' geology, morphology, and habitat to better understand their evolution, stability, and fate.

Ship Island before (top) and after (below) Hurricane Katrina. Storm surge submerged the island and severely widened the breach between East and West Ship Islands—a recurring feature that was named "Camille Cut" after being widened in 1969 by Hurricane Camille.

Coastal processes such as storms affect the islands in many ways. A 2007 report by U.S. Geological Survey (USGS) geologist **Bob Morton** (URL **http://pubs.usgs.gov/of/2007/1161/**) shows that the islands off Mississippi are undergoing rapid land loss and translocation at widely different rates. The study estimates that since the mid-1800s, Horn Island has lost 24 percent of its land area, while neighboring Ship Island has lost a staggering 64 percent. The National Park Service, which manages Gulf Islands National Seashore, has made it a priority to characterize this change through a comprehensive program of elevation and habitat mapping. The USGS has collaborated on these efforts by using airborne lidar (light detection and ranging) data and aerial photographs to construct coastal classification maps. In addition, the USGS is investigating the geology and morphology of this coastal environment through the Northern Gulf of Mexico Ecosystem Change and Hazard Susceptibility Project (URL **http://ngom.er.usgs.gov/**). One task of this project is to identify the influence of the geologic framework—for example, variations in underlying sediment composition—on the observed variability in land-loss and breach locations. As an example, Ship and Horn Islands are subjected to the same climate and wave action, yet Ship Island

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Sound Waves

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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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Fieldwork, continued

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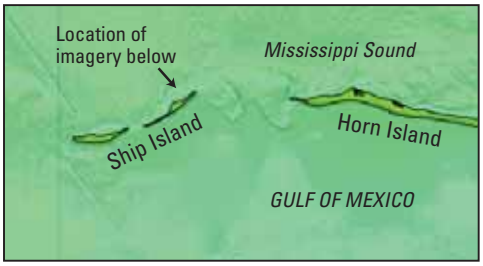
appears to undergo chronic breaching and more extensive island narrowing. Are differences in the underlying geology influencing the fate of these islands? To find out, scientists conducted high-resolution sea-floor and subbottom surveys around the islands in July 2008 to map their morphology and stratigraphy. In addition to producing a modern topobathymetric map of the Mississippi barrier-island chain, the data will be used to identify sea-floor change since the 1800s. These data are also of tremendous value to the U.S. Army Corps of Engineers (USACE), which is studying the feasibility of adding sediment to restore the islands to their previous sizes.

The survey with two vessels began in July 2008. **Nancy DeWitt**, **BJ Reynolds**, **Dana Wiese**, and **Jordan Sanford** of the USGS Florida Integrated Science Center (FISC) office in St. Petersburg used a 10-m Glacier Bay catamaran (URL **http://coastal.er.usgs.gov/capabilities/vessels/catboat.html**) to conduct operations in water as shallow as 1 m. On the research vessel *G.K. Gilbert* (**http://coastal.er.usgs.gov/capabilities/vessels/gilbert.html**), Captains **Rich Young** and **Dave Bennett** teamed with **Jim Flocks** (FISC-St. Petersburg) and **Chuck Worley** (USGS Woods Hole Science Center) to cover the deeper waters (2-15 m). Additional participants included USGS Gulf of Mexico science coordinator **Dawn Lavoie** and University of New Orleans student **Kathryn Rose**, who not only assisted in boat operations but also helped define the "zero contour" by walking the shoreline with a mobile Global Positioning System (GPS) unit.

BJ Reynolds *on Ship Island pier with Global Positioning System (GPS) equipment used to tie barrier-island shoreline to bathymetric dataset.*



The acoustic surveys were conducted by using Edgetech 512i and 424 subbottom chirp profilers, an SEA Submetrix interferometric-sonar (swath) bathymetric system, and a Marimatech E-Sea-103 (single-beam) bathymetric system. All these systems send and receive acoustic (sound) signals that bounce off

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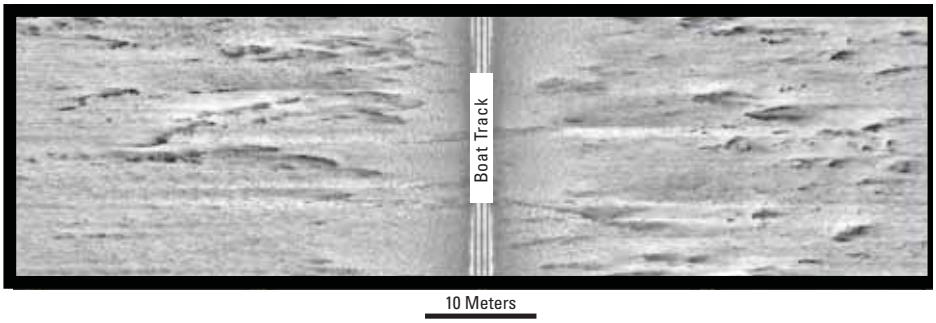

Interferometric-sonar (swath) systems produce an image of the sea floor on either side of the boat track. This example shows "backscatter"—a measure of the amount of acoustic energy returned from the sea floor, which is a proxy for bottom roughness or texture, similar to the data collected by sidescan sonar. Backscatter is useful for identifying changes in bottom type that may cause only a subtle change in bathymetry (elevation). Patchy seagrass beds are visible in this image, which extends about 25 m on each side of the boat track and was acquired in about 2 m of water.

Fieldwork, continued

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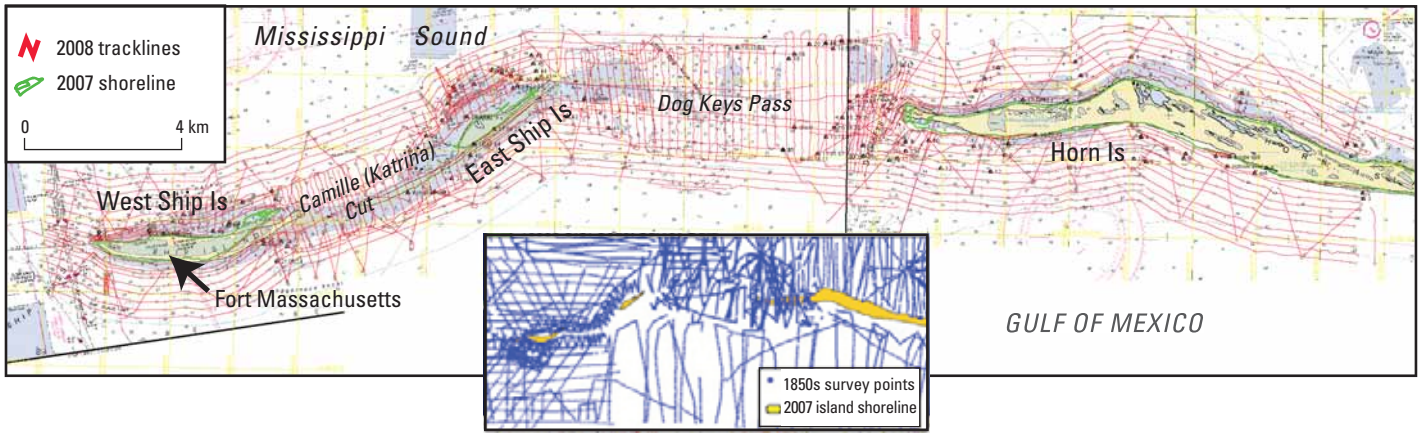

Red tracklines show locations of bathymetric and subbottom surveys conducted in July 2008. Data were collected with chirp seismic profilers and interferometric-sonar (swath) and single-beam bathymetric systems. Surveys along red zig-zag lines tie together shore-parallel surveys and reoccupy survey lines acquired by the U.S. Coast Survey in the 1850s (blue lines on inset).

surfaces separating materials of different density—for example, the boundary between water and sediment (the sea floor), or the boundary between sediment layers of differing density. The chirp systems, which employ an acoustic signal whose frequency increases or decreases over time, were used to provide an image of the subbottom as far as 50 m below the sea floor, with 1-m precision. Such images are commonly called "seismic" profiles because the sound signals travel through the sediment and rock of the subbottom like certain types of earthquake, or "seismic," waves. The interferometric-sonar system collects two types of data along a swath of sea floor: bathymetric data, which are sea-floor-depth measurements; and backscatter data, which are measurements of the amount of acoustic energy returned from the sea floor—a proxy for bottom roughness or texture. Backscatter is useful for identifying changes in bottom type that may cause only a subtle change in bathymetry. The single-beam system was used to obtain depth measurements in waters as shallow as 1 m. Vessel position was constrained by three GPS base stations. One station was maintained on a historical benchmark on Fort Massachusetts, an 1800s-era fortification on West Ship Island. A benchmark on the mainland was also occupied, and the survey team established a third station on Horn Island. The survey area, along with tracklines, is shown on map above.

Like all marine operations, the surveys were interrupted by moments of uninvited

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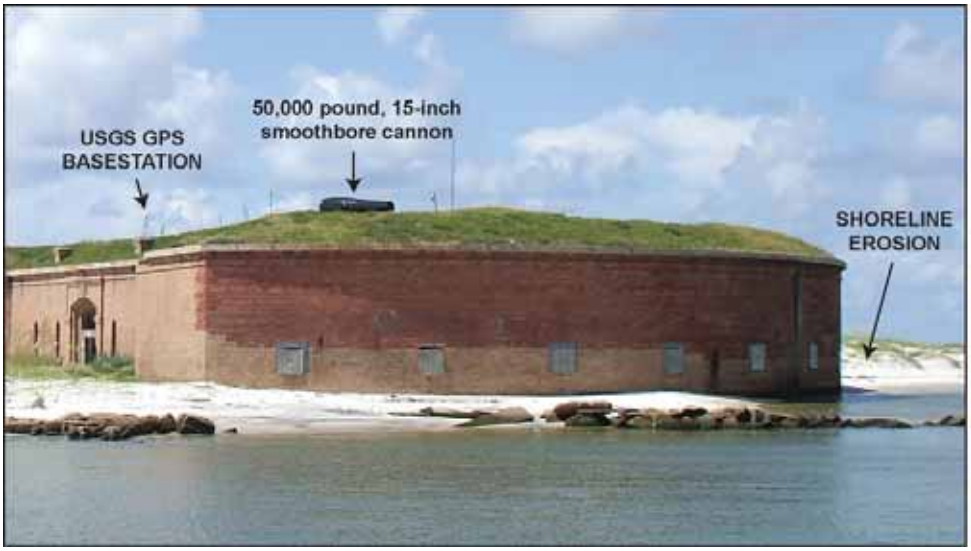
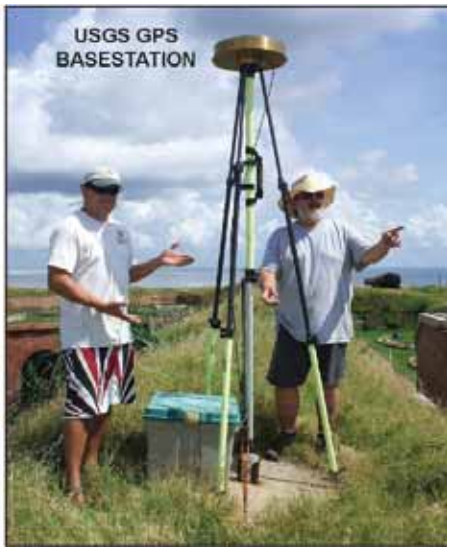


Fort Massachusetts, a pre-Civil War fortification on West Ship Island in Gulf Islands National Seashore, built to protect vital shipping lanes in the northern Gulf of Mexico; view from northeast. Storm surge from Hurricanes Camille (1969) and Katrina (2005) overtopped the fort but failed to undermine the structure; however, winter storms continue to erode the northern shoreline and wall. The National Park Service, which is tasked with preserving the fort and surrounding land, periodically supplies sand to the shoreline.



*On the highest wall of the fort is a benchmark installed in 1944 to provide direct-sight elevations to the mainland. **BJ Reynolds** (left) and **Dana Wiese** demonstrate proper installation of the GPS antenna, positioned over the historical benchmark.*

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excitement: self-deployment of expensive equipment, propulsion failure at sea, ambush by storm, and the inevitable jellyfish attack. The team recovered, repaired, rode out, and remedied these challenges and acquired more than 1,050 km of survey lines around the islands in 3 weeks.

Initial observations of the sea floor show breach enlargement, shoal migration, and sand waves. The process of natural alongshore sediment transport that built and maintains the islands is revealed by seismic profiles, which show Horn Island building out (prograding) westward into the adjacent Dog Keys Pass. Strong tidal currents in the pass are diverting the sediment offshore, reducing the amount that continues alongshore to neighboring Ship Island. Below the sea floor, distinct and persistent seismic patterns reflect the barrier platform, shoaling, and inlet scour. Elsewhere around the islands, the surveys detected a shoreface that is impressively steep, possibly a product of recent storm activity. Initial comparison of the bathymetric data with older navigational charts from the National Oceanic and Atmospheric Administration (NOAA) indicates a general loss of 1 m in nearshore elevation on the Gulf of Mexico side of the islands over the past few decades. The Mississippi Sound side shows no obvious overwash deposits associated with Hurricane Katrina, but submerged aquatic vegetation is depleted and occurs only in patches. This information is being used in a collaborative project with the National Park Service to produce a benthic-habitat map of the area around the islands.

One month after our survey, Hurricanes Gustav and Ike passed by the islands, bringing surges higher than 2.5 m and 1.5 m, respectively, to Ship Island. To monitor storm impact, the USGS used GPS coordinates to reoccupy positions along the survey tracklines collected in July. This rare opportunity allowed scientists to measure the immediate impact of storms on this ecosystem before natural recovery began. In addition, the post-storm comparison will provide the USACE with valuable

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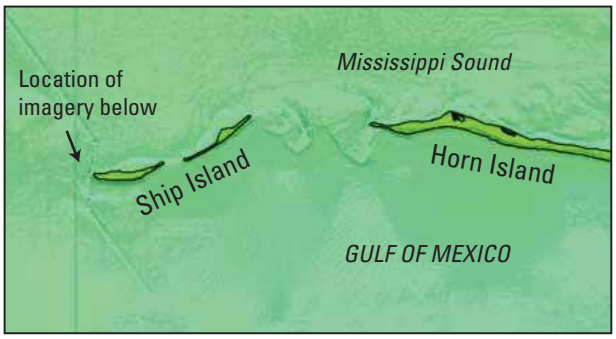
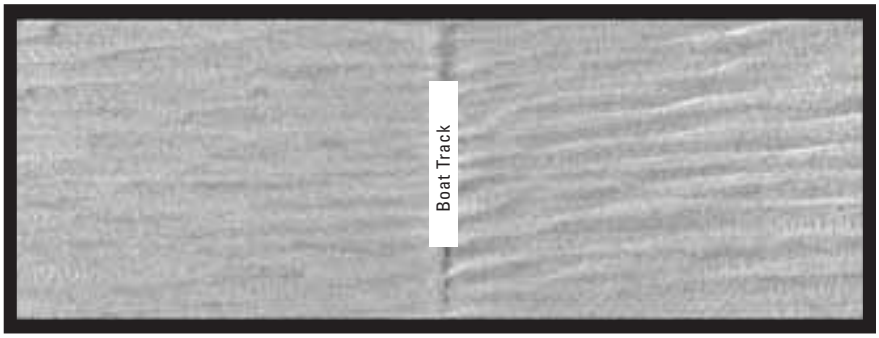
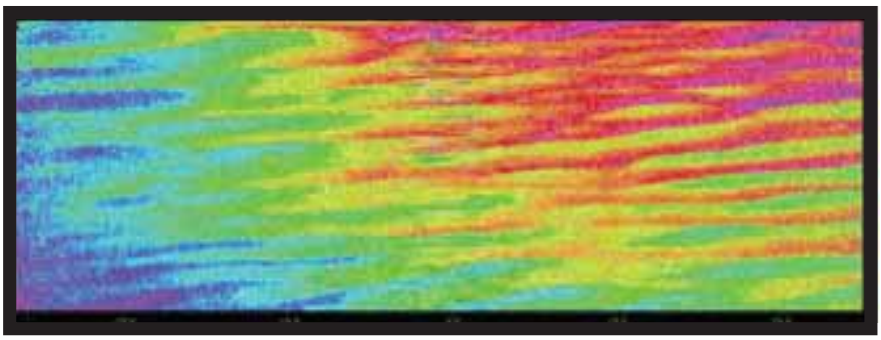


Sample interferometric-sonar (swath) profiles offshore Ship Island show sand waves on the sea floor adjacent to the shipping channel. The swath system returns backscatter (measure of bottom roughness) and bathymetric (measure of depth) data along a profile perpendicular to the boat track. Overall relief is less than 2 m.

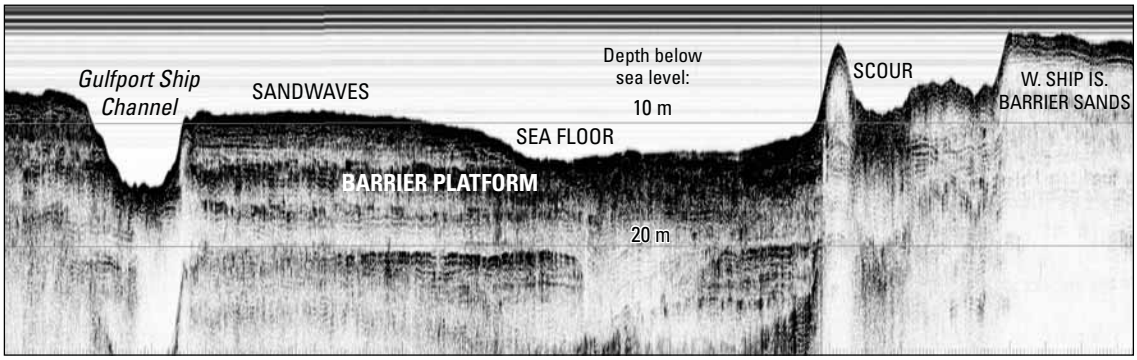
High-resolution swath backscatter image



High-resolution swath bathymetry



Color change represents 0.25 meters



Sample seismic profile west of West Ship Island shows a complex sea floor scoured by tidal currents. Small sand waves shown in previous figure are visible in profile. Gulfport Ship Channel cuts across the stratigraphy.

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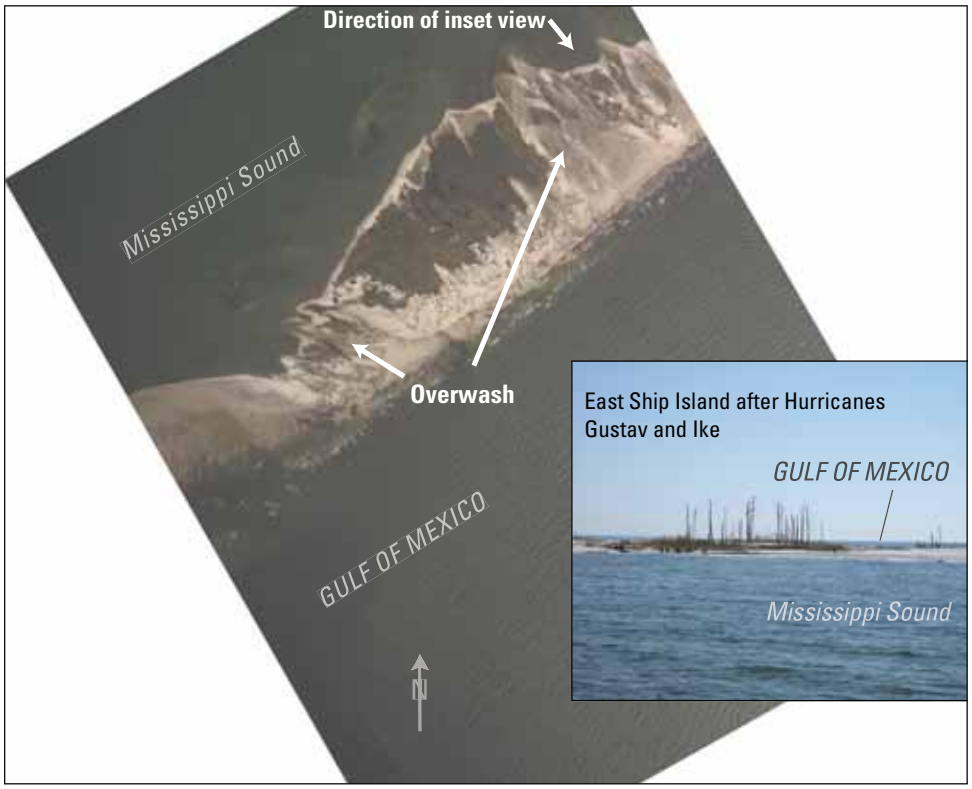
insight into the possible effects of future storms on restoration material.

Data processing and interpretation are ongoing, and completion of a preliminary bathymetric map is anticipated by spring 2009. To further characterize the submerged lands of Gulf Islands National Seashore, the USGS anticipates completing investigation of the submerged parts of Horn Island and adjacent Petit Bois Island in summer 2009 through the Northern Gulf of Mexico Ecosystem Change and Hazard Susceptibility Project.



Images of East Ship Island from overhead and from sea level (inset) after Hurricanes Gustav and Ike show overwash on island flanks, reduced elevation, and damaged trees. Most if not all of the trees had already been killed by storm surge from Hurricane Katrina in 2005.

Team Manatee: A Community Working Together to Assess and Protect Manatee Health and Habitat

By Ann Tihansky and Rachel Pawlitz

The fourth annual manatee-health-assessment season kicked off on December 11, 2008, with stormy conditions as a wintry cold front blasted through Florida's Nature Coast (the inside curve of the State's west coast, stretching approximately from north of Tampa Bay to south of Tallahassee). Such storm fronts cool the coastal waters along the Gulf of Mexico, driving manatees to seek refuge in the numerous coastal springs of the region, where discharging ground water is at a constant temperature of 72°F (22°C). The large spring complexes at Kings Bay in Crystal River, Florida, attract large numbers of manatees every winter, making it an excellent site for capturing manatees and collecting data about their health. This year, the U.S. Geological Survey (USGS) conducted health assessments and were part of a Department of the Interior (DOI) team that recognized local community support for manatee research, education, and protection.

Generalized map of Florida, showing location of Kings Bay in Crystal River, where large, warm spring complexes—including Three Sisters Springs—attract numerous manatees every winter and scientists conduct annual manatee-health assessments.

The assessment team begins by checking each manatee's vital signs.

The Florida manatee (*Trichechus manatus latirostris*) is a subspecies of the West Indian manatee, a marine mammal adapted to tropical and subtropical regions. Monitoring manatee health is required under the Endangered Species Act and the Marine Mammal Act because of the animal's endangered status. Much of the northwest Florida coast is ideal manatee habitat during most of the year, but during the winter,

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water temperatures often go below optimal conditions for manatee survival. The constant flow of ground water discharging from the numerous springs in this coastal region provides important warm-water refuge for manatees during the winter months.

Many manatees depend on this spring flow and return to Crystal River regularly. When the same individual is caught repeatedly, scientists can track its health over time, much like giving it annual physical checkups. Repeat catches provide data on vital signs and yield samples of tears, DNA, blood, urine, and feces for laboratory analysis. They also provide an opportunity to collect visual data on manatees, using such unique marks as boat scars to identify individuals. These data are incorporated into a large photo ID database used to research manatee life histories, migration patterns, and population dynamics.

Pulling an aquatic mammal that weighs more than half a ton out of the water is a carefully choreographed operation requiring teamwork and experience. Generally, manatees are captured by using rescue boats designed specifically for hauling the large animals out of the water. The annual assessments, however, are large group efforts designed to examine as many manatees as possible over a short timeframe, and so small beaches are used as examining tables. The beaches are cleared of rocks and hard objects, and commonly a rug is placed over the sand to minimize any injury and make the manatee as comfortable as possible. The beaches are exposed only at low tide, creating a short window of time for the health assessments.

Blood analysis begins onsite with centrifuging. Blood biochemical and hematologic research benefit manatee clinical medicine.

"This year, we're transporting the manatees to a second beach so that we can begin netting the next manatee while the first one is being assessed," said USGS Sirenia Project biologist **Bob Bonde**, who leads the manatee captures. "This allows us to increase the number of manatees that we can examine."

The team sets up along a stretch of river near Three Sisters Springs within a fairly restricted area, making it easy to spot and capture manatees as they pass. A point person watches for an approaching manatee. With the help of a circling boat, the experienced capture crew nets the manatee, hauls it close to shore, transfers it onto a stretcher, and carefully transports the manatee onto the nearby beach. The highly skilled health-assessment team then conducts a detailed physical examination.

Watching the team at work, an observer can see that **Bonde** has built partnerships with a wide variety of veterinarians and marine-mammal medical experts. This season, **Bonde** created separate capture and assessment teams, with at least one veterinarian leading each manatee assessment. Capture teams included partners experienced in manatee-rescue procedures, such as the U.S. Fish and Wildlife Service (USFWS), the Florida Fish and Wildlife Conservation Commission (FWCC), and the Volusia County Manatee Watch Program. Other participants included university students involved in related research projects and staff from zoos and aquariums nationwide who provided help while learning more about assessing manatee health. DOI Assistant Secretary **Lynn Scarlett** and then-USGS Director **Mark Myers** observed some of this year's health-assessment activities.

The USFWS manages the Chassahowitzka National Wildlife Refuge, which includes various smaller refuges within Kings Bay, creating a series of protected springs and keys that stretch as far south as Tampa Bay. The Friends of Chassahowitzka National Wildlife Refuge Complex is a support organization that works with

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An experienced capture team carefully pulls a manatee to shore.

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USFWS staff to keep the general public informed about ecosystem resources and policies needed to protect them.

Many residents of Florida's Nature Coast, aware that manatees give a special status to their springs, do much throughout the year to increase awareness and protect the springs for the manatees. Additionally, much of the area is part of a national wildlife refuge system encompassing the Chassahowitzka National Wildlife Refuge, the Crystal River National Wildlife Refuge, and three refuges in Tampa Bay. Within this system, specific areas designated as "manatee-only" sanctuaries create a refuge from boats and snorkelers. Unfortunately, these areas are not interconnected, and so manatees risk injury from motorboat traffic when moving from one protected area to another.

Adjacent to Three Sisters Springs is a 57-acre plot that has been filled and leveled but remains largely undeveloped. The current owners are considering selling the land, and a joint effort by State, Federal, and regional agencies and private organizations is underway to purchase the land and have it managed by the USFWS as part of the Crystal River National Wildlife Refuge. Purchase of the area would preserve the springs as an additional sanctuary as well as a public resource; plans include an educational information center and an observation area that would enable visitors to see manatees without going out into the water by boat.

DOI Assistant Secretary **Lynn Scarlett** visited Three Sisters Springs to recognize Felburn Foundation Executive Director **Ellie Schiller** on behalf of the USFWS—which, like the USGS, is a DOI agency—and the Friends of Chassahowitzka National Wildlife Refuge Complex ("Friends"). Her visit included a swim with the manatees and a chance to observe the health-assessment teams at work. **Scarlett** recognized **Schiller** for her tireless work in assisting State, Federal, and regional efforts to acquire lands for the protection of manatee habitat. **Scarlett** presented **Schiller** with a framed photograph and brief life history of "Ellie," a 30-year old manatee who had a long history of recorded sightings and was named to honor **Schiller**. **Scarlett** announced that if the land purchase is successful, the proposed interpretive center will be named in **Schiller's** honor. Several USGS and USFWS personnel attended the ceremony, along with many community leaders. Among the attendees were Crystal River Mayor **Ron Kitchen, Jr.**, then-USGS Director **Myers**, and Friends President **Lacy Blue-McLean**. USGS Eastern Region Communications Chief **AB Wade** and Public Affairs Specialist **Hannah Hamilton** also participated in the event, gathering information and video footage.

*At Three Sisters Springs, DOI Assistant Secretary **Lynn Scarlett** (right) recognizes an award given by USFWS and the Friends of Chassahowitzka National Wildlife Refuge Complex to **Ellie Schiller** (center) for her "steadfast support in the efforts to protect the Three Sisters Springs for the education and enjoyment of future generations." Chassahowitzka NWR manager **Keith Ramos** holds a framed photograph of "Ellie" the Manatee, also presented to **Schiller**.*

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*USGS biologist **Bob Bonde** instructs a multi-agency crew before the assessment.*

Members of the Florida Fish and Wildlife Conservation Commission help transport a manatee to the assessment site.

***Hannah Hamilton**, USGS Eastern Region Communications, documents manatee-health-assessment activities.*

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A manatee at Three Sisters Springs heads toward the surface for air.

USGS biologists prepare to radiotag the manatee "Ellie."

Despite stormy conditions, the USGS manatee-health-assessment season was an overall success, resulting in the capture and assessment of 13 manatees. The annual assessment, now in its fourth year at Crystal River, is building on a historic USGS database that contains data from the examination of more than 300 manatees throughout the State. The assessment is a valuable tool in determining the fitness of manatees and has been used to improve the handling of wild manatees and to determine clinical standards for captive manatees. The data have overall implications for monitoring ecosystem health because many marine mammals are commonly used as sentinels for identifying emerging threats to the ocean environment and human health.

Manatee-assessment data can be used in conjunction with other USGS research to model spring and coastal ecosystem change and its effects on manatees. For example, a recent USGS threat analysis (URL **http://www.pwrc.usgs.gov/resshow/manatee/#threats**) modeled the potential risks that various scenarios pose to manatee populations and generated data that USFWS could use in management decisions (visit URL **http://www.fws.gov/northflorida/Manatee/manatees.htm** and click on link "Manatee Five-Year Review"). The survival and reproduction estimates were made possible by the USGS photo ID database that tracks individual manatees.

The assessment season came to a fitting end when the research crew spotted "Ellie" again on January 12 as they were finishing up their fieldwork. The team succeeded in radiotagging her and will continue documenting the next chapter of her life history.

For additional information about USGS manatee research, visit URL **http://fl.biology.usgs.gov/Manatees/manatees.html**.

Food Choices and Location Influence California Sea Otter Exposure to Disease

By Tim Tinker and Gloria Maender

Sea otters living along the central California coast risk higher exposure to disease-causing parasites as a consequence of the food they eat and where they feed.

Sea otters that eat small marine snails are at a higher risk of exposure to *Toxoplasma gondii*, a potentially deadly protozoal pathogen, than animals that feed exclusively on other prey, while sea otters living along the coast near San Simeon and Cambria are more at risk than otters that live outside this area.

Similarly, sea otters that commonly feed on clams and fat innkeeper worms at the southern end of Monterey Bay have a higher risk of exposure to another dangerous protozoal pathogen, *Sarcocystis neurona*. On the other hand, sea otters whose diet includes significant amounts of abalone, a preferred prey species when sufficiently abundant, have a very low risk of infection with either pathogen.

"Recovery of the sea otter in California has been especially sluggish at the center portion of its range, where sea otter densities are highest and where most of the reproduction occurs," said **Tim Tinker**, a U.S. Geological Survey (USGS) sea otter expert at Santa Cruz, California, and co-lead of a new study led by the University of California, Davis (UC Davis) and the USGS. "Where food resources are limited, individual sea otters tend to become diet specialists, and the specific skills used to secure food are passed on from mother to pup."

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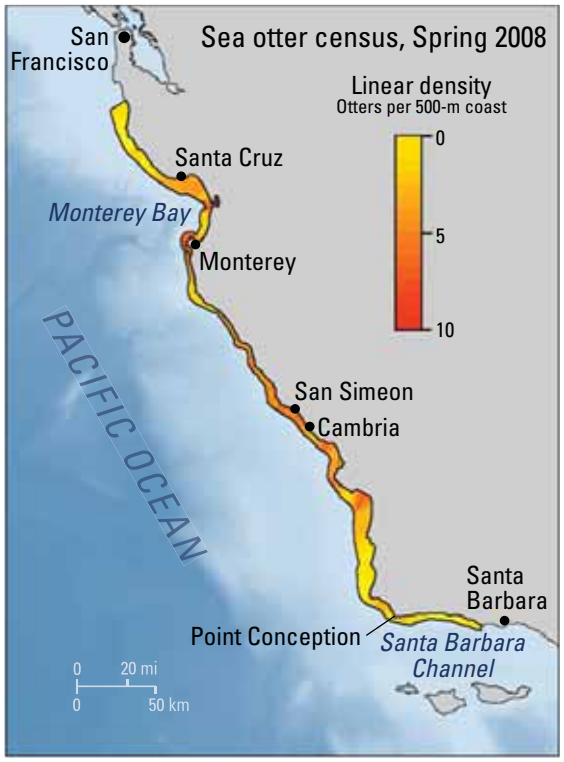
The result is that individual otters inhabiting the same area can have very different diets from one another, and it now appears that high levels of infection with *T. gondii* or *S. neurona* may be a consequence of this dietary diversification. "Our findings indicate that prey choice in sea otters has very real implications for their health," said **Christine Johnson**, co-lead author and epidemiologist at UC Davis. "Depleted resources and high rates of infectious disease may be acting in concert to limit the recovery of this threatened species."

T. gondii and *S. neurona* both have complex life cycles involving multiple hosts. They complete their life cycle in their respective final hosts, cats (*T. gondii*) and opossums (*S. neurona*), which then shed new infective life stages of the parasites into the environment. These infective oocysts can persist for months in the environment outside a host. Although these parasites are believed to have land origins, many oocysts end up in the marine environment, where they can be consumed by invertebrates in the marine food web, **Tinker** said. While invertebrates are not themselves affected by the parasites, invertebrates can act as intermediate or transport hosts, and sea otters that become infected from consuming infected prey may eventually die from protozoal encephalitis (inflammation of the brain).

A key challenge for scientists has been to determine exactly how the parasites are getting to sea otters. Identifying specific routes of infection has been difficult because it is almost impossible to detect the parasites in the environment. "What we have done with this work is demonstrate how sea otters themselves can show us how they are becoming infected," says **Tinker**. "By studying relationships between sea otter behavioral patterns and disease exposure, we can infer a great deal about the mechanisms of exposure, in much the same way as human-disease specialists investigate how certain behaviors, such as smoking, increase our risk of disease."

Complete findings appear in the *Proceedings of the National Academy of Sciences*. The article, titled "Prey choice and habitat use drive sea otter pathogen exposure in a resource-limited coastal system" (v. 106, no. 7, p. 2242-2247, URL **http://dx.doi.org/10.1073/pnas.0806449106**), was authored by **Christine K. Johnson**, University of California, Davis; **Martin T. Tinker**, U.S. Geological Survey; **James A. Estes**, University of California, Santa Cruz; **Patricia A. Conrad**, University of California, Davis; **Michelle Staedler**, Monterey Bay Aquarium; **Melissa A. Miller**, California Department of Fish and Game; **David A. Jessup**, California Department of Fish and Game; and **Jonna A.K. Mazet**, University of California, Davis. ❁

*A tagged sea otter feeds on a rock crab near Monterey, California. By carefully studying the diet, movements, and health of radiotagged sea otters like this one, researchers have found that individual food preferences and locations are good predictors of disease exposure. Photograph by **Tania Larson**, USGS.*



*Generalized map of California coast, showing spatial variation in population density of sea otters as determined from the spring 2008 sea otter census (see URL **http://soundwaves.usgs.gov/2008/09/**). Population growth has been sluggish in the center of the range (Monterey to Cambria), where sea otter densities are highest and most reproduction occurs. Dietary diversification in densely populated areas may be making sea otters there more vulnerable to infectious diseases.*

Establishment of Three New Marine National Monuments Assisted by Information from the USGS

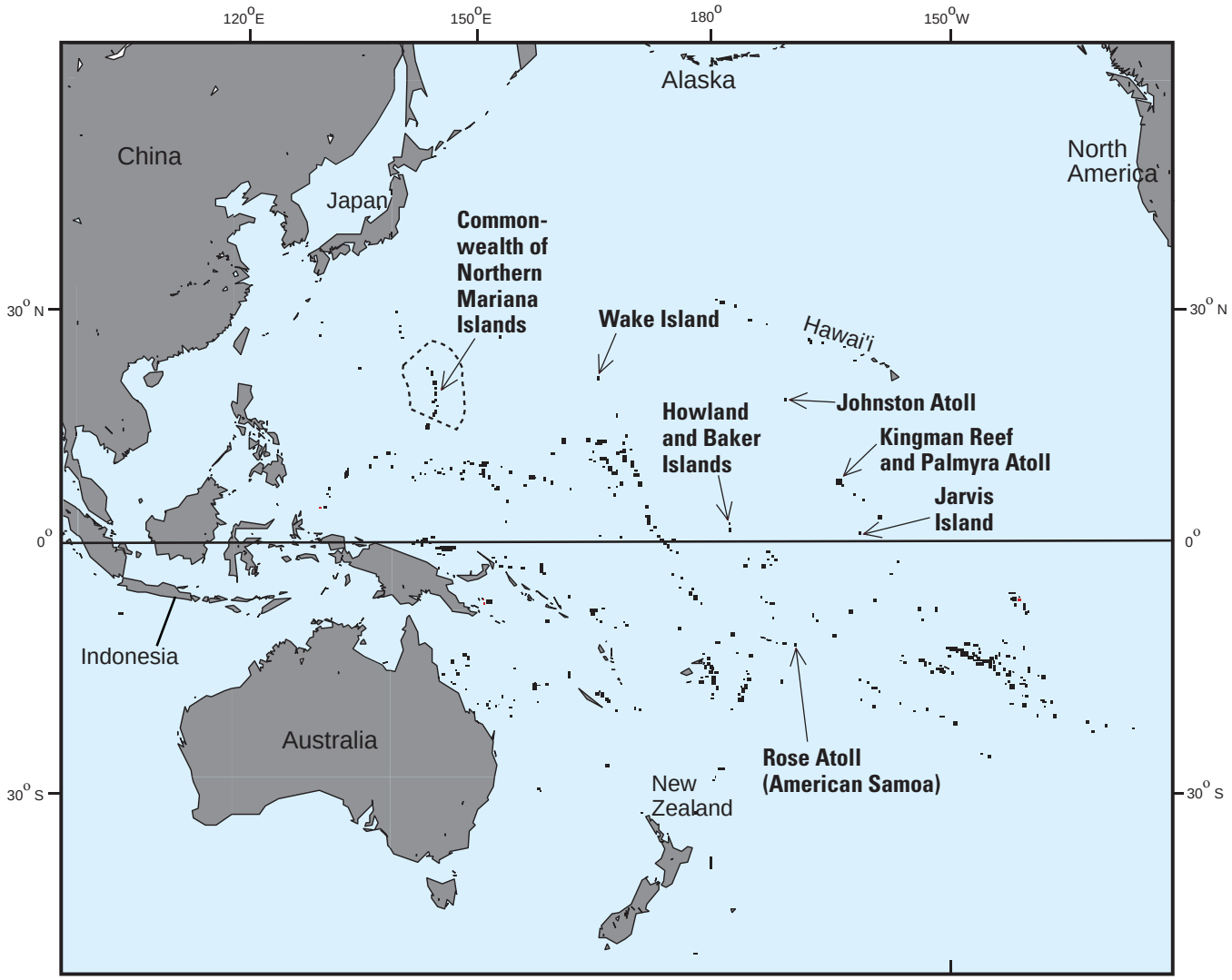
By Helen Gibbons

The deepest point on Earth, exotic animals living around deep-ocean hot springs, an undersea pool of molten sulfur, spectacular coral reefs, and habitat for rare sea turtles, whales, and seabirds recently received protection as part of three new marine national monuments in the Pacific Ocean.

At a White House ceremony on January 6, 2009, President **George W. Bush** announced the new national monuments:

- Rose Atoll Marine National Monument protects the pristine coral reef ecosystem around a remote part of American Samoa. One of its most striking features is the pink hue of fringing reef caused by the dominance of reef-building coralline algae.
- Pacific Remote Islands Marine National Monument protects the pristine coral reef ecosystems around Kingman Reef; Palmyra Atoll; Howland, Baker, and Jarvis Islands; Johnston Atoll; and Wake Island—the site of a pivotal battle in World War II and a key habitat for nesting seabirds and migratory shorebirds.
- Mariana Trench Marine National Monument consists of three components:
  1. The waters and submerged lands encompassing the coral reef ecosystem of the three northernmost

(Monuments continued on page 11)



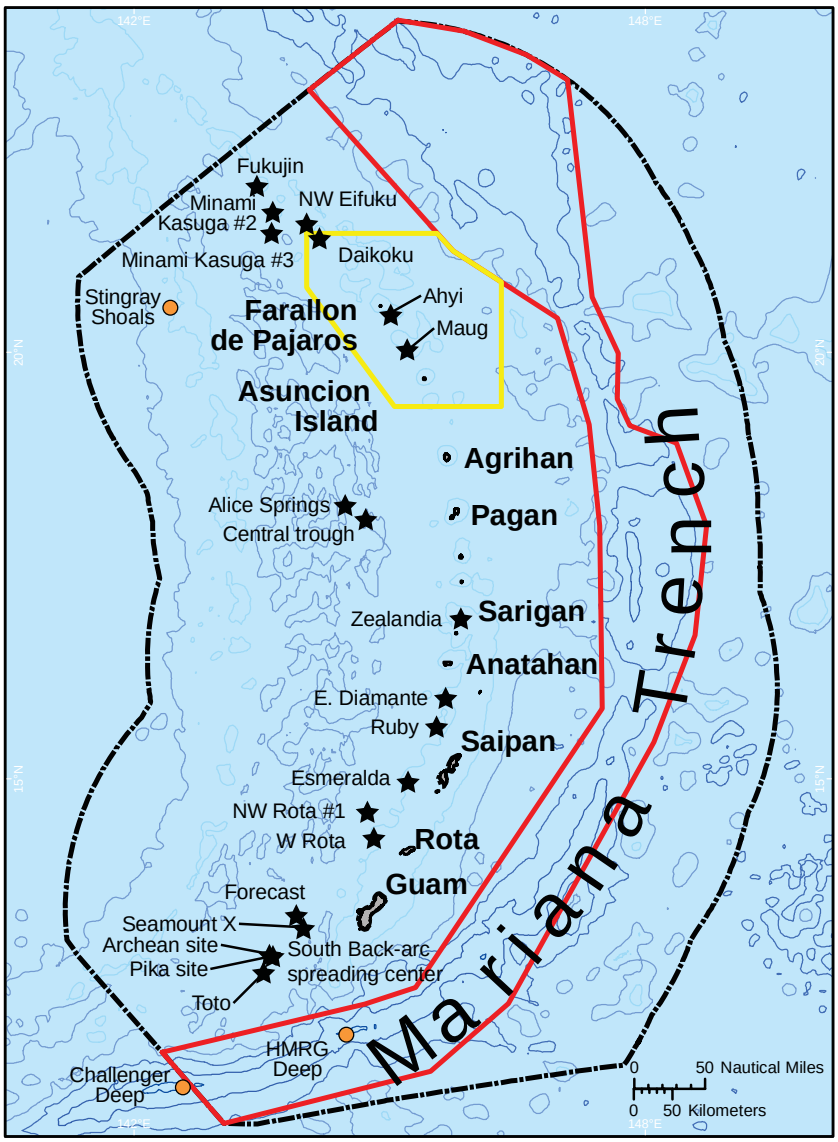
Pacific Ocean region, showing locations of islands and atolls included in three new marine national monuments announced January 6, 2009. Map modified from figure 1 in Marine Mineral Resources of Pacific Islands—A Review of the Exclusive Economic Zones of U.S. Affiliation, Excluding the State of Hawaii *(USGS Circular 1286, URL* ***http://pubs.usgs.gov/circ/2005/1286/****).*

(Monuments continued from page 10)

islands of the Commonwealth of the Northern Mariana Islands. These islands are home to a striking diversity of marine life—from such large predators as sharks and rays to more than 300 species of stony corals.

2. The Mariana Trench, approximately 940 nautical miles long and 38 nautical miles wide and site of the Challenger Deep—the deepest point on the ocean floor at approximately 11,000 m (36,000 ft) below sea level.
3. Active undersea volcanoes and thermal vents in the Mariana volcanic arc and backarc, which support life under enormously harsh conditions. Many scientists believe that extreme conditions like these could have been the first incubators of life on Earth.

During the planning of these marine national monuments, the U.S. Geological Survey (USGS) was asked for scientific background information, and numerous USGS scientists contributed their knowledge about the areas under consideration. One of these, research geologist **Jim Hein** of the Western Coastal and Marine Geology team, has studied sea-floor geology and mineralization in the Mariana Islands since 1986. **Hein** was consulted many times by personnel in the Department of the Interior (DOI) and the President's Council on Environmental Quality (CEQ) as they planned the Mariana Trench Marine National Monument. These consultations included an October 2008 briefing for then-CEQ Chairman **James Connaughton** and his staff on the geology and mineral resources of the Commonwealth of the Northern Mariana Islands (see related article in *Sound Waves*, July 2004, URL **http://soundwaves.usgs.gov/2004/07/**). Additional information from many USGS researchers was compiled and forwarded to DOI and CEQ for use during delineation of the new monuments. Briefings and background information were also provided by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Fish and Wildlife Service (USFWS).



*Map of Mariana Trench Marine National Monument. USGS geologist **Jim Hein** has studied sea-floor geology and mineralization in this area since 1986 and was consulted frequently by Federal officials planning the monument. (HMRG, Hawaii Mapping Research Group.)*

The Mariana Trench National Marine Monument is located at a subduction zone where two of the Earth's great tectonic plates, the Pacific Plate and the Philippine Sea Plate, converge. During this

(Monuments continued on page 12)

► *Liquid CO_2 bubbles being released from fractures adjacent to white-smoker sulfur chimneys at the Champagne vent, NW Eifuku volcano in Mariana Trench Marine National Monument. (See URL **http://soundwaves.usgs.gov/2004/07/**.)*

(Monuments continued from page 11)

slow-motion collision, the Pacific Plate is plunging westward beneath the Philippine Sea Plate, creating the Mariana Trench. Melting of sediment and rock on the upper part of the diving plate produces magma that rises through the overlying crust and erupts to form a chain of sea-floor volcanoes and thermal vents—the Mariana volcanic arc—west of the trench. Many of the volcanoes break the surface, forming the Mariana Islands. The Mariana Trench Marine National Monument contains the largest active serpentine-mud volcanoes on Earth, including one that is more than 30 miles across. The Champagne vent, located at the Eifuku submarine volcano, produces almost pure liquid carbon dioxide; this phenomenon has been observed at only one other site in the world, the Okinawa Trough. A pool of liquid sulfur, the Sulfur Cauldron, occurs at Daikoku submarine volcano. The northernmost Mariana reefs, unlike other reefs across the Pacific, provide unique volcanic habitats that support marine biological communities requiring basalt. East Diamante volcano and Maug Caldera are two of just a handful of places on Earth where photosynthetic and chemosynthetic communities of life are known to come together.

The Pacific Remote Islands Marine National Monument spans seven areas to the far south and west of Hawai'i. In addition to some of the most pristine and spectacular coral reefs in the world, it includes habitat for nesting seabirds and migratory shorebirds; unique trees, grasses, and birds adapted to life at the Equator; and rare sea turtles, whales, and Hawaiian monk seals. These isolated specks of land and rich marine ecosystems are almost completely undisturbed by humankind. As part of the Pacific Remote Islands Marine National Monument, they will be ideal laboratories for scientific research.

The Rose Atoll Marine National Monument centers around a diamond-shaped island in American Samoa—the United States' southernmost territory. It includes rare species of nesting petrels, shearwaters, and terns, which account for its native name meaning "Island of Seabirds." The waters surrounding the atoll are home to many rare species, including giant clams and reef sharks, as well as an unusual abundance of rose-colored coralline algae.

Photographs taken during a 2005 multinational exploration of the South Pacific, sponsored in part by the NOAA Office of Ocean Exploration and its Undersea Research Program (NURP). Large photo, submersible Pisces IV *at 320-m depth in Kingman Reef, one of the few locations where the expedition found gold coral. Inset, roughy fish species seen at Rose Atoll, Jarvis Island, Kingman Reef, and Palmyra Atoll at depths of 350-500 m. To learn more about the expedition, visit URL* ***http://www.noaanews.noaa.gov/stories2005/s2487.htm****. Photographs courtesy of NOAA/NURP.*

Rose Atoll from space. The rim is a broad, continuous reef enclosing a shallow central lagoon as much as 20 m in depth; a single narrow passage in the north connects the lagoon to the open sea. Two islets on the eastern side—Rose Island and the smaller Sand Island—have a combined land area of 6 hectares. Scale approximate. (Modified from image ISS013-E-66000.JPG, courtesy of Image Science and Analysis Laboratory, NASA-Johnson Space Center, "The Gateway to Astronaut Photography of Earth"; see URL ***http://www.oceandots.com/pacific/samoa/rose.php****.)*

Taken together, the three new marine national monuments encompass 195,274 mi^2, even more area than the Papahānaumokuākea Marine National Monument (139,797 mi^2), which was established in the northwestern Hawaiian Islands by **President Bush** in 2006 (see URL **http://hawaiireef.noaa.gov/**). As national monuments, all are protected under the 1906 Antiquities Act, which allows the government to immediately phase out waste dumping, as well as commercial fishing and other extractive uses. Recreational fishing, tourism, and scientific research with a Federal permit can still occur inside the marine national monuments. The designations also will not conflict with U.S. military activities or freedom of navigation. ❁

Western Coastal and Marine Geology Team Welcomes New Engineering Technician

By Jon Childs

Engineering technician **Pete Dal Ferro** recently joined the U.S. Geological Survey (USGS)'s Western Coastal and Marine Geology Team (CMG) at the Pacific Science Center in Santa Cruz, California. **Pete** started work at the beginning of the New Year in the center's Marine Facility, and he is a tremendous addition to the team. **Pete** didn't have to travel far to join us—his previous job was about a mile away, at the University of California, Santa Cruz

(UCSC)'s Long Marine Laboratory, where he provided marine-science support of all types for more than 10 years. **Pete** has extensive experience in designing, fabricating, deploying, and supporting a wide variety of scientific instrument packages. He is a small-boat operator and safety instructor, and a certified diver. **Pete** also has large-boat experience, having spent the past eight austral summers working aboard the National Science Foundation's research vessels *Nathaniel B. Palmer* and *Laurence M. Gould* in the Antarctic and Southern Oceans.

Pete earned a Bachelor's degree in marine biology from UCSC and has worked with several CMG researchers in the past. **Pete** credits a cruise with **Brian Edwards** for getting him started in marine science.

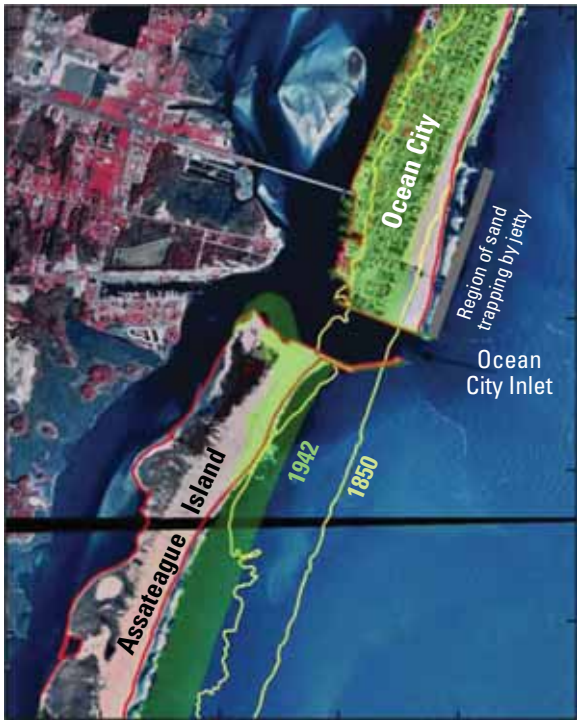
Welcome, **Pete**! We wish you a long and productive career with CMG and the USGS.

USGS Scientists Are Major Contributors to New Report on Sea-Level Rise

Global sea level is rising, and there is evidence that the rate is accelerating. Increasing atmospheric concentrations of greenhouse gases, primarily from human contributions, are very likely warming the atmosphere and oceans. The warmer temperatures raise sea level by expanding ocean water, melting glaciers and icecaps, and possibly increasing the rate at which ice sheets discharge ice and water into the oceans. Rising sea level and the potential for stronger storms pose an increasing threat to coastal cities, infrastructure, beaches, wetlands, and ecosystems. The potential impacts to the United States extend across the entire country: ports provide gateways for transport of goods domestically and abroad; coastal resorts and beaches are central to the U.S. economy; and wetlands provide valuable ecosystem services, such as filtering water, buffering storm surge, and providing spawning grounds for commercially important fish. How people respond to sea-level rise in the coastal zone will have potentially large economic and environmental costs.

A new report addressing these issues was recently released by the U.S. Climate Change Science Program. The report, titled *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*, provides a detailed assessment of the effects of sea-level rise and examines multiple opportunities for governments and coastal communities to plan for and adapt to rising sea levels. The U.S. Environmental Protection Agency (EPA), the U.S. Geological Survey (USGS), and the National Oceanic and Atmospheric Administration (NOAA) prepared the report, with additional contributions from the U.S. Department of Transportation. Numerous authors from national, State, and local agencies and organizations, academic institutions, and private consulting firms contributed to the 300-page document, which describes potential changes to barrier islands, wetlands, other coastal habitat, and vulnerable species; societal impacts and im-

(Sea Level continued on page 14)



Aerial photograph of northern Assateague Island and Ocean City, Maryland, from chapter 3 ("Ocean Coasts"), showing former barrier positions. In 1850, a single barrier island, shown outlined in yellow, occupied this stretch of coast. In 1933, Ocean City inlet was created by a hurricane and soon after was stabilized by jetties. By 1942, the barrier south of the inlet had migrated landward (green shaded area) in response to a drastic reduction in sediment supply. Such changes may become more widespread in response to future accelerated sea-level rise. Shorelines from Maryland Geological Survey; photograph from National Park Service.

(Sea Level continued from page 13)

plications of sea-level rise; decisions that may be sensitive to sea-level rise; opportunities for adaptation; and institutional barriers to adaptation. It also outlines current coastal policies in the mid-Atlantic region and implications for the other regions of the United States. Finally, the report discusses opportunities for natural and social science to enhance our understanding of the potential impacts of sea-level rise and society's ability to respond.

Although the issues apply to coastal regions across the country, the report focuses on the mid-Atlantic region of the United States, where rates of sea-level rise are moderately high, severe storms are fairly common, and a large extent of critical habitat (marshes), high population densities, and infrastructure exist in low-lying areas.

Sea-level rise can affect coastal communities and habitats in various ways, including submerging low-lying lands, eroding beaches, converting wetlands to open water, intensifying coastal flooding, and increasing the salinity of estuaries and freshwater aquifers. Some impacts of sea-level rise can already be observed along the U.S. coast, underscoring the immediate need for improving scientific understanding and the ability to predict the effects of rising sea level. Beginning to incorporate sea-level rise into coastal planning, in combination with the development of decision-support tools for taking further adaptive action, could lessen the economic and environmental impacts of sea-level rise on the United States.

Six of the new report's lead authors are USGS scientists: **Donald R. Cahoon** (Patuxent Wildlife Research Center, Beltsville, Md.), **Dean B. Gesch** (Earth Resources Observation and Science [EROS], Sioux Falls, S.D.), **Benjamin T. Gutierrez** (Woods Hole Science Center, Woods Hole, Mass.), **E. Robert Thieler** (Woods Hole Science Center), **S. Jeffress Williams** (Woods Hole Science Center), and **K. Eric Anderson** (retired). The USGS Office of Global Change recently recognized the authors' contributions to this more-than-3-year effort. Over the past several weeks, **Pat Jellison**, Chief of Global Change Research and Development, traveled to the authors' science centers to present them with STAR Awards and to address each center about the importance of USGS contributions to the U.S. Climate Change Science Program (CCSP). The new report is one of 21 climate-change synthesis and assessment products commissioned by the CCSP, which was established in 2002 to provide the United States with science-based knowledge to manage the risks and opportunities of change in the climate and related environmental systems. The CCSP is responsible for coordinating and integrating the research of 13 Federal agencies on climate and global change.

The full reference for the new report is:

U.S. Climate Change Science Program, 2009, Coastal sensitivity to sea-level rise; a focus on the mid-Atlantic region. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [James G. Titus (coordinating lead author), K. Eric Anderson, Donald R. Cahoon, Dean B. Gesch, Stephen K. Gill, Benjamin T. Gutierrez, E. Robert Thieler, and S. Jeffress Williams (lead authors)]: Washington D.C., U.S. Environmental Protection Agency, 300 p.

For more information and to download a copy of the report, visit URL **http://www.climatescience.gov/Library/sap/sap4-1/final-report/**. For information on the U.S. Climate Change Science Program, visit URL **http://www.climatescience.gov/**.

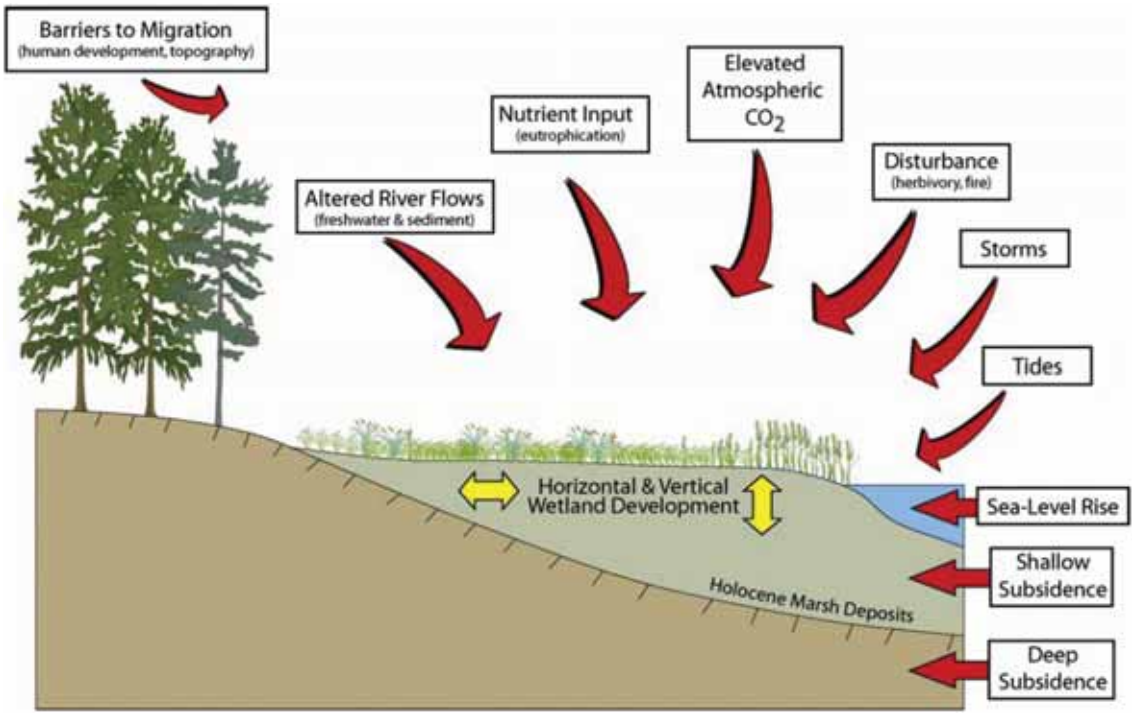
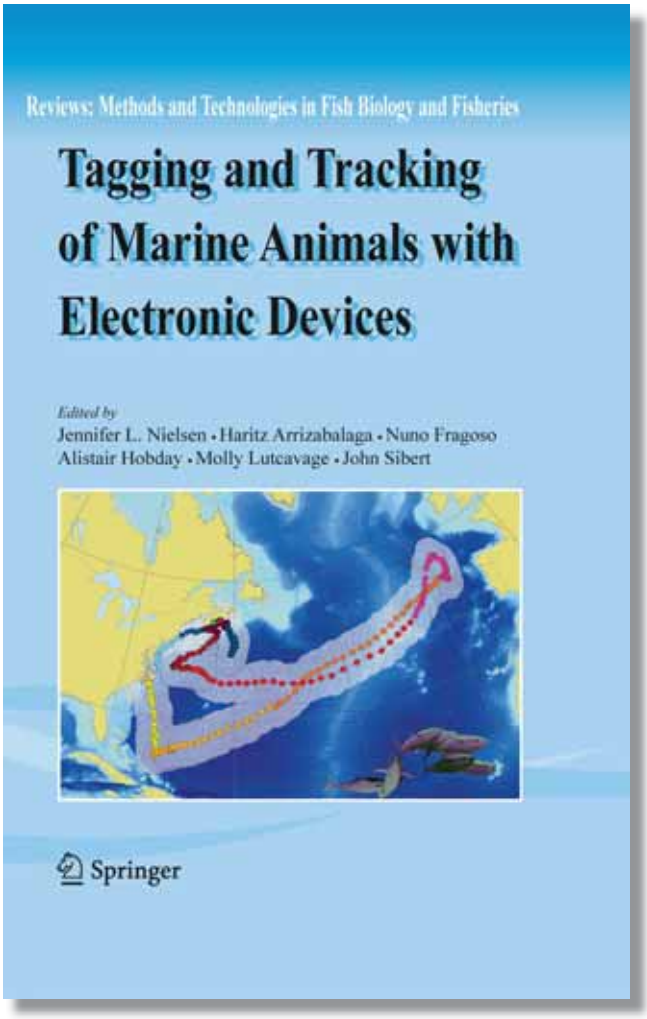


Diagram from chapter 4 ("Coastal Wetland Sustainability"), illustrating climate and environmental drivers influencing vertical and horizontal wetland development. The authors state, "It is virtually certain that tidal wetlands already experiencing submergence by sea-level rise and associated high rates of loss (e.g., Mississippi River Delta in Louisiana, Blackwater River marshes in Maryland) will continue to lose area in response to future accelerated rates of sea-level rise and changes in other climate and environmental drivers."

New Proceedings Volume Will Discuss *Tagging and Tracking of Marine Animals with Electronic Devices*

U.S. Geological Survey (USGS) research fishery biologist **Jennifer L. Nielsen** of the USGS Alaska Science Center is lead editor of a soon-to-be-released book titled *Tagging and Tracking of Marine Animals with Electronic Devices*. Scheduled for release in May 2009, the book contains 25 chapters dealing with advances in electronic-tagging technologies in marine ecosystems, the behavior of aquatic animals tracked by using electronic tags, new innovations in geolocation estimates by using electronic tags, and fisheries applications for electronic devices in marine animals.



The book is a compilation of papers from the Second International Symposium on Tagging and Tracking Marine Fish with Electronic Devices, which was held in San Sebastian, Spain, in October 2007, 7 years after the first symposium was held in Hawaii in 2000. In the intervening 7 years, major advances have occurred both in the capability and reliability of electronic tags and in analytical approaches for geolocation of tagged animals in marine habitats. Such advances as increased data-storage capacity, sensor development, and tag miniaturization have allowed researchers to track a much wider array of marine animals, not just large and charismatic species. Importantly, data returned by these tags are now being used in population analyses and movement simulations that can be directly utilized in stock assessments and other management applications. Papers in this volume are divided into three sections, the first describing insights in behavior achieved by using acoustic, archival, and novel tags; the second reporting on advances in methods of geolocation; and the third describing how tag data have been used in management of marine species. Accurate documentation of animal movements and behaviors in critical marine habitats are impossible to obtain with other technologies. The management and conservation of marine species are critical in today's changing ocean environment, and as electronic tags become more accurate and functional for a diversity of organisms, their application continues to grow, setting new standards in science and technology.

The book's editors are **Nielsen**, **Haritz Arrizabalaga** (AZTI, Spain), **Nuno Fragoso** (University of New Hampshire), **Alistair Hobday** (Commonwealth Scientific and Industrial Research Organisation [CSIRO], Australia), **Molly Lutcavage** (University of New Hampshire), and **John Sibert** (University of Hawaii). This is the 9th volume in the series "Reviews: Methods and Technologies in Fish Biology and Fisheries" (REME), published by Springer. **Nielsen** is the REME Series Editor. The book will be available May 4, 2009; more information is posted at URL **http://www.springer.com/life+sci/ecology/book/978-1-4020-9639-6.**

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