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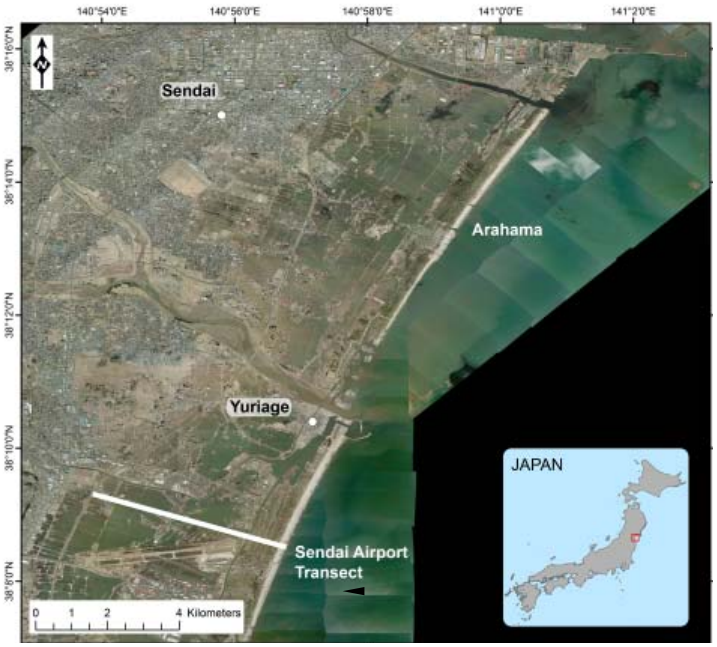
Fieldwork

International Team Studies Tsunami Deposits in Japan to Improve Understanding and Mitigation of Tsunami Hazards

By Bruce Jaffe, Bruce Richmond, and Helen Gibbons

The March 11, 2011, magnitude 9.0 Tohoku earthquake off the coast of Japan generated a tsunami that inundated a large area on the northeast coast of Honshu, the country's main island, resulting in widespread devastation (see related *Sound Waves* article at **http://soundwaves.usgs.gov/2011/03/**). At this writing (June 1), the death toll stands at approximately 15,000 and the number of missing at approximately 8,000 (**http://earthquake-report.com/2011/05/13/japan-tsunami-a-massive-update-for-our-catdat-situation-report-part-15/**). The earthquake was one of the five most powerful earthquakes recorded in the world since instrumental detection and record keeping began around 1900. The resulting tsunami flooded dozens of coastal cities, numerous ports, and the broad coastal plain around Sendai—the nearest major city to the earthquake, at a distance of 130 km (80 mi) from the epicenter. It is now estimated from aerial and satellite photography that an area of almost 500 km^2 (200 mi^2) was inundated by the tsunami.



*Sites where the international tsunami survey team worked on the Sendai coastal plain in Japan in May 2011. Background images, taken before the March 11, 2011, earthquake and tsunami, are from the Geospatial Information Authority of Japan (GSI) Web site (**http://www.gsi.go.jp/ENGLISH/**).*

In May 2011, U.S. Geological Survey (USGS) scientists **Bruce Jaffe** and **Bruce Richmond** examined sediment deposited by the tsunami in and around Sendai as part of an international tsunami survey team organized by Japanese scientific cooperators. The 11 members of the team came from Japan, the United States, Australia, Poland, the United Kingdom, and Indonesia.

Survey teams try to enter tsunami-stricken areas as soon as possible after rescue and recovery work to document physical evidence of tsunami flow characteristics—such as debris in trees, high-water stains on buildings, and sedimentary deposits—before it is degraded or destroyed by natural forces or cleanup activities. Japanese researchers began this process during the second week after the earthquake; as the situation in Japan improved, they invited scientists from the

(Tsunami Survey continued on page 2)

The March 11, 2011, tsunami destroyed most buildings in Yuriage, leaving exposed foundations and scattered debris. The tsunami flow was about 8 m (26 ft) deep here and moved a stone monument off the top of the artificial hill in the background on the left side of the photograph. The stone had been placed as a reminder of the 1933 Showa tsunami that killed many in Yuriage.

Sound Waves

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Contents

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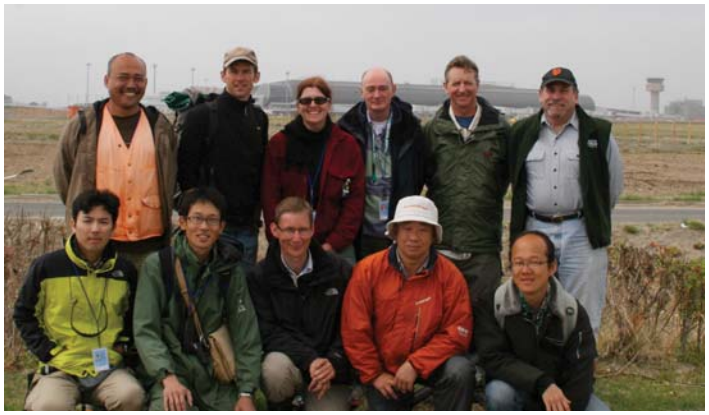
Fieldwork, continued

(Tsunami Survey continued from page 1)



Members of the May 2011 international tsunami survey team near their main survey transect. Sendai Airport is in the background. Survey team members and affiliations are (bottom row, left to right) ***Kazuhisa Goto*** *(Chiba Institute of Technology, Japan),* ***Shigehiro Fujino*** *(University of Tsukuba, Japan),* ***Witek Szczuciski*** *(Adam Mickiewicz University, Poland),* ***Yuichi Nishimura*** *(Hokkaido University, Japan),* ***Daisuke Sugawara*** *(Tohoku University, Japan); (top row, left to right)* ***Eko Yulianto*** *(Indonesian Institute of Science, Indonesia),* ***Rob Witter*** *(Oregon Department of Geology and Mineral Industries, U.S.A.),* ***Catherine Chagué-Goff*** *(University of New South Wales, Australia),* ***Dave Tappin*** *(British Geological Survey, United Kingdom),* ***Bruce Richmond*** *(USGS, U.S.A.), and* ***Bruce Jaffe*** *(USGS, U.S.A.).*

international tsunami-research community to assist with gathering data from the large area affected by the tsunami.

The May reconnaissance survey focused on the characteristics of tsunami sediment deposits in the vicinity of Sendai Airport, with a specific emphasis on how these characteristics varied with tsunami speed and flow depth, topography (including microtopography), distance from the coast, urban and rural settings, land subsidence caused by the earthquake, and other aspects of natural and man-made features of the landscape. Among the information the scientists collected were data on water levels, flow directions, topography, sediment thickness, grain size, and sedimentary structures (patterns in the sediment produced by variations in such factors as the speed of the water from which the sediment was deposited and the composition and grain size of the sediment). They also collected sediment samples for microfossil, geochemical, and other analyses. The sedimentary evidence of the tsunami was complicated by liquefaction of some coastal-plain sediment during the earthquake and an extensive

(Tsunami Survey continued on page 3)

Building damaged by the tsunami in Yuriage. The tsunami flow depth here was approximately 8 m (26 ft).

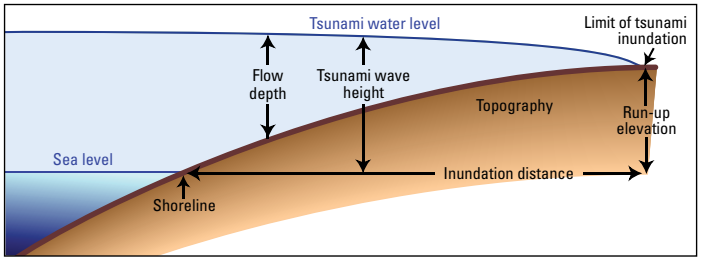


Diagram illustrating some of the terms used to describe tsunami characteristics.

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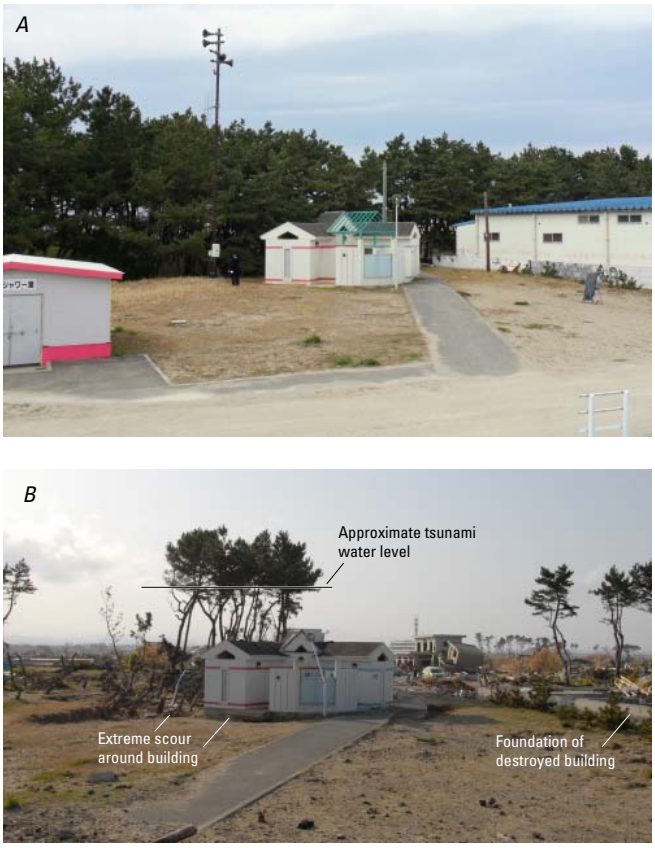


Photographs from Arahama beach on the Sendai coastal plain taken (A) before (April 11, 2010) and (B) after (May 4, 2011) the tsunami show damage to vegetation, landscape, and buildings. The buildings at far right and left were completely destroyed; all that remains are their foundations. The restroom building in the center survived the tsunami but underwent extreme scour and channeling around its base. The highest point of limb removal on the trees (trim line) shows the minimum water level of the tsunami in this area, which was measured as between 7 and 9 m (23 and 30 ft) above the ground (10-12 m [33-39 ft] above sea level).

canal system that affected the movement of the tsunami waves and the sediment they carried.

This tsunami was particularly well documented in video footage shot by news agencies and citizens. The survey team took advantage of the video data by focusing their measurement and sampling efforts on areas where footage is available. One video they are using, posted at **http://www.zimbio.com/Japan+Earthquake+2011/articles/PF8WtyjiF4c/Sendai+Tsunami+Video+Japan**, shows the tsunami hitting the Sendai Airport. The team collected data along a transect near the airport where sand and mud were deposited more than 4 km inland—the longest post-tsunami transect in which tsunami deposits have been mapped in detail. The scientists will compare data from the sediment deposits with data from the video in hopes of relating characteristics of the deposits to the flow history of the tsunami. For example, they will compare the number and thickness of layers in the tsunami deposits with the number of waves and the flow speeds observed in the video.

The data collected in Japan, like data collected in field surveys after other recent tsunamis, will improve scientists' ability to recognize and interpret tsunami deposits from ancient events. Some of the scientists on the survey team will use the data to develop numerical models of tsunami sediment transport that can be applied to tsunami deposits in the geologic record to determine the characteristics—approximate size and speed, for example—of ancient tsunamis. Data from the Japanese study will also help scientists improve criteria for distinguishing tsunami deposits from large-storm deposits (see related *Sound Waves* article at **http://soundwaves.usgs.gov/2007/11/**).

Additionally, the reconnaissance team will attempt to draw analogies between the March 11, 2011, tsunami deposits and deposits of predecessor events, such as the Jōgan tsunami, which struck the Sendai plain in A.D. 869 and was named after the emperor of the time. Japanese scientist **Koji Minoura** (Tohoku University) and colleagues published a paper in 2001 describing Jōgan tsunami sand deposits and two older sand deposits interpreted as evidence of earlier large tsunamis (*Journal of Natural Disaster Science*, v. 23, no. 2, p. 83-88, **http://www.jsnds.org/contents/jnds/23_2.html**). The ages of the two earlier tsunami deposits are A.D. 140-150 and 910-670 B.C. On the basis of this limited paleotsunami record for the Sendai coastal plain, the authors inferred a tsunami recurrence interval of 800-1,100 years. At the end of the paper they wrote, "More than 1,100 years have passed since the Jōgan tsunami and, given the reoccurrence interval, the possibility of a large tsunami striking the Sendai plain is high. Our numerical findings indicate that a tsunami similar to the Jōgan one would inundate the present coastal plain for about 2.5-3 km inland," a prediction that proved remarkably accurate.

Japan not only has the longest written record of historical tsunamis in the world, but it also has a vigorous paleotsunami re-

(Tsunami Survey continued on page 4

Wall of excavated trench showing the sedimentary structures of a tsunami deposit (mostly horizontal sand layers) and locations (rectangular markers on right) where sediment samples were collected for laboratory analyses.

(Tsunami Survey continued from page 3)

***Yuichi Nishimura** shows other members of the international tsunami survey team a sediment core taken by the geoslicer, a tool used to search for ancient tsunami deposits.*

search program designed to extend the tsunami record into the past and improve tsunami-hazard assessments. Examining field evidence of recent and historical tsunamis is critical to understanding these infrequent but catastrophic phenomena. The data collected recently in Japan by the international tsunami survey team will be used to develop tools for interpreting the geologic record of tsunamis. These tools can be applied to other areas where the same coastal hazard is present, such as the Pacific Northwest coast of the United States, and used to decrease future loss of life and property from tsunamis.

To view additional photographs of the March 2011 tsunami's impacts, please visit the USGS Pacific Coastal and Marine Science Center Web page at **http://walrus.wr.usgs.gov/news/field.html**.

► *Core collected by the survey team 1.6 km (1 mi) inland at Arahama on the Sendai coastal plain contains sandy deposits from the A.D. 869 Jōgan tsunami about 40 cm beneath the March 11, 2011, tsunami deposits. We chose the site on the basis of a report of the Jōgan tsunami deposits by **Yuki Sawai** (Active Fault Research Center) and colleagues in the* Annual Report on Active Fault and Paleoearthquake Researches *(2008, no. 8, p. 17-70, **http://unit.aist.go.jp/actfault-eq/seika/h19seika/pdf/02.sawai.pdf** [5.5 MB]) and numerical modeling of Jōgan tsunami inundation by **Kenji Satake** (Active Fault Research Center) and colleagues (same volume, p. 71-89, **http://unit.aist.go.jp/actfault-eq/seika/h19seika/pdf/03.satake.pdf** [7.1 MB]). The relative magnitudes of the Jōgan and 2011 tsunamis cannot be inferred from the thickness of each deposit, which is affected by local topography as well as sediment grain size and tsunami flow speed.*

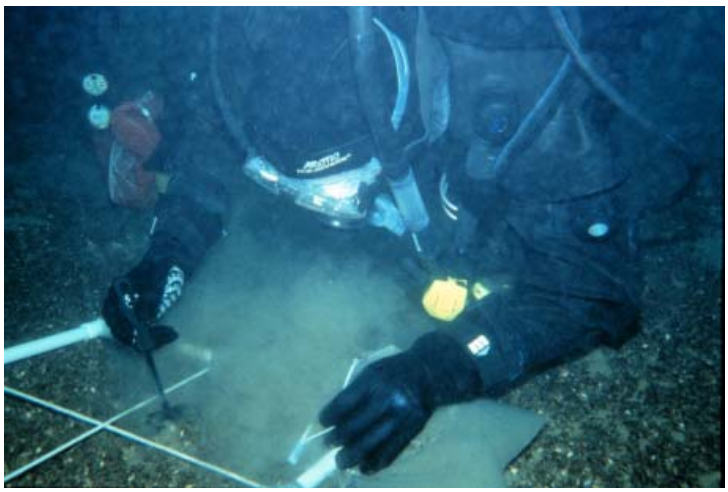
USGS Scuba Diving Expertise: An Important Tool in Marine Research

By Matthew Cimitile

In November 2010, the U.S. Geological Survey (USGS) Dive Safety Board received the U.S. Department of the Interior's Safety and Occupational Health Excellence Award in the Group category at a ceremony in Washington, D.C. The award is a reflection not only of the board's exemplary service but of the increasing use of scuba diving in USGS studies of the aquatic environment.

"Use of scuba diving is expanding so much within the USGS due to the capabilities of new technology. As the technology develops, we are able to deploy instruments underwater and learn about the marine environment as we have never been able to before," said **Marc Blouin**, USGS Dive Safety Program Manager.

Some recent USGS research and fieldwork involving diving include:



USGS diver performs a quadrat survey of invasive zebra mussels in Lake Ontario, New York.

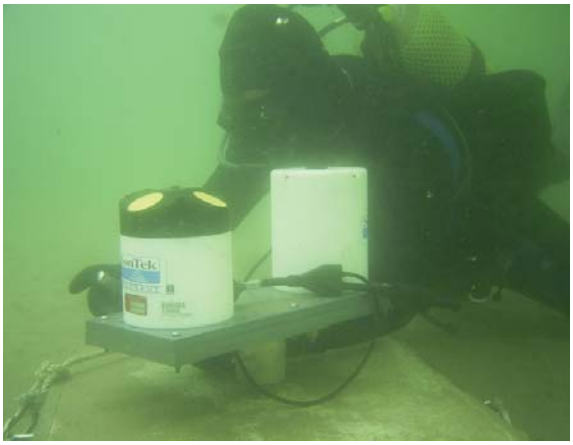
- Studying the impacts of invasive species on native species in the Great Lakes, where researchers and research divers created and installed various sampling devices to look at the effects that exotic gobies are having on sturgeon and their eggs.

(USGS Scuba continued on page 5)

(USGS Scuba continued from page 4)

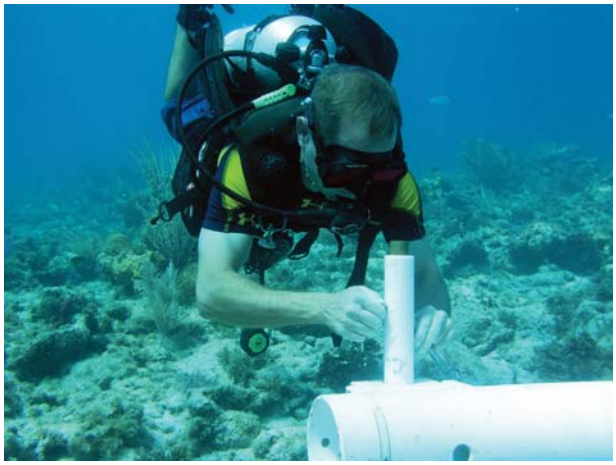
(View video clip "Invasive Species" at **http://soundwaves.usgs.gov/2011/06/fieldwork2.html**.)

- Monitoring groundwater and surface-water flow in real time using Acoustic Doppler Current Profilers (ADCPs). Research divers install and maintain these instruments in rivers, lakes, and estuaries nationwide. Data obtained are extremely valuable for estimating the magnitude of floods and when floodwaters will recede. (View video clip "Acoustic Doppler Current Profilers" at **http://soundwaves.usgs.gov/2011/06/fieldwork2.html**.)
- Acquiring data on coral calcification rates and coral health as ocean conditions change. Divers set up equipment and also monitor stations that measure baseline calcification rates and map metabolic characteristics of benthic communities off South Florida and in the Caribbean Sea.



USGS diver installs an Acoustic Doppler Current Profiler (ADCP) in Lake Ontario, New York. Research divers deploy and maintain these instruments in rivers, lakes, and estuaries nationwide to monitor groundwater and surface-water flow.

"The research that we do pertaining to coral reefs couldn't be done without scuba diving," said **Don Hickey**, a geologist and Eastern Region Dive Safety Officer at the St. Petersburg Coastal and Marine Science Center in Florida. "You need divers to set up instruments and collect data. Scuba is another tool used to conduct the science, and it needs to be done safely." (View video clip "Coral Reefs" at **http://soundwaves.usgs.gov/2011/06/fieldwork2.html**.)



***Don Hickey** attaches a PVC (polyvinyl chloride) housing to the seafloor. The instrument in the housing collects conductivity (related to salinity) and temperature data at a site in Dry Tortugas National Park where researchers are studying coral calcification.*

Setting up the tools and technology to study, monitor, and acquire underwater information takes expertise and extensive safety training in scuba diving. This is where the USGS Dive Safety Board comes in. The six members of the board—all active scientific divers—help manage USGS scuba diving activities and formulate the agency's dive-safety policies. They approve dive plans, identify dive-related safety issues, and develop annual program goals. Another 19 Dive Safety Officers in field facilities keep track of dive records, such as medical exams and training.

To be authorized to dive, USGS employees need to obtain supervisory approval, complete scuba certification, pass a dive medical exam, gain certifications in cardiopulmonary resuscitation (CPR) first aid and emergency oxygen administration, and pass an open-water checkout dive with a Dive Safety Officer. The authorization process ensures that USGS diving personnel have the training and experience necessary to dive safely while carrying out fieldwork.

The rigorous safety planning and preparation needed for a successful research dive were exemplified in fieldwork conducted almost a year ago at the Florida Middle Grounds, a roughly 460-mi^2 area about 120 mi off the northwest coast of Florida. The Middle Grounds support stony corals, nearly 200 fish species, sponges, and other marine life, as well as giant limestone pinnacles and ledges whose origins have long been a mystery to scientists. In early August 2010, 11 USGS research divers, along with an additional diver from the Florida Department of Environmental Protection and another from the National Coral Reef Institute, took shifts in pairs to descend 85 ft to the floor of the Gulf of Mexico, where they drilled into the seafloor to recover cores. The cores will reveal what lies beneath the modern ecosystem.

"There has always been an effort over the last 30 years to try and drill the Florida Middle Grounds because we didn't know if they accumulated in place like a coral reef or if they were erosional features," said **Hickey**. "Retrieved cores could provide information to help us answer that question, and dating the core could help us determine the timing of past sea levels in the region." Previous attempts at obtaining geologic information at the Florida Middle Grounds had been difficult because of the extreme depths and thus the high pressures in which scientists must work.

(USGS Scuba continued on page 6)

Florida and the Gulf of Mexico, showing approximate location of the Florida Middle Grounds (gray oval).

(USGS Scuba continued from page 5)

Before making the research dives, several USGS researchers and dive safety officers conducted reconnaissance to determine precise diving depths and to familiarize themselves with conditions, currents, and water temperatures at the site. "There is a lot of reconnaissance that is done prior to a dive. We run trips out to the dive site to see what the conditions are and what we will have to deal with," said **Blouin**. Information obtained through prior reconnaissance is vital to plan for the type of air to dive on, the tanks to use, the amount of bottom time, and the surface interval for each diver. Seismic-reflection profiles were also recorded and provided the science team with an idea of the subsurface structure.

Using Nitrox 36, a gas mixture composed of 36 percent oxygen and 64 percent nitrogen, researchers slowly dived to the ocean floor with tools in hand. These included hammers, wrenches, bolts, and other equipment necessary to construct a tripod on the seafloor and attach a drill. As the drill stem of core barrels churned deeper into the ocean floor, additional segments were attached to recover cores as long as 60 ft. The divers were split up into six dive teams that alternated descents. Each team spent about 40 minutes on the seafloor before ascending back to the surface. When the work was complete, the team members had collected four geologic cores ranging from 2 to 57 ft long that will tell the story of how the Florida Middle Grounds formed. Overall, 13 divers conducted 65 dives and collectively spent 101 hours underwater.

USGS scientists operate a hydraulic rotary drill to collect cores that will help them better understand the geology and formation of the Florida Middle Grounds.

Years ago, the ability to obtain geologic information at such depths, as well as constantly monitor biologic and hydrologic activity in the marine environment, would have seemed impossible. Today, such research is becoming more common and is a testament to improved diving techniques and enhanced technological capabilities.

Wildfire in the Florida Everglades Changes Fieldwork Schedule, Gives Scientists Views of Large Prescribed Burn

By Paul R. Nelson

Departing Flamingo Utility Basin in Florida's Everglades National Park on April 7, 2011, and boating north through Whitewater Bay, we noticed a thin plume of smoke rising midway along Cape Sable to the west. Our task for the day involved sampling five Surface Elevation Tables (SETs) established in 1996 and measured quarterly. (SETs are mechanical leveling devices for measuring the elevation change of wetland sediment; visit **http://www.pwrc.usgs.gov/set/** for more information.)

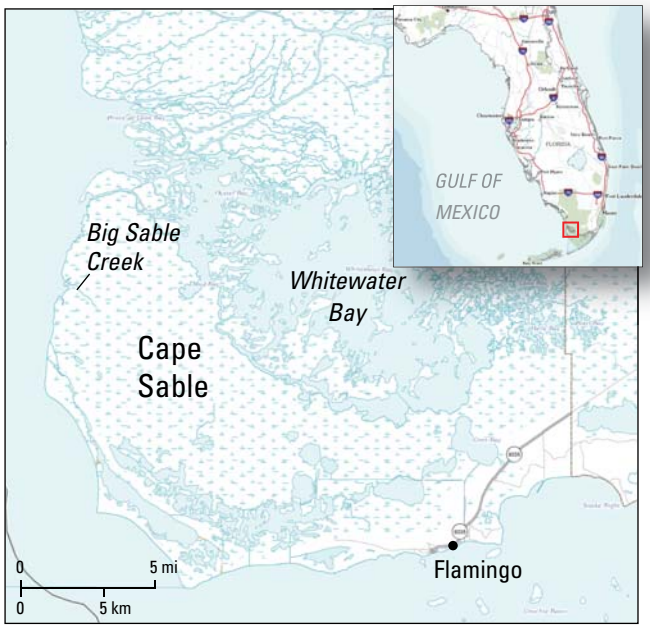
The SETs are located along Big Sable Creek on the northwest coast of Cape

(Cape Sable Fire continued on page 7)

*USGS intern **Marie Andersson** (see "New Intern from Sweden…" in* Sound Waves*, March 2011, **http://soundwaves.usgs.gov/2011/03/staff.html**) and the Cape Sable fire.*

Ash falling at Big Sable Creek hydrostation.

(Cape Sable Fire continued from page 6)



Cape Sable in southwest Florida (red square on inset map).

Sable within Everglades National Park. By the time we arrived, tethered our vessel to the shore, and set up our equipment, the sky had darkened and ash had begun to fall. Winds were light and steady from the southeast; I estimated that the fire was still several miles away and no threat to us.

The irony was that we had been scheduled to fly by helicopter that day to our sites up on the Lostmans River, many miles to the north, but because of a fire in Big Cypress National Preserve, ignited by lightning the day before, the National Park Service (NPS) needed the helicopter to assist in monitoring and containing that fire. The lack of a helicopter moved us up a day in our sampling schedule and routed us here within sight and smell of the Cape Sable fire.

After completing the sampling and exiting Big Sable Creek into the Gulf of Mexico for the return trip to Flamingo, we saw that the smoke had risen high above and drifted several miles westward out to sea. Running parallel to Cape Sable from north to south on the inside passage of Whitewater Bay, we saw now that much of the cape was burning, and new, isolated blazes were beginning to grow. I suspected a prescribed burn. The presence of NPS fire-management personnel had increased around Flamingo over the past few days, and the park had been under "high fire risk" for weeks.

Upon calling NPS Dispatch and closing our float plan, we were informed by an NPS employee that it was indeed a prescribed burn, involving nearly 8,000 acres, including much of the area burned by wildfire in 2008 as well as some areas not exposed to fire for more than 10 years. Fires are essential to the region in clearing, restoring, and maintaining habitat (especially that of the critically endangered Cape Sable Seaside Sparrow) and reducing the accumulation of hazardous fuel.

*Cape Sable Seaside Sparrow (*Ammodramus maritimus mirabilis*) in Everglades National Park. This individual was part of a demographic study of the effects of fire on sparrow abundance and nesting success. Photograph taken by* ***David A. La Puma*** *on January 8, 2006 (****http://en.wikipedia.org/wiki/File:CSSS1.jpg****)*

Smoke drifting off Cape Sable into the Gulf of Mexico.

Cape Sable fire reaching the shores of Whitewater Bay.

Extent and Speed of Lionfish Spread Unprecedented—Invasive Marine Fish May Stress Coral Reef Ecosystems

By Pam Schofield and Rachel Pawlitz

The rapid spread of lionfishes along the U.S. eastern seaboard, Gulf of Mexico, and Caribbean is the first documented case of a nonnative marine fish establishing a self-sustaining population in the region, according to recent U.S. Geological Survey (USGS) studies.

"Nothing like this has been seen before in these waters," said **Pam Schofield**, a research fishery biologist with the USGS Southeast Ecological Science Center in Gainesville, Florida. "We've observed sightings of numerous nonnative species, but the extent and speed with which lionfishes have spread has been unprecedented; lionfishes pretty much blanketed the Caribbean in three short years."

More than 30 species of nonnative marine fishes have been sighted off the coast of Florida alone (see *Field Guide to the Nonindigenous Marine Fishes of Florida* at **http://fl.biology.usgs.gov/Marine_Fish_ID/**), but none of these have demonstrated the ability to survive, reproduce, and spread successfully until now. Originally from tropical waters of the Indian and western Pacific Oceans, two species of lionfish, *Pterois volitans* and *Pterois miles*, have been documented spreading along the Atlantic coast of the United States and throughout the Caribbean. Their populations in the region are now self-sustaining.

It is not yet clear exactly how the new invasive species will affect coral reef ecosystems in this part of the world. Foremost on the minds of both citizens and scientists is the lionfishes' predatory behavior, which may negatively impact native species in the newly invaded reef ecosystems. Generalist species with a broad diet, they have already been observed preying on and competing with a wide range of native species.

Invasive lionfishes were first reported off Florida's Atlantic coast in the mid-1980s but did not become numerous in the region until 2000. Since then, the lionfish population has rapidly spread north along the Atlantic coast and south throughout most of the Caribbean. The spreading population is now working its way around the Gulf of Mexico.

*Adult lionfish, approximately 250 mm in total length. Photograph taken in October 2004 by **James Morris, Jr.**, an ecologist with NOAA's National Ocean Service, at his lab in Beaufort, North Carolina.*

Schofield spent years compiling and verifying lionfish sightings, reaching out to local experts such as biologists, museum curators, natural-resource managers, divemasters, and citizens' groups to collect detailed records of specimen collections and sightings throughout the region. The records were compiled in the USGS Nonindigenous Aquatic Species database (**http://nas.er.usgs.gov/**) and used to map the fishes' spread.

No one knows for sure exactly how the predecessors of the current population first made it into the Atlantic and Caribbean. It is unlikely, based on their biology, that lionfishes could have arrived as many marine invaders do, by hitching a ride in the ballast water of commercial ships.

Lionfishes have several distinct biological characteristics that may have helped them become established—their decorative spines, valued in the ornamental pet trade for their aesthetic appeal, are venomous to any would-be predators. Their broad diet, high reproductive potential, and ability to survive at a wide range of depths are other factors that may have helped them become established.

Schofield believes the invasion serves as a warning of the dangers posed by introductions of nonnative fishes into an ecosystem. Some scientists even view invasive species as a form of biological pollution, notes **Schofield**, who is concerned about the possibility of other nonnative fishes becoming established. One thing is clear—as the first exotic fish species to actively breed and expand into Caribbean reefs, the lionfish illustrates the relatively short time required by nonnative marine fishes, once established, to spread.

"This invasion may constitute a harbinger of the emerging threat of nonnative marine fishes to coastal systems," **Schofield** said.

In the Florida Keys, **Schofield** and her team are working closely with partners from the National Oceanic and Atmospheric Administration (NOAA) in Beaufort, North Carolina, and Reef Environmental Education Foundation (REEF) in Key Largo, Florida, to analyze lionfish diets, an important first step in understanding their impact on reef ecosystems.

Eradication of lionfishes is probably not possible, admits **Schofield**. Yet, local control efforts may be able to keep the population tamped down, releasing pressure on the native ecosystem. Many Caribbean countries, such as Bermuda and the Cayman Islands, have begun lionfish control programs. In the United States, REEF held a series of lionfish derbies in the Florida

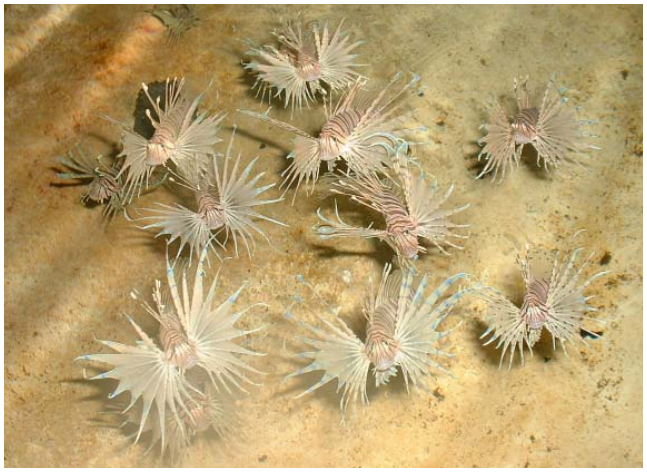
(Lionfish Spread continued on page 9)

(Lionfish Spread continued from page 8)

Keys that resulted in more than 600 lionfishes being removed from the Florida Keys National Marine Sanctuary.

Schofield's most recent paper, "Update on geographic spread of invasive lionfishes (*Pterois volitans* [Linnaeus, 1758] and *P. miles* [Bennett, 1828]) in the western North Atlantic Ocean, Caribbean Sea and Gulf of Mexico," was published in December 2010 in volume 5, supplement 1 of the journal *Aquatic Invasions* (**http://dx.doi.org/10.3391/ai.2010.5.S1.024**); it updates a September 2009 article published in the same journal (**http://dx.doi.org/10.3391/ai.2009.4.3.5**).

For more information on lionfishes, visit the USGS Nonindigenous Aquatic Species lionfish page at **http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=963**. Background on lionfish biology and ecology is also available on NOAA's Invasive Lionfish Web site at **http://www.ccfhr.noaa.gov/stressors/lionfish.aspx**. Visit **http://www.reef.org/programs/exotic/lionfish** for information on REEF's Lionfish Research Program. ❁



*Group of juvenile lionfish, each fish approximately 120 mm in total length. Photograph taken in October 2004 by **James Morris, Jr.**, an ecologist with NOAA's National Ocean Service, at his lab in Beaufort, North Carolina.*

Life in San Francisco Bay Influenced by Factors Far Out at Sea

By Paul Laustsen and Jim Cloern

Marine life in San Francisco Bay has flourished over the past decade in concert with a large-scale climatic shift originating far out in the Pacific Ocean, according to a U.S. Geological Survey (USGS) study released in November 2010. The study challenges the established principle that water quality in bays and estuaries is driven primarily by human-caused changes in the surrounding landscape.

By documenting changes in two dominant climatic cycles in the north Pacific basin and looking at correlations with population abundances of marine life over the past 30 years, scientists have linked broader changes in climate to local manifestations, including record-high abundances of marine species in San Francisco Bay.

"While some native species of fish are near extinction in the upstream [Sacramento-San Joaquin] Delta, bottom fish, crabs, and shrimp are thriving in the marine waters of the bay," said **Jim Cloern**, research ecologist with the USGS. "Discovery that the bay's biological communities are linked to climate patterns thousands of miles offshore is essential information for environmental managers."

Studying trends revealed by three decades of observation, scientists from the USGS, the California Department of Fish and Game, the National Oceanic and Atmospheric Administration (NOAA), and five universities found that one particular atmospheric pattern over the Pacific Ocean developed in 1999 and has persisted through most of the 2000s. This atmospheric pattern resulted from the interaction of two large-scale climatic cycles known as the Pacific Decadal Oscillation and the North Pacific Gyre Oscillation. The atmospheric pattern altered winds, ocean currents, and upwelling to establish a coastal habitat that promotes the population growth of flatfish, crab, and shrimp species that migrate into estuaries such as San Francisco Bay.

USGS scientists have monitored San Francisco Bay continually since 1968, resulting in hundreds of scientific articles to draw from for this study.

The report "Biological Communities in San Francisco Bay Track Large-Scale Climate Forcing Over the North Pacific" was released November 8, 2010, in the journal *Geophysical Research Letters*, at **http://dx.doi.org/10.1029/2010GL044774**. The full citation is Cloern, J.E., Hieb, K.A., Jacobson, T., Sansó, B., Di Lorenzo, E., Stacey, M.T., Largier, J.L., Meiring, W., Peterson, W.T., Powell, T.M., Winder, M., and Jassby, A.D., 2010, Biological communities in San Francisco Bay track large-scale climate forcing over the North Pacific: Geophysical Research Letters, v. 37, L21602, 6 p., doi:10.1029/2010GL044774. ❁

*The Dungeness crab (*Metacarcinus magister*), whose range extends from the Aleutian Islands to the coast of California, is one of the species whose populations in San Francisco Bay have increased with a large-scale climatic shift that began in 1999. Photograph courtesy of the U.S. Fish and Wildlife Service (**http://en.wikipedia.org/wiki/File:DungenessCrab.jpg**).*

USGS Scientist Wins National Wildlife Federation Award

By Jennifer LaVista

U.S. Geological Survey (USGS) scientist **Virginia Burkett** was awarded the 2011 National Wildlife Federation's (NWF) National Conservation Achievement Award for Science at the NWF awards gala on April 13, in Washington, D.C.

Burkett shared the stage with other prestigious award winners, including actor **Robert Redford** and **U.S. Senator Richard Lugar**. The National Conservation Achievement Awards—known informally as the "Connie Awards"—were established in 1965 to recognize individuals and organizations playing a leadership role in advancing knowledge and action to protect and restore our environment.

USGS Senior Scientist for Climate and Land Use Change, **Burkett** was an early leader in the movement for addressing climate change when she began focusing on the issue in 1990. She has since become known as one of the most knowledgeable and accomplished scientists in the field. **Burkett** was a lead author of the United Nation's Intergovernmental Panel on Climate Change (IPCC) Third and Fourth Assessment Reports, for which the IPCC received the 2007 Nobel Peace Prize. Her leadership in these efforts has contributed immensely to the public's understanding of the scientific basis for responding to global warming and land-cover change. **Burkett** has been tireless in her efforts to educate professional and lay audiences about climate change and its impacts on natural resources.

Currently based in Many, Louisiana, **Burkett** was formerly Chief of the Forest Ecology Branch at the USGS National Wetlands Research Center in Lafayette, Louisiana. **Burkett** has also served as Secretary/Director of the Louisiana Department of Wildlife and Fisheries, Acting Director of the Louisiana Coastal Zone Management Program, and Assistant Director of the Louisiana Geological Survey. She received her doctoral degree in forestry from Stephen F. Austin State University in Nacogdoches, Texas, in 1996.

The National Wildlife Federation was established 75 years ago and is one of America's premier conservation organizations. To learn more about the Connie Awards, visit the National Wildlife Federation Web site at **http://www.nwf.org/About/Conservation-Awards/Honorees.aspx**.

Virginia Burkett *(left) and* ***Gloria Reuben*** *(actress from the TV show* ER*) next to one of the crane awards given to each award recipient.*

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(Recently Published continued from page 10)

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