USGS

Sound Waves

Coastal and Marine Research News from Across the USGS

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Research

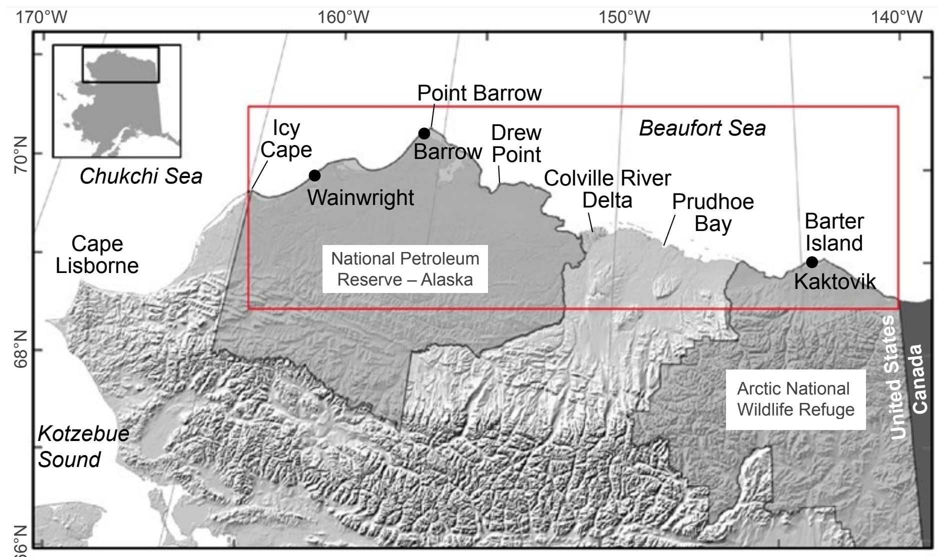
Northern Alaska Coastal Erosion Threatens Habitat and Infrastructure

By Paul Laustsen and Ann Gibbs

In a new study published July 2015, scientists from the U.S. Geological Survey (USGS) found that the remote northern Alaska coast has some of the highest shoreline-erosion rates in the nation. Analyzing more than half a century of shoreline-change data, scientists discovered that the pattern is extremely variable, with most of the coast retreating at rates of more than 1 meter per year.

"Coastal erosion along the Arctic coast of Alaska is threatening Native Alaskan villages, sensitive ecosystems, energy- and defense-related infrastructure, and large tracts of Native Alaskan, State, and Federally managed land," said **Suzette Kimball**, acting director of the USGS.

Scientists studied more than 1,600 kilometers of the Alaskan coast between the U.S.-Canadian border and Icy Cape, Alaska, and found that the average rate of shoreline change, taking into account beaches that are both eroding and expanding, was a loss of 1.4 meters per year. Of those beaches that are eroding, the most extreme case exceeded 18.6 meters per year.

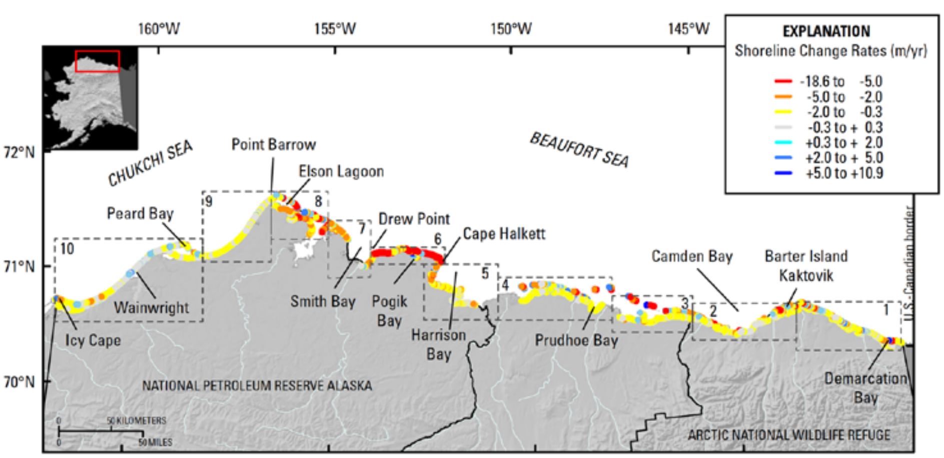


*Shaded-relief map of the north coast of Alaska showing study area (U.S.-Canadian border to Icy Cape; rectangular box) and selected geographic locations. Modified from figure 1 of "National Assessment of Shoreline Change: Historical Shoreline Change Along the North Coast of Alaska, U.S.-Canadian Border to Icy Cape" (<**http://dx.doi.org/10.3133/ofr20151048**>).*

"This report provides invaluable objective data to help Native communities, scientists, and land managers understand natural changes and human impacts on the Alaskan coast," said **Ann Gibbs**, USGS geologist and lead author of the new report.

Coastlines change in response to a variety of factors, including changes in the amount of available sediment, storm impacts, sea-level rise, and human activities. How much a coast erodes or expands in any given location is due to some combination of these factors, which vary from place to place.

(Coastal Erosion continued on page 2)



*North coast of Alaska study area showing color-coded shoreline-change rates, boundaries of the 10 analysis regions (dashed boxes and numbers) used in the study, and key geographic locations. Figure 72 in "National Assessment of Shoreline Change: Historical Shoreline Change Along the North Coast of Alaska, U.S.-Canadian Border to Icy Cape" (<**http://dx.doi.org/10.3133/ofr20151048**>).*

Sound Waves

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Submission Guidelines

Deadline: The deadline for news items and publication lists for the Oct./Nov. issue of *Sound Waves* is Wednesday, October 14, 2015.
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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Need to find natural-science data or information? Visit the USGS Frequently Asked Questions (FAQ's) at URL **http://www.usgs.gov/faq/**
Can't find the answer to your question on the Web? Call 1-888-ASK-USGS
Want to e-mail your question to the USGS? Send it to this address: ask@usgs.gov

(Coastal Erosion continued from page 1)

"There is increasing need for this kind of comprehensive assessment in all coastal environments to guide managed response to sea-level rise and storm impacts," said **Bruce Richmond**, USGS research geologist and coauthor of the new report. "It is very difficult to predict what may happen in the future without a solid understanding of what has happened in the past. Comprehensive regional studies such as this are an important tool to better understand coastal change."

The recent study is part of the National Assessment of Coastal Change Hazards (<**http://marine.usgs.gov/coastalchangehazards/**>), a USGS project that combines observation and modeling of the nation's shorelines to help identify areas most vulnerable to diverse coastal change hazards, including beach and dune erosion, long-term shoreline change, and sea-level rise.

Compared with other coastal areas of the United States, where typically four or more historical shoreline data sets are available, generally back to the mid-1800s, shoreline data for the coast of Alaska are limited. The researchers used two historical data sources, from the 1940s and 2000s, which include maps and aerial photographs, as well as modern sources, such as elevation data from lidar ("light detection and ranging," <**https://lta.cr.usgs.gov/LIDAR**>). Combining the historical and modern data, the researchers calculated shoreline change at nearly 27,000 locations.

There is no widely accepted standard for analyzing shoreline change. One impetus behind the National Assessment of Coastal Change Hazards project was to develop a standardized method of measuring changes in shoreline position that is consistent on all coasts of the country. The goal was to facilitate the process of periodically and systematically updating the results in a consistent manner.

The new report, titled "National Assessment of Shoreline Change: Historical Shoreline Change Along the North Coast of Alaska, U.S.-Canadian Border to Icy Cape" (<**http://dx.doi.org/10.3133/ofr20151048**>), is the eighth report on Long-Term Coastal Change (<**http://marine.usgs.gov/coastalchangehazards/research/long-term-change.html**>) produced as part of the USGS National Assessment of Coastal Change Hazards project (<**http://marine.usgs.gov/coastalchangehazards/**>). A comprehensive database of digital vector shorelines and rates of shoreline change for Alaska from the U.S.-Canadian border to Icy Cape (<**http://dx.doi.org/10.3133/ofr20151030**>) is presented along with this report. Data for all eight long-term coastal change reports are also available on the USGS Coastal Change Hazards Portal (<**http://marine.usgs.gov/coastalchangehazardsportal/**>).

(Coastal Erosion continued on page 3)

*Erosion of the coastal bluff on Barter Island, 2011. Photograph by **Benjamin Jones**, USGS Alaska Science Center.*

(Coastal Erosion continued from page 2)

*Screenshot from sequence of time-lapse photographs of Barter Island in Alaska during three summer months in 2014. Note the slumping bluffs. The full time-lapse video, at <**https://walrus.wr.usgs.gov/climate-change/hiLat.html**>, shows melting of pack ice and subsequent impacts to the beach and bluffs by storms.*

Oblique aerial photograph from 2006 showing the Barter Island long-range radar station landfill threatened by coastal erosion. The landfill was subsequently relocated further inland; the coastal bluffs continue to retreat. ☸

Climate Change Reduces Coral Reefs' Ability to Protect Coasts

By Ap van Dongeren (Deltares), Leslie Gordon (USGS), and Curt Storlazzi (USGS)

Climate change may reduce the ability of coral reefs to protect tropical islands against wave attack, erosion, and salinization of the drinking-water resources that help to sustain life on those islands. A new paper by researchers from the Dutch independent institute for applied research Deltares (<**https://www.deltares.nl/en/**>) and the U.S. Geological Survey (USGS) gives guidance to coastal managers to assess how climate change will affect a coral reef's ability to mitigate coastal hazards.

*Aerial photograph of Kwajalein Atoll in the Republic of the Marshall Islands, showing its low-lying islands and coral reefs. The line of breaking waves on the left marks the reef crest, where much of the waves' energy is dissipated. Additional energy is lost through friction as the water flows shoreward over the rough surface of the healthy reef flat. USGS photograph taken May 2015 by **Tom Reiss**.*

About 30 million people live on low-lying coral islands and atolls where they depend on coral reefs for protection against waves. Healthy coral reefs have rough surfaces and complex structures that slow incoming waves. Coral reef health, however, is threatened by the effects of climate change, including ocean acidification caused by increasing carbon dioxide in the atmosphere and ocean, coral bleaching caused by warming ocean temperatures, and smothering and light reduction caused by sediment stirred up by large waves that will become more common as sea-level rise outstrips coral reef growth.

At present, some low-lying tropical islands are flooded by wave events a few times per decade. It is expected that this rate of flooding will increase as sea level rises and coral reefs decay, because the remaining dead corals are generally smoother in structure and do less to dissipate wave energy. Loss of coral cover not only causes increased shoreline erosion but also affects the sparse drinking-water resources on these islands by allowing saltwater to wash inland. Deterioration of freshwater resources may eventually make some islands uninhabitable.

In order to prevent or mitigate these impacts, coastal managers need know to what extent their reef system may

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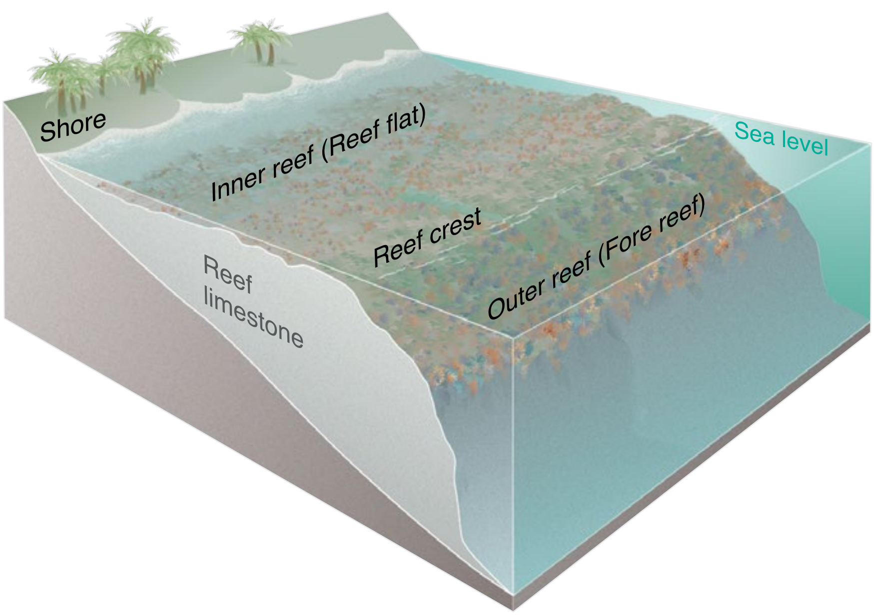
lose its protective function so that they can take action. The new paper, titled "The influence of coral reefs and climate change on wave-driven flooding of tropical coastlines," gives guidance on a local reef's sensitivity to change. It was published 4 August 2015 in *Geophysical Research Letters*, a journal of the American Geophysical Union, at <**http://dx.doi.org/10.1002/2015GL064861**>.

To gain insight into effects of changing conditions on coral reefs, the study authors used Xbeach, an open-source wave model (<**http://oss.deltares.nl/web/xbeach/**>). The computer model was first validated with field measurements obtained on the Kwajalein Atoll in the Republic of the Marshall Islands in the Pacific Ocean, and was then used to investigate how changes in certain reef properties would affect water levels, waves, and wave-driven runup (the maximum height above sea level reached by the uprushing wave). Reef roughness, steepness, width, and the water depth above the reef platform are all important factors for coastal managers to consider when planning mitigating measures.

*In March 2014, a combination of unusually high tides and large swells flooded many areas within the Republic of the Marshall Islands. During this event, seawater regularly topped the manmade perimeter berm on the island of Roi-Namur and covered large areas of the adjacent land surface (see <**http://soundwaves.usgs.gov/2014/04/**>). Such events are likely to occur more frequently as sea level continues to rise. Inset shows location of photograph, taken March 2, 2014, by **Peter Swarzenski**, USGS. The paper at <**http://dx.doi.org/10.1002/2015GL064861**> provides details about the wave data collected during this event.*

The results suggest that coasts fronted by relatively narrow reefs with steep faces and deeper, smoother reef flats are expected to experience the highest wave runup and thus the greatest potential for island flooding. Wave runup increases for higher water levels (expected with sea-level rise), higher waves, and lower bed roughness (as coral degrades and becomes smoother), which are all expected effects of climate change. The authors conclude that rising sea levels and climate change will have a significant negative impact on the ability of coral reefs to mitigate the effects of coastal hazards in the future.



*Many coral reefs consist of nearshore inner reef flats that slope to deeper water fore reefs farther offshore. The reef crest, between the inner reef flat and outer fore reef, lies in extremely shallow water and may be exposed during the lowest tides. Waves commonly crash against or break on the reef crest. From "U.S. Coral Reefs—Imperiled National Treasures," <**http://pubs.usgs.gov/fs/2002/fs025-02/**>.*

The research paper, published as an open-access paper, is available online at <**http://dx.doi.org/10.1002/2015GL064861**>.

The complete citation is:

Quataert, E., Storlazzi, C., van Rooijen, A., Cheriton, O., and van Dongeren, A., 2015, The influence of coral reefs and climate change on wave-driven flooding of tropical coastlines, Geophysical Research Letters, 42, doi: 10.1002/2015GL064861 [**http://dx.doi.org/10.1002/2015GL064861**].

Learn more about USGS coral reef studies in the Pacific at <**http://coralreefs.wr.usgs.gov/**>. Learn more about Deltares, an independent institute for applied research in the field of water and subsurface, at <**https://www.deltares.nl/en/**>. ☸

Polar Bears Forced on Shore by Sea-Ice Loss Are Unlikely to Thrive on Land-Based Foods

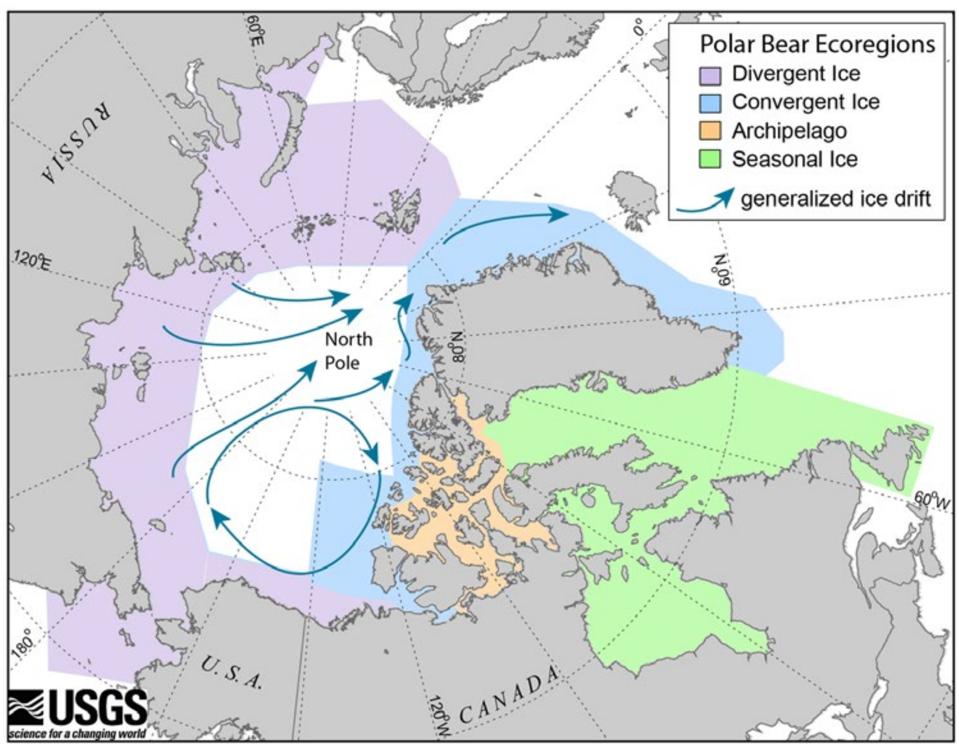
By Karyn Rode, Todd Atwood, Paul Laustsen, and Catherine Puckett

Two studies by the U.S. Geological Survey (USGS) suggest a rough outlook for polar bears as climate warming continues to reduce sea ice in the Arctic. In a review article published in the April 2015 issue of *Frontiers in Ecology and the Environment*, titled "Can Polar Bears Use Terrestrial Foods to Offset Lost Ice-Based Hunting Opportunities?" (<**http://dx.doi.org/10.1890/140202**>), the authors report that polar bears forced on shore due to sea-ice loss may be eating terrestrial foods, including berries, birds, and eggs, but any nutritional gains are limited to a few individuals and likely cannot compensate for lost opportunities to consume their traditional, lipid-rich prey—ice seals. They conclude that "Warming-induced loss of sea ice remains the primary threat faced by polar bears."

Polar bear climbing onto the sea ice after a swim in the Chukchi Sea off the northwest coast of Alaska. USGS photograph taken June 15, 2014, by ***Brian Battaile****.*

The second study, "Evaluating and Ranking Threats to the Long-Term Persistence of Polar Bears" (<**http://dx.doi.org/10.3133/ofr20141254**>), reports results from a recently updated USGS forecasting model indicating that the state of the worldwide polar bear population will likely worsen over time through the end of this century, mainly because of continuing sea-ice loss.

The modeling effort examined the prognosis for polar bear populations in four ecoregions (see map) using sea-ice projections from the Intergovernmental Panel on Climate Change for two greenhouse gas emission scenarios: one scenario in which climate warming is stabilized by century's end because of reduced greenhouse gas emissions, and the other in which the unabated rise of greenhouse gas emissions leads to increased warming by century's end. Under both scenarios, the outcome for the worldwide polar bear population will very likely worsen over time through the end of the century.



*Map of the four ecoregions that make up the polar bear's range, plus a depiction of seasonal patterns of ice motion and distribution. Simplified from figure 1 in USGS Open-File Report 2014–1254, "Evaluating and Ranking Threats to the Long-Term Persistence of Polar Bears" (<****http://dx.doi.org/10.3133/ofr20141254****>).*

"Substantial sea ice loss and expected declines in the availability of marine prey that polar bears eat are the most important

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((Polar Bears continued from page 5)

specific reasons for the increasingly worse outlook for polar bear populations," said **Todd Atwood**, research wildlife biologist with the USGS and lead author of the modeling study. "We found that other environmental stressors such as trans-Arctic shipping, oil and gas exploration, disease and contaminants, sustainable harvest, and defense-of-life takes, had only negligible effects on polar bear populations—compared with the much larger effects of sea-ice loss and associated declines in their ability to access fat-rich marine mammal prey."

Few foods are as energetically dense as marine prey. Studies suggest that polar bears consume the highest lipid diet of any species, which provides all essential nutrients and is ideal for maximizing fat deposition and minimizing energetic requirements. Potential foods found in the terrestrial environment are dominated by high-protein, low-fat animals and vegetation. Although most bear species consume at least some vegetation, bears that consume high dietary proportions of vegetation are among the smallest. For example, Arctic grizzly bears whose diet is primarily vegetation are the smallest of their species and occur at the lowest densities of any populations. Thus, it would be difficult for polar bears, the largest of all bears, to ingest and digest sufficient volumes of terrestrial foods required to support their large body size.

"The evidence thus far suggests that increased consumption of terrestrial foods by polar bears is unlikely to offset declines in body condition and survival resulting from sea-ice loss," said **Karyn Rode**, a USGS research wildlife biologist who is the lead author of the *Frontiers in Ecology and the Environment* paper and a coauthor of the modeling study.

The modeling study was conducted by USGS scientists together with collaborators from the U.S. Forest Service and Polar Bears International; the full report is available online at <**http://dx.doi.org/10.3133/ofr20141254**>, and a fact sheet summary is at <**http://dx.doi.org/10.3133/fs20153042**>. The review article was written by researchers at the USGS, Washington State University,

Polar bear lying on the sea ice to dry off after a swim in the Chukchi Sea, Alaska. USGS photograph taken June 15, 2014, by ***Brian Battaile****.*

and Polar Bears International and is available online at <**http://dx.doi.org/10.1890/140202**>. Both studies are part of the USGS Changing Arctic Ecosystems Initiative (<**http://alaska.usgs.gov/science/interdisciplinary_science/cae/**>). For further information, read about USGS Polar Bear Research at <**http://alaska.usgs.gov/science/biology/polar_bears/**>. ❆

Many Dry Tortugas Loggerheads Actually Bahamas Residents

By Kristen Hart and Gabrielle Bodin

Many loggerhead sea turtles (*Caretta caretta*) that nest in Dry Tortugas National Park head to rich feeding sites in the Bahamas after nesting, a discovery that may help those working to protect this threatened species.

Researchers from the U.S. Geological Survey (USGS) used satellites to track the population of loggerheads that nest in the Dry Tortugas—the smallest subpopulation of loggerheads in the northwest Atlantic—and found that the turtles actually spend a considerable part of their lives in the Bahamas, returning to the Dry Tortugas to nest every two to five years. They then spend three to four months nesting in the Dry Tortugas before returning to the Bahamas.

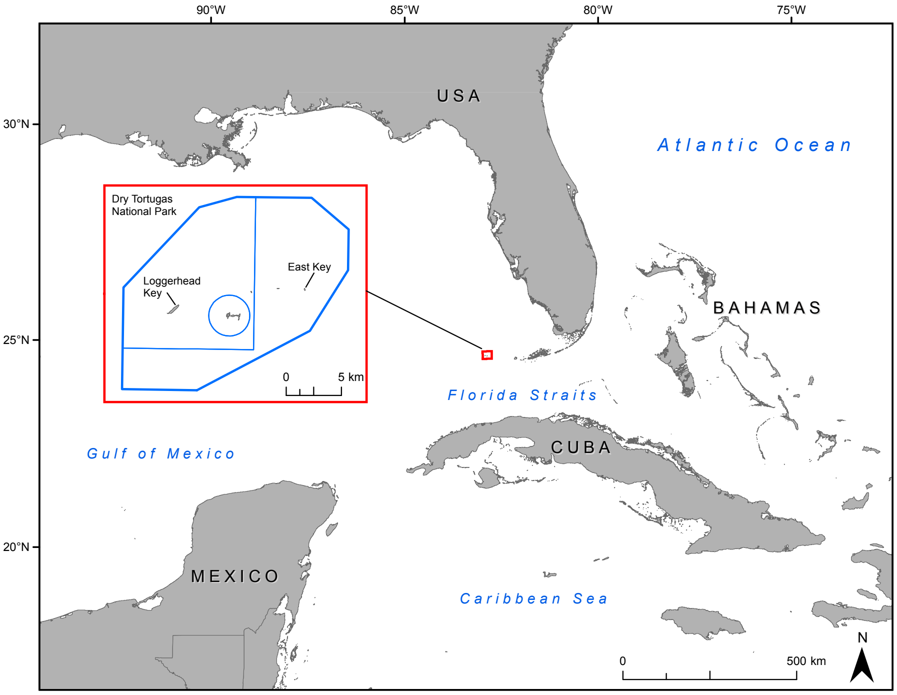
*Young loggerhead sea turtle (*Caretta caretta*) escaping a net equipped with a turtle excluder device (TED; <**http://www.nmfs.noaa.gov/pr/species/turtles/teds.htm**>). TEDs were developed to reduce a major threat to sea turtles: incidental capture in fishing gear. Photograph courtesy of National Oceanic and Atmospheric Administration (NOAA).*

This new article—published in February 2015 in the journal *Animal Biotelemetry* (<**http://dx.doi.org/10.1186/s40317-014-0019-2**>)—will help resource managers better identify areas to target for conservation efforts.

"Collaborative conservation efforts focused on protecting important loggerhead residence and foraging areas between the United States and Bahamas could offer significant protection for the Dry Tortugas loggerheads," said USGS research ecologist **Kristen Hart**, lead author of the study. "Two other subpopulations of loggerheads that nest in northern and pen-

(Dry Tortugas Loggerheads continued on page 7)

(Dry Tortugas Loggerheads continued from page 6)



*Female loggerhead sea turtles (*Caretta caretta*) were tagged at Loggerhead Key and East Key in Dry Tortugas National Park (zoomed-in area in red box; thick blue line is outer boundary of the park, thin blue line delineates management zones within the park). Turtles migrated from the Dry Tortugas through Florida Straits to the Bahamas. Figure 1 from paper at <**http://dx.doi.org/10.1186/s40317-014-0019-2**>.*

insular Florida and also travel to residence areas in the Bahamas would benefit from this protection as well."

The current estimate of the subpopulation of loggerheads that nest in the Dry Tortugas hovers between 258–496 females. Populations of the turtle are difficult to estimate. Loggerheads start nesting when they are approximately 25 years old, and then nest every two to five years until they die. Researchers have found that marking females that return to the same beach to nest every two to five years is the most practical way to get an indication of population size.

The northwest Atlantic population of loggerhead turtles is listed as "threatened" under the Endangered Species Act (<**http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=C00U**>), which provides them protection from intentional harm or harvest and protects their most important habitats within the United States and its waters.

In this study, researchers tracked marked turtles over six nesting seasons. Results showed that the turtles selected almost the exact same residence area in the Bahamas during their second tracking event. In addition, tracking data showed that individual residence areas generally did not overlap, leading the scientists to believe that loggerheads at this foraging ground may establish territories.

Turtles tagged in more than one Dry Tortugas nesting season showed similar migration paths and timing as compared with their own previous migrations. Their migratory paths included the Florida Straits, a major shipping lane where ship strikes could threaten the turtles.

After traveling through non-protected waters from the Dry Tortugas, the turtles primarily selected residence areas in non-protected zones in the Bahamas. Although direct turtle harvest has been illegal in the Bahamas since 2009, commercial fishing has the potential to impact the loggerheads' food resources and poses a direct threat to them as they can become entangled in lines attached to gear.

Loggerhead sea turtles are primarily carnivorous and feed mostly on shellfish that live on the bottom of the ocean, such as horseshoe crabs, clams, mussels, and other invertebrates. Their powerful jaw muscles help them to easily crush the shellfish. Once they reach sexual maturity, the turtles nest every two to five years, depositing two to six clutches of 75 to 120 eggs approximately every two weeks during the nesting season. After nesting, they migrate back to their foraging site.

The northwest Atlantic loggerhead nesting numbers declined sharply in the 1990s and then increased over the past six years, making it difficult to assess the trend at this point. Scientists remain concerned about the ongoing threats to this population, which include loss or degradation of nesting habitat from coastal development and beach armoring, disorientation of hatchlings by beachfront lighting, nest predation by native and non-native predators, degradation of foraging habitat, marine pollution and debris, watercraft strikes, disease, and incidental take from channel dredging and commercial trawling, longline, and gill net fisheries.

Future studies to characterize the resources within residence areas and individual loggerhead behaviors at their residence areas will also help to guide conservation efforts.

The study, "Bahamas connection: residence areas selected by breeding female loggerheads tagged in Dry Tortugas National Park, USA," by **Kristen M. Hart** (USGS), **Autumn R. Sartain** (contractor with the USGS), and **Ikuko Fujisaki** (University of Florida) is available at <**http://dx.doi.org/10.1186/s40317-014-0019-2**>. ❁

Loggerhead sea turtle hatchling. Photograph courtesy of U.S. Fish and Wildlife Service (USFWS).

USGS Oceanographer Participating on Collaborative U.S. and Canadian Research Cruise in the Davis Strait between Greenland and Canada

By Kira Barerra

U.S. Geological Survey (USGS) scientist **Lisa Robbins** is aboard the research vessel (R/V) *Atlantis* in the Davis Strait near the Arctic Circle. The cruise, a collaborative effort between U.S. and Canadian scientists, runs from September 4–26, 2015, and is led by **Craig Lee**, a Senior Principal Oceanographer at the University of Washington's Applied Physics Laboratory. This cruise is part of the Go-Ship Program (<**http://www.go-ship.org/**>), which has been deploying and retrieving physical oceanographic instrumentation and collecting chemical oceanographic data in the select areas since 2003.

The cruise focuses on the Davis Strait, which connects the North Atlantic and the Arctic Ocean through the Canadian Arctic Archipelago and Baffin Bay. Currents through the archipelago are integrated at the strait, making it an ideal location to observe the interaction between the Arctic Ocean and the North Atlantic. The rapidly changing polar environment—including melting sea ice, surface warming, enhanced transport of warm water from the south, and Greenland ice-sheet melt—can influence air-sea carbon dioxide (CO_2) flux, nutrient cycles, and ocean acidification (<**http://coastal.er.usgs.gov/ocean-acidification/overview.html**>), providing an opportunity to collect data critical for understanding climate change.

Robbins and **Jonathan Wynn** (University of South Florida–USF) will collect both discrete seawater samples and data acquired underway from water in the ship's "uncontaminated seawater system," which takes in seawater and delivers it to different laboratories on the ship. Discrete samples will be collected, preserved, and sealed for later analysis of total alkalinity, total carbon, and dissolved organic carbon. Surface seawater will be analyzed onboard for oxygen and carbon isotopes, partial pressure of CO_2 (pCO_2), and pH. Three different instruments will be used to measure pH: a SeaFET Ocean pH Sensor, a spectrophotometer, and a new handheld pH photometer recently developed by USGS and USF and funded by a USGS Innovations grant. The cruise is the first field test of the handheld pH photometer, and its measurements will be compared to those obtained from the other instruments. Atmospheric CO_2 will be monitored throughout the cruise using a real-time trace gas monitor capable of measuring gases at concentrations of parts per billion.

Canadian scientists from the Bedford Institute of Oceanography will collect data "on station" (while the ship is stopped), including samples for analysis of dissolved inorganic carbon and alkalinity, pCO_2 and methane, oxygen, nutrients, transient tracers (sulfur hexafluoride [SF6]; <**http://www.whoi.edu/oceanus/feature/transient-tracers-track-ocean-cimate-signals**>) and dichlorodifluoromethane [CFC-12]) and oxygen isotopes. They will also collect underway pCO_2 measurements and phytoplankton and zooplankton information.

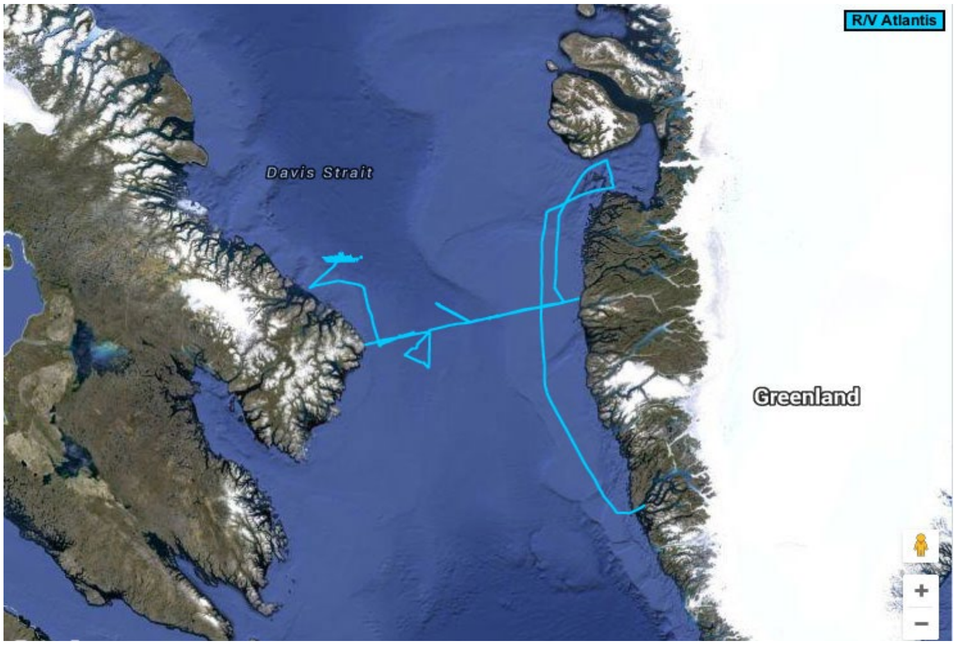
Robbins and Wynn will compare data collected during the 2015 cruise to car-

(Davis Strait Research Cruise continued on page 9)

*USGS scientist **Lisa Robbins** next to the research vessel (R/V)* Atlantis*, which is owned by the U.S. Navy and operated by the Woods Hole Oceanographic Institution (<**http://www.whoi.edu/main/ships/atlantis**>).*

Fieldwork, continued

(Davis Strait Research Cruise continued from page 9)



Screenshot on September 3, 2015, of the track of the R/V Atlantis *displayed on the Woods Hole Oceanographic Institution's website (<***http://www.whoi.edu/main/ships/atlantis***>).*

bonate chemistry data collected previously from Arctic cruises (2010–2012) in higher latitudes. These comparisons will be used to understand ocean acidification and carbon fluxes in the Arctic and sub-Arctic. (See related Sound Waves articles "Unprecedented Rate and Scale of Ocean Acidification Found in the Arctic," <**http://soundwaves.usgs.gov/2013/12/research2.html**>; "USGS Arctic Ocean Research: A Polar Ocean Acidification Study," <**http://soundwaves.usgs.gov/2011/08/**>; and "Ocean Acidification: Research on Top of the World," <**http://soundwaves.usgs.gov/2010/08/fieldwork2.html**>).

For more information about the 2015 Davis Strait - Arctic Circle cruise, including blog posts from scientists onboard, visit: <**http://coastal.er.usgs.gov/ocean-acidification/arcticcruise2015/**>. ☸

Spotlight on Sandy

Detailed Flood Information Key to More Reliable Coastal Storm Impact Estimates

By Christopher Schubert, Ronald Busciolano, and Vic Hines

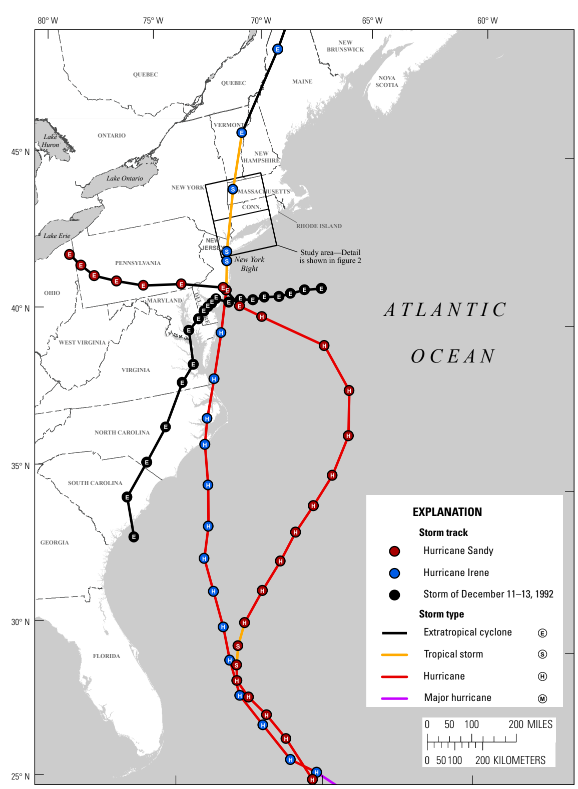
A new study that looked in part at how damage estimates evolve following a storm puts the total amount of building damage caused by Hurricane Sandy for all evaluated counties in New York at $23 billion. Estimates of damage by county ranged from $380 million to $5.9 billion.

The study, "Analysis of storm-tide impacts from Hurricane Sandy in New York," U.S. Geological Survey (USGS) Scientific Investigations Report 2015–5036, prepared in cooperation with the Federal Emergency Management Agency (FEMA), marks the first time the agency has done this type of analysis and cost estimation for a coastal storm.

"We looked at how estimates of building damage change depending on the amount of information available at the time of the estimate, looking at three time periods—storm landfall, two weeks later, and then three months later," said **Chris Schubert**, a USGS hydrologist and lead author of the study. "What we found was that the biggest jump in estimate reliability comes between the initial estimate and the two-week mark, but that the additional information available three months after an event greatly helps refine the estimates even further."

The USGS researcher called the study a "proof of concept" that really showcased the value of gathering storm data

(Detailed Information is Key continued on page 10)



*Location of study area in New York and tracks of Hurricane Sandy, Tropical Storm Irene, and the storm of December 11–13, 1992, in the North Atlantic region. From figure 1 in "Analysis of storm-tide impacts from Hurricane Sandy in New York" (<***http://dx.doi.org/10.3133/sir20155036***>).*

(Detailed Information is Key continued from page 9)

before and after a storm.

"FEMA funded the sensor placement we did prior to the storm and our assessment of how high the water reached after the storm," Schubert said. "The results from this new study demonstrated how the additional resolution and accuracy of flood depictions resulting from these efforts greatly improved the damage estimates."

Damage estimates can be used by FEMA and other stakeholders to help prioritize relief and reconstruction efforts following a storm. The results can also assist with resiliency planning that helps communities prepare for future storms.

The researchers came up with the estimates by using census data and FEMA's HAZUS (<**https://www.fema.gov/hazus**>) modeling software program. The HAZUS program is used to estimate potential loss from disasters such as earthquakes, wind, hurricanes, and floods. This program allows for an assessment of building loss on a block-by-block level.

Hurricane Sandy's impact was the first time in recent memory, and record, that coastal water levels had reached the heights they attained in many places in the state of New York. Flood effects of Hurricane Sandy, in comparison with those from Tropical Storm Irene in 2011, were significantly more extensive, with most water levels rising at least 2.5 feet higher than in the 2011 storm.

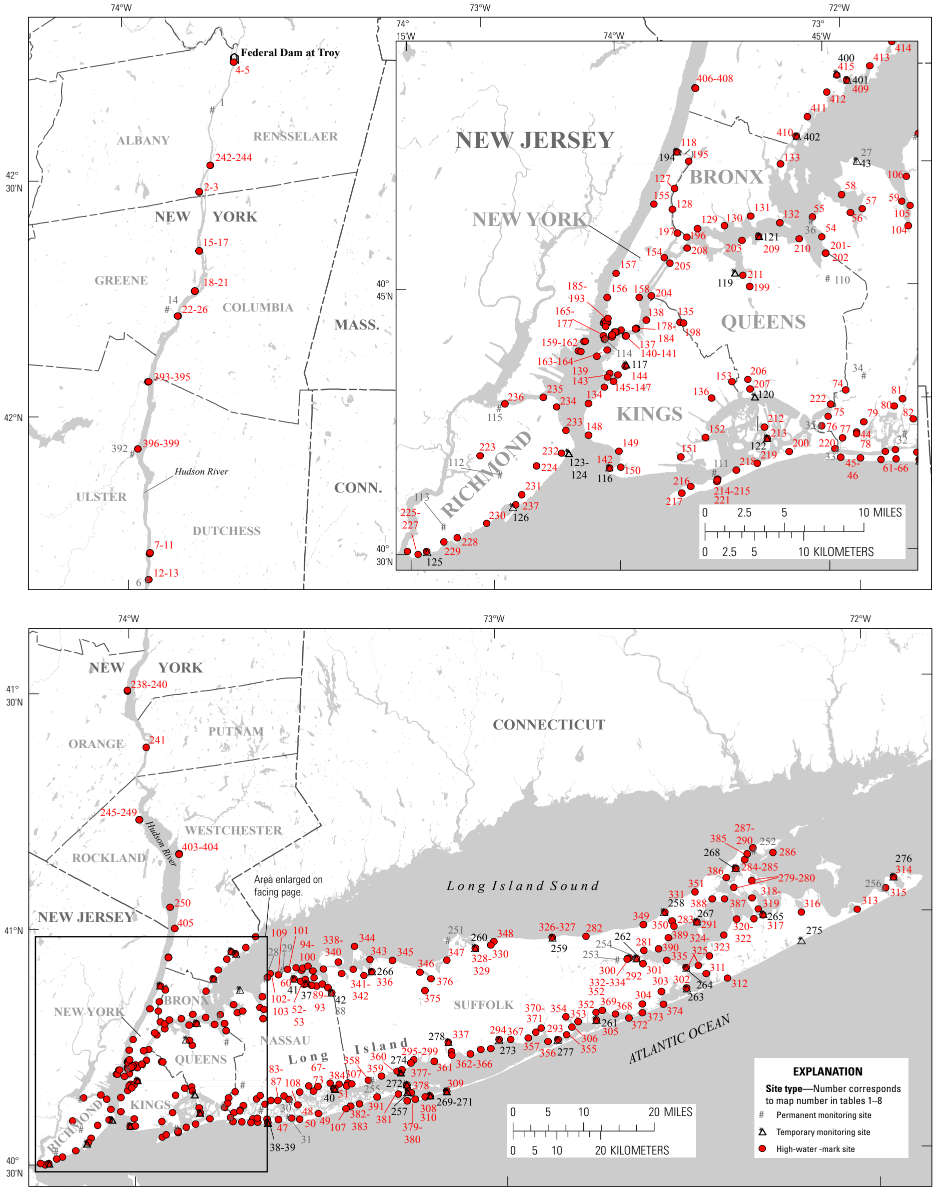
With the latest USGS analysis, a comprehensive picture of the magnitude of Sandy's impact is now available. Without the sensor placement before the storm, and assessment of high-water marks after, this level of understanding wouldn't be possible.

"This is the first time USGS has done this type of analysis and cost estimation for a coastal storm," said Schubert. "The effort incorporates what we learned from previous storms going back to Katrina, and the storm-tide information we provided to FEMA in the immediate aftermath of Sandy is one of the building blocks for this research. The additional fidelity of the damage estimate underscores the tremendous value of the dataset for this storm."

Interpretation of storm-tide data from a variety of tools such as tide gauges, stream gauges, and temporary sensors, combined with high-water marks showed the extreme nature of storm-tide flooding and, at some sites, the severity and arrival time of the storm surge. Storm surge is the height of water above the normal astronomical tide level due to a storm. Storm tide is the storm surge in addition to the regular tide.

"Timing matters, though every storm is different," said Schubert. "Throughout southeastern New York, we saw that timing of the surge arrival determined how high the storm tide reached. The worst flooding impacts occurred along the Atlantic Ocean-facing parts of New York City and western Long Island, where the peak storm surge arrived at high tide. So the resulting storm tide was five to six feet higher than it would have been had the peak surge arrived at low tide."

The full citation of the report is: Schubert, C.E., Busciolano, Ronald, Hearn, P.P., Jr., Rahav, A.N., Behrens, Riley, Finkelstein, Jason, Monti, Jack, Jr., and Simonson, A.E., 2015, Analysis of storm-tide impacts from Hurricane Sandy in New York: U.S. Geological Survey Scientific Investigations Report 2015–5036, 75 p., doi:10.3133/sir20155036 [**http://dx.doi.org/10.3133/sir20155036**]. ❁



Locations of permanent and temporary monitoring sites and high-water-mark sites that documented the storm tide of Hurricane Sandy in New York counties. Inset shows enlargement of the five counties that comprise New York City—Bronx, Kings, New York, Queens, and Richmond. From figure 2 in "Analysis of storm-tide impacts from Hurricane Sandy in New York" (< ***http://dx.doi.org/10.3133/sir20155036****>).*

USGS Underwater Coral Photo Selected as *Popular Photography*'s "Photo of the Day"

An underwater coral photograph taken by USGS research geologist **Curt Storlazzi** in Kwajalein Atoll, Republic of the Marshall Islands, was chosen by *Popular Photography* magazine as its Photo of the Day for August 3, 2015: <**http://www.popphoto.com/photo-day-gallery-august-2015**>. The photo shows a wave breaking over a section of coral reef. A healthy coral reef can help prevent island erosion and flooding by reducing the energy of waves before they hit the shoreline. Storlazzi, of the Pacific Coastal and Marine Science Center in Santa Cruz, California, took the photo for a project he leads titled "Impact of Sea-Level Rise and Climate Change on Pacific Ocean Atolls that House Department of Defense Installations" (<**http://walrus.wr.usgs.gov/climate-change/atolls/**>).

Popular Photography picked up the photo from the USGS Flickr website: <**https://www.flickr.com/photos/usgeologicalsurvey/20260886321/in/dateposted-public/**>.

Learn more about how coral reefs protect coastlines in a newsletter article ("Coral Reefs Provide Critical Coastal Protection," *Sound Waves*, May–June 2014) at <**http://soundwaves.usgs.gov/2014/06/research3.html**>, and in a *Nature Communications* paper coauthored by Storlazzi: "The effectiveness of coral reefs for coastal hazard risk reduction and adaptation," <**http://dx.doi.org/10.1038/ncomms4794**>.

*Research geologist **Curt Storlazzi** took this underwater photograph of a wave breaking over a coral reef on May 5, 2014, on Kwajalein Atoll in the Republic of the Marshall Islands. A healthy coral reef helps prevent erosion and flooding by reducing the energy of waves before they reach the shore. Storlazzi studies factors that affect coral reef health, including sea-level rise and projected impacts of climate change (<**http://walrus.wr.usgs.gov/climate-change/atolls/**>).*

Learn more about USGS studies of coral reefs in the Pacific Ocean at <**http://coralreefs.wr.usgs.gov/**>. ☸

New Marine Facility Chief for the Pacific Coastal and Marine Science Center

By Helen Gibbons

Jenny White is the new Marine Operations Superintendent for the Marine Facility (MarFac) at the U.S. Geological Survey (USGS) Pacific Coastal and Marine Science Center in Santa Cruz, California (<**http://walrus.wr.usgs.gov/**>). She takes over from **George Tate**, who has retired after a long history with the USGS, including leading MarFac since 2011 (see "George Tate Retires from Pacific Coastal and Marine Science Center," this issue, page 13, <**http://soundwaves.usgs.gov/2015/09/staff2.html**>).

"Jenny brings a breadth of experience, vision, enthusiasm, and excellent communication skills to the MarFac lead position," said Center Director **Robert Rosenbauer**.

Jenny has been part of the MarFac team since she joined the USGS in June 2010. During that time, she has served as a vessel mas-

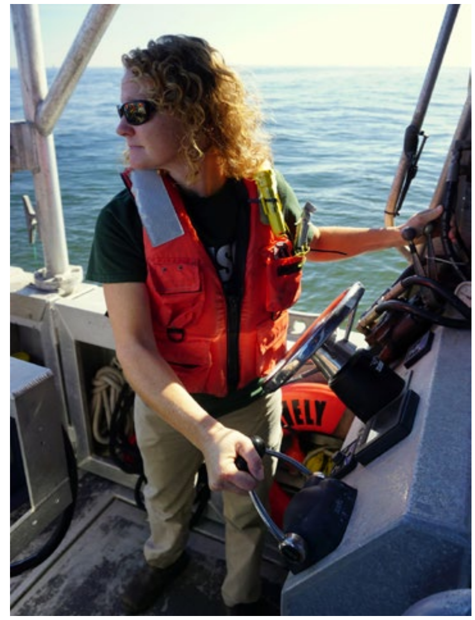
(New MarFac Chief continued on page 12)

***Jenny White** on the U.S. Coast Guard Cutter (USCGC)* Healy *in August 2010, where she supported USGS-led sediment sampling in the Arctic Ocean as part of the U.S. Extended Continental Shelf Project (<**http://continentalshelf.gov/**>). USGS photograph by **Helen Gibbons**.*

(New MarFac Chief continued from page 11)

ter for the USGS research vessel (R/V) *Parke Snavely* and as a marine technician for USGS projects on oceangoing ships. She has supported USGS scientists in operating and maintaining seafloor-mapping and subseafloor-imaging (seismic) equipment, as well as in deploying oceanographic and sampling gear. Before coming to the USGS, Jenny provided science support on various academic research cruises, where she conducted sampling operations and deployed, operated, and repaired mapping and seismic equipment. She spent 10 years working with the United States Antarctic Program (<**http://www.usap.gov/**>) as a marine technician and project coordinator aboard their two icebreakers.

Jenny (seated) repairing a seismic airgun (sound source) on the R/V Marcus G. Langseth *in the Bering Sea, where the USGS collected data in August 2011for the U.S. Extended Continental Shelf Project (<**http://continentalshelf.gov/**>). USGS photograph by **Ginger Barth**.*



Jenny driving the R/V Parke Snavely *from the rear of the vessel in order to deploy an underwater towed camera sled. USGS photograph by **Amy West**.*

Jenny began gravitating toward science support at the University of California, Santa Cruz (UCSC), where she earned a bachelor's degree in molecular biology. As a volunteer at UCSC's Long Marine Laboratory, she trained dolphins and sea lions for UCSC researchers **Terrie Williams** and **Dan Costa**. Then she seized the opportunity to provide technical support to scientific research cruises in the Antarctic.

"What I realized at Long Marine Lab and in the Antarctic is that I really loved being involved in science, but I didn't see myself becoming a research scientist. I preferred tackling logistics, nuts and bolts, the nitty-gritty of science. My love of adventure, travel, and being outside made me want to support scientists in the field."

Jenny learned as she went, on the job. Thanks to her experience with a wide range of oceanographic vessels and research organizations, she has many contacts in the broader science-support community. She served on the Scientific Oversight Committee for the building of the R/V *Sikuliaq*, a 261-foot research vessel that is operated by the University of Alaska Fairbanks in Alaskan and polar waters, and she has been a National Science Foundation proposal evaluation panelist for shipboard scientific support equipment and oceanographic instrumentation. One of Jenny's goals is to create more ties between MarFac and other groups that provide technical support to marine research. "I'm eager to see us share ideas and advice with the broader community," she said.

Jenny became chief of MarFac on July 15. "She has all of the tangibles required for great leadership," said Rosenbauer, "and we welcome her to her new position." ☸

Jenny rigs a gravity corer on the USCGC Healy, *August 11, 2010. USGS photograph by **Helen Gibbons**.*

Jenny driving the USGS research vessel (R/V) Parke Snavely *(<**http://walrus.wr.usgs.gov/mapping/Snavely.html**>) in November 2014 near the entrance to the Santa Cruz Harbor in Santa Cruz, California. USGS photograph by **Amy West**.*

George Tate Retires from the Pacific Coastal and Marine Science Center

By Helen Gibbons

After many years of service to the U.S. Geological Survey (USGS), most recently as the chief of the Marine Facility (MarFac) at the USGS Pacific Coastal and Marine Science Center in Santa Cruz, California, geologist and engineer **George Tate** is retiring. His plans for the future include “chasing waves and trout, sailing fast, and exploring the backcountry and backwaters of places revisited and those not yet traveled.” Marine technician **Jenny White** has taken over his position as MarFac chief (see “New Marine Facility Chief for the Pacific Coastal and Marine Science Center” this issue, <**http://soundwaves.usgs.gov/2015/09/staff.html**>).

Center Director **Robert Rosenbauer** said, “I will miss working with George, who has so capably held this position and advised me so well over the years.”

George joined the center, then called the Branch of Pacific and Arctic Geology, in 1976. He hit the ground running to help USGS oceanographer **Dave Cacchione** and geologist **Dave Drake** (both retired) develop what Cacchione and Drake dubbed the “Geoprobe,” a large tripod that holds instruments for collecting data on sediment movement at and near the seafloor. George provided critical input to the development of the tripod, its instrument packages, and the multifunctional data loggers that enable the Geoprobe to record and store large sets of diverse data while sitting on the seafloor for days to months at a time.

Sensors on the Geoprobe measured such variables as current velocity, suspended-sediment concentration, water temperature, and salinity. Video and still cameras captured images of sediment on the seabed and in the water. These data supported studies of numerous topics in diverse settings. For example, in San Francisco Bay, Puget Sound, Oahu’s Kailua Bay, and off the coast of southern California, the Geoprobe collected data for studies on how sediment and pollutants move in estuaries and nearshore waters (<**http://soundwaves.usgs.gov/2000/02/fieldwork.html**>).

George Tate

Off northern California, the Geoprobe was used to investigate how storm currents and sediment from flooding rivers affect sediment movement near the seabed (<**http://dx.doi.org/10.1016/0278-4343(94)90038-8**>) and how sediment layers form and change on the continental shelf (<**http://soundwaves.usgs.gov/2007/08/pubs.html**>). George led these deployments and many more—in waters off Alaska, in Australia’s Tasman Strait, off the coast of Norway, and near the mouth of the Amazon River.

Designing and deploying instrument packages was just part of the story. Equally important were George’s skill and ingenuity in recovering the instruments and their valuable data. He always had an alternate plan in case of equipment failure—using grappling hooks, divers, tethered systems, remotely operated vehicles, whatever was available.

Cacchione recalled one difficult recovery in 1990 off the coast of Brazil. “When the Geoprobe tripod was stuck in the bottom mud on the submerged edge of the Amazon delta, George organized the recovery using a trawling net on a Brazilian shrimp boat. The data provided important new insights on delta growth by large-scale deposition of fluid muds.” (See <**http://dx.doi.org/ 10.1016/0025-3227(95)00014-P**>.)

“George is the most talented and innovative marine instrument and shipboard operations person I have ever encoun-

(Tate Retires continued on page 14)

George brandishes a grappling hook in a boat in Cook Inlet, Alaska, 1978. The driver (not shown) and George are about to motor away from the research vessel Sea Sounder *to drag for a Geoprobe that had not deployed its recovery float and line. The work was part of a bottom boundary layer/sediment-transport study.*

(Tate Retires continued from page 13)

*George (right, in light baseball cap) drives a raft on the Colorado River in Grand Canyon, 1992. The crane near the bow was used to deploy a small tripod holding a rotating sidescan sonar, which sat on the riverbed recording the motion of underwater sand dunes. The sonar was connected to a computer (in white box on side of raft) by cable that the researchers ran to the river's edge where they tied off for the night. They collected data for at least 12 hours at each site for a project led by USGS sedimentologist **Dave Rubin** on the effect of Glen Canyon Dam on sand resources in the Grand Canyon (<**http://soundwaves.usgs.gov/2002/06/research2.html**>). USGS photograph by **Carol Reiss**.*

tered," Cacchione said, "and his contributions to sediment-processes research are truly remarkable."

Drake added: "Without George on the Geoprobe team, I doubt very much that we would have had the tremendous success we enjoyed (or the fun times) over two decades of cutting-edge research. In many ways, George, with key help from **Joanne Ferreira**, **Rick Vail**, and **Jim Nicholson**, made it all happen."

Together with Cacchione, Drake, and other USGS scientists, George was coauthor on a number of significant scientific papers, including the first recognition of rippled scour depressions on the inner continental shelf off northern California (<**http://dx.doi.org/10.1306/212F85BC-2B24-11D7-8648000102C1865D**>), a discovery that led to observations of these features around the world and ongoing research into how they form and how they influence the abundance and diversity of sediment-dwelling organisms and juvenile fish.

George's expertise with instrumented tripods applied as well to moorings, lines attached to anchors on the seafloor at one end and surface buoys at the other, with instruments mounted at intervals to measure water temperature and salinity, current velocity, suspended-sediment concentration, and other parameters at various water depths. George worked with moorings in many settings, including off northern California for a study led by Cacchione on internal waves—waves within the ocean at the interface between layers of differing density, analogous to waves at the interface between oil and vinegar in a gently tilted jar of salad dressing. (See an animation of internal waves in the South China Sea at <**http://video.mit.edu/watch/internal-waves-26948/**>.) The moorings sat on the continental slope—which ramps downward from the continental shelf toward the deep abyssal plain—and collected data indicating that internal waves not only affect sediment movement along the continental slope but also may control its gradient. (See "Internal Tides and the Continental Slope" at <**http://www.americanscientist.org/libraries/documents/2005428111736_306.pdf**> [413 KB].)

George was also indispensable when an instrument developed for use in marine waters was applied in a river. In the 1990s, he deployed a rotating sidescan sonar to collect images of underwater sand dunes moving along the bed of the Colorado River. That work was part of a project led by USGS sedimentologist **Dave Rubin** (retired) to investigate how Glen Canyon Dam operations affect sediment movement in the Grand Canyon (<**http://www.gcmrc.gov/**>).

In the late 1990s, George left the USGS to do consulting work in the private sector. In 2011, Center Director **Bob Rosenbauer** asked him to return to the Pacific Coastal and Marine Science Center to take over MarFac leadership and, additionally, to become the Center's Deputy Director for Operations.

Once again, George supported the Center's scientific projects and conducted research and development to design tools and techniques used in investigations worldwide. One of George's recent projects, like his earliest work for the USGS, focused on a tripod: George designed a footpad-release mechanism that enables a tripod to rise from the seafloor to the surface without being pulled up by a line. This "free-ascending tripod" can be deployed at much greater water depths than its Geoprobe predecessor (see "Deep-Sea Instrument Tripod Passes Test in Monterey Bay, California—Next Stop is South China Sea," <**http://soundwaves.usgs.gov/2013/08/fieldwork2.html**>), enabling the investigation of currents and sediment movement thousands of meters below the ocean surface.

George's retirement concludes a long period of wide-ranging and innovative work with the USGS. "My career trajectory has been beyond anything my wildest imagination may have conjured up back in the 70s," he wrote in a farewell message to center personnel. "Along the way, I have developed strong rela-

(Tate Retires continued on page 15)

(Tate Retires continued from page 14)

tionships with many of you, and you will always feel like family to me." He expressed admiration for the center's "scientists, admin professionals, support staff, and center management" who "have been wonderful to work with and an inspiration in their dedication and professionalism as they continue to push back the frontiers of modern science."

Happily, George will continue to spend some time at the USGS over the next year assisting new MarFac chief **Jenny White** as she wraps up her marine technician commitments while simultaneously assuming leadership of MarFac.

Please join the Pacific Coastal and Marine Science Center in extending our congratulations and thanks to George! ☸

George beside a "birdsfoot tripod" at the Oyster Point Marina in South San Francisco, 1999. The tripod was designed to measure waves, currents, temperature, conductivity (salinity), and suspended-sediment concentration in shallow water in San Francisco Bay. The footpads are foldable to allow deployment from a small boat.

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