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Fieldwork

Joint U.S.-Canadian Icebreaker Surveys in the Arctic Ocean

By Jonathan R. Childs and Deborah R. Hutchinson

In August and September 2008, a scientific expedition mapped unexplored Arctic Ocean sea floor where the United States and Canada may have sovereign rights over natural resources such as minerals, oil, and gas. Scientists from the U.S. Geological Survey (USGS) and the Canadian Geological Survey jointly conducted bathymetric surveys (mapping of sea-floor depths) and seismic-reflection surveys (imaging of rock and sediment layers beneath the sea floor) in the Beaufort Sea, a part of the Arctic Ocean north of Alaska and western Canada. The data gathered during this highly successful mission will improve understanding of the regional geology and help both countries establish the outer limits of their extended continental shelves according to criteria set out in the United Nations Convention on the Law of the Sea (UNCLOS). The extended continental shelf—the sea floor and subsea floor beyond 200 nautical miles from shore that meet UNCLOS criteria—is an area of great scientific interest and potential economic development.

Canadian Coast Guard Ship Louis S. St-Laurent *(foreground) and U.S. Coast Guard Cutter* Healy *in the Beaufort Sea, September 2008*

U.S. participation in the partnership was sponsored by an interagency Extended Continental Shelf Task Force, composed of representatives from the USGS, the Department of State, the National Oceanographic and Atmospheric Administration, and several other governmental agencies.

The surveys were conducted from two Arctic icebreakers working in tandem: U.S. Coast Guard (USCG) Cutter *Healy*, commanded by Captain **Frederick Sommer**; and Canadian Coast Guard (CCG) Ship *Louis S. St-Laurent* ("*Louis*"), commanded by Captain **Mark Rothwell**. **Jon Childs** (USGS Coastal and Marine Geology Program [CMGP], Menlo Park, Calif.) served as chief scientist aboard *Healy*, and **Debbie Hutchinson** (CMGP, Woods Hole, Mass.) participated as principal investigator and USGS representative aboard *Louis,* with chief scientist **Ruth Jackson** of the Canadian Geological Survey (Halifax, Nova Scotia). **Tom O'Brien**, **Bill Danforth**, and **Ellyn Montgomery** (CMGP, Woods Hole) and **Peter Triezenberg** (CMGP, Menlo Park) composed the USGS scientific staff aboard *Healy*. The USGS contingent on *Healy* was rounded out by **Jessica Robertson** (Office of Communications, Reston, Va.), who served as media coordinator and outreach specialist.

Helicopter about to land one group of scientists on Healy *after a 2-minute flight from Barrow, Alaska, at the beginning of the cruise. Helicopters were also used to transfer scientific personnel between* Healy *and* Louis *during the expedition.*

Louis departed Kugluktuk, Nunavut, Canada, on August 22 and collected

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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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bathymetric and seismic-reflection profiles for 18 days in the Beaufort Sea before rendezvousing at 82°52' N latitude and 141°54' W longitude on September 9 with *Healy*, which had departed Barrow on September 6. The two vessels worked in tandem for another 18 days, with *Healy* escorting *Louis* during seismic-reflection profiling, and *Louis* escorting *Healy* when heavy ice conditions precluded seismic-reflection profiling. The two ships parted company at about midnight on September 27, *Louis* returning to Kugluktuk and *Healy* to Barrow.

*Canadian Geological Survey chief scientist **Ruth Jackson** (left) and USGS principal investigator **Debbie Hutchinson** analyzing seismic-reflection profiles.*

The surveying systems on both ships rely on acoustic (sound) signals that bounce off surfaces separating materials of different density—for example, the boundary between water and sediment (the sea floor), or the boundaries between rock or sediment layers of different types. The frequency of the acoustic signals, produced by sound sources either mounted on or towed behind the vessel, determines how deeply the sound will penetrate beneath

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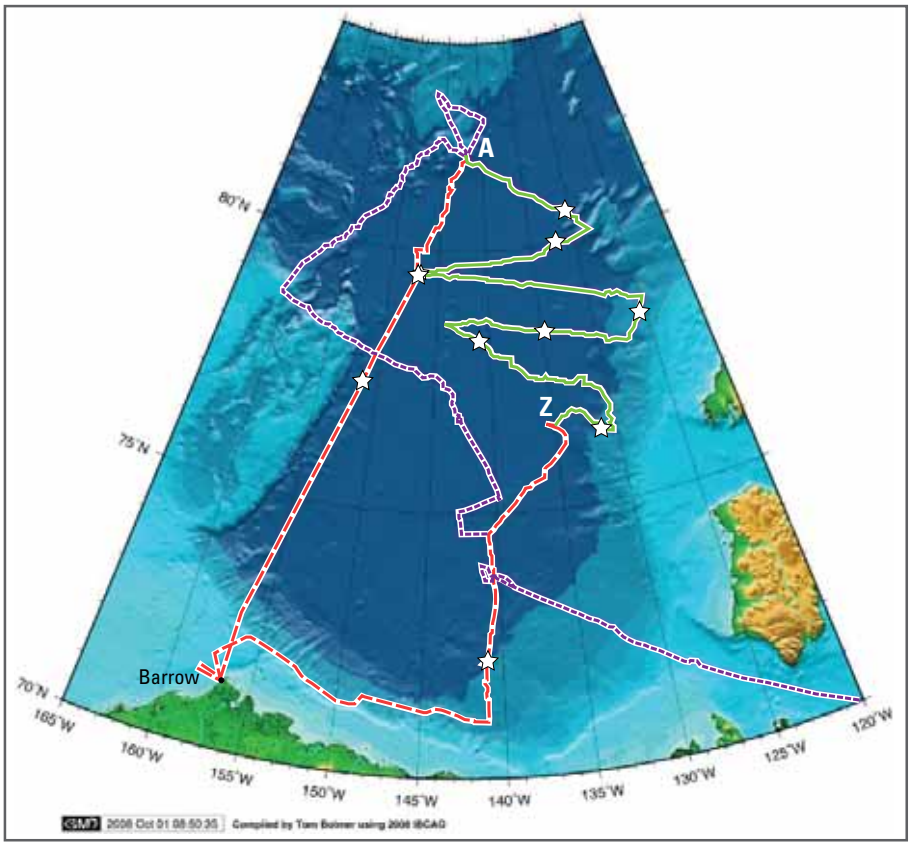

Tracklines for Louis *(short-dashed purple) and* Healy *(long-dashed red) in the Beaufort Sea. The vessels rendezvoused at A, traveled together along solid green line, and parted ways at Z.* Louis' *return track (from point Z back to Kugluktuk, Nunavut, Canada) is not shown. Stars, stations where biological samples were collected from* Healy.

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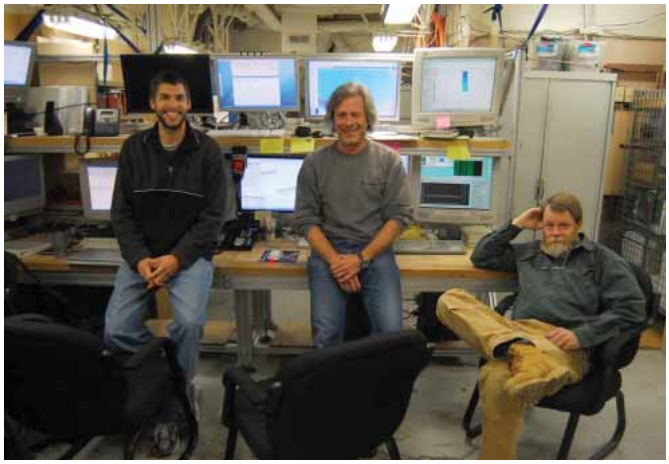
the sea floor and how much detail (resolution) will be revealed in the resulting images. Higher frequencies provide greater resolution but less penetration below the sea floor; lower frequencies yield more penetration but less resolution. (For more information about seismic profiling, visit URL **http://woodshole.er.usgs.gov/operations/sfmapping/seismic.htm**.)

Louis' seismic-reflection profiling system—used to image rock and sediment layers as deep as 10 km beneath the sea floor—employed airguns to produce acoustic signals and a streamer of hydrophones to pick up the returned signals. The source array consisted of three Sercel G-guns with a total volume of 1,190 in^3; the receiver was a digital multichannel streamer with 16 channels (6.25 m per channel in two active sections, each 50 m long). The streamer and the airgun cluster were deployed from a robust, weighted sled towed immediately aft of the icebreaker at a depth of approximately 12 m, which placed them beneath the pack ice. During the program, approximately 2,800 km of seismic-reflection profiles were collected, of which approximately 1,500 km were shot with *Healy* breaking ice for *Louis*.

Healy is equipped with a Seabeam multibeam echosounder for mapping seafloor depths. Unlike single-beam systems, which measure depth to a single point directly beneath the ship and produce a line of depths as the ship moves forward, the multibeam system measures depths along a line perpendicular to the ship's path and produces a swath of depth data as the ship moves forward. The width of that swath depends on the water depth; *Healy's* multibeam system collected a swath of bathymetric data approximately 10 km wide in the 3,800-m-deep Beaufort Sea. The original science plan called for *Healy* to be the lead vessel throughout the program. Early in the two-ship operation, however, it became apparent that the multibeam data collected under the heaviest ice conditions were unusable because the ice interfered with signal transmission from the hull-mounted echosounder transducers. When *Louis* took over as lead vessel, both the multibeam data and the data from *Healy's* 3.5-kHz subbottom profiler (a high-resolution, low-penetration seismic-reflection system, also hull mounted) were greatly improved. Approximately 950 km of multibeam and profile data were collected with *Louis* breaking ice for *Healy*.

*Canadian Coast Guard Captain **Mark Rothwell** (left) and U.S. Coast Guard Captain **Fred Sommer** exchange mementos of their partnership.*



The science team on Healy *monitored recording equipment in two 12-hour shifts. Here (from left), USGS geologists **Peter Triezenberg** and **William Danforth** pose for a photograph with computer technician **Tom Bolmer** (Woods Hole Oceanographic Institute and Lamont Doherty Earth Observatory) during the midnight-to-noon shift. Photograph by **Michael Anderson**, U.S. Coast Guard.*

On September 25, Healy *and* Louis *pulled up alongside one another, a brow (gangway) was placed between them, and the crews joined one another for dinner and tours of the vessels. Photograph by **Jessica Robertson**.*

The data from this program and from an earlier survey conducted in 2007 by the Canadians from a single ship with USGS observer and emeritus **Bob Rowland** aboard are now being interpreted for the new insights they will reveal concerning the geologic history of the Canada Basin and the entire Arctic region.

To prevent the scientific sound sources from harming marine mammals, each ship carried a team of lookouts, or "observers"—three on *Louis* and two on *Healy*—with the sole duty of watching for marine mammals. Most of these observers were from the Canadian and Alaskan Native communities and were experts at spotting and identifying marine animals on the ice. When an animal was nearby, the observer alerted the ship's officers so that they could alter the ship's path and ensure that the animals were not disturbed.

In addition to conducting bathymetric and seismic-reflection surveys, the 2008 expedition collected data on the type and

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extent of sea-ice coverage and the distribution in Arctic waters of microorganisms called mixotrophs. **Pablo Clemente-Colón**, chief scientist of the National Ice Center and an oceanographer with the National Oceanic and Atmospheric Administration (NOAA), routinely monitored the ice coverage visually and recorded what types of ice were dominantly present. These data were used to validate satellite remote-sensing observations of ice coverage used by various groups, including the National Weather Service, the U.S. Navy (particularly for submarine Arctic crossings), and the U.S. Coast Guard for safety of navigation, life, and property at sea. The data can also be used for fisheries support and research, oceanographic and atmospheric modeling, and much more. **Rebecca Gast** (Woods Hole Oceanographic Institution) and **Robert Sanders** (Temple University) collected and studied mixotrophs—algae that eat bacteria as well as use sunlight for photosynthesis, potentially helping them thrive in the extreme polar environment. **Gast** and **Sanders** used a conductivity-temperature-depth (CTD) profiler to collect data and water samples at various depths; then they incubated the water with particles that the mixotrophs can eat, and detected the organisms by microscopic analysis. Their study aims to improve understanding of the food chain, carbon cycle, and nutrient cycle in the Arctic Ocean.

Healy *scientific party on the helicopter deck.*

For more information about the expedition, including photographs and video footage, visit **Jessica Robertson's** blog at URL **http://www.usgs.gov/journals/arctic/**.

Plans are underway for a second two-ship expedition with *Healy* and *Louis*, currently scheduled for August 7-September 16, 2009.

Research Cruises Collect Measurements on the West Florida Shelf for Modeling Climate Change and Ocean Acidification

By Stephan Meylan and Lisa Robbins

For some U.S. Geological Survey (USGS) scientists, "summer cruise" means something quite different than it does for most people. The souvenirs they bring home, for example, are hard drives filled with data. At least this was the case for two research cruises this past summer, including a day-long pilot study in July 2008 and a subsequent week of offshore transects in August. Both cruises collected various measurements of the chemical properties of seawater along the gulf coast of Florida. As part of a collaborative effort funded by the USGS and including scientists from the USGS, the University of South Florida (USF), and the National Oceanographic and Atmospheric Administration (NOAA), the crew took measurements of seawater partial pressure of carbon dioxide (pCO_2), pH, dissolved-inorganic-carbon content, total carbon content, alkalinity, and atmospheric pCO_2. These data will be used to help build a baseline for assessing the impact of ocean acidification on nearshore and offshore ecosystems in the Gulf of Mexico.

Why establish such a baseline? Ocean acidification has the potential to affect marine organisms severely. As the ocean absorbs increasing amounts of CO_2 from the atmosphere, the pH of the ocean decreases, or becomes more acidic, and the carbonate ion concentration decreases. How this change will affect basic geochemical and biological processes is unknown, but key ecosystem organisms will likely have difficulty maintaining their calcium carbonate skeletons. The environmental consequences of such changes could be quite significant. For example, if the lower pH slows down or inhibits the production of calcium carbonate structures (such as shells, corals, and calcifying algae), less

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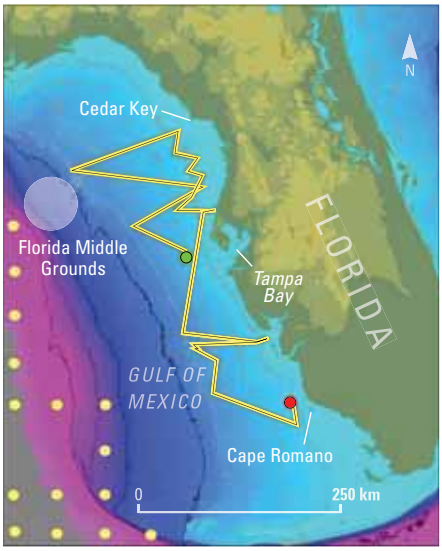
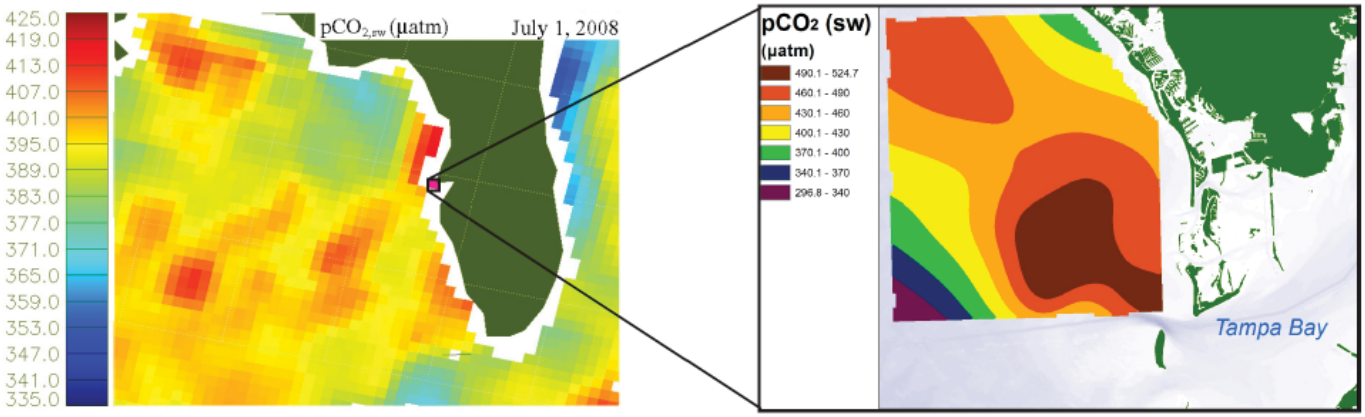


Trackline for the August 2008 cruise off Florida's gulf coast. NOAA will collect data in deeper water (yellow dots offshore). Large gray dot, approximate location of the Florida Middle Grounds.

(Ocean Acidification continued from page 4)



Remotely sensed pCO_2 values offshore (left) versus model constructed from boat-acquired data nearshore (right).

sediment may be produced. With less sediment, coastal erosion, already threatening some communities, could worsen. How fish or shellfish respond to changing water chemistry is also unknown but could have significant impact on a billion-dollar industry.

The creation of baseline maps will allow coastal managers to assess the effects of ocean acidification on the health of nearshore and offshore ecosystems, make predictions about changing conditions, and take effective and targeted protective measures to attempt to offset potential problems. Above and beyond any inherent value, Florida's marine resources contribute tens of billions of dollars annually to the State's economy. Thus, their continued well-being is in the interest of all citizens.

Although some of these parameters can be modeled using satellite remote-sensing data, such data are poorly constrained along the west Florida continental shelf and do not offer the same spatial resolution attainable from data acquired by ship-based measurements. Such spatial resolution is needed for linking seawater chemistry to high-resolution habitat and sediment maps. Although the synoptic (large scale) models being advanced by NOAA have been demonstrated to work well for the oceanic waters in this region, extending these models to coastal zones and along the west Florida shelf demands that the requisite ship-based data be acquired.

For boat-based data acquisition, the crew used the Multiparameter Inorganic Carbon Analyzer (MICA). Designed by scientists at the USF College of Marine Science, the USF Center for Ocean Technology, and SRI International (a nonprofit research institute), the system is capable of taking in four seawater channels to measure pCO_2, pH, dissolved-inorganic-carbon content, and total carbon content, and one air channel to measure atmospheric pCO_2. Importantly, the pumping apparatus allows all of these measurements to be taken while the boat is underway and even traveling as fast as 15 knots. Seawater conductivity, temperature, and depth are concurrently measured. Additional water samples are manually collected at various intervals for backup and comparison after laboratory analyses.

As a part of projects funded by the USGS Climate Change Research and Coastal and Marine Geology Programs, a daylong cruise west of Tampa Bay was run as a pilot study. **Lisa Robbins**, **Paul Knorr**, and **Mark Hansen** of the USGS and **Sherwood Liu** of USF tested

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*USGS geologist **Paul Knorr** manually retrieves a backup water sample.*

*USF scientist **Sherwood Liu** calibrates the Multiparameter Inorganic Carbon Analyzer (MICA) during the August cruise.*

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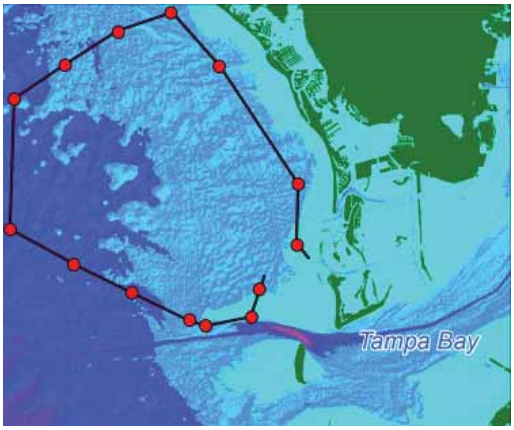
the MICA analyzer, performing the initial calibration and working out various problems in the setup. The expedition, using a 26-ft USGS catboat, yielded 14 discrete point samples of the various parameters; more importantly, the trip prompted **Liu** to redesign the sampling system to sample at a higher rate of once per minute, thus allowing collection of higher-density data, which in turn more accurately capture the spatial variability of shelf chemistry. A description of the cruise and these data was presented in July 2008 at the Ocean Carbon Biogeochemistry Summer Workshop in Woods Hole, Massachusetts (URL **http://www.whoi.edu/sites/ocbworkshop2008/**).

The second cruise, involving a week-long stay aboard a 70-ft ship of opportunity, the *Here Today,* sampled between Cedar Key and Cape Romano (approx 400 km) and as far west as the Florida Middle Grounds. **Nate Smiley** (USGS) and the ship's crew, Captain **Mike Lawrence** and deckhand **Erik Bockman Pederson**, joined **Robbins**, **Knorr**, and **Liu**. Braving rough seas and poor weather for part of the cruise, the group collected approximately 1,100 points over 650 km of trackline. Discrete water samples were collected at approximately 40 localities to corroborate underway data measurements. These samples were also measured for alkinity. Although failure of simple mechanical pumps (for bringing water samples up for analysis while the boat was underway) cut the collection session short by approximately 1 day, overall the cruise was a success, yielding more information over a larger spatial area than ever before acquired.

A similar mission was conducted in February, and more are planned to assess coastal and nearshore seasonal variations, as well as augment existing observations. A NOAA research vessel, the *Gordon Gunter,* is participating in offshore data collection in the Gulf of Mexico. The combination of USGS nearshore and NOAA offshore efforts will enable development of a large, comprehensive baseline of data.

The USGS is also working with and providing data to NOAA to help refine their region-specific algorithm in order to create large-scale maps of the aragonite- and calcite-saturation states of seawater in the greater Caribbean and Gulf of Mexico. Experiments have shown that as saturation states decline, so does the ability of such organisms as corals, foraminifera, and bivalves to produce calcium carbonate shells and skeletons. Currently, the maps cannot resolve the aragonite- or calcite-saturation state of nearshore shelf areas because satellite imagery for coastal sea-surface temperature and salinity (two of the parameters needed to calculate saturation state) are "masked out" (for example, see maps of aragonite-saturation state in the greater Caribbean at URL **http://coralreefwatch.noaa.gov/satellite/oa/saturationState_GCR.html**). Using data from the USGS cruises, NOAA will be able to provide more accurate depictions of nearshore conditions in the regional satellite maps that they are creating.



Trackline and data points for the July 2008 pilot cruise off Tampa Bay, Florida.

***Paul Knorr** (USGS, left) and **Sherwood Liu** (USF) monitor output of the MICA system during the July pilot cruise.*

Robbins and **Dwight Gledhill** (NOAA) envision the combination of remotely sensed and ship-acquired measurements of pCO_2, pCO_2 flux, total carbon content, alkalinity, and sea-surface aragonite-saturation state to develop into new data products that, coupled with habitat and sediment maps, will give coastal-resource managers powerful new tools to enhance their understanding of the effects of ocean acidification on the nearshore coastal environment.

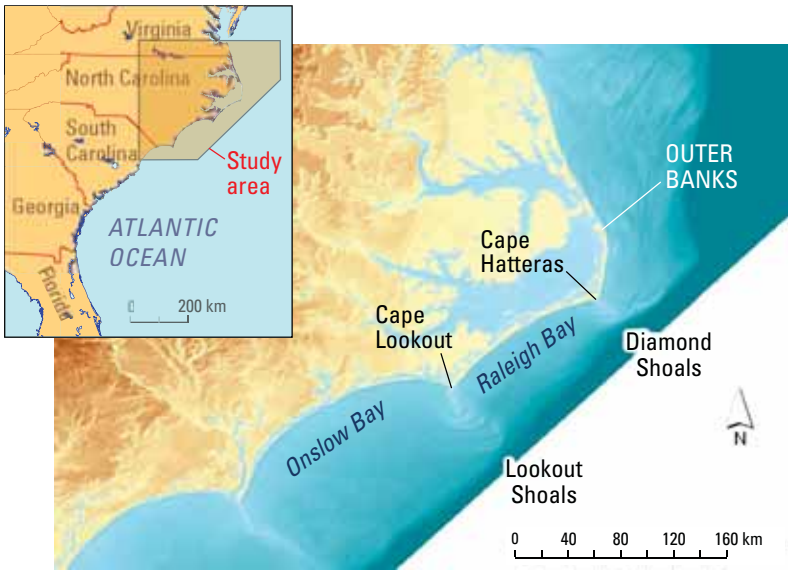
For more information, contact **Lisa Robbins**, USGS (**lrobbins@usgs.gov**, 727-803-8747, x3005). Also see these related publications: Royal Society Ocean Acidification report (URL **http://royalsociety.org/document.asp?tip=0&id=3249**) and "Impacts of Ocean Acidification on Coral Reefs and Other Marine Calcifiers" (URL **http://www.ucar.edu/news/releases/2006/report.shtml**).❁

USGS Studies Sediment Transport at Cape Hatteras, North Carolina

By John Warner and Brandy Armstrong

Reports of hundreds of ships that have sunk in these waters over the past several hundred years have earned the area extending along the Outer Banks of the North Carolina coastline the title "graveyard of the Atlantic." This area is dangerous because ships traveling along coastal currents close to shore can be driven into shallow waters by severe weather and become grounded. Diamond Shoals is a large, shifting sand deposit along the Outer Banks off Cape Hatteras, North Carolina. The shoal is approximately 10 km wide and extends offshore 30 km to the edge of the continental shelf. The abruptly rising shallow depths and crashing waves have battered apart many a grounded vessel.

The U.S. Geological Survey (USGS) Coastal and Marine Geology Program in Woods Hole, Massachusetts, is leading an effort to understand the regional sediment dynamics along the coastline of North and South Carolina. As part of the Carolinas Coastal Change Processes Project (URL **http://woodshole.er.usgs.gov/project-pages/cccp/**), we are investigating the processes that control the dynamics of sediment transport at Diamond Shoals. During the week of January 9-15, 2009, the research vessel (R/V) *Connecticut* and its five crew members transported USGS personnel **John Warner**, **Marinna Martini**, **Jonathan Borden**, **Brandy Armstrong**, **Neil Ganju**, **Elizabeth Pendleton**, and **Sandy Baldwin** to deploy oceanographic equipment at Diamond Shoals.

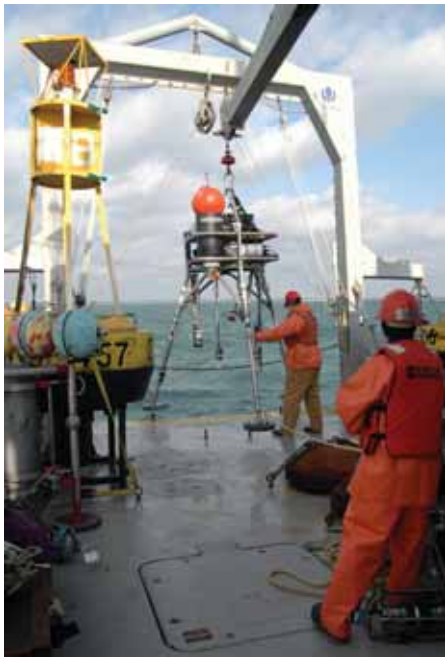


Diamond Shoals off Cape Hatteras, North Carolina.

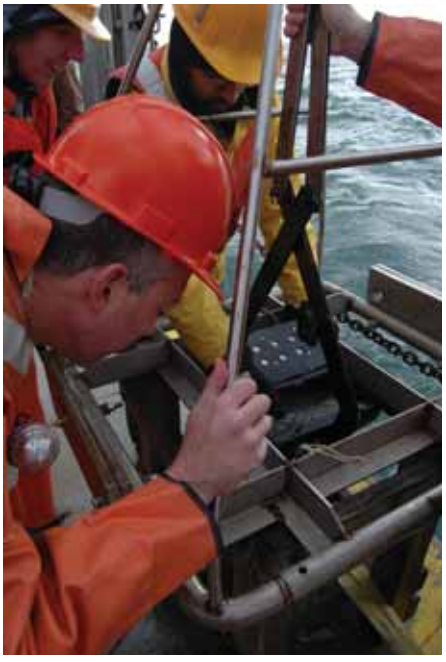
Tripods were deployed at three sites along the outer perimeter of the shoal. Mounted on the tripods were instruments to measure surface waves, pressure, current velocity, bottom turbulence, suspended-sediment profiles, and sea-floor sand-ripple bedforms; one tripod also held a visual camera system. The measurements will be used to explore the oceanographic and sediment-transport processes responsible for maintaining the offshore sand shoal. The tripods were positioned with guidance from data collected during recent cruises by the USGS Sea Floor Mapping Group in Woods Hole. These data were used to identify locations for tripod deployment and to provide navigational assistance to the vessel during deployment.

Surficial grab samples of sediment were obtained at the deployment locations to determine characteristics of the seabed. The samples will be analyzed by the USGS Sediment Lab in Woods Hole for grain-size distribution, information that is critical to understanding the formation of the shoal and the regional sediment dynamics.

We greatly thank the crew of the R/V *Connecticut* for their efforts, and the University of South Carolina and Dalhousie University, who provided additional equipment for the deployment.



Tripod holding oceanographic equipment is deployed from the R/V Connecticut.



A Van Veen-type grab sampler was used to collect surficial sediment samples.

Satellite-Tracked Birds from India Will Provide Clues on How Avian Influenza Spreads: International Team Conducts Research

By Catherine Puckett and John Takekawa

The largest waterbird-congregation area in the Indian subcontinent is the site of a new international study of migratory birds and their role in the spread of highly pathogenic avian influenza (HPAI) H5N1 virus.

In December 2008, a team of international scientists captured, sampled, and marked 70 waterbirds with satellite tags at Chilika Lake, a brackish lagoon connected to the Bay of Bengal on India's east coast. In the coming months, these researchers will track the satellite-marked birds to determine whether relationships exist between the locations of these marked birds and HPAI H5NI outbreaks along their migratory pathways. India was one of eight countries reporting HPAI H5N1 outbreaks in early 2009. Although previous samples collected from wild birds in Chilika Lake and other parts of India have always been negative for HPAI H5N1, waterbirds are frequently pointed to as possible carriers of the disease.

The study, launched by the United Nations Food and Agriculture Organization (FAO) and its partners, is the first of its kind in India. The U.S. Geological Survey (USGS), which is a partner in the study, has set up a Web site where people can follow the daily movements of the satellite-tagged birds, including maps in Google Earth (see URL **http://www.werc.usgs.gov/sattrack/india/overallmaps.html**).

*Bar-headed goose with satellite transmitter, awaiting release. Photograph by **John Takekawa**, USGS.*

"The ongoing HPAI H5N1 outbreaks in domestic poultry in India underscore the need to conduct scientific investigations to identify the mechanisms by which this virus is introduced into poultry or wild bird populations, or into new geographic locations," said **Scott Newman**, wildlife coordinator of FAO's infectious-animal-disease group.

Chilika Lake, in India's Orissa state, is the largest brackish-water lagoon in Asia. It was one of the first internationally important Indian wetland sites listed under

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*First-marked common teal and cooperators in the India satellite-tracking project. Photograph by **Acty George**, Bombay Natural History Society.*

Generalized map of India, showing study sites in the states of Orissa and Tamil Nadu.

(Satellite Tracking continued from page 8)

the Ramsar Convention on Wetlands—an intergovernmental treaty signed in 1971 in Ramsar, Iran, that provides a framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Chilika Lake was designated as a Ramsar site in 1981. More than 890,000 migratory and resident waterbirds, representing at least 226 species, use the lagoon for at least part of their life cycle. Additional research is being conducted in southern India at the Koonthankulam Bird Sanctuary and at wetlands near Kanyakumari in the state of Tamil Nadu.

*A gadwall heads back to the lake after being tested for avian influenza and fitted with a satellite transmitter. Photograph by **Tracy McCracken**, FAO.*

This study in India is part of a global program not only to better understand the movement of avian influenza viruses and other diseases in the Central Asian Flyway, but also to improve understanding of the ecological habits of waterbirds internationally, as well as the interactions among wild and domestic birds.

Species that researchers marked include the common teal (*Anas crecca*), northern pintail (*Anas acuta*), northern shoveler (*Anas clypeata*), and bar-headed goose (*Anser indicus*), all species that have been afflicted with HPAI H5N1 in the past.

*India, showing the locations on March 30, 2009, of all marked birds. (Credit: **William Perry**, USGS)*

The HPAI H5N1 strain of avian influenza has caused the deaths of domestic poultry in India and of domestic poultry, wild birds, and people in many other countries in Asia, Africa, and Europe since 2003.

The study is being conducted in collaboration with the Indian Ministry of Environment and Forests, the Indian Ministry of Agriculture, the Bombay Natural History Society, Wetlands International, the USGS, the United Nations (FAO)-India, and the EMPRES-Wildlife Unit based at UN-FAO headquarters in Rome. Additional collaborators in Orissa are the State Wildlife Wing of the Forest Department, the Chilika Development Authority, and the Directorate of Animal Husbandry and Veterinary Services. Additional collaborators in Tamil Nadu are the State Wildlife Wing of the Forest Department; the Directorate of Animal Husbandry and Veterinary Services; the University of Wales, Bangor; the University of Birmingham; and the Max Planck Institute.

Recovery of Shorebird May Require Further Restrictions on Bait Use of Horseshoe Crabs

By Jonathan Bart (USGS) and Lawrence Niles (Conserve Wildlife Foundation of New Jersey)

Declining numbers of a shorebird called the red knot have been linked to the harvest of horseshoe crabs from Delaware Bay, a large estuary between New Jersey and Delaware that is an important stopover for red knots migrating from South America to the Arctic. This link was investigated by scientists from various federal, state, and nongovernmental entities in several countries, who published their results in the February issue of *BioScience* in an

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*Red knot (*Calidris canutus rufa*) on the shore of Delaware Bay, May 17, 2007. Photograph copyright © by **Mark Peck**, biologist, Royal Ontario Museum, Toronto, Canada; used with permission.*

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article titled "Effects of Horseshoe Crab Harvest in Delaware Bay on Red Knots: Are Harvest Restrictions Working?"

Long-term surveys show that the average weight of red knots when they leave Delaware Bay has declined significantly since their primary food source, the eggs of horseshoe crabs, has been reduced. The study also revealed that red knot survivorship is related to departure weight and that the population size of red knots has declined by more than 75 percent.

"We concluded that the increased harvest of horseshoe crabs led to a reduction in the food supply for red knots at a critical period in their annual cycle, and this led to a dramatic decline in population size," said U.S. Geological Survey (USGS) scientist, **Jonathan Bart**, one of the authors of the study.

There is a long tradition in Delaware Bay of harvesting horseshoe crabs for use as bait in various fisheries. In the years 1992-1997, reported harvest of crabs grew twentyfold, from about 100,000 individuals harvested to more than 2 million. The newly released study shows that this increase in horseshoe crab harvest has led to a dramatic decrease in the number of spawning crabs and a 90-percent decline in crab eggs available for shorebirds to eat.

Delaware Bay is globally recognized as an important feeding stopover for migrating shorebirds, especially red knots. Each year, red knots migrate from Arctic breeding grounds to the southern tip of South America and back, covering more than 18,600 miles. In May, large numbers of red knots migrating northward congregate in the bay, where they gorge on horseshoe crab eggs in preparation for their continued migration to the Arctic. For red knots, Delaware Bay is the final stop before a single direct flight to Arctic breeding grounds, where, on arrival in early June, weather is uncertain and feeding conditions are poor. Body reserves gained on Delaware Bay, therefore, are crucial for both the flight to the Arctic and survival and successful breeding.

Red knots (red breasted), ruddy turnstones (black breasted), and sanderlings (tan speckling) on the shore of Delaware Bay, May 17, 2007. Photograph copyright © by ***Mark Peck****, biologist, Royal Ontario Museum, Toronto, Canada; used with permission.*

Concern over red knot populations led to restrictions in horseshoe crab harvest starting in 1997, but as **Lawrence Niles**, biologist with the Conserve Wildlife Foundation of New Jersey (URL **http://www.conservewildlifenj.org/**) and senior author of the new study, says: "Despite restrictions, the 2007 horseshoe crab harvest was still well above that of 1990, and no recovery of knots was detectable. Recovery of both horseshoe crabs and red knots may require more restrictions on horseshoe crab harvest, possibly even a complete moratorium for some period. We've proposed a program of adaptive management, including monitoring, that should result in the information that managers need to find the right balance."

Red knots migrate annually from Arctic breeding grounds to the southern tip of South America and back, covering more than 30,000 km (18,600 mi). Each May, red knots and other shorebirds stop at Delaware Bay on the U.S. east coast, where they feed on the eggs of spawning horseshoe crabs.

Finding the right balance is a challenge faced by natural-resource managers across the United States, where numerous conflicts have arisen over multiple uses of resources. Examples include the spotted owl and the forest-products industry in the Western United States, wolves and sport hunters in Alaska, Pacific salmon and water resources in the Pacific Northwest, and red knots and horseshoe crab harvesting on Delaware Bay. The recent article calls attention to an educational resource that uses the conflict over red knots and horseshoe crab harvesting to teach students about the complexities of resource conflicts and the methods used to resolve them. To learn more about the curriculum, called "Green Eggs and Sand," visit URL **http://www.dnr.state.md.us/education/are/ges.html**.

The full reference for the article is:

Niles, L.J., Bart, J., Sitters, H.P., Dey, A.D., Clark, K.E., Atkinson, P.W., Baker, A.J., Bennett, K.A., Kalasz, K.S., Clark, N.A., Clark, J., Gillings, S., Gates, A.S., González, P.M., Hernandez, D.E., Minton, C.D.T., Morrison, R.I.G., Porter, R.R., Ross, R.K., and Veitch, C.R., 2009, Effects of horseshoe crab harvest in Delaware Bay on red knots; are harvest restrictions working?: BioScience, v. 59, no. 2, p. 153–164 [URL **http://www.bioone.org/toc/bisi/59/2**].

USGS Scientist Recognized for Research Achievements in Parasitology

U.S. Geological Survey (USGS) scientist **Kevin Lafferty** has been selected by the American Society of Parasitologists (ASP) as the 2009 Henry Baldwin Ward Medalist for outstanding contributions to the field of parasitology. The award recognizes **Lafferty** for "bringing parasites to the forefront of ecological research." **Lafferty's** efforts have extended "the perception of parasites beyond the role of mere pathogens to major players in food-web dynamics and energy transport in ecosystems." This midcareer research achievement award will be presented during the ASP 2009 annual meeting, August 14-17, in Knoxville, Tennessee.

Lafferty is a marine ecologist with the USGS Channel Islands Field Station and an adjunct faculty member at the University of California, Santa Barbara, which provides his office and laboratory space. **Lafferty's** main interest is in how parasites affect ecosystems and, in turn, how ecosystems affect parasites. He also conducts research on the conservation of marine resources—investigating strategies for protecting endangered shorebirds, fish, and abalone—and has assessed the effects of marine reserves. ❁

***Kevin Lafferty** surveying sea otters off Point Conception. Photograph by **J. Altstatt** (Science Director, Santa Barbara Channelkeeper).*

USGS Woods Hole Science Center Hosts a Delegation from India

By Deborah R. Hutchinson

On December 19, 2008, a delegation of seven Indian scientists and managers visited the U.S. Geological Survey (USGS) Woods Hole Science Center in Woods Hole, Massachusetts. The purpose of their visit was to learn about our facilities and, in particular, the gas hydrates laboratory (GHASTLI—Gas Hydrate and Sediment Testing Laboratory Instrument). This delegation of high-level experts had come to Washington, D.C., to sign a Memorandum of Understanding between the USGS and India's Directorate General of Hydrocarbons (DGH) for joint studies of gas hydrates on the continental margins of India. USGS Energy Resources Program Coordinator **Brenda Pierce** and **Tim Collett** (USGS Central Energy Resources Team, Denver, Colorado) were present when **Mark Myers**, then Director of the USGS, signed the Memorandum of Understanding with **V.K. Sibal**, Director of DGH. **R.S. Pandey**, Secretary of Petroleum in India's Ministry of Petroleum and Natural Gas, was also present. After several days of discussions in Washington, D.C., about cooperative studies related to drilling and assessing gas hydrates along the Indian margins, the delegation came to Woods Hole before returning to India. **V.K. Sibal** served as head of the delegation after **Secretary Pandey** returned to India from Washington, D.C.

*Delegation of visitors from India with hosts from the USGS Woods Hole Science Center. From left, **A.V. Sathe** (ONGC, Oil and Natural Gas Corporation of India), **B.S. Balla** (Indian embassy), **R.K. Sinha** (Scientist, DGH), **W.J. Winters** (USGS), **W.F. Waite** (USGS), **D.N. Narasimha Raju** (Ministry of Petroleum and Natural Gas), **V.K. Sibal** (Director, DGH), **D.R. Hutchinson** (USGS), **M. Lall** (Head of the Gas Hydrates Program, DGH), **W.C. Schwab** (USGS), **D. Mason** (USGS), and **B.P. Singh** (GAIL, Gas Authority of India, Ltd.).*

Although the daylong visit was cut short because of an impending snowstorm, the delegation was able to tour the core-storage facility, the sediment lab, the geotechnical lab, and the GHASTLI lab, as well as participate in a short round-table discussion. We had a lively exchange about how gas hydrates occur in the natural environment and how to use laboratory studies to understand and quantify natural gas hydrates. The Indian research program emphasizes the energy-resource aspects of gas hydrates.

USGS scientists know many of the delegation from previous gas-hydrates work. **Bill Winters** had met many of the delegation in 2006 aboard the drill ship *JOIDES Resolution* during initial drilling for gas

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hydrates on the continental margins of India and in followup postcruise science meetings. USGS scientist **Tim Collett** was chief scientist during the drilling; other USGS participants were **Tom Lorenson**, **Warren Agena**, and **Jim Brewton**. Details about the 2006 drilling are posted at URL **http://energy.usgs.gov/other/gashydrates/india.html**. **Tim Collett**, **Warren Agena**, **Tom Lorenson**, **Bill Waite**, and **Bill Winters** worked with scientist **R.K. Sinha** during gas-hydrate drilling on the Alaskan North Slope in February 2007. Details about the 2007 drilling are posted at URL **http://www.netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/rd-program/ANSWell/ANSWell_main.html**.

After their curtailed visit, the delegation reached Boston before the worst of the snowstorm arrived, and made their (delayed) flights back to India and Washington.

USGS Oceanographer Rich Signell Joins NOAA's Integrated Ocean Observing System Program for 1-Year Detail

By John W. Haines

Minutes after U.S. Airways Flight 1549 made an emergency landing in the Hudson River on January 15, 2009, a little-known government partnership began providing crucial information to emergency responders. A detailed report of near-realtime water conditions surrounding the site, weather-forecast and river-current information, and an analysis of the potential fate of the fuel onboard are a few of the contributions that facilitated the safe and timely rescue of passengers and crew and recovery of the aircraft. (To hear a podcast, visit URL **http://oceanservice.noaa.gov/podcast/supp_feb09.html** and select "Making Waves Episode 17.")

The partnership is the Integrated Ocean Observing System (IOOS), led by the National Oceanic and Atmospheric Administration (NOAA). IOOS can be thought of as a "system of systems"—tying together observations from national systems, such as USGS stream gages, with those from regional associations of State, academic, and private-sector partners. NOAA's IOOS Program leads the effort to integrate all the ocean, coastal-water, and Great Lakes data collected by Federal agencies and regional associations around the Nation. The goal is to provide continuous data on our open oceans, coastal waters, and Great Lakes in the formats, rates, and scales required by scientists, managers, businesses, governments, and the public to support research and inform decision-making.

Rich Signell, an oceanographer at the U.S. Geological Survey (USGS) Woods Hole Science Center in Woods Hole, Massachusetts, has joined the IOOS Program's Operations Division for a 1-year detail. The IOOS Program's goals, from streamlining maritime emergency response to improving predictions of climate change and its effects on coastal communities, involve efficiently linking observations, data communications and management, and data analysis and modeling—areas in which **Signell** has particular expertise. During his detail, which began in November 2008, **Signell** is focusing on standardized access to model data by way of Web services that include improved analysis and visualization capabilities. He is also acting as a technical liaison on ocean and coastal modeling with the Interagency Working Group on Ocean Observations (IWGOO), the IOOS Regions, and NOAA.

While **Signell's** expertise will benefit IOOS development broadly, his leadership will also enhance USGS science programs through persistent engagement in the community actively developing IOOS observational, data-management, and modeling systems. **Signell's** efforts will ensure that USGS expertise and programmatic objectives with respect to model development and integration of observations and modeling are reflected in the continued development of IOOS as an interagency priority.

Signell has had a long-standing interest in data management, analysis, and visualization and in promoting standards and standards-based modeling tools. (He coauthored a paper with **Harry Jenter** of the USGS Water Resources Discipline on the benefits of using the NetCDF scientific data format for ocean modeling more than 15 years ago!) He is also chair of the 2011 Gordon Research Conference on Coastal Ocean Modeling, a coauthor

Rich Signell

of the NetCDF Climate and Forecast (CF) Metadata Conventions, a member of the CF Standards Committee, a member of the Integrated Data Viewer (IDV) Steering Committee, and chair of the Gulf of Maine Ocean Data Partnership Modeling Committee. His research interests include physical-oceanographic and sediment-transport processes in estuaries and on shallow continental shelves, bottom- and surface-boundary-layer dynamics, and developing community models, methods, and tools for investigating hydrodynamics and sediment transport in the coastal ocean. During his detail, **Signell** is traveling to Silver Spring, Maryland, approximately every 6-8 weeks while continuing to work out of his USGS office in Woods Hole.

To learn more about the IOOS, visit URL **http://ioos.noaa.gov/**.

New Research Shows Shifts in Killer Whale Diets

Biologist **Daniel Monson** of the U.S. Geological Survey (USGS) Alaska Science Center is coauthor of a recent report on using stable-isotope analysis of teeth to investigate killer whale diets. This approach could shed light on the hypothesized role of killer whales in historical declines of marine-mammal populations in the northeast Pacific Ocean.

Monson and his coauthors—**Seth Newsome** (senior author) and **Marilyn Fogel** of the Carnegie Institution of Washington, and **Michael Etnier** of Applied Osteology—found that dentin growth layers in killer whale teeth provide a record of individual diet with near-annual resolution. Analysis of stable-isotope ratios in the layers revealed such information as changes in individual diets over time and differences in diet between groups. For example, the teeth of most individuals studied showed a decrease in $\delta^{15}N$ values throughout the first 3 years of life that the authors interpret as evidence of gradual weaning. The teeth of two groups of killer whales studied—"resident" whales that inhabit small and predictable areas during the summer months, and "transients" that are generally less predictable and known to migrate over large distances—yielded chemical evidence consistent with expectations that the residents eat primarily fish and the transients eat primarily marine mammals. The analyzed teeth were obtained from archived collections of teeth collected from dead whales in California, Washington, and Alaska during the period 1961-2003.

Analysis of tooth dentin growth layers provides information that cannot be obtained through traditional field observations of such free-ranging and elusive species as killer whales. This approach is especially useful for examining historical dietary shifts because many museum and some archeological collections contain teeth. Analysis of such teeth may help resolve a recent debate concerning the role of killer whales in historical declines of marine mammals in the northeast Pacific Ocean. Killer whale predation is widely accepted as the main cause of the relatively recent (late 1980s and early 1990s) sea otter declines in the central Aleutian Islands; some scientists have hypothesized that shifting killer whale prey preferences also drove earlier declines in the region's populations of harbor seals, northern fur seals, and Steller sea lions. (For example, see "Collapsing Populations of Marine Mammals—the North Pacific's Whaling Legacy?" in *Sound Waves*, October 2003, URL **http://soundwaves.usgs.gov/2003/10/**.) The authors' ongoing analysis of teeth from modern and historically collected individuals, especially individuals from Alaskan waters, may allow them to construct a timeline of foraging information that could be the best way to evaluate the role of killer whales in historical marine mammal declines.

Longitudinal section of a killer whale tooth. Earliest years of growth are to the right, at the tip of the tooth. Oldest, most recent years of growth are to the left, along the hollow pulp cavity. Tooth has been etched in formic acid to highlight growth layers. Scale in millimeters. Digital scan by ***Mike Etnier****; learn more at URL* ***http://www.appliedosteology.com/orca_isotopes.html****.*

The complete reference for the new publication is:

Newsome, S.D., Etnier, M.A., Monson, D.H., and Fogel, M.L., 2009 Retrospective characterization of ontogenetic shifts in killer whale diets via $\delta^{13}C$ and $\delta^{15}N$ analysis of teeth: Marine Ecological Progress Series, v. 374, p. 229-242, doi:10.3354/meps07747 [URL **http://dx.doi.org/10.3354/meps07747**].

Got Teeth? Killer Whale Teeth Sought for Foraging Ecology Project

If you have teeth collected from a killer whale carcass, please consider donating them to **Dan Monson** and his colleagues for analysis. The Killer Whale Foraging Ecology project needs more teeth to test the hypothesis that killer whale diets changed considerably during the second half of the 20th century and that killer whales played a role in historical declines of marine-mammal populations in the northeast Pacific Ocean. Killer whale teeth, along with information about where and when they were collected, would be extremely helpful to the research group. In return, donors of teeth will receive information about the specimen, such as age and ecotype (resident versus transient), based on genetic analysis.

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New Publication on "Predicting 21st-Century Polar Bear Habitat Distribution from Global Climate Models"

In 2007, the U.S. Geological Survey (USGS) Alaska Science Center conducted several modeling studies to inform the U.S. Fish and Wildlife Service decision whether or not to list the polar bear as threatened under the Endangered Species Act. One of the studies examined changes in polar bear sea-ice habitat in the recent past and projected the future distribution of such habitat by using global climate models. This study was recently published in the journal *Ecological Monographs*. The authors concluded that sea-ice habitat losses through the 21st century were expected to be the greatest in the southern seas of the Polar Basin and the least in areas north of Arctic Canada and Greenland. Findings from this study were considered by the Secretary of the Interior in listing the polar bear as threatened in May 2008.

*Polar bear on sea ice in the Beaufort Sea near Barrow, Alaska, near the end of a U.S.-Canadian research cruise (see "Joint U.S.-Canadian Icebreaker Surveys in the Arctic Ocean," this issue). Photograph by **Jessica Robertson**, USGS, taken September 29, 2008.*

The complete reference for the new publication is:

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