NC STATE UNIVERSITY

results.

Research and Innovation at North Carolina State University

XI, No. 1
Winter 2011

Coast is Clearly Filled with NC State Research

VISITORS FLOCK to the North Carolina coast each year to frolic in the waves, stroll on the sand, drop a line in the water and wait for a bite, or just laze under a brilliant sun and deep blue sky. But the coast is more than just a summer getaway. It was North Carolina's "birthplace," serving as the seat of the first colonial governments, and remains a vital link for international trade. It has sustained generations of fishermen—and those they feed with their catch—and even ushered in the aviation age.

Although located more than 100 miles from the coast, NC State has kept more than just a toe in the saltwater in terms of research to benefit the region and its residents. From meteorologists finding better ways to track hurricanes to engineers monitoring shifting dune lines and rip currents to biologists studying harmful algal blooms or the fishing industry, the University supports an array of programs to carry out its land-grant mission on the sandy soil and waves of North Carolina's coast. "The coast is the nexus of land and water," Vice Chancellor for Research and Innovation Terri Lomax says, "and the interplay between the two elements plays to NC State's traditional strengths in sciences and engineering, as well as our emphasis on interdisciplinary research."

"The interplay between land and water plays to NC State's traditional strengths in sciences and engineering, as well as our emphasis on interdisciplinary research."

Terri Lomax,
Vice Chancellor for Research and Innovation

The Center for Marine Science and Technology in Morehead City, which celebrated its 10th anniversary in August, is a prime example of that interdisciplinary approach. Thirty-five faculty members from 17 departments are affiliated with CMAST, and they work together with researchers in Raleigh to discover innovative solutions to questions and problems in coastal and marine systems. Some, for example, are beginning to assess the impact of the recent oil spill in the Gulf of Mexico.

With headquarters on Centennial Campus and administered by NC State, North Carolina Sea Grant identifies emerging coastal and marine research needs by working with communities, state and federal agencies, and varied organizations. Most researchers profiled in this issue have had Sea Grant-funded projects, as have many others across the UNC system. With funding from NOAA and the state, Sea Grant looks ahead to potential environmental changes, yet also has agility to respond rapidly to immediate information needs.

This issue of results highlights various research efforts involving North Carolina's beaches, sounds, and estuaries and the fish and other aquatic life that call the coast home. •

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Researchers Reel in Ways to Aid Fishing Industry

FISHING HAS been part of North Carolina culture for centuries, with indigenous tribes and then generations of coastal residents relying on the fruits of the sea for their food and their livelihoods. Commercial fishing is now a $255 million industry in North Carolina, and recreational fishing adds millions more to the state economy each year. NC State researchers are finding ways to ensure fishing remains a thriving industry and that the seafood brought to dock and sold at supermarkets and restaurants is safe to eat.

Protecting against overfishing and depleted fish stocks is one of Dr. Jeffrey Buckel's primary goals as an associate professor of biology at NC State's Center for Marine Sciences and Technology (CMAST) in Morehead City. Buckel tracks the number of juveniles in various species and studies how fast fish grow and how different species interact. "The production of juveniles is highly, highly variable, and that's what makes management of stocks difficult," he says. The so-called "recruitment" of striped bass, for example, has been reduced for almost a decade in Albemarle Sound. To track fish and help determine natural and fishing-related mortality rates, he catches fish and tags them with either streamers or electronic devices that emit an individualized ping as they enter or leave coastal estuaries.

Buckel's research team also works with the state Division of Marine Fisheries to identify strategic locations for protection under the Coastal Habitat Protection Plan. His group has related the abundance of fish to various factors that determine a healthy habitat, such as the amount of submerged aquatic vegetation in an area and upstream land use patterns. "A single marine fish may lay millions of eggs a year, but more than 99.9 percent don't survive to become juveniles," he says. "Changing the survival rate by even a fraction of a percent could make the difference between an average year and a banner year-class."

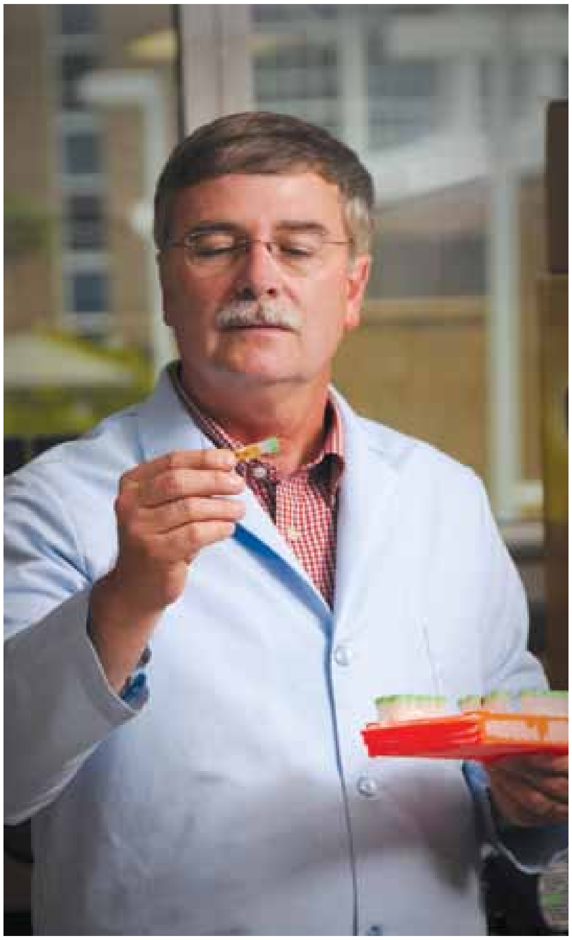
Dr. Jeffrey Buckel tags a fish to track indicators of recruitment variability in marine and estuarine fishes.

Farm-raised fish can help fill the gaps for consumers when wild stocks are experiencing below-average years, says Dr. Tom Losordo, a professor and extension specialist in the Department of Biological and Agricultural Engineering. An aquaculture expert, Losordo has developed a fresh-water system for raising fish, but he says some species cannot be adapted to live in fresh water. So, he opened the Marine Aquaculture Research Center last year on land in Carteret County donated by I.J. Won, a former NC State professor. He designed a pump system to pull water from a salt creek during high tide and cleanse it of silt, and his team is developing constructed wetlands to remove nutrients from water that has circulated through the fish tanks before it is returned to the creek. "There are thousands of acres of land with salt creeks," Losordo says. "If we can manage the engineering, we can open up many coastal areas to aquaculture with no environmental impact." Dr. Marc Turano, a researcher and extension specialist with North Carolina Sea Grant, has already used the facility to demonstrate that farmed fish can be fed soy-based diets without affecting their growth.

"We need to better identify control measures and provide consumers with a greater margin of food safety related to fish consumption."

For North Carolina shrimpers, the challenge is more distribution than engineering. Dr. Robert Handfield, the Bank of America University Distinguished Professor of Supply Chain Management in the Department of Business Management, studied the industry to find the best way for shrimp fishermen to compete with a flood of imports from Southeast Asia. Some supermarket chains and restaurants told Handfield they have no market for fresh North Carolina shrimp—and other seafood branded as "Carteret Catch" to emphasize its local origin and freshness—because seafood distributors have plenty of imported shrimp to offer at lower prices. There is year-round demand for frozen shrimp, he says, but the shrimpers here don't have any facilities to handle that. Handfield suggested that they follow the example of shrimpers in Maine and form a co-op to build a cold-storage distribution facility and jointly market their product. "They need to look at where the markets are nationwide," he says. "Once they find niches, they have to have the coordination to promote their product."

Dr. David Green is working to ensure the seafood that winds up on people's plates is safe to eat. A professor of seafood safety and extension specialist at CMAST, he studies bacteria in fish, such as tuna and mahi-mahi, to get a better understanding of how they form histamines. Such bacteria are responsible for more than a third of the cases of seafood-related food poisoning in the U.S. Certain bacteria can grow and produce histamine when fish aren't adequately chilled after being caught and kept chilled through the entire distribution chain to consumers. "A whole host of spoilage bacteria exist in the marine environment," Green says. "We need to better identify control measures and provide consumers with a greater margin of food safety related to fish consumption." Detecting the bacteria has been troublesome for public health officials. Traditional culture methods often produce false positives, Green says, while some molecular techniques don't pick up certain strains of bacteria because they have unique mechanisms for producing histamines. His research team is developing an assay that targets specific enzymes in histamine-producing bacteria to improve detection and better correlate the presence of bacteria with histamine levels. Preliminary results have shown promise, but the tool needs further refinement and validation. "The success of the fishing industry is important to us," Green says, "but our primary mission is to protect the public from contamination of our food supply." •



Dr. David Green is developing a method to identify bacteria in fish that represent more than a third of seafood-related food poisoning in the U.S.

Commercial fishing is a $255 million industry in North Carolina, involving nearly 4,500 people who catch, harvest and/or sell seafood.

Regional Dialect Fades as Outsiders Move in

As outsiders move to North Carolina's Outer Banks, coastal dialects begin to ebb. Prior to the population boom, the native brogue remained intact due in part to the coast's isolated geography.

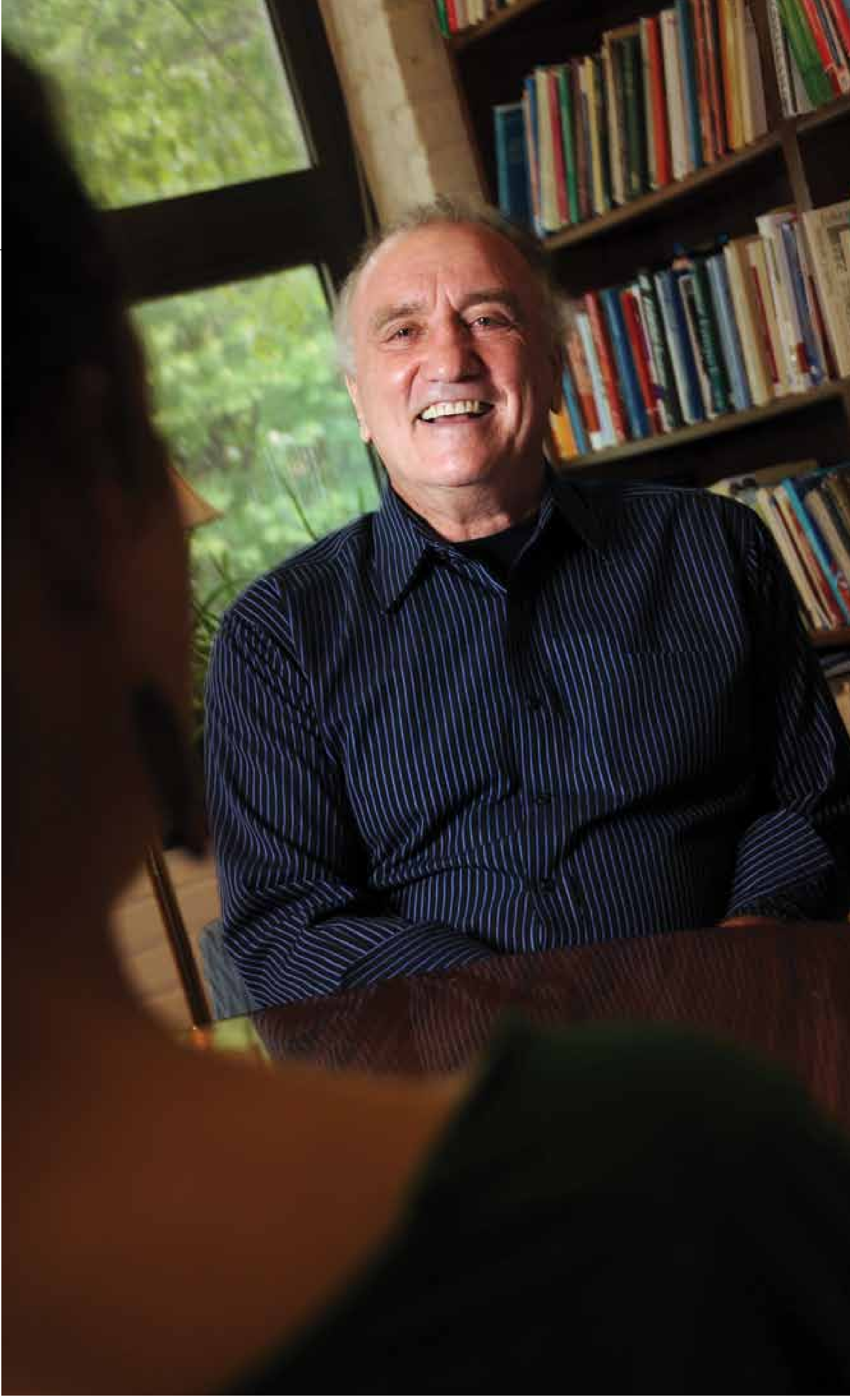
THE SOUNDS of the "hoi toid" are beginning to ebb along much of the Outer Banks. Dr. Walt Wolfram, William C. Friday Distinguished University Professor of English, says the distinctive dialect of area residents is fading as younger generations adopt more mainstream grammar and pronunciation. "It's a slow process," Wolfram says, "but language was never meant to be static. It's always dynamic and changing."

For almost two decades, Wolfram has studied the dialect of people in Hyde County, including Ocracoke Island, as well as residents of Roanoke Island and Harkers Island. Colleagues initially told him people along the coast had a Shakespearian manner of talking because of the words and grammatical constructions they used. Highways and mass communication made the coastal areas less isolated in the mid-20th century, however, and new words started making their way into the local lexicon, he says. For example, the term "dingbatter" for an outsider came from 1970s television character Archie Bunker to designate someone with little sense.

"Language was never meant to be static. It's always dynamic and changing."

During North Carolina's population boom in recent decades, many of the dingbatters moved to the coast to live, and summer tourism became a major regional industry. "This is a region that has gone, in a relatively short period, from a maritime tradition to an economy based on tourism," Wolfram says. "So, the influence of outsiders has grown tremendously." That influence extends to language, where the speech patterns of Latinos, people from the Northeast, and others, have taken hold and begun to replace some of the native brogue. Younger residents are usually the first to adopt the changes. "Teens don't talk like their parents; they talk like their peers," Wolfram says. Some younger residents with a strong island identity do retain the brogue, he says, and the loss of the local dialect is less pronounced on Harkers Island because rural Carteret County is much less touristy than other coastal locations.

Outside influences also have affected the speech patterns of African-Americans in the region, says Wolfram, who has studied several generations of families in Hyde County. His research has shown that the speech of older blacks is nearly indistinguishable from whites to most outside listeners. "These folks have been living together in isolation for centuries, so they have many of the same regional features in their speech," he says. But younger blacks now emulate the urban culture in how they speak, so they sound nothing like their relatives or like other teens in the area. "There are so many changes going on with language in the region," he says. "It's really an intriguing area for research." •



Dr. Walt Wolfram's pioneering research on social and ethnic dialects includes more than 2,500 sociolinguistic interviews with residents of North Carolina and beyond. In 2010, Dr. Wolfram was awarded the Linguistics, Language and the Public award by the Linguistic Society of America.

Buried Treasure: System Cleans Runoff

Heavy rains can wash bacteria directly onto beaches and into oceans requiring official beach warnings.

Dr. Mike Burchell developed an underground stormwater infiltration system to capture bacteria and other debris before runoff reaches the beach or ocean.

YELLOW SIGNS dot North Carolina's beaches, warning people about stormwater discharge from nearby outfall pipes. Heavy rains wash contaminants off coastal roads and parking lots, and the pipes flush the bacteria and other debris onto a beach or directly into the ocean. State health officials sometimes issue beach advisories or alerts when tests show high bacteria levels near outfall pipes, so Kure Beach and state transportation officials asked Dr. Mike Burchell, assistant professor and extension specialist in NC State's Department of Biological and Agricultural Engineering, to find a way to keep their local beaches open rain or shine.

Burchell's team decided to use the most obvious feature of the beach town—sand—to filter the stormwater. "Coastal property is so expensive and scarce that it would be difficult to locate a treatment system downtown or in a neighborhood," Burchell says. So, he designed a system that runs under the dunes and allows the stormwater to seep into the groundwater, where it can flow laterally toward the ocean. Figuring sediment and debris would clog the small pipes in a septic drain field-type of system, he instead used large, open-bottom chambers that are commercially available to create three 100- to 200-foot-long underground infiltration systems situated parallel to the shoreline. Stormwater is diverted before it reaches outfall pipes, filling the chambers before gradually filtering through the underlying sand.

During heavy storms, some overflow still makes it to the outfall pipe, but Burchell says tests have shown that the dune infiltration system captures 80 to 95 percent of the stormwater. "The degree of difficulty in managing stormwater increases as we get closer to the center of town," he says, noting one of the systems is located near the Kure Beach pier, where more parking lots mean more runoff. "We still capture most of the bacteria that washes off early in the storm." Monitoring wells in the dunes also show no appreciable increase in bacteria levels in the groundwater after the runoff drains through the sand. "We want to make sure that diverting stormwater into the groundwater does not have a negative impact," Burchell says.

The dunes atop the filtration system have been replanted with sea oats and grasses, so beachgoers don't even know the underground chambers are there. Burchell says the system could be used on other North Carolina beaches, but it's more efficient on higher and wider beaches, where runoff can filter through more sand before reaching the groundwater. "There is no silver bullet for handling stormwater runoff," Burchell says. "But this system presents a low-cost, low-tech option for many communities." •

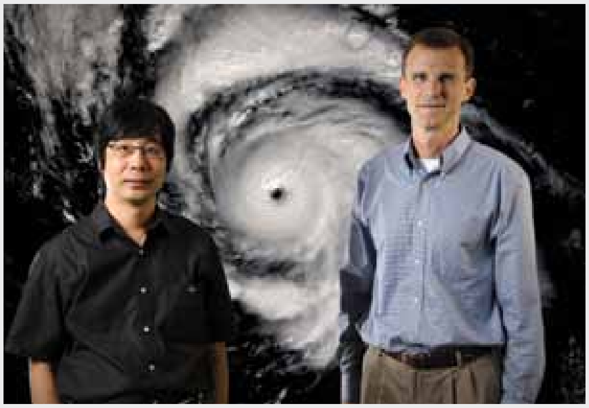
Building a Better Hurricane Forecast

HAZEL, DONNA, Fran, Floyd, Isabel. North Carolina has been smacked so many times by hurricanes that coastal residents are on a first-name basis with some of the worst storms. According to the State Climate Office, a hurricane makes landfall in North Carolina once every four years, and three-fourths of those that have come ashore since 1950 have been major hurricanes. Some people fear that global climate changes will produce even stronger storms in the future, so NC State researchers are trying to gain a better understanding of hurricanes and devise more accurate forecasts.

ian Xie and Dr. y Lackmann use ercomputing nologies and ulation models to dict how climate nges may impact re storms.

Using the supercomputer horsepower of the Renaissance Computing Institute, a collaborative program with NC State, UNC-Chapel Hill and Duke University, Dr. Gary Lackmann, a professor in the Department of Marine, Earth and Atmospheric Sciences (MEAS), and his research team simulate both real and hypothetical hurricanes to gauge the impact of climate change on tropical systems. Some simulated hurricanes are allowed to reach their maximum intensity so researchers can see how they peak in current conditions and those forecasted for the late 21st century by the Intergovernmental Panel on Climate Change (IPCC). "Much of climate change depends on what people do in the coming years," Lackmann says. "So, we must consider a range of solutions."

Lackmann's team uses data from past hurricanes and IPCC projections for sea-surface temperatures, water levels, humidity, and other variables to see what a hurricane like Fran or Floyd might look like in 50 to 75 years. The simulations helped them determine that current storms forming in more humid environments grow larger, with more extensive spiral rain bands at their outer edges. "The strongest storms in the future will likely be slightly stronger than those today, and they will produce heavier rainfall," Lackmann says. "Ocean temperatures will rise, but so will atmospheric temperatures, which will mitigate the increased strength of tropical systems."



MEAS professor Dr. Lian Xie, who has become known for the accuracy of his annual forecast of Atlantic hurricane activity, is developing a computer program to forecast further into the future to discern any impact from climate change. Xie uses a statistical model for the seasonal forecasts, but it cannot predict beyond one year nor foresee record-breaking events because it generates a probability of what will happen in current conditions based on activities in previous years. His new model differs from those Lackmann uses because his seasonal forecasts cover a larger area over a longer time frame. "The dynamic model we're developing will enable us to forecast hurricane activity in both today's environment and in the climate of the future," Xie says. •

Tools Needed to Bounce Back After the Storm

Dr. Billy Edge leads research regarding disaster zone recovery and sustainable engineering practices in disaster environments.

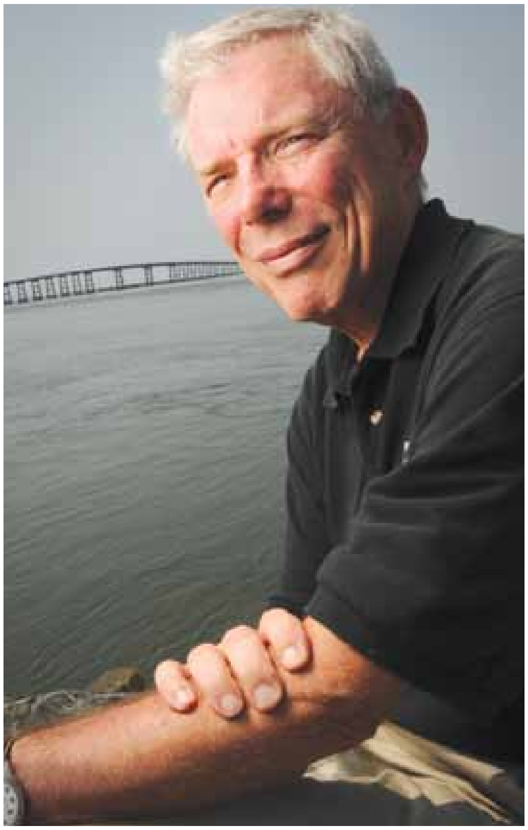
Dr. Mo Gabr (left) and graduate student Cary Caruso (foreground) demonstrate the use of the newly developed scour probe to Dr. Margery Overton in preparation for field work to study the scourability of barrier island dune systems on North Carolina's Outer Banks.

COASTAL STORMS have raked North Carolina, with intense winds demolishing buildings and ripping apart infrastructure. They also have swamped the state, with torrential rains forcing residents to flee for higher ground and leaving homes uninhabitable. NC State researchers are studying ways to design coastal communities—through planning and construction—to be more resilient in future storms. "You know you're going to take a hit," Dr. Margery Overton says. "What we want to know is how well you can handle it and recover."

A professor in the Department of Civil, Construction and Environmental Engineering (CCEE), Overton is leading a team of NC State researchers addressing engineering challenges for a Department of Homeland Security (DHS) center that focuses on natural disasters and emergency management. With 20 years of experience in coastal erosion research, Overton is studying how landforms and structures change before, during, and after coastal storms. She cites Hurricane Isabel, which chewed up the Outer Banks in 2003, creating a new inlet and severing the main road on Hatteras Island. Overton uses different models to measure how variations in storm surge and waves affect the movement of sediment, which could give communities an idea of how much beach and dune erosion to expect during storms. "The more aware you are of the potential for damage, the better you can prepare," she says. "You can take preventive steps or identify ways to quickly recover after a storm."

Research by CCEE professors John Baugh, Downey Brill, Mo Gabr, George List, Ranji Ranjithan, and Rudolf Seracino involves using sensors to monitor the structural integrity of bridges, levees, and other infrastructure and to determine when they have been damaged beyond repair; developing innovative designs and retrofits for flood walls; and creating integrated computer models for in-depth analysis of water and transportation systems and improved disaster preparedness. Overton says the team hopes to develop various tools that can be used by communities to become more resilient. "Comprehensive systems models can be incorporated to identify weak links and ways to establish redundancies in critical systems," she says. "We could potentially identify specific infrastructure that can be designed to higher standards and either rebuilt or relocated."

Design standards are a key element in recovering from coastal storms and other natural disasters, says Dr. Billy Edge, a CCEE professor and director of the Coastal Processes and Engineering Program at the UNC Coastal



Studies Institute in Manteo. Edge is a veteran of disaster zones, having led teams of engineers into the aftermath of the Indonesia tsunami, Hurricane Katrina, and last spring's earthquake in Chile. "Too many areas are unprepared," he says. "People just don't recognize the fragility and the severity of their environments." Normal beach erosion, for example, routinely claims houses on the Outer Banks, and coastal storms place significantly higher stresses on area buildings and infrastructure. "The more intense hurricanes we've seen in recent years have really set a new bar for design to withstand such storms," Edge says.

Devastation by Hurricane Ike two years ago forced the Galveston, Texas, area to build to higher standards—literally. Edge visited the region shortly after the storm to examine damage to buildings, roads, bridges, and the marine infrastructure. He returned last year to measure the rebuilding process and the impact of coastal management plans. The information he collected is helping him and others create statistical models the Federal Emergency Management Agency (FEMA) is using to map flood zones along the Texas and Louisiana coasts. Some Galveston homes now are built more than 20 feet off the ground to get out of the flood zone, and their utilities likewise will need to be elevated and protected from storms. "We need structures at the coast that are sustainable," he says, "and it's my job to find ways to design them."

Dr. Dave Tilotta is trying to find ways to make building materials more storm-proof. An associate professor and extension specialist in the Department of Forest Biomaterials, Tilotta is NC State's point man for the DHS' Resilient Home Program. The effort came about after Hurricane Katrina, when officials realized there was no single place for homeowners whose houses had been damaged in a natural disaster to seek information. Tilotta's team worked with program members at Savannah River National Laboratory, the U.S. Army Corps of Engineers, and Clemson University to create YouTube videos and other means to disseminate information on issues like mold mitigation and ways to retrofit homes. They also developed performance-based guidelines to encourage construction of buildings to better withstand high winds.

"The best way for a community to recover from a natural disaster is to get people back into their homes as quickly as possible."

The Resilient Home Program is now ramping up research efforts, such as determining how resistant building materials are to floodwaters. "FEMA provides guidance on when materials should be considered too damaged for use, but there's no science behind them," Tilotta says. His team dunks flooring into specially built flood-simulation tanks in Hodges Laboratory that contain river water or saltwater. After soaking the boards for up to a couple of weeks and then drying them out, they put the materials through a battery of tests to see how well they meet performance standards like weight-bearing capacity. Eventually, Tilotta says, they will test wall studs and other materials as well. "The best way for a community to recover from a natural disaster is to get people back into their homes as quickly as possible," he says. "Our research and education efforts are designed with that goal in mind." •

Dr. Dave Tilotta (left) and Tyler Strayhorn, an M.S. candidate in Forest Biomaterials, use flood-simulation tanks to test building material resiliency to river water and sea water.

Katie Weaver, an M.S. candidate in Marine, Earth and Atmospheric Sciences, and Dr. Helena Mitasova (right) use a physical model to study topographic change of Jockey's Ridge.

Shifting Sands Part of Jockey's Ridge Evolution

JOCKEY'S RIDGE State Park boasts the tallest natural sand dunes on the East Coast, but the claim to fame doesn't loom as large as it once did. The dunes now measure 21 meters above sea level, down more than a third from when the state park was formed in 1974 and by half from the 42-meter height some 60 years ago. "The dunes are essentially flattening as winds move the sand to the south," says Dr. Helena Mitasova, an associate professor in the Department of Marine, Earth and Atmospheric Sciences.

> "The large dune is a relatively recent and short-term phenomenon."

An expert in coastal topography and landscape evolution, Mitasova has studied Jockey's Ridge for several years. By reviewing hand-drawn and aerial maps dating to the 19th century and using aerial laser scanning to produce high-resolution, 3-D digital models of the area, her research team has determined that the park is undergoing a natural evolution. Geologists who took core samples of the area previously determined that it had cycled between sand dunes and a maritime forest twice in the past millennium. "The large dune is a relatively recent and short-term phenomenon," Mitasova says. The dunes doubled in size between World War I and the early 1950s before shrinking back in recent decades. One of Mitasova's graduate students, Katie Weaver, is studying the vegetation around the dunes to determine if that contributed to their changing stature. Mitasova and Dr. Margery Overton, a professor in the Department of Civil, Construction and Environmental Engineering, have used aerial laser scanning to map the beach and dunes along much of the Outer Banks. They developed techniques to determine the stable "core" of the areas and the surrounding "envelope" of shifting sands. The method allows them to track the extreme changes in the volume of beach and sand, which helps with coastal management strategies. By applying the analysis to Jockey's Ridge, Mitasova's team has determined that the dunes are shifting to the south by 3 to 6 meters a year. "The main dune is now lower than the west dune," she says.

The state scooped out part of the southern edge of Jockey's Ridge in 2003 because it was poised to bury nearby homes, and crews deposited the sand to the north of the main dune. Mitasova says that strategy seems to be replenishing the dunes without interfering with the area's evolutionary cycle. "It's a question of, do we preserve the feature or the process," she says. "Our research is helping to design strategies to preserve this unique landform as a living, ever-changing feature." •

Often referred to as "The Living Dune," Jockey's Ridge is located in Nags Head, North Carolina.

Clinical Experience Shapes Vet's Research

THE HUMPBACK whale was very sick when it became stranded on a sandbar near Ocracoke Island last spring, and Dr. Craig Harms knew the animal wasn't going to make it back to the open water alive. With a team from NC State's Center for Marine Science and Technology in Morehead City, the associate professor of clinical sciences in the College of Veterinary Medicine (CVM) embarked on a mission of mercy. To ensure the euthanasia was humane not only to the whale but also to the gulls and other scavengers that might feed on the carcass, Harms devised a lethal injection protocol using low doses of several drugs that don't leave a toxic residue in the whale's system.

Such clinical experiences—they usually have happier endings than euthanizing an animal—shape much of Harms' research. In addition to handling aquatic animal strandings along the coast, he monitors the health of the fish and marine mammals at North Carolina's three state aquariums and works with a Topsail Island nonprofit group caring for sick and injured sea turtles. "I'm opportunistic," he says. "I collect tissue and blood samples and other data during clinical treatments, and I research things that appear unusual or don't make sense."

During tests on harbor porpoises and bottlenose dolphins, for example, Harms discovered that they carried *Bartonella*, a bacteria spread by fleas and ticks. He also found a strong association between the microbes and animal strandings. Because biting insects aren't known to feed on aquatic mammals, Harms is working with Dr. Ed Breitschwerdt, a CVM professor of internal medicine and *Bartonella* expert, to determine the source of the bacteria. "It could be stormwater runoff," Harms says, "or there could be some aquatic cycle or a land-water linkage that we just don't understand yet."

Likewise, his work with sea turtles led Harms to conduct pharmacological studies to determine the best way to manage pain and inflammation. He has found that some drugs metabolized in the liver are effective for shorter periods in turtles than in mammals, which he says is surprising considering the reptiles' slower metabolism. "We changed our treatment protocols because of our findings," he says. Now, he hopes that necropsies he and colleagues performed last winter on more than 400 turtles that died off the Florida coast after being stunned by a drop in water temperature will provide him with more data for future clinical use and research. "This gives us a good baseline on otherwise healthy sea turtles," he says. "We can study a lot of things with this information." •

> Working with sea turtles led Harms to conduct pharmacological studies to determine the best way to manage pain and inflammation in the reptiles.

NC State research has determined that certain drugs metabolized in the liver are effective for shorter periods in sea turtles than in mammals.

Dr. Craig Harms conducts clinically-applied research aimed at improving health and welfare of aquatic animals.

Algal Studies Aimed at Avoiding Harmful Blooms

Dr. Dan Kamykowski studies plankton ecology to model drivers of algal bloom proliferation (opposite left).

Dr. JoAnn Burkholder's research links environmental factors such as production hog farms to ammonium levels that support algal blooms in the Neuse River Estuary.

A CARPET of algae filled Onslow Bay in October 1987, sickening fishermen and people on central North Carolina beaches and rendering oysters and other shellfish caught in area waters inedible for months. Such harmful algal blooms, often referred to as "red tide" because of the color of the algae, have become more widespread in recent years, according to the National Oceanic and Atmospheric Administration. They cost the U.S. an estimated $82 million a year in lost income from fishing and tourism, treatment of illnesses, and monitoring efforts. NC State researchers are studying different organisms responsible for harmful blooms along the Eastern Seaboard and Gulf Coast to better understand their biology and how to forecast when they grow to unhealthy levels.

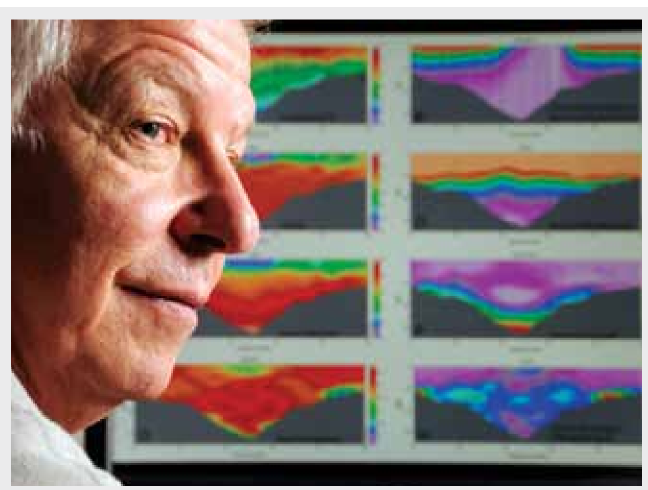
The organism that wreaked havoc in Onslow Bay, *Karenia brevis*, has caused problems in the Gulf of Mexico for centuries, says Dr. Dan Kamykowski, an expert on plankton and a professor in the Department of Marine, Earth and Atmospheric Sciences (MEAS). *K. brevis* is a dinoflagellate—algae that use whip-like appendages to move through the water—that secretes toxins that can become airborne and cause respiratory distress in humans. The toxins also are absorbed by shellfish, which can make people who eat them sick, and have been known to kill birds, fish, and other aquatic animals that feed in the waters near a bloom.

To determine how *K. brevis* blooms are formed, Kamykowski sailed the waters near the Florida panhandle, using an array of monitoring devices to measure factors like algae concentrations, nutrient levels, and water temperature throughout the water column. His studies have shown that, unlike other dinoflagellates that go dormant for a period, *K. brevis* remains active under the surface, moving up to get enough sunlight for photosynthesis and back down to the sediment to find necessary nutrients to survive. A shift in current can then suddenly bring them close to shore and expose them to the surface, Kamykowski says. "They can form a bloom without much growth," he says. Still, nutrient-laden runoff from farm fields, urban stormwater, and septic-enriched groundwater, as well as rising sea temperatures, could be creating larger, more frequent *K. brevis* blooms. "We've shown that red tide is a natural phenomenon," he says, "but man-made troubles might be aggravating the problem."

Dr. JoAnn Burkholder's research has linked production hog farms in eastern North Carolina to growing blooms of *Heterosigma akashiwo* in the Neuse River Estuary. The alga can produce toxins that lead to fish kills. Ammonium levels in the estuary

> "Pollution from continued development is overwhelming the natural balance of the estuarine food web."

have soared by 450 percent since 1993, according to Burkholder, a professor in the Department of Plant Biology and director of NC State's Center for Applied Aquatic Ecology. "Ammonium is a nutrient that many phytoplankton prefer to consume," she says. Her research team has tracked changes in land use in the Neuse River basin over time, and the growth of swine operations in the southeastern part of the state—and the wastes they produce—correlates directly with the increased ammonium levels. "Other factors likely contribute to a degree," she says, "but industrialized swine operations have been the major change in the watershed in that time."



NC State has wired the Neuse River from headwaters to coastal estuary for real-time monitoring of water quality, and Burkholder's data show that the amount of plankton in the estuary has increased by 50 percent in 15 years. The hydrology of the system lends itself to problems—winds routinely roil nutrients up from the sediment in the shallow estuary, and algae aren't easily flushed out because the estuary drains into Pamlico Sound instead of the ocean—but Burkholder says human activities in the river basin have helped a number of algae species thrive in the estuary. "Even with clean-up efforts, we're running to stand still," she says. "Pollution from continued development is overwhelming the natural balance of the estuarine food web."

Accepting red tide as part of the natural balance in the Gulf of Maine, Dr. Ruoying He has developed a forecast model to help public health officials and fishermen in the Northeast work around spikes in algae levels. A physical oceanographer by training, the MEAS associate professor began studying *Alexandrium fundyense* during his previous position at Woods Hole Oceanographic Institute in Massachusetts. The dinoflagellate produces a toxin that is potentially fatal to people who eat shellfish from areas near a recent algal bloom. "I'm used to the physical science of the ocean currents," He says, "but I find the biological interaction in studying algal blooms fascinating."

Biologists at Woods Hole take sediment samples from the ocean every winter to determine the distribution of dormant *A. fundyense* cysts across the region, and they also provide He with algal growth and mortality rates. He combines that information with data on ocean currents, water temperatures, sea levels, and river flows to produce his predictive model. Various scenarios are run through the model to develop a range of possibilities for each season. "We're trying to create an envelope, similar to hurricane forecasting," He says. Water samples are then routinely collected throughout the spring and summer to help validate the model and provide data for shorter-term forecasts, which help determine when to close beaches and shellfish beds and to monitor oysters, clams, and mussels for toxicity. "Red tide is very problematic," he says. "We need a better understanding of algae to combat harmful blooms and avoid the dangers they pose to public health." •

Certain algal blooms contain photosynthetic pigments making the water column appear red. The algae known as Karenia brevis *secretes toxins that are harmful to humans.*

Dr. Ruoying He monitors and forecasts algae levels using data from a coastal ocean glider outfitted with temperature and conductivity sensors.

Eye in Sky Can See Underwater Greenery

Dr. Stacy Nelson and Brett Hartis, a Ph.D. candidate in Forestry and Environmental Resources, examine underwater vegetation in the Currituck Sound.

UNDER A searing summer sun, an NC State research team takes a small boat out onto Currituck Sound and drops some lines in the water. This is no ordinary fishing expedition, however. The group is reeling in samples of plants growing in the sediment a few feet below the surface so they can correlate their findings with images snapped by a satellite soaring more than 275 miles over their heads.

Determining the location and variety of vegetation submerged in a body of water has always been a labor-intensive process. It's also one with the potential for inaccuracy, as researchers pull samples from various points and then extrapolate their findings over a wider area. The North Carolina Department of Transportation (NCDOT) asked Dr. Stacy Nelson, associate professor in the Department of Forestry and Environmental Resources, to find an easier and more reliable way to inventory underwater plants. Submerged vegetation often presents planning problems for NCDOT engineers on projects that cross water. They must either avoid areas teeming with plants because those spots often are also teeming with fish or mitigate the construction damage by replanting elsewhere. "If you don't have an accurate inventory of what's there," Nelson says, "you don't know where to avoid and what to mitigate."

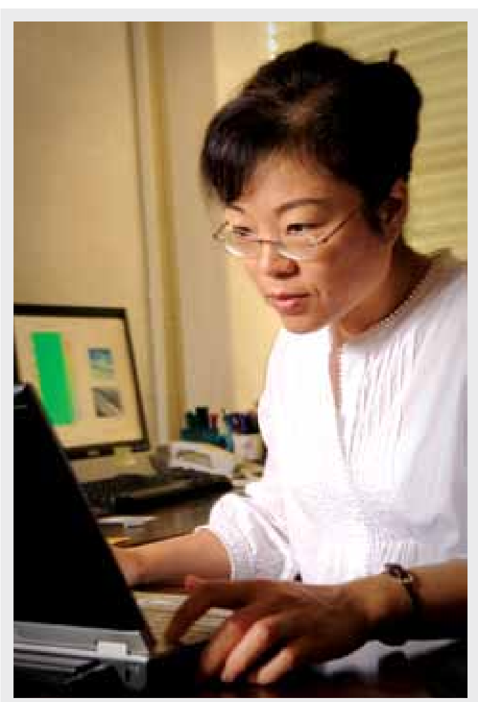
Nelson, who works in the College of Natural Resources' (CNR) Center for Earth Observation, believes high-resolution satellite images can be used to pinpoint submerged vegetation. He says he had good results using satellite photos to map lakes in Michigan a few years back, and now he is tapping into more detailed photos from a commercial satellite called Quickbird to develop a mathematical model for predicting what plants are where underwater. The model also will include data on water quality and the "reflective signature" of various plants.

Submerged vegetation often presents planning problems for NCDOT engineers on projects that cross water.

Getting the signature for each species is where the boat trips on Currituck Sound come in. "Water either scatters or absorbs the reflective energy the satellite is trying to capture, so there's little left to develop a signature," Nelson says. Together with Dr. Tom Colson, a geographic information systems expert in CNR, and two graduate students, he had to conduct a manual inventory so they could match their findings to the Quickbird photos. They collected samples at 276 points over 270 square miles three times during the summer as vegetation changed, noting the global-positioning satellite coordinates of each point so they would sample the exact spots each time. "If we can use the model to preserve healthy plant communities," Nelson says, "we can boost the underwater ecology along our coast." •

Changing the Tide on Rip Currents

RIP CURRENTS can turn a carefree day into a tragedy. At least three people drowned off the North Carolina coast last summer after getting dragged offshore, and lifeguards and bystanders had to pull hundreds of others to safety from the powerful currents. Dr. Jie Yu, an assistant professor in the Department of Civil, Construction and Environmental Engineering, is trying to gain a better understanding of the mechanisms involved in the formation of rip currents so coastal communities can better forecast them and make beaches safer.



An expert in fluid mechanics, Yu is studying the interaction between waves, currents, and the movement of sand. A rip current can begin to form when waves break near shore, she says. "Once a wave breaks, its energy and momentum dramatically change and are transferred to form surf-zone currents," Yu says. Under certain conditions, these currents move in a circular pattern—water moves onshore in some places and flows back out to sea in others. The beach topography affects this circular flow since wave crests tend to follow the depth contours in the shallows near shore. Undulations in the beach can make the wave non-uniform when it rolls in perpendicular to the shoreline, Yu says, forcing the water to move sideways and converge into offshore flows—rip currents—at the low spots in the beach topography.

As the circular flows develop, they interact with the waves. "This can make the sideways and circular motions speed up," Yu says. When two of these circulation patterns are in close proximity, the outward flow confined between them becomes very strong. "Is the lack of uniformity on the beach causing the rip current, or does the circular motion create the beach undulations?" she says. "It's a chicken-and-egg proposition."

To solve the riddle, Yu is developing mathematical models that include data like wave height, the angle at which waves hit the beach, and the location of nearby sandbars. In a five-year project funded by the National Science Foundation, she will combine models to reflect the interaction of waves and currents, nonlinear dynamics, and sediment movement along the shore. "Rip currents threaten the public safety and affect the form and structure of beaches," Yu says. "If we have more knowledge about them, I hope we can make them less of a hazard." •

Dr. Jie Yu uses mathematical models to better understand the interaction between waves, currents and topography that result in rip currents.

In 2010, the U.S. Lifesaving Association reported that of 10,449 rescues performed nationally last year, 6,498 were due to rip currents.

results.
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