

Coastwatch

NORTH CAROLINA SEA GRANT • WINTER • 2013 • ISSUE 1 • \$3.75

RESEARCH,
RECREATION
AND REPAST:
*Treasuring
Gifts of the Sea*

It's Good To Be Home

Having grown up in Orange County, I really did not expect to be able to utter those words from Raleigh, given my coastal research background. It is with pleasure that I have begun a new adventure here with North Carolina Sea Grant. With many wonderful opportunities to engage with a range of partners from across the state, inland to coastal, I often now feel closer to the coast than when I was living in Charleston, S.C.

Getting to know Sea Grant leaders and staff in Raleigh and along the coast, becoming more familiar with our current partners, and beginning to look toward new opportunities to continue to provide programmatic relevance and excellence to address our state's needs have been eye-opening, educational experiences for me. My respect for the commitment of Michael Voiland and Steve Rebach, previous executive director and associate director, respectively, has been solidified from learning of the expansive range of excellent programming these two spearheaded. Both these leaders transitioned to their well-earned retirement at the end of 2012 and I commend their contributions to this program.

In becoming more familiar with the current range of Sea Grant-supported research and extension projects, I have found this

diversity to be both a strategic decision and a sound investment for the state. The long-term excellence of the program is a result of the forward-looking planning and anticipation of coastal informational needs, the program's capacity to provide rapid support for research and extension needs, and the long-term community partnerships that enable the application of results for positive impact.

Currently, we are fine-tuning the latest strategic plan, which lists our anticipated future focus areas. In January, Sea Grant participated in a University of North Carolina systemwide coastal and marine science review that was conducted by the American Association for the Advancement of Science. I will tell you more about both of these activities in a future issue of *Coastwatch*.

As Sea Grant continues to evolve to address long- and short-term coastal resource management issues, I anticipate that the program will maintain programmatic flexibility to address priority coastal concerns and look to expand activities that provide additional information on the linkages between the health of coastal ecosystems, humans and economies.

I came on board at North Carolina State University with a dual hat: directorship of Sea

Grant and the Water Resources Research Institute of the University of North Carolina. Both programs are interinstitutional and designed to serve the entire state. While they both support research and extension needs, one focuses from the ocean to the inland riverine and estuarine reaches of the coast, and the other from the coastal plain and piedmont up to the mountains. I feel strongly that these two separate program resources bring great opportunity for research collaboration to address the pressing issues facing North Carolina in coastal and water resource management. Our freshwater and saltwater resource issues are more closely related than is often realized. I look forward to sharing these joint research and extension successes in the coming years as we continue to understand the watershed connections, from the mountains to the sea, that impact the health of our coastal resources.

I hope to continue our conversation together. I encourage you to reach out to me at snwhite3@ncsu.edu or 919/513-1145 so that we can work together to address the coastal resource issues facing North Carolina, both now and into the future.

— Susan White, Executive Director
North Carolina Sea Grant

I N T H I S I S S U E

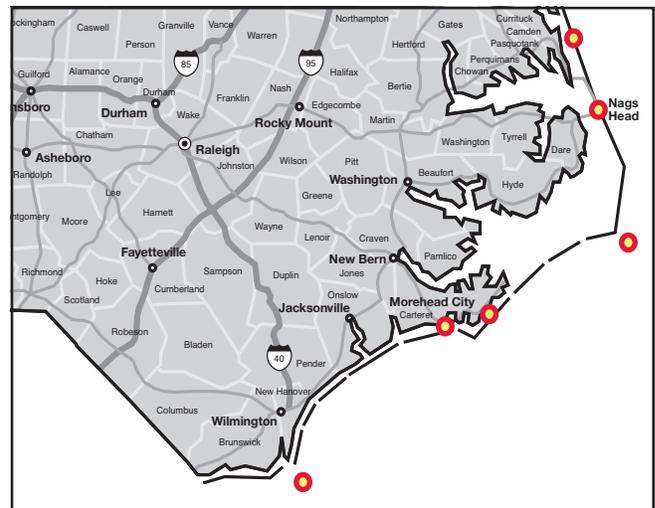
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North Carolina's diverse coast offers countless interesting subjects.
The map indicates story settings in this issue —
including Currituck, Dare and Carteret counties.





Coastwatch

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A hard-to-open shell holds a tasty treat. Try this oyster recipe from *Mariner's Menu: 30 Years of Fresh Seafood Ideas*.back cover

Coastwatch

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The North Carolina Sea Grant College Program is a federal/state program that promotes stewardship of coastal and marine resources through research and outreach.

It joined the National Sea Grant College Network in 1970 as an institutional program.

Six years later, it was designated a Sea Grant College.

Today, North Carolina Sea Grant supports research projects, an extension program and a communications staff.

Susan White is executive director.

The program is funded by the U.S. Department of Commerce's

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C O A S T A L T I D I N G S

Roger Winslow/NC State University

Winter and spring events are aimed at groups including high school students, recreational fishermen and seafood retailers.

MARK THE CALENDAR FOR WINTER, SPRING EVENTS

North Carolina Sea Grant and its partners have many activities through April.

- Visit the **Nature in Black & White** special exhibit at the N.C. Aquarium on Roanoke Island. Through April 3, students from a North Carolina State University biological illustration class will display a selection of their work. For more, visit www.ncaquariums.com/archives/15143.

- The **2013 N.C. Marine Recreational Fishing Forum**, sponsored by Sea Grant, will be held on Feb. 16 at the McKimmon Center in Raleigh. Registration is required for this free event. Brad Gentner, president of Gentner Consulting Group and nationally recognized for his economic analysis of saltwater recreational fishing, is a confirmed speaker. For more information and to register, visit www.ncseagrant.org/recfishforum.

- N.C. Catch, the statewide group that markets local seafood and educates consumers, is organizing the **Local Catch Summit** on Feb. 21 and 22 at the University of North Carolina Coastal Studies Institute in Wanchese. Sea Grant is an event sponsor. The meeting starts with N.C. Catch's board meeting, followed by a kickoff dinner that is open to the public. Talks on assisting catch group member businesses

and general seafood education are scheduled for day two. More information is under the News & Events tab at www.outerbanksatch.com.

- The **2013 Blue Heron Bowl** is set for Feb. 23 in Raleigh. North Carolina State University is the host and Sea Grant is one of the sponsors. The winner of this regional marine science quiz bowl will advance to the National Ocean Sciences Bowl in Milwaukee, Wis., from April 18 to 21. Learn about the Blue Heron Bowl at sites.google.com/site/blueheronbowl/ and about the national competition at www.nosb.org.

- The **American Fisheries Society Tidewater Chapter annual meeting** will be held March 21 to 23 in Solomons, Md. Look for North Carolina research results at the opening poster session, and talks over the next two days. For details, go to www.sdafs.org/tidewater/AFSTidewater/Home.html.

- From April 5 to 21, the **N.C. Science Festival** will have activities throughout the state for the whole family. For more, visit www.ncsciencefestival.org. And don't forget to celebrate **Earth Day** on April 22. Many local science museums and organizations will hold related events, so check their calendars.

Visit www.ncseagrant.org for more. — E.L.

COASTWATCH IN THIS ISSUE

Greenville-based writer Marion Blackburn writes about preserving wrecks along our coast on page 12. She focuses on archeology and wrote about the Corolla shipwreck for *Archaeology* magazine in 2010. Jack Horan contributes an article about light towers on page 24. He is a retired reporter for the *Charlotte Observer*.

HATHAWAY RECEIVES ENVIRONMENTAL EDUCATOR KUDOS



Terri Kirby Hathaway receives her award from Keith Bamberger, EENC membership co-chair.

Terri Kirby Hathaway, North Carolina Sea Grant marine education specialist, was recognized as the 2012 Outstanding Practitioner by the Environmental Educators of North Carolina, or EENC.

The award recognizes an EENC member who helps to build environmental education as a profession through statewide efforts and leadership, as well as by being an advocate for excellent education.

“Terri has been a leader in environmental education in North Carolina, and the South Atlantic and Mid-Atlantic regions, as well as on the national level. It is great to see her creativity

and hard work recognized by the EENC,” says Jack Thigpen, Sea Grant extension director.

Hathaway was cited for her dedication to environmental education and educators statewide, her enthusiasm for the discipline, and her long-term impact in the field.

“It is Terri’s contagious enthusiasm for anything related to the ocean and teaching that makes her an outstanding practitioner of environmental education,” notes Beth Cranford in the nomination. Cranford, an educator at the N.C. Museum of Natural Sciences, writes that Hathaway’s warmth and passion is “a priceless contribution” to the profession.

Hathaway facilitates the Methods of Teaching Environmental Education course, which is required for EE certification, and trains state educators on ocean-related topics. She develops coastal curricula for North Carolina classrooms and organizes teacher workshops. In addition, she serves as an education specialist with the Center for Ocean Sciences Education Excellence SouthEast, serving North Carolina, South Carolina and Georgia.

She writes *Scotch Bonnet* (blogs.ncseagrant.org/scotchbonnet), a marine education newsletter, three times a year. She also is a regular contributor to *Coastwatch*.

In 2009, Hathaway was named the Monitor National Marine Sanctuary’s Volunteer of the Year for her work on educating the public about the sanctuary. — E.L.



Sea Grant’s mock retail counter draws curious visitors.

FIRST OUTER BANKS SEAFOOD FESTIVAL HELD

The inaugural Outer Banks Seafood festival, held at Nags Head in October 2012, featured local seafood. Cooking demonstrations, education tents, a photo contest and performances by local bands filled the day.

Outer Banks Catch, a local seafood marketing initiative, played a founding role in the event.

Sara Mirabilio, North Carolina Sea Grant fisheries specialist, assisted in planning numerous education tents that showed how seafood moves from the net to the table. Sea Grant set up a mock retail counter displaying “what is in season, how it is caught, how to prepare it and what to look for when you buy a fresh fish,” Mirabilio explains.

Historical cookbooks displayed past fishing styles and recipes. Local elder fishermen also were in attendance to tell stories of their days on the water.

The 2013 Outer Banks Seafood Festival is set for Oct. 19. — M.J.

ANNUAL WATER CONFERENCE SET FOR MARCH

The Water Resources Research Institute of the University of North Carolina is hosting its annual conference from March 20 to 21 at North Carolina State University’s McKimmon Center in Raleigh.

The event is open to people with an interest in water-related issues, including North Carolina’s water resource problems, solutions and opportunities. The North Carolina Water Resources Association Annual Symposium is an integral element of the program.

The symposium will include discussions on nutrient credit trading, and explore the barriers and opportunities for such a program in the state. The conference will conclude with the free Progress Energy Seminar — Water, Energy, Security: Colliding Imperatives. It is open to the public.

For early rates, register by March 15. For details, visit www.ncsu.edu/wrri/code/events/annualconference.htm. — M.J.



WRRI’s conference will focus on North Carolina’s water resource issues, solutions and opportunities.

NC SCHOLARS START MARINE POLICY FELLOWSHIP

Noah Chesnin and Wendy Piniak will begin their assignments as Dean John A. Knauss Marine Policy Fellows in February. This one-year post-graduate fellowship will give them experience shaping national policy issues affecting ocean, coastal and Great Lakes resources.

Chesnin, who received his master's in environmental management from Duke University's Nicholas School of the Environment, will work for U.S. Rep. Sam Farr, who represents California's 17th Congressional District.



Noah Chesnin



Wendy Piniak

"I am passionate about public participation in marine decision making and hope to learn firsthand how resource users, other stakeholders and the general public can be engaged in the legislative process in order to help protect and sustainably use our oceans," Chesnin says. The Seattle native has an undergraduate degree from Yale University.

Piniak, who holds a doctoral degree in marine science and conservation from Duke University, will join the National Oceanic and Atmospheric Administration Fisheries' Office of Protected Resources.

Piniak, who hails from Islesboro, Maine, also has a master's in environmental management from Duke and a bachelor's degree in biology and environmental studies from Gettysburg College in Pennsylvania.

Funded by the National Sea Grant Program, the fellowship honors John A. Knauss, a Sea Grant founder, NOAA administrator and former dean of the University of Rhode Island's Graduate School of Oceanography. The application deadline for the 2014 Knauss Fellowship is Feb. 15. Learn more at www.ncseagrant.org/s/knauss. — E.L.

C O A S T A L T I D I N G S

DUKE DOCTORAL STUDENT IS NOAA FISHERIES FELLOW

Meagan Dunphy-Daly started her three-year stint as a National Oceanic and Atmospheric Administration Fisheries/Sea Grant Fellow in June 2012. The fellowship supports doctoral students in fisheries population dynamics or marine resource economics.

Dunphy-Daly, from Duke University's Nicholas School of the Environment, is studying the effect of marine protected areas, or MPAs, on populations of top open-ocean predators, such as tunas, billfishes and sharks.

The population dynamics fellowship, which funds her dissertation research, has enabled her to assess fishing effort as a function of distance from an MPA in the Northwestern Hawaiian Islands. She seeks to determine if the amount of fishing increases around an MPA over time and how that affects predators.

"Being able to work with scientists who are familiar with the data that I am analyzing is invaluable. I got to experience daily life at a NOAA center and I will have a chance to join in a NOAA research cruise in July," Dunphy-Daly says. She is collaborating with fellowship mentor Jeffrey Polovina and colleagues at NOAA's Pacific Islands Fisheries Science Center.

The Ferndale, Mich., native received bachelor's degrees in biology and studio art from Oberlin College, and a master's degree in biological sciences from Florida International University.

"The fellowship is an excellent means of promoting conservation and management of living marine resources," says Sara Mirabilio, N.C. fellowship coordinator. "It provides real-world experience to doctoral students and increases their expertise in this discipline, as well as fosters closer relationships between academic scientists and federal fisheries managers." Mirabilio also is a fisheries specialist for North Carolina Sea Grant. — E.L.



Meagan Dunphy-Daly



Sierra Schelegle

UNC-CH STUDENT RECEIVES COASTAL POLICY FELLOWSHIP

North Carolina Sea Grant and the N.C. Coastal Resources Law, Planning and Policy Center awarded the 2013 Coastal Policy Fellowship to Sierra Schelegle.

She is a doctoral candidate at the University of North Carolina at Chapel Hill's Curriculum for the Environment and Ecology program.

"The fellowship is the first of its kind for Sea Grant and the Center," says Lisa Schiavinato, Sea Grant coastal law, policy and community development specialist and co-director of the center. The program fosters research on coastal policy issues within North Carolina, including exploration of the legal implications.

Schelegle will compare and contrast climate adaptation practices in North Carolina and Maryland. She is assessing factors that influence a community's degree of planning for sea-level rise. "This fellowship is an amazing opportunity to delve into a subject of great personal interest and extreme importance to coastal North Carolina," she says.

A native of Davis, Calif., Schelegle received her bachelor's degree in ecology and evolutionary biology from Princeton University.

"Schelegle has a dynamic background and demonstrated commitment to climate change research. Her research on the motivations of sea-level rise planning will add value to conversations occurring in our coastal communities and amongst coastal resource managers." Schiavinato says.

Schelegle's academic advisor is Philip Berke, of the UNC Institute for the Environment and a faculty member in the city and regional planning department.

For more about the N.C. Coastal Resources Law, Planning and Policy Center, see www.nccoastallaw.org. Information about Sea Grant fellowships can be found at www.ncseagrant.org/home/research/fellowships. — S.B.S.



A federal agency has started a process that might bring wind farms to the state.

STATE STARTS INVESTIGATING WIND LEASES

In December 2012, the federal Bureau of Ocean Energy Management, or BOEM, began a process that could lead to leases for wind farms in federal waters off North Carolina.

The first phase is intended to gauge industry interest and provide public input for three potential offshore lease areas. One is 6 miles off Kitty Hawk, running 45 nautical miles north and south. The other two are 7 and 13 miles south of Wilmington, forming blocks 11 by 15 miles and 21 by 28 miles, respectively.

Lisa Schiavinato, co-director of the N.C. Coastal Resources Law, Planning and Policy Center and North Carolina Sea Grant law, policy and community development specialist, is a member of the N.C. Renewable Energy Task Force. “This is the time wind-energy companies can show their interest to the federal government and the state of North Carolina,” says Schiavinato.

Schiavinato adds that the three wind-rich lease areas were screened for desirable wind speeds and for potential use conflicts, such as military training corridors, shipping lanes and productive fishing grounds. Officials at Cape Hatteras National Seashore raised concerns that wind turbines could mar scenic views.

The planning process will consider environmental impacts, socioeconomic issues and siting concerns. Should BOEM offer leases, companies awarded leases must get agency approval for site assessment plans, and construction and operations plans. Thus, any prospective wind farms offshore of North Carolina are years away, she says.

BOEM will schedule public information meetings. For more information, visit www.boem.gov/Renewable-Energy-Program/State-Activities/North-Carolina.aspx. —J.H.



COASTWATCH WRITERS WIN AWARDS

North Carolina Sea Grant staff took honors in a yearly communications contest held by the North Carolina Association of Government Information Officers.

Coastwatch managing editor, E-Ching Lee, took home first place in feature writing for her Summer 2012 story on “Hunting for Quicksilver: Testing Local Seafood for Mercury.” Lee talked with scientists who found that, in many cases, North Carolina seafood had lower mercury levels than the same species in national studies.

“It is an honor to receive this award,” Lee notes. “And even more so because it was with a story that highlighted the benefits of eating North Carolina seafood.”

Sharon Settlage, 2012 *Coastwatch* contributing editor, received third place in feature writing for her Spring 2012 story on dune grass research, titled “Advancing Sea Oat Biology: Advancing Dunes.”

Settlage also won honorable mentions for “The Pamlico Sound: Fishing Gem of North Carolina,” which told of the Coastal Habitat Protection Plan in the Pamlico Sound region, and “The Multitalented Oyster,” an article about the environmental benefits of oyster reefs. They were published in the Summer 2012 and Autumn 2012 issues of *Coastwatch*, respectively.

“These three articles were a pleasure to write. I hope that they help our readers see the benefits of North Carolina Sea Grant research, and foster further appreciation of the state’s coastal environment,” Settlage comments.

Lee and Settlage both credit editor Katie Mosher for providing guidance in a friendly and insightful manner.

“I am proud of E-Ching and Sharon for being recognized by their peers across the state,” adds Susan White, Sea Grant executive director. “They continue a fine *Coastwatch* tradition of sharing research results with broad audiences.” — S.B.S.

LEFT: Jennifer Garifo, NCAGIO president, hands awards to E-Ching Lee (top) and Sharon Settlage (bottom).



BY SHARON SETTLAGE

MUMMICHOG TAGGING: 384.36F2B3418C IS IN THE CREEK

Beside a small creek in Beaufort, Paul Rudershausen struggles to unlock a transceiver unit. His effort is a sign that the device has been working well. When the unit was first installed, he said, he might have had to unlock the big metal door several times a day to troubleshoot. Now the lock has become stiff from limited use because all is working as it should.

The transceiver unit looks like a park kiosk. It is informational, with a notice explaining that scientists from North Carolina State University are assessing the population of creek fish. As described, the team will tag fish and place antennas in local creeks to monitor fish movement and “determine population demographics such as growth, age structure, and population size.”

Behind the door of the transceiver unit lies a complex array of high-tech equipment, including a modem that transmits data to Rudershausen’s email, a multiplex antenna receiver, an AC-DC converter and four large batteries.

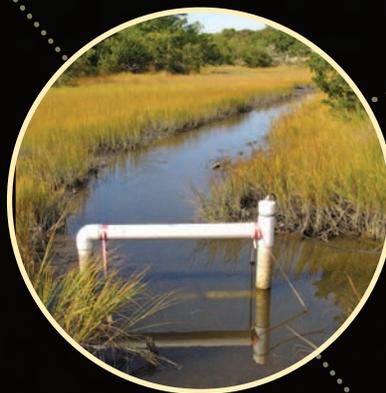
All this to detect the movement of a small fish.

Called mummichog, Native American for “goes in crowds,” it also is known as a mud minnow, or, up north, as a killifish. The fish frequently is used as live bait to catch many other marine fishes because it is their preferred natural prey.

North Carolina Sea Grant is funding NC State fisheries biologists Jeff Buckel and Joe Hightower, who are Rudershausen’s graduate advisors, to determine if the small fish can act as sentinels for the health of tidal creeks. Buckel is at the Center for Marine Sciences and Technology in Morehead City. Hightower is with the U.S. Geological Survey and the N.C. Cooperative Fish and Wildlife Research Unit at NC State in Raleigh. *Continued*

*Mummichogs, or *Fundulus heteroclitus*,*

CENTER: CALLED MUMMICHOG, NATIVE AMERICAN FOR “GOES IN CROWDS,” IT ALSO IS KNOWN AS A MUD MINNOW, OR,





UP NORTH, AS A KILLIFISH. THE FISH FREQUENTLY IS USED AS LIVE BAIT TO CATCH MANY OTHER MARINE FISHES BECAUSE IT IS THEIR PREFERRED NATURAL PREY. *Scott Taylor*

TOP: FLOODED MARSH IN THE HEADWATERS OF PORTERS CREEK ON A FALL DAY.
 MIDDLE: PELLETIER CREEK IS LOCATED IN A DEVELOPED AREA OF MOREHEAD CITY.
 BOTTOM: PORTERS CREEK DRAINS INTO THE NEWPORT RIVER NEAR FARMLAND.



can be found in tidal creeks from Quebec to Texas. According to Rudershausen, in the U.S. Southeast they do best in creeks surrounded by *Spartina alterniflora*, or smooth cordgrass. As the tide rises, the *Spartina* grass is flooded. The mummichogs follow the tide onto the flooded marsh.

ALTERED AREAS

Rudershausen installed antenna units in three locations in Morehead City — Pelletier, Porters and Spooner creeks — and an unnamed creek in Beaufort he calls AV Creek. The creeks are found in areas with different “alteration scores” as calculated by the N.C. Coastal Habitat Protection Plan, or CHPP, committee.

Generally, high alteration scores are associated with more development. Jen Weaver, a former Sea Grant/N.C. Division of Marine Fisheries fellow, worked with DMF and Buckel to recommend alteration scores. (See Summer 2012 *Coastwatch* for a story on CHPP)

Rudershausen, Buckel and Hightower are testing whether the health of the primary fish species living in the tidal creeks is related to the alteration scores, and thus to coastal development.

Gloria Putnam, Sea Grant coastal resources and communities specialist, agrees with the approach. “A lot of what we look at now is related to bacterial counts and whether the water is safe for human contact and consuming oysters. But we don’t have a lot of biological indicators to assess creek health.” Putnam continues, “I think that’s something we need to look at and focus on more, so we can really tell how these creeks are altered.”

Mummichogs are an ideal type of fish for this study because they tend to stay in or near the location where they are spawned. Thus, the team theorized that mummichogs would be good barometers for the health of the creeks.

As Buckel recounts it, the original grant proposal called for studying two creeks, but the energetic Rudershausen expanded the study to four creeks with antennas, plus two more creeks where he is monitoring the mummichog

population.

They are measuring physical parameters of the fish’s growth and movements, as well as biochemical metrics of fish health.

ELECTRONIC DATA

Buckel and Hightower previously led Sea Grant-funded projects to monitor red drum and spot populations using tagging methods. However, mummichogs need an exceptionally small tag because of their size — they are about 2 inches long.

The tags are radio-frequency tags known as Passive Integrated Transponder, or PIT, tags. The PIT tags are the same as those used for microchipping dogs and cats.

The transceiver detects the electrical current that is produced when the magnetic chip in the tags is close to the antenna wire. Enclosed in PVC pipe, the wire is anchored in the creek and connected to the transceiver unit.

Detecting small tags in marine waters is difficult because salt water masks electrical currents, Rudershausen explains. In tidal creeks it is doubly difficult because salinity varies with rainfall. A downpour can reduce the salinity of the creek. Fortunately, the reader automatically adjusts for the salinity changes.

Rudershausen and Buckel credit Ben Letcher, Matt O’Donnell and Todd Dubreuil at the S.O. Conte Anadromous Fish Research Center in Turners Falls, Mass., for helping them to customize the system for salt water. That group continues to collaborate with the NC State team on improvements in antenna design and ways to analyze the data. The center, named for the late U.S. congressman Silvio O. Conte, was established by the USGS, and is



affiliated with the University of Massachusetts Amherst campus.

Several times a year, Rudershausen surgically implants upwards of 100 fish per creek with PIT tags, each coded with a unique combination of 13 numbers and letters. When the tagged fish passes near the antenna wire, it is logged as a detection event.

To insert the tag into a mummichog,

TOP: PAUL RUDERSHAUSEN INSPECTS THE ANTENNA RECEIVER INSIDE A TRANSCIEVER UNIT AT THE BEAUFORT LOCATION HE DUBS AV CREEK.
 BOTTOM LEFT: JEFF BUCKEL USES TANKS TO HOUSE FISH WHEN TESTING THE VIABILITY OF TAGGED MUMMICHOGS.
 BOTTOM RIGHT: AN ANTENNA UNIT MONITORS FISH IN AV CREEK.



Sharon Seiffage

mummichogs using minnow traps baited with dry cat food. He measures each fish's weight, length and sex and checks how many of the captures are tagged. These data allow him to calculate how many fish are in each creek.

GOING WITH THE FLOW

In an earlier Sea Grant-funded study, Rudershausen installed three antennas in Porters Creek, located in a rural area outside of the Morehead City limits off the Newport River.

He found that he could follow the movements of individual fish in the creek. He initially tagged 44 fish and recorded 1,112 moves past the antennas over four months.

A total of 42 of the 44 tagged fish were detected at some point between November 2010 and August 2011, indicating a high detection rate. But by the end of the study, the apparent survival was

only 3 percent, which verifies other studies indicating that the fish are naturally short lived. They also are prey for birds, crabs and other fish.

Rudershausen recounts a winter day when he saw a cormorant scooping up mummichogs. He also has seen blue crab and bluefish having mummichogs for a meal.

The three antennas showed that mummichogs move predominantly in the direction of the tide. They move upstream into the creek headwaters during flood tide and leave

the creek headwaters to return to the mouth of the creek, where it drains into the Newport River, late in ebb tide.

Buckel explains that the original function of the antennas was to monitor any fish emigration from the creek, which they assumed would be rare. Instead the team found that the fish were regularly moving out of, and then back into, the marsh creek.

"It was really beautiful data. Every day as the water started to recede, we'd see antennas 3, 2 and 1 register the fish as they moved out of the creek and as soon as the water started to come back in we'd see 1, 2, 3 as the fish came back in. We learned they were moving in and out with the tide and our original supposition that the bulk of these animals would stay in the creek above the antennas was incorrect," Buckel recalls.

The movements into the creek maximize the fish's access to the intertidal marsh, which is flooded for about three hours, twice per day in Porters Creek.

At high tides, when the marsh is flooded, mummichogs enter into the *Spartina* grass to feed and find refuge. A study conducted near Beaufort in the 1980s by National Oceanic and Atmospheric Administration Fisheries researcher William F. Hettler Jr., at the NOAA Beaufort Laboratory, used nets to capture fish during high tide in the marsh. Mummichogs were the most prevalent species.

A Sea Grant-funded study from the 1970s by R.T Kneib and S.E. Stiven of the University of North Carolina at Chapel Hill, showed that mummichogs feed on small crustaceans, insects, algae, fecal pellets and detritus in the marsh grass. Because mummichogs are prey for larger fish such as red drum, they are an important part of the transfer of energy from the marsh to deeper-water fish species.

BACK IN THE LAB

Rudershausen and Buckel are collaborating with NC State toxicologist, Pat McClellan-Green at CMAST, to conduct biochemical measures of fish health. Rudershausen captures and sacrifices untagged

Continued



Marc Hall/NC State University



Sharon Seiffage

Rudershausen uses a sterile scalpel to make a small slit in the anesthetized fish's belly and slides the tag in. Afterwards he applies an iodine mixture and returns the fish to a recovery tank. No suturing is required. In about 10 minutes or less, the fish is swimming about again. He has never lost a fish from the procedure, developed in collaboration with Craig Harms of NC State's College of Veterinary Medicine.

Once per month, Rudershausen captures

TOP: AN ANESTHETIZED MUMMICHOG BESIDE A PIT TAG, WHICH IS ABOUT HALF AN INCH LONG. MIDDLE LEFT: AN ELECTRONIC READER SHOWS THE 13-DIGIT CODE THAT IDENTIFIES EACH FISH. MIDDLE RIGHT: MALE (TOP) AND FEMALE MUMMICHOGS HAVE DIFFERENT SIZE AND COLORATION. BOTTOM: MUMMICHOGS RECOVER IN CREEK WATER AFTER BEING TAGGED.



Sharon Settlage

fish, measures their length, weight and sex, and then dissects their livers and gonads. He weighs the organs to get a measure of the fish's metabolic and reproductive health.

McClellen-Green is examining the amount of an indicator protein, CYP1A, that is typically expressed when fish are exposed to contaminants such as polycyclic aromatic hydrocarbons, dioxins, PCBs and many pesticides.

Some polycyclic aromatic hydrocarbons, or PAHs, are toxic to aquatic animals. A recent N.C. Cooperative Extension bulletin detailed the sources as motor oil, tire particles, vehicle exhaust, crumbling asphalt and parking lot sealants. All are components of urban land use. The CHPP committee identified developed land as a significant contributor to alteration of coastal creeks.

Therefore, the creeks in more developed areas or near marinas, such as Pelletier Creek, would have higher alteration scores and also would be expected to contain more PAH contaminants.

In preliminary work, McClellen-Green found that most of the creeks with higher alteration scores also produced fish with more indicator protein. The fish from creeks in developed areas also had larger livers than those from the undeveloped creeks, raising the possibility that livers increased in size in response to contaminants.

McClellen-Green tells of a study in Elizabeth River in Virginia where mummichogs live downstream of a former creosote plant. Creosote, a black tar-like substance used as a wood preservative, leaches PAHs.

Most of the Elizabeth River mummichogs downstream of the plant "have massive liver tumors, but they live a normal lifespan," McClellen-Green says. These fish have become adapted to the high chemical levels. She says changes have occurred in the fish's genetics.

McClellen-Green also will measure

biochemical indicators of fish reproduction in both males and females.

EPHEMERAL WATER

Fred Holland, retired director of the Hollings Marine Laboratory run by NOAA in Charleston, S.C., coauthored a booklet with Denise Sanger, now with the S.C. Department of Natural Resources, titled *Tidal Creek Habitats, Sentinels of Coastal Health*, published by the South Carolina Sea Grant Consortium.

Tidal creeks, as their name implies, rise and fall with the tide. At the 2011 Southeast Tidal Creek Summit organized by Sea Grant programs in North Carolina, South Carolina and Georgia, Holland reported that small tidal creeks drain almost completely at low tide while only about 25 percent of the water drains from the largest tidal creeks at low tide. Rudershausen is working with smaller creeks.

Holland and Sanger's booklet title is apt. A healthy tidal creek indicates a healthy coastal area.

Sea Grant researcher Martin Posey at the University of North Carolina Wilmington presented research at the summit on the health of oyster populations in New Hanover County tidal creeks. He noted that healthy tidal creeks



Sharon Settlage



Marc Turano

are nursery habitat for shrimp, blue crab, and many commercially important fish species such as spot, croaker, flounder, menhaden and drum. Crab, oysters, pinfish and mummichogs are common adult residents of the creeks, Posey adds. Wading birds frequent the creeks also.

Holland and Sanger's publication calls the headwaters of tidal creeks "first responders to stormwater runoff and are an important habitat for evaluating the impacts of coastal development on aquatic ecosystems." Their stressors include nearby impervious surfaces, where stormwater drains unimpeded into the creeks.

Although Holland is retired, he remains active in supporting tidal creek research.



Sharon Settlage



TOP: RUDERSHAUSEN TAGS ONE OF 40 FISH ON A NOVEMBER DAY.

BOTTOM: THE RESEARCHERS HAVE YET TO LOSE A FISH TO THE TAG-INSERTION PROCEDURE, DEVELOPED WITH NC STATE'S COLLEGE OF VETERINARY MEDICINE.

CLEVER FISH

ON WARM NIGHTS WITH A FULL OR NEW MOON, MUMMICHOGS CAN BE HEARD SPLASHING ABOUT IN THE MARSH WATER. MALES ARE IN THEIR FULL NUPTIAL COLORATION.

BACK IN THE 1970S, RESEARCHERS FROM UNIVERSITY OF DELAWARE SHOWED THAT MUMMICHOGS SPAWN IN RESPONSE TO THE SEMIMONTHLY TIDAL CYCLE.

REPRODUCTION IS LINKED TO THE HIGHEST TIDES. THE TIDES, KNOWN AS SPRING TIDES, OCCUR THROUGHOUT THE YEAR. (SEE THE *COASTWATCH* SUMMER 2012 ISSUE FOR A STORY ON TIDAL CYCLES.) LINKING REPRODUCTION TO AN OUTSIDE SIGNAL ENSURES THAT THE MALES AND FEMALES ARE READY TO SPAWN AT THE SAME TIME. WHERE THE EGGS ARE LAID ALONG GRASS STEMS ALSO IS IMPORTANT.

AROUND THE SPRING TIDES, THE HIGH TIDE IS AT ITS PEAK AND THE WATER LEVEL ON THE *SPARTINA* GRASS IN THE MARSH ALSO IS AT ITS HIGHEST. DURING THIS TIME OF HIGH WATER, FEMALES ATTACH CLUTCHES OF FERTILIZED EGGS TO GRASS STEMS. THE DESICCATION-RESISTANT EGGS THEN DEVELOP AT THE HIGH-WATER LINE, AWAY FROM UNDERWATER PREDATORS. TWO WEEKS LATER, AT THE NEXT SPRING TIDE, THE EGGS ARE SUBMERGED ONCE AGAIN AND HATCH. THE FRY GROW TO ADULTHOOD IN SMALL MARSH POOLS WHERE THEY ARE PROTECTED BY PREDATION FROM LARGER FISH.

THE CALIFORNIA GRUNION IS ANOTHER FISH THAT FAMOUSLY SPAWNS DURING SPRING TIDES. THE GRUNION RIDE THE SPRING TIDE WAVES TO REACH AS HIGH ON THE SANDY BEACH AS POSSIBLE WHERE THEY MATE AND LAY THEIR EGGS IN THE SAND. GRUNION RUNS HAVE BEEN FEATURED IN MUSIC AND TELEVISION.

SO FAR THE MUMMICHOG IS NOT QUITE SO FAMOUS, BUT MAYBE THAT'S ABOUT TO CHANGE.

the period of inundation of the marsh upstream of the road here was longer, so larger organisms like red drum could utilize this marsh system.”

Barbara Doll, water quality specialist at Sea Grant weighs in. “Incorrectly sized or poorly configured culverts can impede water flow and restrict passage of aquatic organisms. Reduced flow can result in upstream sedimentation that buries benthic habitat as well.”

Narrow culverts, developed land use, marinas and other factors considered by the CHPP committee may affect the health of the ecosystem, including the creeks and mummichogs.

Holland is looking forward to the results of the team’s work. “If they successfully demonstrate that the condition of the mummichog population is related to the ecological state of tidal creeks, their research will represent an important contribution to the growing body of science suggesting that tidal creeks are indicators of the health and sustainability of coastal ecosystems.”

Download *Tidal Creek Habitats, Sentinels of Coastal Health* at www.sceagrants.org/pdf_files/tidal_creeks_booklet.pdf. View documents from the 2011 Southeast Tidal Creeks Summit at www.ncseagrants.org/2011tidalcreekssummit. And read *The World of the Saltmarsh* by Charles Seabrook.

“If tidal creeks are in good condition, we can expect them to support bountiful seafood supplies that are safe to eat. If our creeks are impaired, it will not be safe to swim in them or eat the seafood they produce,” Holland stresses. “The condition of southeastern tidal creeks tells us if we have managed our landscape in a sustainable manner.”

Rudershausen is still gathering data to study potential differences in mummichog density or growth rates that he can correlate to the health of tidal creeks. But his anecdotal evidence indicates that something is going on in AV Creek in Beaufort. The creek flows through a dilapidated under-road pipe.

“A couple of locals have told me, ‘When I was a kid, there used to be red drum in this creek.’ But something has changed. Probably



the

THE RICHES OF THE NORTH CAROLINA COAST — sparkling beaches, winding shores and hidden coves, vibrant port cities, and abundant fishing — include another kind of treasure, often the buried kind.

Hundreds of historic shipwrecks lie underwater, typically within a few hundred feet of shore. Occasionally they rise up from their watery resting places to emerge just beyond the waves or even wash onto the beach. Others, including *Queen Anne's Revenge*, Blackbeard's flagship, rest on the sea floor, attracting recreational and scientific divers who are curious about these vessels' history and cargo.

Along with romance and mystery, these shipwrecks carry priceless caches of artifacts and information, making them valuable sites for scientific research and archaeology.

Since 2007, North Carolina Sea Grant has supported promising research at East Carolina University through its Maritime Heritage Fellows program for graduate students. In 2012, the program funded two projects that will significantly advance underwater archaeology and conservation.

Daniel Brown is looking for clues about the identity of an ancient wooden shipwreck that floated to shore near Corolla about three years ago. The oldest found in North Carolina, it also may be the oldest on the East Coast.

Thomas Horn is studying the 1877 wreck of the *USS Huron* just off the coast of Nags Head. His study will evaluate how seasonal variables, such as temperature changes, affect corrosion on an iron vessel.

These projects, undertaken as part of their master's degree studies, will answer some long-standing questions about the effects of salt water, ocean currents and the passage of time on ships of all kinds, while uncovering missing pieces of the state's own story.

Continued

RIGHT: THIS DOUBLE-TOURNOIS COIN SHOWING THREE FLEUR-DE-LIS IMPRIMATURS DATES FROM THE REIGN OF LOUIS XIII AND WAS FOUND ATTACHED TO THE COROLLA SHIPWRECK.

BY MARION BLACKBURN

SCIENCE *of Shipwrecks*

"THERE IS AN ENTIRELY UNWRITTEN HISTORY OF

NORTH CAROLINA THAT WE'RE TRYING TO DISCOVER.

THESE ARE NONRENEWABLE RESOURCES. IF THEY ARE DESTROYED,

EITHER BY MAN OR BY NATURE, WE LOSE A BIG CHUNK OF OUR PAST.

THEY ARE TIME CAPSULES OF THE PERIOD FOR WHICH THEY EXISTED.

IF THEY DISAPPEAR, WE LOSE OUR KNOWLEDGE OF THAT PERIOD."

— BRADLEY RODGERS, DIRECTOR, ECU'S MARITIME STUDIES PROGRAM



Journal



TOP LEFT: CONCRETION CONTAINING LEAD SHOT WAS FOUND ON THE SHIPWRECK AT COROLLA. TOP RIGHT: BRADLEY RODGERS (LEFT), JOSH MARANO AND DAN BROWN EXAMINE A CHARRED AREA OF THE COROLLA SHIPWRECK. BOTTOM LEFT: EAST CAROLINA UNIVERSITY STUDENTS MEASURE AND ASSESS THE COROLLA SHIPWRECK. BOTTOM RIGHT: THE COROLLA SHIPWRECK REMAINED ON DISPLAY AT THE CURRITUCK BEACH LIGHTHOUSE FOR SEVERAL WEEKS IN SUMMER 2010, WHERE CURIOUS VISITORS AND RESEARCHERS CAME TO STUDY IT.

“There is an entirely unwritten history of North Carolina that we’re trying to discover,” says Bradley Rodgers, director of ECU’s maritime studies program, who serves as Brown’s adviser. “These are nonrenewable resources. If they are destroyed, either by man or by nature, we lose a big chunk of our past. They are time capsules of the period for which they existed. If they disappear, we lose our knowledge of that period.”

Nathan Richards, ECU faculty member and head of the maritime heritage program at the University of North Carolina Coastal Studies Institute, advises Horn on his study of the *Huron*. Richards cites the significance of these wrecks — and the research on them — for their contributions to maritime history and archaeology.

“A lot of people care about the *Huron*,” he

says. “The best way to manage a ship like this one is to be armed with data. If we can tell if the *Huron* is stable or corroding, then activities can be determined to potentially save it, so it can be preserved and enjoyed by future generations.” What’s more, Richards adds, the research will contribute to worldwide understanding of saltwater corrosion.

Shipwrecks attract more than historians and archaeologists. Divers and tourists from around the world come to the state’s shores and coastal museums to learn more about colonial times, pirates, smugglers, Confederate blockade-runners and even the German U-boats that stalked the U.S. Navy near the Outer Banks during World War II.

Littered with shoals, shallow waters and irregular borders, the coast earned its nickname as the Graveyard of the Atlantic. Indeed,

thousands of wrecks may lie off the state’s coast. Most remain buried in the seabed, somewhat protected from destruction, but exposed to decay from salt water, sea life and hurricanes. Knowing the best ways to preserve them under water or above ground will protect these assets for researchers, tourists and historians alike.

MYSTERY WRECK

For two years, residents of Corolla, a small village in the northern Outer Banks, watched a battered wooden hull floating just beyond the shore. It bobbed on the waves and occasionally landed onto the beach before washing away again. A strong nor’easter in late 2009 dislodged it from the sand and in the subfreezing temperatures, the ship began to break apart.

If it shattered, it would be lost forever. Thus, a group of interested volunteers were joined by

staff from the state Underwater Archaeology Branch, part of the N.C. Department of Cultural Resources, to haul the remains inland to safety.

It remained for a time on the grounds of the Currituck Beach Lighthouse, where visitors, researchers and archaeologists had a chance to get close to one of the oldest shipwrecks on the East Coast. Little is known about the ship, which is believed to date from the early 17th century, possibly as early as 1609.

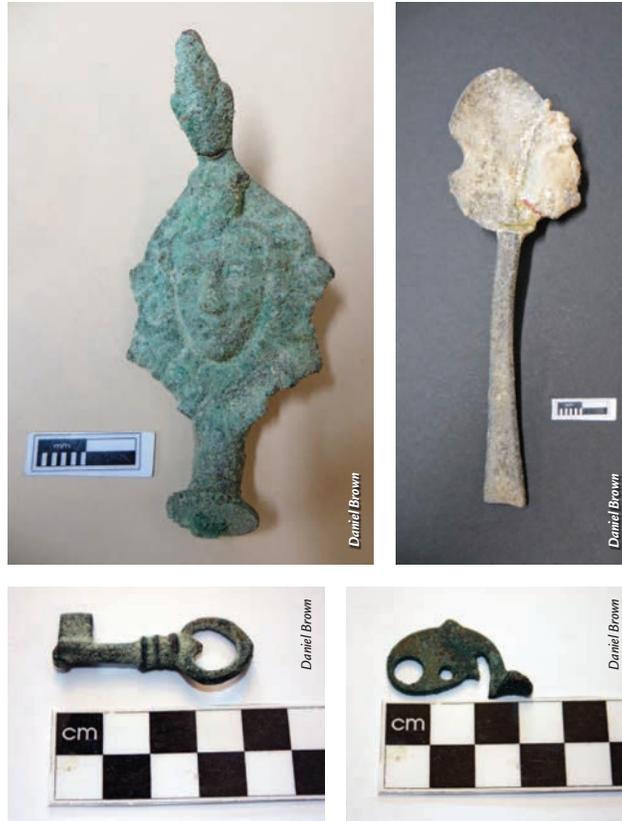
Many ECU maritime studies students worked on the ship in 2010, measuring it, drawing its features and examining it for identifying clues. But for Brown, it was more than a summer job — it became his master’s project. He’s since spent countless hours searching for information about its origin, construction and precise age. While no one knows its name, the ship bears a stunning resemblance to a famous vessel from Bermuda, *Sea Venture*, that was the subject of Shakespeare’s *The Tempest*.

“It’s been very much of a detective story,” says Brown, who is one of the Sea Grant fellows. “I’m trying to find evidence about it, facts, where it came from, what it was doing. Was it a warship? Merchant vessel? Privateer? There’s no bumper sticker. There’s no license plate.” The ship is believed to predate the *Queen Anne’s Revenge* by about a century.

Facts about the mystery wreck don’t come easily. Even determining the wood type and construction methods has taken months of scouring and translating records to learn about types of European timber used in shipbuilding.

“Waterlogged wood is very delicate,” he says. Once wood dries out, the DNA disappears with the other living material, leaving only a hollow cell wall. Without any contents to support it, the cell wall collapses, accounting for the shrinking and eventual decay of wooden ships once they’re on dry ground.

So far, Brown feels comfortable identifying the wooden hull as white oak. A very common European species, *Quercus*



ABOVE: THE ECU RESEARCHERS FOUND MANY ARTIFACTS ON THE COROLLA SHIPWRECK, INCLUDING AN ELIZABETHAN-ERA CLOTHING HOOK (TOP LEFT); A PEWTER SPOON, LIKELY FROM THE 17TH CENTURY (TOP RIGHT); A BRASS ALLOY KEY (BOTTOM LEFT); AND A BRASS ALLOY GUNLOCK FROM A MUSKET (BOTTOM RIGHT).

sessiliflora grows across the continent as far south as the Spanish Mediterranean and into England. Yet even pinning down the type of wood may not give up much information about the ship’s provenance, as timber was traded from the Baltics to the Mediterranean and beyond to locations in the Netherlands, England and Spain.

It’s likely the ship, a large galleon estimated at 70 to 90 feet long, could have carried as much as 300 tons and was engaged in the lucrative colonial triangular trade between England and Europe, the Caribbean, and the New World. It was probably hauling or retrieving tobacco, wood or even settlers, who may or may not have made it to shore.

WINDOW TO THE PAST

In addition to searching for clues about its origins and identity, Brown believes his work will lead to better conservation methods for

wooden ships. Once dry, a dramatic and rapid deterioration begins. “There are too many shipwrecks to save them all,” he says. “It’s a good policy to leave them in place.” Indeed, he notes, the United Nations Educational, Scientific and Cultural Organization, or UNESCO, standard is to preserve wrecks in situ.

Once this wreck washed ashore, however, it became critical to save it before more damage occurred, providing researchers like Brown a golden opportunity. He has spent time, and is now considered a contributing researcher, on *Vasa*, the famous Swedish ship that sank in the Stockholm harbor in 1628 and now has its own museum. That ship has been kept in a constant stream of preservatives and carefully controlled humidity for years to

slow its decay.

Like *Vasa*, Corolla’s mystery ship “is a window to the past,” Brown says. In addition to focusing on the ship’s construction and materials, including the oakum — old rope pounded into cracks and used as caulking — he’s studying the artifacts found stuck to it.

They include coins dating from the time of Louis XIII who reigned in France from 1610 to 1642. These coins, with embossed fleur-de-lis imprints, help date the vessel. In addition, a brass pin found on the wreck is undergoing conservation. These pins are so ubiquitous, however, that their diagnostic value is limited.

Brown has compared the unnamed wreck to 20 other wrecks so far, and feels confident that it is not Spanish or Portuguese because its construction uses more wood fasteners, known as trenails — pronounced “trunnels” — than iron ones. The wreck yielded hundreds of trenails, and only nine iron bolts.

He believes it probably sank in deep water, and made its way over the centuries to shore. That so much of it remains intact — it’s about 17 by 30 feet today — serves as a testament to the sturdiness of its construction.

Before it washed up, the keel was visibly

Continued

attached to it. Although it broke away by the time the wreck reached the shore, the keel was still useful in identifying the type of ship.

His next research steps include possibly having a timber lab examine the wood at a microscopic level for clues about its identity and origins. To do so, though, would mean removing a sizeable piece, several inches wide. He wonders if it's worth it to cause so much damage.

"I took the topic on because I was interested in ship construction," he says. "I did not know what I was getting into — how much of an enigma this ship would be. I've had to be creative in my research techniques to get evidence."

Brown has about 1,700 photos, which he has cross-referenced to date its recent history. "You can see the wreck over two years move around and break up, a piece here, a piece here, until in 2010 you get that big break up," he says.

"Everybody thinks Pilgrims came to America and it was a happy story," he continues. But he notes that there were many unsuccessful attempts before the English were able to achieve their first settlement in Virginia. This nameless ship might be part of that narrative.

"North Carolina was a stepping-stone to establishing Jamestown. It plays a bigger role in history than most people realize," Brown explains.

VITAL SIGNS

The iron steamship *USS Huron* left port at Hampton Roads, Va., on Nov. 23, 1877, for a scientific trip to Cuba. However, it wrecked near Nags Head, taking 98 men to their death in the frigid water.

This notorious episode made it "the Hindenburg of its time," Horn says, and led to more federal funding for lifesaving stations. Built in 1875, the ship represents a transitional period in shipbuilding, an original hybrid iron steamship with supplemental sails. Steel ships



George Browne



John McCord/N.C. Coastal Studies Institute



Courtesy U.S. Naval Historical Center

TOP: THE COROLLA SHIPWRECK WASHED ASHORE AND WAS MOVED INLAND IN SUMMER 2010.

BOTTOM LEFT: DAVE SYBERT LIGHTS THE HULL DURING A RECONNAISSANCE DIVE ON THE *USS HURON*. BOTTOM RIGHT: AN ENGRAVING OF THE SINKING OF THE *USS HURON*.

would soon become standard. The *USS Huron* is the state's first designated shipwreck preserve, and the site of much diving and exploration.

One of the oddest forms of ship deterioration happens when metal, especially iron, is submerged for long periods of time in sea water. Salt water creates a highly corrosive setting and the metal oxidizes or rusts, just as it does on dry ground. Meanwhile, tiny life forms such as coralline algae attach to shipwrecks, while other sea creatures take advantage of the presence of minerals or organic materials that were used in construction or found on board.

Movements of sea water, combined with the salt-ion exchange and natural secretions of sea life, create a dynamic underwater setting that develops a life of its own. Concretion, which is a plaster-like casing, forms around the metals, affixing items to each other like glue. It protects some with a cement-type casing by hiding them beneath layers, often several inches thick.

Some maritime archaeologists believe leaving wrecks in place may be the best way to preserve them. Their research must determine first the conditions that lead to the worst forms of corrosion. Along with location, storm frequency and currents, water temperature may be an important variable.

That theory led to Horn's study. Originally from Los Angeles, Horn graduated from the University of Hawaii with a degree in

anthropology. While he's been diving most of his life, a trip to Easter Island in 2007 sealed his interest in archaeology. His Sea Grant-funded study, *Determining Seasonal Rates of Corrosion in Ferrous-Hulled Shipwrecks: A Case Study of the USS Huron*, will examine the rate of corrosion and concretion build up on this iron ship.

"Corrosion monitoring is interesting — and a challenge," he says. "I enjoy the electrochemistry of it."

Horn is investigating whether changes in temperature, salinity and dissolved oxygen content affect corrosion rates. His results will help determine how best to manage the site in situ, such as by installing sacrificial metals that will corrode instead of the ship, to protect critical areas. Once completed, his study will help map out a way to conserve this ship and others like it in the area — and the world.

"The issue of ferrous material corrosion in the ocean is an international area of inquiry," says adviser Richards. "Wooden shipwrecks, once they are buried in anaerobic settings, tend to be fairly well preserved. With iron it's different because you have galvanic corrosion and other corrosion processes that are happening. We've presumed that wood is less hardy than iron, when it's afloat. But when it's buried, iron is undergoing these electrochemical processes."



Marion Blackburn



Marion Blackburn



Marion Blackburn



TOP LEFT: THOMAS HORN (LEFT) AND HIS ADVISER, NATHAN RICHARDS, AT ELLER HOUSE, HOME OF THE MARITIME STUDIES PROGRAM AT ECU. TOP RIGHT: HORN USES A SILVER-SILVER CHLORIDE REFERENCE ELECTRODE ENCASED IN A CERAMIC SHELL, IN CONJUNCTION WITH A PLATINUM ELECTRODE, TO MEASURE THE CORROSION POTENTIAL OF METAL IN SEAWATER. BOTTOM LEFT: BRADLEY RODGERS, DIRECTOR OF MARITIME STUDIES (LEFT), WITH DANIEL BROWN. BOTTOM RIGHT: BROWN SOAKS A LOUIS XIII COIN IN SODIUM BICARBONATE SOLUTION TO REMOVE SALT AND OTHER MARINE DEPOSITS.

CORROSION AND ENCROACHMENT

Horn's study requires him to make several visits to the *Huron*, and to dive on it at least once every season. He was set to dive in early January, when water temperatures should be in the mid-40s, and plans to make his final dive for the study in late spring. By then, he should have all the data he needs to start "crunching the numbers" during the summer to determine how the variables work together to affect deterioration.

On each visit, he uses a multimeter, an instrument that measures the properties of electrical circuits, in a small hole created with a pneumatic drill through the concretion into the metal. He checks for the growth of additional concretion, as well as the corrosion potential using a platinum electrode.

He'll also make note of sedimentation. He has created a digital three-dimensional map of the wreck site. His results will be used to create a management plan for this ship, which is currently under the supervision of the N.C. Department of Cultural Resources and the Town of Nags Head.

It's popular with divers and snorklers, located about 250 yards from the beach. The boilers, cannonball racks, propeller and rudder make it a compelling location for exploration. Preservation, however, is essential. Not only does the wreck face the natural risks of corrosion and other deterioration, there's human encroachment as well. Sunglasses, for instance, dropped by careless visitors, also disturb and corrupt the site.

Corrosion can be minimized by using sacrificial anodes that deteriorate instead of

nearby ship metal, but protecting the site from human intrusion may be more difficult. Seeing the residents of Easter Island embrace their heritage may provide a suitable model, Horn says. The archaeological record is concentrated, but also cherished by the island residents.

"They take great care of their cultural heritage," he says. "It gave me a great respect for what I'm studying." Likewise, the culture of shipwrecks — and their preservation — has integral ties with life in Nags Head and the Outer Banks.

"One of the reasons I was drawn to this field is my connection to the sea," he says. "At Nags Head, everywhere you look there are shipwrecks — in front of restaurants, in front of houses. The sea affects how you live your life, every day." 📷

BY PAM SMITH

MARC A Center for

By design and location, North Carolina State University's Marine Aquaculture Research Center, or MARC, is something of a hybrid — a mix of opportunity and challenge, science and economics.

With access to salt water from nearby Sleepy Creek in rural Carteret County, researchers focus on growing marine species to help meet global consumer demand for fresh seafood that cannot be met by wild harvests.

“MARC is a tremendous resource to test new ideas on a small scale, or address saltwater species production issues in a controlled environment,” says Marc Turano, interim center director and North Carolina Sea Grant mariculture and blue crab specialist.

Turano describes MARC as a unique facility meant to help growers become more efficient and profitable.

Its 4,200-square-foot building houses a large wet lab with two replicated recirculating aquaculture systems, or RAS; four smaller wet-lab rooms with varying sized tanks; and a chemistry lab for water-quality testing and other analytical needs.

MARC also addresses a major financial obstacle for prospective marine aquaculture, or mariculture, entrepreneurs.

As Turano explains, freshwater aquaculture operations have thrived for 25 years across North Carolina, thanks, in part, to easy access to affordable water supplies — from mountain streams to groundwater.

On the other hand, costly price tags for coastal waterfront sites render salt water not very accessible or affordable for a start-up mariculture operation.

MARC is meant to demonstrate an economically feasible alternative. And, it's all about location.

The center intentionally is situated on a six-acre site at the headwaters of Sleepy Creek, two miles *away* from Core Sound's pricey shores. Yet, the creek provides an ample saltwater supply for the center's multiple projects.

“There are many places like this one in coastal North Carolina with saltwater access — and affordable land costs,” Turano says. “We hope our accomplishments here will be a catalyst for mariculture development.”

Collaborative History

MARC's academic home is NC State's College of Agriculture and Life Sciences, or CALS, where Sea Grant has a decades-long partnership in aquaculture research. The center is a byproduct of the ongoing collaborative history.

MARC is located within the 275-acre Marshallberg Farm owned and operated by Sue and I.J. Won, a former NC State faculty member. In 2009, the Wons donated \$500,000 to the CALS North Carolina Agriculture Foundation to establish the center and advance aquaculture in the coastal region.

Continued

- *TOP: Research at MARC includes developing ideal growing conditions for hybrid striped bass.*
- *BOTTOM LEFT: The MARC facility includes a large wet lab with multiple growing tanks and recirculating aquaculture systems.*
- *BOTTOM RIGHT: The six-acre facility is located on Sleepy Creek in rural Carteret County.*



Becky Kirkland/NC State University



Marc Turano

SEAFOOD TESTING IDEAS



Marc Turano



• FAR LEFT: Ryan Kelly, site manager, and Marc Turano, MARC interim director, oversee projects designed to help growers become more profitable. • TOP RIGHT: An open house in October 2012 drew area residents and NC State supporters to MARC. • MIDDLE RIGHT: CALS Dean Richard Linton, Turano and I.J. Won toured Marshallberg Farm during the fall open house. • BOTTOM RIGHT: The MARC facility enables Turano to test the most efficient feed regimens.

The complex puts a modern spin on Carteret County farming and fishing traditions. The Wons' grass-fed, certified organic Black Angus cattle roam on part of the spread. Rows of organic vegetable crops occupy still another plot.

But the Wons seem proudest of their venture into the realm of fish farming. They are cultivating Russian sturgeon for meat and caviar in a 27,600-square-foot fish barn. The facility, which is totally separate from MARC, houses 26 freshwater tanks, with a 400,000-gallon total capacity. Its state-of-the-art RAS was designed in part by Tom Losordo, now an NC State professor emeritus of agricultural engineering.

Doing the Science

Turano and Losordo also conferred to tailor MARC's recirculating system to meet complex saltwater aquaculture requirements — from intake to outflow.

The "made-to-order" setup is ideal for projects that are funded through the N.C. Fishery Resource Grant Program, or FRG, Turano says. Aquaculture and mariculture are among the priorities of the state program that is administered by Sea Grant.

For Nelson Paul, who owns a 33-acre farm in nearby Bettie, MARC and the FRG program provided the perfect opportunity to explore the economic feasibility of raising mud minnows, or mummichogs, in farm ponds.

Mud minnows, a denizen of coastal brackish waters, are the live bait of choice for recreational saltwater anglers — and not coincidentally, an important part of the diets of flounder, red drum and blue crab. In North Carolina, mud minnows are second only to bloodworms in total volume of sales by bait dealers.

"We have been looking for an alternative crop to ensure the sustainability of the farm, with a special interest in the area of aquaculture," Paul says.

But pond construction would be a costly investment, as well as a permanent alteration to valuable land that is farmed mostly in soy.

"It is productive, excellent soil — a good reason not to disrupt it for untested outcomes," he points out.

Paul's idea was to "do the science" at MARC to determine the spawning activity of mud minnows and the volume that could be cultured using a tank-based system. The data collected over a two-year period would

be deciding factors in the economic viability of going forward with a start-up aquaculture operation.

“Nelson was very hands on throughout the project,” Turano says. “He worked closely with Ryan Kelly, who manages day-to-day operations at the center.”

Paul’s middle-school aged son, Tim, often accompanied his dad on regular visits to MARC. The pair harvested mud minnow brooders, and participated in collecting, counting and sorting eggs.

Based on Paul’s findings, mud minnows in captivity don’t produce enough eggs to make it financially viable to move to the next level.

“Mother Nature determined it is not possible to create an assembly line for minnow production. We also learned that we would constantly have to change out brood fish to maintain brood stock — another practical and economic stumbling block,” Paul reports.

While his FRG did not spawn a new business, Paul views the project as a success story.

“Testing ideas is what the center is all about. Thanks to the FRG and MARC, we saved thousands of dollars by investigating the premise before investing in pond construction,” he adds.

Turano plans to continue the mud minnow research. “As with other marine species, the first few batches of fish typically have poor survival. We think we can overcome those challenges,” he says, explaining that other production methods and different salinities might improve the survival rate.

Works in Progress

Turano envisions MARC playing an increasingly important role in science and technology transfer to support the growth of mariculture.

“In North Carolina, growers regard university researchers and extension specialists as partners who are trying to make science work for their industry,” he says.

Nancy Sugg, who manages Castle Hayne Fisheries in Aurora, agrees. “All the research in the world doesn’t do any good unless it’s out there for public use. We’re lucky in North Carolina to have such an exchange of information. It takes the pressure off when you know you can call on experts to address certain issues,” she says.

For example, Turano is conducting a study with Sugg at MARC to

Continued



• ABOVE: Turano is partnering with Castle Hayne Fisheries for a MARC project helping to evaluate the growth rates of various sizes of hybrid striped bass fingerlings.

evaluate the growth rates of various sizes of hybrid striped bass fingerlings.

Castle Hayne Fisheries is one of the state's two hatcheries that culture hybrid striped bass. During the Phase I hatchery stage, fry grow for 30 to 60 days to reach 1- to 3-inch fingerling size. Fingerlings then are graded according to size — small, medium and large.

“Nancy usually throws the smallest fingerlings back into the pond to allow them to continue to grow,” Turano explains. “But the question remains: Do they catch up in size? We want to study the throwbacks in a controlled tank environment to see how well they grow, compared to the other grades of fish.”

In another MARC study, Turano and Kelly are comparing feeds — one regular and one nutrient dense — for domesticated and wild hybrid striped bass.

“In theory, we should be able to feed less frequently with an enriched diet. But we have to minimize the fish's fat content. Fatty fish are not desirable,” Turano explains.

Growers are looking to science to help find alternatives to fish meal as a protein source in feeding regimens. The ultimate goal is to reduce feed costs *and* maintain the omega-3 nutritional levels consumers desire.

The Green Challenge

While the location of MARC helps overcome the saltwater access issue for marine aquaculture, it also presents a set of environmental challenges for use and discharge.

To start with, water pulled from the salt creek at high tide must undergo a multistage filtration process before being pumped to the indoor tanks for various research projects.

The added challenge comes in developing environmentally sound methods to deal with salt-laden and nutrient-rich wastewater — fish poop — from multiple recirculating tanks. This effluent flows to large tanks outside the building, where it is treated to remove nitrogen, phosphorous and solid fish waste.

The wastewater is pumped into a geo-textile “tube” which traps the solids, leaving clarified water. That water is then filtered through a series of biological filters and finally flows through an experimental constructed wetland.

“The water leaving and returning to the creek must be as good or better than when we pumped it into the center,” Turano says. “We plan to work with other researchers from NC State to look at additional methods



• LEFT: Aquaculture technician Thomas Wade checks water quality at I.J. Won's sturgeon farm. • TOP RIGHT: The endangered Russian sturgeon is being cultivated for meat and caviar at Won's Marshallberg Farm. • BOTTOM RIGHT: NC State aquaculture researcher Harry Daniels checks out the experimental discharge 'garden' at MARC.



Nelson Paul



Pam Smith



Marc Turano



Pam Smith

• TOP LEFT: Tim Paul helps his dad, Nelson Paul, test the viability of raising mud minnows in a two-year FRG project at MARC. • MIDDLE LEFT: Mud minnows, aka mummichogs, are the live bait of choice for recreational saltwater anglers. • BOTTOM LEFT: Turano hopes the MARC facility will be the catalyst for mariculture operations in the state. • RIGHT: Wes Carter, an engineer with Hart Power Solutions, says the wind tower and solar array help provide electric power for MARC.

to tackle the wastewater issue.”

To make things even more interesting, as part of an NC State alternative energy study, a photovoltaic array and wind tower provide part of the energy needs for the complex.

An open house in October 2012 drew a crowd of area residents and university supporters. The event was part of Dean Richard Linton’s statewide get-acquainted tour, having assumed CALS leadership at the start of the fall semester.

Dave Eggleston, director of NC State’s Center for Marine Sciences and Technology, or CMAST, in Morehead City, explained that the wind and solar installations at MARC and CMAST are supported by a grant from the N.C. Green Business Fund.

“We are serious about looking at alternative energy sources,” Eggleston said. “Data from the wind and solar studies are acquired online in real time.”

The tower at MARC was erected in April 2012 and constructed with all recyclable or relocatable material, according to Wes Carter, an engineer with Hart Power Solutions. The company also constructed wind towers at Jockey’s Ridge, Jennette’s Pier and several schools on the Outer Banks.

Carter said the wind tower at MARC converts DC to AC and can produce 10,000 watts of energy. The windy season, from October through May, should deliver substantial energy benefits to the center as the tower blades swivel according to the prevailing winds.

The solar array has a 9,600-watt capacity and produces energy on sunny or cloudy days. It is set at a fixed 32-degree angle, a happy medium for all seasons, Carter adds.

Linton told guests at the open house that he was still in a “learning mode” after a short time on the job. But just two days into his statewide tour, he noted that it was clear to see the passion that stakeholders have in moving agriculture and aquaculture forward.

Turano sees a bright future for both freshwater and saltwater aquaculture in North Carolina.

“We have researchers working with growers who are committed to producing the highest quality products. And we have increasing consumer acceptance and trust that U.S. aquaculture growers, packers and distributors comply with strict food handling safety standards mandated by the Food and Drug Administration,” he concludes. ■



Jeffrey K. Johnson



Jack Horen



Jack Horen





Jeffrey K. Johnson

DIAMOND SHOALS AND FRYING PAN: Offshore Light Towers Beckon New Missions

BY JACK HORAN

FOR 35 YEARS, DIAMOND SHOALS LIGHT TOWER PERFORMED ITS DUTY ADMIRABLY, BEAMING A FLASHING LIGHT ACROSS THE WAVE-TOSSED ATLANTIC. IT WARNED PASSING SHIPS TO STEER CLEAR OF THE SHALLOW SANDBARS EXTENDING FROM THE OUTER BANKS.

U.S. Coast Guard crews manned the tower from 1966 to 1977 until the beacon was automated. With the advent of GPS navigation systems, the Coast Guard declared Diamond Shoals obsolete in 2001, turned off its light and abandoned the tower 13 miles southeast of Cape Hatteras.

The light tower stood unattended 11 more years, awaiting dismantling. With no money to cut it down, the Coast Guard eventually decided to auction it off.

Last October, David Schneider won Diamond Shoals with a bid of \$20,000. The Minnesota business executive, who had never seen the light tower except for photos posted on a federal surplus property website, became the second private owner of a North Carolina offshore light tower.

Richard Neal of Mint Hill, near Charlotte, bought the other — Frying Pan Tower, 30 miles southeast of Southport — in 2010.

Continued

CLOCKWISE FROM TOP: David Schneider makes his first inspection of Diamond Shoals Light Tower in November 2012. • Volunteer worker Mike Vickery (left), owner Richard Neal and volunteer David Wood attach solar panels to Frying Pan Tower. • Jeff Riecken (left) and Neal attach a ladder to Frying Pan Tower piling to facilitate boat access. • Neal is converting the 49-year-old Frying Pan Tower into a bed-and-breakfast at sea. • Diamond Shoals Light Tower has stood off Cape Hatteras since 1966.



Jack Horan

“I can also see interests from biologists, marine biologists, climatologists, and even those developing products that need to be tested in an actual marine setting — metallurgists, desalination technologies, fishing equipment, coatings manufacturers, diving equipment.” — DAVID SCHNEIDER

• TOWER RESCUED

Once doomed, both light towers are getting new missions that include becoming platforms for research miles out at sea.

At Diamond Shoals, Schneider plans to restore the corroded tower into an on-ocean center for research, development and product testing. He envisions enlisting technology partners to demonstrate wind, solar and emerging energy sources.

“I can also see interests from biologists, marine biologists, climatologists, and even those developing products that need to be tested in an actual marine setting — metallurgists, desalination technologies, fishing equipment, coatings manufacturers, diving equipment,” Schneider says.

First, Diamond Shoals needs work. It has languished in the harsh, salt-strewn environment with no maintenance. An engineering firm hired by the federal General Services Administration, which auctioned the 120-foot-high tower, determined primary structural elements were sound. But the firm noted four large depressions, plus several holes open to the ocean, in the flooring in the living quarters. Furthermore, the bottom staircase is gone, making access by boat difficult.

In November 2012, Schneider flew to Diamond Shoals for his first visit. He and a friend landed by helicopter, and spent six hours there. “There was just ocean everywhere. It’s incredible,” he says, marveling at the first sight of his property.

Schneider’s inspection found some sturdy walkway grating but a deteriorating maintenance deck, a broken window, and lots of debris in the seven bedrooms, rec room, galley and storage rooms. “Some things were better than I thought, some things were worse than I thought,” he recalls.

He plans another trip this spring, this time by boat. To climb aboard, Schneider left a 75-foot rope ladder and a hand-operated winch to hoist people and cargo.

Restoring the tower means not only making

it safe but also reviving basic services. The engineering firm estimated renovations would cost \$2.3 million. That includes \$1 million to rent a jack-up barge to perform work. But Schneider believes he can do repairs for much less, in part by tapping into volunteer welders, electricians and mechanics. They, in return, would get time to fish and relax on his high-seas hideaway.

• MAKING HEADWAY

That’s what Neal did during the past two years to get Frying Pan Tower up and running. Though Frying Pan is still a work in progress, Neal says a cadre of volunteers has kept renovation costs at a fraction of an engineering firm’s estimate of \$1.3 million.

Neal paid \$85,000 at auction for Frying Pan Tower, a twin of Diamond Shoals. Similar to an offshore oil-drilling platform, they were built for \$2 million each. Frying Pan was erected in 1964.

Neal’s original aim was to transform Frying Pan into a bed-and-breakfast at sea, catering to the adventurous. With the planned additions in 2013 of a mooring buoy and a lower staircase, thus making access by boat easier, he can appeal to sport fishermen and scuba divers for overnight or weekend stays.

At the same time, he’s broadening the facility’s scope into a platform for research. An environmental consulting firm, Normandeau Associates, has leased space for thermal and acoustic sensors that detect birds and bats so the firm can characterize potential collision risks from offshore wind farms. And in late 2012, Neal lined up the University of Miami to conduct shark tagging.

“It should be something people can use,” he says of the tower.

Both towers could benefit from the development of offshore wind farms. Along the North Carolina coast, potential offshore wind lease areas have been identified but no lease sales have been scheduled by the Bureau of Ocean Energy Management. (See the related tiding on page 5.)

“We’re very close to seeing the beginning of lease sales,” predicts Brian O’Hara, president of the Southeastern Coastal Wind Coalition, based in Raleigh. In 2013, BOEM plans to sell competitive leases for wind farms off the coasts of Massachusetts, Rhode Island and Virginia, a process that took 10 to 16 months from the initial BOEM Call for Information and Nominations for the three states.

Neal said based on informal conversations with state energy officials, he anticipates leasing space at Frying Pan for instruments to measure wind speeds to provide data for wind farm companies. The average wind speed at the tower is 12 mph.

• LONG-TERM PLANS

At Diamond Shoals, Schneider’s short-term goal is to clear out junk, replace missing panels and install hot water. He says he hasn’t worked up a budget yet. Diamond Shoal’s timetable will turn on how quickly potential academic, corporate and technology partners begin participating. “We could be doing research in 12 months,” he predicts.

Schneider’s own company, Zap Water Technology, which makes a nontoxic sanitizing agent, is the first partner.

While on the tower, Schneider videotaped one- to two-minute spots to invite Minnesota-based companies and other potential technology and corporate partners to participate in the project.

Schneider says he doesn’t intend to fix up the tower and flip it for a quick profit. His business model for Diamond Shoals, he explains, is for a self-sustaining co-op-type venture. He believes the tower’s strategic location makes it intrinsically valuable.

“It’s too great of a structure to let it sit out there and rust away,” he says. “My interest is to make it into a place for betterment.”

For more information about the towers, visit: www.diamondshoalslight.com for Diamond Shoals and www.fptower.com for Frying Pan.

RIGHT, TOP TO BOTTOM: David Schneider checks out a walkway after buying Diamond Shoals Light Tower. • Richard Neal operates a hoist to lift people and cargo 80 feet onto Frying Pan Tower. • Lightships preceded the towers, warning sailors of the treacherous shoals lurking in the Graveyard of the Atlantic.

Light towers and lightships

The purchase of Diamond Shoals and Frying Pan light towers preserves a legacy of North Carolina's maritime history that dates to the 1800s. Prior to the sales, both towers had been slated for demolition.

The towers marked the waters around treacherous shoals. Diamond Shoals sticks out from Cape Hatteras. Frying Pan Shoals juts out from Bald Head Island like a long-handled pan.

The light towers were the most recent sentinels that have stood guard to warn mariners of dangerous, shifting sandbars in the Graveyard of the Atlantic. Today, ships rely on GPS technology to avoid the shoals.

The towers were preceded by lightships, basically floating lighthouses. The first, at Diamond Shoals, was put into service in 1824. That ship wrecked at Ocracoke Inlet in a storm in 1827, according to *Lighthouses of the Carolinas* by Terrance Zepke. Several lighthouses or buoys were moored at the shoals from 1827 to 1897, when the Coast Guard began continuously stationing lightships there.

In 1918, during World War I, the crew on *Lightship LV-71* radioed nearby ships about the presence of a German submarine. The crew safely left the lightship. The sub, provoked by the warning message, shelled the ship and sank it, according to www.uscglightshipsailors.org.

A lightship had been stationed at Frying Pan Shoals since 1854, except for intervals that included World War II, according to the Coast Guard. One of the last surviving lightships, *Lightship LV-115*, has been docked on the Hudson River in New York City since 1989. It is open for tours and can be booked for parties and special events, according to www.fryingpan.com.

The lightships were replaced by Frying Pan Light Tower in 1964 and Diamond Shoals Light Tower in 1966.



Jeffrey K. Johnson



Jack Horan



Courtesy Outer Banks History Center

Traditional Working Boats of the Outer Banks

BY MORGAN A. JONES

THE WATERS OF THE STATE ARE AS DIVERSE AS THE SKIFFS AND BOATS THAT USE THEM.

Often, boats are specific to their intended catch, with adaptations to produce a higher-quality product. These adjustments include unique gear, as well as distinctive structural features on the vessel.

Here are some boats that were highlighted at the 2012 Outer Banks Seafood Festival in Nags Head. See the tiding on page 3 for more about the event.



ABOVE: The Roanoke Island Maritime Museum sails the *Spirit of the Roanoke Island* replica shad boat in the summer. LEFT: The mullet skiff is a flat-bottomed boat that is adapted to work in shallow waters.



Albemarle and northern Pamlico sounds, where the water is shallow and the weather changes rapidly.

Initially, these boats had round-bottomed hulls that made them expensive and complicated to build, explains Michael B. Alford, author of *Traditional Work Boats of North Carolina*. In the early 1900s, shad boat hulls were shaped into a “V” bottom to lower expense and support an engine, he continues.

The boat also had a single mast rigged with a spritsail, a four-cornered fore-and-aft sail named for a specialized spar. The spar, also called a sprit, supports the peak of the sail and extends it out from the mast.

In its heyday, the shad boat was the “pickup truck” of eastern North Carolina waters, and was used to fish pound nets, a common method used to catch shad and herring. The small boat would pull up to a square net enclosure known as a pound, and

fishermen would bring the catch on board by hand or by using a dip net.

The Roanoke Island Maritime Museum houses the *Ella View*. Built in 1889, it is one of the last known shad boats in existence built by Creef. The museum staff use the *Spirit of the Roanoke Island*, a Creef-style replica boat, to conduct summer sailing tours and educational sails in Shallow Bag Bay.

• MULLET SKIFF

Flat-bottom work skiffs, such as the mullet skiff, were less expensive and easier to build.

Because mullet are harvested in shallow sounds and estuaries, these skiffs typically have an outboard engine that is mounted in a well and can be moved forward, sometimes to the bow.

In his book, Alford writes that “The well keeps the engine and propeller away from trawl and towing lines, reducing the chance of costly entanglements that could damage gear and result in time lost from fishing.” In addition,

• SHAD BOAT

The shad boat was developed on Roanoke Island by George Washington Creef and is specific to the northern Outer Banks. The boat, which was adopted as the official State Historical Boat in 1987, was originally used to harvest shad with a gill net, a vertically hung net that traps fish as they swim into it.

“The North Carolina shad boat played an important part in the daily lives of people living on the coast during mid 1800s and early 1900s,” says Barry Wickre, manager of the Roanoke Island Maritime Museum. “The boat is known for its easy handling and sea kindness, and was used in everyday life from fishing and delivering the mail to hauling supplies and people.”

The shad boat is designed for the upper

mullet boats require a flat unobstructed area in the stern to work the nets.

Although mullet skiffs were common until the late 1980s, few are left in North Carolina because of decreased demand for the fish, as well as better fishing methods.

“Most commercial exploitation for mullet targets roe-carrying females for the Asian market. A depressed Asian economy in the late 1990s may have led to a decline in roe demand, a decline in overall harvest of roe mullet and the associated decline in mullet skiff fishing,” says Sara Mirabilio, North Carolina Sea Grant fisheries specialist.

Mullet are harvested with a runaround gill net or strike net, she adds. The monofilament net hangs vertically and is not anchored.

them to haul large trawl nets.”

The engine well allows fishermen to run nets and lines directly off the stern, or back of the boat, a situation that is ideal for flounder fishing. Small, open fiberglass skiffs were modified with the outboard motor in a well, or by moving forward part of the transom, or the stern, where the outboard motor bracket rests.

• BEACH DORY

Traditionally used only along the Outer Banks, a beach dory is a small boat that is launched from the ocean shoreline into the surf. It is 16 to 18 feet long, and has a high bow that cuts and plunges into the surf. A motor mounted inside a well in the center of the boat allows fishing in very shallow water.

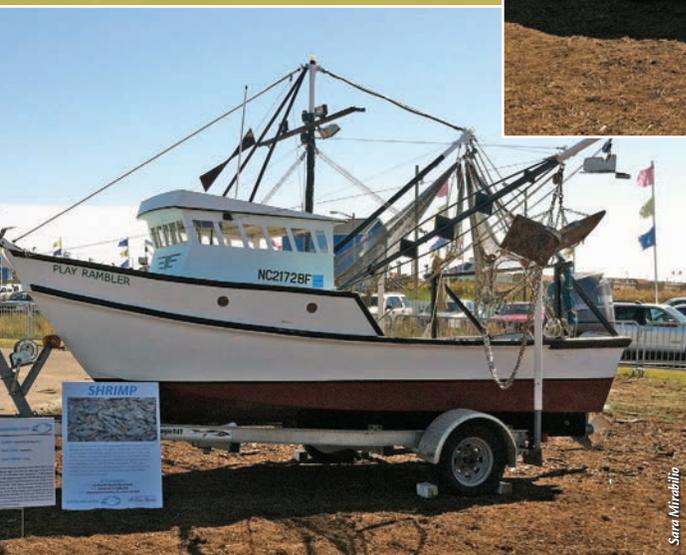
“Beach dories do not need powerful motors, just one strong enough to carry the net around in a circle,” Mirabilio says.

Once in the surf, the dory crew deploys a beach haul seine to surround a school of fish swimming near shore. Native Americans used these hand-pulled seines centuries ago. This encircling type of net is made of mesh webbing with two wings and a bag. Floats keep the top line at the surface, while the bottom line is weighted.

Years ago, horses pulled the net to the shore, but now trucks do the hard



ABOVE: The beach dory is used near the ocean shoreline and has a motor mounted in its center. LEFT: Shrimp trawlers are typically double- or quad-rigs, pulling two or four nets, respectively.



By the end of the 1990s, more than half of all North Carolina inshore flounder catches were caught with large mesh, monofilament gill nets. One of the state's main flounder fisheries was the shallow-water fishery along the sound side of the Outer Banks.

“During the flounder fishing peak, from September through December, as the flounder migrate out of the sounds and estuaries into the ocean to spawn, flounder fishermen only can fish large-mesh gill nets in shallow coastal waters inside the Pamlico Sound Gill Net Restricted Areas,” Mirabilio explains. The restrictions are to limit interactions with sea turtles.

Fishermen use gill nets with weighted bottom lines in deeper water, and keep the height of the net to about 4 feet off the bottom by tying down the float line. This technique creates a loose, baggy net that is very effective at catching bottom-dwelling flounder.

work of hauling.

After launching the dory through the breakers, a shore-based crew secures a line to one end of the net, while the dory crew feeds out the seine. The net is pulled straight offshore, and guided depending on the direction of the migrating fish. The dory crew traps the school and wraps the net in a U-shape back toward the beach. The fish, located in the net bag or bunt, are dragged ashore and sorted.

Fish harvested with this technique often include weakfish, spotted sea trout, bluefish, striped mullet, striped bass and Atlantic croaker.

• SHRIMP TRAWLER

The fishing fleet along the Outer Banks also includes some larger boats, such as shrimp trawlers.

Fishermen along the Outer Banks were among the last to join the shrimping industry, entering in the early 1950s. Area residents considered shrimp a trash species that fouled nets, and called them “pests,” according to

Continued

Floats are attached to the top of the net and the bottom is weighted so that a current will not bunch the net.

Once a school of fish is sighted, one end of the gill net is deployed with a buoy and a small weight. The weight creates drag, which pulls the rest of the net out as the boat encircles the school. The net is immediately hauled back by hand over the flat stern to unload the catch.

• FLOUNDER BOAT

Another boat that uses an engine well is a flounder boat. Alford reports, “Powerful outboard motors mounted in wells built inside the skiff make these boats very swift and enable

former Sea Grant researcher John Maiolo, author of *Hard Times and a Nickel a Bucket: Struggle and Survival in North Carolina's Shrimp Industry*.

"The historical vessels pulled one net from the stern because that is all the technology they had," Mirabilio says. However, the development of otter boards — used to keep the nets open under water — and engines changed that.

Today, small trawlers generally pull two trawl nets, called a double-rig. Large vessels can be outfitted with four nets, called a quad-rig. In both cases, nets drop back from outrigger booms off the side of the vessel.

Shrimp trawlers work day and night. By using ice or freezers on their boats, they are able to keep the catch fresh.

North Carolina fishermen comply with federal sea turtle conservation requirements, including using turtle excluder devices and bycatch reduction devices to allow unwanted fish to escape.

Another vessel called a skimmer trawl or rig, which is popular along the central coast, uses aluminum triangular frames to push nets through the water, explains Brian Efland, former Sea Grant marine conservation and enterprise development specialist.

Skimmer rig technology was pioneered by Gulf Coast fishermen and transferred to North Carolina by Sea Grant specialists Bob Hines and Jim Bahen during the late 1980s.

• SET-NET BOATS

A set-net boat has a hydraulically powered net reel to haul and release a gill net. The set net is the primary gill net method used in North Carolina. It is a stationary, monofilament mesh net of varying sizes that is most often fished without anchoring to the bottom. The set-net category can be separated into float and sink gill nets.

The top line of a float gill net floats on the water surface, while the top line of a sink gill net is submerged below the water surface. The sink gill net fishery began in Hatteras in the 1920s. "The sink gill net sector of the coastal gill net fishery comprises 99.6 percent of trips and fish catch nearshore, and all offshore set nets," Mirabilio says.

The nets are either retrieved after a short soak or left for several days. Weather

RIGHT: Crab-pot boats are adapted to haul and stack crab pots. BELOW: The set-net boat hauls the set net, the main gill net method used in the state.

NORTH CAROLINA'S WATERS ARE USED DAILY BY SKILLED FISHERMEN. THE VARIETY OF WORKING SKIFFS AND COMMERCIAL FISHERIES THAT LINE THE COAST ARE SPECIFIC TO THE REGION IN WHICH THEY FISH.

according to N.C. Division of Marine Fisheries 2011 reports.

Crab-pot boats have specific adaptations for hauling crab pots, such as stacking racks on the stern of the boat. Crab-pot buoy lines are retrieved by hand, then wrapped around a puller disk to be hauled up by an electric or hydraulic pot puller and stacked. The boats also have a powerful transom-mounted engine to cover large distances in deeper water.



Crab pots, crab trawls and peeler pots are the major pieces of equipment used in crab fisheries. A crab pot is a square trap, often constructed of galvanized chicken wire. It has a bottom chamber, or "downstairs," with two to four funnels, called throats. The bait well, in the center of the pot, is made of fine-mesh galvanized wire so that crabs cannot reach the bait. The top chamber is the holding area, known as the "parlor" or "upstairs." These pots use crabs' escape instincts to trap them. It remains in the parlor until it is shaken out through an opening.

A peeler pot is specially designed to catch mate-seeking female peeler, or soft-shell, crabs. Similar to a standard crab pot, a peeler pot contains a special holding cell, in lieu of a bait well, where a live male crab is placed.

North Carolina's waters are used daily by skilled fishermen. The variety of working skiffs and commercial fisheries that line the coast are specific to the region in which they fish. Along the state's Outer Banks, each area requires specific adaptations to the gear and the vessel used. □

conditions, regulations and the intended catch determine the length of time the net remains in the water. A crew picks up the net using hydraulically powered net reels.

Typical target species include bluefish, weakfish, Atlantic croaker, kingfish, Spanish mackerel, dogfish, shark and monkfish.

• CRAB-POT BOATS

Blue crab was the state's highest grossing commercial fishery in 2011. Between 1994 and 2009, North Carolina ranked second among blue crab-producing states in the country, accounting for 22 percent of the total harvest,

New Challenges Ahead

BY E-CHING LEE

WHEN COLLEAGUES DISCUSS STEVE REBACH, THEY USE MANY ADJECTIVES – PASSIONATE, EFFICIENT, SMART. BUT INVARIABLY, THEY ALL AGREE ON ONE THING: WHEN REBACH IS AROUND, THERE WILL BE LAUGHS.



E-Ching Lee



Courtesy Steve Rebach



Robin Wienke



Courtesy Steve Rebach

TOP LEFT: Steve Rebach is known for his sense of humor. • TOP RIGHT: Sea Grant staff, including Rebach, hosted an Indonesian delegation in 2008. • BOTTOM LEFT: Melinda Baran and Rebach plan to travel during their retirement. • BOTTOM RIGHT: Sons Ari (left) and Ben keep in close contact with Rebach.

Rebach, North Carolina Sea Grant's associate director, retired at the end of 2012. He joined Sea Grant in 2000, fresh from a 31-year stint in academia, including many years in the biology department at the University of Maryland Eastern Shore.

"Steve is the quintessential research coordinator for an organization such as North Carolina Sea Grant," says Michael Voiland,

Sea Grant executive director who retired at the same time. "He has a broad grasp of the marine science field while maintaining specialized expertise in fisheries, which is a strong component of Sea Grant."

Ron Hodson, Voiland's predecessor, remembers that selecting Rebach boiled down to several factors. "He was very, very, eager to work for Sea Grant," Hodson recalls, adding

that Rebach "was a good choice to be heading up the research effort. And he's done a good job with that."

Rebach explains his role simply: "Everything that comes in here that is competitive, it's my role to get strong reviews and to present the work to a professional peer panel."

Besides research quality, Rebach cites another important contribution. "I think the biggest change that may be attributed to me is going from paper to

electronics," he says of the proposal process, noting that Sea Grant was still requiring paper submissions in 2000.

"We started moving right away to email, and then Webnibus and now eSeaGrant," explains Rebach, naming two online tracking systems that he championed.

• HANDLING THE RESEARCH

In his tenure, Rebach had managed the N.C. Fishery Resource Grant Program that was in its early stages when he started, and the N.C. Blue Crab and Shellfish Research Program that began after he joined.

He also collaborated with Sea Grant partners — the N.C. Division of Marine Fisheries, the N.C. Coastal Reserve and the Water Resources Research Institute of the University of North Carolina, among others — on joint

Continued

fellowships, and with the National Oceanic and Atmospheric Administration Fisheries on the Bycatch Reduction of Marine Mammals in Mid-Atlantic Fisheries Program.

Rebach enjoyed the variety and challenges Sea Grant presented after decades of teaching and research.

“What Sea Grant did for me was, all of a sudden, I’m reading about fisheries which I didn’t do before, about beach erosion, about coastal communities. And I think this has been the most broadening part of my education since I was in college taking general courses,” he says. “It’s been a wonderful experience.”

In particular, Rebach points to the applied research that Sea Grant supports. Scientists, particularly those funded by the FRG and Blue Crab programs, are required to ensure that their work is in collaboration with and can be used by stakeholders, be they commercial fishermen, recreational anglers or the general public.

THIS PAGE, TOP: During his Sea Grant tenure, Rebach administered a NOAA grant program on marine mammals, including pilot whales. • BOTTOM LEFT: Crabs were a big part of Rebach’s work, before and at Sea Grant. • BOTTOM RIGHT: Rebach (left) visits an aquaculture facility with NC State faculty and Sea Grant guests. • FACING PAGE, TOP: At Sea Grant, Rebach’s focus was wider than his earlier biology research. • BOTTOM: Gear research is an important part of the FRG program that Rebach administers.

David Taylor, chief of the state’s Fisheries Management Section, reviewed FRG proposals with Rebach. “Steve played a major role in seeing that we were all well-prepared for discussion and made us feel that our time and input were valuable,” he says.

Taylor notes that Rebach handled most of FRG’s nitty-gritty details, including distributing proposals to reviewers, taking notes, and even tracking comments and recommendations. And he praises Rebach’s understanding of the issues.

“He participated in discussions of the proposals and was very aware and knowledgeable of existing research in the fields we dealt with, particularly crustacean projects,” Taylor adds. “I wish him well in his well-earned retirement.”

Jeff Buckel, a faculty member in the biology department at North Carolina State University’s Center for Marine Sciences and Technology, is the Sea Grant mentor for the joint Sea Grant/DMF fellowship. This program offers graduate students the opportunity to spend a year



Kim Urian



Robin Wienke



NCSU Communications Services

working on a critical management topic facing important marine resources.

“Steve’s been involved in every interview of every Sea Grant/DMF fellow,” says Buckel, who collaborates with Rebach to screen potential applicants. “It’s going to be big shoes to fill, that’s for sure,” he adds.

“I learned a lot from both Steve and Ron Hodson on how to handle candidates as they’re coming through,” Buckel explains. He cites valuable interview techniques, from how to put an interviewee at ease, to how to practice discretion, such as making sure applicants enter in one door and leave through another so they never meet the competition.

“I certainly draw on that experience when I interview my own grad students now,” he says.

But Buckel, a successful Sea Grant-supported researcher with multiple projects under his belt, also interacts with Rebach on the receiving end of things.

“When I think of Steve, I think of his phone calls,” Buckel says with a laugh. Rebach typically

calls applicants to notify them about the status of their proposals.

“You hear his voice and you think, ‘I hope this is good news about the grant.’” Often, these initial conversations are the start of cost negotiations and project adjustments, Buckel notes.

• WORKING WITH PARTNERS

Rebach also has made contributions to regional and national Sea Grant programs.

He collaborated with NOAA Fisheries folks to run a marine mammal grant program, modeled along the lines of the FRG, to learn more about dolphin stocks and reduce marine mammal bycatch.

This bycatch reduction research supports two NOAA programs – the Bottlenose Dolphin Take Reduction Plan and the Pelagic Longline Take Reduction Plan.

“Steve helped us figure out a way to help meet some of our bycatch reduction needs in terms of research recommendations that were coming out of our stakeholder groups and what information is needed to help reduce bycatch of marine mammals in those fisheries, while still allowing those fisheries to thrive,” says Stacey

Horstman, bottlenose dolphin conservation coordinator with NOAA Fisheries in the Southeast Regional Office.

“We have had some really, really good outcomes, and every step of the way, he’s there to help do whatever he needs to do to make it happen,” she continues.

Horstman had been working with Rebach



Roger Winstead/NC State University



Marc Turano

since the start of the bycatch grant program in 2004. They have had calls for proposals most years. There even are funds for 2013, something Rebach’s successor will inherit.

On the national stage, Rebach led the Sea Grant Research Coordinators Network from 2006 to 2008. The group consists of his counterparts from Sea Grant programs nationwide. He was an important figure in the development of this network.

“Steve was really instrumental with the research coordinators in starting the discussion to move the research coordinators towards becoming a formal network within the Sea Grant Association,” recalls Fredrika Moser, who worked with him to formalize the group when she headed research at Maryland Sea Grant.

“He started with work on developing bylaws and basically getting agreement through the network to become formal,” adds Moser, who now is director of Maryland Sea Grant.

Through this group, research coordinators are able to have a presence on the National Sea Grant Network Advisory Council that helps to shape the direction of nationwide efforts.

But more than his leadership abilities, Moser notes that Rebach is a good collaborator.

“He always brings good humor and thoughtfulness to any of the issues we’ve worked on together,” she says, wishing him the best in retirement. “It’ll be a loss to the network.”

• MAKING AN ADJUSTMENT

Old habits die hard — and retirement won’t keep Rebach from reviewing proposals. He has volunteered to sit on a committee that decides how proceeds from a local art festival should be allocated to nonprofit organizations in his community. Rebach will review proposals and help decide how to distribute the funds.

“It’s something I’ve done before,” he notes wryly.

But perhaps retired life might be a change after decades of working.

“The first thing that comes to mind is the difficulty Dad is going to have in adapting to unstructured life,” says Ben, Rebach’s elder son. “This will be the first time without a job since he was 11. I have no doubt he will adapt, but I know that he is still struggling with the concept.”

Melinda Baran, Rebach’s partner, also is confident that he will adjust. “I’m sure he’ll be as focused on his freedom as he has been as associate director of Sea Grant,” Baran says. She will retire in the spring and is looking forward to checking off more items on their “bucket list.”

True to her prediction, Rebach already has plans for his free time. “I will read 20 years of piles of stuff that I said I’m going to read as soon as I get a chance,” he says, adding that sons Ben and Ari have given him a lifetime supply of books to read on his Kindle.

In addition, Rebach intends to travel. He has trips to Florida, Mexico and Japan in the works. His sons have encouraged him to spend his last dime on his last day, rather than worrying about their inheritance.

And Rebach is ready to meet this new challenge. “It’s time to go and play.” ■



E-Ching Lee



E-Ching Lee

TOP: Terri Lomax, NC State vice chancellor for research, innovation and economic development (center), congratulates Michael Voiland (left) and Steve Rebach on their retirement. BOTTOM: Susan White, Ron Hodson, Voiland and B.J. Copeland, current and former Sea Grant directors, attended the reception.

NC SEA GRANT’S VOILAND, REBACH RETIRE

North Carolina Sea Grant thanked Michael Voiland and Steve Rebach for their service during a campus reception.

Executive Director Voiland and Associate Director Rebach both retired at the end of 2012. This event was an opportunity for colleagues to wish them well. Voiland and Rebach were presented with letters from Gov. Bev Perdue, commending them for their service.

“What Mike’s done exceptionally well is building the community and developing the grant programs,” said Terri Lomax, North Carolina State University vice chancellor for research, innovation and economic development, citing Voiland’s emphasis of minigrants that offer great return on investment.

She also highlighted the synergy that he created as director of Sea Grant and the Water Resources Research Institute of the University of North Carolina System.

— E.L.



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PERIODICALS
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BROILED OYSTERS

When selecting oysters in the shell, make sure they are alive. Their shells should be tightly closed or should close tightly when tapped.

- 1 pint oysters, drained
- 2 slices bacon
- 2 tablespoons margarine or butter
- 1 teaspoon fresh lemon juice
- 1/4 teaspoon freshly ground black pepper
- 1/4 cup thinly sliced green onion
- flour

Fry bacon until crisp. Remove bacon from pan, reserving 1 1/2 tablespoons bacon grease. Add margarine to pan and melt. Add lemon juice, pepper and green onion. Cook until onion is tender, about 2 minutes.

Place oysters in lightly greased shells or ramekins. Dust lightly with flour. Spoon margarine mixture over oysters. Broil about 4 inches from heat until done, about 8 to 10 minutes. Sprinkle with crumbled bacon. Serves 4.

From *Mariner's Menu: 30 Years of Fresh Seafood Ideas*. Available from local bookstores or by calling 919/515-9101.

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