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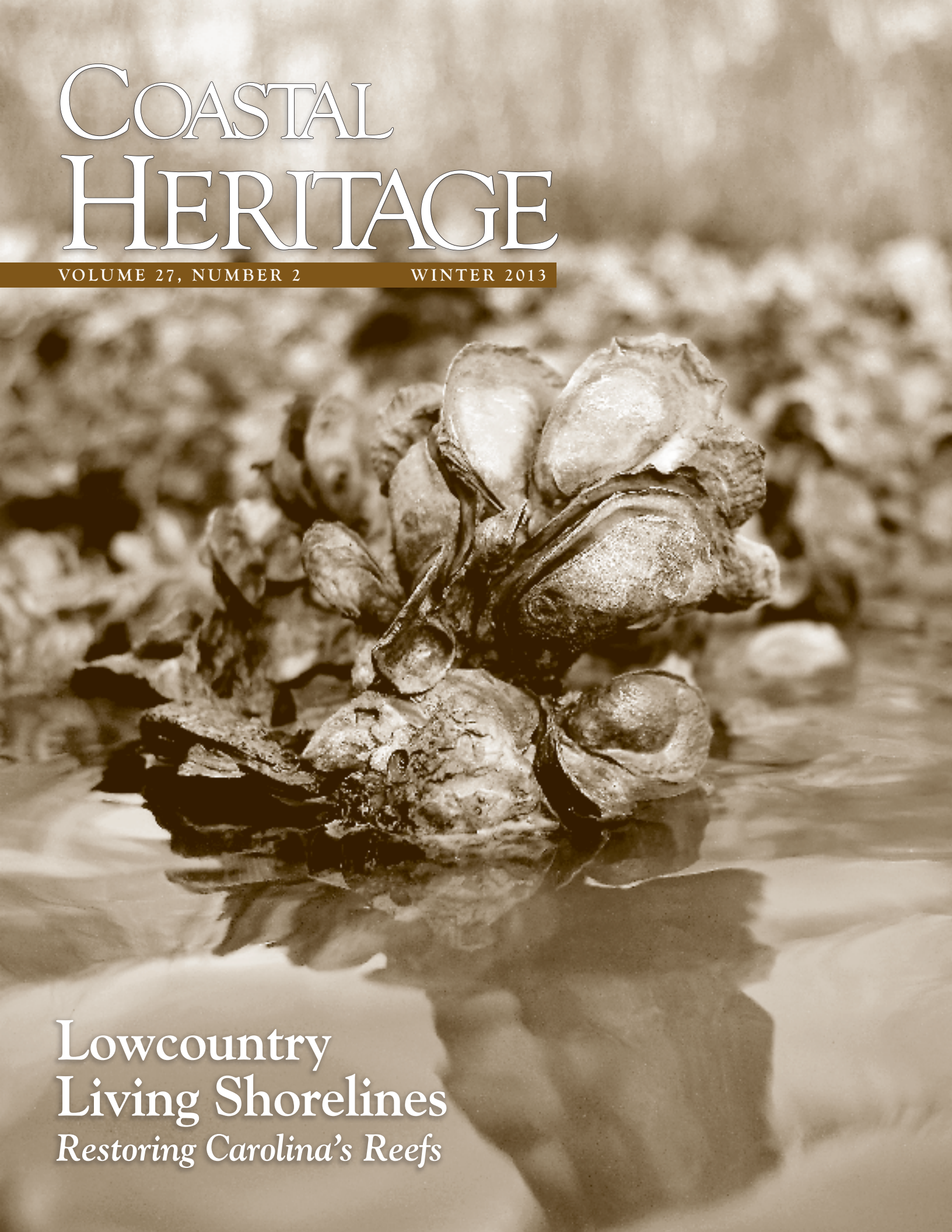

Lowcountry Living Shorelines

Restoring Carolina's Reefs

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ON THE COVER:

Oysters filter large volumes of water, help stabilize salt-marsh shorelines, and provide essential habitat for fish and shellfish.

PHOTO/GRACE BEAHM

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CULTIVATOR. *Michael Hodges, lead field biologist for the South Carolina Oyster Restoration and Enhancement (SCORE) program, collaborates with volunteers to bag empty shells and deploy them along shorelines to attract oyster larvae and restore reefs.*
PHOTO/GRACE BEAHM

Lowcountry Living Shorelines

Restoring Carolina's Reefs

by John H. Tibbetts

It's quiet on the Ashley River after Michael Hodges cuts the engine. The only sound is the wake lapping on shore. The city marina is across the river, but on a Monday morning under a gray-and-black sky threatening rain, this stretch of Charleston Harbor is still sleeping.

Hodges has landed the 20-foot aluminum boat on a mound of loose, dead oyster shells along the shore. He steps into the shallows, his rubber boots crunching on the bottom, and then reaches down, grabs a shell, shakes out salt water, and holds it like a cup.

"There," he says, running his finger across dime-sized bumps on the shell's pearly inner surface. "Those are young oysters. Attached a few weeks ago."

An empty oyster shell looks like a humble thing, but don't throw it away. Recycle it. A shell is the best substrate, or foundation, to attract swimming young oysters looking for permanent homes.

Hodges is the lead field biologist for several oyster-restoration efforts, including the influential South Carolina Oyster Restoration and Enhancement program (SCORE), one of the first statewide, all-volunteer efforts outside the Chesapeake Bay.

Today, though, he's checking on other projects in Charleston Harbor, also managed by the S.C. Department of Natural Resources (SCDNR).

One is a $1 million mitigation project funded by the Port of Charleston for a facility expansion; two others provide $472,500 and $121,478 for mitigations as part of court-ordered settlements to address past industrial contamination of harbor sediments; and the fourth is a $100,000 erosion-control effort supported by federal "stimulus" funds.

Since 2008, Hodges and his team have planted about 34,000 bushels of loose shell annually on 40 sites—14 acres total—for the four restoration projects. So far, measurements show that empty shell planted in 2008 is attracting oyster larvae, and reefs are

HABITAT CREATION. ***The S.C. Department of Natural Resources sprays recycled oyster shells onto estuarine shorelines to rebuild oyster populations.***
PHOTO/S.C. DEPARTMENT OF NATURAL RESOURCES

growing substantially larger.

These oysters aren't for human consumption. The harbor is polluted, and fishermen—recreational and commercial—harvest shellfish only from clean waters.

Instead, harbor oysters are being restored for their ecological services. Oyster reefs filter large volumes of water, help stabilize salt marsh fringing shorelines, and provide essential habitat for many species of finfish and invertebrates such as crab and shrimp.

Restoration scientists hope that more coastal residents and visitors will learn to see oysters in a broader way—not only as food but as keystone species in healthy estuaries and salt-marsh ecosystems.

The Eastern oyster *(Crassostrea virginica)* is a hardy, adaptable species. During the last ice age, the Eastern oyster grew along stretches of the North American coastline and migrated inland along with the rising sea level. After the Earth's climate and sea level stabilized about 8,000 years ago, it colonized shorelines along thousands of miles from Canada into the Gulf of Mexico and south to Brazil.

Various oyster species once flourished in temperate estuaries around the world where reefs were the dominant ecological feature. Now most of those reefs are gone. Oyster populations have lost more than 90% of their historical abundance in North America, Europe, and Australia, according to a 2001 study published in *Science* by Jeremy Jackson, an oceanographer at Scripps Institute of Oceanography.

A recent report produced by The Nature Conservancy, *Shellfish Reefs at Risk*, estimated that globally 85% of oyster reefs have been lost since the 1880s and 1890s because of pollution, overharvesting, disease, habitat loss, and other impacts.

South Carolina's oysters, though, are in comparatively good shape in many locations.

"When I moved to South Carolina from Virginia four years ago, I was amazed by the abundance of oysters here," says Peter Kingsley-Smith, associate marine scientist and shellfish research section manager at the SCDNR Marine Resources Research Institute. Now, as a Sea Grant researcher, he is studying the potential for producing single, more valuable triploid oysters (having an extra set of chromosomes) with improved meat quality and superior growth.

Boze Hancock, a marine restoration scientist with The Nature Conservancy, says that South Carolina is one of the few places in the world where oysters are in reasonable abundance and in good fishing condition. The great majority of other temperate estuaries have seen their oyster resources "crushed by overfishing," he says. "You should keep looking after your oysters in South Carolina."

Even so, wakes from boats, ships, and jet skis are eroding South Carolina salt-marsh shorelines and damaging reefs. Runoff pollution continues to threaten oyster habitats. Dredging for navigation, moreover, removes marsh-building sediments and deepens waterway channels, increasing stream flows that cause more shoreline erosion.

South Carolina estuaries are blessed with vast numbers of oyster larvae but far too little shell and other substrate for them to settle on.

Oyster larvae attach to dock pilings, concrete, broken pottery, glass bottles, floating tree limbs—you name it. If the surface is hard and clean, larvae will settle on it. Still, a young oyster strongly prefers an oyster shell (empty or not, doesn't matter) for its texture, firmness, and chemical cues.

South Carolina shucking houses and canneries once held gigantic mounds of empty shell to be planted along shorelines for reef substrate. But the last cannery in the state closed in 1986, and just one shucking house, the Bluffton Oyster Company, is still in operation. The company stockpiles shell on-site to replant on locally leased bottoms.

Loose shell for Charleston Harbor restoration sites is trucked in from shucking houses in the Gulf of Mexico at a cost of about $2.50 a bushel. Most of that price tag is for diesel fuel. Says Hodges, "It's getting a little more expensive every year." Shell, in fact, is now in short supply all around the United States.

Hodges pushes the boat off the Ashley River shoreline and steers north, passing the Battery, into the Cooper River. He rides under the Ravenel Bridge against an ebbing tide, crosses the ship channel to the Wando River, and turns into Hobcaw Creek where handsome homes and boat docks line one shore, and salt marshes, mud flats, and small reefs cover the opposite shore.

Oysters are subtidal in estuaries from Chesapeake Bay to New England, where they spend their lives underwater. In South Carolina, though, 95% of the oyster reefs by acreage are intertidal—that is, they are under water at high tide and exposed to the air at low tide.

South Carolina has nearly 5,000 acres of oyster beds growing along fringes of salt marsh bordering creeks and rivers, and along isolated mud flats, according to recent estimates from an almost decade-long survey of oyster reefs by SCDNR scientists. South Carolina once had considerable populations of subtidal oysters, most of which have been lost because of siltation, overharvesting, and other impacts.

In Hobcaw Creek, the sun briefly comes out, and Hodges points to a restored reef along a muddy shoreline. Young, bright-green shoots of cordgrass *(Spartina alterniflora)* have colonized pluff mud immediately behind the reef. That's one of the results, he says, of the oyster's function as a shoreline stabilizer.

When a high tide washes over a reef, some suspended sediments fall out and sink onto the muddy bottom behind it. Later, when the tide lowers, the reef blocks some of these sediments from washing back into the creek. Over time, sediments can accumulate behind the reef like a snowdrift against a wall.

As more sediments fall out, they firm up the shoreline in some cases. Finally, the fringing marsh sends out *Spartina* rhizomes—plant stems that spread underground—to colonize the site. The growing reef functions as a breakwater for the salt-marsh fringe, protecting it from waves, tidal currents, and boat wakes and allowing the marsh to build more habitat.

In the construction of new intertidal reefs and replenishment of existing ones, scientists depend on the oyster's extraordinarily high fertility and its ability to colonize a variety of hard, clean surfaces.

When a South Carolina estuary turns balmy in May, a single mature female oyster will release millions of microscopic eggs, and a mature male discharges countless sperm.

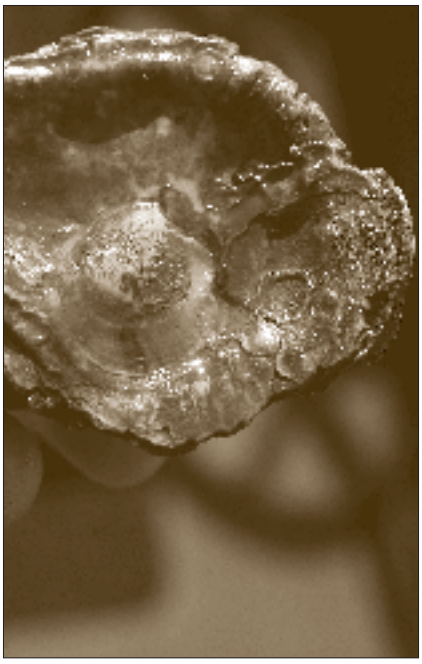
Folklore traditions say that an oyster's reproductive vitality is passed to the person who slurps it down—that is, it's supposedly an aphrodisiac. Casanova claimed that he ate as many as 60 a day. "Do oysters enhance sexual prowess?" asked the British scholar Rebecca Stott in a 2004 book. "Well, if they don't do so chemically, they certainly do so by their age-old associations with flesh, hunger, and intimacy."

As the songwriter Cole Porter pointed out, "Even oysters in Oyster Bay do it." The Eastern oyster does it most prolifically in the months from late spring to mid-summer, months without an "R" in their names—May through August—in salty waterways of South Carolina, but spawning can continue into November if the weather is warm.

Fertilized eggs quickly develop into swimming larvae that feed on microscopic algae in the water column. During this swimming period, which typically lasts two-to-three weeks, winds, tides, and currents carry larvae large distances into estuaries where they can colonize existing reefs or start new ones on dead shells or other substrate. Fish and other animals eat countless larvae, so even under pristine conditions only a tiny percentage of them survive.

Each larva grows a single, sturdy appendage—a foot—while building up a store of sticky, cement-like material. A larva must find a permanent place to land or it will die within a few days; its window of opportunity is short, and

INNOVATIVE. ***Reef structures called "oyster castles" have been built on 20 sites in Winyah Bay and along the Intracoastal Waterway on Jeremy Island in Cape Romain. Each oyster castle, weighing 25 pounds, consists of a four-walled block made of limestone, concrete, silica, and crushed oyster shells. These structures have attracted large numbers of oyster larvae, which are building taller reefs more quickly, providing shoreline protection from boat wakes and attracting a higher diversity and greater abundance of juvenile fish such as red drum and spotted sea trout.***
PHOTO/GRACE BEAHM



ABODE. *A young oyster has attached itself to the smooth surface of an empty oyster shell.*
PHOTO/GRACE BEAHM

closes quickly.

If the larva lands on a soft, mucky bottom, it will be smothered; a paper-thin layer of sediment becomes a burial ground. If a larva lands on a hard but fouled or slimy surface, it can be washed away, failing to cement itself to the underlying substrate. The lucky larva, though, finds a just-right substrate—such as an oyster shell—and attaches using its sticky foot.

Location, location, location—it's not just a formula for real estate. The best sites for a young oyster are found where currents and tides will bring well-oxygenated water and plentiful food; where shorelines are somewhat sheltered from destructive boat wakes, wind waves, and strong tides; where sediments won't smother it while the young oyster is still small; and, of course, where substrate, especially oyster shell, is clean and available.

Once attached, the young oyster is called "spat" because fishermen once referred to clouds of sperm and eggs in waterways as "spitting." A spat draws lime-like material—calcium carbonate—from surrounding waters to build two thick, sturdy shells. As the spat grows larger, it must build armor against predators such as starfish, blue crabs, sponge borers, and a few fish species with very strong jaws.

The oyster is a filter feeder that draws in the estuary's rich organic soup through its open shell and gills, consuming microscopic plants and animals called plankton. The oyster diverts undigested materials—called pseudo-feces—and mixes them with mucus and feces to form long strings of nutrient-rich goop.

Invertebrates and juvenile fish gobble up this goop, and the leftovers dribble onto bottom sediments where they are processed by bacteria and released through the water column into the atmosphere as inert nitrogen gas. In this way, the oyster helps remove excess nutrients from the estuary. One mature oyster can filter and help remove excess nutrients from 1.5 gallons of water in an hour.

An oyster can start reproducing as early as four-to-six months after settlement, and it can grow to a very large size and potentially live for decades. In a mature reef, however, generations of young oysters settle on shells of older oysters, eventually blocking their access to food and oxygen. Older oysters smother or starve beneath the growing colony. Yet dead oysters are critical to a mature reef's structure. They form the "rock" base of a reef, which is eventually covered by a veneer of live animals.

Shrimp, blue crabs, gobies, blennies, and other creatures look for food and shelter in the reef. Gag grouper use oyster reefs during their juvenile stage for a temporary refuge. Studies also show that various juvenile finfish populations are more abundant in waters near oyster reefs compared with waters near mud flats. And mature bigger fish—red drum, spotted sea trout, and sheepshead—feed in and around reefs.

In the 1990s and early 2000s, a research project with support from the S.C. Sea Grant Consortium established that lowcountry oyster reefs are crucial habitat for dozens of estuarine species.

Loren Coen, a marine scientist who was then at SCDNR and is now at Florida Atlantic University and the College of Charleston, and his team found more than 75 invertebrate species on natural and constructed oyster reefs when reefs were exposed to air at low tide and 59 finfish and invertebrate transient species using reefs when submerged. Numerous other filter-feeding bivalves, such as mussels, were also found on reefs along with oysters. In addition, the scientists compared faunas on adjacent natural reefs as well as mud bottoms and fringing salt marsh.

"This research project was one of the first to refocus efforts on oyster restoration for restoration's sake in the U.S. Southeast," says Coen. It was also the first and perhaps best monitored and sampled intertidal restoration effort, with reefs built and monitored for 10 years.

ECOLOGICAL HISTORY

Charleston Harbor was once oyster-rich. Native Americans called it "Oyster Bay," and the peninsula of Charleston was known as "Oyster Point." Archeologists have found gigantic ancient mounds known as middens where Native Americans consumed huge volumes of oysters and piled up empty shells. One midden discovered in Awendaw, about 25 miles north of Charleston, is the size of three football fields.

Carolina's oyster riches impressed 18th century naturalists and explorers. In his 1709 book, *A New Voyage to Carolina*, the Briton John Lawson wrote: "Oysters, great and small are found almost in every Creek and Gut of Salt-Water, and are very good and well-relish'd." He noted that Native Americans built canoes with double hulls to guard against sharp-edged oysters.

In the 1720s, British naturalist Mark Catesby visited the Atlantic coast from Virginia to Carolina. "At low water there appears in the Rivers

and Creeks immense Beds of Oysters, covering the muddy Banks many Miles together; in some great Rivers extending thirty or forty miles from the Sea; they do not lie separate but are closely joined to one another, and appear as a solid Rock a foot and half or two Feet in Depth, with their Edges upwards." Ship logbooks of the same era describe vast "live rock"—usually oyster reefs—in the mid-Atlantic.

Farther north, the Hudson River estuary of New York and New Jersey continued 350 square miles of oyster beds.

Reefs lined the shores and inlets of Manhattan, Brooklyn, Queens, Staten Island, and City Island. Ellis Island was called Little Oyster Island. Oyster beds stretched up the Hudson more than 35 miles as far as present-day Ossining.

The first commercial oyster fishery in North America began in the lower Hudson estuary in the early 1600s. The Dutch colonists were oyster gourmands, and in 1658 local officials outlawed destructive shellfish dredging along some stretches of the Manhattan shoreline.

The English, who captured Manhattan in 1674, gorged on oysters too and shipped pickled ones to the West Indies.

By 1715, some reefs were overharvested, so New York officials banned oystering from May to September 1—spawning season—and prohibited slaves and servants from taking or selling them, according to historian Mark Kurlansky in his 2008 book, *The Big Oyster.*

The colonies of New York and New Jersey subsequently battled over access to lucrative oyster beds. A nonresident caught harvesting oysters could have his vessel and equipment confiscated.

In the late 18th century, dredgers were destroying many New England reefs. A dredge would rip away the upper surface of a reef, capturing living oysters but also removing dead oyster materials below, shrinking the reef's height. Dredgers "ground the reefs down strip by strip, pass after pass, until there was nothing firm left for juvenile oysters to settle on," writes Callum Roberts in a 2007 book.

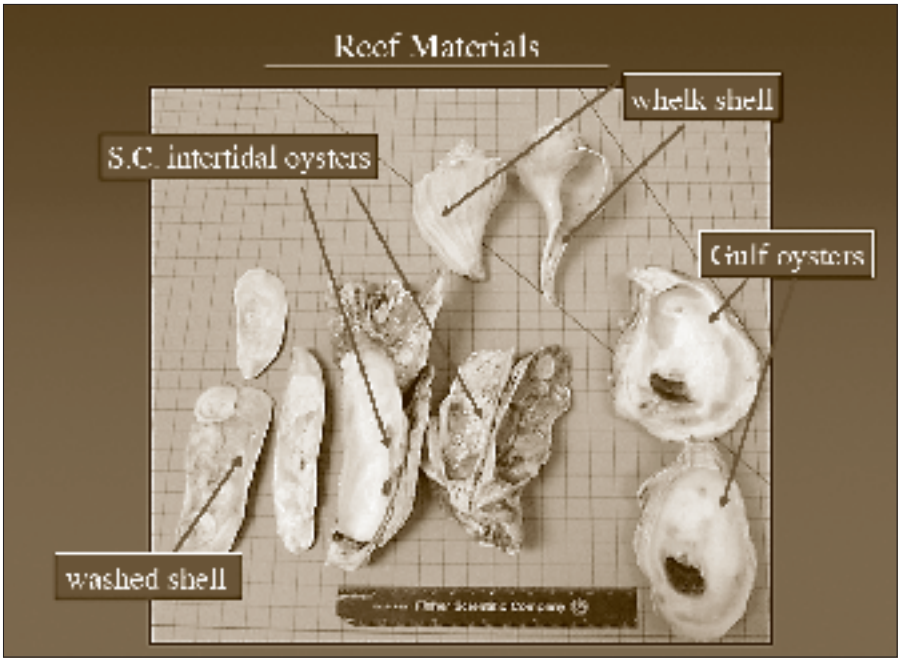
By the beginning of the 19th century, some of the natural Great Beds of New York and New Jersey were declining as growing numbers of fishermen used long, scissor-like "tongs" to harvest them. Oystermen traveled to distant bays of Long Island and New Jersey, where they would rake up immature or "seed" oysters and bring them home to sell to coastal landowners who would "bed" them in local waters.

"Bedding" oysters was profitable as consumer demand continued to accelerate. In the 1820s, a group of Staten Island ship owners acquired oyster seed from Chesapeake Bay and bedded them. Before long, schooners would arrive each spring in New York with hundreds of thousands of bushels of seed oysters from the Chesapeake and other wild-reef regions.

In the 1840s and early 1850s, refrigerated rail cars from New York hauled huge volumes of raw, unshucked oysters first to Cleveland, then Chicago, and then St. Louis. Railroads from Baltimore carrying Chesapeake oysters soon followed. Live, unshucked oysters, if kept chilled, were sturdy travelers for a week or more, and every ambitious burg on the prairie hankered for the juicy bivalves. As a young politician and attorney, Abraham Lincoln hosted oyster parties in Springfield, Illinois, a small city on the windy western plains a thousand miles from the sea.

For decades after the Civil War, the Eastern oyster was America's favorite protein. Saloons in Rocky Mountain mining towns served Eastern oysters for free, to be washed down with beer. Wealthy Londoners swallowed Eatstern oysters with champagne. Celebrations—birthdays, anniversaries, job promotions—called for oysters and more oysters, many of which were harvested from Chesapeake Bay, where from 1860 to 1920 harvesters removed 75% of the oyster habitat.

By the end of the Civil War, New Yorkers had learned the art and science of farming large, succulent oysters on the harbor bottom. Some 9,000 acres of New York Harbor bottom, split up in various sized plots,



An oyster larva will attach to any hard, clean surface but strongly prefers an oyster or whelk shell.
PHOTO/S.C. DEPARTMENT OF NATURAL RESOURCES

SUSTENANCE. *An April 1862 photograph shows a mound of empty oyster shells near slave shacks after U.S. troops invaded Port Royal during the Civil War.* PHOTO/LIBRARY OF CONGRESS

were leased from the state and marked off by hemlock poles.

By the 1890s, New Yorkers, who consumed a million oysters a day, comprised the nation's largest oyster market.

Ernest Ingersoll, a naturalist and author, described New Yorkers' passion for oysters that were "pickled, stewed, baked, roasted, fried, and scalloped; oysters made into soups, patties, and puddings; oysters with condiments and without condiments; oysters for breakfast, dinner, supper; oysters without stint or limit, fresh as the pure air, and almost as abundant, are daily offered to the palates of the Manhattanese, and appreciated with all the gratitude which such a bounty of nature ought to inspire."

Some Staten Island bedders became so rich that they built big wooden mansions, but when typhoid was traced to sewage-polluted harbor beds in the 1920s, the New York City Sanitation Department shut them down. New Yorkers continued to eat oysters, though not ones from once-productive harbor beds.

THE LOWCOUNTRY EXPERIENCE

South Carolina was late to America's oyster boom. The lowcountry's small-sized oysters grow in dense, vertical clusters. They were unappealing to consumers who were seeking large, single oysters from the Chesapeake Bay or New York.

Still, there was a strong local oyster trade. In winter, Charleston's "mosquito fleet"—a group of local black fishermen in small boats—harvested oysters along lowcountry shorelines. Oysters were peddled on streets or sold in local eating establishments where people ate them raw on the half-shell.

Shells were crushed for use in chicken feed, lime for farms, and primitive concrete called "tabby." Virtually every lowcountry town and many rural areas built and repaired roads with shell. In 1890, Charleston applied 36,000 bushels of shell to maintain Meeting Street.

That same year, L.P. Maggioni and Company opened the state's first oyster cannery in Port Royal. Gullah men harvested the oysters, and Polish-

BYGONE DAYS. *South Carolina shucking houses and canneries once held huge mounds of empty oyster shells, like these in 1909 in Florida, for use as road-bed materials and reef substrate.*
PHOTO/LEWIS WICKES HINES/LIBRARY OF CONGRESS

American workers, recruited from the Chesapeake Bay area, labored in the steam canneries. For a time, the Maggioni Company was the largest producer in the world for "cove" oysters, as steamed oysters were called.

In 1891, the South Carolina legislature created a leasing system for oyster beds and required leaseholders to plant a certain volume of substrate—usually oyster shell—per acre during spawning season. One reason that South Carolina took this step was to prevent neighboring Georgia from gaining valuable shell.

The great majority of oysters harvested from Chesapeake Bay and the New York Harbor were distributed whole to markets around the country and abroad, especially to Britain. Of course, shells were scattered far and wide, so they weren't available to be planted in estuaries, and overharvesting permanently damaged or destroyed many reefs.

By contrast, most of South Carolina's commercial oysters were shucked and most often canned or eaten along the coast at oyster roasts and in restaurants, and many shells were stockpiled locally. Several lowcountry shell-crushing factories sold this material for road construction and other purposes. But leaseholders understood that it was in their best interest to hold shell to cultivate oyster beds. No shell planting meant eventually no new oysters.

From 1893 to 1908, the peak years of South Carolina's oyster production, 16 canneries operated in South Carolina. Most were in Beaufort County, close to Savannah's railroad yards. During fall and winter, men went out in flat-bottomed boats called "bateaux" or in larger sloops or engine-powered scows. They used short-handled "grabs" to harvest oysters from the creek banks and long-handled "tongs" to get them from deeper water.

HARVEST TIME. *In 1939, Gullah Geechee men worked on oyster beds in Beaufort County.*
PHOTO/NOAA FISHERIES

LOW-COST LABOR. *Rosy, an eight-year-old oyster shucker (right front), worked 14-hour days in a cannery in Dunbar, Louisiana.*
PHOTO/LIBRARY OF CONGRESS

Harvested oysters were hauled by sailboat to canneries, where they were steamed, shucked, and canned. In spawning season, Gullah men shoveled empty shells onto oyster grounds to attract larvae.

During the Great Depression, South Carolina's oyster industry contracted sharply because of rising labor costs and lower consumer demand. New York's typhoid alarms of the 1920s struck down U.S. oyster harvests. Although canneries heat-treated oysters and killed pathogens, many Americans stopped eating them.

Shortly after World War II, some South Carolina canneries reopened in Beaufort and Charleston counties. But during the 1960s and '70s, pollution closures, rising labor costs, and competition from cheap Asian oysters squeezed lowcountry canneries, according to a 2003 history by the late Victor G. Burrell, Jr., a former director of the SCDNR Marine Resources Research Institute.

In 1986, the last cannery—on Lady's Island in Beaufort County—closed and the lowcountry oyster industry turned to supplying oyster roasts and similar events.

Also in 1986, SCDNR became responsible for managing three categories of oyster beds: public shellfish grounds harvested by recreational fishermen; state shellfish grounds used by both recreational and, today, about 500 commercial harvesters; and culture permits in areas that had once been leased.

In 2011, there were 130 culture permits containing about 2,200 acres of intertidal oysters. Permits allow holders to harvest oysters from specific areas and require them to plant reef-replenishing shells or other substrate.

SCDNR plants a total of 35,000 to 45,000 bushels of shell annually on public and state shellfish beds during spawning season and closes overharvested beds, sometimes for half of a year or more, sometimes for several years in a row.

"The fishing pressure is very high," says Nancy Hadley, manager of SCDNR's Shellfish Management Section. "As soon as oysters are there,

REPLENISH. *Ben Dyar, of the S.C. Department of Natural Resources, checks on recycled shells at a quarantine site at the former naval base in North Charleston. After months of quarantine have eliminated disease, these shells will be planted along shorelines to attract oyster larvae and restore reefs.*
PHOTO/GRACE BEAHM

they are going to be harvested. So planting shell is never completely finished. It's a process every year to replenish the habitat, and it's expensive."

Canneries and shucking houses once provided shell that leaseholders could plant each spring. Shell planting was a privately funded effort, though monitored by the state.

Today, most oysters are sold live to caterers and restaurants, and SCDNR is responsible for acquiring shell and planting it on public and state shellfish grounds.

"Now that the canneries are gone, there just isn't as much shell out there" in the estuaries, says Ben Dyar, manager of the SCDNR Oyster Recycling and Planting Program.

About 240,000 bushels of oysters a year are consumed in South Carolina, including about 120,000 shipped here from the Gulf. The vast majority of those empty shells are thrown in the trash or used as road materials.

The SCDNR's shell-recycling program acquires about 20,000 bushels of oysters from restaurants, caterers, and dropoff sites in nine counties, less than 10% of the shell that should be available for recycling in the state.

To make up the difference, SCDNR purchases shells from out-of-state shucking houses, purchases that are supported by recreational saltwater fishing stamps.

"Our biggest hurdle is public education and awareness," says Dyar. "We advertise and do other activities to get our message out, but many people still don't realize that we do recycling, or they don't understand why we do it. But when they hear about us and learn that the shells are going right back into the water, creating new oyster beds, they are more willing to recycle and talk to their neighbors and communities about it."

Jamie Westendorff, owner of Charleston Outdoor Catering, who sends empty shells to the SCDNR's recycling program, says, "I have to turn down a lot of people, and I've made some enemies. People want to use crushed shell on their driveways because that says, you know, that you've arrived on the coast. Crushed shell is a hallmark of the coast. But I explain to them that they need to look out for their grandchildren. If shell isn't put back into the water, there will be fewer oysters in the future."

VOLUNTEERS PLANTING SHELL

Bill Thielfoldt, a retired sales and marketing executive, found a new way of understanding the natural world when he volunteered for the South Carolina Oyster Restoration and Enhancement (SCORE) program managed by SCDNR.

It was in the early 2000s that scientists, government agencies, and nonprofit groups began building volunteer efforts to restore reefs in U.S. estuaries and build grassroots networks for coastal stewardship.

Established in 2000, SCORE was initially supported in part by the S.C. Sea Grant Consortium as one of the first statewide oyster-recycling programs outside of the Chesapeake Bay region.

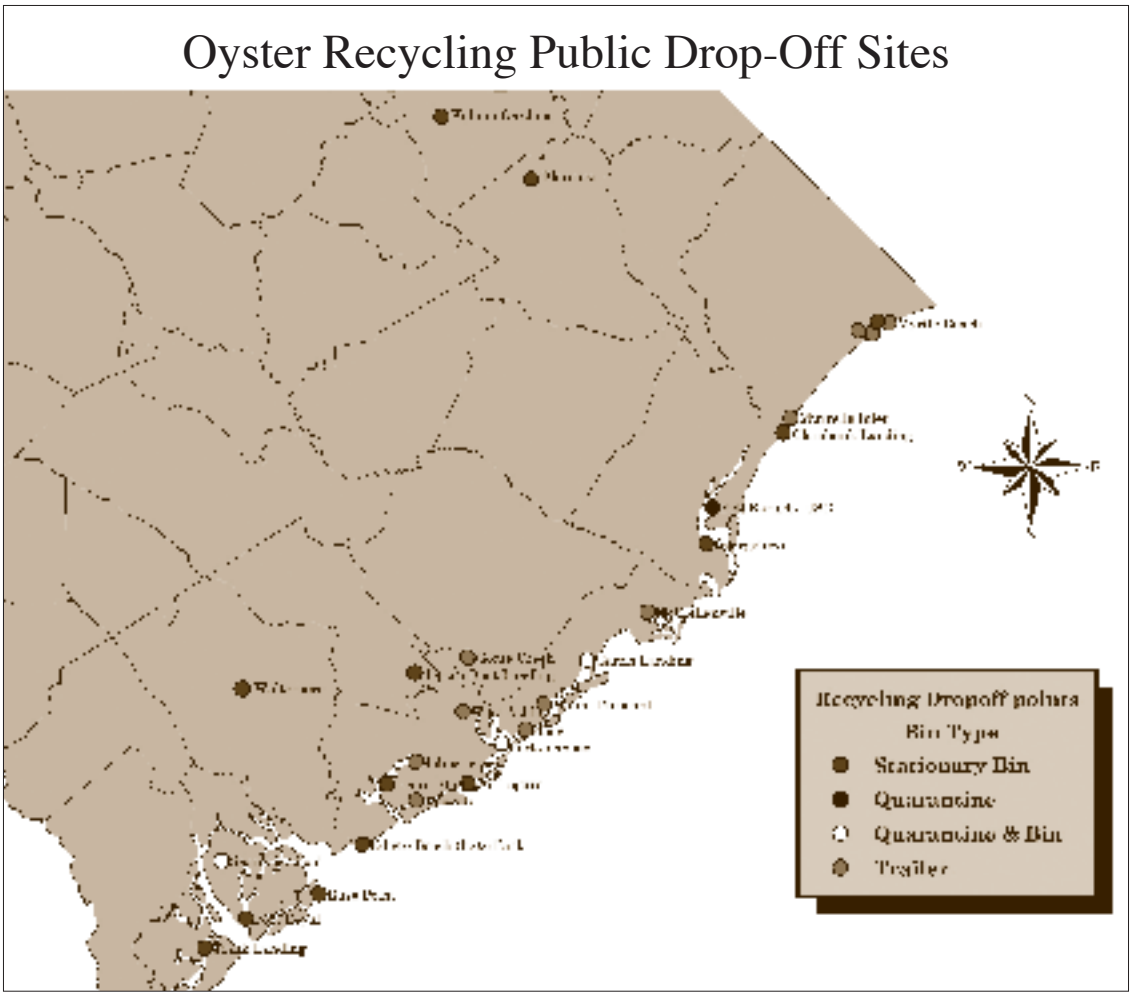
About 17,000 SCORE volunteers have donated more than 43,000 volunteer hours to build over two acres of oyster-reef habitat at more than 50 sites along the South Carolina coastline. Volunteers fill polypropylene mesh bags with shell and plant them fire-brigade style along shorelines to provide a clean hard substrate for oyster larvae to settle on.

Bags of oyster shell are used to

DELECTABLE. *Jenks Roberts eats an oyster during an afternoon oyster roast at Roberts Supply Co. Inc. in Charleston.*
PHOTO/GRACE BEAHM

elevate the substrate's profile off intertidal muddy bottoms; loose shells are more likely to sink in the mud. SCORE volunteers also test water quality, oyster survival and growth, and other parameters near restored reefs.

Three years ago, Thielfoldt joined a SCORE restoration effort near his home on Daniel Island. "We could see the difference in a very short period of time as the *Spartina* grew up behind the new reef, stabilizing the shoreline. We've gone back every year and added shell to the original reef, and the oysters have grown up into towers. This experience has made me very interested in the environment of the coast. It's piqued my interest in all of the things that go on in this magnificent estuary."



The S.C. Department of Natural Resources has created numerous drop-off sites for oyster-shell recycling. Please separate trash from shell and remove trash from all containers when you recycle.
MAP/S.C. DEPARTMENT OF NATURAL RESOURCES

Some SCORE volunteers have become ambassadors of reef restoration, distributing literature, assisting with school field trips, collaborating with restaurants and caterers to find ways to increase shell recycling, and aiding SCDNR staff with the management of recycled shell.

Fishing clubs are joining SCORE too. The Coastal Conservation Association (CCA)–South Carolina Chapter donated a trailer for the state recycling program and two johnboats to build SCORE reefs on otherwise inaccessible shorelines such as the one at Daniel Island. Fishermen organized volunteers for the annual Boone Hall oyster roast, where they emptied shells into recycling stations and passed out information.

Most Atlantic and Gulf coast states rely heavily on oyster shell to restore and enhance reefs. Because oyster shell is increasingly scarce, many new restoration programs are constructing reefs out of various materials including fossil-mined shell, concrete, and other recyclable materials.

Many of these newer structures are constructed to rise several feet off the muddy bottom, providing vertical relief where oysters can grow into "live rock," according to Nancy Hadley of SCDNR.

Some states like New York have very low numbers of oyster larvae in their estuaries, according to assessments by Hudson River Foundation and their collaborators. New York oyster populations, for instance, are small compared to what they once were in the 18th and 19th centuries, so researchers often set spat on shells in hatcheries and then deposit them in estuaries.

But in places like South Carolina, larvae from abundant adult populations are plentiful. Substrate is what is limiting. It's troubling, then, that so many empty shells in South Carolina—almost a quarter-million bushels in total annually—end up lost to landfills, road construction, and decorative uses on building facades.

More of those shells could be planted to attract oyster larvae looking for permanent homes. As Loren Coen puts it, "If we plant it, they will come."

SUSTAINABLE CROP. *Commercial fisherman Mark Van Buren of Tobias Seafood harvests oysters along a shoreline behind the Isle of Palms.*
PHOTO/GRACE BEAHM

Oysters and the public trust doctrine

Nineteenth century legal battles over the Eastern oyster helped determine how submerged lands in various states would be managed and how lines would be drawn and redrawn between private and public rights.

In 1818, Robert Arnold, a New Jersey farmer, purchased several boatloads of immature oysters and "bedded" them in the Raritan River in front of his farm, and then put up willow twigs to mark off his claim.

Bedding was still a new practice in America. Historically, wild oyster beds had once been immensely rich, but overharvesting was exhausting them. So bedders acquired seed oysters harvested from distant wild reefs and planted them on estuary bottoms.

Robert Arnold defended his river claim, driving off "so far as he was able, every one who attempted to take oysters without his leave." But one day, a fisherman named Benajah Mundy, "came, at the head of a small fleet of skiffs, and took away oysters." So Arnold brought a suit that came before the New Jersey Supreme Court in 1821 as a case about property rights.

Arnold claimed he owned the submerged lands—and the oysters—in front of his farm under a grant from the Proprietors, who had received these lands from the Duke of York, who in turn had received them from Charles II, King of England.

Mundy, however, claimed that "all the citizens of the state had a common right to take oysters therein" because the Raritan was a navigable river.

The United States was still a new nation, but this dispute had ancient roots. In 1775, when American colonies rebelled, British common law, based in part on the Magna Carta, held that the King and Parliament were allowed sovereignty over wild game and navigable waters in "sacred trust" for the people. Under this trust, the people could use waterways as fishing grounds and highways. British common law, then, designated submerged areas as places available for public uses. After the American Revolution, these common-law principles were usually transferred to the 13 states.

But New Jersey did not have a king. What to do? The New Jersey Supreme Court ruled that the American Revolution had transferred sovereignty over wildlife and submerged areas from the British Crown and Parliament to the American people. The state legislature, then, became the people's "rightful represen-

tative in this respect" and could exercise responsibility over tidal areas.

The state legislature, the Court ruled, "may lawfully erect ports, harbours, basins, docks, and wharves on the coasts of the sea . . . [and] create, enlarge, and improve oyster beds, by planting oysters therein in order to procure a more ample supply."

Because New Jersey held sovereignty over oyster beds and other submerged areas, it could devise a system under which these sites might be used for private purposes. In 1825, the New Jersey legislature passed a law allowing the state to issue leases on public shellfish beds with a known history of cultivation.

Fishermen objected, arguing that the law would allow wealthy investors to acquire leases on the best oyster beds in the state and manage them as private property. Shellfish resources that were once common property, open to all, would now be privatized for all practical purposes, opponents said. Moreover, the state of New Jersey lacked constitutional authority to stop oystermen from harvesting on leased oyster grounds, critics said.

In 1842, a New Jersey case about oysters and submerged lands reached the U.S. Supreme Court. A landowner on New Jersey's Raritan River claimed to own riparian land beneath the river and all rights to wildlife there, including oysters, tracing his title to a grant from King Charles to the Duke of York in 1664.

In *Martin v. Waddell*, Chief Justice Taney confirmed that states were the successors to the Parliament and the British Crown as having sovereignty over navigable waters, submerged lands, fish, and wildlife. Taney noted that when "the people of New Jersey took possession of the reins of government, and took into their own hands the powers of sovereignty, the prerogatives and regalities which before belonged to either the crown or the parliament, became immediately and rightly vested in the state."

Martin v. Waddell was followed by a series of cases establishing that submerged lands would be held in trust by government, which must manage their use on behalf of the citizenry. Over time, this principle would be called the "public trust doctrine."

By 1855, the state legislatures of New York, Connecticut, Rhode Island, and Massachusetts had passed laws allowing leasing of public shellfish beds. South Carolina followed in 1891.

By the mid-20th century, South Carolina's leasing system was often criticized for allowing an individual or a single company to control thousands of acres of shellfish beds through multiple permits.

In the mid-1960s, the state established new recreational shellfish grounds, most of which were carved out of leased areas as a result of state managers negotiating with leaseholders.

In 1986, the South Carolina legislature eliminated the leasing system and created a permit system for public shellfish grounds managed by the SCDNR for recreational and commercial fishermen. Most leases became permits. A single firm or individual could acquire multiple permits with an overall maximum of 500 acres. There are now about 130 permitted areas averaging about 20 acres apiece.

The 1986 state law also provides SCDNR with direct authority over permit holders to ensure that they comply with fees and replanting requirements, according to Bill Anderson, a retired biologist who once supervised the SCDNR shellfish management section. Many more state shellfish grounds have been added over the years when culture permits were revoked for failure to pay annual rental fees or plant oyster shell or other substrate, he adds.

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NEWS & NOTES

Knauss fellows from S.C. schools selected

Two South Carolina graduate students were selected as Knauss fellows in the 2013 class of the prestigious John A. Knauss Marine Policy Fellowship. Nominated by the S.C. Sea Grant Consortium, the students were among 49 selected from a nationwide pool of more than 100 candidates.

During her Knauss fellow year, Leah Fisher, who completed an M.S. in marine science at the College of Charleston, serves as a coastal policy analyst in the National Oceanic and Atmospheric Administration/National Ocean Service (NOAA/NOS) Planning, Policy, and Analysis Division. She will provide assistance to a NOAA-wide Arctic Task Force, among other duties.

Leah Fisher
PHOTO/NOAA

"I'm excited to bring my scientific background to Washington and see how the knowledge obtained through research can actually inform policy decisions," Fisher says.

Elizabeth Fly, who completed a Ph.D. in biological sciences, serves as a climate and marine ecosystems policy fellow within the NOAA Climate Program Office. She will help coordinate and produce material to support the National Climate Assessment, which is a high-impact, interagency activity of the U.S. Global Change Research Program.

Elizabeth Fly
PHOTO/NOAA

"This is such a critical time to relate scientific findings to policymakers and the general public in an effective, user-friendly manner," Fly says. "The Knauss fellowship has given me the opportunity to be deeply involved in this effort. Following this fellowship, I hope to continue in helping make science more accessible to non-scientists for policymaking that can balance a variety of parties' interests."

To further the education of tomorrow's leaders, the National Sea Grant Office sponsors the John A. Knauss Marine Policy Fellowship Program, bringing a select group of graduate students to the nation's capital, where they work in the federal government's legislative and executive branches.

The students learn about federal policy regarding marine and Great Lakes natural resources and lend their scientific expertise to federal agencies and congressional staff offices.

Each of the nation's 33 Sea Grant programs can nominate up to six students to the Knauss fellows program annually. Selections are then made competitively from among those nominations. Visit www.scseagrant.org/Content/?cid=56 for more information about the Knauss fellowship.

What do coastal residents want?

Residents of three rapidly changing communities in northern Charleston County share respect for the health of local waterways that transcends divisions of race or household wealth.

"We're trying to get a holistic picture of what people are thinking about the coast and its waterways and what they want for the coast," says Sea Grant researcher Annette Watson, a geographer at the College of Charleston.

Watson and her colleagues are studying three different populations—commercial, subsistence, and recreational fishermen—in rural McClellanville, suburbanizing Awendaw, and urbanizing Mount Pleasant.

Additional growth is predicted to occur along this corridor of Interstate 17 known as the "Sewee to Santee" region, which is the focus of an ongoing planning effort.

This research will not focus on tensions that exist but instead will address similarities in social-ecological relationships for the purpose of planning, Watson says.

In-migrants are often considerably wealthier than their neighbors, driving up the cost of living and economically marginalizing longtime residents. In some coastal communities, commercial fishermen are in conflict with recreational or subsistence fishermen.

But Watson and her colleagues will use innovative interviewing techniques and quantitative analysis to help long-time residents and in-migrants identify special fishing places that they want to protect, and find commonalities for planning purposes.

The project aims to determine the senses of place experienced by life-long residents; spatially measure access to coastal resources historically used by

NEWS & NOTES

life-long residents; determine the relationship between long-term residents' economic practices and their environmental values; test whether different community identities can find commonalities in their values; and develop common indicators that community leaders can use to track changes through time.

Extension specialist joins Consortium

Julie E. Davis has joined the S.C. Sea Grant Extension Program as a living marine resources specialist. She is completing an M.S. in fisheries and aquaculture from Auburn University.

Julie Davis
PHOTO/S.C. SEA GRANT CONSORTIUM

She will focus on issues associated with fisheries policy and management, sustainable aquaculture development, seafood business planning and marketing, working waterfronts, fisheries ecology, and fisheries/aquaculture gear and technology.

In Alabama, Davis previously worked on a National Sea Grant Aquaculture Extension project, helping to develop off-bottom oyster farming in the north central Gulf of Mexico. This form of oyster farming would supply the high-value, premium, half-shell market in addition to the shucked-meat market already served.

"South Carolina and Alabama share some of the same challenges," Davis says, "and I am excited about working with growers to adapt some of the techniques we've used successfully in the Gulf to South Carolina waters."

Improved septic systems aid water quality

The Charleston Soil and Water Conservation District and partners, based on information provided by the S.C. Sea Grant Consortium and S.C. Department of Health and Environmental Control, recently installed 62 replacement septic systems and repaired four systems in the Sewee to Santee priority watershed.

Sites for the repair and replacement of septic systems were focused in areas with underprivileged households, mainly in the towns of McClellanville and Awendaw, S.C.

Eight homeowner septic education workshops were held, starting in July 2009 and ending in September 2012.

Other elements included implementation of best management practices (BMPs) on pastureland or hobby farms, pet waste control, marine sanitary waste measures, and an extensive education and outreach campaign targeting both home and watercraft owners.

Eliminating septic system backups in the household or sewage outbreaks in the yard reduced the amount of fecal coliform bacteria going into waterways, helping to improve water quality and contributing to the re-opening of 883 acres of shellfish harvesting beds near McClellanville.

This project was funded by the Environmental Protection Agency's Section 319 grant program for non-point source pollution management. To view the complete project report, visit the Coastal Growth Publications web page at www.scseagrant.org/Content/?cid=135.

Coastal Heritage wins prestigious award

Coastal Heritage has received a Distinguished Award from the 2012-2013 Society for Technical Communication Carolina Chapter competition. The rigorous judging process was based on content and organization, copyediting, visual design, and creativity. The entry now moves on to the international competition.

Subscriptions to *Coastal Heritage* are available upon request by contacting Annette Dunmeyer at (843) 953-2078 or via e-mail at Annette.Dunmeyer@scseagrant.org. Current and past issues are available online at www.scseagrant.org/Products.

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EBBS & FLOWS

4th National Forum—Challenges of Natural Resource Economics and Policy

New Orleans, Louisiana
March 24-26, 2013

This Forum will address topics such as social sciences in calculating the market and non-market values of ecosystem goods and services; identification of linkages between coastal resources and regional economic activity; the use of indicators for resource management and project prioritization; and the role of energy industries and policy in coastal environments and communities. Visit www.cnrep.lsu.edu for more information.

National Working Waterfronts and Waterways Symposium

Tacoma, Washington
March 25-28, 2013

Washington Sea Grant and Oregon Sea Grant are sponsoring the 3rd national symposium on issues faced by working waterfronts throughout the U.S. Topics to be covered include the economic and social impacts of working waterfronts; successful local, regional, state, and federal strategies to address working waterfront issues; and keeping waterfront industries commercially viable. For more information, visit www.workingwaterfronts2013.org.

OCEANS 2013

San Diego, California
September 23-26, 2013

The OCEANS 2013 conference is jointly sponsored by the Institute of Electrical and Electronics Engineers (IEEE) Oceanic Engineering Society and the Marine Technology Society (MTS). This international conference is a major forum for scientists, engineers, and those with an interest in the oceans to gather and exchange their knowledge and ideas regarding the future of the world's most critical resource. The conference theme is "An Ocean in Common." Visit www.oceans13mtsieeesandiego.org for more information.

Subscriptions are free upon request by contacting: Annette.Dunmeyer@scseagrant.org

ATTENTION SCHOOL TEACHERS! The S.C. Sea Grant Consortium has designed supplemental classroom resources for this and past issues of *Coastal Heritage* magazine. *Coastal Heritage Curriculum Connection*, written for K-12 educators and their students, is aligned with the South Carolina state standards for the appropriate grade levels. Includes standards-based inquiry questions to lead students through explorations of the topic discussed. *Curriculum Connection* is available on-line at www.scseagrant.org/education.