COASTAL HERITAGE

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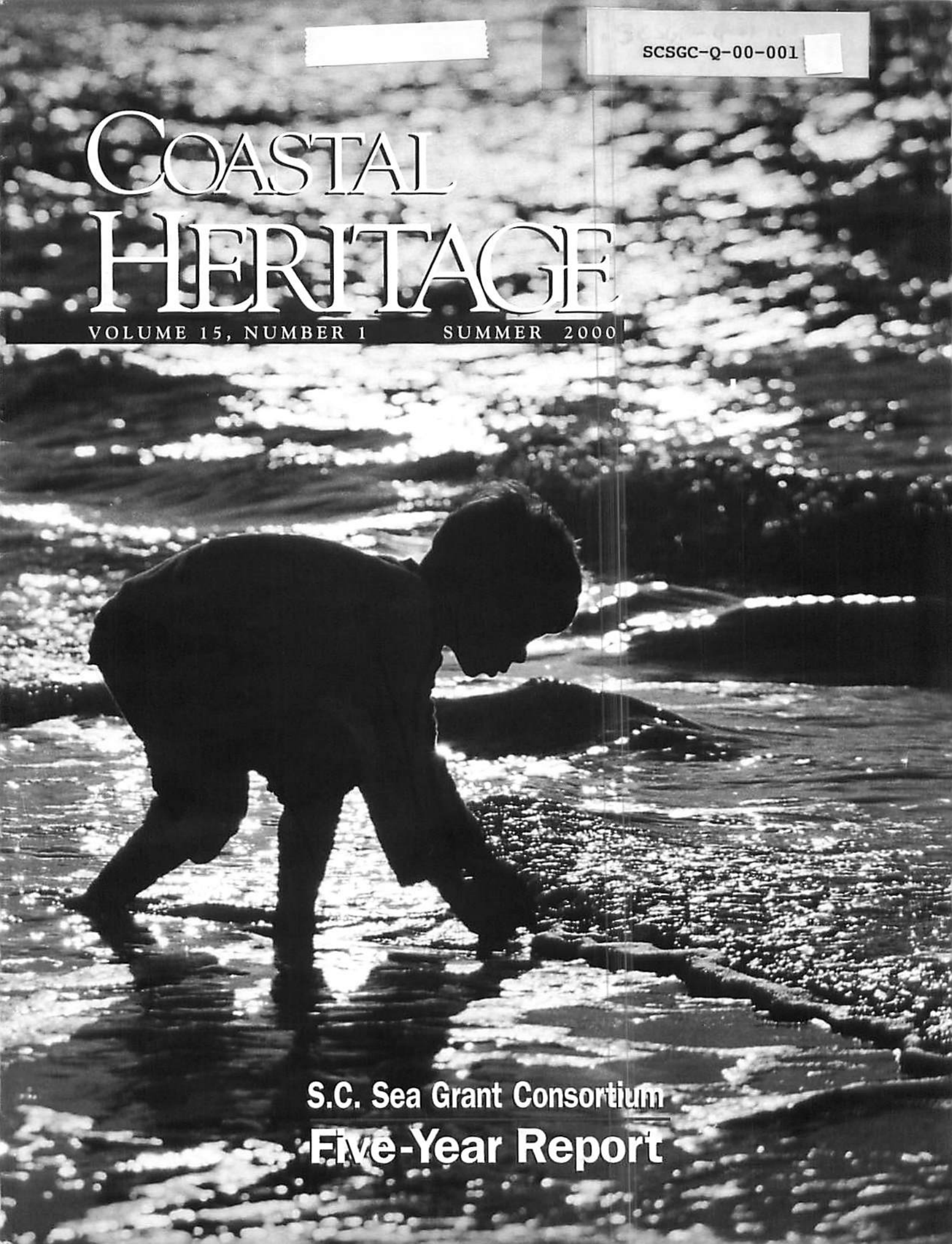

S.C. Sea Grant Consortium

Five-Year Report

CONTENTS

COVER PHOTO/WADE SPEES

TAKING FLIGHT. *Egrets feed in the Ace Basin, one of the South Carolina Lowcountry's ecological treasures.*
PHOTO/WADE SPEES–COURTESY OF THE POST & COURIER

Sea Grant
S.C. Sea Grant Consortium

Committed to maximizing the economic, social, and environmental potential of the state's coastal and marine resources.

Coastal Heritage is a quarterly publication of the S.C. Sea Grant Consortium, a university-based network supporting research, education, and outreach to conserve coastal resources and enhance economic opportunity for the people of South Carolina. Comments regarding this or future issues of ***Coastal Heritage*** are welcomed. Subscriptions are free upon request by contacting:

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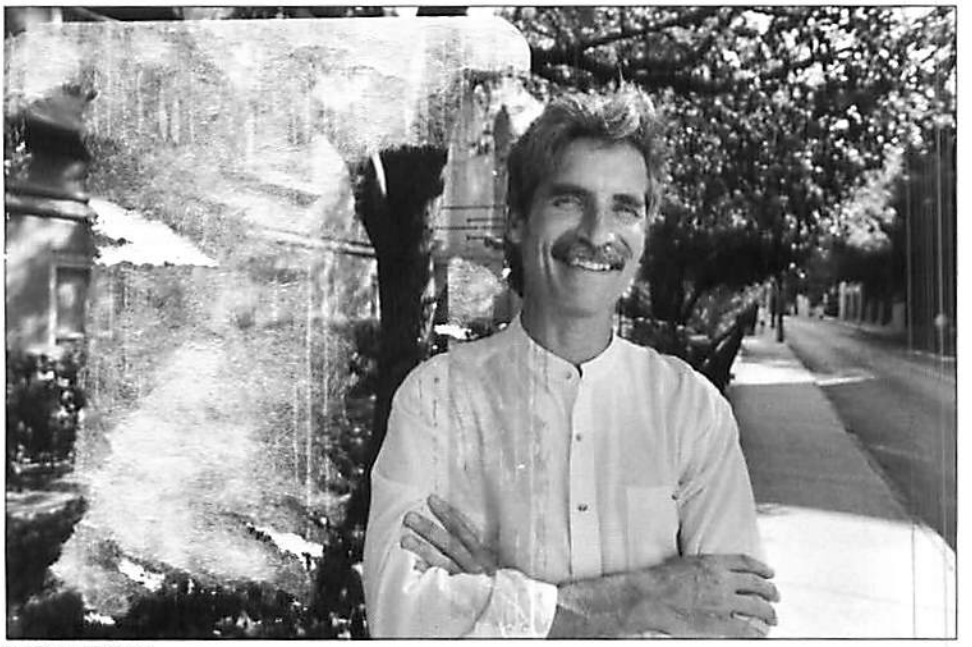
EXECUTIVE DIRECTOR'S MESSAGE

Although South Carolina has one of the smallest populations in the country, its coastal region is expected to experience unprecedented growth in the coming decades. People are attracted to the economic, recreational, and retirement opportunities the state's coastal resources provide. But this growth is placing enormous pressures on our coastal watersheds, infrastructure, and way of life. We still have an opportunity to employ proactive management and planning approaches based on sound science to minimize the anticipated impacts of this rapid growth. But much of the necessary scientific knowledge needed to make informed decisions does not exist or has not been provided to those concerned.

For 20 years, the S.C. Sea Grant Consortium has provided crucial two-way information exchange between those who work to understand the limits of the state's coastal and marine resources and those who seek to take advantage of the opportunities they afford. The Consortium's integrated triad of research, education, and extension programs represents a concerted effort to link government, industry, academia, coastal users, and the public in a mutual pursuit of a sustainable economy for South Carolina and an improved quality of life for South Carolinians.

M. Richard DeVoe
Executive Director
S.C. Sea Grant Consortium



PHOTO/WADE SPEES

S.C. Sea Grant Program Goals

- **Coastal Ocean Studies:** Identify and understand the processes dominating the coastal ocean as they affect coastal processes, pollution of the coastal zone, fisheries dynamics and mineral resource management, and are influenced by global climate change and sea level rise.
- **Ecosystem Dynamics:** Enhance the availability, quality and appreciation of marine, estuarine and freshwater resources that support economic and quality-of-life needs.
- **Climate and Hazards:** Reduce life and property loss by examining the forces of climate and hazards, and providing information to the public on the nature of hazards, and how to prepare for and respond to them.
- **Emerging Technologies:** Develop techniques, technologies and new products based on marine systems for use in commercial and industrial applications, and apply low-cost technologies to coastal and marine resource problems.
- **Sustainable Economic Development:** Identify and promote economically viable business and municipal opportunities that are compatible with the long-term conservation of natural and cultural resources.
- **Marine Education:** Generate and deliver information related to the sustained use and conservation of marine and coastal resources through K-12, university, and public education programs.

Bending to the Forces

WHEN HURRICANE HUGO barreled into McClellanville, a coastal village about 35 miles north of Charleston, the storm surge drove at least eight feet of seawater into Thomas Williams' small frame house. As the water rose to the ceiling, Williams helped his family into the attic, where they huddled the rest of the night, though half of the roof was blown off. The storm surge knocked the house off its foundation and carried it 100 feet across the backyard, where it crashed into a big tree. "If that tree hadn't stopped the house," Williams says, "who knows where we would've ended up?"

After the hurricane, local residents saw debris everywhere and assumed that thousands of homes had been similarly destroyed. After paying out $5 billion after the storm, insurers also believed that the storm had caused catastrophic damage to homes and businesses.

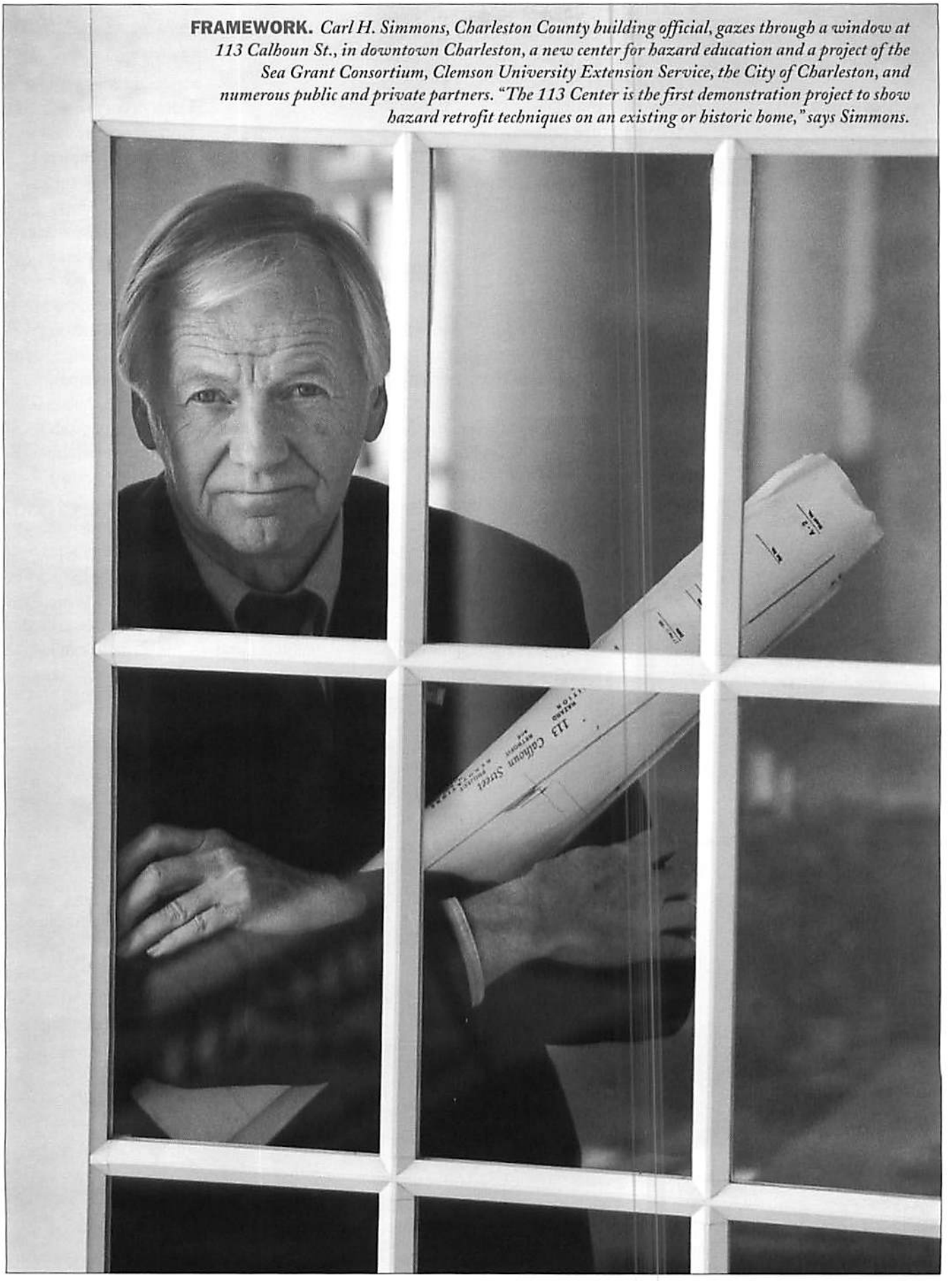
But Sea Grant researcher Peter Sparks, Clemson University civil engineer, decided to test those assumptions. He studied insurance records and found that, outside of the barrier islands, very few homes suffered complete losses. In South Carolina, 80 percent of the storm's insured losses were caused by relatively minor wind damage to roofs, windows, and doors. Most damaged buildings did not lose entire roofs, but instead suffered small tears to their roof "envelope," where rain poured in and ruined furniture, carpets, and other expensive property. The leaking roofs would have cost just a few thousand dollars to repair, but the water that got inside buildings damaged contents, magnifying costs ten-fold.

So Sea Grant researchers realized that it's possible to reduce and even eliminate a large portion of hurricane destruction. Through the 1990s, scientists have studied hurricane effects on buildings at the Clemson University wind-engineering facility, searching for practical, low-cost techniques that homeowners could use to retrofit their homes.

Clemson engineers have focused retrofitting efforts on the most vulnerable parts of the building "envelope": the roof plus window and door openings. Tim Reinhold and Scott Schiff tested caulk-like adhesives that homeowners can apply to the connection between roofing plywood sheets and roof trusses. They learned that the adhesives improve a roof's capacity to withstand hurricane-wind pressures by a factor of four or five. A homeowner can apply this

"The 113 Calhoun Street educational program strives to teach techniques of protecting structures from natural disasters," says ***Carl H. Simmons, Charleston County building official and director of the county Project Impact****, a federal/local program to reduce disaster damages. "We at the Charleston County Area Project Impact Program applaud and appreciate the 113 Street partnership for its unique effort to educate people about the hazards that face our area."*

PHOTO/ WADE SPEES



FRAMEWORK. *Carl H. Simmons, Charleston County building official, gazes through a window at 113 Calhoun St., in downtown Charleston, a new center for hazard education and a project of the Sea Grant Consortium, Clemson University Extension Service, the City of Charleston, and numerous public and private partners. "The 113 Center is the first demonstration project to show hazard retrofit techniques on an existing or historic home," says Simmons.*

Climate and Hazards Program Activities

- Analyzed insured hurricane wind losses, leading to better understanding of damages that produce greatest property losses.
- Evaluated designed wind loads of building codes.
- Developing GIS-based hurricane-wind models to help predict degree and extent of property damage.
- Developed a special sensor to measure wind pressures on homes.
- Established a hazards mitigation program at 113 Calhoun Street in downtown Charleston.
- Supported research that led to the publication of "The Risk of Hurricane Wind Damage to Buildings in South Carolina."
- Supporting research to develop low-cost and self-help retrofit techniques for reduction of damage and losses in severe wind storms.
- Co-founded the S.C. Association for Hazard Mitigation to enhance the exchange of hazards-related information among public and private sectors in the state.
- Employed a coastal hazard extension specialist to develop education programs.

caulk adhesive in an attic for about $300 to $500, excluding labor costs. Reinhold and Schiff also discovered that roofing materials secured properly with screws withstood up to five times more wind pressure than materials held in place by nails only.

In another study, Reinhold and Schiff tested inexpensive ways to build a safe haven in a home. They learned that installing a single layer of plywood beneath one room's interior walls could reduce the chances that falling small trees would cut through walls. To retrofit a four-foot by eight-foot room, a homeowner would spend between $500 and $1,000 for materials, depending on the level of protection selected.

Reinhold is also is working on a five-year project with the Florida Department of Community Affairs to monitor how hurricanes affect single-family homes along the South Florida coast. "We want to know what kind of forces act upon a house during a major hurricane," says Reinhold. "We also need better information on how strong the storm is." As part of a Sea Grant Industrial Fellowship, a graduate student developed an "absolute pressure transducer," measuring wind pressures on test homes.

Ten homeowners participating in the research project's first phase can spend up to $10,000 for retrofit improvements to their homes in exchange for allowing researchers to check instruments on their houses during a five-year period. Homeowners could retrofit their homes by attaching the roof sheathing better with additional fasteners or adhesive, adding approved shutters, protecting entry and garage doors, and installing hurricane straps.

Meanwhile, a building in downtown Charleston is now a demonstration project for hazard mitigation. Called "113 Calhoun Street: A Center for Sustainable Living," the structure is an example of how improved building materials and methods can help buildings survive high winds, flood, and earthquake hazards.

TOO CLOSE FOR COMFORT. *A fisherman seems to ignore the crashing waves against this walkway along a Grand Strand eroded beachfront.* PHOTO/WADE SPEES

SHIPWRECKED. *Hurricane activity has increased dramatically in recent years. Hurricane Fran, which battered this marina near Wilmington, N.C., was just one of four large tropical cyclones that hit the Carolinas from 1996 to 1998.*
PHOTO/WADE SPEES

The center is a partnership of the Sea Grant Consortium, Clemson University Extension Service, the City of Charleston, the Federal Emergency Management Agency, South Carolina state government, and Charleston County. The center is a public/private partnership undertaken with the support of many businesses, organizations, and individuals. Elizabeth Judge, S.C. Sea Grant Extension Program coastal hazard specialist, is developing and implementing education programs for design professionals, the building industry, local building officials, and homeowners. "At 113 Calhoun, we demonstrate how people can take off-the-shelf, economically feasible materials and techniques to make their houses safer from natural disasters," says Judge.

South Carolina communities also need more information about storms' potential impacts so they can plan better. David Rosowsky, another Clemson civil engineer, is working with Peter Sparks to develop a user-friendly Web-based computer application to predict hurricane wind speed and expected damage. Soon localities could study a geographic information system (GIS) map that would show a hurricane's expected wind speeds and insurance losses 24 hours in advance of the storm's landfall. The model would continue updating information as the storm approaches the coast. "It could show what you'd expect from a storm in your town, in terms you could understand," says Rosowsky. On GIS maps, officials could see how many people and structures would be affected, so they could plan response efforts and better locate staging areas for storing and disseminating supplies.

Tending the Coast

RURAL LANDSCAPES—FORESTS, fields, and wetlands—are important to South Carolinians, who hold strong attachments to their heritage. But in recent years, rapid development and social and economic changes have battered rural traditions along the coast. Now, in this era of abrupt transitions, how should South Carolinians manage natural resources with complex cultural and ecological values?

Over the past two decades, landowners, ecologists, fishermen, and resource managers have debated over how to manage historic rice fields, sprinkled from the Savannah River to Winyah Bay. Some impoundment owners want to rebuild the former rice dikes and manage for waterfowl. But some boaters and fishermen want fields left undiked because remnant impoundments provide excellent places to fish.

For generations before the Civil War, landowners cleared cypress-gum forests along rivers and built extensive dikes to control flooding of rice fields. Planters drained and irrigated these fields to kill weeds and encourage rice to germinate. But in the decades following the war, landowners abandoned the impoundments.

"Sea Grant is providing scientific information so we can make better management decisions about the former rice fields" along the Cooper River, says Ben Miller, general manager of Mulberry Plantation.

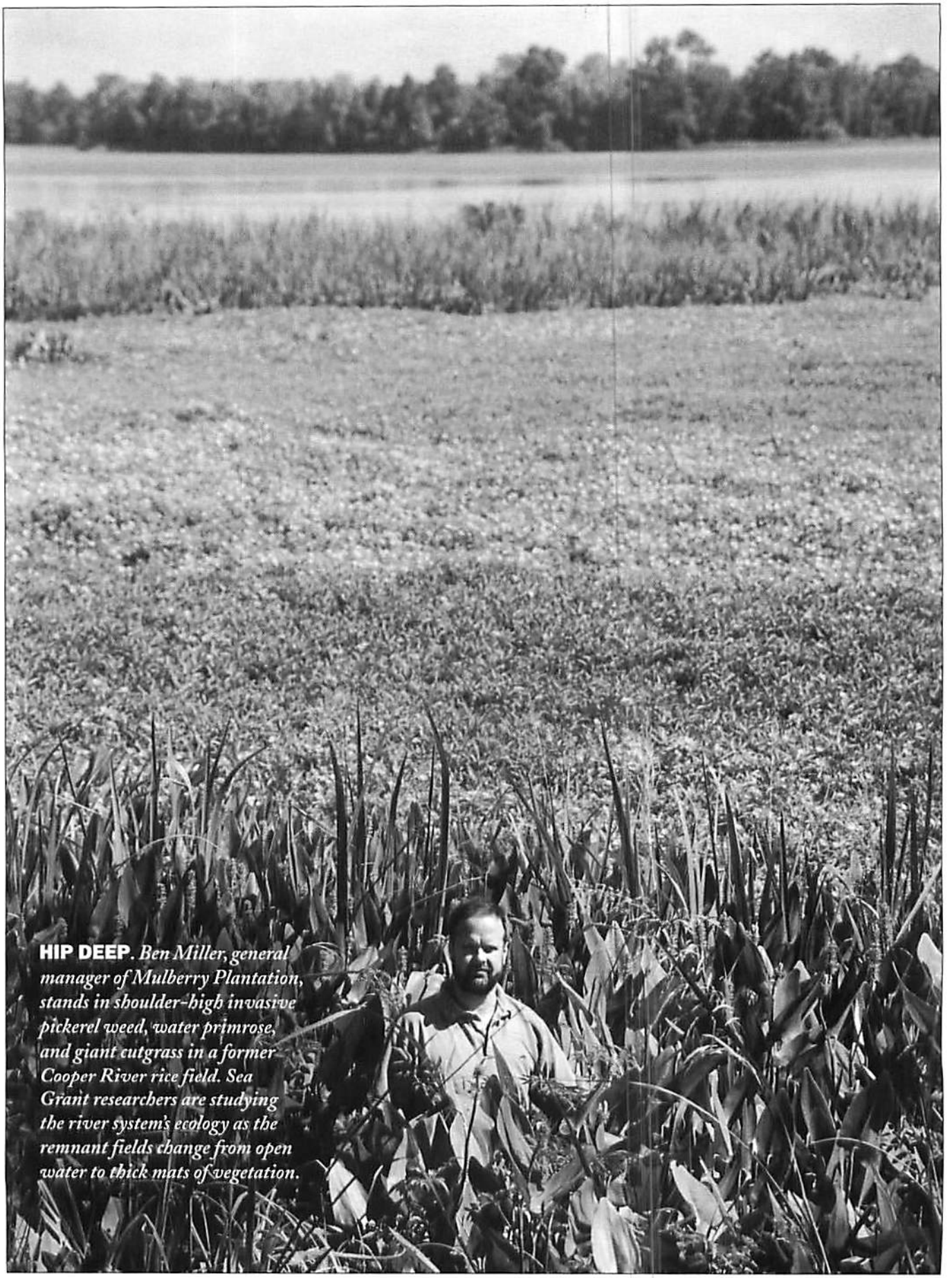
In the early 20th century, wealthy Northerners bought up former rice plantations for hunting preserves and timber operations. In the Cooper River system, many dikes broke, water levels dropped, and vegetation grew in the remnant fields. In 1985, a portion of the Cooper River flow was diverted to the Santee River, and average water levels dropped further, encouraging plant and tree growth.

Today, the Cooper River fields continue to grow thick with vegetation. Unless dikes are repaired or river water levels altered, the fields could become cypress-gum forests again. Sea Grant researcher James T. Morris, University of South Carolina marine biologist, is studying how plant communities are evolving in the remnant fields.

Morris is a member of a team of scientists, including Hank McKellar, USC environmental scientist; Joe Kelley and Richard Porcher, biologists at The Citadel; and James Bulak, S.C. Department of Natural Resources research coordinator, who want to learn more about both ecological functions and human uses of the Cooper River rice fields.

These Sea Grant researchers are studying the river system's ecology as remnant fields change from open water to forest. For example, larger amounts of vegetation in the fields could soak up nutrients, potentially improving water quality. Yet more vegetation could reduce fish habitat. This information might help resource managers and property owners decide how to manage the fields.

"We're playing a neutral role," providing scientific guidance to property owners and regulatory agencies, says Morris. "We want to understand the ecological impact of different management options. These could include



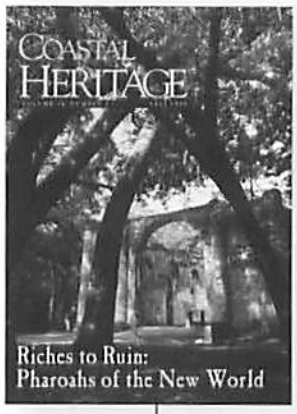
HIP DEEP. *Ben Miller, general manager of Mulberry Plantation, stands in shoulder-high invasive pickerel weed, water primrose, and giant cutgrass in a former Cooper River rice field. Sea Grant researchers are studying the river system's ecology as the remnant fields change from open water to thick mats of vegetation.*

PHOTO/ WADE SPEES

Ecosystem Dynamics Activities

- Developing ecological tools to assess ecosystem health.
- Generating science-based information for improved management of freshwater tidal marshes in the Cooper River.
- Supporting studies on the ecological value of the state's oyster reefs.
- Established a state task force on harmful algae to improve public understanding of nuisance algal outbreaks.

rediking the impoundments to keep the fields flooded for waterfowl hunting, or allowing the fields to return to cypress forest, or increasing water flow at the Pinopolis dam upstream to halt the growth of plants."



Oyster reef restoration

For generations, coastal managers and scientists virtually ignored oyster reefs as valuable ecosystems. Sea Grant scientists had to start from scratch when they began studying how to restore South Carolina's oyster reefs, which had been previously slighted as an important marine ecosystem and as a subject for research.

Oyster landings around the country have declined precipitously over recent decades. Oyster reefs, in fact, are often thought as having relatively small value as an fishery resource. But even when these reefs are closed to public harvesting, they have value as habitat.

Sea Grant researcher Loren Coen, marine ecologist at the S.C. Department of Natural Resources, and his colleagues have built a total of six experimental reefs at two sites at Inlet Creek and Toler's Cove in Mt. Pleasant. The scientists compared the biodiversity within natural and artificial oyster reefs to the biodiversity of adjacent unstructured habitat, such as mud flats. They found a greater number of species within the oyster reefs compared to species that visited mud flats. Finally, the researchers discovered that biodiversity was higher for oyster reefs in undeveloped areas compared to reefs located in developed areas.

Assessing ecosystems

Coastal managers need more sophisticated tools to judge ecosystem health. As part of an effort to create such tools, researchers are using advanced genetic techniques to study the impacts of pollutants on tiny marine creatures called copepods, which provide an important food source for bottom-feeding fish.

Sea Grant researcher Thomas Chandler, ecotoxicologist at the University of

RAKING IT IN. *A man digs for clams or conch on St. Helena Island.* PHOTO/WADE SPEES

South Carolina School of Public Health, is working with USC marine biologists Bruce C. Coull, Joe Quattro, Nick Schizas, and Joe Staton to learn whether copepods have a genetic advantage that help them survive contaminants. The researchers sequenced a portion of the copepod's genetic code. Next, they developed a rapid and reliable method to identify three major genetic variants, without the use of cumbersome and costly DNA technology. Chandler and his colleagues hope that coastal managers could use this tool as an indicator of ecosystem health.

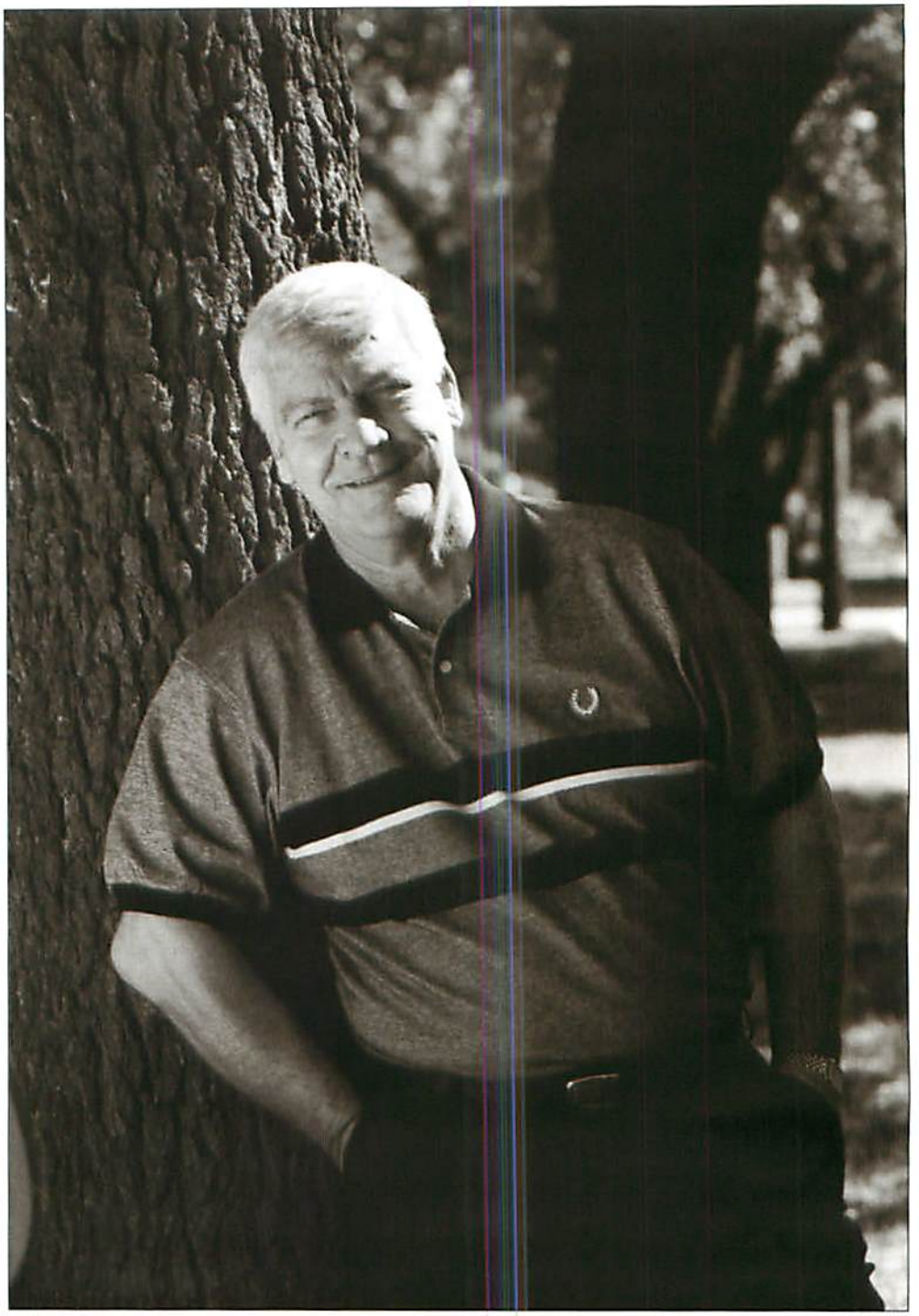
Controlling runoff

With the help of a new pilot program, Non-Point Source Education for Municipal Officials (NEMO), public officials in Horry and Georgetown counties are learning how various land-use techniques can reduce the amount of paved and hardened areas such as roads, parking lots, and bridges. A higher percentage of paved surfaces in a watershed usually increases the degree of flooding and runoff pollution.

The S.C. Sea Grant Extension Program is working with the Waccamaw Regional Planning and Development Council to implement the NEMO program, which teaches local officials how to encourage development that minimizes runoff pollution.

"NEMO educates planning staff and elected officials about simple, affordable design recommendations they can make to developers to reduce pollution stormwater runoff in new subdivisions," says Bill Schwartzkopf, assistant executive director of the Waccamaw Regional Planning and Development Council.

With a number of techniques, developers can significantly reduce the amount of impervious cover in new subdivisions, says Cal Sawyer, coastal environmental quality specialist with the S.C. Sea Grant Extension Program. Developers can build narrower roads, cluster homes together to create open space, and provide gravel or structurally supported grass on driveways and parking lots.



FORWARD THINKING. *With help from the S.C. Sea Grant Consortium, a new pilot program called "NEMO educates planning staff and elected officials about simple, affordable design recommendations they can make to developers to reduce pollution stormwater runoff in new subdivisions," says Bill Schwartzkopf, assistant executive director of the Waccamaw Regional Planning and Development Council.* PHOTO/WADE SPEES

Sea of Plenty

WHEN YOU CHOOSE A PACKAGE OFF the grocery shelf, odds are that some of its ingredients came from the sea. Marine algae and their byproducts help stabilize pulp in orange-juice concentrate, thicken instant soups, firm up breads, and provide coloring for cheese and popcorn. Marine substances are important components of many vitamins and marine compounds may yield new medicines.

Yet scientists are just beginning to learn about the vast storehouse of the sea's molecular compounds, some of which can be mimicked in the laboratory to make new products. Marine biotechnology offers chances to help develop products that provide profits, protect the environment, and improve human health.

Sea Grant researcher A.P. "Hap" Wheeler, Clemson University biologist, has explored a variety of potential commercial uses for polyaspartic acid, modeled after Eastern oyster *Crassostrea virginicus* shell proteins. Based on Wheeler's research, scientists discovered that polyaspartic acid helps plants absorb additional nutrients from the soil. By applying this polymer to soils, farmers can gain greater yields with smaller amounts of fertilizer.

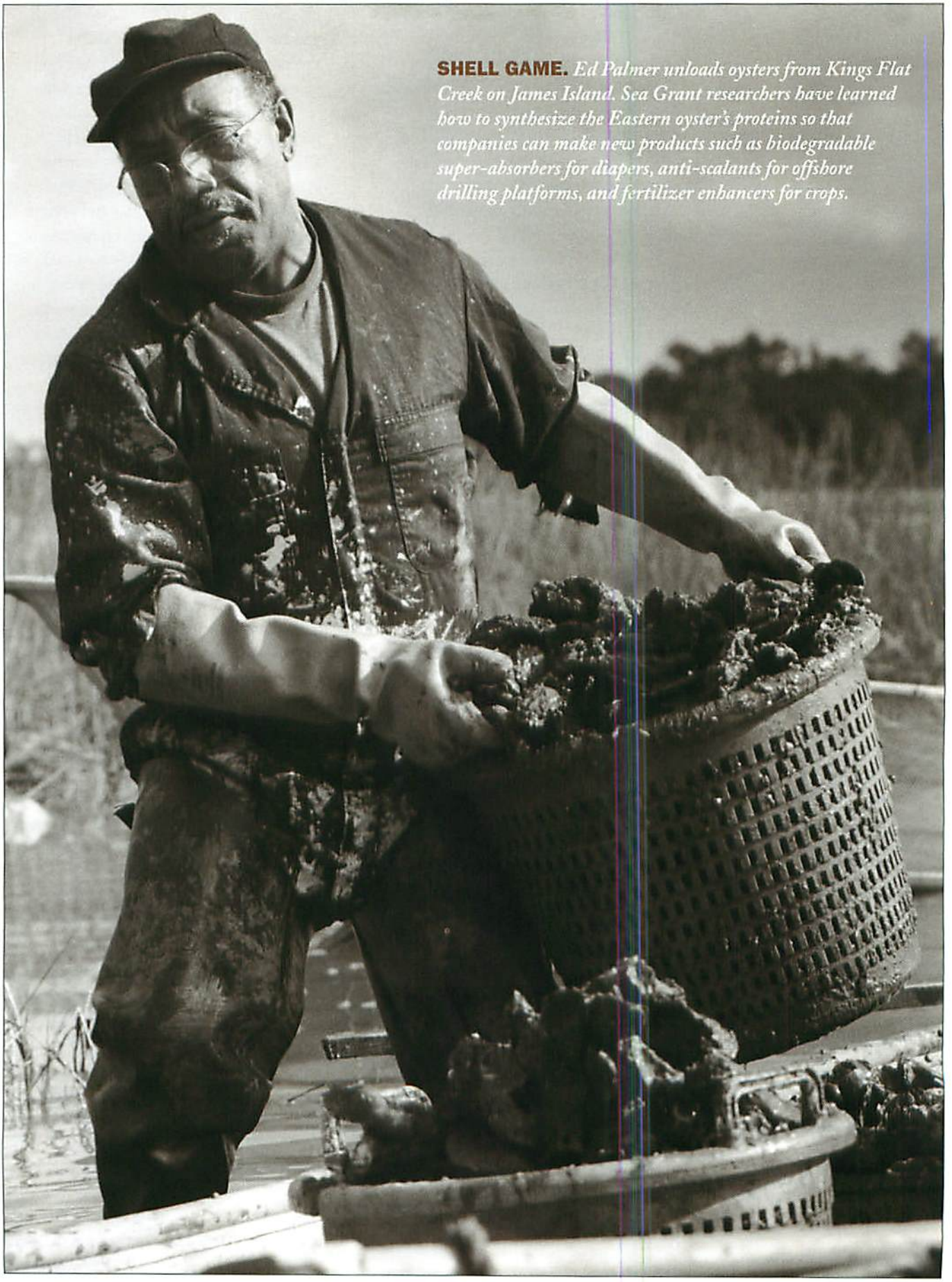
Donlar Corp., based in Bedford Park, Ill., manufactures polyaspartic acid with the branded names AmiSorb, used on agricultural crops such as corn and wheat, and Magnet, used on vegetable crops such as tomatoes. In the 1980s, Wheeler and a colleague joined Larry Koskan, who later became the founder and CEO of Donlar Corp., to perfect an inexpensive process to produce polyaspartic acid, a commercial form of the oyster protein.

Wheeler doesn't knows exactly how these products help plants absorb nutrients more efficiently. "They seem to enhance movement of nutrients in soils to the plant root," says Wheeler.

Yet "the polymer does not penetrate inside the plant," says Ramon Georgis, Donlar's director of research and development. Because the fertilizer enhancer does not reach into the plant, and because it is biodegradable, the Environmental Protection Agency waived a hurdle in its normal approval process for new agricultural products.

Farmers and environmental regulators have been searching for ways to reduce fertilizer loads, because fertilizers often run off into waterways during heavy rains. Using Donlar's polymer, farmers could protect water quality and save money. With an investment of $8-10 dollars on

"Donlar Corporation has benefited greatly from Sea Grant research," says ***Larry P. Koskan, President of the Donlar Corp.*** *"In collaboration with Professor A.P. Wheeler of Clemson University, supported by Sea Grant, Donlar has developed a new environmentally friendly chemical technology with applications in industrial water treatment and agriculture. The cooperation between Donlar and Professor Wheeler has spawned a profitable business that is beneficial to the environment."*



SHELL GAME. *Ed Palmer unloads oysters from Kings Flat Creek on James Island. Sea Grant researchers have learned how to synthesize the Eastern oyster's proteins so that companies can make new products such as biodegradable super-absorbers for diapers, anti-scalants for offshore drilling platforms, and fertilizer enhancers for crops.*

PHOTO/ WADE SPEES

Emerging Technologies Activities

- Identifying effective bioremediation methods to restore degraded coastal habitats.
- Supported development of biodegradable antifouling and superabsorbant chemicals.
- Developed bioassays that detect contaminants in marine ecosystems.
- Exploring the marine environment for new drugs.
- Examining the use of marsh mussels as bioindicators of the state of aquatic habitats.

AmiSorb, farmers can enhance their crop yield by $20, says Georgis.

More than two decades ago, Wheeler and Steve Sikes, University of South Alabama biologist, began examining the oyster to learn how it developed and shaped its shell. They found that an oyster protein regulated the growth of minerals in the oyster's shell, and that this protein could regulate the growth of other minerals too.

The buildup of mineral scales in pipes is a big problem for offshore drilling and mining operations, making their cooling mechanisms useless. Traditionally, the oil and mining industries have used nonbiodegradable compounds to control this mineralization. But "there's a great deal of sensitivity about dumping nonbiodegradable materials into the sea," says Wheeler. So now polyaspartic acid is increasingly used on offshore drilling platforms to reduce mineral growth. "Donlar's product works and it's biodegradable, which are strong motivators for the oil industry."

Continuing their investigation of the oyster protein, Wheeler and colleagues also produced a biodegradable super- absorber that can soak up 80 times its weight. Potential commercial uses include disposable diapers and personal sanitary products.

Detergent formulas are another commercial use for polyaspartic acid. Detergents include polymers with molecules that stick to dirt and mineral particles, suspending them in the water and preventing them from landing back on clothes or dishes. But these compounds are usually not biodegradable. Polyspartic acid molecules, however, also can stick to dirt and mineral particles while retaining biodegradability. Polyaspartic acid is already used in "green" detergents in Europe. And American companies, including Donlar, are exploring this polymer's use in detergents in the United States.

Scientists hope to harvest pollutants from wetlands

Many plants naturally absorb certain pollutants from soils and store or degrade these contaminants in their tissues. Sea Grant researcher Laszlo Marton, biologist at the University of South Carolina, is studying how one species of salt-marsh plant can be manipulated to absorb pollutants more efficiently.

Spartina alterniflora naturally accumulates heavy metals such as zinc, copper, tin, cadmium, and lead, but only in its root system. This plant stores heavy metals in an "internal dump site" within its root vacuoles, Marton says. But using *Spartina* in constructed wetlands to clean contaminated sites would require ripping out the plant's root system, an expensive, difficult, and environmentally unfriendly process.

So Marton and USC colleagues Yungpin Chen, James T. Morris, and Mihaly Czako are searching for a plant that could transfer the heavy metals into its leaves. Through genetic engineering, the researchers would exagger-

"Nature has a strong healing power and we're trying to enhance that natural ability," says ***Paul Calvo, President and CEO of Landtec, Inc.,*** *a bioremediation firm. Perhaps soon, with the aid of Sea Grant researcher Laszlo Marton's studies of genetic engineering of* Spartina alterniflora, *"we'll try to make wetlands more efficient in taking up pollutants."*

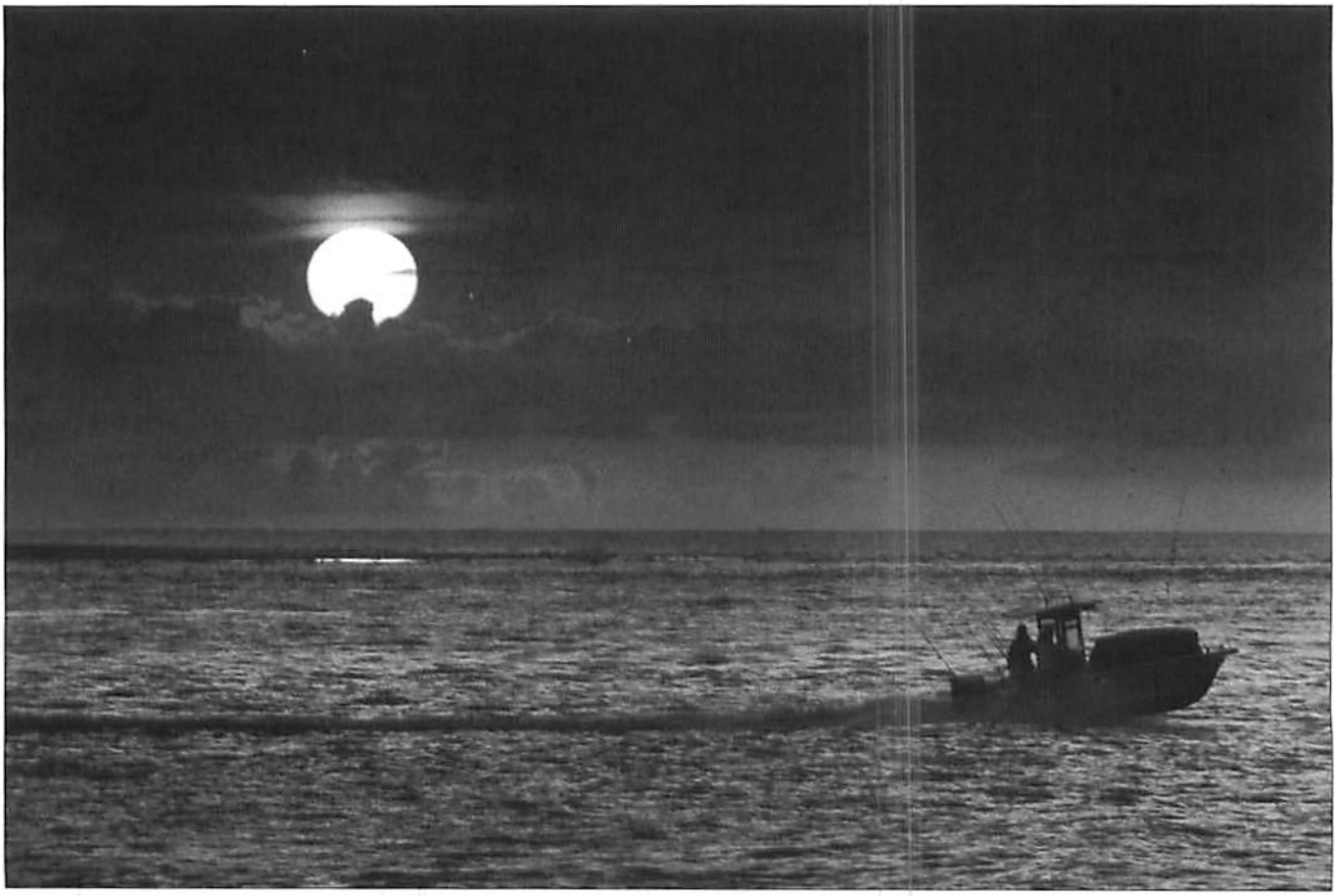
ate this capacity, which could be repeatedly harvested.

"We would introduce a gene into the plant that would induce high levels of heavy-metal accumulation in its leaves, which could be cut down, burned, and the heavy metals could be extracted and recycled."

Finally, the researchers are studying a genetic tool to improve *Spartina's* capacity to take up mercury from marsh sediments and reduce it to elementary mercury vapor, which is its least harmful form. Mercury is highly poisonous and bio-accumulates in the food chain, reaching humans through seafood consumption. Perhaps the best way to remove mercury pollution from sediments is to grow plants that take it up.

Marton and USC colleagues have identified a naturally occurring enzyme associated with the roots of the salt-marsh plant *Spartina alterniflora* that breaks down organic material in the marsh soils. The researchers are now attempting to locate and identify *Spartina* in degraded environments that appear to be the most efficient at organic matter decomposition. They hope to isolate and clone these plants to ultimately create a genetic line of *Spartina* that could be planted for use as organic pollutant absorbers.

A high-tech company can use the new cloning techniques to mop up polluted sites with super-cleaning *Spartina.* The Sea Grant researchers hold two patents on tools used to control expression of certain genes in *Spartina alterniflora.* "We're toolmakers," Marton says. "We're negotiating with a company that might want to convert the tools into effective technologies."



SCRATCHING THE SURFACE. *Scientists are just beginning to learn about the ocean's storehouse of molecular compounds, some of which can be mimicked in the laboratory to make new products.* PHOTO/WADE SPEES

Ahead of the Curve

OVER THE PAST 25 YEARS, SEAFOOD prices have shot up dramatically—faster than those of beef, chicken, or pork—yet consumers are demanding fish and shellfish more than ever. Wild catches, however, have leveled off. Nine of the world's 17 major fishery regions are in serious decline, and four others are classified as "commercially depleted" by the United Nations Food and Agriculture Organization. "Oceans and lakes just aren't going to provide enough seafood," says Rick Eager, owner of the 10-acre Swimming Rock Fish & Shrimp Farm, near Meggett, S.C. So consumers are increasingly buying farm-raised seafood. Today, aquaculture is by far the seafood market's fastest growing segment. In South Carolina, farmers grow tilapia, shrimp, catfish, crawfish, hard clams, hybrid striped bass, and rainbow trout.

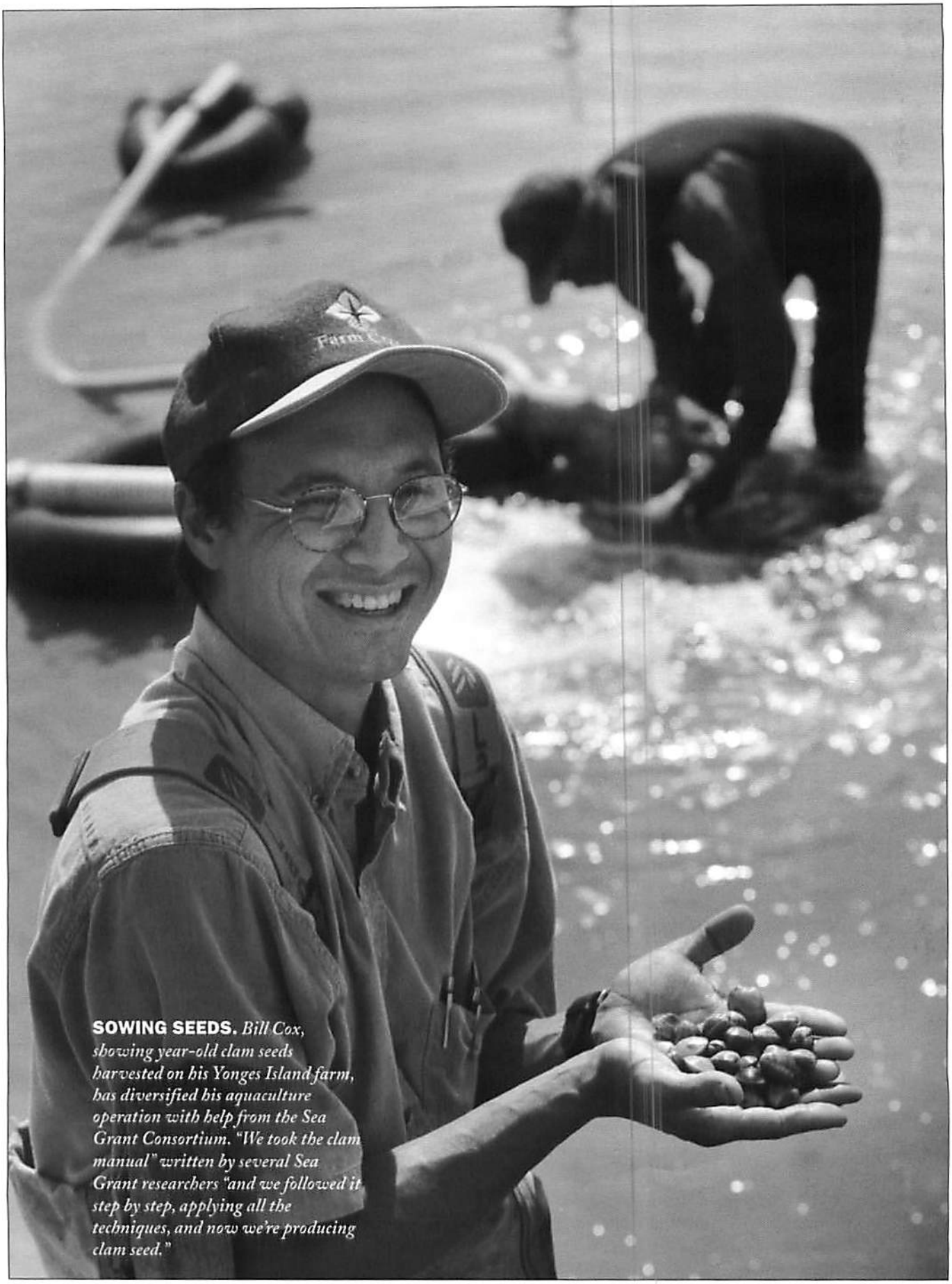
Despite growing demand for their products, the state's aquaculturists have faced numerous regulatory obstacles. In the mid-1990s, for example, strict laws and regulations on the commercial culture and in-state sale of hybrid striped bass inhibited cultivation and in-state sales of that fish.

"The problem was that restaurants and retail markets were required to get an annual, fee-based permit from the S.C. Department of Natural Resources to sell hybrid striped bass," says Jack Whetstone, aquaculture specialist with the S.C. Sea Grant Extension Program. "DNR worried that people would go out with gill nets and poach these valuable fish from local lakes and sell them to restaurants. But restaurant owners and retail markets didn't want the regulatory hassle with permits, so they refused to sell the fish. It became very difficult to sell hybrid striped bass in South Carolina."

So in 1997 Whetstone worked with DNR, the South Carolina Aquaculture Association, and the South Carolina Department of Agriculture to write state legislation establishing reasonable regulations on hybrid striped bass wholesaling and retailing. As a result, restaurants and retail markets today do not need annual, fee-based permits to sell hybrids. Instead, they can get permanent, no-cost certificates, a regulatory change that makes it easier for restaurants to sell hybrids and encourages further growth in this industry in South Carolina, says Whetstone.

Another problem was that state regulators had included aquaculture operations in the same category with large industrial operations in terms of wastewater discharges into waterways. Like major factories, aquaculture operations were required to have a permit based on their maximum daily waste discharges. State regula-

After the 1996 virus disaster South Carolina aquaculturists applied for the USDA crop insurance program for the first time. Eight shrimp farmers received a total of almost $200,000 for their losses. "Sea Grant Extension specialist Jack Whetstone was instrumental in getting shrimp farmers covered," says ***Bill Cox, owner of Island Fresh Seafood on Yonges Island.*** *"This change in insurance was a milestone for the industry."*



SOWING SEEDS. *Bill Cox, showing year-old clam seeds harvested on his Yonges Island farm, has diversified his aquaculture operation with help from the Sea Grant Consortium. "We took the clam manual" written by several Sea Grant researchers "and we followed it step by step, applying all the techniques, and now we're producing clam seed."*

PHOTO/WADE SPEES

Sustainable Economic Development Activities

- Helped develop state legislation to ease the regulatory process for establishing a hybrid bass aquaculture industry.
- Aided in establishment of a state regulation creating a regulatory waiver for small-scale aquaculture.
- Helped secure federal crop insurance for shrimp and clam farms in the state.
- Began a pilot program (NEMO) to educate local officials about non-point source runoff pollution.
- Produced and distributed map/guides, "Touring the S.C. African American Trail of Charleston, Colleton and Dorchester Counties."
- Supporting research to develop sustainable practices for the marine shrimp aquaculture industry.
- Supporting research on and developed a grower's manual for hybrid striped bass aquaculture.

FLYING FISH. *"I am in business because of the research on shrimp and hybrid striped bass funded by Sea Grant, and I might add, successfully so," says Rick Eager, owner of Swimming Rock Fish & Shrimp Farm, near Meggett, S.C.*
PHOTO/WADE SPEES–COURTESY OF THE POST & COURIER

tors assumed that fish and shellfish farmers would discharge wastewater virtually every day, but actually aquaculturists generally drain ponds just once a year. In any case, "aquaculture operations are relatively clean systems," says Whetstone. "These are places where fish are being grown, and they shouldn't be regulated the same as industrial facilities."

In 1997, the S.C. Sea Grant Extension Program cooperated with the S.C. Department of Health and Environmental Control to establish a regulatory waiver for small aquaculturists. Under the new rule, smaller growers—producing 100,000 pounds of seafood annually—do not have to apply for a permit to discharge wastewater, though they must apply specific Best Management Practices to control potential pollution. About 90 percent of the aquaculture operations in the state are smaller ones. "The new regulations have saved us a good bit of extra work," says Bill Cox, owner of Island Fresh Seafood on Yonges Island. "We don't have to get involved with water testing and sampling on a continuing basis," which is expensive and time-consuming.

After the state's shrimp growers enjoyed a dramatic, three-fold economic expansion during 1991–1995, a shrimp virus in 1996 reduced crop yields by more than 50 percent and threatened the industry with collapse. But S.C. Sea Grant Extension quickly began helping producers and regulators address this disaster by eradicating the disease from farms, encouraging farmers to diversify their crops, and pushing for establishment of crop insurance for aquaculturists. Whetstone submitted a proposal to the U.S. Department of Agriculture for aquaculture's addition to the eligible categories that could receive aid for uninsured crop losses.

After the 1996 virus disaster South Carolina aquaculturists applied for the USDA crop insurance program for the first time. Eight shrimp farmers received a total of almost $200,000 for their losses. "Sea Grant Extension specialist Jack

Whetstone was instrumental in getting shrimp farmers covered," says Cox. "This change in insurance was a milestone for the industry."

And, finally, with help from the S.C. Sea Grant Extension Program, Charleston County was recently accepted as one of the five counties nationwide in the first-ever pilot program for mainline crop insurance on hard-clam aquaculture. Banks see clam farms with this form of disaster insurance as much less risky investments. "This insurance should take an element of risk out of the business," says Knox Grant, general manager of Atlantic Farms, Inc., a clam aquaculture operation on James Island.

S.C. Sea Grant Highlights African-American Heritage

HERITAGE TRAIL. *National Park Service Ranger Mike Allen, shown here at the Charles Pinckney National Historic Site, has distributed 1,000 copies of the Spring 2000 issue of* Coastal Heritage *titled "Living Soul of Gullah" to public meetings along the coast of South Carolina, Georgia, and Florida. The Park Service is studying how to preserve and promote Gullah culture and heritage.* PHOTO/WADE SPEES

Guide helps visitors find history

The S. C. Sea Grant Extension Program collaborated with the S.C. Heritage Corridor and the S.C. African-American Heritage Council to produce a guide, "Touring the S.C. African American Trail of Charleston, Colleton and Dorchester Counties." This guide helps visitors explore a route of special and diverse places, highlighting points of interest in African-American heritage and black-owned businesses in Charleston, Dorchester, and Colleton counties. View a copy on the Web at <www.sc-heritagecorridor.org/html/african.html>

Sifting for Clues

FOR YEARS, WHEN OCEANFRONT homeowners have seen beach erosion threatening their property, they have often called Bill Eiser, oceanographer with S.C. Ocean and Coastal Resource Management (OCRM). But Eiser could provide only a rough guess about where sand would disappear near many beachfront properties.

That's changed since June 1994, when the S.C. Sea Grant Consortium initiated the S.C. Coastal Erosion Study, a research program funded by the U.S. Geological Survey, with the ultimate goal to establish the "sand budget" for the state's coastline.

"The biggest benefit of the Coastal Erosion Study is that now we can actually say how much a beach is eroding," says Eiser. "This study gives us real data, so we can quantify the erosion on particular beaches."

Seven researchers from four of the Consortium's member institutions, along with scientists from the U.S. Geological Survey's Marine and Coastal Geology Program, worked on the program's initial, five-year phase, measuring where sand is located and the degree to which beaches are growing or eroding in the region from Bulls Bay to the Edisto River. Researchers surveyed the beach from the dune out onto the continental shelf. In 2000, the study's second phase begins to address the remaining portions of the South Carolina coast and portions of the Georgia coast.

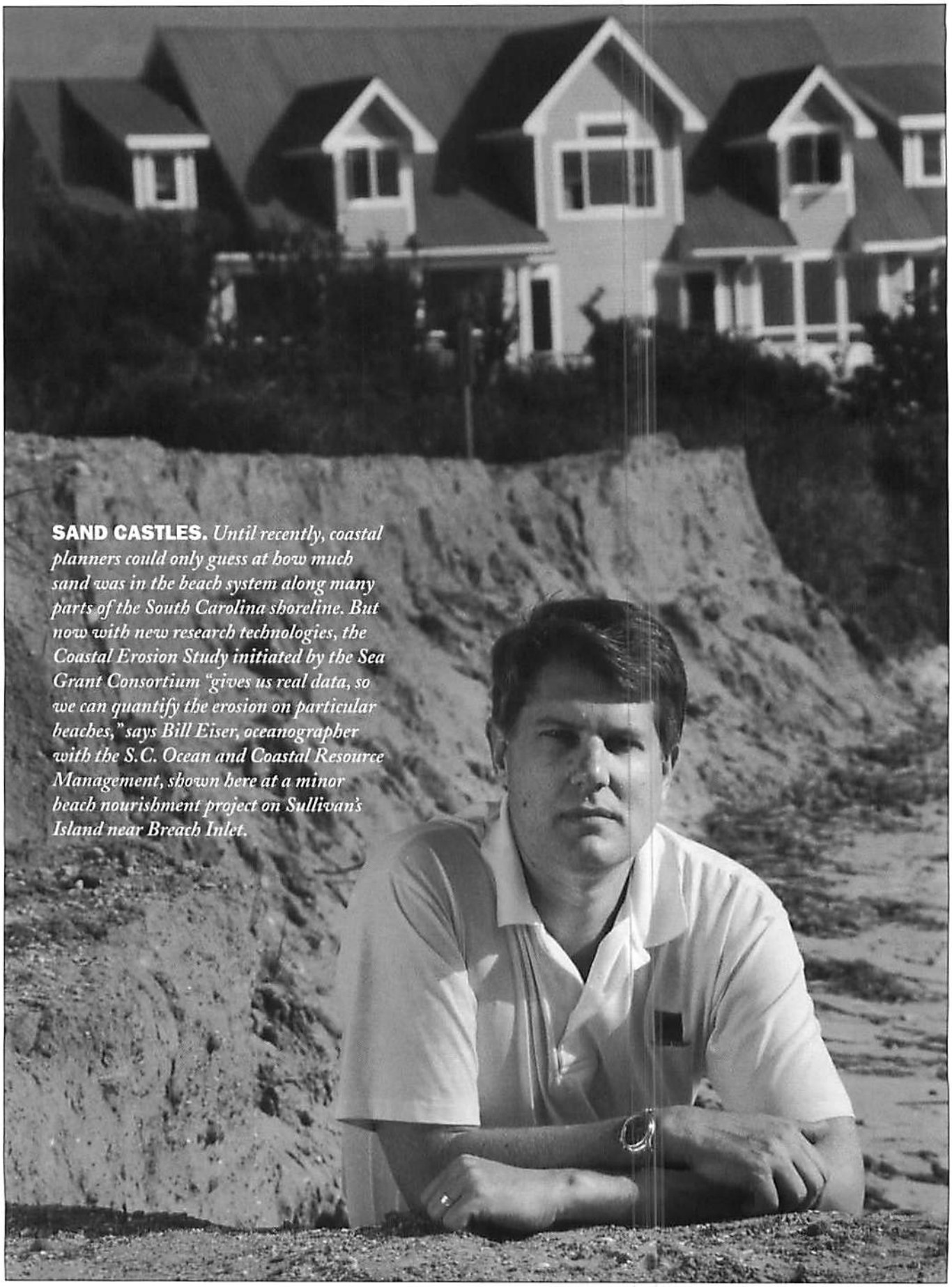
Scientists have established a system to collect beach profiles statewide across the entire beach system, tracing sand movements within and beyond the surf zone, says Sea Grant researcher Paul Gayes, Coastal Carolina University marine scientist. These areas have not been accessible from traditional wading depth studies (too deep) nor from shipboard surveying (too shallow).

The study provides important geological data about the coast's history. "We're trying to understand how the coastline works and how it has evolved over time," says Sea Grant researcher Mike Katuna, University of Charleston geologist.

Over the past century, sea level has risen an average of one foot on Gulf and Atlantic beaches. Shorelines have migrated landward at an average rate of one or two feet per year, but local conditions vary dramatically. The annual erosion rate can be more than 20 feet annually in certain "hot spots," though many other areas are stable or growing. Because many beach dwellers still want to be as close to the ocean as possible, they need better information about the erosion threat.

One option for communities is to nourish beaches when it's economically feasible. With

"The biggest benefit of the Coastal Erosion Study is that now we can actually say how much a beach is eroding," says ***Bill Eiser, oceanographer with S.C. Ocean and Coastal Resource Management.***



SAND CASTLES. *Until recently, coastal planners could only guess at how much sand was in the beach system along many parts of the South Carolina shoreline. But now with new research technologies, the Coastal Erosion Study initiated by the Sea Grant Consortium "gives us real data, so we can quantify the erosion on particular beaches," says Bill Eiser, oceanographer with the S.C. Ocean and Coastal Resource Management, shown here at a minor beach nourishment project on Sullivan's Island near Breach Inlet.*

PHOTO/ WADE SPEES

Coastal Ocean Studies Activities

- Initiated research and outreach to examine the effects of land use on marine resources.
- Continued research to develop a "sand budget" for South Carolina's beaches.
- Explored the processes that influence how juvenile white shrimp are recruited to southeastern estuaries.
- Organized and convened a biennial southeastern coastal ocean research conference.

these new data on beach systems, Eiser sees a potential for improved nourishment projects. The Coastal Erosion Study's beach profiles offer more accurate information about how much sand is being lost on sections of shoreline and where the sand is moving, says Eiser.

Scientists locate disappearing sand

Sea Grant researchers might have figured out why nourishment sand erodes so quickly from some beaches. Using geophysical surveys, repeated beach profiles, and sonar imagery, scientists have found that significant quantities of nourishment sand are transported directly offshore from shorelines at localized sites along the coast.

One such site near an area of chronic erosion is locally known as "The Washout" on Folly Beach near Charleston, where beach sand has moved to the inner continental shelf.

"There is a field of mobile sand that extends from surf zone directly offshore for several kilometers from the beach," says Gayes, who is working with U.S. Geological Survey and Coastal Carolina colleagues.

"We're still trying to work through the physical processes that push the sand offshore and connect the beach to the inner shelf on such a large scale," he said. "It's likely that waves, tides, and storm-generated currents interact at these sites and produce the large-scale deposits."

When sand is transported offshore, it does not naturally recirculate onto the beach again. As a result, the sand is permanently lost to the beach system, contributing to local erosion. Researchers have traditionally thought that small-scale processes within the surf zone, such as rip currents, caused such sand losses. But the new findings show that permanent loss from the beach can happen locally on a

WHERE'S THE BEACH? *The beach at the northeastern tip of the Isle of Palms was eroding rapidly in 1997. Some portions of the island will continue to have periodic, dramatic losses of sand caused by migrating shoals every five to 10 years. Numerous South Carolina beaches have similar "hotspots" of erosion.* PHOTO/WADE SPEES

larger scale, and influence the stability of a wider stretch of the adjacent coast.

Each year over the past decade, nourishment projects have cost $100 million nationally from all government and private sources. Today, borrowing sand for nourishment projects from nearshore areas, such as tidal inlets, is becoming more difficult due to navigational conflicts and environment concerns. So engineers are increasingly turning to offshore sources of sand.

The large localized deposit of sand on the inner continental shelf near Folly Beach could be a potentially useful source of nourishment material, says Gayes.

"This deposit contains less than half of the volume needed to repeat Folly's nourishment completed in 1993," he says, but the alternative is usually to look even farther offshore where it becomes progressively more expensive to mine the sand for nourishment projects. Locating some inshore deposits of sand could help coastal communities save money as they fight erosion through beach nourishment, says Gayes

Effects of land-use on ecosystems

For nearly 30 years, Woody Collins harvested oysters and clams from Hilton Head Island's creeks and rivers. But today hundreds of acres of oyster and clam beds in Hilton Head's Broad Creek are closed because of bacterial pollution and declining water quality.

A member of the Clean Water Task Force, a citizen group in Beaufort County, Collins says that rapid development in and around the island has increased runoff pollution into waterways. "Drainage from residential areas, roadways, parking lots, rooftops—this runoff pollution all winds up in the creeks." To protect human health from bacterial pollution, the state closed off shellfish harvesting in certain areas. Commercial watermen like Collins worry that closed beds are a sign that the regional environment is being degraded. "Oysters are the canaries in the cage. They're pretty important."

The South Atlantic Bight—from Cape Hatteras in North Carolina to Cape Canaveral in Florida—has suffered less pollution and urban development than many other coastal regions. But over the past few decades, an enormous influx of tourists, retirees, and new residents has transformed this coastline. Communities have built growing numbers of condominiums, motels, shopping centers, golf courses, plus new bridges and roads—each adding pressure to coastal waters. Fertilizers, pesticides, and other pollutants are washed off the landscape into the coastal ocean, potentially damaging fisheries and other marine life.

A serious problem is that "community leaders and resource managers often lack scientific information about the effects of various types and intensities of development on coastal ecosystems," says Rick DeVoe, executive director of the S.C. Sea Grant Consortium. "People need better information to make decisions, but it's often unavailable or it's in a form that local leaders can't use."

Scientists have established detailed studies of contaminants in coastal waters. But frequently these studies do not directly show how these contaminants enter the marine environment and affect biological resources. Even more important, study results are often not linked to a geographic information system (GIS), a sophisticated computer mapping tool.

Many community planners are already using GIS maps to manage development and its impact on natural resources. Planners are creating GIS maps that identify undeveloped land, properties under conservation easements, public utilities in the areas, topography, and recent population growth, and other demographic patterns. With GIS, communities have a powerful tool to understand how various development patterns could affect their future. But in many cases, planners still do not have access to GIS information on local environmental resources.

That's why the S.C. Sea Grant Consortium, with support from the NOAA Coastal Ocean Program, initiated the South Atlantic Bight Land Use-Coastal Ecosystem Study (LU-CES). This research program is examining how various land uses affect marine resources, and will develop GIS tools and information that communities can use as they establish and update land-use plans. "The intent of LU-CES is to first understand the cause-and-effect relationship between land use activities and ecosystem condition" says DeVoe. "Next, based on research results, LU-CES will develop models and tools that could help communities make decisions about how they could minimize the impacts of land use change on their environment."

Think Science!

THE AUTHOR E.B. WHITE SAID: "I arise in the morning torn between a desire to improve the world and a desire to enjoy the world. This makes it hard to plan the day." What if you didn't have to choose between the two? Some teachers who have participated in the COASTeam program believe that they and their students improve and enjoy the world simultaneously.

The S.C. Sea Grant-funded COASTeam Program is a series of year-long, graduate-level courses in which teams of teachers are trained in marine science education. Each team represents a single school committed to improving marine science instruction.

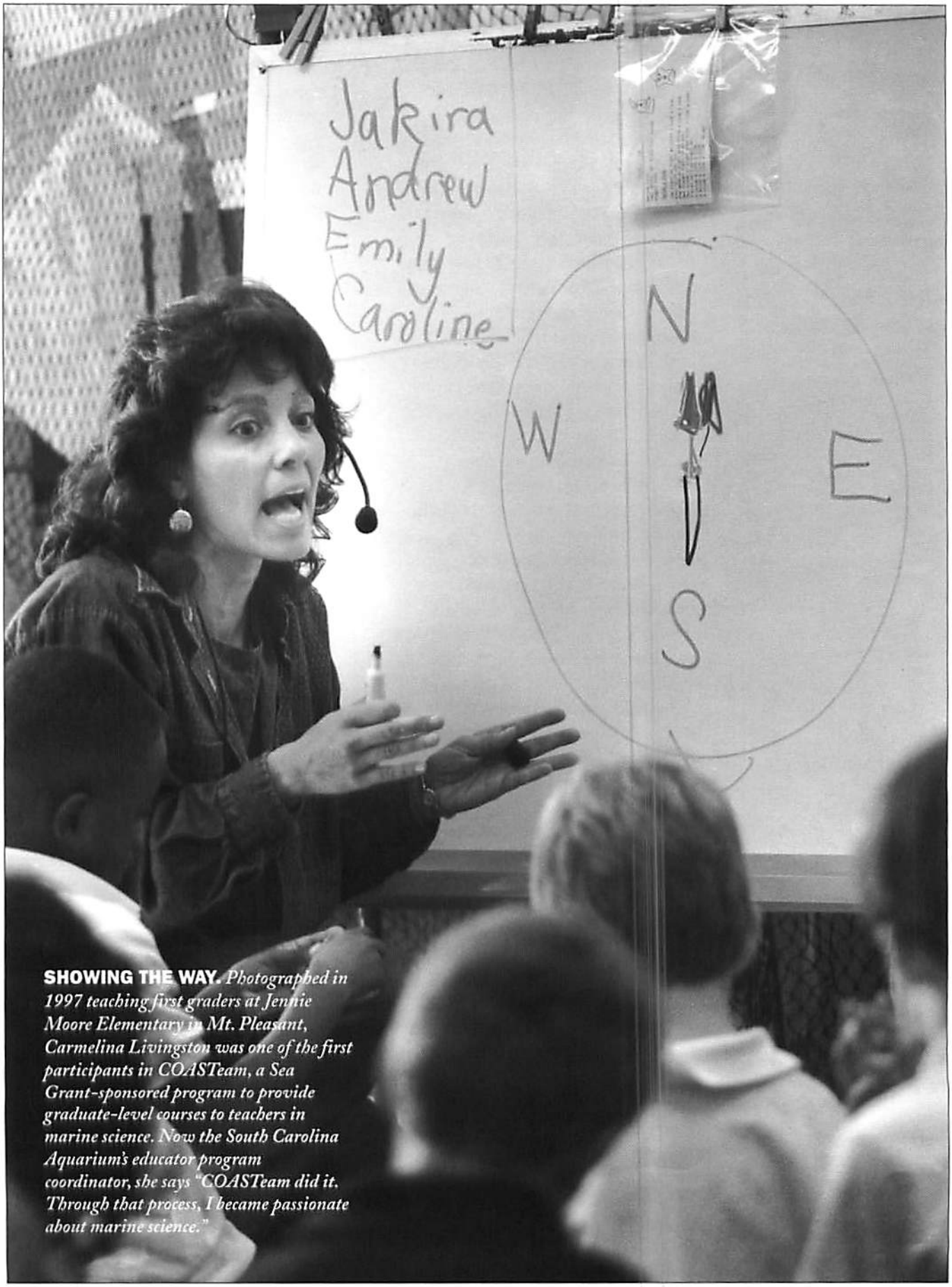
Angela King, a Dorchester County kindergarten teacher at Beech Hill Elementary in Summerville, says, "I have always felt that starting students at a young age with environmental ecology is important." King and her teammate Carole Spiller teach a four-week unit on the ocean each year. They also present a COASTeam lesson each Friday afternoon.

"The lesson my children enjoy most is the Bird Beak Buffet," King says. It focuses on various waterfowl's adaptions to living in the salt marsh. Students use objects such as tweezers, spoons and chopsticks to represent different beak types. With their new "beaks," students are transformed into "birds" that munch "clams" (pennies), "worms" (rubber bands), or "shrimp" (toothpicks). Graphing results, the students learn quickly which foods different birds are best adapted to eat with their bills.

The COASTeam program, which Leslie Sautter, marine geologist at the College of Charleston, developed in 1994, has evolved since its inception. It now trains middle and high school teachers as well as the elementary teachers that it initially served exclusively. Sautter and S.C. Sea Grant marine educator Elizabeth King developed and implemented the Sea Grant-funded course for the new wave of teachers. Elizabeth King was pleased with the first 1999 summer session that included midlands and upstate educators in addition to coastal teachers.

South Carolina has just adopted new science standards that require teachers to address all science disciplines. Elizabeth King says, "Marine science provides an excellent theme through which all sciences may be explored, whether the subject is biology, earth science, physical science, or chemistry. By approaching science through ocean topics—the ocean seems to fascinate all of us—then teachers are likely to capture students' interest."

"I have always taught marine science with the emphasis on ecosystems and organisms and left out the geology," says ***Fanya Paouris, who teaches at Greenville High School.*** *"But now after taking the COASTeam course, I know more—and I am eager to learn even more...."*



SHOWING THE WAY. *Photographed in 1997 teaching first graders at Jennie Moore Elementary in Mt. Pleasant, Carmelina Livingston was one of the first participants in COASTeam, a Sea Grant-sponsored program to provide graduate-level courses to teachers in marine science. Now the South Carolina Aquarium's educator program coordinator, she says "COASTeam did it. Through that process, I became passionate about marine science."*

PHOTO/ WADE SPEES

Marine Education Activities

- Designed, implemented and evaluated a marine science teaching model (COASTeam) for training the state's K-9 school teachers.
- Provided support and leadership in founding the South Carolina Marine Educators Association.
- Produced *Of Sand and Sea: Teachings from the Southeastern Shoreline*, a marine science text for teachers, as a product of the COASTeam Program.
- Employed a Marine Science Educator to enhance the Consortium's marine education efforts.
- Co-sponsors the National Ocean Science Bowl regional marine science competition for high school students.

A new compilation of nationally tested hands-on exercises *Explore the Ocean* in marine science has been compiled with Sea Grant funding. The COASTeam Middle School Development Team, which Sautter spearheaded, compiled activities based on South Carolina science curriculum standards for grades 6–8. This sourcebook serves as the COASTeam course outline.

Fanya Paouris, who teaches at Greenville High School, says, "I have always taught marine science with the emphasis on ecosystems and organisms and left out the geology. But now after taking the COASTeam course, I know more—and I am eager to learn even more. My students love the unit on plate tectonics, and they understand the mechanism involved with the theory."

Besides increasing educators' confidence in teaching marine science concepts, the COASTeam course is popular for its multitude of resource materials. *Sea Things ... Objectively*, 2nd edition, edited by Paula Keener-Chavis, Cammie Camp, and Sautter, contains more than 45 hands-on activities. Sea Grant supported this curriculum resource and the Consortium staff helped publish it.

Another important goal of the COASTeam program is to increase teachers' professional development. After completing the course, educators become Teacher Leaders within their own schools, presenting a six-hour, in-service marine-science course. Carmelina Livingston, the South Carolina Aquarium's educator program coordinator says of the textbook *Of Sand and Sea: Teachings from the Southeastern Shoreline*, "It's my bible!"

Livingston was one of the first COASTeam program participants. Then an early childhood educator at Jennie Moore Elementary in Mt. Pleasant, Livingston says she knew nothing about her local coastal environment. "COASTeam did it. Through that program, I became passionate about marine science." Livingston is excited about her new position with the Aquarium, for "now I can reflect my passion back to others when I'm teaching them or serving as a resource."

Fellowships

To further the education of tomorrow's leaders, the National Office of Sea Grant sponsors the John Knauss Marine Policy Fellowship Program, bringing a select group of graduate students to Washington, D.C., 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 individual scientific expertise to federal agencies and congressional staff offices. S.C. Sea Grant sent five fellows to Washington during 1994–1999.

Knauss Fellow Barbara Bach, a University of South Carolina graduate student, is working in the Marine Mammal Conservation division of the National Marine Fisheries Service, Office of Protected Species.

"The first thing I thought of when I learned of the fellowship and the opportunities it would give was, 'You're kidding! I get to do all that and they pay me!'. I haven't changed my opinion one iota since then. It's amazing and I'll reap the benefits for the rest of my life."

Last year's Knauss fellow, Elizabeth Day, was placed at the National Science Foundation (NSF) during her fellowship and says that she was pleased with how her "opinion was valued and sought for marine education related activities."

"I fit a niche that wasn't filled there," Day says. Now a marine educator with the National Sea Grant Program, she was the NSF contact for a workshop that brought together ocean science educators and research scientists to discuss how to improve marine science education at all levels.

Day worked hard to see worthy projects get funded in which researchers collaborate with young students, especially minority students. Only a small percentage of minority students in the United States enter the science "pipeline," preparing for careers as science professionals.

PUBLIC/PRIVATE ORGANIZATIONS

Selected Examples of Public/Private Organizations with whom S.C. Sea Grant has Cooperated

Following is a partial listing of the agencies and organizations (local, state, federal, public, and private), with which the S.C. Sea Grant Consortium has interacted in the past five years:

Federal Government

Federal Emergency Management Agency
NOAA/Coastal Ocean Program
NOAA/Coastal Services Center
NOAA/National Coastal Resources Research and Development Institute
NOAA/National Marine Fisheries Service
NOAA/National Sea Grant College Program
NOAA/Office of Oceanic and Atmospheric Research
U.S. Agricultural Stabilization and Conservation Service
U.S. Coast Guard
U.S. Department of Agriculture
U.S. Fish and Wildlife Service
U.S. Geological Survey
- Marine and Coastal Geology Program
- Water Resources Division

State Government

Clemson University
- PSA/Cooperative Extension Service
- Recreation, Travel and Tourism Institute
- Strom Thurmond Institute

Coastal Carolina University
- Center for Economic Development

Office of the Governor
Office of the Lt. Governor
Patriot's Point Development Authority
Santee Cooper
S.C. Department of Agriculture
S.C. Department of Health and Environmental Control
- SCDHEC/Bureau of Water Pollution Control
- SCDHEC/Office of Coastal Resource Management

S.C. Department of Natural Resources
- SCDNR/Division of Marine Resources
  - SCDNR/ACE Basin
  - SCDNR/Marine Resources Research Institute
  - SCDNR/Office of Fisheries Management
  - SCDNR/Waddell Mariculture Center

S.C. Department of Parks, Recreation and Tourism
- SCPRT/Heritage Program

S.C. Educational Television
S.C. Electric and Gas Co.
S.C. Emergency Preparedness Division
S.C. Forestry Commission
S.C. Ports Authority
S.C. Rural Economic Development Council
S.C. Small Business Development Center
The South Carolina Aquarium
University of Charleston, S.C.
- Hall of Science and Math Education
- Lowcountry Science Fair
- S.C. Space Grant Consortium

University of South Carolina
- Institute for Tourism Research
- Institute for Public Policy

Local/Regional Governments

Beaufort County
Berkeley-Charleston-Dorchester Council of Governments
Charleston County
- Department of Education
- Parks and Recreation Commission

Charleston County Math and Science HUB
City of Charleston
City of Conway
Dorchester County
Georgetown County
Horry County
- Economic Development Commission

Lowcountry Council of Governments
Town of Hilton Head
Town of Myrtle Beach
Waccamaw Regional Planning and Development Council
Winyah Bay Focus Committee

Non-governmental Organizations

Beaufort Water Quality Task Force
Center for Marine Conservation
Estuarine Research Federation
National Fisheries Institute
National Shellfisheries Association
Public Relations Society of America
S.C. Aquaculture Association
S.C. Association for Hazard Mitigation
S.C. Coastal Conservation League
S.C. Crab Industry Association
S.C. Crawfish Growers Association
S.C. Downtown Development Association
S.C. Marina Association
S.C. Marine Educators Association
S.C. Nature-Based Tourism Association
S.C. Seafood Alliance
S.C. Shrimp Growers Association
S.C. Shrimpers Association
S.C. Sweetgrass Basketmakers Association
S.C. Wildlife Federation
Sea Grant Association
Small Business Assistance Network
The Coastal Society
Trident Community Foundation
U.S. Aquatic Plant Management Society
U.S. Chapter/World Aquaculture Society
Waccamaw Audubon Society
World Aquaculture Society
113 Calhoun St. Foundation

Private Business and Industry:

Alcoa, S.C./Dataw Island
Amoco Chemical
Ashley Marina and Yacht Sales
BMW Manufacturing Corp.
BOC Group
C.J. Cantwell Architect
Conway Chamber of Commerce
Conway Tourism Committee
Crowne Plaza, Hilton Head
Del Webb Corp.
Duke Power Company Foundation
Dunes West Golf Club
Georgetown County Chamber of Commerce
Georgetown Steel Corp.
Greater Beaufort Chamber of Commerce
Harbour Town Properties
Hard Rock Cafe, Myrtle Beach
Hyatt Regency, Hilton Head
Ilderton Contractors, Inc.
Institute for Building and Home Safety
Insurance Institute for Property Loss Reduction
Kiawah Resort Associates
Lockheed Aeronautical Corp.
Lowcountry Tourism Commission
Low Country Seafood, Inc.
Myrtle Beach Area Chamber of Commerce
Myrtle Beach Sun News
Oneita Industries
Post and Courier
Ripley's Aquarium
R.L. Bryan Printing
Roper Care Alliance
Royal Insurance
SCANA Corporation
S.C. Chamber of Commerce
S.C. Electric & Gas
S.C. Farm Bureau Insurance
Shoolbred Engineering, Inc.
Sonoco Products, Inc.
South Atlantic Region Aquaculture Conf.
Springs Industries
State Farm Insurance Company
Trident Chamber of Commerce
Trident Community Foundation
Unisun Insurance
Wachovia Bank
Walterboro/Colleton Chamber of Commerce
WAVE 104 (Radio)
WCSC-TV 5
Wentworth Printing
Westvaco - Timberlands Division
Wild Dunes Yacht Harbor, Inc.
WPDE-TV 15
WJWJ-TV
WXTC radio

5-YEAR REPORT PUBLICATIONS LIST

Climate and Hazards

"Choosing a Roofing Contractor," *Coastal Hazards Bulletin*, 1999.

"Consumer Tips: Selecting Storm Shutters," *Coastal Hazards Bulletin*, 1998.

"Disasters and Property Insurance: Coping with the Aftershocks," *Coastal Heritage,* Winter 1994-95.

"Early Europeans in America: Hurricanes Steer the Course of History," *Coastal Heritage,* Summer 1998.

"El Niño Forecasts: Looking Into the Crystal Ball," *Coastal Heritage*, Summer 1996.

"Exotic Species: The Aliens Have Landed," *Coastal Heritage,* Spring 1997.

"Guidelines for New Home Construction in Hurricane-prone Areas," *Coastal Hazards Bulletin*, 1999.

"Hurricanes 101: Lessons on Saving Lives & Property," *Coastal Heritage,* Summer 1997.

"Hurricane Preparation Checklists." Flyer. 1998.

"Improving the Wind Resistance of Roof Shingles: Asphalt Shingle Roof," *Coastal Hazards Bulletin*, 1998.

"Preparing Your Business for a Hurricane," *Coastal Hazards Bulletin*, 1998 .

"Racing to Catch Up: Florida's Battle Over Building Codes," *America's Hurricane Threat,* Fall 1998.

"Raising Up and Moving Out, Elevation and Buyout of Floodprone Buildings: Do they Work?," *America's Hurricane Threat,* Summer 1999.

"Storm Front," *Coastal Heritage,* Summer 1999.

Emerging Technologies

Construction and Operations Manual for a Tidal-Powered Upwelling Nursery System. 1995. Booklet.

"You Are Here: New Horizons for Geography," *Coastal Heritage,* Winter 1998-99.

Sustainable Economic Development

A Guide to Pond Culture of Hybrid Striped Bass. 1996. Booklet.

A Manual for the Culture of the Hard Clam Mercenaria *spp. in South Carolina.* 1997. Book.

Coastal South Carolina Small Business Assistance Directory. 1996. Booklet.

Community Resource Directory. 1995. Booklet.

Economic Development Resource Guide. 1995. Booklet.

"Environmental Regulatory Reform: Progress of Retreat?," *Coastal Heritage,* Spring 1996.

Guidelines and Recommendations for Nature-Based Tourism Planning and Practice in South Carolina. 1996. Book.

Handbook of Relative Acute Toxicity Values for Crayfish. 1996. Booklet.

"Life after the Cold War: Revitalizing Coastal Economics in a New Era." *Coastal Heritage*, Fall 1994.

"Nature-Based Tourism: A Walk on the Wild Side," *Coastal Heritage,* Winter 1995-96.

"New Visions for Growth: Investing in Open Spaces," *Coastal Heritage,* Spring 1998.

The South Carolina Nature-Based Tourism Directory and Listing of the South Carolina Nature Based Tourism Association Members, 1997-98. 1998. Booklet.

"South Carolina's Wild Places: Who Gets Custody?," *Coastal Heritage,* Winter 1996-97.

Survey & Census of Colonial Nesting Seabirds in South Carolina, 1988-89 and 1993-96, Vol. 1. Booklet. 1996.

Survey & Census of Colonial Nesting Seabirds in South Carolina, 1988-89 and 1993-96, Vol. 2. Booklet. 1996.

"Sustainable Design: Blending Practicality and Stewardship," *Coastal Heritage,* Fall 1995.

"Sustainable Use: Balancing Biodiversity and Property Rights," *Coastal Heritage*, Spring 1995.

"Sweetgrass Baskets of Mount Pleasant, South Carolina." 1995. Brochure.

"Touring the SC African American Trail of Charleston, Colleton and Dorchester Counties," 1999. Map.

"United States (U.S.) Chapter of the World Aquaculture Society: Membership Application Form," 1998. Flyer.

"What's the Catch? Seafood's New Frontier," *Coastal Heritage,* Fall 1996.

Coastal Ocean Studies

A Guide to Pond Culture of Hybrid Striped Bass. 1996. Booklet.

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"What's the Catch? Seafood's New Frontier," *Coastal Heritage,* Fall 1996.

Ecosystem Dynamics

"*Pfiesteria* Hysteria: Just When You Thought It Was Safe," *Coastal Heritage,* Fall 1998.

"South Carolina Task Group on Toxic Algae Newsletter," Spring 1998.

"South Carolina Task Group on Toxic Algae Newsletter," Winter 1998-99.

"South Carolina Task Group on Toxic Algae Newsletter," Summer 1999.

"South Carolina Task Group on Toxic Algae Newsletter," Winter 2000.

Marine Education

"The ABC's of Science Education," *Coastal Heritage,* Winter 1997-98.

"Do the Sweep!" 1999. Newspaper insert.

How We Can Keep Our Waters Clean: With Petey Pelican and Otto Otter. 1998. Booklet.

"Nature's Lessons: A Closer Look," *Coastal Heritage,* Spring 1999.
"Sea Things Objectively." 1995. Notebook.

FINANCIAL REPORTS 1994–1997

Sept. 1, 1994 – Aug. 31, 1995

PROGRAM AREA	STATE & OTHER MATCHING FUNDS	FEDERAL FUNDS
Program Management & Development	$46,714	$ 218,301
Marine Outreach	33,450	105,642
Marine Extension	228,909	293,271
Coastal Ocean Studies	80,911	156,958
Watershed Dynamics	29,948	59,892
Climate & Hazards	19,484	42,356
Emerging Technologies	158,988	149,277
Sustainable Economic Development	47,295	90,000
Coastal Heritage	19,737	9,200
United States Geological Survey (USGS)	88,139	249,005
Sea Grant Knauss Fellows		30,000
Commercial Net Collection & Recycling Study		3,000
Commercialization and Cstl. & Env. Technology		106,835
Fishtec	24,433	566,001
TOTAL	**$ 778,008**	**$ 2,079,738**

Sept. 1, 1995 – Aug. 31, 1996

PROGRAM AREA	STATE & OTHER MATCHING FUNDS	FEDERAL FUNDS
Program Management & Development	$ 46,714	$ 211,888
Marine Outreach	33,450	95,108
Marine Extension	170,543	240,275
Coastal Ocean Studies	67,297	113,542
Watershed Dynamics	89,622	95,729
Climate & Hazards	22,371	52,633
Emerging Technologies	36,869	80,150
Sustainable Economic Development	115,691	201,175
Coastal Heritage	19,852	9,400
United States Geological Survey (USGS)	99,659	249,000
Sea Grant Knauss Fellows		36,000
Fishtec	29,452	432,891
Land Use Coastal Ecosystems Study (LUCES)	7,730	100,000
Urbanization & Southeastern Estuarine Systems	161,889	600,000
Public Bldg. Retrofit Research & Demo Project		26,800
Training & Education Program/Cstl. Research Mgrs.	3,247	225,000
Nature Based Tourism	770	17,605
Upweller		15,000
TOTAL	**$ 905,156**	**$ 2,802,196**

Sept. 1, 1996 – Aug. 31, 1997

PROGRAM AREA	STATE & OTHER MATCHING FUNDS	FEDERAL FUNDS
Program Management & Development	$ 30,407	$ 188,405
Marine Outreach	16,726	47,539
Marine Extension	130,480	143,052
Coastal Ocean Studies	51,312	124,806
Ecosystem Dynamics	60,691	138,812
Climate & Hazards	20,901	45,436
Emerging Technologies	18,746	35,200
Sustainable Economic Development	125,129	173,204
Fishtec	29,173	586,097
Public Bldg. Retrofit Research & Demo Project		100,404
Enhancements	229,230	325,322
TOTAL	**$ 712,795**	**$ 1,908,277**

S.C. Sea Grant Consortium Staff

M. Richard DeVoe, Executive Director
Elaine L. Knight, Assistant Director
Linda J. Blackwell, Director of Communications
John J. Dwyer, Assistant to the Director for Program Management

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Miles Phillips, Coastal Recreation and Tourism Specialist
Cal Sawyer, Coastal Environmental Quality Specialist
April Turner, Coastal Communities Specialist
Jack Whetstone, Marine Aquaculture Specialist

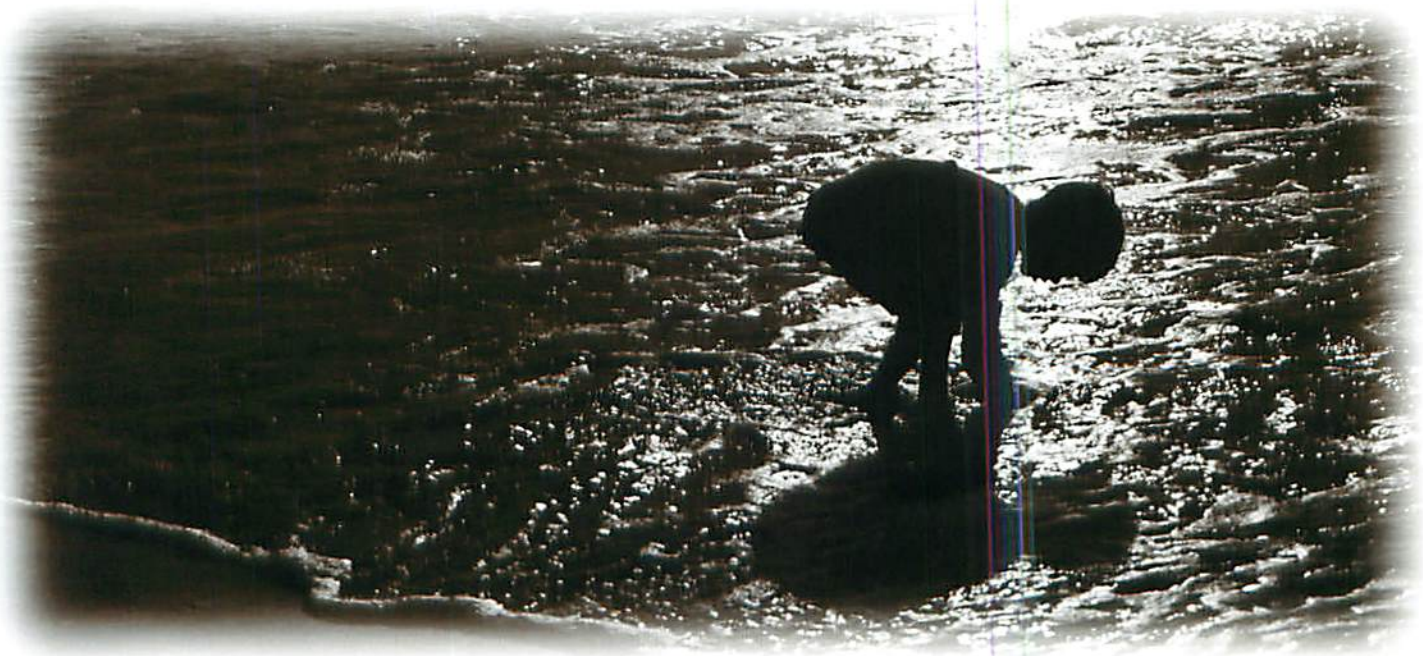
FINANCIAL REPORTS 1997–1999

Sept. 1, 1997 – Aug. 31, 1998

PROGRAM AREA	STATE & OTHER MATCHING FUNDS	FEDERAL FUNDS
Program Management & Development	$ 47,354	$ 240,726
Marine Outreach	33,450	95,108
Marine Extension	201,761	264,816
Coastal Ocean Studies	18,786	49,137
Ecosystem Dynamics	117,895	184,316
Emerging Technologies	47,854	85,005
Sustainable Economic Development	105,934	185,792
United States Geological Survey (USGS)	108,272	254,100
Sea Grant Knauss Fellows		36,000
Fishtec	38,314	388,500
Land Use Coastal Ecosystems Study (LUCES)	9,187	85,000
Urbanization & S.E. Estuarine Systems (USES)	105,252	665,000
Public Bldg. Retrofit Research & Demo Project		64,067
Training & Education Program/Cstl. Research Mgrs.		287,000
Coastal Services Center Fellows Program		152,000
Overview Public Accountability/Ten Year Report		36,000
Trophic Pathways in Pelagic Env./Florida Bay		27,000
The Communicator		25,000
Oyster Disease Research	133,120	177,628
Industrial Fellows	50,066	27,383
Commercialization and Cstl. & Env. Technology		154,466
TOTAL	**$ 1,017,245**	**$ 3,484,044**

Sept. 1, 1998 – Aug. 31, 1999

PROGRAM AREA	STATE & OTHER MATCHING FUNDS	FEDERAL FUNDS
Program Management & Development	$ 52,611	$ 251,879
Marine Outreach	41,526	95,108
Marine Extension	228,973	261,464
Coastal Ocean Studies	32,400	76,000
Ecosystem Dynamics	204,121	283,585
Climate & Hazards	24,505	48,924
Emerging Technologies	60,275	117,990
Sustainable Economic Development	40,820	80,000
Sea Grant National Media Relations		174,000
Sea Grant Haznet	2,648	7,000
NOAA Sea Grant Partnership (NSI)	137,582	55,614
United States Geological Survey (USGS)	100,750	224,500
Sea Grant Knauss Fellows		72,000
Fishtec	37,883	388,500
Land Use Coastal Ecosystems Study (LUCES)	6,260	185,000
Urbanization & S.E. Estuarine Systems (USES)	138,589	700,000
Training & Education Program/Cstl. Research Mgrs.		300,000
The Communicator		33,750
Oyster Disease Research	78,072	154,507
Industrial Fellows	37,552	27,286
NPS Education for Municipal Officials (NEMO)		43,020
113 Calhoun St. Mitigation Grant		157,785
Public Accting./Sea Grant Accomplishments & Themes for the New Millennium	9,916	92,412
TOTAL	**$ 1,234,483**	**$ 3,830,324**



FUNDED PROJECTS

PROGRAM MANAGEMENT AND OUTREACH

P/M-1 Program Management—DeVoe (SCSGC)

P/M-2 Program Development—DeVoe (SCSGC)

P/M-3 Communication and Information Services—Blackwell (SCSGC)

P/M-4 Sea Grant National Media Relations Project—Blackwell (SCSGC)

A/E-1 S.C. Sea Grant Extension Program—Bacon (SCSGEP)

NA86RG0103, NA86RG0052, NA46RG0484 National Sea Grant Knauss Marine Policy Fellowship Program—NOAA National Sea Grant College Program—DeVoe (SCSGC)

NA56RG0521 Sea Grant Industrial Fellowship Program (1997-99)—DeVoe (SCSGC) and Reinhold (Clemson)

P/M-5 An Overview and Public Accounting of the National Sea Grant College Program's Research, Educational and Outreach Accomplishments—Blackwell (SCSGC)

P/M-6 An Overview and Public Accounting of Sea Grant Accomplishments 1966-1999, and a Network Approach to Documenting Programmatic Themes for the New Millennium—Blackwell (SCSGC)

NA66RG0351 Coastal Management Fellows Program—NOAA Coastal Services Center (1996-98)—DeVoe (SCSGC)

COASTAL OCEAN STUDIES

Coastal Processes Subprogram

R/CP-10 Mesoscale Modeling of Sediment Transport and Morphologic Changes at Tidal Inlets—Kana (USC) & Hayter (Clemson)

Ocean Processes Subprogram

R/CO-1 Mechanisms of Transport of Decapod Crustaceans Through Estuarine Inlets—Barans & E. Wenner (SCDNR)

R/CO-2 Sources and Transport Mechanisms of White Shrimp in Southeastern Coastal Waters—Wenner & Barans (SCDNR)

R/CO-3 Transport Mechanisms and Estuary/Tidal Creek Exchanges of White Shrimp in Contrasting High and Low Discharge Southeastern Estuaries—Wenner & Barans (SCDNR)

ECOSYSTEM DYNAMICS *(formerly Watershed Dynamics)*

R/ER-9 Development of Meiobenthos Based Microcosm Bioassay for Community-Level Effects of Contaminated Estuarine Sediments—Chandler & Coull (USC)

R/ER-10 Functional Role of Oyster Reefs as "Biologically Critical" Estuarine Ecosystems —Coen, Ringwood & E. Wenner (SCDNR)

R/ER-13 New Techniques for Assessment of Estuarine Sediment Habitat Quality: Transfer Experiments Using Meiobenthos—Chandler & Coull (USC)

R/ER-14 Environmental Hypoxia and CO_2 Influence on the Propagation, the Physiology, and the Biochemistry of Infections of *Perkinsus marinus* in Oysters—L. Burnett (USCS)

R/ER-15 Development of a Molecular Genetics-Based Bioassay of Sediment Contaminant Effects on Benthos—Chandler & Coull (USC)

R/ER-16 Structure and Functions of Tidal Freshwater Wetlands on the Cooper River, S.C.: Effects of Water Management on Succession, Nutrient Cycling and Fish Habitat—Morris (USC) et al.

R/ER-17 Adenosine Phosphates and Ecosystem Health: A New Approach to Environmental Assessment—Kleppel (USC) & Moeller (NMFS)

R/CF-11 Quantitative Growth Dynamics of Flatfish as a Test of the Recruitment Hypothesis—Dean & Feller (USC)

CLIMATE AND HAZARDS

R/CE-1 Development of PC-Based Program to Refine Emergency Preparations and Assist in Responding Effectively (PREPARE) to Hurricane Hazards—Sill & Reinhold (Clemson)

R/CE-2 Wind Effects on Coastal Structures: Protection of the Building Envelope and Structure—Reinhold (Clemson)

R/CE-3 Development of Low-Cost and Self-Help Retrofit Techniques for Reduction of Damage and Losses in Severe Windstorms—Reinhold (Clemson)

R/RP-1 Enhancing Regional Natural Resource Policy-making: Understanding Local Policy-makers—Felts (UCSC)

EMERGING TECHNOLOGIES

R/MX-6 Proteins from Oyster Shell as a Basis for Biodegradable Water Treatment and Super-Absorbent Polymers—Wheeler (Clemson)

R/MX-7 Environmental and Biological Fate of New Polymer Additives for Industrial and Agricultural Applications—Wheeler (Clemson)

R/EM-7 Cellular Immunity in a Marine Teleost, the Red Drum, as a Potential Model for Environmental Health Assessment—K. Burnett (MUSC)

R/ER-12 Development of Models for the Study of Environmentally Mediated Signal Transduction and Development in Marine Species—Pollenz (MUSC)

R/MT-1 Developing the Foundations of a Heavy Metal Waste Processing Technology by Genetic Engineering of *Spartina alterniflora* for Constructed Wetlands—Marton (USC)

R/MT-2 Development of Aquatic Bioassay Models for Evaluating Physiologically Based Biomarkers of Exposure to Environmental Contaminants—Pollenz & Morris (MUSC)

SUSTAINABLE ECONOMIC DEVELOPMENT

R/A-25 Improvement of Hybrid Striped Bass Aquaculture Through Development of Cultured Broodstock and Improved Spawning Techniques—Phase II—Smith (SCDNR)

R/A-26 Development of Environmentally Friendly Coastal Aquaculture Technologies—Sandifer & Hopkins (SCDNR)

R/A-27 Management of Sludge Accumulations in Intensive Pond Culture of Shrimp—Sandifer, Hopkins & Browdy (SCDNR)

R/A-28 Development of Aquaculture Techniques for Southern Flounder: Phase I—Spawning and Nursery Techniques—Smith (SCDNR

R/A-29 Hyperintensive Aquaculture of Red Drum in Recirculating Systems: Identification and Management of Stressful and Non-optimal Environments—Tomasso (Clemson)

FUNDED PROJECTS

A/A-1 A Technology Transfer Program for Environmentally Friendly Coastal Aquaculture—Whetstone (SCSGEP), Stokes (SCDNR), Rhodes (SCDNR) & Brune (Clemson)

R/CH-3 Optimization of Domesticated Sweetgrass Quality and Supply to Support Nature-based Tourism Enterprises—Dufault (Clemson)

R/CH-4 The Impact of Tourism on Social and Cultural Diversity in Coastal Counties in South Carolina—Backman (Clemson)

MARINE EDUCATION (*formerly "Marine Outreach"*)

E/O-10 Testing and Evaluating a Teaching Model in Marine Science: The COASTeam Program—Sautter (UCSC)

E/O-11 The Effects of Summer Science Programs on In-school Science Activity Participation of Minority Youth—Sproatt (USC)

E/O-12 Testing and Evaluating a Teaching Model in Marine Science: The COASTeam Program—Sautter (UCSC)

E/O-13 Testing and Evaluating a Teaching Model in Marine Science: The COASTeam Program—Phase II—Sautter (UCSC)

A/O-6 South Carolina Zebra Mussel Outreach Program—DeVoe & Bacon (SCSGC)

NOAA/SEA GRANT NATIONAL OUTREACH NSI

A/NO-1 National Sea Grant Hazards Mitigation Network (HAZNET)—Bacon (SCSGEP) et al.

A/NO-2 The *Communicator*: Enhancing Sea Grant's Outreach Effectiveness by Building a More Cohesive and Informed Network—Blackwell (SCSGC)

NOAA/SEA GRANT PARTNERSHIP NSI

R/NP-1 Wise Investments/Shared Benefits: Development of a Sustainable Infrastructure Planning Model in a Coastal Region—Price & Peters (USC)

NOAA/SEA GRANT AQUACULTURE NSI

R/A-30 Technology Transfer to Establish Black Sea Bass Aquaculture as a Commercial Reality—NOAA National Sea Grant College Program—Smith (SCDNR)

NOAA/SEA GRANT OYSTER DISEASE RESEARCH PROGRAM

R/OD-1 The Influence of Ecological Processes on Transmission of *Perkinsus Marinus*: Dispersal Dilution and Host Filtration – Bushek (USC) et al.

R/OD-2 Molecular Genetic Analysis of *Perkinsus marinus*: Comparisons Among Laboratory Isolates and Natural Populations – Bushek (USC) et al.

OTHER GRANTS & ACTIVITIES

Federal Emergency Management Agency (FEMA)

Public Building Retrofit Research and Demonstration Project—Davidson (SCSGC)

NOAA National Marine Fisheries Service

Support for the Cooperative Institute for Fisheries Molecular Biology (FISHTEC)—Dean (USC) & DeVoe (SCSGC)

NOAA/NOS Coastal Ocean Program

Georges Bank Food Web Studies Using Polyclonal Immunoassays—Feller (USC)

Salt Marsh Geomorphology and Ecological Development: Influence Upon Habitat Linkages Within and Across Ecosystem Boundaries—Koepfler (CCU)

Urbanization and Southeastern Estuarine Systems (USES)—Vernberg (USC)

South Atlantic Bight Land Use—Coastal Ecosystem Study (LU-CES)—DeVoe (SCSGC) & Kleppel (USC)

ECOHAB-GOM: The Ecology and Oceanography of Toxic *Alexandrium* Blooms in the Gulf of Maine—NOAA Coastal Ocean Program (Year 1 of 5)—Doucette (MUSC)

Trophic Pathways in the Pelagic Environment of Florida Bay—NOAA Coastal Ocean Program (Year 1 of 2)—Kleppel (USC)

NOAA/NOS Coastal Services Center

Promoting Healthy Coastal Ecosystems in the Southeastern U.S.—Davidson (SCSGC)

Training, Outreach and Education Element of the Coastal Management Services Component—CCEH—Scholz (NOAA-CCEH)

Internships to Assist in the Commercialization of Coastal Environmental Technologies—DeVoe (SCSGC)

A Training and Education Program for Coastal Resource Managers—NOAA Coastal Services Center—DeVoe (SCSGC)

NOAA National Coastal Resources Research and Development Institute

Support for Production of a Video on the Hard Clam Tidal Powered Nursery System—Bacon (SCSGEP)

The Coastal Community and Economic Development Project—Bacon (SCSGEP)

Development and Demonstration of a Tidal-Powered Nursery Upwelling System—Phase II—DeVoe (SCSGC)

NOAA Ocean and Coastal Resources Management

NOAA Eutrophication Indicator Development Efforts—Knight (SCSGC)

NOAA Fleet

Continuation of Sediment-Water Interface Studies (October-November 1994—NOAA Ship Ferrel)—Gayes (CCU)

Continuation of Sediment-Water Interface Studies (May 1995—NOAA Ship Ferrel)—Gayes (CCU)

Continuation of Sediment-Water Interface Studies (Fall 1995—NOAA Ship Ferrel)—Gayes (CCU)

Undergraduate Experiences for Undergraduates (Summer 1996—NOAA Ship Ferrel)—Sautter (UCSC)

U.S. Geological Survey—USDOI

South Carolina Coastal Erosion Study—DeVoe (SCSGC)

S.C. Department of Health and Environmental Control

FUNDED PROJECTS

NPS Education for Municipal Officials (NEMO)—Merrill (SCSGC) & Schwartzkopf (Waccamaw Regional Planning Council)

Private Funds (misc.)

Support for Beach Sweep/River Sweep 1994-1999 Activities—Handal & Blackwell (SCSGC)

Support for the 1994 Plus-One Boating Campaign—Handal (SCSGC)

SEA GRANT DEVELOPMENT PROJECTS (1994-95)

P/M-2A Molecular Evolutionary Genetics of the Hard Clam *Mercenaria*—Hilbish (USC)

P/M-2B Evaluating the Historical Record of Non-Point Source Pollution in the ACE Basin and Sapelo Island National Estuarine Research Reserves—E. Wenner (SCDNR) & Alexander (Skidaway Institute of Oceanography)

P/M-2C Summer Science Camps for Minority Youth—Sproatt (SC-B)

P/M-2D Waccamaw & Atlantic Varied Education (WAVE) Program —Gilman (CCU)

P/M-2E 1995 Science Fair—Peters (UCSC)

P/M-2F S.C. Sea Grant Consortium Strategic Planning—Davidson & DeVoe (SCSGC)

P/M-2G Project Interface—Pilot Experiment—Kineke (USC)

P/M-2H Pilot Study: Full-Scale Testing to Evaluate Structural Capacities and Measures—Schiff & Rosowsky (Clemson)

P/M-2I Developing the Foundations of a Genetic Engineering Approach to Phytoremediation using *Spartina alterniflora*—Marton, Morris, & Czako (USC)

SEA GRANT DEVELOPMENT PROJECTS (1995-96)

P/M-2A Chlorine Tolerance of the Eastern Oyster Pathogen *Perkinsus marinus*: Standards for Sterilization and Quarantine—Bushek (USC)

P/M-2B Mechanisms for Variation in Marsh Fertility along Estuarine Salinity Gradients (Phase I)—Morris (USC)

P/M-2C Developing the Foundations of a Heavy Metal Waste Processing Technology by Genetic Engineering of *Spartina alterniflora* for Constructed Wetlands (Phase I)—Marton, Czako & Morris (USC)

P/M-2D The Use of Estuarine Deposit Feeders in Monitoring Pathogenic and Indicator Bacteria—Plante (UCSC)

P/M-2E Environmental Hypoxia and Carbon Dioxide Influence on the Propagation, the Physiology, and the Biochemistry of Infections of *Perkinsus marinus* in Oysters—Burnett (UCSC)

P/M-2F Production of a New Antibiotic Factor by a Marine Microbe—Yoch (USC)

P/M-2G Symposium on the Consequences and Management of Fisheries Bycatch—Rawson (University of Georgia)

SEA GRANT DEVELOPMENT PROJECTS (1996-97)

P/M-2A Mechanisms for Variation in Marsh Fertility Along Estuarine Salinity Gradients (Phase II)—Morris (USC)

P/M-2B Developing the Foundations of a Heavy Metal Waste Processing Technology by Genetic Engineering of *Spartina alterniflora* for Constructed Wetlands (Phase II)—Marton (USC)

P/M-2C Effects of Hypoxia and High CO_2 on Oyster Physiology: Implications for the Oyster Disease *Perkinsus marinus*—Burnett (UCSC)

P/M-2D The Use of Natural Habitat Aquaria in Elementary Schools—Sproatt (USC-Beaufort)

P/M-2E Coastal Development: The Long-term Effects on Benthic Estuarine Infauna—Woodin (USC)

P/M-2F Coastal Ocean Boundaries Interactions and Assessments (COBIA): Development of a Network of Marine Scientists in the Southeastern U.S.—Kleppel (USC)

PM/F-2G Polyclonal Rabbit anti-*Perkinsus marinus* Antiserum Crossreactivity with Dinophyceae: Evolutionary Implications and Potential for a Broad Spectrum Detection Assay—Bushek (USC)

P/M-2H Agricultural Pesticide Runoff in Tidal Creeks and its Effects on Microbial Loop Communities—Ross (the Citadel)

P/M-2I Pilot Testing the MARE Program—Sautter (UCSC)

P/M-2J Assessment of the Population Biology and Critical Habitat for *Limulus polyphemus* in South Carolina—Wenner & Thompson (SCDNR)

P/M-2K Growth Management Mediation Summer Internship—Bacon (SCSGEP)

SEA GRANT DEVELOPMENT PROJECTS (1997-98)

P/M-2A Undergraduate Education and Outreach Fellowships: Issues in Coastal Environmental Research—Burnett (MUSC)

P/M-2B A Risk-based Geographic Information System (GIS) Platform for Hazard Assessment in South Carolina—Rosowsky (Clemson)

P/M-2C Undergraduate Education and Outreach Fellowships: Issues in Coastal Environmental Research—Supplement—Burnett (MUSC)

P/M-2D Do Endocrine Disruptors Mimic or Inhibit Retinoic Acid Controlled Signaling Pathways During Embryogenesis: Development Assays to Test for Interactions—McCarthy & Smith (UCSC)

P/M-2E Comparison of Teaching Models for Introductory Marine Sciences Laboratory Courses—Feller (USC)

P/M-2G Comparison of Teaching Models for Introductory Marine Sciences Laboratory Courses—Feller (USC)

P/M-2I Coastal Ocean Boundaries Interactions and Assessments (COBIA): Development of a Network of Marine Scientists in the Southeastern U.S.—Kleppel (USC)

P/M-2J Undergraduate Research and Outreach Fellowships: Issues in Coastal and Environmental Research—Burnett (CofC)

P/M-2K Wind Field Modeling and Hurricane Loss Estimation in South Carolina, Part 1:

FUNDED PROJECTS

Development of Wind Field, Vulnerability, and Loss Models (Phase 1)—Rosowsky (Clemson)

SEA GRANT DEVELOPMENT PROJECTS (1998-99)

P/M-2A Preliminary Studies Regarding the Use of Cellular Responses in Marsh Mussels, *Geukensia demissa*, as Potentially Valuable Indicators of Habitat Condition—Ringwood (SCDNR)

P/M-2B The Role of Quorum Sensing Mechanism in Bacterial Biofilm Production—Plante (UCSC)

P/M-2C State of Knowledge on GIS Databases and Land-use Cover Patterns: South Carolina—Cowen (USC)

P/M-2D Pulsed Field Gel Electrophoresis: a Potential Management Tool to Differentiate Human and Animal Sources of *E. coli* Contamination—G. Scott (NOAA/NOS)

P/M 2E Biology and Distribution of a Newly Discovered Non-indigenous Anomuran Crab, *Petrolisthes armatus*—Coen (SCDNR)

P/M-2F Investigation of Effects of Highway Embankment Reduction and Subsequent Changes in Hydrodynamics on a Tidal Marsh Habitat—Curran (USC-Beaufort)

P/M-2G Georgia-South Carolina Regional Competition of the National Sciences Bowl—Feller (USC)

P/M-2H An Urban Growth Scenario for the Charleston Area of the South Carolina Coast—Allen (Clemson)

P/M-2I Glenn McConnell Parkway Charette—D. Beach (S.C. Coastal Conservation League)

P/M-2J Isolation and Identification of a New Antibiotic Factor Produced by a Marine Microbe—Yoch (USC)

P/M-2K Undergraduate Research and Outreach Fellowships: Issues in Coastal and Environmental Research—L. Burnett (UCSC)

STATE DEVELOPMENT PROJECTS (1995-1999)

SD95-1 Development of Waste Load Allocation and TMDLs for Point Sources And Non-point Sources for Complex Estuarine Conditions: Cooper River and Charleston Harbor—Phase II—McCutcheon (Clemson)

SD95-2 Pilot Testing the COASTeam Program—Sautter (UCSC)

SD95-4 Winyah Bay Focus Area Video—Gordon (Ducks Unlimited)

SD95-5 Remote Sensing Laboratory Equipment—Kelley (The Citadel)

SD95-6 Research Support—Paleontological Microscope—Sautter (UCSC)

SD95-7 Kathleen Sullivan Award—Herrin (USC)

SD95-8 Travel Support for the Southern Beaufort County Land Use Symposium—Cahill (Bluffton Area Community Association)

SD95-9 An Expert System Combining Science and Policy for the Coastal Zone: A Case Study (Phase I)—Evans (USC)

SD96-1 An Expert System Combining Science and Policy for the Coastal Zone: A Case Study (Phase II)—Evans (USC)

SD96-2 Investigation of Salinity Effects Upon Porewater Exchange Mechanisms at the Sediment-Water Interface—Ramsden (Clemson)

SD96-3 Dionex Ion Chromatograph Equipment—Morris (USC)

SD96-5 Development and Assessment of Shore-based and Boat Census Techniques for Atlantic Coastal Bottlenose Dolphins—Young (CCU)

SD96-6 Support for the Fishing Fair—Farmer (SCDNR)

SD96-7 Community Sustainability and Learning Center—Boling (Clemson)

SD97-1 The Economic Impact of Bicycle Touring: Prospects for Coastal South Carolina—Sparks (The Citadel)

SD97-2 Policy Options to Address Shoreline Erosion—London (Clemson)

SD97-3 Enrichment Program for the 1997 Lowcountry Science Fair—Kille-Marino (UCSC)

SD97-4 South Carolina 4-H Marine Science Camp Scholarships—Ardern (Clemson)

SD97-5 Oyster Reef Project Equipment—Coen (SCDNR)

SD97-6 Support for the Production of "A Manual for the Culture of the Hard Clam *Mercenaria* spp. in South Carolina"—Handal (SCSGC)

SD98-2 Document of the 25th Anniversary of the Marine Resources Division—Farmer & Laurie (SCDNR)

SD98-3 Implementation of the Sea Partners Program—Quattrochi (U.S. Coast Guard)

SD98-4 South Carolina 4-H Marine Science Camp Scholarships—Ardern (Clemson)

SD98-6 Enrichment Program for the 1998 Lowcountry Science Fair—Kille-Marino (UCSC)

SD98-7 1998 Marine Resources Fair and Open House—Farmer (SCDNR)

SD99-1 Acoustic Doppler Current Profiler Measurements Near Folly Beach—Cooney (USGS)

SD99-2 South Carolina's 1999 National Aerial Photography Program (NAPP)—Vang (SCDNR)

SD99-3 Green Village Expo '98—Goodwin (Green Village Expo)

SD99-4 South Carolina Marine Science Camp—Ardern (Clemson)

SD99-5 Sea Sweepers Program—Quattrochi (U.S. Coast Guard)

SD99-6 Investigating Tourist Attachment to Selected Coastal Destinations in S.C.—Allen (Clemson)

SD99-7 Civil War Fortifications Survey—Hackett (SCDHEC)

SD99-9 East Cooper Heritage Trail—Wilson (Rural Economic Development, Inc.)

SD99-10 Economic Impact Analysis of South Carolina's Marina Industry—Schilling (S.C. Marina Association)

SD99-11 Genetics in the Toolbox for Managing Striped Bass—Christie (S.C. Chapter of American Fisheries Society)

SD99-12 Enrichment Program for the 1999 Lowcountry Science Fair—Kille-Marino (UCSC)

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