

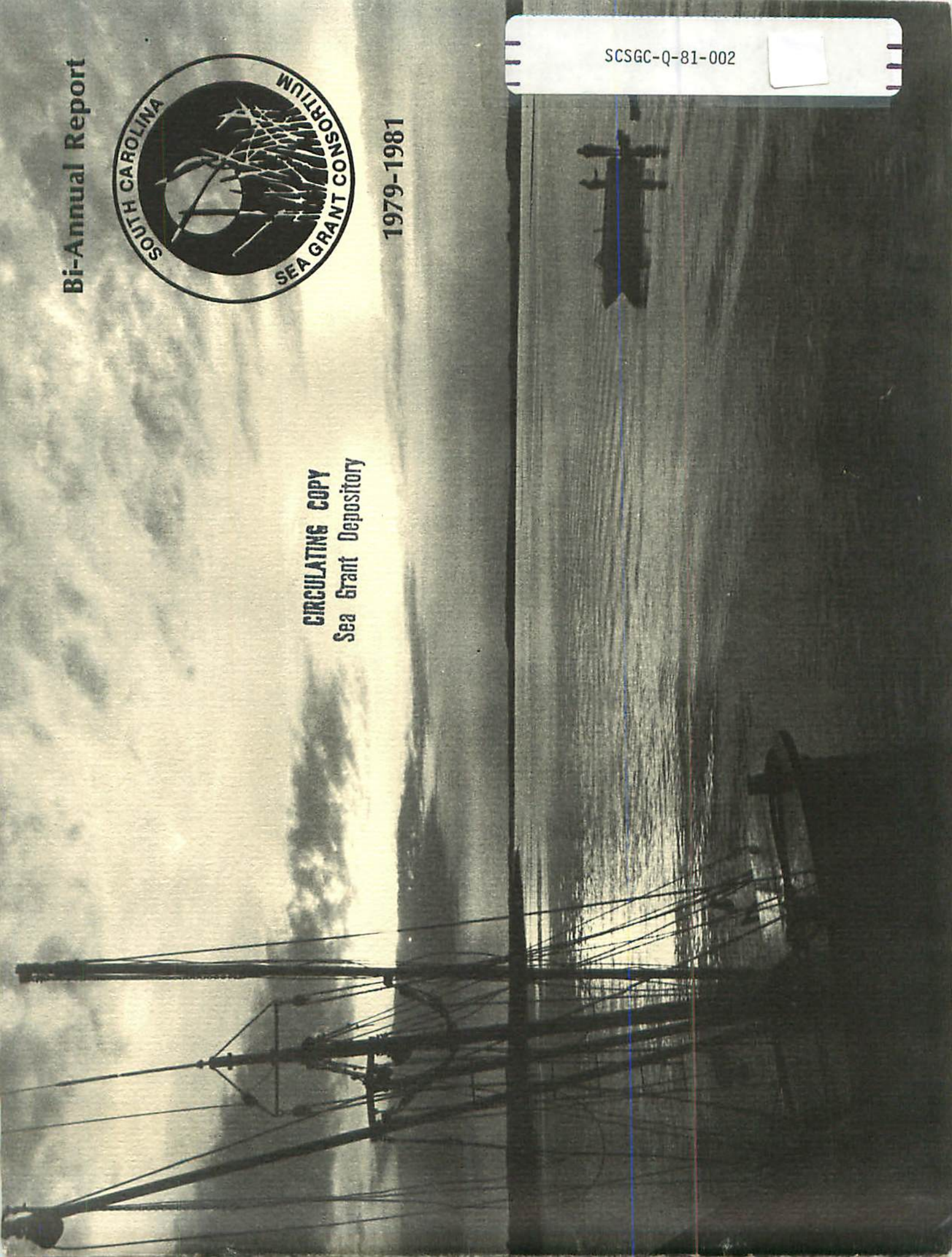
Bi-Annual Report



1979-1981

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**Communications
South Carolina Sea Grant Consortium
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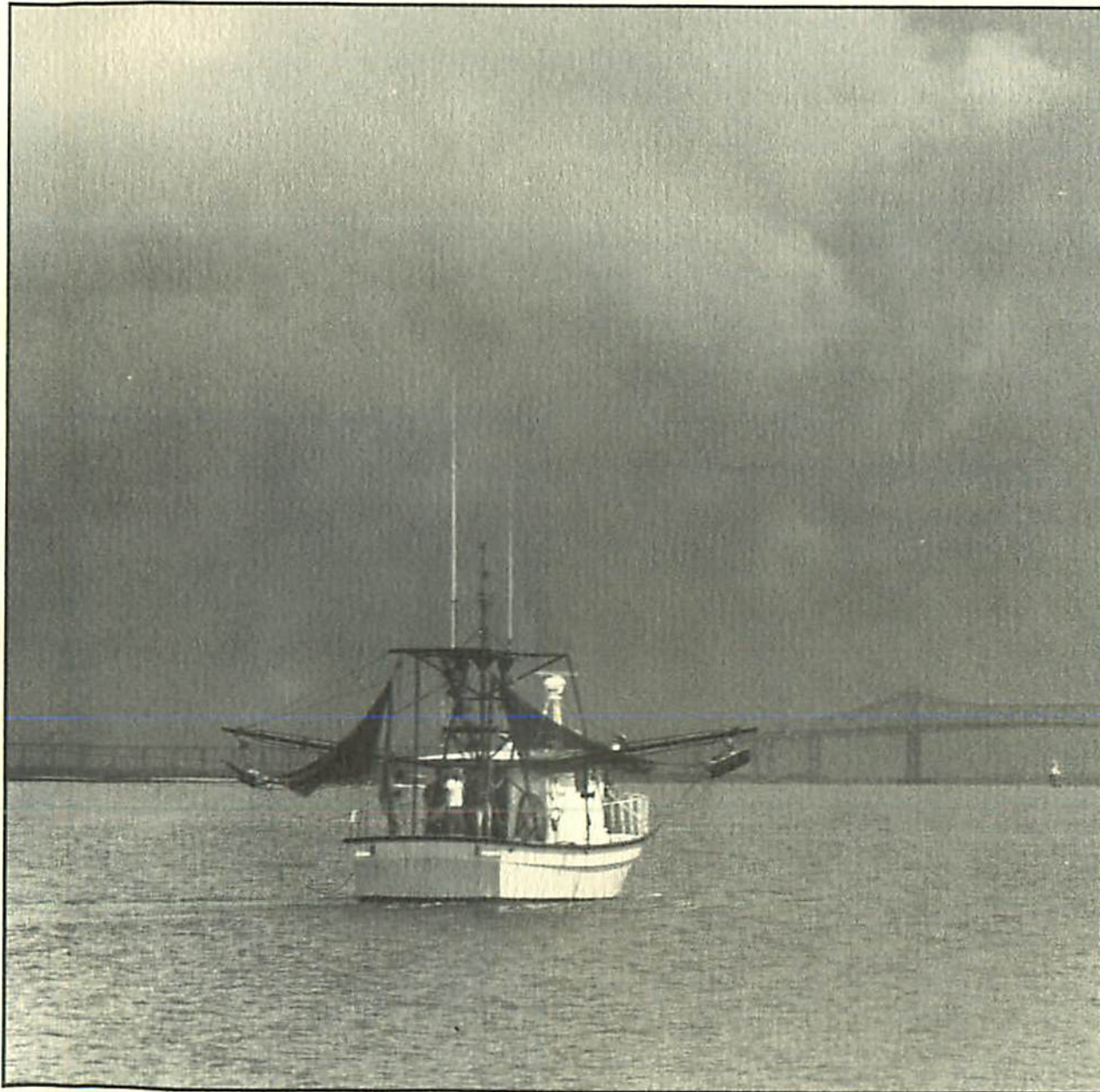
Director of Communications: Anne R. Hill

Written and Designed by Stephen G. Hoffius
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Thanks to Pete Laurie for photographs on the cover, and pages 1, 5, 15 and 37.

Between the years covered by this report and its publication, a number of changes have taken place within the South Carolina Sea Grant Consortium. Presidents at some of the member institutions have changed, as has the Director of the Consortium. Those changes will be reflected in future reports.

June 1983



Bi-Annual Report



1979-1981

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Director's Statement

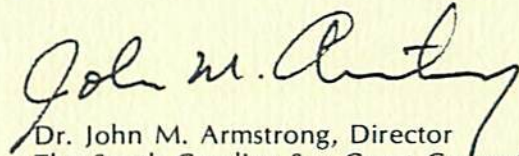
With the nation's farmlands disappearing at an alarming rate, our energy needs steadily increasing and food production threatened on a global scale, our future depends on the sensible development and management of our ocean and coastal resources.

South Carolina is blessed with an abundance of these resources. With its beautiful barrier islands, estuaries and salt marshes, our state boasts some of the most unique and valuable coastal and marine resources in the world. South Carolina, however, is not only rich in natural resources, but in human resources as well. Our colleges, universities and state agencies offer many programs relating to ocean and coastal topics, and a number of researchers within these programs have received international recognition for their studies in coastal and marine-related fields.

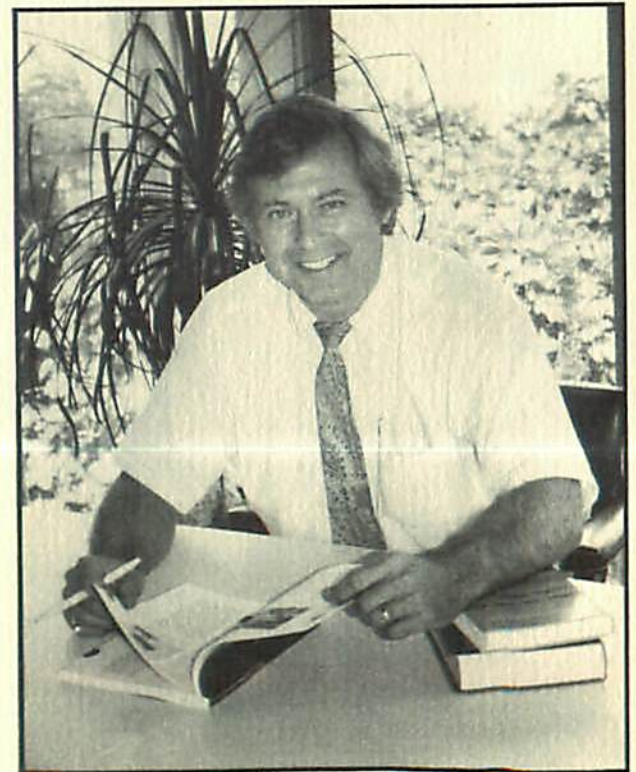
The purpose behind this report is to highlight the resources within these programs and show

how they relate to our growing dependence on the world's oceans and coastal areas. By closely examining the seven institutions that comprise the South Carolina Sea Grant Consortium, we are able to provide the reader with valuable information pertaining to the many opportunities and capabilities that each institution offers in the area of ocean and coastal studies.

We are proud of the work being done in this state to promote, through education and research, a better understanding of our ocean and coastal resources. It is our hope that this report will help focus an even greater amount of attention on the need for continued and growing support of our programs of marine education and research.



Dr. John M. Armstrong, Director
The South Carolina Sea Grant Consortium



Assistant Director's Statement

The Sea Grant program in South Carolina is a unique program in a unique environment. Along its remarkably diverse coastline, one-half million acres of wetlands serve as vital nursery habitat for South Carolina's traditional commercial fisheries that also range far beyond state boundaries. Additionally, some 70,000 acres of wetlands, once impounded for rice production, are believed to offer significant potential for the controlled rearing and harvest of aquatic organisms: aquaculture is being carefully considered for its potential in supplementing traditional fisheries and generating new industry.

South Carolina is also possessed of the greatest number of barrier islands in North America, nearly fifty per cent of which are excluded from the private market. As a result, developmental pressures have only intensified in the past decade: coastal communities now face, for the first time, difficult decisions arising from resource problems. Conflicting pressures can only be expected to intensify as the state's sea islands and alluring climate continue to attract both settlers and visitors. It is noteworthy that income generated from coastal recreational activities is now estimated to exceed all revenue sectors except the state's textile and manufacturing industries.

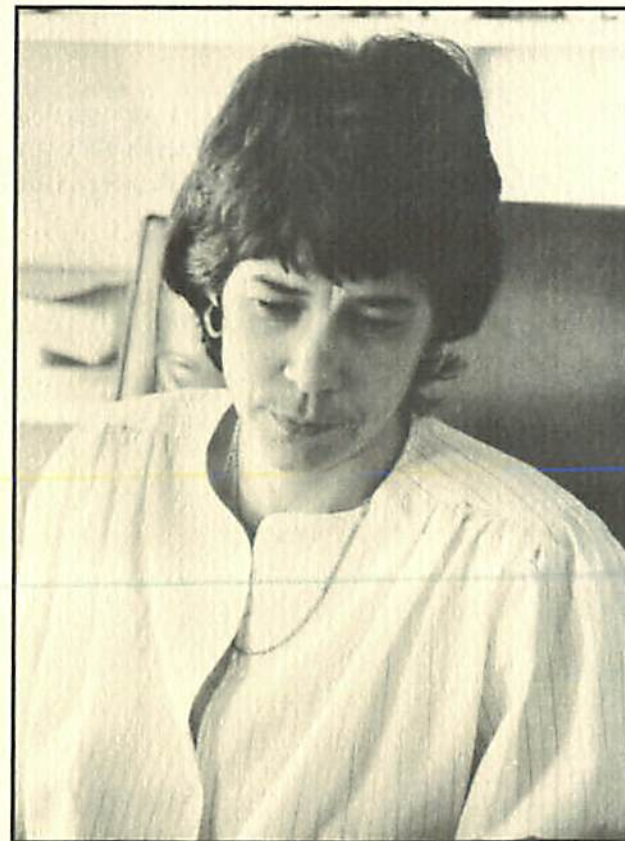
Compounding the difficulties is the fact that over fifty per cent of the coastal population has moved to the state within the past fifteen years. A lack of awareness regarding historical trends of this land limits both an understanding of these complex issues and an ability to effectively participate in the crucial decisions now unfolding. Water access and allocation issues are a critical concern to the state and all who live, work, and play along the coast.

To address these difficult problems, the South Carolina Sea Grant Consortium brings together the talents and expertise of the state's major academic and research institutions: The Citadel, Clemson University, College of Charleston, Medical University of South Carolina, South Carolina State College, University of South Carolina, and Marine Resources Research Institute-South Carolina Wildlife and Marine Resources Department. Through Consortium support and enhancement of these members' research, education, and extension activities, the state's coastal and marine resource problems are identified in consultation with the state legislature and industry advisory groups as well as state and federal resource management agencies and methodically addressed. We strive to provide vital information to the state and its citizenry, information that is timely and responsive. Through our collaborative efforts with the Clemson Extension Service, scientific data is delivered to the state's coastal users for integration into their activities; in turn, those users provide valuable feedback to Sea Grant as we work together on difficult problems.

Users, researchers, and public officials: we are all striving to attain a balanced program to resolve coastal and marine resource issues of concern to us all. Our concerted efforts will help ensure the health and vitality of South Carolina's coast and its diverse ecosystem, in order that we may all enjoy the benefits which accrue while sharing the responsibilities for careful management of our resources.

Margaret A. Davidson

Margaret A. Davidson, Assistant Director
The South Carolina Sea Grant Consortium



THE CONSORTIUM

The South Carolina Sea Grant Consortium is a unique partnership of universities, colleges, and state agencies working together to promote and implement research, education, and advisory services in the sphere of marine and coastal resources. The Consortium accomplishes these concurrent tasks by drawing on the diverse and extensive talents and facilities available at its seven member institutions.

The Consortium is charged with bringing together its constituent institutions to assist the state, the region and the nation in resolving coastal and marine issues. Three distinct advantages are realized by this "partnership" arrangement:

- Duplication, often a problem in scientific research, is avoided by encouraging cooperation among the different institutions and among the different disciplines within the institutions.
- The promotion of manpower sharing results in greater productivity and lower costs.

- The ability to put together teams of faculty and staff from various member institutions to help solve problems of concern to the state and the nation maximizes the effectiveness of existing personnel.

Research, education and advisory work on Consortium projects is carried out by the faculty and staff at the Consortium's member institutions. Their expertise is the strength of the South Carolina Sea Grant Consortium, enabling it to meet the challenges of developing and managing coastal resources in an efficient and comprehensive fashion. Both faculty and staff approach this challenge from the variety of perspectives inherent in their multi-disciplinary fields.

In addition to providing professional expertise in many marine and coastal disciplines, member institutions are able to provide a wide range of facilities for use by the Consortium's project investigators. These researchers have access to more than 30 research laboratories, including those of the South Carolina Wildlife and Marine Resources Department, the University of South Carolina's Belle Baruch Laboratory, the agricultural engineering facilities at Clemson University, and a large biomedical research facility of the Medical University of South Carolina. In addition, six research vessels are available for field studies.



The Citadel

The Citadel's location in Charleston has provided it with an exceptional opportunity to study coastal issues, and a number of departments have made them a special concern.

Marine research and education activities are primarily conducted by members of the school's biology faculty. However the geology division of the Department of Chemistry offers a course in marine geology and the Department of Civil Engineering is involved in a number of studies with coastal and marine applications. The school



Dr. Robert Baldwin
Department of Biology
Campus Coordinator

offers a graduate program that leads to the Master of Arts in Teaching (MAT) degree, including courses covering marine biology, marine invertebrates, pollution ecology, vascular flora of South Carolina, medical entomology, and an environmental studies seminar.

Through The Citadel's various programs in civil engineering, emphasis is being focused on coastal engineering and the problems associated with the coastal zone. The department's program in transportation engineering allows students to concentrate on such topics as the planning, financing and design of seaport facilities, as well as other transportation facilities.

Facilities in the Department of Biology are well-suited for teaching and research on coastal and marine subjects. Laboratory facilities are modern and well-equipped, with special capabilities in the areas of marine biology, vertebrate zoology, vector biology, microbiology and physiology. In addition, the department maintains one of the largest herbariums in the Southeast, especially noted for its collection of coastal specimens.

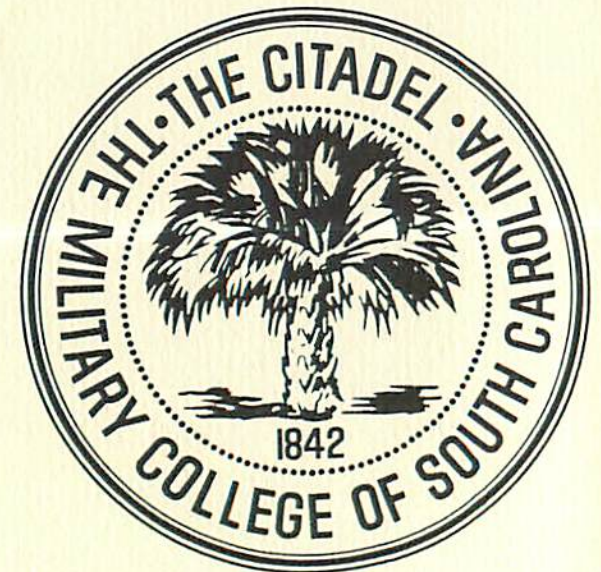
In 1980, The Citadel established the Vector Biology Program within the Department of Biology. This program is particularly significant in its relation to our coastal and marine environments. The objectives of this program are three-fold: the development of practical water management techniques to reduce mosquito populations in spoil areas, duck ponds, high marsh and rice fields; surveillance for incidence of arboviruses in bird and mosquito populations; and the development of laboratory and field methods for controlling mosquito populations with biological agents. The director of the Vector Biology Program is a trained ornithologist specializing in shore birds.

Through The Citadel's various programs in civil engineering, greater emphasis is being focused on coastal engineering and the problems associated with the coastal zone. A number of courses offered by the Department of Civil Engineering

give students and faculty the opportunity to apply specific skills to engineering problems related to this area. Among the courses which place particular emphasis on coastal areas are Environmental Engineering, Transportation Engineering and Soil Mechanics.

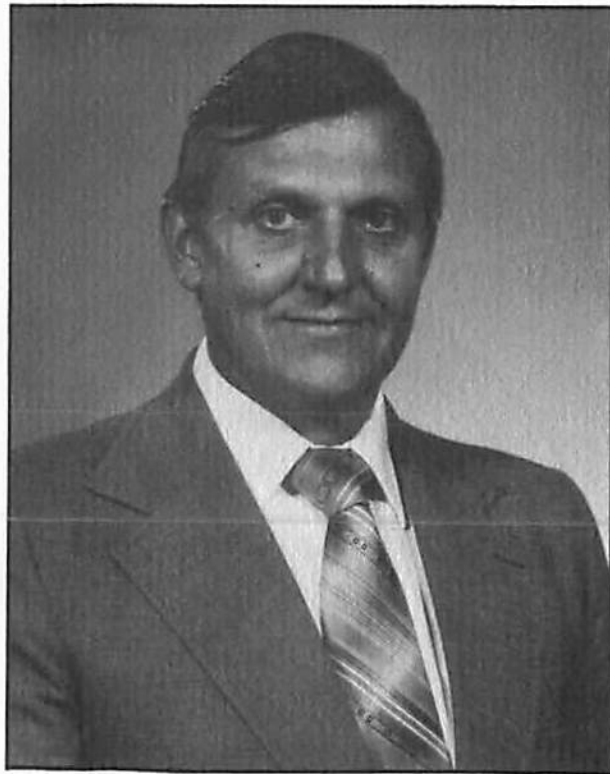
The Department of Civil Engineering contains excellent facilities for coastal engineering research. The school's well-equipped facilities include a concrete laboratory, materials testing laboratory, bituminous materials testing laboratory, soil mechanics laboratory, fluid mechanics laboratory and an environmental engineering laboratory.

Environmental engineering places particular emphasis on such topics as the relationship of water supply and waste water treatment to public health, hydrology, water consumption, and water quality standards.



Clemson University

As South Carolina's land grant university, Clemson University has an extensive history of service to the thousands of people in the state involved in agriculture and farming. For some time, many of these same skills have been applied to coastal and marine issues. With the expansion of such coastal activities as aquaculture, this work is growing in scope and has been crucial to the development of South Carolina's coastal resources. In addition, the South Carolina Sea Grant Consortium Marine Advisory Service is operated through the Clemson



Dr. Paul B. Zielinski
Environmental Systems Engineering
Campus Coordinator

Cooperative Extension Service, and the marine advisory specialists located in the coastal cities of Beaufort, Charleston and Georgetown provide a link between academic researchers and individuals and organizations facing marine-related problems requiring technical solutions.

The school's Department of Civil Engineering has focused considerable attention on the problems of coastal erosion, sedimentation and dredge disposal at sea. Much of this work has been done at the Clemson Hydraulics Laboratory, one of the most extensive physical modeling facilities in the Southeast, consisting of recirculating water channels, wave tanks, a stratified model basin and a deep dispersion basin. The hydraulics lab has capabilities for a broad range of studies, including coastal engineering, thermal pollution, sediment dynamics and applied hydrology.

Coastal and marine-related studies by researchers in Clemson's Department of Civil Engineering include such topics as physical and mathematical modeling of industrial discharges into estuaries, low-cost shoreline protection, ocean wave monitoring programs, sediment transport in estuaries, coastal erosion analyses, marine siting and coastal circulation.

The Department of Environmental Systems Engineering is involved in wastewater process design, water resources engineering, air pollution control, heavy metals pollution, and saltwater intrusion.

The Department of Entomology, Fisheries and Wildlife centers its work on such topics as aquaculture techniques, fishery biology, biology of marine organisms, aquatic productivity, parasites and diseases of marine animals, shellfish biology, biology of migratory fish and directed studies and fieldwork in marine biology. Though most studies focus on freshwater systems, a large number are marine-related. Recent and on-going studies conducted by the department include work with hard clams, American eels, blueback herring, drum, crawfish and freshwater prawns.

The Departments of Microbiology, Zoology, Agricultural Engineering, Planning Studies, and Agricultural Economics and Rural Sociology all work on coastal and marine issues.

In the two years covered by this report, the South Carolina Sea Grant Consortium has worked with Clemson researchers in a wide variety of areas: from the economics of pond culture of prawns to the development of an automatic shrimp deheading system; from the development of hurricane-resistant building standards to studies of tire structures as artificial reefs. In addition, the Marine Advisory Service provides the Consortium with its most important link to fishermen, dockowners and marine resource users and consumers, identifying their concerns and needs. With this information, Sea Grant projects are shaped.



The College of Charleston

The College of Charleston's commitment to marine issues is extensive. The school operates a graduate Marine Biology Program in cooperation with the Charleston Higher Education Consortium. It is based at the Grice Marine Biological Laboratory on the grounds of historic Fort Johnson, situated on the southern rim of Charleston Harbor. The modern facility houses classrooms, student and research labs, dormitory and kitchen space, an aquarium room equipped with running salt water, and one of the largest marine science



Dr. Paul Hamill
Office of Research
Campus Coordinator

libraries in the Southeast.

In addition to the laboratory facilities at Fort Johnson, the Marine Resources Library, supported jointly by the College and the South Carolina Wildlife and Marine Resources Department, provides students and researchers an excellent source for materials relating to coastal and marine studies. Established in 1972, the facility has developed into one of the largest marine science libraries in the Southeast. The library's major focus is on marine biology and oceanography, but aquaculture, marine chemistry, marine geology, marine and estuarine ecology, fisheries management and economics, and coastal zone management are also emphasized.

Students may also earn undergraduate degree credits through the College's two summer sessions in marine biology. Held at the Grice lab, students may participate in such classes as Marine Biology, Biology of the Crustacea, Problems of Marine Biology, Marine Invertebrate Embryology and Salt Marsh Ecology.

The Center for Metropolitan Affairs and Public Policy offers a Masters in Public Administration Program, concentrating on coastal zone and natural resource management. Course work addresses ecological processes, management of environmental resources, the legal and administrative framework, and implementation problems.

Aside from its educational programs, the Center is involved in numerous marine-related projects, many of them funded through the South Carolina Sea Grant Consortium. These projects include the development of a multi-jurisdictional urban waterfront planning and management model used for effecting orderly growth, development, redevelopment and modernization of the urban waterfront; a survey of coastal evacuation needs and capabilities; and the development of shore erosion management options.

Other coastal and marine-related projects undertaken by the center include the implementation of a storm water program for Myrtle Beach,

and a symposium for public officials assessing energy-related impacts in coastal areas.

The Department of Geology offers courses which emphasize marine and sedimentary geology. Students and faculty in the department are involved in numerous research projects involved with coastal and estuarine research, carbonate environments and marine ecology, coastal plain mapping and stratigraphy, and condonont paleoecology and carboniferous stratigraphy.

College of Charleston researchers have contributed valuable research on major South Carolina fishery species. The S.C. Sea Grant Consortium has funded investigations on such species as rock shrimp, groupers and snappers.



The Medical University of South Carolina

Researchers at the Medical University of South Carolina (MUSC) have used their health science expertise to pursue two marine science-related fields. First, they have investigated marine biomedicine, or the use of marine plants and organisms to produce medicinal compounds. Second, they have studied the effect of various man-made materials on marine organisms. To pursue this work, the University maintains laboratories at both the Marine Resources Research Institute at Fort Johnson and at the main Charleston campus seven miles away.



Dr. Thomas C. Cheng
Department of Marine Biomedicine
Campus Coordinator

Specifically, MUSC has three large research laboratories located at Fort Johnson which are equipped for research pertaining to comparative immunology, pathology of marine animals, marine toxicology, marine parasitology and microbiology, and the cell biology of blood cells in marine organisms.

In addition to the three major labs, there are four private laboratory rooms, a photographic darkroom and a shared wet lab for maintaining marine animals.

On MUSC's main campus are three well-equipped laboratories available to graduate and medical students interested in marine biomedicine. These include the facilities of the Departments of Biochemistry, Anatomy, Basic and Clinical Immunology and Microbiology, Physiology, Pathology, Pharmacology and Biometry.

Some 30 members of the MUSC faculty have research interests involving the use of marine organisms as models for biomedical investigations. Areas of expertise include: immunology, microbiology, parasitology, comparative physiology, fine structure, biochemistry, neurobiology and neurochemistry, developmental biology, genetics, epizootology and epidemiology, histochemistry and comparative pathology.

Graduate students working with marine organisms can earn the Ph.D. degree in Anatomy, Biochemistry, Immunology and Microbiology, or the interdisciplinary Ph.D. degree in Molecular and Cellular Biology and Pathobiology.

The internationally-recognized expertise of MUSC personnel, the excellent equipment of a number of departments, and the school's proximity to a great variety of marine resources provide it with a unique opportunity for involvement with marine science issues. By working within the partnership arrangement encouraged by the structure of the South Carolina Sea Grant Consortium, the Medical University can make major contributions in the fields of study that combine both medical research and marine

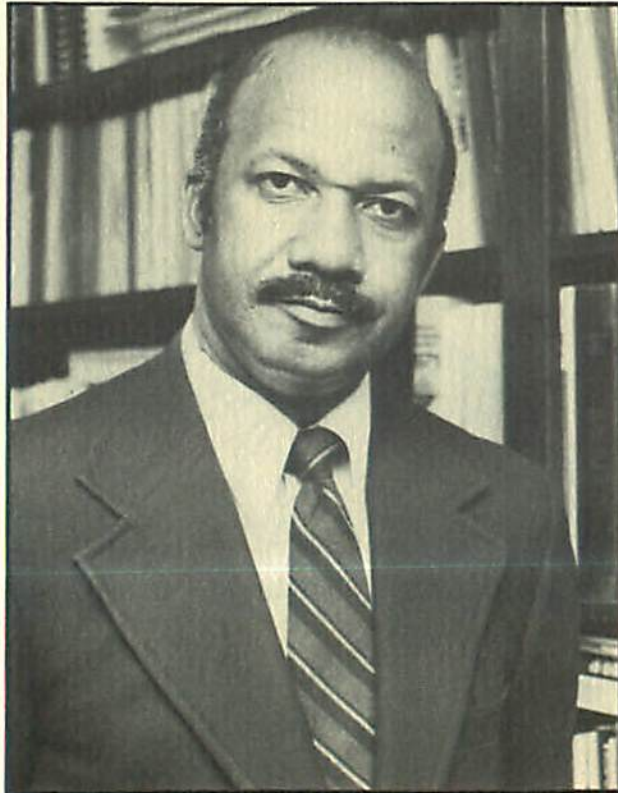
science. At the same time, other institutions can quickly and easily broaden their work into important new areas by tapping into MUSC's resources.



South Carolina State College

The vast majority of minority college students in South Carolina are educated at the state's five black institutions. South Carolina State College, with an enrollment of 3,200 students, is by far the largest. Faculty and staff of South Carolina State College have attempted to expand the involvement of South Carolina minorities in marine education and in marine science careers.

Within the Department of Natural Sciences faculty members with expertise and interest in



Dr. James Arrington
Department of Natural Sciences
Campus Coordinator

marine-related studies have undertaken a number of marine research projects. Research focusing on trace elements in fish and other selected seafoods, and a study of oxygen equilibrium binding in the blood of marine organisms are two examples of marine-related projects underway within the Department of Natural Sciences.

For the past several summers, South Carolina minority students have been involved in a marine science study program, sponsored by S.C. State, in cooperation with the University of South Carolina's Marine Science Program and the Belle W. Baruch Institute for Marine Biology and Coastal Research. The South Carolina Sea Grant Consortium has helped fund this program, which has provided students with both intensive laboratory work and coastal fieldwork. S.C. State officials also encourage their students to take part in marine science seminars at the University of South Carolina.

The response of the students to this program has been extremely positive. They unanimously expressed the opinion that the three weeks of the program was too short, and they wished to see it extended. The program was successful in stimulating several students to pursue additional marine-related experiences and to consider careers in marine science. Two students from the program have begun efforts to establish a Marine Science Interest Club at South Carolina State.

In addition, the College's School of Home Economics has sponsored workshops in Orangeburg to educate community people about seafood. The workshops have emphasized the availability of inexpensive and nutritious species of fish, often overlooked by consumers.

S.C. State also houses the Cooperative Extension Service's 1890 program, which has been instrumental in providing basic technical assistance and information to the state's black, small-scale farmers. Plans are being made to expand the program to include the state's minority coastal fishermen.

South Carolina State worked with the South Carolina Marine Advisory Service to set up a workshop in Beaufort for blue crabbers. Fifteen crabbers attended the workshop, at which new technology was demonstrated and discussed.



South Carolina Wildlife and Marine Resource Department

Located at historic Fort Johnson on Charleston Harbor, the S.C. Wildlife and Marine Resources Department is responsible for the management, development and proper use of the state's wildlife and marine resources. The Division of Marine Resources consists of two functional units: the Office of Conservation, Management and Marketing, and the Marine Resources Research Institute.



Dr. Paul A. Sandifer
Marine Resources Research Institute
Campus Coordinator

The Office of Conservation, Management and Marketing has primary responsibilities for management and development of the commercial and recreational fisheries in the state's coastal areas. This includes the regulation and control of commercial fishing seasons, areas and equipment; the issuance of licenses and permits for fishing; the management of public shellfish grounds; the collection and maintenance of fisheries statistics; the leasing of state bottoms for shellfish culture and other forms of mariculture; the promotion of seafood products; and the development of seafood markets.

Recently, the Office has become increasingly active in a broad spectrum of environmental and ecological concerns, especially those which have an impact on fisheries and marine habitats.

The Marine Resources Research Institute's activities are clustered into four areas: fisheries, environmental sciences, aquaculture and educational support services. Research interests include fisheries biology, fishery population dynamics, oceanography, marine biology, benthic ecology, marine and estuarine ecology and aquaculture.

The MRRRI occupies some 60,000 square feet of space, with the main laboratory building containing 12 laboratories, a central artificial sea water system, two large constant-temperature rooms, a walk-in chiller and freezer, and offices for the scientific staff.

An additional 30,000 square feet of space contains teaching as well as research laboratories, an auditorium, library and computer terminals.

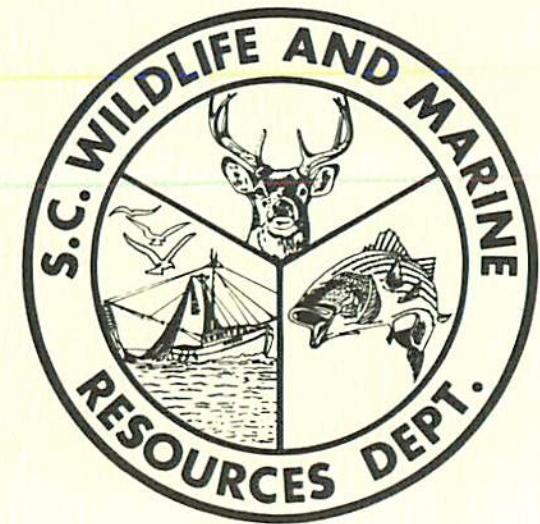
Three smaller buildings at Fort Johnson have been modified to house a geology laboratory, finfish and shellfish taxonomic work-up facility, and an aquaculture project. Shop facilities are maintained to provide some instrument maintenance and fabrication.

The Institute also provides facilities which support the Charleston Higher Education Consortium's Marine Biology Graduate Program and the Medical University of South Carolina's Ma-

rine Biomedical Research Program. Other state colleges and universities have access to the institute's facilities.

The Department's emphasis on aquaculture has been of crucial importance to the development of several projects involving prawns and hard clams, all supported by the South Carolina Sea Grant Consortium. State-wide aquaculture activity is expected to increase with the 1984 completion of the James M. Waddell Mariculture Research and Development Center at Victoria Bluff, near Beaufort. This new facility will include 24 ponds of various size, a 265-foot pier with a floating dock, and a 10,000 square foot hatchery and research building.

The Department has also worked with the Consortium on a number of projects involving South Carolina's more traditional fisheries, seeking a better understanding of the seasonal distribution, abundance, and habitat of a number of species. In addition, the department has worked with the Consortium on efforts to improve recreational fishing off the coast of South Carolina.



University of South Carolina

The faculty, facilities and coursework associated with the University of South Carolina form a hub of marine science work in South Carolina. The University offers an interdisciplinary Marine Sciences Program, including more than 100 courses available throughout the University's academic departments, all of which may be counted as credit toward a degree in the Program. Seminar courses in specialized areas such as coral reef fish ecology, biological clocks, coastal



Dr. John M. Dean
Department of Marine Science
Campus Coordinator

processes, plate tectonics, benthic ecology and bioenergetics are regularly offered by the faculty in response to student requests.

Students in the program also have an opportunity to participate in the Summer Field Program. Each summer, two five-week sessions allow students in Marine Science to earn credit through intensive field and laboratory studies at various locations along the coast.

The University's Belle W. Baruch Institute for Marine Biology and Coastal Research provides a focal point for marine research in the state by maintaining educational and research facilities on both the Columbia campus and at the Baruch Foundation's Hobcaw Barony just north of Georgetown, S.C. These facilities enable the Marine Science Program to accommodate the research goals of individual students and faculty.

Faculty and graduate student research, along with numerous field education projects, take place at the Institute's facilities located at Hobcaw.

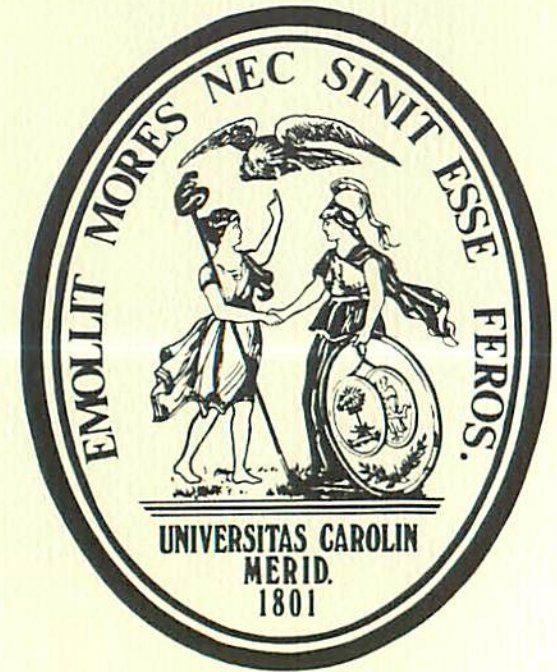
Research at the Hobcaw Barony has led to increased emphasis on coastal and estuarine research, and most of the current research efforts take place along the S.C. coast. However, there are many opportunities for deep-sea oceanography and research cruises throughout the world.

In addition, a number of other programs are actively involved in coastal and marine-related research and instruction. These include the Departments of Geology, Biology, Chemistry, Mathematics, Computer Sciences, the College of Engineering, the Institute of Archeology, the College of Business Administration, the Institute of Government and International Studies, and the School of Law.

Further interest in marine issues has been expressed by faculty members of some of the other University of South Carolina campuses, especially the University of South Carolina-Beaufort and the Coastal Carolina College in Conway. A Consortium-funded research project by a

U.S.C.-Beaufort professor began a survey of all tabby structures within the county and efforts to preserve some of the most significance.

During the two years covered by this report, the South Carolina Sea Grant Consortium developed a great many projects in cooperation with USC faculty and staff. Sea Grant has helped USC researchers consider the impact on coastal products of runoff from toxaphene and insect growth regulators; study the biomedical potential of S.C. marine invertebrates and salt marsh organisms; identify the predators of juvenile hard clams and survivorship of young adult hard clams; and analyze the laws involving emergencies and erosion control devices and the impact of the Law of the Sea negotiations on South Carolina. The interest in marine issues and breadth of expertise suggested by this partial list make USC a valuable member of the Consortium.



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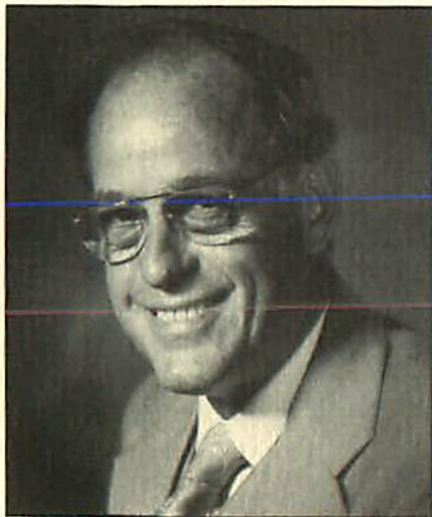
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THE RESEARCH

The ultimate goal of the South Carolina Sea Grant Consortium is to coordinate the talents, expertise, and facilities of its member institutions in order to develop, implement, and disseminate coastal and marine-related research. The emphasis is placed upon applied research that is based on the needs and concerns of the Consortium's constituents. Through the research, education and advisory service components, marine-related issues are raised, researched and concrete information is transferred to appropriate user groups.

A structured mechanism has been instituted by which program areas are identified. The Consortium in consultation with state and federal natural resource agencies, private industries and Marine Advisory Service personnel selects key targets for future Consortium research. For fiscal years 1979-1980 and 1980-1981, the first years of its operation, the Consortium structured those programs to address a wide range of marine and coastal issues and concerns of interest to the state and the region. By taking this approach, the Consortium sought to focus on those issues of greatest concern in a continuing effort to centralize the thrust of the Consortium's marine and coastal programs.

The research, education, and advisory service program projects presented in this report constitute the initial efforts of the Consortium to implement the National Sea Grant College Program in the state of South Carolina. For ease of presentation, these projects have been categorized as follows:

- Biological Science:** research on aquaculture and fisheries development and management;
- Environmental Science:** research on aspects of environmental pollution, pesticide impacts, parasitic infections, and marine biomedicine;
- Physical Science:** research on coastal processes, coastal engineering, and marine technology;
- Social Science:** research on law, economics, architecture, marine education, and technical assistance.
- Marine Advisory Service**

Thus, the projects summarized represent a firm foundation for the development of a well-focused program that responds to the evolving needs and concerns of the changing coast that is South Carolina.



Development of Malaysian Prawn Aquaculture

During the last ten years, pond culture of Malaysian prawns, *Macrobrachium rosenbergii*, has become commercially attractive in tropical and temperate climates. In this major project, Theodore I.J. Smith and Paul A. Sandifer of the Marine Resources Research Institute provided information which could lead to the development of viable prawn farming in South Carolina and elsewhere in the Southeastern United States. Pilot-scale rearing trials tested and evaluated pond stocking strategies; feed management practices; pond environmental conditions; and various means of reducing labor costs.

Stocking strategies: Test ponds (.25 hectare) were stocked with prawns of three sizes (post-larvae, juveniles, and a mixture of the two) and at three densities (2.14/m², 6.46/m², and 8.61/m²). The research indicated highest economic return from ponds stocked with small juveniles or mixed populations of postlarvae plus juveniles at low to moderate densities (4.3-6.5/m²). This approach provided the greatest return per unit of investment by reducing seed stock costs, increasing production levels, and increasing prawn harvest size and value of the crop.

Environmental conditions: Of all parameters measured, dissolved oxygen levels appeared to be the most critical. The best procedure tested for replenishing oxygen levels was to drain off the oxygen-depleted bottom water while adding new oxygen-rich surface water. Temperature, besides directly influencing growth rates of the tropical species, is especially important at the beginning and end of the growing season as it defines the appropriate time for stocking and harvesting of the prawns. Based on the research, a chart was prepared identifying satisfactory ranges for various environmental parameters.

Salinity: Prawns can tolerate and survive high salinity levels. Preliminary comparisons suggest

that at levels of 13.0 and 15.3 parts per thousand, prawn growth and survival rates were not substantially depressed. However, brackish waters up to about ten parts per thousand are probably most suitable for farming prawns.

Feed: Five diets were selected for study, based on commercial availability or potential availability, as well as protein content. In tank tests, the commercially available Purina 25% high fat diet was shown to be satisfactory and provided similar results to an experimental diet (NMFS 40%) containing 15% more protein. The Purina 20% high fat diet had potential and would cost less per kilogram. However, in this study the feed conversion (2.8) was 33% greater than the Purina 25%

high fat and NMFS 40% diets (2.1 and 2.2, respectively).

Processing: Prawns were processed by freezing both whole animals and a tails-only product, and by pre-cooking before freezing. The cooperative study with NMFS demonstrated that prawns can be frozen whole or as tails without substantial loss of quality. However, proper handling initially is extremely important. Pre-cooking whole prawns before freezing was not beneficial and may have caused some slight textural changes.

Marketing: Farm-reared freshwater prawns had good acceptability among seafood retailers and consumers. Retailers preferred fresh prawn tails in the medium-size count categories (78-110/kg),



Because Malaysian prawns cannot tolerate cold water temperatures, ponds in which they are cultured are drained each fall. The prawns that have not been harvested earlier are then removed, as shown above.

with prices competitive with marine shrimp. The method of preparation is important to overall acceptance, since 76% of those who rated the prawns fair or poor in texture and/or taste had boiled or sauteed them. Retailers experienced no difficulty in marketing previously frozen prawn tails.

The project's findings suggest good potential for viable prawn farming in South Carolina and throughout the southeastern United States as part of existing agricultural operations, if low cost seed stock are available. These data will provide the basis for the development of a prawn farming manual which will provide detailed recommended prawn culture management techniques.

Biology of the Rock Shrimp

Only since the mid-1970's has rock shrimp become recognized as a viable fishery resource in South Carolina. However, the fishery continues to show extreme fluctuations partly because the best fishing period for rock shrimp occurs during the nearshore commercial shrimp season.

Jane Davis, an M.S. student at the College of Charleston, under the direction of Dr. Norman Chamberlain, collected a total of 2,139 rock shrimp, *Sicyonia brevirostris*, off the South Carolina coast and examined them for basic life history information. Rock shrimp were captured in all months but April; the catch in July was limited.

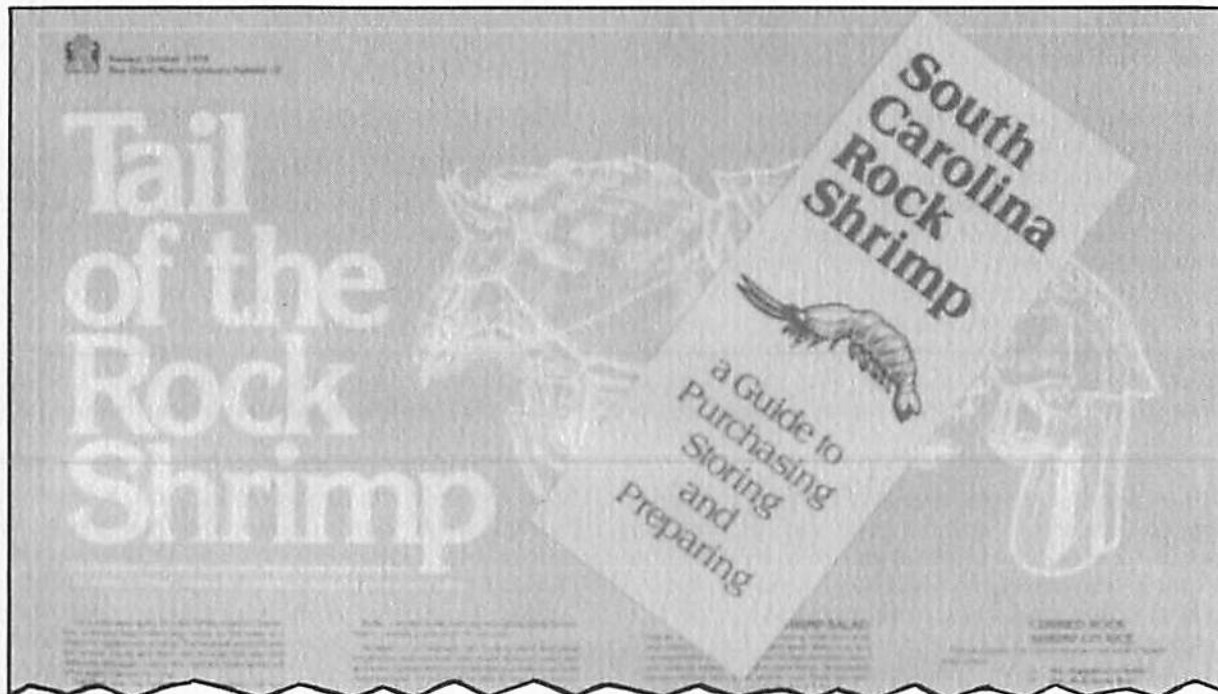
The sex ratio was found to be 1:1 overall, with no significant seasonal differences. Females appear to increase in weight faster and grow larger than males. In all size classes from 19 to 26 mm (all measurements = carapace length), males were more numerous than females, comprising 64% of the catch. However, the reverse held true for rock shrimp between 27 and 33 mm: 75% were females, 25% males. The largest numbers of sexually mature males were found in the months of September through January. Major months of spawning were found to be September through March. Length frequency analysis indicated that primary recruitment took place in March, May, and June.

The abundance of rock shrimp was found to decrease with increasing latitude and to be greatest in depths of 40 to 50 meters. Additional abundance data were obtained from MARMAP for 1973-1979, and analyzed by latitude, depth, and season. Parasites were found encapsulated in the heart muscles of 56.5% of those rock shrimp which were examined for this (all but 11 of the total samples). The diet of rock shrimp included family bivalves, gastropods, amphipods, and decapods, with evidence of opportunistic feeding.

Prior to this research, little was known about rock shrimp stocks off South Carolina. This baseline study provides initial biological information necessary for proper management of rock shrimp stocks off South Carolina.

Fishes and Decapod Crustacea in Four South Carolina Estuaries

The Marine Resources Research Institute has gathered data on fish and decapod crustacea from four major South Carolina estuaries — the North and South Santee Rivers, Cooper River and Charleston Harbor, Winyah Bay, and North and South Edisto Rivers — as part of the Estuarine Survey undertaken in South Carolina. Elizabeth



As the price of white and brown shrimp has risen since the mid-1970s, consumers have increasingly turned to rock shrimp as an alternative. Both the Consortium and the South Carolina Wildlife and Marine Resources Department have produced literature promoting its use.

Wenner of the Marine Resources Research Institute analyzed the data to determine the seasonal distribution and diversity of fishes and decapod crustacea in the four estuaries relative to environmental factors such as salinity and temperature.

In each of the estuaries, between seven and eleven species of fish were dominant in abundance (at least 90% of the total catch) and weight (at least 70% of the total biomass for all but Winyah Bay, where this was not recorded). Of decapod crustacea, three or four species made up over 90% of the number and weight in each of the estuaries studied. Atlantic croaker, star drum, weakfish, spot, hogchoker, and Atlantic menhaden were the major fish species; the dominant decapod crustacea were white and brown shrimp and blue crabs. Also found in quantity, though not in each estuary, were sea bob shrimp, bay anchovy, Atlantic bumper, white catfish and spotted hake.

In the Santee Rivers, the dominant fishes were present in fairly equitable numbers throughout the year; however, shrimp were more seasonal. Although species diversity was found to be related to salinity, temperature, depth, and dissolved oxygen, it was most noticeably affected by a spring freshet which considerably lowered richness and abundance. In the Cooper River and Charleston Harbor, the dominant species of fish and decapod crustacea formed species assemblages which were consistently encountered at every station during all seasons. In Winyah Bay and the Edisto Rivers, the number of species and individuals increased in the spring, became more abundant in summer with the addition of stenohaline marine species, and decreased sharply in the winter. Winyah Bay, the Cooper River, and the Santee Rivers were all found to be important nursery areas.

This project yielded a thorough assessment of the species composition of fish and decapods in the four target estuaries, providing baseline data for further comparative and impact studies.

Habitat Identification of Juvenile Snappers and Groupers

One of the most important commercial and recreational fisheries of the southeastern United States is based on the Snapper-Grouper complex in continental shelf waters. Yet little is known of the distribution and biology of the juveniles in the South Atlantic Bight from the time they settle from the plankton until they reach sexual maturity. One logistical reason is that the juveniles are rarely collected by conventional sampling techniques.

G. David Johnson of the Marine Resources Research Institute sought to test alternative methods (habitat traps and poison) of collecting these small secretive fishes, particularly juvenile groupers, that inhabit untrawlable rocky bottoms off the South Carolina coast. A total of 134 traps and ten poison collections (using rotenone) were made at two offshore locations. The traps produced 353 specimens representing 32 species; the poison collections produced 424 specimens representing 42 species. Of the 57 total species, 17 had not previously been recorded or are rarely taken from South Carolina waters. Thirteen juvenile grouper, representing four species, were collected. These results suggest that juveniles of these four commercially important species of grouper inhabit high relief, rocky, live bottoms of the outer continental shelf.

In preliminary experiments with habitat traps in inshore estuarine waters, juveniles of the gag grouper were consistently captured, allowing for identification of typical habitats, feeding habits, growth rates and recruitment pathways of this species.

In addition, over 500 postlarval gag grouper were collected with plankton nets as they entered Price's Inlet, a barrier island inlet north of Charleston, between April 2 and June 18, 1981. In general, the larvae enter on swift surface flood

tides and drop to the bottom to spend the next few months living among oyster beds in the tidal creeks. A total of 142 of the settled juveniles were collected during the summer.

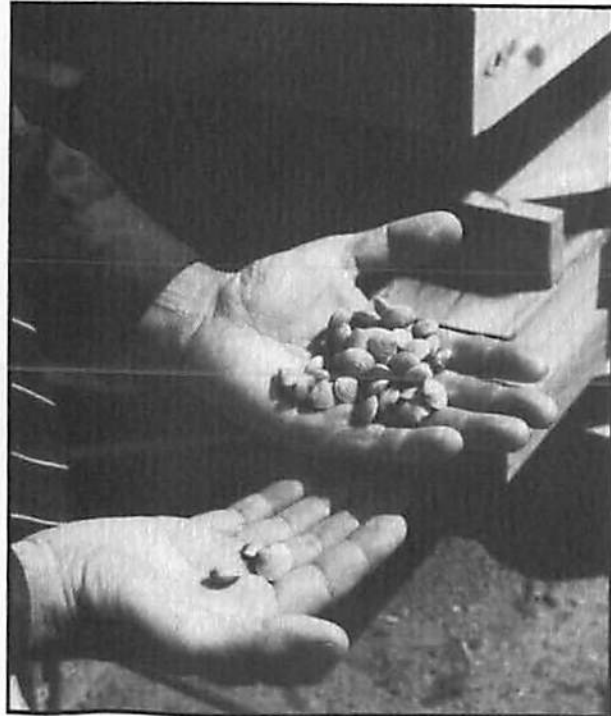
Johnson estimated that 210,000-530,000 post-larval gag grouper entered Price's Inlet in the nearly four months of the study. Significantly, these were large postlarvae (10-17 mm) which were almost certainly beyond the major early impact of larval mortality. Daily growth increments were counted in the otoliths of larva and juvenile gag grouper and used to derive information on spawning times and early growth rates of this species. These results confirm that estuarine tidal creeks serve as major nursery grounds for juvenile gag grouper.

Immunological Identification of Predators of Juvenile Hard Clam Cultures

Shellfish production on the east coast of the United States and specifically in South Carolina is dominated by two commercially important bivalves, the American oyster, *Crassostrea virginica*, and the hard clam, *Mercenaria mercenaria*. Because favorable conditions for growth of the hard clam exist in the relatively warm estuarine waters of South Carolina, a pilot-scale mariculture facility operated by Trident Seafarms, Inc. was established near Charleston to estimate growth and survivorship of seed clams in subtidal cages. However, under both natural and artificial conditions, unprotected juvenile hard clams are known to suffer tremendous mortality soon after settlement, and only a limited number of predators of juvenile hard clams have yet been identified.

Since successful culture of hard clams requires high survivorship of seed stock during subtidal growout, Robert J. Feller of the University of South Carolina sought to identify losses to predators of juvenile clams at the Trident Seafarms

facility. Immunological techniques were used to identify hard clam proteins in the guts of their natural invertebrate predators and to characterize antigen preparations (whole organism extracts) of different size classes. Logistic difficulties prevented a thorough temporal examination of potential clam predators, but the grass shrimp was found to eat juvenile hard clams. Immunoelectrophoretic separations of the whole-organism extracts revealed the presence of characteristic unique antigens among several size classes: veliger larvae, newly-settled spat, juveniles, and adults. These results reflect expected changes which occur for distinct morphological age or development stages of hard clams. Antisera useful for detecting this bivalve when visual methods are inadequate are available for use by others.



Demonstration of Hard Clam Aquaculture

The hard clam industry in the U.S. has traditionally been centered in southern New England, Long Island and Chesapeake Bay. Recently, however, poor clam harvests in many of these traditionally major production areas has led to increased interest in hard clam aquaculture in the Southeast.

John J. Manzi of the Marine Resources Research Institute has worked with Trident Seafarms, Inc. and the staff of the Marine Advisory Service to

establish a demonstration-scale hard clam project in Charleston County. A major goal of the project has been the development of raceway systems in which seed clams (0.5-6.0 mm) could be grown to field planting size (greater than 10 mm). Research on the biology of the hard clams raised in the raceways and the environmental parameters affecting survival and growth of the hard clams constitute the thrust of the project.

All experimental evidence has supported the concept of intensive hard clam aquaculture in South Carolina. Nursery systems appear necessary to support any aquaculture operation ap-



In clam aquaculture efforts, seed clams are grown from about one millimeter in size to more than ten millimeters (left) in nurseries. They are then transferred to cage trays, like those above, in areas between the low and high tide marks where they grow to market size. The cage trays protect the clams from many predators.

proaching commercial scale. Intertidal field grow-out units may be an economic alternative to subtidal or floating units. Field unit design alterations have been implemented which have successfully excluded predators from all field units. Survival rates of seed clams grown to field planting size have been unexpectedly high.

In the second year of this three-year project, Manzi will continue his work with nursery and field growout systems, determine chemical and physical water quality parameters and the biological constraints of specific culture protocols, provide an economic analysis of the project and review the extant and pending legislation and permitting regulations.

Advancements in Controlled Breeding of Crustacea

The aquaculture of crustacea demands major improvements in controlled breeding. For instance, although scientists and culturists can now reproduce several species of shrimp, problems frequently arise with spermatophore transfer by the male, the loss of the spermatophore by the female prior to spawning, or the inability to mate specific pairs. To correct this situation, scientists must gain a detailed understanding of fertilization events in shrimp, and then use that understanding to determine the possibility of artificial insemination and "test-tube" fertilization of shrimp eggs.

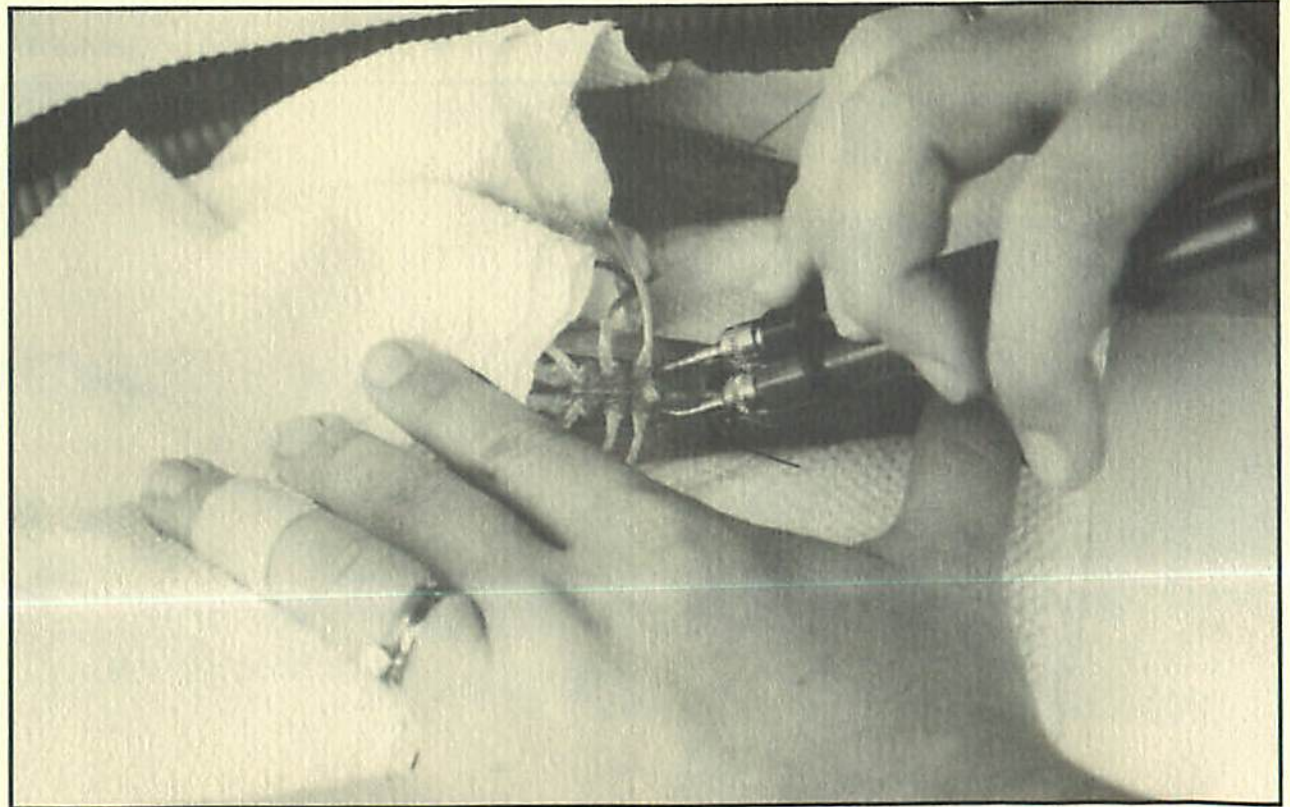
Paul A. Sandifer of the Maine Resources Research Institute is developing a detailed description of spermatophore fine structure and of the egg coats and cortical regions of the ovum. He has improved techniques of artificial insemination of prawns without apparent harm to the animals and developed the use of a chemical glue to attach the spermatophore to a receptive female. A simple apparatus for bringing free spawning grass shrimp eggs into contact with a sperm suspension was developed through a series

of experimental manipulations.

In the second year of this three-year study, work will focus on the refinement of artificial insemination techniques for multiple, simultaneous and sequential matings. Research will also involve the use of artificial insemination techniques to produce hybrids with improved characteristics for aquaculture.

Swordfish: Age Determination and Ecology

The swordfish in South Carolina is an increasingly popular recreational fishery species. Yet age estimation in such large pelagic predators has lagged behind work done with many other economically important fishes. Though the otolith is one of several hard parts utilized for age determination of fishes, the billfish otolith was



The possibility of Malaysian prawn aquaculture has led to studies of controlled breeding of the crustacea. Previous attempts generally resulted in the sterilization of the male prawns. A project of the Marine Resources Research Institute has found that slight electric shocks, as illustrated above, can be effective stimulus without damaging the animals.

thought to be either too minute, unclear for aging purposes, or without recognized circular annulae.

John Mark Dean and Charles A. Wilson of the University of South Carolina have collected 121 swordfish aboard commercial fishing vessels, located and removed their otoliths and examined them with a variety of techniques. Lengths and weights of the otoliths were determined and morphologies of these "earstones" were described using light and scanning electron microscopy. Examination of internal features of the sagittal otolith disclosed incremental patterns similar to daily and annual events of other fishes. Based on this microscopic examination, the

swordfish ranged in age from 50 days to 15 years. The vast majority (88%) were 2-3 years old, including equal numbers of males and females. Most swordfish in that age range weighed 35-50 pounds. This data has been used to validate age estimates made by other swordfish researchers, using the second anal spines.

This work made up the first year of a three year project. In the second and third years of this project, first-year research will provide the basis for data collection on the age structure, growth rate, and age at maturity of swordfish landed in South Carolina.

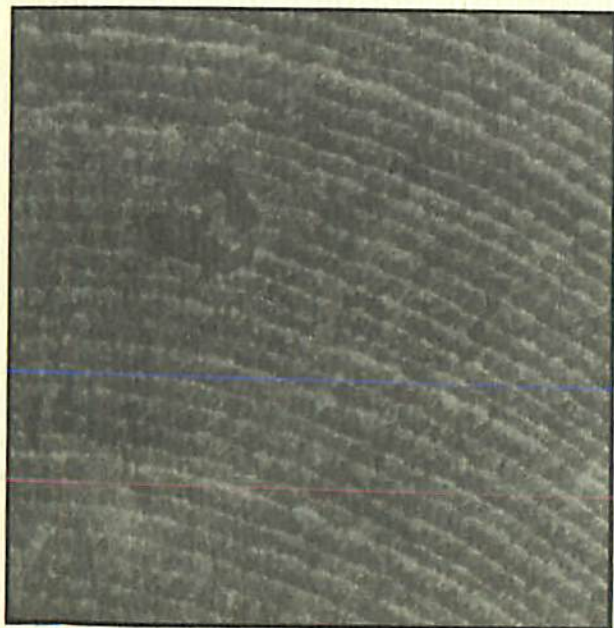
Shark Reproduction and Development

A by-catch fishery for sharks has recently emerged in South Carolina. State officials had earlier estimated that total annual landings of shark in this state were about 24,000 pounds. John P. Wourms of Clemson University has initially determined that the figure appears to be significantly higher. Yet unusual reproductive features, such as viviparity and the production of only a few offspring each generation, make shark popula-

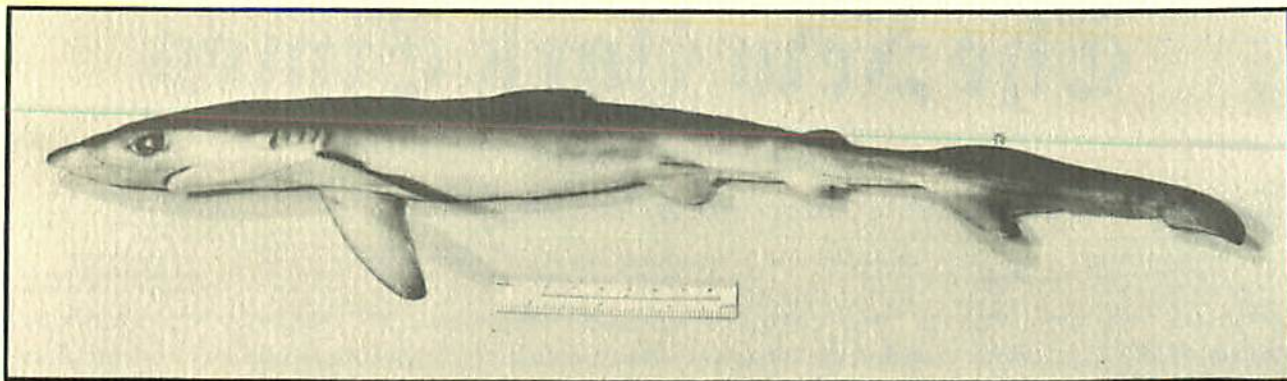
tions susceptible to overfishing.

Wourms has collected information about the reproductive biology of those shark species that inhabit S.C. waters. He has found that the fishery shows a seasonal progression of species caught, beginning with sharpnose and sandbars in late spring, progressing to blacktip, blacknose, spinner, and fine tooth. Smooth and spiny dogfishes dominate the winter catch. A preliminary estimate has been made of the yearly reproductive cycle of sharpnosed and sandtiger sharks. In winter, sharpnose sharks apparently migrate offshore. South Carolina appears to be a major pupping ground, nursery area, and mating site.

Two years remain in Dr. Wourms' three-year project. He originally intended to study skates and rays as well as sharks, but because these species are generally not targeted by the fishing industry (though both could be lucrative market fishes), Wourms will concentrate his work on sharks. A second phase of intense research activity will be pursued, in which the analysis of reproductive cycles and patterns will be initiated. A final phase will include the completion of data acquisition, analyses, and synthesis, and the generation and possible testing of models.



The age of many fish can be determined by counting and measuring the rings of their otoliths, or "earstones." Until recently, scientists thought swordfish otoliths could not be measured. U.S.C. researchers have proven otherwise. The otoliths, after laboratory preparation, can be read somewhat like the rings of a tree (above).



At birth, shark pups, like the full term blue shark embryo above, measure between 16 and 20 inches. Sharks are the target of a growing South Carolina by-catch fishery.

Effects of Toxaphene Insecticide on Estuarine Fish

Toxaphene is a heavily-used insecticide; over 26 million kilograms are applied annually to cotton, soybeans, grain and many other agricultural crops. Toxaphene is acutely toxic to estuarine organisms at low (ppb; parts per billion) concentrations. Lower levels (ppt; parts per trillion) have been reported to cause growth inhibitions and bone composition changes in fresh and estuarine organisms. The chemical nature of toxaphene is changed upon exposure to the highly reducing, anoxic sediments typical of southeastern estuaries. Both toxaphene and its degraded products accumulate in fish at concentrations up to 5000 times the levels found in the environment.

Terry F. Bidleman and Howard W. Harder of the University of South Carolina sought to determine changes in toxicity which occur when technical toxaphene is altered, or degraded, in reducing estuarine sediments. Experiments were carried out to determine the relative toxicity of an

environmentally-altered form of toxaphene to two species of common estuarine fish, spot and mullet. Acute toxicity tests were conducted, where 50% of the specimens died within 96 hours. Both technical and degraded toxaphene were used on both species.

Degraded toxaphene was found to be at least as acutely toxic as technical toxaphene. The toxicity of both compounds was approximately the same to spot, but degraded toxaphene was three times more toxic to mullet than was the technical form.

Sublethal effects of the two forms were assessed by exposing spot for nine weeks to 60-110 ppt of each of the chemicals. Growth was significantly lowered at all test concentrations for both technical and degraded toxaphene. All exposed fish were significantly smaller than the controls. This reduced growth was evident as early as week five of the experiment. Preliminary analyses of backbones (reflected by calcium and collagen) indicate some slight compositional changes in the exposed fish.

Update: On October 18, 1982, the U.S. Environmental Protection Agency cited health problems associated with toxaphene and banned most of its uses.

Effects of Insect Growth Regulators on Malaysian Prawns

During the last several years a new class of insecticide called growth regulators has been developed. These insecticides act by interfering with hormonal processes which control growth, reproduction, and/or molting. One type of growth regulating insecticide inhibits chitin formation and molting by interfering with the primary molting hormone. Since crustacea have the same basic molting hormone structure as insects, they could be affected by such insecticides.

Thomas K. Borg of the University of South Carolina sought to determine the effects of Dimilin, a chitin inhibitor that is currently registered for mosquito control, on larval and postlarval Malaysian prawns, *Macrobrachium rosenbergii*, a species which has shown potential as an aquaculture crop in South Carolina.

A total of 300 prawn larvae from several hatchings were tested in various levels of diluted Dimilin—10 ppm (parts per million), 1 ppm, 0.1 ppm, 10 ppb (parts per billion), 5 ppb, and 1 ppb. In addition, animals were tested in two control situations: in 1 ppt (part per thousand) acetone, the carrier solvent for Dimilin, and in 12 ppt Instant Ocean.

No difference was found in larval mortality between the two control situations over a ten day period in initial experiments. Subsequent experiments using Dimilin levels of 10 ppm, 1 ppm, and 0.1 ppm showed high toxicity to larvae, with 100% mortality occurring at each level by Day 3. Results indicate high mortality rates by Day 8 of both experimental and control situations at Dimilin levels of 10 ppb, 5 ppb, and 1 ppb.

Preliminary results from experiments on ten postlarvae indicate 100% mortality in all experimental groups—Dimilin levels of 10 ppb, 1 ppb,

The New York Times

THE NEW YORK TIMES, SUNDAY, OCTOBER 17, 1982

E.P.A. Plans to Curb Use of Toxaphene, a Pesticide

By IRVIN MOBOTSKY

Special to The New York Times

WASHINGTON, Oct. 16—The Environmental Protection Agency will restrict the use of toxaphene which was

conclude that winds were sweeping the pesticide into far wider areas.

William A. Butler, the Audubon Society's vice president for government relations, asserted today that the re-

He said the Federal agency had not acted until it was prodded by a measure to ban the substance that was passed by the House, until this year's crop season had ended and overall production

four years. The previous Administration did nothing."

Representative Sidney R. Yates, Democrat of Illinois, who sponsored the bill to restrict use of the pesticide, said today he became concerned after toxaphene was detected in the Great Lakes. "It is transmitted by the winds to the lakes along the East Coast as

President Reagan signed, called on environmental agency to reach so decision within 90 days on what to about the pesticide.

Personal Motivation

Mr. Yates had a personal motivation as well in seeking the ban on the pesticide. In debating his amendment on 1

Studies by U.S.C. scientists revealed great harm to estuarine fish after exposure to minute concentrations of the insecticide toxaphene. Soon after that research was completed, the dangers were spotlighted by newspapers throughout the country. Toxaphene has subsequently been removed from use by the Environmental Protection Agency.

and 0.1 ppb—by Day 4. Controls and 1 ppt acetone postlarvae showed 100% survival through Day 10.

In this project, Malaysian prawn larvae, like insect larvae in nature, experienced difficulty in successfully molting; after exposure to 10 ppm, 1 ppm, and 0.1 ppm of Dimilin, experimental groups were found floating with their exoskeletons partially shed. The larvae apparently died during unsuccessful attempts to molt from Stage 1 to Stage 2. In contrast, control and 1 ppt acetone larvae molted without problems and were actively swimming.

These preliminary data strongly indicate a high toxicity of Dimilin at very low levels to larval and postlarval prawns. Further examination of this insecticide and its effects on crustacea is necessary as this insecticide becomes licensed for more uses and as the feasibility of farm-pond rearing of prawns (and other crustacea) in South Carolina improves.

A Simulation Model of Mercury Toxicity in the Salt Marsh

Many cases of mercury contamination have been documented along the South Carolina coast. Concentrations of mercury in oyster tissue from several of South Carolina's coastal marshes have been recorded in levels higher than 200 parts per billion (ppb).

H. N. McKellar, Jr. of the University of South Carolina sought to integrate the available information on life cycle kinetics of marine organisms with the distribution and biological effects of toxic substances in the marine environment. As a test case, the effects of mercury, a heavy metal, on the fiddler crab, a dominant and well-researched organism on the S.C. coast, were evaluated. The primary focus was on literature synthesis and model development; some baseline data were collected on levels of mercury contamination in several sites.

A simplified base model was formulated incorporating much of the published information on population energetics and life cycle dynamics. The model is based on seasonal exchanges between the adult fiddler crabs in the marsh and their larval stages in estuarine waters.

Laboratory studies have shown that mortality was 17.5% higher among fiddler crab larvae exposed to 1.8 ppb mercury than among control larvae. A normal mortality rate of planktonic larvae in the North Inlet estuary was estimated at 1,742 individuals/m²/day. The additional mortality due to the contamination of 1.8 ppb mercury would be an additional 304.9 individuals/m²/day. Such conditions were simulated using the model to project possible effects on the adult population and their long-term survival.

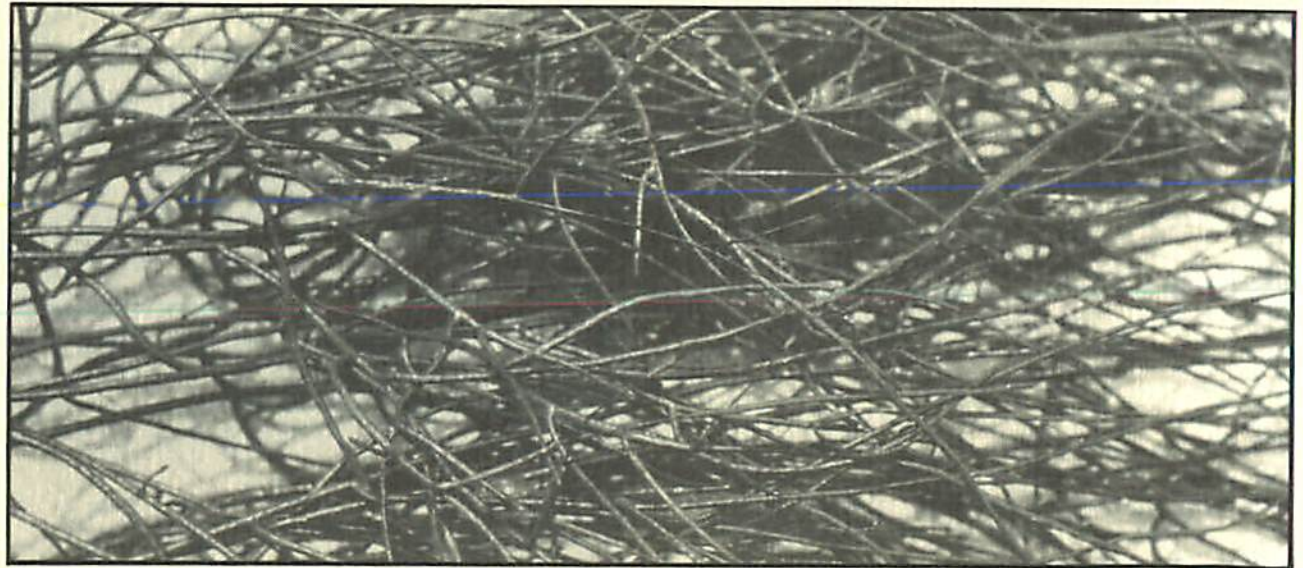
The model developed in this study represents an initial attempt to address the critical issues of the long-term impact of toxic substances on estuarine organisms.

Identification of Biologically Important Lectins in South Carolina Invertebrates

Edwin H. Liu of the University of South Carolina sought to determine whether biochemicals with possible commercial importance could be found in near-shore organisms along the South Carolina coast. Specifically, marine invertebrates were analyzed for significant quantities of lectin, a group of carbohydrate-binding proteins which are currently of great interest in medical and genetic engineering research.

Lectins were found in more than a quarter of the 47 organisms tested. In 12 of the species, the presence of these types of compounds had not previously been reported.

In addition to the initial screening of the 47 organisms, the biochemical structure of the lectin from the marine coral *Leptogorgia virgulata* and



A common inshore coral, *Leptogorgia virgulata* (above), was shown in studies by a U.S.C. scientist to contain a powerful carbohydrate-binding lectin, useful in biomedicine and pharmacology.

its mechanism of action were identified. This lectin is a compound which attaches to precise combinations of more than one sugar unit. These sugar arrangements are important units of the membranes of mammalian cells.

L. virgulata had not previously been reported to contain lectins. The study has shown that this lectin has useful properties which had not been found in other organisms, and which make it potentially important for medical research. The lectin is comparable to another now being sold by biochemical supply houses, and could provide an alternative source for the production of the presently-marketed lectin.

Environmental Factors Affecting Hard Clam Survival

Though the hard clam shows promise as a South Carolina aquaculture species, much information is still unavailable on the environmental factors affecting its growth and survival. F. John Vernberg and T.J. Pandian of the University of South Carolina sought to analyze the responses of young adult hard clams exposed to various combinations of environmental factors. They will then compare these results with those of larger-sized individuals.

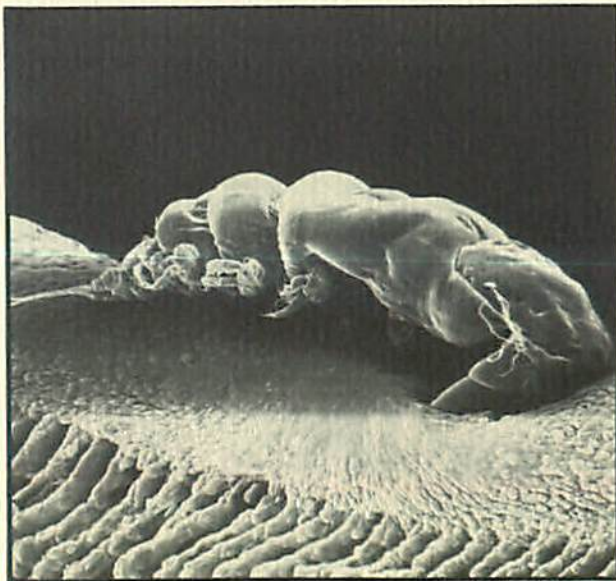
Techniques have been developed to maintain both small and large adults under laboratory conditions necessary for experimental purposes. Beginning efforts have been made to induce spawning. Studies have sought the response of small-sized clams to five different temperatures (35°, 17°, 15°, 5°, and 0°C) and five salinities (40‰, 30‰, 15‰, 10‰ and 5‰) in 25 different combinations. The data are currently being statistically analyzed. In general, the highest temperature was harmful at all five salinities, while little mortality was observed at the other combinations of temperature and salinity. Specific attention has also been given to respiration studies. Other experimental variables which were studied

include temperature, number of animals per flask, and size of flasks.

This is the first year of a two-year project. Based on the temperature and salinity studies, additional experiments on young adult hard clams are planned. Further analysis of temperature, salinity and respiration studies will be conducted and the work on reproduction will continue.

Parasites of Cultured American Eels

A major factor limiting the development of eel aquaculture is the susceptibility of eels to parasitic diseases. Arnold G. Eversole and Steven S. Hayasaka of Clemson University have monitored eels at a commercial aquaculture facility on a monthly basis for animal parasites, disease, and disease susceptibility. Glass eels and early elver stages were found to be resistant to bacterial diseases. Adult eels were shown to be most susceptible to bacterial disease during warm



summer months as a result of higher water temperatures.

Prophylactic treatment with formalin on elvers for one hour resulted in significant decreases of the frequently-occurring species of parasite, *Trichodina*. Significant declines in infestation were not observed in other parasites after treatment. In similar tests, dip treatments with potassium permanganate appeared to be more effective and safer than salt in treating elvers infested with another parasite species.

Bacterial pathogens causing disease in adult eels were isolated, identified, screened for antibiotic



Two Clemson researchers have successfully identified a number of parasites that infect eels. *Ergasilus celestis*, left on the gills of an American eel, is just one of the many parasites. *Opecoeloides fibriatus*, above, is a trematode found in the visceral mass of the animal. Infection and disease is a major consideration in eel aquaculture.

susceptibility and a fluorescent antibody technique was developed for identification of the primary bacterial pathogen. A fluorescent antibiotic technique was developed to identify quickly a primary etiological disease agent in eels. Antibiotics were also screened for their effectiveness in inhibiting the growth of pathogenic isolates.

One year of study remains in this two-year project. Examination and treatment of monthly samples from culture ponds will continue until the eels are ready for market.

Using Marine Substances to Reduce Disease in Aquatic Animals

M. M. Sigel and L. J. McCumber of the University of South Carolina have demonstrated that Ete, an extract of a marine invertebrate, is capable of enhancing the resistance of the American eel to disease caused by at least one pathogenic bacterium. Their research suggests that Ete may enhance resistance of other aquatic animals to infection and disease.

This research indicates that the time of Ete injection, route of administration and the temperature at which the animals are maintained may all determine the ability of Ete to enhance resistance to infection. The results also suggest that the survival of the infected animals is influenced not only by the ability of the animal to produce antibodies but by nonspecific factors such as phagocytosis. Ete has a very definite effect on phagocytic activity.

One year of work has been completed on this three-year project. Although injection has been the primary method used thusfar for testing the ability of Ete to enhance resistance, subsequent research will include the testing of other methods of application, such as immersion. Future work will continue on the examination of the physical

mechanisms by which Ete is effective, will develop exposure techniques for use of Ete in field applications, and will determine the molecular nature of the active components in Ete.

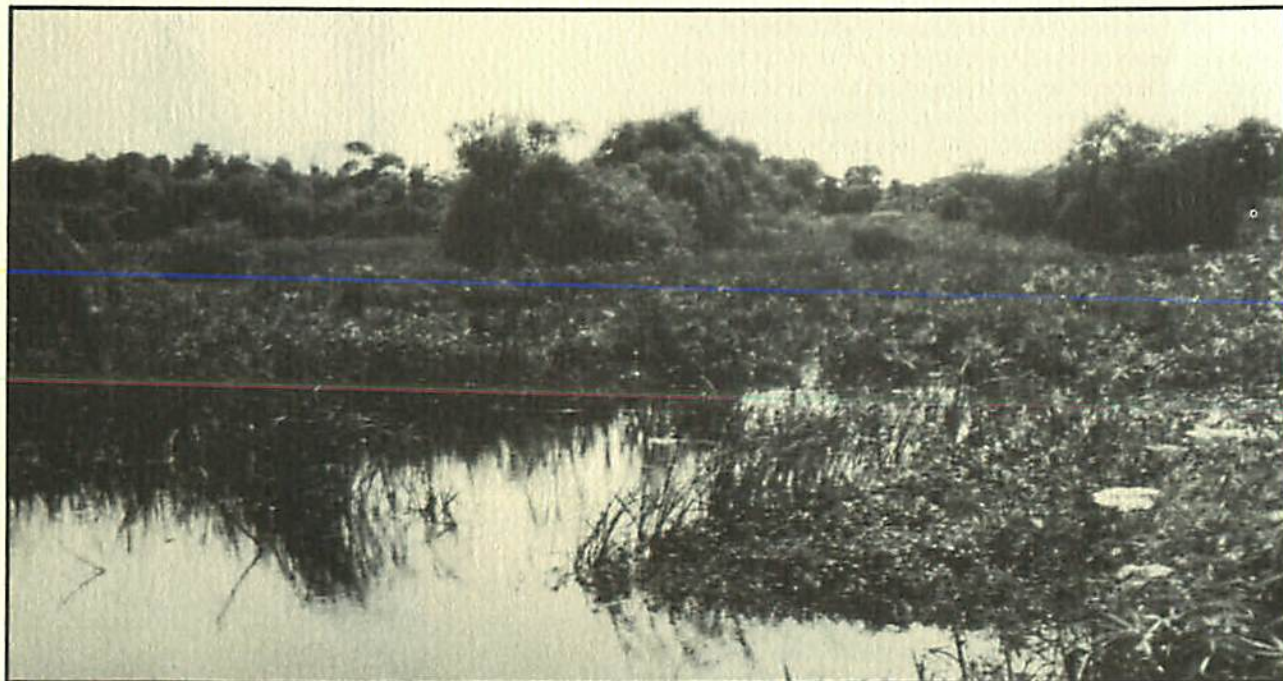
Discovering New Medicinal Agents from Marsh and Sea Plants

More than half of the most important drugs used worldwide come from natural sources. The salt marsh especially can provide alternatives to drugs that originate in petroleum products.

T. A. Bryson of the University of South Carolina has sought to isolate, purify, and characterize new medicinal agents of marsh and sea plants. He has

identified plants (including salt grass and bull rush) whose crude extracts display anti-cancer activity, and has discovered groups of other plants which appear likely to exhibit such activity. In-house testing procedures as well as new separation techniques for efficient isolation of natural products have been developed which complement external testing methods. A furano compound with juvenile hormone activity has been identified, and several purified compounds have been isolated from active plants.

This has been accomplished in the first year of a four year project. Having purified the active agents of these plants, the researchers will now direct more attention to isolating and identifying those natural products that are unique, structurally intriguing, or of significance to chemically inter-related inland, sea, and marsh plants.



A number of plants from the salt marsh have been found to have medicinal properties.

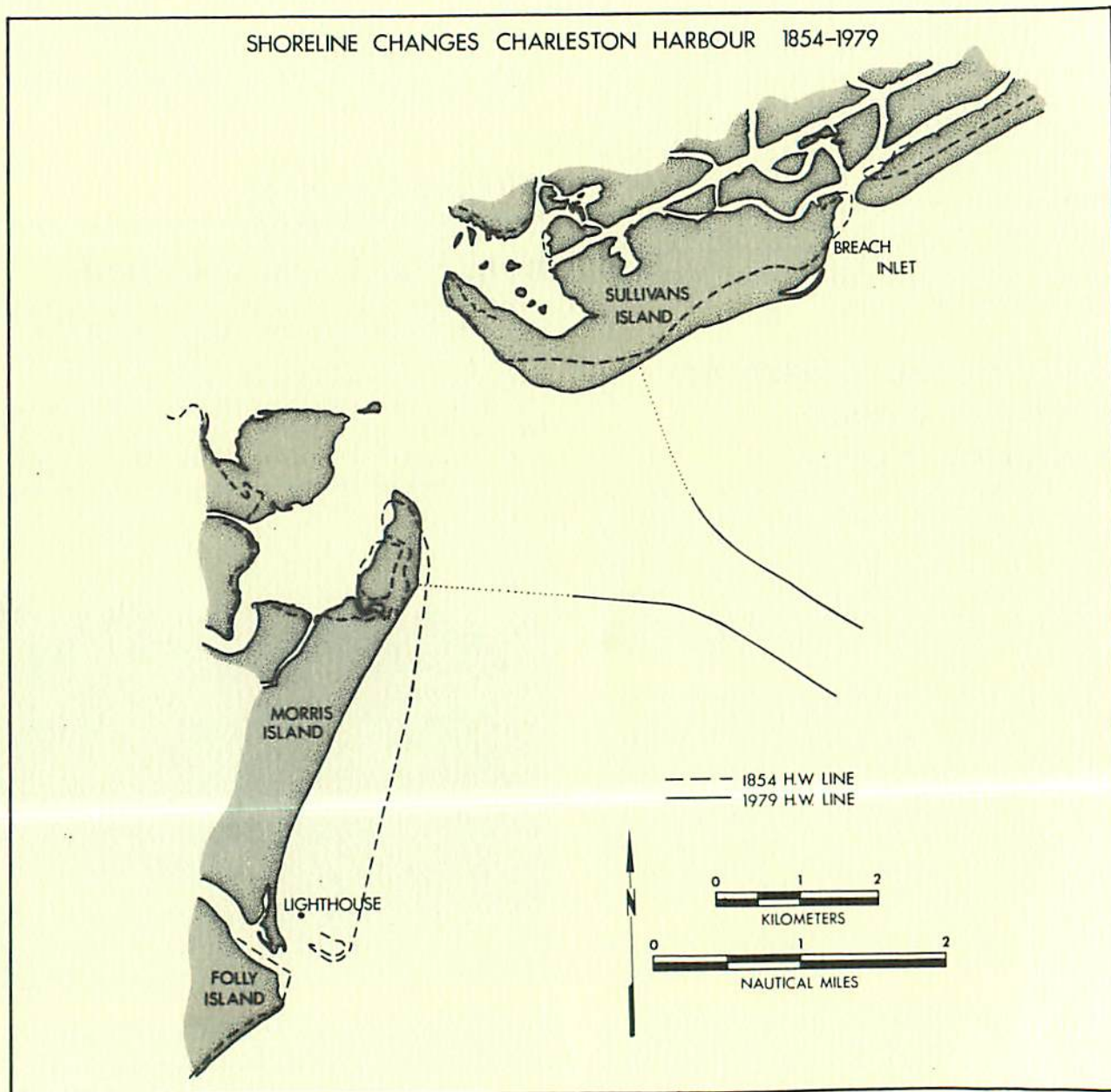
The Stability of South Carolina Navigational Channels

The coast of South Carolina is characterized by a variety of navigable channels which include tidal creeks, salt marsh rivers, tidal inlets between barrier islands, harbor entrances, and the major South Carolina sounds. The effects of ebb and flood tides, wave patterns, and longshore transport of sand upon the stability of these channels can be profound. The movement of sand along the beaches resulting from longshore transport is significantly affected by the presence of tidal inlet channels. Tidal creek and river channel behavior is quite variable and complex. Sounds and embayments, characterized by the presence of intertidal-subtidal sandbodies and wide muddy tidal flats and marshes, are significantly influenced by ebb and flood tidal currents. The effects of tides, waves, and longshore transport upon these channels include channel shoaling, channel variability (i.e., migration, depth), and adjacent shoreline erosion and accretion.

Miles O. Hayes and Gary Zarillo of the University of South Carolina sought to summarize the historical changes of all major inlets along the South Carolina coast, along with the important aspects of coastal processes that control the stability and patterns of change for navigable waterways. In addition, the effects of inlets on the adjacent shoreline were summarized.

These data have been incorporated into an historical atlas of tidal inlet changes along the coast of South Carolina. The atlas presents in-

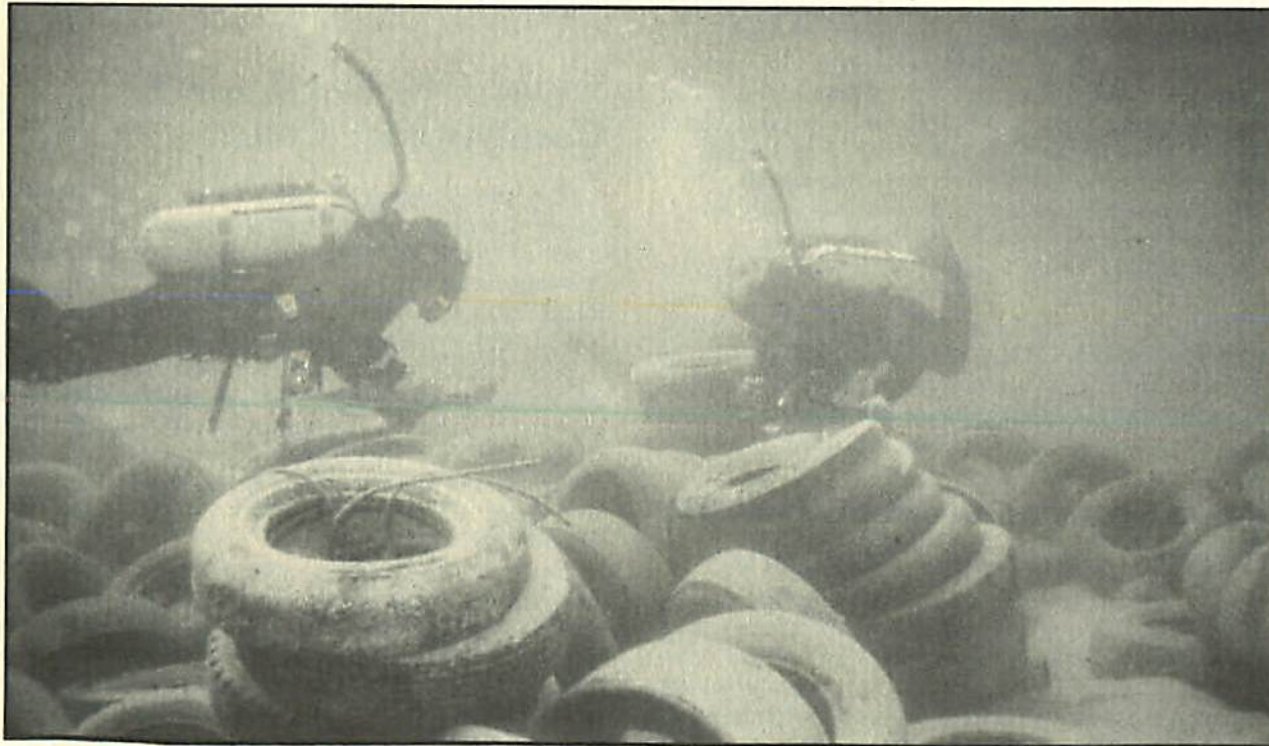
South Carolina navigational channels have shifted considerably over the past 100 years, and U.S.C. geologists have recently succeeded in documenting those changes. Their discoveries will be included in an atlas, to be published by the Sea Grant Consortium, with illustrations like the one on the right.



formation concerning the variability of inlet types along the Southeastern coast, provides a review of the historical development of major South Carolina inlets, emphasizing changes in channel configuration with time, and describes historical changes for inlets and embayments along the coast of South Carolina. Specifically, the atlas details the historical changes for the following inlets: Little River, Murrells Inlet, North Inlet, Winyah Bay, Price Inlet, Capers Inlet, Dewees Inlet, Breach Inlet, Charleston Harbor, Stono Inlet, North Edisto, St. Helena Sound, Fripp Inlet, Trenchards Inlet, Port Royal Sound, and Calibogue Sound.

The information contained in the atlas illustrates the behavior of navigable channels along the

South Carolina coast, which is extremely important to the economy of the state. The atlas can provide a basis for decision-making regarding building of coastal structures, (i.e., jetties), design of dredging plans and issuance of permits, and proper design of setback lines adjacent to inlets. The location of preferred natural orientations of inlet channels and channels across embayments identified in the atlas will aid in the logical development and maintenance of dredging programs. Information on shoaling behavior in major embayments can help eliminate or monitor navigational obstacles. Finally, the location of problem areas and variability of tidal channels within marsh and back-barrier environments can be used as an aid to coastal management and planning of future growth.



The Stability of Tire Unit Artificial Reefs

Artificial reefs have often been used to improve fish habitat where ocean bottom topography is relatively simple and barren. Automotive tires have been employed because they are abundant, relatively easy to handle, insoluble in water, ideal substrate for encrusting organisms, and provide excellent fish habitat. However, tire units have often migrated during exceptionally severe weather and have littered beaches, hampered commercial trawl fisheries and eluded potential anglers.

DeWitt O. Myatt of the Marine Resources Research Institute studied tire unit stability by establishing three experimental test plots off the South Carolina coast. The sites are:

- 3½ miles offshore of Murrell's Inlet—30 feet of water
- 6 miles offshore of Kiawah Island—45 feet of water
- 10.9 miles offshore of Hunting Island—60 feet of water

Five types of tire units were tested: unballasted single tires, ten-tire bales, 24-tire triads, 100-tire units and six-tire mid-water units.

Observations by divers revealed that 100-tire bales were unsuitable because they moved off the test sites. Triad units had mixed results—one unit, located in 60 feet of water, migrated within an hour of submersion, while another, located in 45 feet of water, has remained stable for six months and hosts an excellent population of fish. Ten-tire bales, ventilated single tires and mid-water units have not moved at any of the test sites and appear to be the best units of those tested for artificial reef construction in the South Atlantic Bight.

Divers (left) check the stability of tire unit artificial reefs built off the South Carolina coast. Though some of the tire units moved, many appeared stable and provided excellent fish habitat.

Since no severe weather conditions developed off the South Carolina coast during this study, conclusive information about the stability of the units under those conditions is still lacking. The sites are now being monitored by the S.C. Wildlife and Marine Resources Department.

In addition, Billy Edge of Clemson studied the forces on artificial tire reefs. Calculations were made of horizontal velocities and forces on the reefs, as well as wave energies per unit crest width. With this data, the stability of similar units can be predicted at sites with comparable depths and wave climates.

The Exchange of Organic Materials Between Marsh and Ocean

For years, scientists were unable to detail the exchange of materials that occurs between coastal marshes and oceans. L. Harold Stevenson of the University of South Carolina tested the hypothesis that filamentous fungi could serve as an indicator of the flushing of intertidal detritus and sediment components into the water column, specifically within the North Inlet ecosystem near Georgetown, South Carolina.

The research found that waters in the high marsh move horizontally in the marsh during tidal action. In addition, the tidally-induced rhythmic behavior of fungi concentrations was found to be constant through all seasons. These patterns at the marsh-ocean interface indicate a predominance of filamentous fungi in water that is draining from the marsh surface. During four individual studies (February, May, July and October-November) in a high marsh area, 122 observations were made. The propagule densities measured during late summer and fall were two to three times greater than spring and summer samples.

The project found that the magnitude of export of fungi from the marsh far exceeds the magni-

tude of import from the ocean. The net exports were similar for both spring and winter. In the spring tide sampling, only on the second tidal cycle were fungi imported to the marsh; the net import was small compared to the export rates. No instance of net import over a tidal cycle was recorded for the summer expedition. During the fall sampling period, two instances of net import per tidal cycle were noted. However, the net transports calculated for the neap-tide expedition were the lowest rates encountered throughout the study.

The variations in propagules per liter over a tide cycle indicated that new ocean water that enters the marsh with the tide does not intrude appreciably into the high marsh. Apparently marsh water that remains in the system during low tide is pushed back into the high-marsh area during the following flooding tide.

This study suggests possible uses for filamentous fungi in other oceanographic areas. Since fungi are exported from the marsh on a regular basis, they might be used to trace the movements of water that enter and then exit the marsh. They may also be employed to determine the re-entry of water into the marsh on rising tides.

In addition, since fungi were earlier found to colonize the marsh grass, *Spartina*, further research might consider if they were the result of hyphal fragments found within small bits of *Spartina* detritus. If so, fungi may be a useful tool in examining benthic-pelagic coupling.

Development of an Automatic Shrimp Deheader Machine

By far the most important fishery off the coast of South Carolina is the commercial brown and white shrimp fishery. Harvesting techniques continue to improve, but the post-harvest processing of shrimp is still conducted manually. Since costs related to shrimping continue to increase, cost-

saving steps are being explored.

John A. Collier of Clemson University has begun the development of a prototype dockside shrimp deheading machine, which has the potential to dehead shrimp at three to four times the rate of manual deheading. Initial test runs have shown that 65-70% of the shrimp processed through the machine are deheaded—the goal of the research is to bring that figure up to 98-99%. In addition, the deheader is being fit with a “sizer,” which would enable it to separate the shrimp by size before they are deheaded.

Further research will continue on this project. The efficiency of the deheader will be improved, laboratory testing will continue, and an examination of applying this technology toward the development of an “on-board” deheader will begin.

South Carolina Coastal Construction Codes

Not since Hurricane Gracie in 1959 has the South Carolina coast been battered by a major storm. Construction in the coastal area of the state has increased dramatically since that time, and much of it has been designed with little concern for potential storm damage.

Billy Edge, John Fisher, William Connor and Soronadi Nnaji of Clemson University are preparing a South Carolina Coastal Construction Code (SCCCC) which would help builders avoid future storm damage. This work was initiated by the Consortium, and continued by the South Carolina Coastal Council.

Most South Carolina coastal counties now depend on the Southern Building Code Congress (SBCC) regulations for their building codes. Though the SBCC is an excellent code for normal building construction, it is woefully inadequate as a hurricane code. The SCCC improves on existing codes by utilizing the Federal Insurance

Administration guidelines. It is also more performance-oriented and gives extensive latitude to the designer to fulfill the basic requirements.

The two most important storm characteristics for which the S.C. regulations were designed were wind speed and storm surge height. In addition, the code was planned to protect buildings from scouring, battering, water load, and storm waves.



help protect future buildings from hurricane damage. (Photo courtesy of the Charleston Evening Post/News & Courier.)

The last major hurricane to strike the South Carolina coast was over 20 years ago, when Hurricane Gracie put much of Charleston's Battery underwater (above). A Clemson professor has proposed a construction code that would

Economics of Pond Culture of Malaysian Prawns

Pond cultivation of freshwater prawns, *Macrobrachium rosenbergii*, has become commercially attractive in many parts of the world, especially in climates where the prawns can be grown year-round. In temperate areas such as South Carolina, the growing season is restricted and discontinuous since winter water temperatures are lethal to prawns. The economic feasibility of such farming is, therefore, significantly different from similar farming projects in warmer climates.

Larry Bauer of Clemson University sought to determine costs and returns for prawn farming as a supplemental enterprise in South Carolina. He considered the following alternatives:

- Existing vs. new investment in the ponds and a water well,
- Two marketing strategies (all prawns deheaded and tails sold at local shrimp prices; larger prawns sold as whole frozen animals with remainder deheaded, and tails sold at local shrimp prices),
- Three stocking rates (4.3, 6.5, and 8.6 animals/square meter),
- Various prices for seed stock.

In addition, annual fixed and variable costs were estimated. Fixed costs included construction of ponds and harvest basins, levee stabilization, well drilling, and purchase of pump, pipe, seines, instruments, feeder, storage space, and aerators. Variable costs were labor, fertilizer, lime, feed, electricity, ice, tractor and truck use, and machine maintenance and repair.

The net revenue estimates conclude that prawn aquaculture has the potential to become a source

Malaysian prawns have shown promise as a South Carolina aquaculture species, and have been well received by seafood retailers and consumers. But the potential problems — especially those involving cost — still need to be resolved.

of supplemental income to farmers in South Carolina's coastal plain area and throughout much of the American Southeast. This is especially true if the enterprise can make use of existing facilities that are already discounted into the value of the land or were constructed during a period of lower investment costs. Seed stock prices are significant and have dropped markedly in recent years. A further drop in the price of seed stock, perhaps through government subsidy, could greatly enhance the development of the state's prawn farming operations.

Tabby Structures in Beaufort County

Tabby is a substance composed of lime derived from calcined shell, whole shell aggregate, sand, and water. It was used as a building concrete on the southeastern coast in the 18th and early 19th centuries. Larry Lepionka of the University of South Carolina-Beaufort surveyed tabby structures in Beaufort County, preparatory to a larger study of the South Carolina coast.



Eighty tabby sites, some consisting of several structures, were investigated. Particular attention was paid to types and functions of structures, methods of construction, relationship to other building materials, proximity to shell sources, roads and navigable waters, dating from documentary and artifactual evidence, distinctive ceramic associations, evidence of former floral regimes, present and former shorelines and sea levels, and spatio-temporal distribution.

Some of the structures studied have undergone virtually total destruction, while others have been continually maintained. A major concentration is located in the town of Beaufort; otherwise, tabby

was found primarily in plantation clusters, most frequently on St. Helena and other small islands (Datha, Spring, Callawassie) in the estuary. Dates of the structures range from the 1730s to the 1840s.

Based on this project, a number of semi-public utilized sites and ruins will be recommended for inclusion in the National Register of Historic Sites, pending consultation with developers and, in some cases, excavation to determine full significance. Certain high priority sites were selected as warranting intensive excavation, notably on Datha, Daufuskie and Callawassie Islands, at Fort Lyttleton near Beaufort and at the Coffin Point Plantation slave quarters.



When a U.S.C.-Beaufort professor sought examples of tabby in Beaufort County, he found that it ranged from standing, occupied buildings to others which demanded excavation, as illustrated above.

UN Law of the Sea Negotiations: Impact on S.C.

The Third United Nations Conference on the Law of the Sea (L.O.S.) was convened in December, 1973 with 140 nations present. The largest international conference ever assembled, it was to draft a comprehensive treaty which could serve as the basis for a new international regime for the oceans.

Robert S. Jordan of the University of South Carolina studied the L.O.S. negotiations and concluded that whatever the U.S.'s level of participation, this country would face considerable pressure to declare a 12-mile territorial sea. If it does, the management of this expanded oceanic territory will probably be the single most important issue to face coastal states. Jordan explored six strategies by which South Carolina could manage this expanded territory.

Since South Carolina's coastal waters contain limited valuable mineral and fisheries resources, the state would gain questionable benefits by assuming direct management over the expanded territory. Because of this, Jordan suggested that the state support the adoption of a joint state-federal management option for the outer nine-mile area of the expanded territorial sea. Such a plan would allow South Carolina to gain revenues from leases while not unduly burdening itself with the costs of managing the territory.

UPDATE: On April 30, 1982, the United Nations voted 130-4 in favor of the Law of the Sea treaty. The United States, Israel, Turkey and Venezuela voted against it. Abstentions were cast by 17 nations.

In view of the current Administration's contention that the United States will tacitly abide by many sections of the LOS treaty, the United States will most likely move toward a 12-mile territorial sea as other states begin to implement those provisions of the treaty.

Undergraduate Summer Research Opportunities

During the summer of 1979, James W. Smiley of the College of Charleston organized a multi-disciplinary project to encourage outstanding undergraduate science students to pursue graduate studies and careers in marine science. Students from throughout the state competed for the opportunity to participate in a full-time research project at one of the state's two major marine science facilities, Fort Johnson or Hobcaw Barony. Twelve students were chosen to participate in the program.

The requirements of the program included full-time work during the summer on a research project which was completed at the end of the fall semester. All students attended a bi-weekly interdisciplinary seminar alternating between Fort Johnson and Hobcaw Barony. In addition, a final report on the results of their projects and an oral presentation of those results were required from each student.

In addition to providing a unique opportunity to observe and participate in a supervised research project, the program gave students more information about the various marine research fields and the impact of such research on coastal and marine resource users.

Marine Science Education for Minority Students

The percentages of minority involvement in marine science research or businesses is small, however, South Carolina houses 5 black colleges; among the largest, South Carolina State College.

J. H. Arrington of South Carolina State College conducted a project which sought to emphasize marine science education in predominantly black institutions and communities.

In one aspect of the project, ten minority students from South Carolina State College, Benedict College and Voorhees College took part in a six-week marine education program during the summer of 1980. In a highly cooperative, inter-university program one half of that time was spent in science classrooms at USC-Columbia, the other half involved field studies in Beaufort, including individual research projects. The student response was positive; many sought to continue their studies after completion of the summer program.

The project also sponsored a Community Workshop in Orangeburg which attracted over 120 people. This workshop sought to introduce low-

income families to the availability of little-used seafoods, and discussed possible means to enhance their nutrition and flavor. A faculty member from South Carolina State's School of Home Economics discussed the selection, storage and nutrition of seafoods. A variety of seafoods were displayed, and samples of shrimp and rice, broiled rock shrimp and smoked mullet were prepared.

The program provided a good basis for cooperative efforts between the University of South Carolina, Clemson University and South Carolina State College (and other minority colleges) to increase the awareness of participation of minority individuals in marine-related fields.



South Carolina State College has sponsored a summer program which introduces minority college students to marine science. The program includes both field research and classroom study.

Plans for Coastal Education Activities

Despite the significance of coastal and marine issues in the lives of South Carolinians, educational activities about those issues have been limited. An Education Study Group, chaired by

John Mark Dean of the University of South Carolina, was established by the Consortium to investigate the needs for educational activities: to "provide the citizens of South Carolina with the opportunities to become knowledgeable and develop a sense of responsibility for the wise use of South Carolina's marine resources." The group



Marine education classes have been increasingly included in South Carolina school coursework. A Consortium-funded project considered the future needs of such programs, and recommended steps to improve them.

considered the educational needs of three groups: Kindergarten through Grade 12, undergraduate and graduate education, and public education.

K-12: The study group recommended the immediate establishment of a team to review educational materials for K-12 instruction in marine studies, and recommend those that can be used in this state. The study group expects that some material will have to be revised or written. Workshops would allow for the revision and writing of needed material, and the training of state teachers in the use of those materials. The greatest need was expected to be in grades K-5.

In addition, the study group recommended that the S.C. Sea Grant Consortium develop a plan for coordination of marine science education activities on a project basis. The group also proposed establishment of three marine science education centers, with specialists at each one.

Undergraduate and graduate: The study group suggested establishment of at least three graduate student fellowships supported by the Consortium in areas consistent with the interests and objectives of Sea Grant. These fellowships would be offered each year and would be renewable for one year for Master's students, and for two years for Doctoral candidates. Among the areas that were recommended for emphasis and continuation were: research experiences for undergraduates (as at the College of Charleston); minority student programs (as cooperatively run by S.C. State College and USC); summer courses (as offered by College of Charleston, USC, and USC-Beaufort); intern programs with businesses and federal and state agencies; such applied sciences as aquaculture, fisheries management, marine policy, and marine biomedical research. A planning process was recommended for an advanced degree program (M.S. and Ph.D.) in coastal zone management in South Carolina. A review of existing curricula and programs for marine education with the fishing industry led to

the proposal that students be supported with tuition grants for existing institutions (none existed in the state) in two-year programs in "Fisheries Technology" or "Marine Technology."

Public Education: The study group recommended: publication of a directory containing the marine research and education people in the state, their areas of expertise, and where they can be located; a public lecture series such as that run by the Belle Baruch Marine Field Lab; coastal ecology classes for children, such as those offered in Georgetown; coastal issue workshops and field trips for policy and decision-makers; workshops for the Parks, Recreation and Tourism naturalists; one-day workshops for teachers on coastal topics; and public interest spots on radio and television.

Coastal Powers of Government Agencies

The beauty and economic value of the South Carolina coast has produced a not surprising conflict about the area's use and development. Property owners, developers, industrial and commercial concerns often believe that this area should be fully utilized, and that they should be restrained minimally with regard to the environmental impact of any particular activity. At the same time, many conservation and preservation groups demand that due consideration be given to the environmental effects of any proposed activity, thereby restricting development. State and local governments have responded to this conflict by producing a maze of often-contradictory regulations.

R.M. Chastain, of the University of South Carolina Law School, has discovered that though the South Carolina Coastal Council is the primary state agency responsible for permitting activities in the "critical areas" of the coastal zone, at least 17 other state agencies also currently or

potentially exercise regulatory authority there. In addition, a number of local agencies are also involved in coastal permitting.

Statutes, cases, regulations and ordinances which effect coastal issues have been researched, especially regarding emergency authority and the regulation of erosion control structures. The responsibilities of all major state and local agencies have been identified and their permitting procedures explained in detail. Areas of potential conflict between state agencies are suggested.

This work received major funding from the Coastal Council.

A Management Model for the Charleston Metropolitan Waterfront

Throughout the 1970's urban waterfront revitalization was adopted as a means for promoting economic development in many U.S. cities, becoming a major economic development "tool" in many of the country's older declining cities. Charleston, however, is a growth city with a relatively underdeveloped waterfront. The primary issue in Charleston will be the management of new waterfront development and its social and environmental impacts. Roger R. Stough of the



Many South Carolina communities, like Folly Beach, shown above in a 1969 photo, have suffered severe erosion problems for many years. Local governments have too often responded by passing contradictory laws. A recent Consortium study has sorted out the responsibilities of both local and state governments. (Photo courtesy of Charleston Evening Post/News & Courier.)

College of Charleston developed a public/private sector multi-political jurisdiction process to enhance the management of Charleston's waterfront development.

During the summer of 1980 a parcel-by-parcel land use map of the Charleston metropolitan waterfront was produced. This map also included the ownership of each waterfront parcel. These data were used to determine the use status for each ¼ mile segment of waterfrontage in the region. A multiple objective waterfront land-use

programming model is being developed and tested using the land-use data. This model will be used to forecast future waterfront land-uses under different assumptions concerning future growth pressure on waterfront land. Plans have been made to meet with public and private sector decision makers and discuss waterfront development issues. The alternative land-use forecasts will be used to identify and qualify waterfront use problems and to assist decision makers in their attempts to resolve use conflicts and, therefore, to manage the Charleston metropolitan waterfront.



The Charleston waterfront is used for both residential and commercial purposes, and includes one of the East Coast's busiest ports. The great potential for conflicting development has led to the production of a detailed land use programming model.

Demonstration of Malaysian Prawn Farming

Years of study have been devoted to the consideration of technical and economic questions regarding the feasibility of Malaysian prawn farming in South Carolina. T.I.J. Smith and Paul A. Sandifer of the Marine Resources Research Institute have begun the next step by taking that technical information out to farmers and extension agents in the state.

In cooperation with the Consortium's MAS aquaculture specialist, they have conducted cooperative pond culture trials with seven carefully-selected private growers, and shared prawn-farming information with many others. The trials demonstrated that prawns could be farmed along almost the entire coast of South Carolina and well inland. Based on the trials, a number of farmers have determined that there is sufficient economic potential to warrant additional personal investment. Restaurants, seafood retail outlets, and direct sales to customers have been identified as market channels. Information services have been provided to numerous in-state and out-of-state people, and an aquaculture specialist has been trained in the Marine Advisory Program through direct interaction with the research staff and private farmers.

During the first year of this two-year project, the degree of on-site management was quite varied, as were the problems encountered by the inexperienced prawn growers. Survival rates were less than anticipated. Problems have been identified, and farmers in the second year of the project will be much better trained. Detailed lists of recommended site characteristics and management procedures have been produced based on the first year experience.

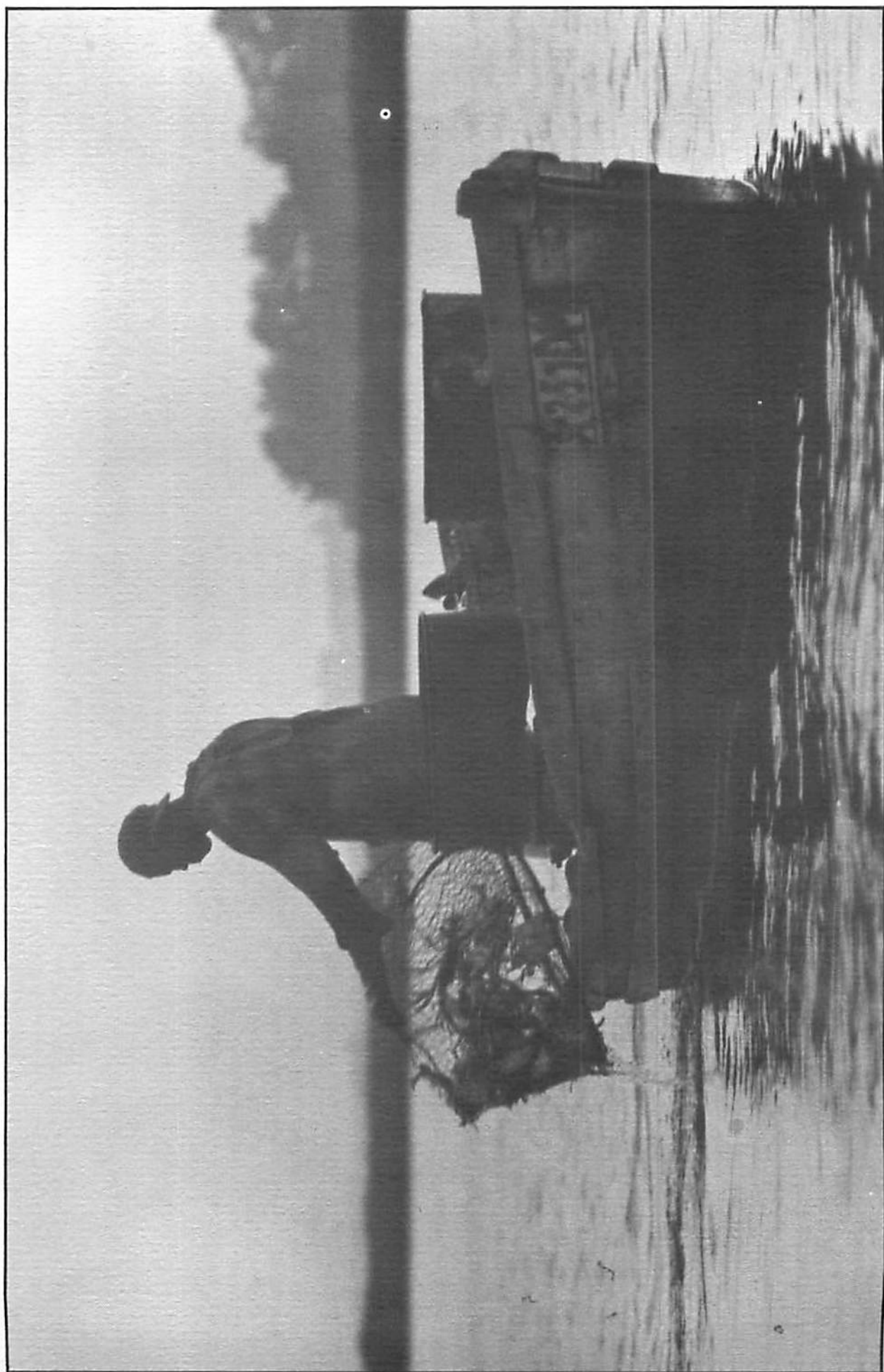
MARINE ADVISORY SERVICE

The South Carolina Marine Advisory Service represents the Sea Grant Consortium's extension of Consortium member expertise and skills to all the people of South Carolina. Basically, the Marine Advisory Service operates under a philosophy of transferring skills and knowledge to a variety of marine user groups. More specifically, the goal of the Marine Advisory Service is to enhance the knowledge both of targeted constituencies and the general public about South Carolina's marine resources and coastal environment through information dissemination and education. The Marine Advisory Service, as is the case in several other states, functions within the structure of the Cooperative Extension Service of the state Land Grant College; in this case, Clemson University. Marine Advisory specialists are located in Georgetown, Charleston, and Beaufort, the three main centers of marine activity on the South Carolina coast.

During the past year, the Marine Advisory Service provided technical

assistance in commercial fishing, aquaculture, recreation, coastal zone management, seafood utilization, and general public education. The Marine Advisory Service has been involved in coordinating workshops on Hard Clam Culture, Crawfish Culture, Marine Baitfish, Prawn Farming, and Aquaculture Legislation. Specialists have also worked closely with other Sea Grant programs, the U.S. Coast Guard, National Marine Fisheries Service, National Weather Service, the S.C. Coastal Council, the Cooperative Extension Program, and other government entities to bring timely and practical information to specific user groups.

The Marine Advisory Service designs its activities to meet the needs of marine resource users and provides the information necessary to ensure wise and effective use of South Carolina's marine resources. Through Marine Advisory Service identification of needs, research efforts can be identified and conducted in a responsive and efficient manner. Marine Advisory Service cooperative efforts in the development of new technology and provision of advisory services to coastal and marine related businesses enhance the sound growth of the economy of South Carolina.



Marine Advisory Service

The South Carolina Marine Advisory Service, a part of the Cooperative Extension Service of Clemson University, provides the crucial link between Consortium researchers and coast and marine resource users. Headquartered with the Consortium in Charleston, MAS specialists are located in the coastal cities of Georgetown, Charleston and Beaufort.

"The philosophy of MAS," explains specialist Jack Keener, "is to teach people how to think, not what to think. People — fishermen, dockowners, recreational boaters — come to us with various problems. We suggest alternatives to them and let them choose the solution that would be best for them."

For instance, when Hurricane David swept through the South Carolina coast on Labor Day 1979, serious problems arose involving property damage and beach erosion. MAS specialists produced information on efforts that could stabilize the sand dunes, and allowed each property owner to choose the protective steps most appropriate.

Though much of MAS's work is directed toward individuals, the specialists have held workshops and conferences throughout the area for the exchange of information. Among the subjects: diving, seafood cookery, native plants for dune stabilization, mariculture, LORAN C, energy conservation in the fishing industry, federal loan guarantees, crab sorting tables, finfish trawling, and marine bait.

Among the groups which have been served by the MAS staff have been:

- Shrimpers continued to make use of the MAS information transfer of fish trawling techniques, resulting in at least 15 vessels landing over a half-million dollars worth of finfish in a single year;
- Injured mariners benefited from MAS assistance to the U.S. Public Health Service in the establishment of free medical care

facilities for seamen in Georgetown and Beaufort;

- Seafood consumers were shown the proper utilization of S.C. seafood at a coastal workshop that drew a crowd of 3,000 people;
- Navigators were able to convert 4500 LORAN readings through an MAS-sponsored computer program;
- Boat-owners took part in a workshop on energy conservation in the fishing industry, primarily through new vessel construction;
- Mariculturists were assisted in the demonstration of a small-scale clam mariculture program that tested the feasibility of such programs in South Carolina.

In addition, MAS provides the transfer of expertise and skills from the Sea Grant Consortium research projects to the people of the state. Marine resource users, for instance, have turned to MAS for suggestions in responding to a number of marine problems. When possible, the MAS staff provide the necessary assistance, drawing on their own experience, available research, and the extensive body of knowledge gathered by other MAS programs around the country. When South Carolina problems can not be resolved by these means, the MAS personnel route the problems to the Consortium staff, who work with researchers at one or more of the Consortium's member institutions to find a solution. By turning to MAS, marine resource users in South Carolina have access to a network that includes experts in nearly every marine-related field.

For example, shrimp dock operators explained to MAS that they were having trouble finding labor to dehead shrimp. The cost of such labor was increasing, and that increase was cutting into shrimp profits. MAS specialists, working through the Consortium, were able to encourage Clemson engineers to take on the problem, and they have just completed the first year of a three year effort to develop a mechanical shrimp deheader. This is

a good example of the Marine Advisory Service in action: using extensive resources to aid those who are involved in South Carolina's coast and ocean resources.

Photos, next page: The Georgetown bateau is a popular boat in South Carolina, commonly used for shrimping. It has traditionally been built of plywood skin over a wooden frame and has rarely lasted more than two or three years.

At the request of a Georgetown boatbuilder, the South Carolina Marine Extension specialists conducted a demonstration project to see if Georgetown bateaus could be built of fiberglass.

The agents built a fiberglass boat of C-Flex around an existing wooden boat. In the first photo, agent Jack Whetstone adds battens between the wooden boat's spray rail and its cap rail, to be sure that the fiberglass boat will release cleanly. In Photo 2, agent Jack Keener applies the initial coat of low shrink resin onto the C-Flex. In Photo 3, the C-Flex fully fixed, alternating layers of chopped strand mat and woven roving were added. After four laminations, the fiberglass boat was removed. Inside laminations were applied, and the floor and seats were added.

The resulting boat, on the right in Photo 4 with Georgetown fisherman Bobby Ackerman, is barely distinguishable from a wooden boat. Extension agents estimate that two people spent about 40 hours and \$1000 of materials to build it. The real savings, though, are still to come, in the expected long life of the boats.

The Georgetown boatbuilder who originally expressed interest in the design now builds and sells about ten of the fiberglass boats every year. A company has begun production of them, and a number of individual fishermen have built them on their own.



THE BUDGET

Fiscal Year 1979-80 Budget Summary

	<i>Sea Grant Funds</i>	<i>Matching Funds</i>
Administration		
Administration Project	\$ 32,000	\$126,300
Aquaculture/Mariculture		
Aquaculture	94,500	68,800
Living Resources Other than Aquaculture	22,000	12,000
Fishery Development Management		
Pollution-Pesticides Ecosystems & Research	36,000	20,000
New Marine Products		
Marine Biomedicinals and Extracts	36,400	25,000
Marine Environmental Research		
Pollution Studies	34,200	34,000
Coastal Resources and Management Development		
Coastal Zone Management	31,200	27,000
Marine Education and Training		
Education-Other	50,400	9,700
Advisory Services		
Extension Marine Advisory Program	<u>85,000</u>	<u>83,900</u>
	<u>\$421,700</u>	<u>\$406,700</u>

Fiscal Year 1980-81 Budget Summary

	<i>Sea Grant Funds</i>	<i>Matching Funds</i>
Administration		
Administration Project	\$ 33,100	\$169,600
Aquaculture/Mariculture		
Aquaculture	107,900	68,000
Fishery Development Management		
Commercial Fisheries	67,600	53,800
Pathology of Marine Organisms	10,000	11,000
Pollution-Pesticides	24,000	14,300
Ecosystems Research	20,400	9,300
Marine Environmental Research		
Marine Extracts	52,200	54,900
Environmental Models	10,200	6,100
Coastal Processes & Engineering		
Applied Oceanography	10,500	8,900
Coastal Resources & Management Development		
Coastal Zone Management	16,100	28,500
Marine Law	40,100	36,200
International Program		
Coastal Zone Management Issues—U.S. and Israel*	70,000	
Marine Education & Training		
Education-Other		18,000
Advisory Services		
Extension Marine Advisory Program	115,000	98,400
	<u>\$577,100</u>	<u>\$577,000</u>

*This separately-funded project is described in a publication, available from the Consortium, which highlights the organization's international work.

Program Summary

		Year Beginning	
		1979	1980
<i>Program Area—Research</i>			
<i>Marine Resources Development</i>			
R/A-1	Development of Macrobrachium Aquaculture, P.A. Sandifer	CP	
R/A-2	Demonstration of Commercial Prawn Farming, T.I.J. Smith		NS
R/A-3	Artificial Insemination of Prawns, P.A. Sandifer		NS
R/A-5	Economics of Pond Culture of Prawns, L.L. Bauer	CP	
R/A-10	Hard Clam Culture in South Carolina, J.J. Manzi	NS	CG
R/A-1a	Parasites of Cutured American Eel, A.G. Eversole		NS
R/CF-2	Biology of the Rock Shrimp, <i>Sicyonia</i> , N.A. Chamberlain	CP	
R/CF-1	Reproduction and Development of Sharks, J.P. Wourms		NS
R/CF-2a	Development of an Automatic Shrimp Deheader, J.A. Collier		NS
R/CF-4	Bioenergetics of Juvenile Hard Clams, F.J. Vernberg		NS
R/CF-5	Biology and Ecology of Juvenile Snappers & Groupers, G.D. Johnson	NS	CP
R/PO-1	Immunological Identification of Hard Clam Predators, R.J. Feller		CP
R/PO-2	Age and Ecology of Swordfish, J.M. Dean		NS
R/MX-1	Substances from Invertebrates Affecting Aquatic Species Disease, M. M. Siegel		NS
R/MX-2	Identification of Lectins in Marine Invertebrates, E.H. Liu	NS	CP
R/MX-3	New Medicinal Agents of the Salt Marsh, T.A. Bryson	NS	CP
<i>Socio-Economic and Legal Studies</i>			
R/ML-1	Effects of U. N. LOS on South Carolina, R.S. Jordan		CP
R/ML-2	Levels of Laws Affecting Gov't. Action Regarding Emergencies, R.M. Chastain		CP
R/ML-3	Tabby Structures Along the S.C. Coast, L.B. Lepionka		CP
<i>Marine Environmental Research</i>			
R/CZ-1	Development of Hurricane-Resistant Building Standards, B.L. Edge		CP
R/CZ-2	Tidal Inlet Atlas for S.C., M.O. Hayes	CP	
R/CZ-3	Urban Waterfront Planning and Management Model, R.R. Stough		NS
R/ER-2	Fungi as an Indicator of Microflora Movement in Marshes, L.H. Stevenson	CP	
R/ER-3	Fish and Decapod Crustacea in S.C. Estuaries, E.L. Wenner	NS	CP
R/PS-2	Effects of Insecticides on Marine Crustacea, T.K. Borg	CG	TM
R/PS-3	Effects of Toxaphene on Estuarine Fish, T.F. Bidleman	NS	CP
R/EM-1	Simulation Model of Mercury Stress in Marshes, H.N. McKellar		NS
R/AO-1	Stability of Tire Unit Artificial Reefs, D.O. Myatt		CP
<i>Marine Education and Training</i>			
E/ME-3	Undergraduate Summer Research Opportunities, J.W. Smiley	CP	
E/O-1	Marine Education Activities, J.M. Armstrong		CP
E/O-2	Minority Marine Education Program, J.A. Arrington	NS	CP

Advisory Services

A/E-1	Extension Marine Advisory Program, D.C. Smith, Cranger	CG	CG
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Program Management and Development

P/AD-1	Program Administration, J.M. Armstrong	CG	CG
P/AD-1	Program Development	CG	CG
	—Marine Research for Gifted Students, P. Fisher	CP	
	—Review of K-6 Marine Education Materials, W.B. Allen	CP	
	—Cattails as an Energy Source, K. Landenburg	CP	
	—Dissemination of Gulf Stream Telemetry Maps, J.M. Dean	CP	
	—Examination of Groundwater on Barrier Islands, S. Shelton		CP
	—“Sea Watch” Public Service Announcements, J. Burnett	CP	
	—Charleston Museum “Touch Tank”, K. King	CP	
	—Crawfish Aquaculture Development, L. Osteen	CP	
	—Urban Waterfront Model Development, R. Stough	CP	
	—Marine Bait Workshop, M.A. Davidson	CP	
	—Environmental Characteristics of Impoundments, F.J. Vernberg	CP	

NS = New Start

CG = Continuing Project

TM = Terminated Project

CP = Completed Project

Publications:

- Breeding depressions in culture ponds for Malaysian prawns. T.I.J. Smith and P.A. Sandifer. (Aquaculture 18 (1979) 51-57) 7pp. SC-SG-RE-79-1.
- Coastal Development: Barrier Islands, Flood Insurance, and Policy: Proceedings of a Conference. S. Forester, ed. 58 pp. SC-SG-PR-80-02.
- The Effects of Dredging Salt Marsh Creeks. E.A. Caine and E.W.S. Hull. 44pp. SC-SG-TR-81-05.
- Epibionts of pond-reared adult Malaysian prawns, *Macrobrachium rosenbergii* (De Man) in South Carolina. R.I.J. Smith, P.A. Sandifer, and J.J. Manzi. (Aquaculture 16 (1979) 299-308) 10pp. SC-SG-RE-79-2.
- Genetic divergence and biogeography of natural populations of *Macrobrachium rosenbergii*. D. Hedgecock, D.J. Stelmach, K. Nelson, M.E. Lidenfelser and S.R. Valecha. (pages 873-879 in Proceedings of the Tenth Annual Meeting World Mariculture Society, Honolulu, Hawaii, January 22-26, 1979.) 7pp. SC-SG-PR-79-1.
- Growing shrimp in South Carolina. D. Florio. (Sea Grant '70's 9(1):(1979)4-6,11.) 4 pp SC-SG-RE-79-3.
- Guide to Flounder Fishing in South Carolina. J.W. Smith. SC-MAS-81-02.
- Influence of three stocking strategies on the production of prawns, *Macrobrachium rosenbergii*, from ponds in South Carolina, U.S.A. T.I.J. Smith and P.A. Sandifer (Proceedings of the Symposium on Coastal Aquaculture, Cochin, India, January 12-18, 1980.) 21pp. SC-SG-PR-80-2.
- Intensive Hard Clam Mariculture: A Primer for South Carolina Watermen. J.J. Manzi and J.M. Whetstone. SC-MAS-81-01.
- Management of an Expanded Territorial Sea: Impact of the Third United Nations Law of the Sea Conference on South Carolina and the Nation. R.S. Jordan and C.W. Herrick. 170pp. SC-SG-TR-80-01.
- A Method for artificial insemination of macrobrachium prawns and its potential use in inheritance and hybridization studies. P.A. Sandifer and T.I.J. Smith. (pages 403-418 in Proceedings of the Tenth Annual Meeting World Mariculture Society, Honolulu, Hawaii, January 22-26, 1979.) 16pp. SC-SG-PR-79-2.
- Processing yields for Malaysian prawns and the implications. T.I.J. Smith, W. Waltz and P.A. Sandifer. (pages 557-569 in Proceedings of the Eleventh Annual Meeting World Mariculture Society, New Orleans, Louisiana, March 5-8, 1980.) 13pp. SC-SG-PR-80-3.
- Production Guidelines for Crawfish Farming in South Carolina. N.C. Alon and J.M. Dean. 71pp. SC-SG-TR-80-03.
- The Relationship of Port Development and Urban Waterfront Revitalization. J.M. Armstrong, H.M. Johnson, R.G. Ciabattari, and R.R. Stough. 103pp. SC-SG-TR-81-02.
- Species Assemblages, Distribution, and Abundance of Fishes and Decapod Crustaceans from the Winyah Bay Estuarine System, South Carolina. E.L. Wenner, W.P. Coon, M.H. Shealy and P.A. Sandifer. 61pp. SC-SG-TR-81-03.
- A Study of Shore Erosion Management Options in South Carolina. J.B. London, J.S. Fisher, G.A. Zarillo, J.E. Montgomery, and B.L. Edge. 246pp. SC-SG-TR-81-01.
- Temporal fluctuations in the density of filamentous fungal propagules in the water of a high-marsh creek. L.H. Stevenson, T.H. Chrzanowski and C.W. Erkenbrecher. (Mycologia 73(2): 274-281) 8pp. SC-SG-RE-81-2.
- Test marketing of freshwater prawns, *Macrobrachium rosenbergii*, in South Carolina. D.S. Liao and T.I.J. Smith. (Aquaculture 23 (1981) 373-379) 7pp. SC-SG-RE-81-3.
- Viviparity: the maternal-fetal relationship in fishes. J.P. Wourms. (Amer. Zool. 21-473-515) 43pp. SC-SG-RE-81-4.

Abbreviations used in Publication Numbers

SC	South Carolina
SG	Sea Grant
TR	Technical Report
PR	Proceedings
MAS	Marine Advisory Service
RE	Reprint