A Report on

south carolina sea grant

July 1, 1973 – June 30, 1975

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sea grant

is sponsored by the Office of Sea Grant, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, and the State of South Carolina. Participating institutions include: S. C. Wildlife and Marine Resources Department, University of South Carolina, Clemson University, Medical University of South Carolina, College of Charleston, and The Citadel.

annual report

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introduction

About a half mile offshore from Morris Island, two shrimp boats are plying the calm Atlantic virtually side by side in their quest for shrimp. One trawler pulls a pair of nets from each outrigger—a twin trawl—and the other uses a single net on each side as do 99% of the other shrimp trawlers in South Carolina.

Although there is evidence from other states that the new twin trawls are extremely effective, the captains *don't know* which set of nets will do the better job of catching shrimp in South Carolina. But at their own suggestion, they are being given the chance to find out without investing huge sums of money in experimental gear.

And the information they are gathering on shrimp catch and fuel

consumption using the twin trawls is being transmitted on a regular basis to shrimpers up and down the coast, shrimpers who also may be contemplating a switch to the newer gear.

At the same time, miles away in a laboratory overlooking Charleston Harbor, scientists are experimenting with giant fresh/brackish water prawns to see what kind of diet is best to maintain growth at the least cost.

Some day, pond rearing of the exotic prawns may supplement natural shrimp harvesting and agricultural production in lowcountry Carolina, but right now the aquaculture researchers, like the shrimp boat captains, don't know exactly what they will learn from these experiments. But they are establishing the dietary requirements for an optimum, low-cost feed so that, one day, much of the uncertainty and economic risk will be removed for the fledgling shellfish farmer who, by his own initiative, may go on to build a vital new food-producing industry for South Carolina.

What do these two people, the shrimper and the scientist, have in common?

They are but two of the many people involved in a larger experiment called "Sea Grant," and they illustrate the essence of the Sea Grant concept—research working hand in hand with education and service to the public to improve the way we use the sea and our sea resources. It's just as simple as that.

Initiated in 1967, Sea Grant found a precedent and model in the almost century-old Land Grant College Program, which set up academic institutions to research problems in agriculture and to pass along new advances in agricultural practices to farmers.

With seven universities nationwide designated Sea Grant Colleges, the Sea Grant mission parallels the Land Grant concept, but is much broader in some respects. Sea Grant works to improve the productivity and job opportunities from every kind of economic activity involving marine and coastal zone resources.

Here in South Carolina, there is no single Sea Grant College, but rather a consortium of state universities and agencies under one coherent Sea Grant program. The lead agency in this consortium is the South Carolina Wildlife and Marine Resources Department, whose Marine Resources Center represents the largest professional staff of marine research and management scientists of any state agency in the Southeast.

Complementing the research staff of the Center are the marine science faculties of the state's major colleges and universities, Clemson University, University of South Carolina, The Citadel, College of Charleston, and Medical University of South Carolina. In addition to being a multi-institutional program, Sea Grant embodies a multi-disciplinary approach to solving marine related problems, drawing researchers from the fields of marine biology, geology, economics, agricultural and mechanical engineering, political science, law and many others.

Now entering its fourth year, Sea Grant in South Carolina has provided the springboard for increased cooperation in marine research programs among the various state institutions. The program has made important advances in:

- **aquaculture technology**—South Carolina now has a working hatchery producing thousands of postlarval *Macrobrachium* prawns for Sea Grant's own pond experiments and for other projects in the program. Sea Grant engineers have developed heretofore unknown data on the performance characteristics of small air lift pumps—pumps which now can be used in aquaculture, waste treatment and in many other ways.
- **advisory program involvement**—fishermen and coastal property owners are now coming to Sea Grant advisory specialists with their problems after two years of advisory going to them to establish contact. A group of shrimpers' wives came to Sea Grant advisory economists recently and requested that they conduct a "workshop for wives" on tax preparation.
- **oyster industry revitalization**—as a result of Sea Grant research, shellfish management personnel now know the best times of year to plant shell and recruit seed oysters. Engineers have developed a prototype mechanical oyster harvester for intertidal oysters which may help solve some of the labor problems in South Carolina's ailing oyster industry.
- and many, many others.

As with most research and advisory programs such as Sea Grant, the pay-offs are difficult to see and even more difficult to document in the short term. But the dangers of not doing our best, as a nation, to develop fully our economic marine resources are very real.

The objectives and achievements of Sea Grant's early years have grown logically into current research planning. The Steering Committee two years ago made a determination of potential growth areas and of potential problem areas in marine resources. They then designed what they feel is the best possible program of research to meet the information and data needs that these priorities demand.

For example, early work in research designed to capitalize on South Carolina's coastal impoundments has led to the current emphasis in ongoing crustacean aquaculture research. Aquaculture, along with research aimed at improving utilization of marine resources and research to aid in coastal zone planning and decision-making, comprise the three broad priority areas for the research program.

In addition to research, advisory and educational programs are equally important in meeting the goal of enhanced economic return and employment opportunities from marine resources.

South Carolina Sea Grant has grown steadily over the past two years documented in this report. Even with prospects for future increases in funding uncertain, the program will continue to expand on the firm foundation it has built so far.

With good contacts in the commercial fishing community, in state and local government, and in other research centers across the state and nation, Sea Grant researchers and staff are building the kind of reputation for service that reaches far beyond the boundaries of state and program.

aquaculture

Larger than shrimp and as tasty as lobster, *Macrobrachium* prawns are fast becoming one of the most talked about candidates for large scale and profitable crustacean aquaculture—shrimp farming, that is.

They have been identified by Sea Grant's parent agency, NOAA, as deserving of top priority attention from aquaculture researchers because of their potential high market value, the relative ease with which they will reproduce and prosper in captivity, and the fact that *Macrobrachium,* which spend only the first few weeks of life in salt water, do not require large expanses of expensive shore side real estate or vast salt water impoundments for growing. They can be reared from the postlarval stage to market

size almost anywhere the weather is mild enough to afford them a five to six month growing season.

In South Carolina, *Macrobrachium* research has been a top priority in the three-year-old Sea Grant Program since its birth in 1972, and today the state boasts the largest-scale prawn research effort on the East Coast.

After several years of pioneering work in Hawaii and elsewhere, Sea Grant scientists at the Marine Resources Research Institute (MRRI) began in 1972 by surveying the state-of-the-art of prawn culture and investigating the feasibility of transferring and improving existing culture technology for use in South Carolina. Much of the initial research concerned techniques for raising larvae in salt water tanks.

multi-institutional approach

As the work progressed, it became evident that many of the problems needing study crossed traditional disciplinary lines and that they could be attacked most effectively through a multi-disciplinary team effort. So in 1973, two engineers from Clemson University were brought into the program to work on larval tank design, and in 1974, two more research projects were added.

Progress in the basic *Macrobrachium* culture work has been steady and impressive in the past two years. After a few rearing trials with several species of the big prawn, the researchers quickly narrowed the field to the most promising one, *M. rosenbergii*, and began a wide range of biological experiments on postlarval and juvenile prawns of this species.

They established the tolerance of the postlarvae to rapidly and slowly increased salinities, and studied the effects of salinity and diet on postlarval growth. The research shows that:

- Acclimation can increase slightly the tolerance of post-larval prawns to salt water, but they begin to die at salinities of 25 o/oo whether the salinity is increased rapidly or slowly.
- Postlarvae will survive and grow if transferred directly to freshwater after completing the larval stage, but they grow faster if kept in a slightly saline environment during the first two to three months of juvenile development.
- Postlarvae fed a diet of commercial pellet food grew faster than those fed a natural algal-animal complex (derived from outdoor algae pools), or a combination of both diets. The predominantly algal diet supplied sufficient nutrition for maintenance, but was not adequate for growth.
- The combination diet is *almost* as satisfactory as the pelleted diet, meaning that prawn farmers may be able to save money and still grow large animals by counting on natural food sources to supplement the feed.

After establishing these biological parameters for growing postlarval prawns, researchers on the core culture project began in mid-1973 to construct a pilot scale hatchery to provide postlarvae for other researchers and for their own pond grow-out studies which began in the spring of 1974. Supported in part by the Coastal Plains Regional Commission, the MRRI hatchery is now routinely producing postlarvae on a laboratory scale to this and other projects.

outdoor ponds stocked

In the spring of 1974, five outdoor freshwater ponds were stocked with from 300 to 15,000 postlarval prawns. When the ponds were harvested three to five months later, 60 to 70 percent of the prawns had survived and most had reached a good marketable size. Two of the ponds used for stocking were newly constructed, so they lacked the build-up of vegetation which supplemented the diet of the prawns placed in the remaining three ponds. After harvesting in October by draining the ponds and concentrating the animals in a catch basin, the following observations were recorded:

- One pond stocked with very small juvenile prawns (0.04 grams mean weight) yielded the equivalent of nearly 600 pounds per acre after only about four months of rearing.
- The greatest projected yield, 1400 pounds per acre, came from the pond which was stocked the earliest and with the largest prawns (2.87 g).
- The prawns reared in the older ponds containing established vegetation were much darker in color, and therefore potentially more attractive to consumers, than the ones reared in the newer ponds.

The aquaculturists also conducted additional feeding studies during 1974-1975, and took a preliminary look at the feasibility of rearing *Macrobrachium* in protective cages in freshwater ponds. After a four and a half month growing season in cages, 68% of the prawns in the experiment had survived and all had more than doubled in size, with one growing over 500%. The researchers concluded that cage culture has definite potential, but that much additional research needs to be done in this area.

hybridization studies planned

Preliminary work has also been done on hybridization of *Macrobrachium* species, two of which *(M. acanthurus* and *M. ohione)* occur naturally in South Carolina coastal waters. Though less suitable for commercial culture than *M. rosenbergii,* these two species are probably hardier and can tolerate cooler water temperatures than their Far Eastern relative. A technique for obtaining ripe, free-spawned eggs from *Macrobrachium* females, a necessary prerequisite to *in vitro* fertilization attempts, was developed for one species and is being tested on another.

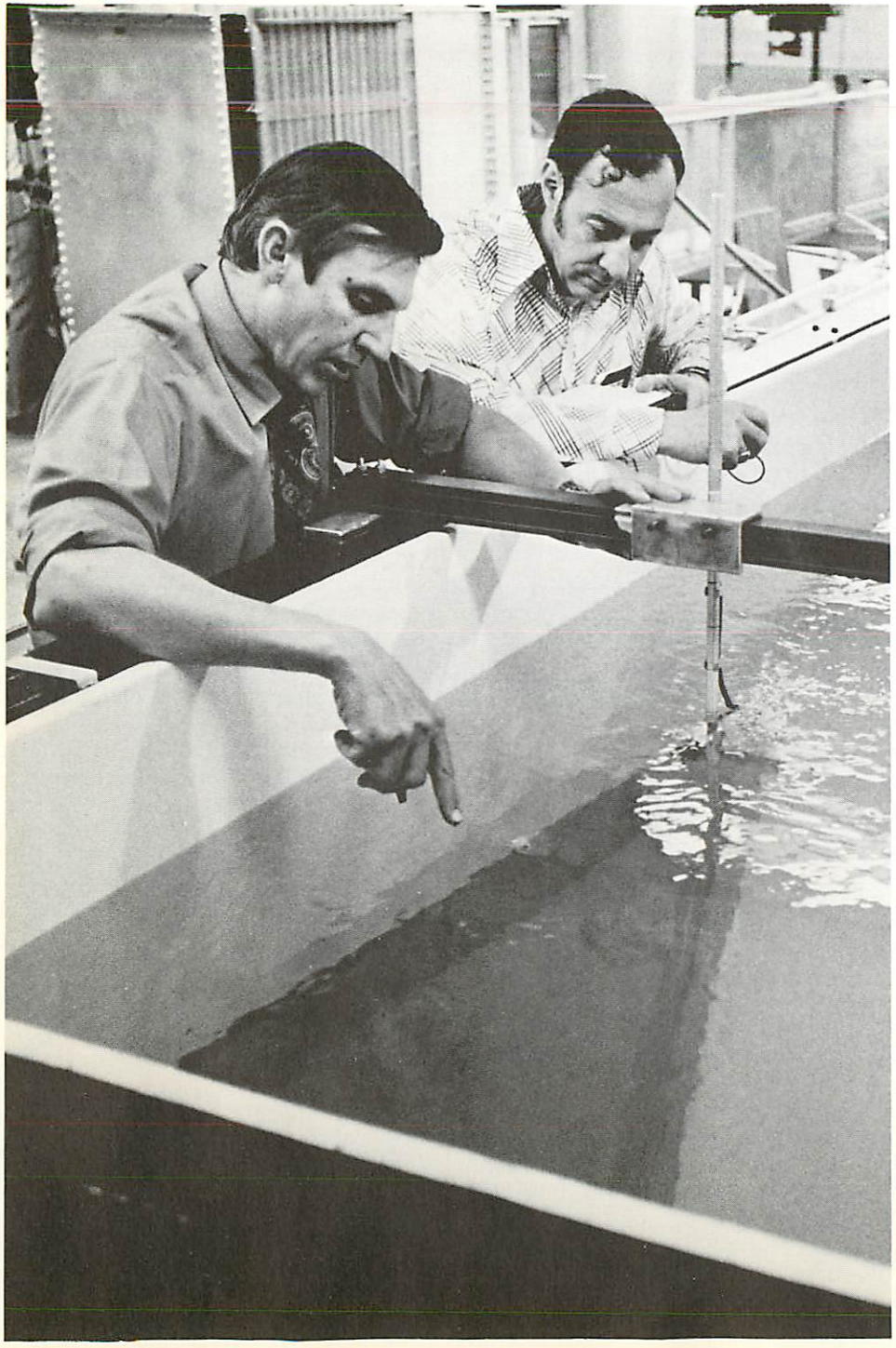
Further work on pond culture and hatchery development will dominate the coming grant year. In the spring of 1975, ponds in the semi-tropical low-country and in the temperate midlands sections of the state were again stocked with over 55,000 postlarval prawns which will be harvested before cold weather returns in October.

The researchers will be looking closely at the effects of stocking density and the size of prawns at stocking on production in the ponds. They will also continue to monitor the effects of the physical condition of the ponds on the growth and development of prawns, and the further work indicated for cage culture will be conducted.

engineering studies

While the biologists were pressing toward their successes in hatchery development and pond culture, support projects were brought in along the way to work on specific problems. The culturists had a system that would work, obviously, but was it the best system?

What *is* the best kind of tank for rearing larvae to the stocking stage?



How do you achieve the best circulation patterns to keep food in suspension and yet concentrate waste particles in one area for easy removal? The biologists are concerned with diet, reproduction and growth, yet there are also questions of hydraulics, design and support systems which need to be answered.

Two Clemson University engineers were brought into the project in 1973 to provide fundamental engineering information on tank design, pond design, circulation patterns and support systems for *Macrobrachium* aquaculture. They have worked primarily with two tank designs, rectangular and cone-shaped, to determine flow patterns by using dye and coffee grounds as tracers of the flow.

A look at the feasibility of using air lift pumps to increase circulation in culture tanks turned up an interesting bit of information—since air lift pumps have been used in the past primarily for deep well pumping, mining operations and such, no one knows how efficiently the shorter length (15 feet and under) pumps operate. Before they could evaluate the pump's value to aquaculture, the engineers had to spend a considerable amount of time just filling in the information gap on how low lift pumps work.

air lifts ideal

It now appears that short length, small diameter air lift pumps are an ideal means of increasing circulation and aeration, maintaining food particles in suspension, and improving water quality in culture tanks. They also have potential applications in related fields such as waste treatment.

Clemson engineers Paul Zielinski (left) and Walter Castro check the flow rate in a larval rearing tank equipped with air lift pumps.

Waste treatment is, in fact, a very large headache for aquaculturists of any species, whether it be catfish or *Macrobrachium* prawns. Waste materials must be removed from culture tanks to provide a healthy environment for the growing animals, and federal and state water quality watchdogs are becoming increasingly specific about how this effluent waste should be handled. The Clemson engineers are also investigating the use of a new circular swirl chamber device to help clean up the aquaculture effluent.

The swirl chamber works on a principle similar to a settling pond, but because it takes advantage of dynamic, rather than static, settling principles, the swirl chamber takes up much less space than a traditional settling pool.

The dirty water is pumped into a conical shaped tank where it passes under an inner baffle into a calm settling region. The settleable solids sink to the conical bottom, while the clean water rises and overflows into an outflow basin.

The engineers will couple this new system with additional filters and run a series of experiments to determine if sufficient water quality can be achieved to allow the effluent to flow directly back into the culture tanks.

algal studies

Because they filter their food from the water around them, molluscan shellfish like clams and oysters depend on algae and plants in the water for a significant portion of their diets. For this reason, algal culture experiments have often gone hand in hand with shellfish culture work in other research centers.

Crustaceans, including *Macrobrachium* prawns, shrimp and crabs, have larval and postlarval forms which

are generally less dependent on plants, relying instead upon the animal components of aquatic systems. However, available evidence suggests that algae are a relatively important complement to the culture of some shrimp larvae.

Penaeid shrimp culturists have established the necessity of algae in early larval stages and the culture of *Macrobrachium* prawns in Hawaii and elsewhere suggests that algae may be important supplements for larval growth and survival for this genus as well.

In South Carolina, an investigation into the effects of algal supplements on the static system culture of *M. rosenbergii* was initiated in the summer of 1974 by biologists from the College of Charleston and the Marine Resources Research Institute. Thus far, these studies have indicated that algal supplements in sufficient quantities enhance larval development, survival and postlarval production of *M. rosenbergii* in static water culture. This was particularly evident when high concentrations (100,000 to 500,000 cells/ml) of certain algal supplements (Bacillariophyceae and chrysophyceae) were used.

After these findings, the investigators turned their attention to determining why the algae have a beneficial effect on larval culture. They looked at three possible mechanisms:

1. the larvae use the algae directly as food (direct nutrition)
2. the algae are eaten by the primary ration, brine shrimp (artemia), thereby improving the primary feed (indirect nutrition)
3. the algae improve water quality by providing oxygen and consuming waste products

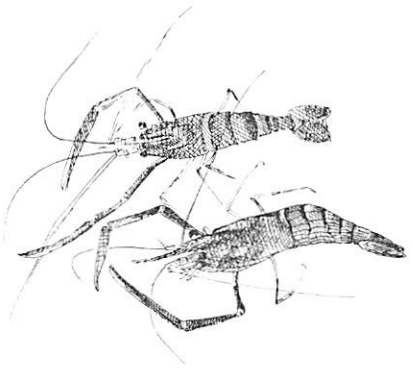
Of the three mechanisms under consideration, indirect nutrition is the most doubtful. Direct nutrition is, at this time, difficult to determine. Although larvae in algae-supplemented culture normally have large numbers of algal cells visible in the gut, the occurrence of those cells, whether actively consumed or accidentally ingested, does not constitute assimilation or direct nutrition.

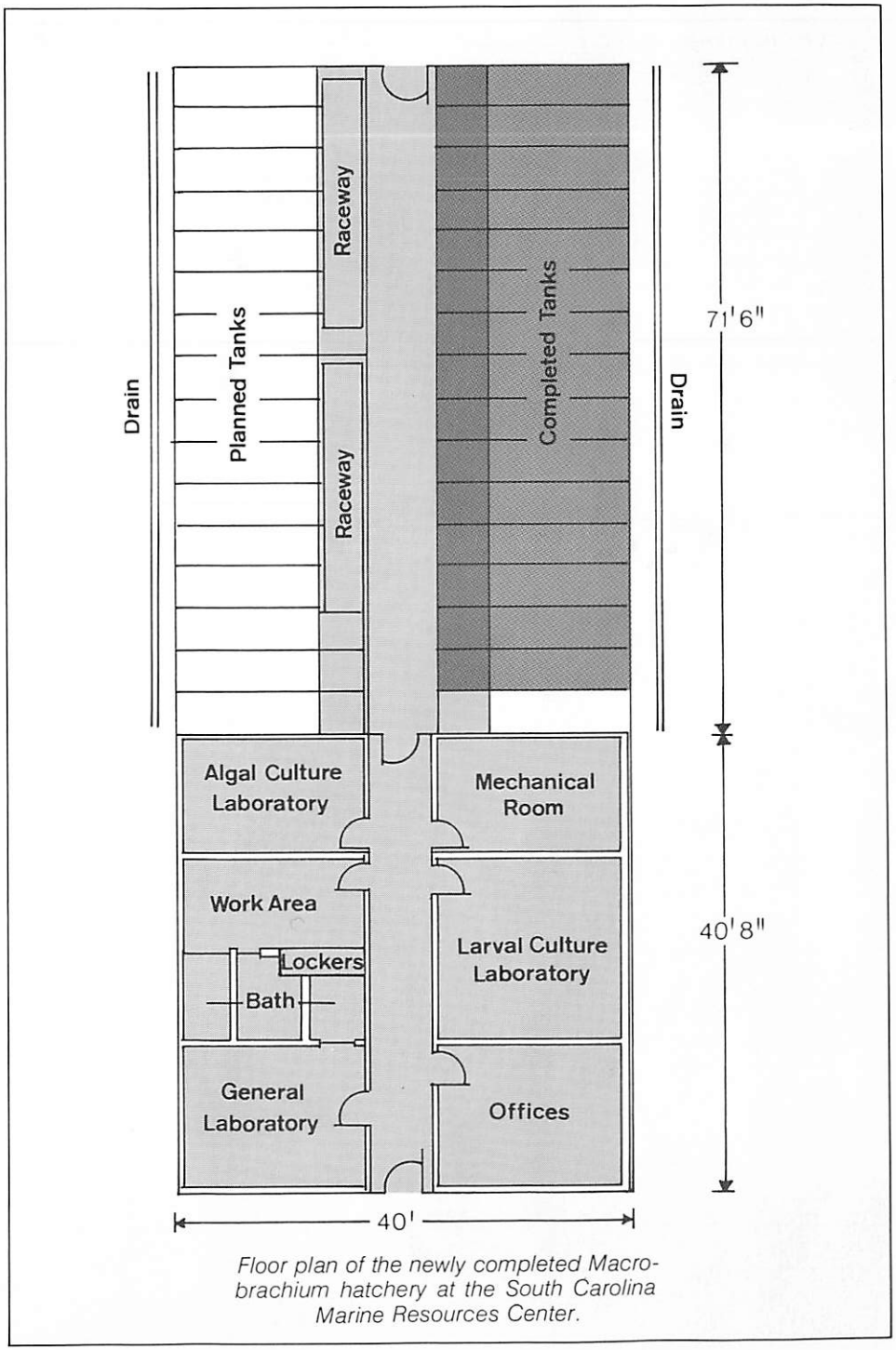
Algal supplements can also be acting as a water conditioner, utilizing the nitrogenous waste products of the larvae or perhaps supplying metabolites that act as growth factors for these crustacean larvae.

In addition to the above, two other areas of investigation are being pursued under the umbrella project on algal studies.

A survey of the dominant phytoplankton populations of the Charleston area was completed in January, 1975. Dominant forms have been identified, isolated and placed in culture to provide native algal populations for present and possible future mariculture operations.

The second area of investigation concerned the determination of the naturally occurring floral components of prawn grow-out ponds. A floral survey of the ponds used in culture operations was performed, and together with data from laboratory experiments and gut content analysis, is being used to determine if plants play a prominent role in the diet of juvenile and adult *Macrobrachium*.





Floor plan of the newly completed Macrobrachium hatchery at the South Carolina Marine Resources Center.

lipid studies

Another project in the overall *Macrobrachium* aquaculture program is also concerned with the dietary requirements of prawns, this time in relation to important groups of nutrients, lipids and fatty acids.

Linoleic and linolenic acid are called essential fatty acids (EFA) because they cannot be synthesized by animals from precursors, but *must* be obtained through proper diet. Studies with penaeid shrimp and lobster have suggested that linoleic acid (18:2w6) inhibits crustacean growth while linolenic acid (18:3w3) and other fatty acids of the w3 family promote growth.

In an effort to establish the optimum balance of these two fatty acids for the prawn, scientists at MRRI developed an experimental ration, utilizing the oil extracted from waste penaeid shrimp heads which is rich in w3 fatty acids. This oil was added to the ration which is routinely used in feeding the prawns (Ralston-Purina Marine Ration 25) and which contains large amounts of w6 fatty acids.

Prawns receiving the shrimp-oil diet survived as well as those receiving the unmodified diet over 12 weeks time, and were twice as large (1.06 g mean weight) as those fed the unmodified diet (0.5 g mean weight). Another group of prawns fed Tetramin, which contains less w6 fatty acids than the shrimp-oil diet, weighed 1.2 g (mean weight) at 12 weeks, but did not survive as well.

These results suggest that w6 fatty acids inhibit growth in *Macrobrachium,* but more definitive work is necessary to establish this fact. Such studies are now in progress.

Dr. Edwin B. Joseph, South Carolina Sea Grant Director, examines a giant Macrobrachium prawn newly harvested from a brackish water pond near Charleston.

As an added benefit, the researchers found that carotenoids (pigments) were transferred from the shrimp oil in the experimental diet to the prawns. This resulted in a pinker, more attractive prawn after cooking.

Prawns reared in grow-out ponds with a rich, natural biota obtain these pigments from plants or animals which supplement their diet. Carotenoids should therefore probably be considered essential dietary ingredients for prawns whose diet consists solely of a formulated feed.

The scientists have also analyzed the fatty acid composition of developing prawn eggs, larvae and juveniles. Substantial differences in fatty acid composition would suggest developmental changes in lipid and fatty acid metabolism and the need for specialized diets for the different morphologic stages.

macrobrachium research personnel

Core Culture Project:
Dr. Paul A. Sandifer, Dr. Theodore I. J. Smith, *Marine Resources Research Institute*

Engineering Sub-Project:
Dr. Paul B. Zielinski, Dr. Walter E. Castro, *College of Engineering, Clemson University*

Algae Sub-Project:
Dr. John J. Manzi, *Marine Resources Research Institute (formerly College of charleston)*

Lipid Sub-Project:
Jeanne D. Joseph, *Marine Resources Research Institute*

resource utilization

In a world faced with food shortages, energy shortages, shortages of every kind, man's attention has turned for relief to the sea, in many ways our last largely unexplored frontier. But how realistic are our expectations for increased development and use of the sea's bounty, particularly the living marine resources?

Sea Grant researchers across the Nation and here in South Carolina are trying to answer these questions by investigating specific new or improved ways to use the undersea environment and the myriad life that inhabits it.

For example, South Carolina's extensive estuarine-marsh environment provides hundreds of thousands of acres of subtidal and intertidal bottoms suitable for oyster culture, but

they are not being utilized to their full potential by the ailing oyster industry. Because of pollution, dwindling labor supplies and the difficulty of harvesting cluster-type intertidal oysters (which make up 95% of the state's oyster harvest), the industry has been in a steady decline since the early part of this century.

There were at one time over a dozen steam oyster canneries in South Carolina; today there is only one. From a peak harvest of 3¼ million bushels in 1908, oyster production had dropped to less than 300,000 bushels by 1974.

For the past three years, Sea Grant has supported a two-pronged research effort aimed at modernizing and revitalizing the South Carolina oyster industry by researchers from the South Carolina Marine Resources Research Institute (MRRI) and Clemson University's Department of Agricultural Engineering. The MRRI scientists are looking into the biological and management steps which need to be taken; the Clemson engineers are investigating technological advances needed to improve harvesting techniques.

South Carolina oystermen have special problems with mechanical harvesting because the predominant intertidal oysters grow as large clusters of irregularly shaped shells, firmly attached to an underlying matrix of old shell. The Clemson engineers began their work by trying to modify a subtidal oyster harvesting head developed by scientists at the Virginia Institute of Marine Science, but they wound up developing a completely different device.

The Clemson harvester consists of a rectangular head mounted on an outrigger and connected to an escalator which delivers the harvested oysters up to the boat. Two conveyor belts with steel teeth rotate in opposite directions while the first belt detaches the oyster from the substrate and the second conveyor picks it up for delivery to the escalator.

The new head is expected to cause a minimum of damage to muddy oyster bottoms because it merely lifts off the top layer of oysters and does not dredge up the underlying substrate as well.

In designing the head, the Sea Grant engineers had to consider all the variables at work in oyster harvesting—bottom type, boat speed, tine speed, size, shape and specific gravity of the oysters, and the forces required to detach oysters from the substrate. They also used a computer program to simulate the action of oysters when engaged by the tines. Harvesting efficiencies were predicted for the head while operating at varying depths and at varying speeds with straight tines and with tines angled forward 15 degrees. Since the computer predicted greater efficiency for the slightly angled tines, they incorporated this design feature into the prototype head.

In preliminary tests conducted in the spring of 1975 at Clemson, where artificial reservoirs were constructed and "planted" with oysters, the overall mean efficiency of the harvester was 63%. Actual field testing of the device will begin during the coming grant year, as more improvements and modifications are made on the prototype head.

The second facet of the Sea Grant effort to modernize the oyster industry is more biological than technological in nature. MRRI researchers are investigating the possibility of growing subtidal, single oysters in South Carolina because they are easier to harvest and shuck, they bring a higher price in the market place, and their cultivation offers more attractive employment opportunities since they require year round attention to prepare beds and plant seed.

The biologists began by looking into naturally occurring subtidal oysters in the Wando River as a possible source of seed for other areas. They found that Wando seed transplanted in trays to open water growing areas can grow rapidly and reach marketable size in as little as six months. Seed oysters transplanted to unprotected bottoms in many cases suffered high mortalities due to disease, predation or poaching.

To find out how much seed might be available for transplanting in any given year, the researchers set out shell bags and shell strings and monitored oyster strike (the settling of young oysters on some hard surface or substrate). They found that:

- strike is light in the Wando but it occurs every year
- the planting of shell material as cultch significantly increases the numbers of available seed oysters per bushel of cultch. This means that the number of seed oysters can be increased simply by planting cultch material at the right time of year, probably in July.
- young seed caught on recently planted cultch grows faster and survives better than naturally occurring seed which is probably over two years old when transplanted.

In the coming year, investigators will look more closely at the potential for growing subtidal oysters in salt water ponds and impoundments, hundreds of which dot the lowcountry landscape. Seed oysters will be planted in trays, floats and on hard bottoms in impoundments where a battery of tests will determine the effects of planting densities, disease, and alterations in salinity and chemical parameters in the ponds.

Such intensive pond culture offers advantages over the present system, or more correctly, "non-system," of extensive culture and natural recruitment: Impoundments can be supervised, controlled and harvested with greater ease than open areas. And if oysters could be cultivated commercially in ponds, the combination of this intensive culture and the state's naturally productive oyster bottoms could signal a new era in oyster production in South Carolina.

cash for trash

Oysters, of course, are an established marine industry in South Carolina, but what about the many products of the sea which have no industry and no market? Isn't there something useful we can do with them?

Sea Grant says yes, and has funded projects in many universities to come up with new uses for underutilized marine species. One example in South Carolina is "sea pork," *Amaroucium stellatum.*

Common to the state's near shore waters during certain times of the year, this unusual lump-shaped animal is actually a large colony of microscopic organisms which have demonstrated a number of properties potentially useful to man. For one thing, they have shown anti-tumor activity against two different types of cancer.

Sea pork is similar to a related anti-tumor tunicate which also happens to be toxic to mice. Researchers from the Medical University of South Carolina (MUSC) have found that sea pork, on the other hand, is apparently non-toxic and also has a high concentration of arachidonic acid, a precursor of prostaglandins. Pharmaceutical companies are marketing prostaglandin products and are constantly

searching for natural sources of these essential biochemical compounds, since many prostaglandins cannot be synthesized in the laboratory.

In addition to establishing the relative safety of sea pork as a possible cancer drug, the pharmacologists have also discovered a high protein content in the organism. Freeze-dried sea pork pellets have been fed to mice in laboratory nutrition studies with encouraging results.

Some day the ubiquitous sea pork may serve as a cheap source of protein, particularly in pet foods, although much additional work needs to be done before an economically marketable product of any kind is produced from *Amaroucium.*

But if such a day ever comes, shrimp fishermen in South Carolina will rejoice, because they catch hundreds of pounds of worthless sea pork in their nets every year. They will be more than happy to add this strange looking, lumpish animal to their list of marketable products of the sea.

recycling shrimp heads

Yet another project at MUSC may ultimately benefit shrimpers by helping to solve their shrimp head waste disposal problems.

The head of the shrimp makes up over 30% of its total weight, so shrimp processors produce almost as much waste as they do product. Federal, state and local water quality control regulations prevent the disposal of shrimp heads and other processing wastes into certain inshore waters, so the shrimp dock owner must either pay to transport heads inland to a landfill, or find an outlet for them in the market place. Unfortunately, no such market exists in South Carolina.

Helping to find this economic outlet is where Sea Grant steps in with the scientific expertise of biochemists at MUSC. They began two years ago trying to extract the chemical flavor compounds from shrimp heads and to test them for use as flavor additives in foods and pet foods.

The researchers have clearly established that a high quality shrimp flavor can be obtained from shrimp heads and that it is composed of amines. They have also discovered two other extracts which have potential commercial value—shrimp oil (lipids) and a meal made entirely from shrimp heads.

The three stage process the chemists have developed includes extraction with chloroform-methanol followed by filtration. This yields a soluble and an insoluble residue.

After oven drying, the insoluble residue is a nearly fat free, high protein dry meal with a slight seafood odor. The meal has been analyzed by the Ralston-Purina Company and found to contain 53% protein.

When the soluble residue is mixed with water, a phase separation occurs. The upper phase contains the flavoring and chemotropic components and the lower phase contains shrimp oil.

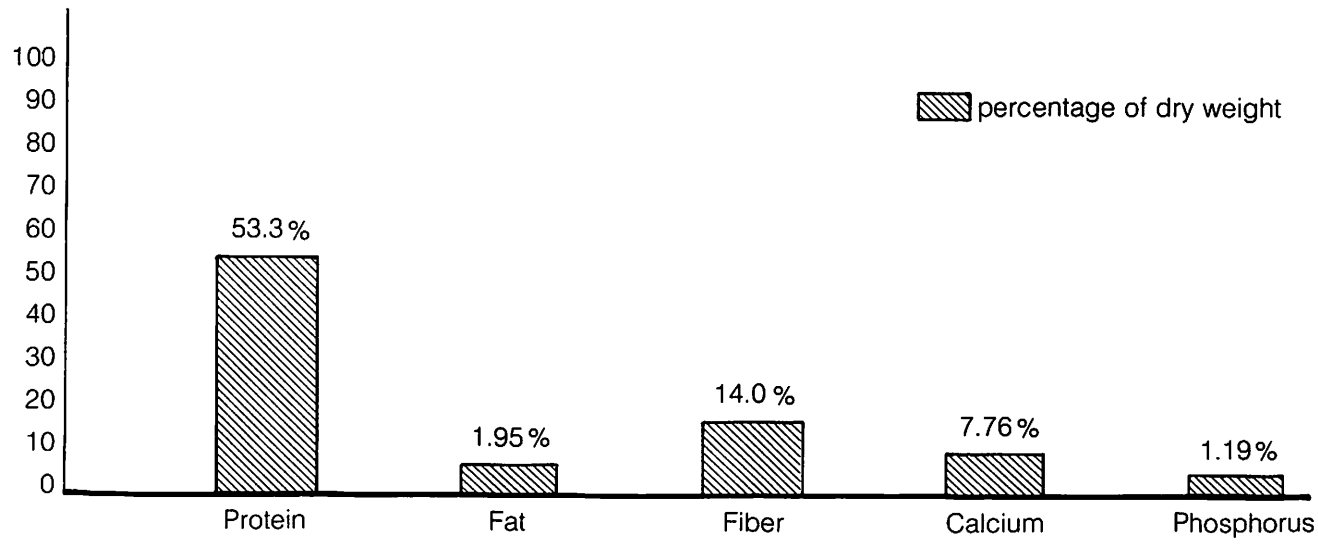
Some of the flavoring and chemotropic components are probably identical amine compounds. A minute amount of this material introduced into an aquarium will induce a very strong feeding response in blue crabs.

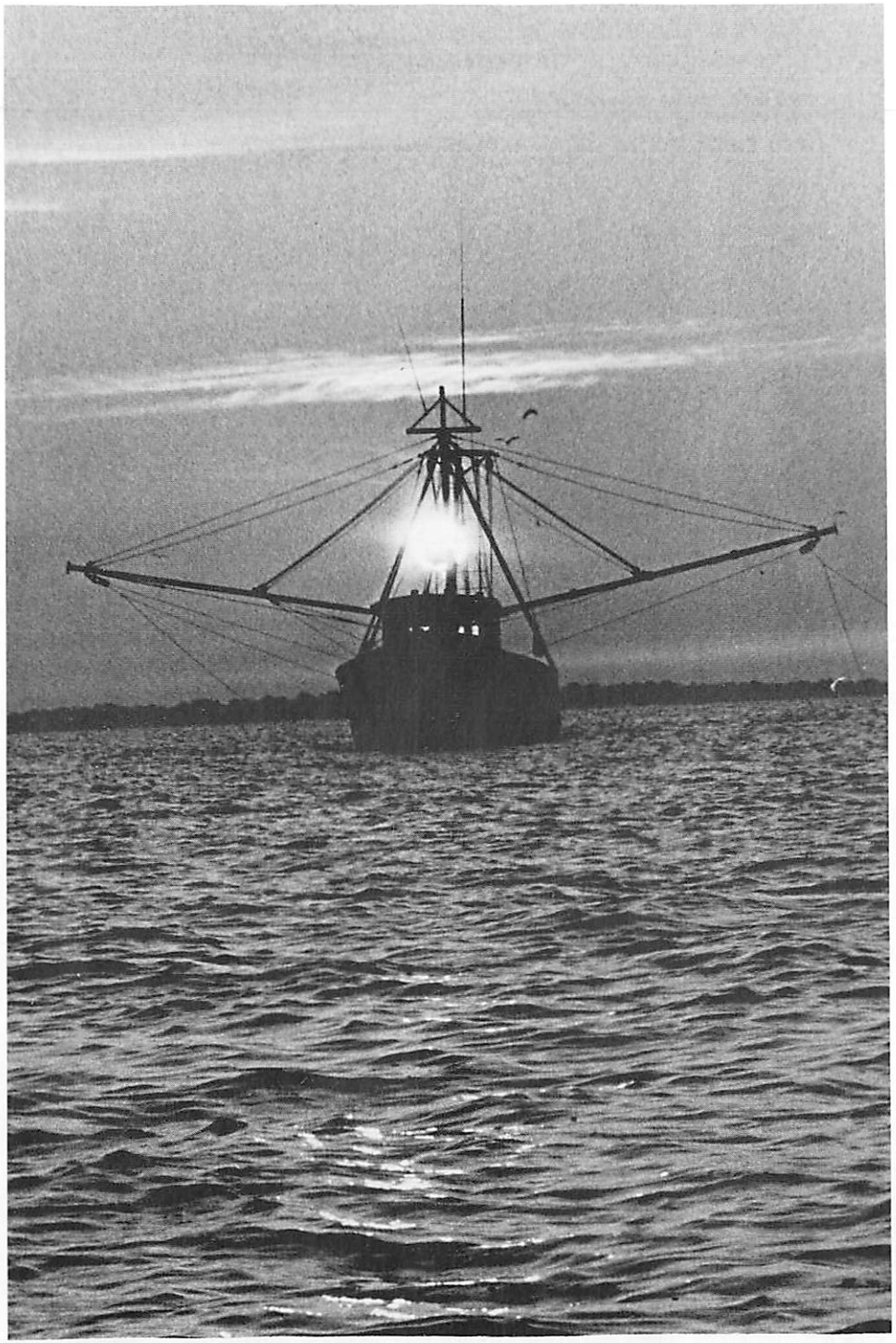
The value of this chemical attractant is obvious. Potential uses include bait for blue crab traps, an aid in harvesting cultured crustaceans, and others. A major problem is the instability of the flavor-containing extracts during freezer storage, so the researchers will look this year at the effects of structural changes on flavor and chemotropic characteristics.

If only fresh or newly frozen shrimp heads can be used, the economic feasibility of extracting these compounds diminishes. Processing plants would have to be located very close to a large concentration of shrimp head waste, and the plants could not operate year round. It is hoped, however, that new technology can be developed to prevent rapid decomposition by chemical methods.

Shrimp Head Meal

Sea Grant scientists at the Medical University of South Carolina discovered one by-product of "recycled" shrimp head wastes, a high protein meal, that is nearly fat-free and has commercial potential as a feed additive.





As mentioned earlier in the aquaculture section, the shrimp head oil residue may have commercial value as a source of pigment in the diets of cultured seafood species such as salmon and prawns.

In the coming year, research efforts will move from the laboratory to the preliminary production scale. When large enough quantities of extract have been gathered, aroma and flavor quality will be judged by a panel of food scientists and experts, and attempts will be made to interest industry in testing all three forms of extract in their products.

legal look

Biological and economic factors are not the only ones limiting full utilization of marine resources. Sometimes things such as laws, or the lack of them, can be significant too.

A professor in the USC School of Law has spent the last year surveying South Carolina's marine laws to provide some guidelines to understanding the tangled web of legalities. He has found, for example, that South Carolina has no legal structure for the protection and development of aquaculture. And there are other areas where laws and jurisdictions overlap, or where new laws are needed to fill the gaps.

These and other potential problem areas will be the focus of study during the coming year, as the USC lawyers get together with state agency officials and others to draft new laws.

In another aspect of the project, the lawyers will look at Amendment One of the Atlantic States Marine Fisheries Commission compact which authorizes several states to enter into joint agreements without seeking Congresional approval of their actions. They hope to clear up any uncertainties as to the legal meaning of the compact and explore ways in which this mechanism might be useful to regional fisheries management plans such as the South Atlantic plan currently under development.

resource utilization research personnel

Oyster Project:
Dr. Victor G. Burrell, *Marine Resources Research Institute*
Dr. B. K. Webb, Andrew G. Jordan, *Clemson University*

Amaroucium Project:
Dr. Wilbert G. Walter, *Medical University of South Carolina*

Shrimp Head Project:
Dr. Lewis Stillway, *Medical University of South Carolina*

Legal Project:
Dr. John E. Montgomery, *School of Law, University of South Carolina*

environmental studies

heavy metal pollution

Real progress toward proper management and development of marine resources is hampered by a basic lack of understanding of many aspects of the marine environment. Consequently, environmental research is often an integral part of programs designed to develop our sea resources.

Two Sea Grant supported research projects here in South Carolina have dealt with the important topic of pollution by heavy metals in the state's tidelands and estuaries. A College of Charleston chemist has analyzed surface foams that collect in Charleston Harbor for indications of heavy metal concentration. It has been shown elsewhere that metals, if present, do

tend to concentrate in these foams and they can then be used as an indicator of pollution by heavy metals in estuarine waters.

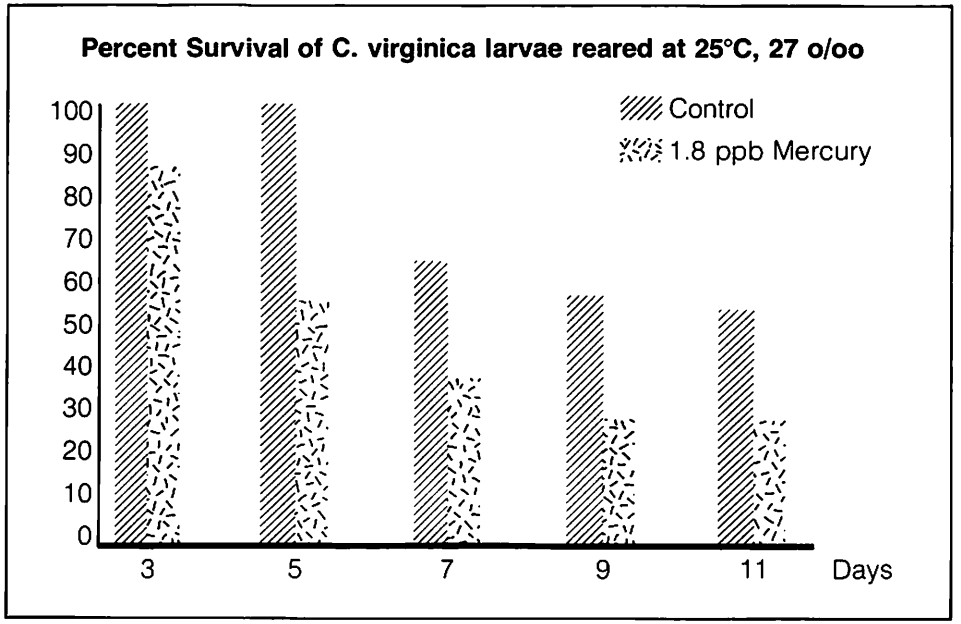
The South Carolina study has indicated that solids found in the surface foams of Charleston Harbor are primarily suspended clays. The levels of alkali and alkaline earth metals such as cadmium and mercury are 100 to 1,000 times greater than their concentrations in river waters. Other heavy metals such as iron and zinc show similar concentration factors.

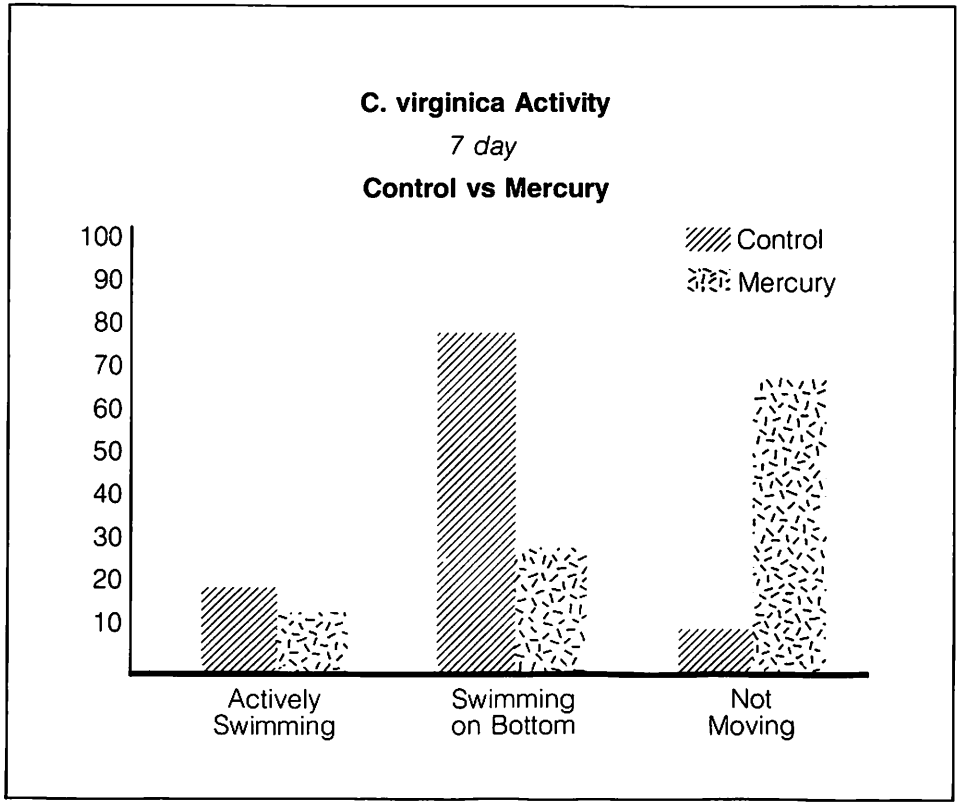
The effects of heavy metals such as cadmium and mercury have come under the scrutiny of a team of marine biologists from the University of South Carolina. Using a range of physiological indicators which included survival rate, metabolism and behavior, the scientists tested marine larvae under control conditions and under the added stress of low level concentrations of mercury and cadmium.

They found that larvae of fiddler crabs, mud snails, oysters and other marine animals can survive low levels of metal pollution under optimum conditions, that is, if conditions in the estuary are just right for survival in the first place. But as everyone knows, estuarine conditions are extremely changeable. A sudden summer rainstorm can alter salinity and water temperature in an estuary in a matter of minutes. The combination of these two stress factors—metal pollution and suboptimum conditions—can cause increased mortalities among larvae.

For example, larvae of the commercially important American oyster are very sensitive to low level concentrations of mercury. In one experiment, half the larvae exposed to mercury were dead within five days whereas the control group was almost 100% alive.

Perhaps even more striking than the mortality rate was the observed





Tests by University of South Carolina ecologists on oyster larvae exposed to low levels of mercury showed a marked difference in survival after only five days (top). Even more striking than the mortality rate was the observed change in swimming behavior. After seven days, 70% of the mercury exposed larvae, though technically still alive, were not moving or feeding at all.

change in swimming behavior. By the seventh day of the experiment, 90% of the control larvae were still swimming actively in the water column or were swimming above the bottom of the test container. In contrast, nearly 70% of the mercury exposed larvae were not moving at all, even though their cilia were still beating and they were technically alive.

Obviously, these extreme alterations in normal larval behavior inhibit the organism's ability to find food and make it easier prey to its enemies. The low levels of pollution may not kill the organism outright, but they make it infinitely more difficult for the larvae to survive to adulthood. The levels of mercury used in these experiments are below those levels considered "safe" for adult marine organisms, and are well within the range found today in some South Carolina estuaries.

parasite studies

Another form of pollution, silt pollution, was suggested by a Sea Grant researcher from the College of Charleston to be related to the increased incidence of parasitism in another commercially important marine species, the Atlantic menhaden. In experiments ranging over a two year period, marine biologists from the College and the Marine Resources Center studied the parasitic relationship between menhaden and a previously unknown species of blood sucking marine leech. The leech appeared on the scene suddenly in 1971, infesting almost 100% of the menhaden caught in Charleston Harbor that year and the next.

Concerned that the leech may transmit debilitating blood parasite diseases, the biologists went to work on establishing the cause of the epidemic infestation and determining the life cycle of the new parasite. The biology of the leech is now well documented but the cause of the epidemic remains something of a mystery, although the biologists theorized that excessive turbidity of estuarine waters may have protected the leech from the sight of natural predators and triggered the population explosion.

environmental research personnel

Surface Foam Project:
Dr. Frank Kinard, *College of Charleston*

Heavy Metal Pollution:
Dr. Winona B. Vernberg, *University of South Carolina*

Menhaden Parasite Project:
Dr. Roy T. Sawyer, *College of Charleston*

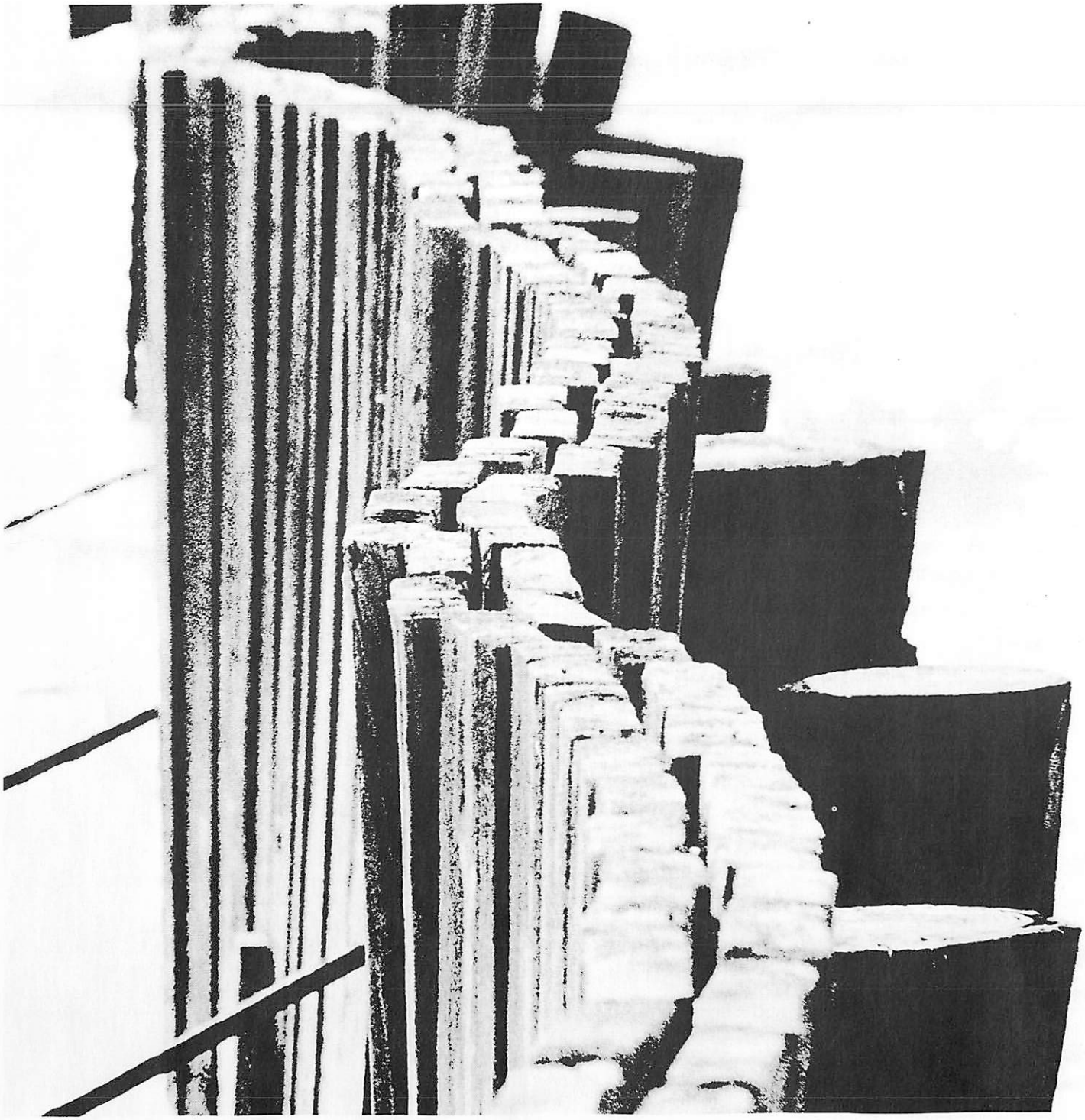


Photo by McComb, courtesy Charleston News and Courier

marine technology

Ocean engineers from Clemson University have worked for the past year on two projects involved with stabilizing waterfront property. One study, aimed at stabilizing dredge spoil material to make it suitable for construction, has made little progress.

The other project has shown encouraging results. Synthetic fiber materials are being tested as a possible aid in controlling beach erosion. Anchored to short stretches of shoreline, fiber mats show promise as erosion retardants and offer the advantage of being relatively inexpensive, light weight, and non-permanent when compared to expensive, permanent erosion control structures like groins and sea walls.

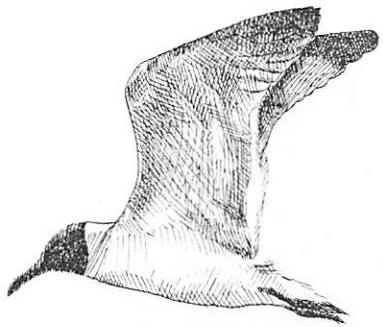
Laboratory experiments were conducted this year to screen materials, the most promising of which will be field tested later. Using a 35-foot wave tank, the engineers installed a model beach at one end and a wave generator at the other. Wave frequency, height and velocity can be varied to simulate different seasonal and weather characteristics.

Control experiments were run to establish how the beach reacted to the wave action with no protection, then materials were installed both on the surface and buried beneath the sand. During each run the beach was subjected to storm waves to cause erosion and summer waves to cause a build-up of sand.

The results were evaluated with the use of statistical analysis. On all runs except one, the buried installation was superior to the surface installation. Of the materials tested, only two proved to be statistically significant in controlling erosion.

Those two materials will be tested in the field next year. Anchoring the mats will be the most troublesome problem to surmount, since the force and fury of the real Atlantic is much greater than the Clemson wave tank. Researchers are hopeful, however, that the material will prove to be an easy, inexpensive and temporary way of controlling serious localized erosion and of helping to rebuild seriously eroded beaches.

Dr. Billy Edge studies the effect of synthetic fiber mats on "beach erosion" in his 35-foot wave tank at Clemson.



marine technology research personnel

Spoil Stabilization Project:
Dr. William Baron, *Clemson University*

Erosion Control Project:
Dr. Billy L. Edge, *Clemson University*

coastal zone planning

physical sciences

The future of South Carolina's coastal and marine resources will be determined in large measure by coastal zone planning and management activities now under way. Under a grant from NOAA, the South Carolina Coastal Zone Planning and Management Council is at work delineating the coastal zone boundary and formulating a preliminary management plan.

Such a broad planning and management effort calls for an extensive research base in both the physical and social sciences. To help meet this burgeoning research need, South Carolina Sea Grant developed a program area devoted to research in support of coastal planning activities.

A comprehensive research effort in the field of physical science involves geologists from the University of South Carolina. One project, aimed at defining the nature of bottom sediments, bedforms, subsurface structure, and stratigraphy in South Carolina estuaries and marshes, has been completed. Using seismic profiles in combination with bottom samples and core samples, the geologists are providing bottom charts and subsurface cross-sections of sediment and rock likely to be encountered in dredging and construction projects.

The practical value of these charts and maps is obvious. Before these studies were conducted, one could only guess at how much and what type of material had to be dredged to create or maintain harbors and navigation channels. Now profiles and bottom samples are complete for Charleston Harbor (Cooper River), Winyah Bay, Port Royal Sound, and numerous lesser estuaries.

Seismic profiling was also done in the North and South Santee Rivers, but the other phases of study, including bottom sampling, were carried out by USC geologists at work on a separate project to study the Santee system in greater detail.

The Santee represents an unusual opportunity for estuarine studies because the river is scheduled to undergo a massive rediversion project which will alter drastically its salinity and biotic composition. Originally a great river with a mighty flow and a heavy sediment load, the Santee has been steadily eaten away by a hodge-podge of small dams on its steams and tributaries.

The vast 1942 hydroelectric project which created lakes Marion and Moultrie diverted a major portion of the Santee's flow into the Cooper River and Charleston Harbor. The increased sediment flowing into the harbor has caused major problems for port officials struggling to keep the shipping lanes open and deep. A plan to redivert the Santee back into its old channel is now in the early stages of implementation.

The goals of the recently completed USC Santee study were to:

1. determine the effects of the original diversion on the Santee River system,

2. establish the present hydrological and sedimentological conditions, and

3. develop a hypothesis to describe the effects of rediversion on the system.

The geologists began by plotting 250 sampling stations in both rivers and in Santee Bay. Through the use of bottom samples, core samples, hydrological, bathymetric and atmospheric data, they have come up with some valuable information on what to expect from rediversion. Among their findings:

- the original diversion changed the hydrological and sedimentological characteristics of the Santee River estuaries (North and South Santee). They changed from the salt-wedge stratified type estuary to a partially mixed type.

- the original diversion decreased the sediment supply to the Santee Delta, causing the delta to be cut back and the estuaries to fill with ocean sediments. Decreasing water depths have effectively plugged the mouths of both rivers.

- after rediversion, the system will revert to a salt-wedge stratified estuary.

- the post-rediversion river will probably re-establish old channels except in areas where the marine deposits are very deep. In these places, there is a danger of the river "jumping" its channel and eroding a new path through existing land area.

erosion inventory

The geologists working on the Santee project have also theorized about one other possible consequence of the original diversion project—increased beach erosion on sea island beaches south of the delta. If the Santee system was supplying substantial sediment to renourish beaches, then diversion no doubt had a lot to do with recent erosion.

It is true that many South Carolina beaches have been eroding steadily over the past forty years, but at present, no one knows where the sand goes, at what rate erosion occurs, or even which beaches are eroding. Another team of geologists from USC and the Marine Resources Center last year began a comprehensive beach erosion inventory of South Carolina's coastline to answer just such questions as these.

A major component of the new investigation is beach profiling. The researchers have set up 90 profile stations which they monitor on a monthly basis to determine short term changes in the beach face. In addition to the profiles, data is recorded monthly on wave direction and velocity.

Sand samples are taken on a quarterly basis at each station and analyzed to determine mineralogic content and grain size. By characterizing the sand in this manner—what size is the average grain, and is the sand mostly shell material or quartz?—The researchers can infer things about the origin of the sand and how it was transported to the beach.

For example, many people have long assumed that there is a "river of sand" flowing in a north to south direction just off the coast of South Carolina. Groins have been built to try to intercept this "river" and rebuild selected beaches along its path. Now however, the MRC geologists have found evidence that this time-honored theory may not explain adequately the movement of sand along our coast.

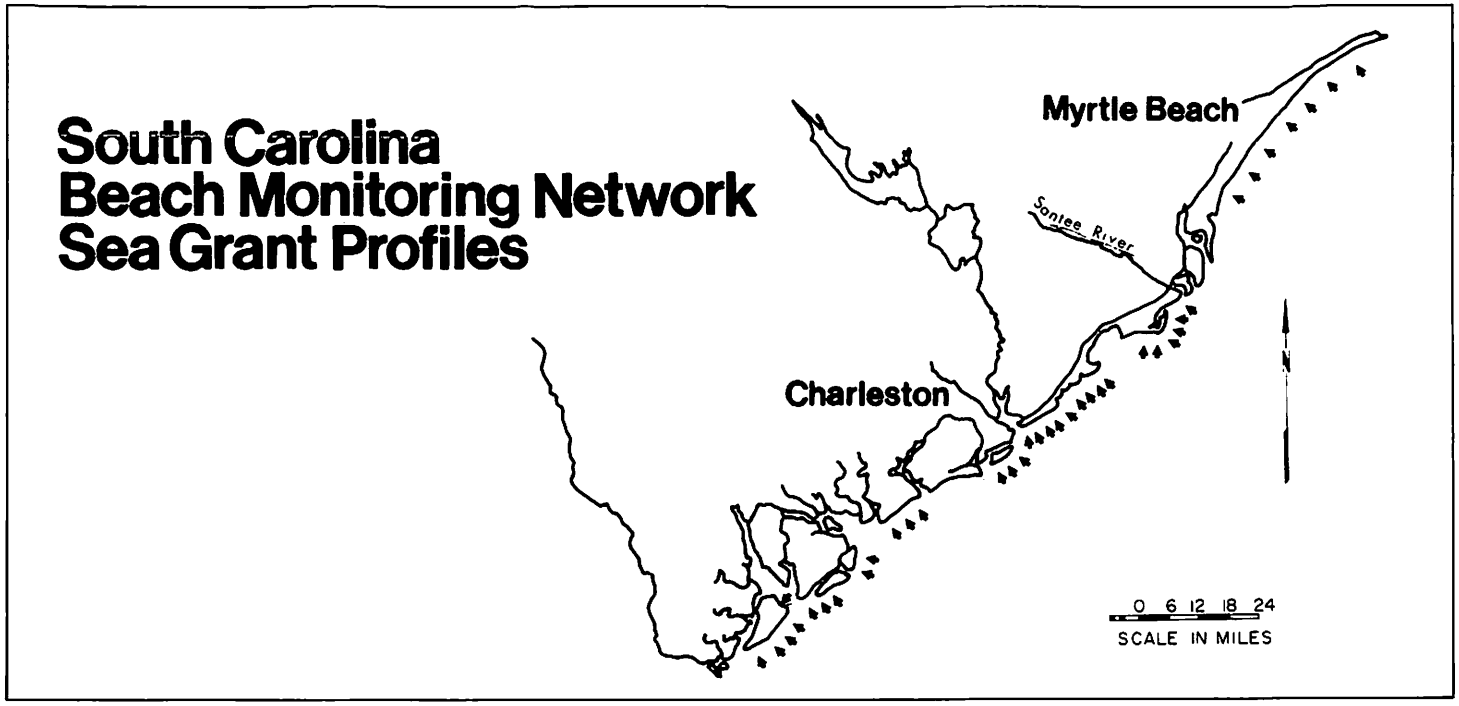
If indeed there is this "river of sand," the sand along the entire coast would have a similar mineralogic content but the coarser grains would be found on the northern beaches and finer sands would be found on the beaches to the south.

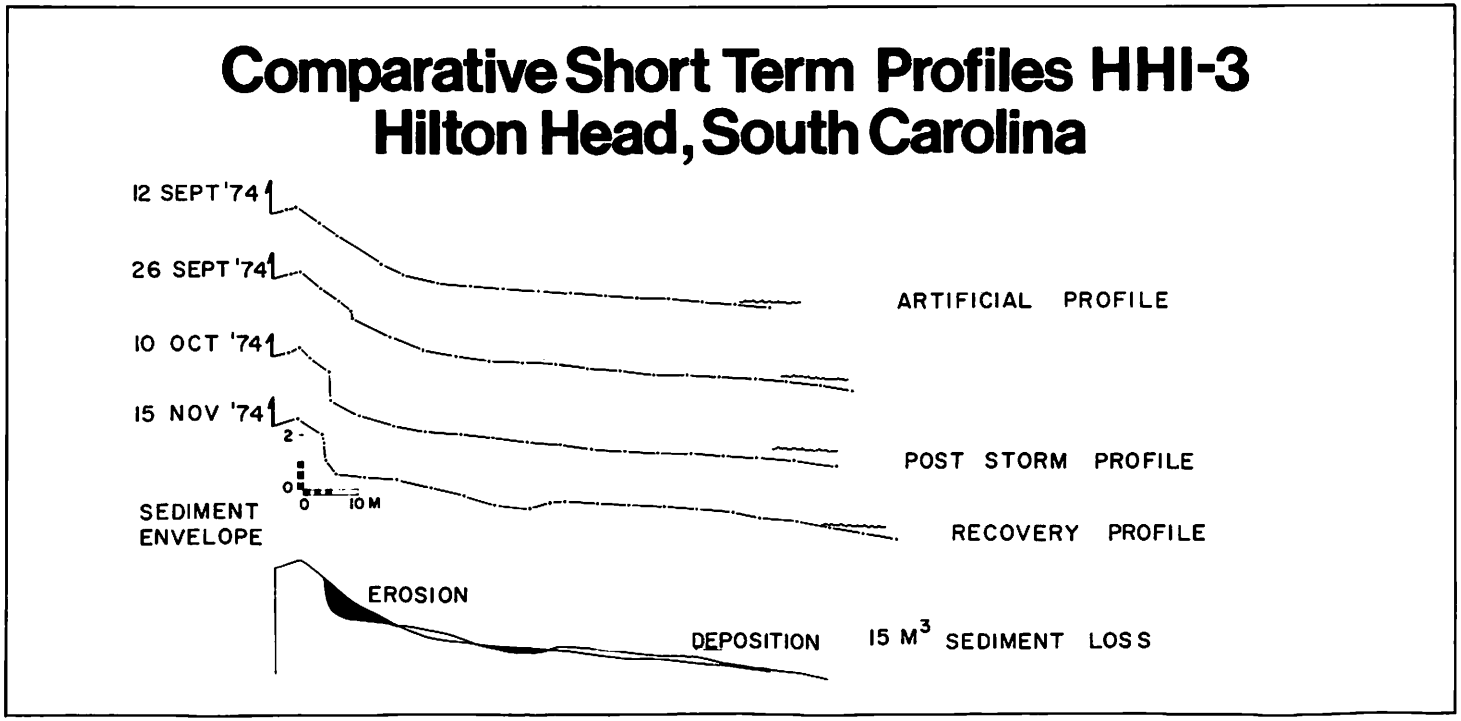
This is not the case. The geologists have found that the sands of the Grand Strand area (Horry and Georgetown counties) are much different from the types of sand found on the southern, or sea island, stretch of the coast, and the sand found on Edisto Beach, almost the center link in the sea island chain, is different from that of any other beach.

All of these tools used in the study of beach erosion—profiling, grain size and hydrological analysis—are important but they deal with very small localized sections of the beach. It may take years of profiling to establish any long term erosion or deposition trends.

Fortunately, the Sea Grant geologists have another valuable tool at hand—aerial photography. In addition to immediate trends, historical changes in erosion-deposition patterns are determined by comparison of aerial photographs, maps and charts for successively longer time periods. This allows examination of the position of the shoreline through time.

A prelimary report illustrating these trends has been published for Charleston County, with similar reports for the remainder of the coast forthcoming. In Charleston County, the geologists found that a number of beaches are eroding severely while others are relatively stable. Maps and graphs are provided to show exactly where erosion and deposition have





occurred and all the beaches in the county are classified as either eroding, accreting, stable or unstable. These publications allow examination of the behavior of short segments of beach, and set back lines or shoreline stability may be determined directly from the graphs presented in the report.

The studies also have identified the tidal inlets which separate individual barrier islands and their associated sand shoals as having a major role or influence on beach erosion and deposition trends. The inlets are felt to be a critical area in which further studies are needed. In addition to their control of erosion trends, they are of major economic importance as channels for commercial shipping and fishing activity, and for recreational boaters and fishermen.

social sciences

In addition to work in the physical sciences, like geology, an understanding of social and economic factors is also important to planning for the orderly growth of the coastal zone. To this end, social scientists from across the state have received support from Sea Grant in their efforts to shed light on the economic and social climate of the coastal zone.

By comparing income, employment and other indicators of economic activity, economists from USC's Bureau of Business and Economic Research were able to determine the overall impact of the sea and coastal zone resources on the economies of

USC geologists have set up 90 beach profile stations (top) all along the South Carolina coast. They are monitored on a monthly basis to provide graphic evidence of the changes in the beach face caused by erosion and deposition.

two counties and to predict future economic activity in the area.

In a technical report entitled "A Study of Economic Change in Two Coastal South Carolina Counties: Georgetown and Horry," the author reports that the counties depend on their uniquely coastal zone resources for about 75% of their total economic activity. This figure is expected to rise during the latter part of this decade.

As far as land-sea resources are concerned, the economists foresee no shortage of land in Georgetown County. Since manufacturing is not particularly land-intensive, and no great increase in residential land-use or tourism are foreseen, the use-related conflicts should be manageable.

Horry County presents a different picture. This tourist oriented community will see a continued growth of tourism, causing a concentration of commercial and residential facilities in the immediate coastal zone. Because the sea-related tourism presses too much activity into a relatively small area along the shore, a shortage of "prime sites" is predicted in a few years.

These and other economic predictions resulting from the Sea Grant study will be of great help to planners in the next few critical years.

labor is scarce

Another social study was begun in 1973 to assess the labor situation in South Carolina's commercial fisheries. The first half of the investigation provided an analysis of the usable income from public assistance programs as a competitive alternative to employment.

The results of this first phase of the labor study were published as a Sea Grant technical report titled, "A Comparison of Usable Income Potential: Public Assistance Payments vs. Employment in Fisheries Related Industries in South Carolina." The economists found that public assistance may well be a competitive alternative to employment in low paying industries such as fisheries.

For a family of five people, the economists noted, fishing industries and other potential employers would have to pay a minimum of $1.60 to $3.00 per hour to be equivalent to, or break even with, welfare assistance, depending on the employment period and whether the wage earner took advantage of low income "bonus" food stamps. When one considers that industries would probably have to offer a wage rate higher that the "break-even" wage, public assistance appears to be an even more competititve alternative in those cases where potential wage earners are elibigle for assistance.

The second phase of the two-part study, this one aimed at assessing the availability of labor now and in the future, was completed in mid-1975. Before any assessment or predictions could be made, however, the economists first had to determine the labor characteristics of the industry they were studying.

They found that in the four coastal counties of South Carolina, fishing attracts mostly non-white workers with limited or no skills. Shrimping is by far the most important of South Carolina's fisheries, accounting for almost 80% of the total value of fishery products landed in 1973.

Not counting the boat captain, who is often the owner of the fishing vessel, the typical shrimp boat employed two crew members each year from 1960 to 1970. During this same period, however, the average vessel size increased from 27 tons to 38 tons, suggesting that there has been an increasing trend toward the substitution of capital for labor in the shrimp industry.

Projections of the supply of labor in the four counties indicate that approximately 50,000 to 53,000 workers will be available in 1980, of which 1,000—1,400 will be needed by the fishing industry, according to demand projections. Since this 1,000 to 1,400 workers represent only 3 percent of the projected unskilled, black civilian work force in 1980, fisheries will face stiff competition from other employers.

In fact, the economists predict that the supply of labor to fisheries industries will be even more limited by 1980, and that shortages are likely to occur at present wage rates. Obviously, wage rates must increase in order to prevent labor shortages, and the economists endorsed current efforts to expand markets and the industry as a whole. The economists also predicted that fishery product prices are likely to rise as a result of industry expansion and wage increases, and encouraged the further development of labor-saving mechanical harvesting devices, particularly for shellfish.

attitudinal surveys

Turning from economics to political science, Sea Grant social scientists from the College of Charleston surveyed the attitudes of South Carolina citizens toward wetland resources and public access to beaches.

In the first study, 200 influential decision-makers, including legislators, marshland owners, developers and environmental leaders were interviewed about their attitudes toward marshlands. Almost without exception, these "elites" could give a scientifically acceptable definition of "marshland," and 97% of them felt salt water marshes are among the state's most valuable natural resources.

A surprising 93% of the survey sample said that they thought government should regulate commercial development, with state government mentioned most frequently as the proper level of authority to regulate the tidelands. In addition, 73% of the sample did not favor an owner being free to do what he wants with his marshlands property.

Concerning the types of control, 83% favored zoning and 73% responded favorably to a system of leasing permits. In expressing priorities for the uses of wetlands, conservation far outranked any other priority (56%).

The survey also revealed that more than three-quarters of the respondents believe offshore activities which could affect marshlands, such as offshore drilling, port siting, mining and waste dumping, should be regulated by the state.

The survey showed a surprisingly high level of awareness and concern over one of South Carolina's most important coastal zone resources, and indicates a strong consensus for marshland legislation by the State of South Carolina. These attitudinal results should help planners devise programs for managing valuable wetlands.

A similarly high level of concern over public access to beaches was voiced by Charleston County voters in a separate survey completed last year. A random sample of over 300 Charleston voters reported extensive usage of coastal waterfront property. For example, over 60% had used the beaches for swimming and over 33% for fishing during the preceding year.

A majority of the sample rated public access to beaches as fair or poor rather than good or excellent. According to the voters, the greatest access problem is inadequate public parking for automobiles.

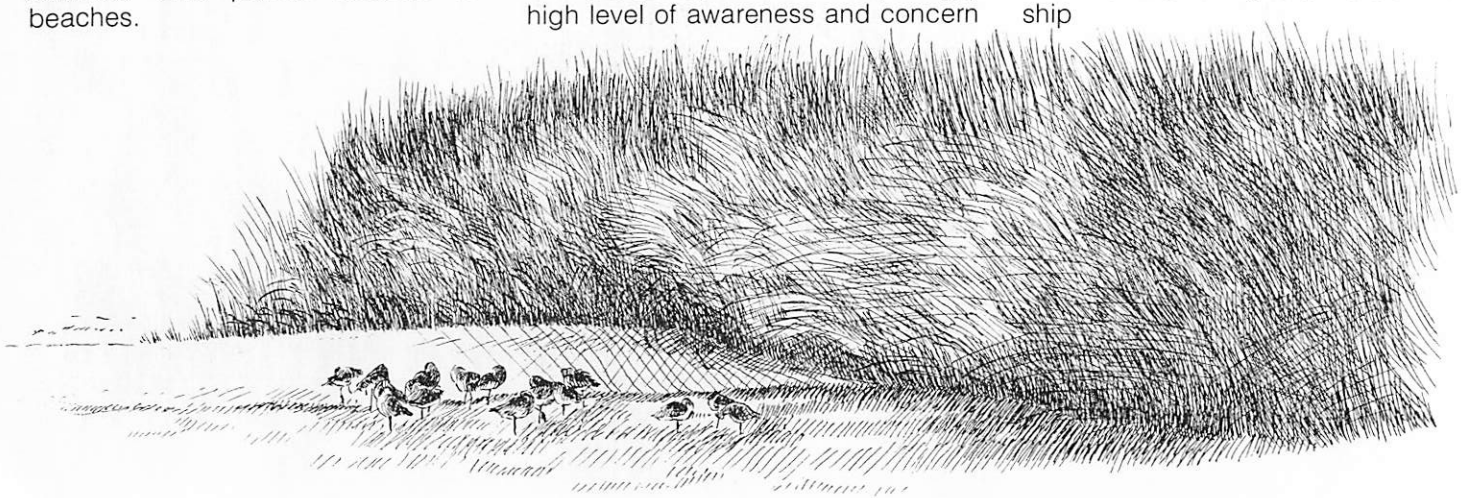
In other important areas, the researchers found that the respondents showed:

- limited knowledge of the laws relating to beach ownership and public access.

- a preference for state ownership and control of beaches, rather than federal, county or private ownership

- almost 90% support for government acquisition of access strips to guarantee public accessibility to beaches. Although the respondents were wary of federal ownership and control of beach, most supported federal financing of public access costs.

In general the public did not object to local development projects now under way, although over 90% thought that the state should pass a law protecting sand dunes. The voters stated that the two top priorities in the use of coastal waterfront property should be public recreational development and conservation.



coastal zone planning research personnel

Estuarine Stratigraphy Project: Dr. Donald J. Colquhoun, *University of South Carolina*

Santee Delta Project: Dr. William Kanes, *University of South Carolina*

Beach Erosion Inventory Project: Dr. Miles O. Hayes, *University of South Carolina*

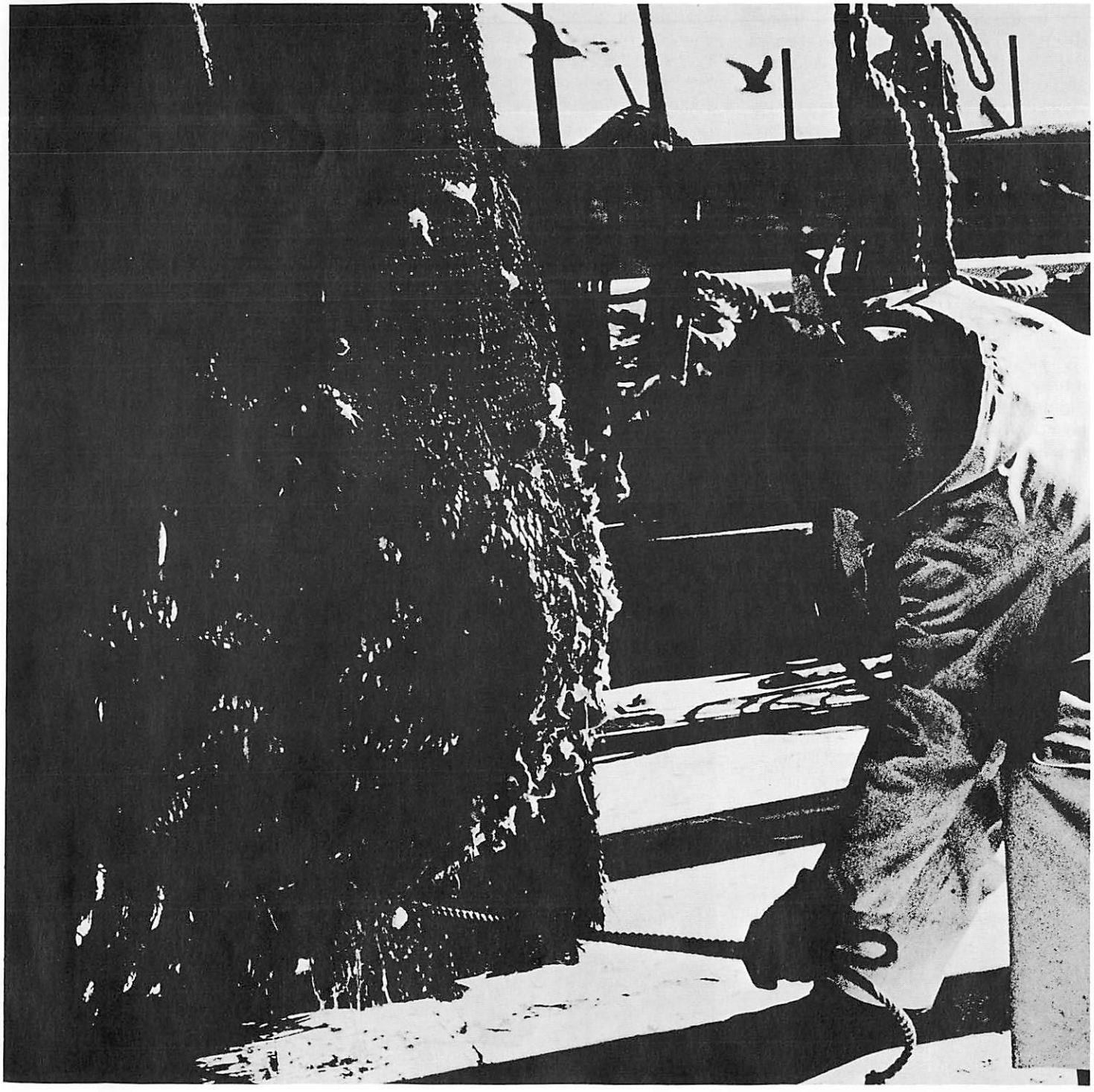
Economic Impact of Coastal Zone: Dr. J. Michael Marr, Dr. Olin Pugh, *University of South Carolina*

Income vs. Public Assistance Project: Dr. John W. McAlhany, *The Citadel*
Lowell E. Nordquist, *Clemson University*

Fisheries Labor Assessment Project: Dr. B. R. Skelton, Dr. Cliff Patrick, *Clemson University*
Dr. John W. McAlhany, *The Citadel*

Attitudes Toward Marshlands Project: Dr. Earl O. Kline, *College of Charleston*

Attitudes Toward Beach Access Project: Dr. James Bickley, *College of Charleston*



advisory program

Forming the link between professional and public—the marine researcher and the marine resource user—is the Sea Grant Marine Advisory Program. Through personal contact, the printed word, media coverage, public meetings and a host of other techniques, Advisory personnel establish the two-way contact so necessary to the Sea Grant concept of putting science to work on the problems of the sea and coastal environment.

South Carolina's marine and coastal community serves not only as audience, but also as participant in advisory program work, providing constant input and feedback to aid in planning for the Sea Grant program as a whole. For example, an advisory

agent may identify a problem with existing fishing gear through contact with mariners. He can relay this problem to engineers with the know-how to invent a new or modified piece of gear, and then report the results back to this and other fishermen.

This active outreach component is what makes Sea Grant unique. The Advisory Program can draw upon all of a university's resources and all of the expertise within state agencies and make them available to the marine resource user.

In keeping with the multi-institutional character of South Carolina Sea Grant, the Marine Advisory Program is a joint project involving principal investigators from Clemson University, USC, and the Marine Resources Center. Advisory activities serve the entire Sea Grant community, dispensing information on research results and calling upon investigators in every institution to aid in public programs.

Because of the small size of the South Carolina Sea Grant program, advisory staffers must sometimes go outside their particular fields of expertise to work with people on problems. The advisory program has been involved in projects ranging in diversity from advising fishermen of new tax laws to teaching young 4-H Club members about marine life. Among its many benefits to the coastal community, the advisory program has:

- helped a local TEC school add a fishing business management component to its commercial fishing curriculum
- conducted sanitation and seafood handling workshops in conjunction with the National Marine Fisheries Service
- helped get fishermen and industry together to supply horseshoe crabs for pharmaceutical research. The research has now turned into production of a derivative of horseshoe blood, creating a new industry for South Carolina fishermen.
- completed economic feasibility studies for two separate groups considering entering the fishing industry
- held a sportfishing clinic for cobia fishermen, three fishing business management seminars, an eel fishing and marketing workshop, two industry-wide conferences for commercial fishermen, and two seminars on beach erosion for coastal property owners
- produced two popular films on marine recreational activities, a bimonthly advisory newsletter and bulletins to inform the public of advances in marine research
- developed a series of audio-visual educational modules on marine biology, coastal processes, and commercial fishing lifestyles. These will be used by extension agents and public school educators, as well as Sea Grant and university speakers' bureaus.
- designed and staffed marine life exhibits for 4-H Club camps, state and county fairs.
- assisted the shrimping industry in drafting a shrimp marketing order to help resolve shrimp industry problems.
- helped open new avenues of financing for commercial fishing boat owners by acquainting fishermen with the Farm Credit System. The Production Credit Association (PCA) is now the largest fishing vessel lender in South Carolina, and the Coastal PCA office is the largest fishing vessel lender among PCA's in the Southeast.

As the staff expands, Advisory Program work will become more diversified in the years ahead. Increased effort will be devoted to coastal engineering problems, including shoreline stabilization, design of coastal structures, and permit application procedures. This future work, which is in response to audience needs, is an example of how the Advisory Program maintains flexibility in programming and techniques while delivering an informal educational program for marine resource users of all kinds.

When you work with fishermen, you have to go where the fish are. Ken Roberts (right), leader of the Sea Grant Extension Marine Advisory program, dons the gloves and lends a hand while advising Captain Freddy Vaigneur on his tax problems.

advisory personnel

Extension Marine Advisory Project: Dr. Kenneth J. Roberts, *Clemson University* (Project Leader)
David C. Smith, *Clemson University*
Neale Bird, *Clemson University*

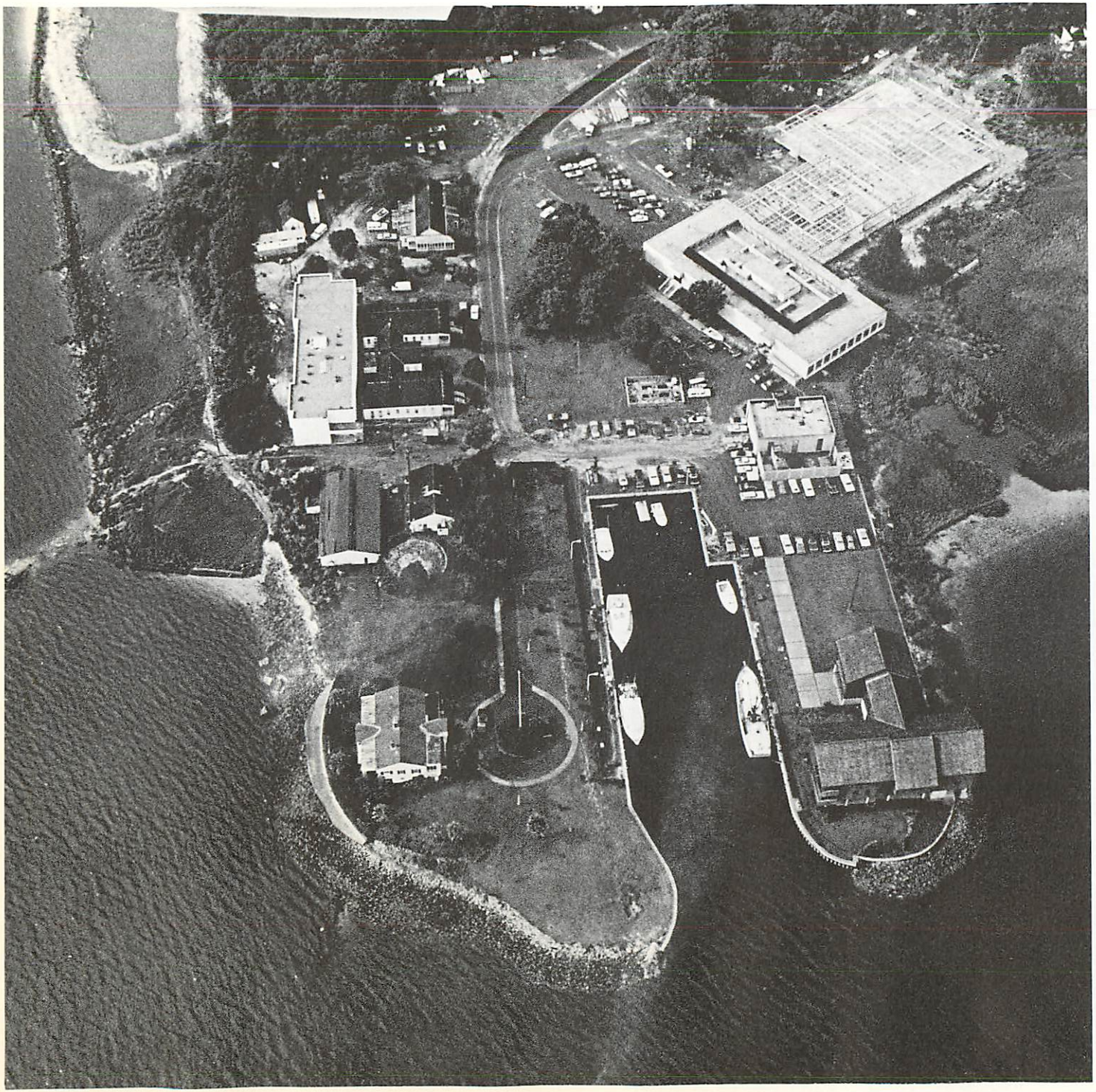
Information Project: Margaret C. Pridgen, *S. C. Wildlife & Marine Resources Department* (Sea Grant Editor)

Public & User Oriented Education Project: Dr. John M. Dean, University of South Carolina

education

As a result of Sea Grant support to design and implement a course in general marine science, the College of Charleston now offers an evening program for interested laymen and non-professionals as a part of their continuing education program.

The first such course was offered in the spring of 1974, with 34 students representing all walks of life successfully completing the 14-week course. Subjects covered included physical oceanography, chemical oceanography, instrumentation, major invertebrate forms and life histories, commercially important marine fisheries, phytoplankton, ichthyoplankton, oyster culture, life history and anatomy of the copepod and coelenterate,



mariculture, fishery science and management, ocean birds, reptiles and mammals, and environmental economics.

One feature of the course is the balanced mix of pure biology and fishery management information which is presented. Instead of merely learning the life histories of the major marine species, the students also got a chance to study their relative importance in the commercial market and the techniques which are used to manage them for the benefit of all. Doctoral level staff members of the Marine Resources Center assisted the College of Charleston marine biology faculty in instructing the course.

An aerial view of the expanded Marine Resources Center near Charleston shows a new addition to the College of Charleston Grice Marine Biological Laboratory (upper left) and the new Cooperative Research Center (upper right, under construction) being built jointly by the Commission on Higher Education and the South Carolina Wildlife and Marine Resources Department. Upon completion, the new lab will house students and researchers from all of the state's public colleges and universities, making the Marine Resources Center one of the largest marine research and education complexes on the East Coast.

education personnel

Marine Science Education Project: Dr. Harry W. Freeman, *College of Charleston*

program summary

project	1972-73	1973-74	1974-75	1975-76
1. Program Administration & Development	N	C	C	C
2. Marine Advisory Program	N	C	C	C
3. Public and User Oriented Marine Science Education	—	—	N	C
4. Course Development & Offering: General Marine Science	N	C-F	—	—
5. The Potential for Culture of *Macrobrachium* Prawns in S. C.	N	C	C	R-N
6. Engineering Support for *Macrobrachium* Culture	—	N	C	C
7. Investigation of the Use of Batch & Continuous Cultured Algae in Crustacean Mariculture	—	—	N	C
8. Lipids & Fatty Acids of Laboratory Reared *Macrobrachium*	—	—	N	C
9. Revitalization of the S. C. Oyster Industry through Modern Culture Techniques— Investigation of the Potential of Intensive Oyster Culture in Impoundments	N	C	C	R-N
10. Shrimp Heads as a Source of Flavoring Components	—	N	C	C
11. Isolation & Study of Antitumor Principles of *Amaroucium*	N	C	C-F	—
12. A Study of Laws Relating to Utilization of S. C. Marine Resources	—	—	N	C
13. Marsh Production & the Effects of Environmental Perturbation: Physiology, Behavior, & Energetics of Larval Zooplankton	N	C	R-F	—
14. A Preliminary Investigation of Heavy Metals Associated with Estuarine Mixing	—	N-T	—	—
15. Host-Parasite Relationship Between the Menhaden & Its Blood-sucking parasite *Calliobdella carolinensis*	N	C-T	—	—
16. Sedimentation, Bed-form Analysis, and Stratigraphy of South Carolina Estuaries and Marshes	N	C-F	—	—
17. Sedimentary Framework of the Santee Estuarine-Delta Complex	N	C	C-F	—
18. South Carolina Coastal Erosion Inventory	—	—	N	C
19. Economic Base Analysis of Georgetown & Horry Counties	—	N-F	—	—
20. Program to Document & Assess Factors Affecting the Supply of Labor as a Marine Resource in South Carolina	—	N-F	—	—
21. Assessment of Labor Availability for S. C. Fishery Industries	—	—	N-F	—
22. Elite & Public Attitudes Toward Coastal Marshlands	—	N-F	—	—
23. Charleston Attitudes Toward Public Access to Coastal Areas	—	—	N-F	—
24. Utilization of Diked Disposal Areas in South Carolina	N	C-T	—	—
25. Fabric Materials for Coastal Protection	—	N	C-F	—

N—New Project
C—Continuing
R—Restructured
T—Terminated
F—Project Completed

1973-1975 sea grant program budget

	FY 1974		FY 1975	
	NOAA Funds	Matching Funds	NOAA Funds	Matching Funds
marine resources development				
Aquaculture	$ 30,700	$ 14,300	$ 96,600	$ 51,700
Living Resources (other than aquaculture)	3,300	7,400	42,300	24,400
Marine Biomedicinals & Extracts	27,300	17,700	29,200	21,500
Marine Law & Socio-Economics	18,600	11,400	23,000	11,000
marine technology research and development				
Coastal Engineering	31,300	13,700	19,500	7,900
Aquaculture Engineering	16,800	6,800		
marine environmental research				
Research in Support of Coastal Zone Management	5,000	7,500	48,300	27,500
Ecosystems Research	40,100	20,100		
Pollution Studies	3,300	6,900		
Environmental Models	7,800	4,500		
marine education and training				
College Level	2,800	5,300		
advisory services	53,000	18,200	84,100	44,300
program management & development				
Program Administration	5,000	23,400	7,700	14,300
Program Development	5,000	—	20,000	—
Totals	$250,000	$157,200	$370,700	$202,600

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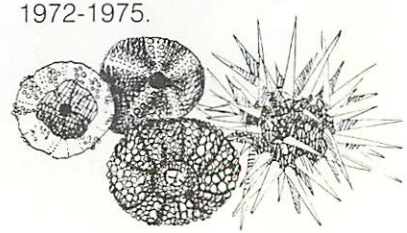

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