Sea Grant at Texas A&M

A Biennial Report

TABLE OF CONTENTS

The two years covered by this report have provided cause for an anniversary celebration, for excitement about scientific breakthroughs, and for concern about Sea Grant's future.

We celebrated the tenth anniversary of the Texas A&M Sea Grant College Program on September 17, 1981. Throughout this decade, we have focused on the goals implied by this Sea Grant College designation — encouraging the wise development, use, maintenance and conservation of our marine resources. We have developed a team of marine advisory agents and specialists to work with our coastal communities; a marine education program to prepare teaching materials and show teachers how to conduct programs using these materials; and a marine research program which recognizes that research is an investment that frequently requires many years of continuous support before returns are realized.

And it's when the returns come in — often in the form of scientific or technological breakthroughs — that we have a sense of gratification. Then we realize that our contribution, however modest, helps improve our way of life and builds a stronger state and national economy.

Several such breakthroughs occurred in our shrimp mariculture research during the past two years. For the first time in the United States, Sea Grant researchers succeeded in spawning the native Texas shrimp in captivity. It is no longer necessary to capture pregnant shrimp from the Gulf of Mexico to supply seedstock for the shrimp ponds. Another first for Texas occurred when researchers succeeded in growing two crops of shrimp in outside ponds without artificial heat during one warm South Texas growing season. This achievement greatly enhances the productivity of shrimp farming during Texas' long growing season. Finally, our scientists succeeded in immunizing shrimp against a wide range of diseases. Higher production in the ponds stocked with vaccinated shrimp, and laboratory tests on harvested live shrimp proved that the immunity lasted throughout the growing season. These milestones have brought shrimp mariculture in Texas to the verge of commercial reality.

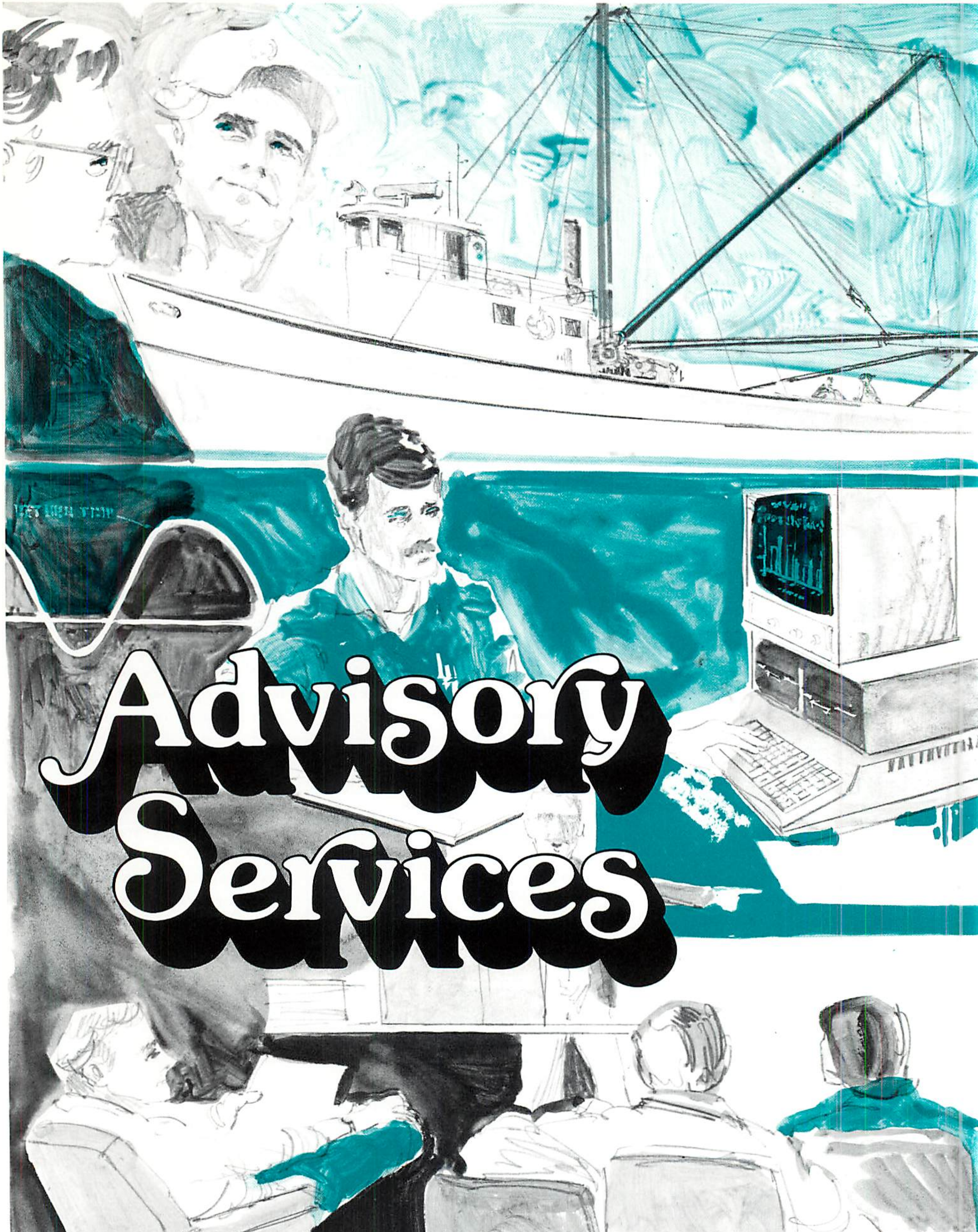
Another source of gratification comes from the satisfaction we feel when findings from our research projects are used to solve some of the many problems people encounter in dealing with the oceans and their resources. For example, one study of water-related deaths in Texas directly led to a complete revamping of the lifeguard system for Galveston beaches. With financial help from the Galveston Park Board of Trustees, the Galveston County Sheriff's Department and the philanthropic Moody Foundation, the beach patrol became a regular part of the sheriff's department. New, sophisticated equipment was purchased, the lifeguard force was expanded and trained by U.S. Lifeguard Association experts, and a Sea Grant education brochure was distributed. All of this has made Galveston's beaches among the best protected in the country.

Even with our successes — and we think they are substantial — we are concerned about the future of Sea Grant because the Reagan Administration, in the interest of reducing the budget, seems determined to eliminate the Federal support for Sea Grant. For those of us familiar with the economic importance of the oceans and Sea Grant's growing contribution to this part of the economy, it's hard to understand the Administration's failure to distinguish between short-term budget savings and the long-term economic and social consequences of killing the program.

Fortunately, Congress, which established the National Sea Grant Program in 1966, has not agreed with the Administration, and, through Congress' intervention, we hope that the federal government will continue its partnership role of supporting the program. Congress has been strengthened in its resolve by the people and industries served by the program throughout the country who have voiced strong objections to terminating the program. We owe a sincere vote of thanks to all of the citizens who came to our defense here in Texas and elsewhere. We intend to continue to work with Congress and the Administration to correct any perceived deficiencies in the program and to continue to strengthen our Texas A&M Sea Grant Program so that it will best serve the interests of both the state and the nation.

Feenan D Jennings

Feenan D. Jennings
Director


Advisory
Services

Texas' coastal waters stretch 367 miles from Cameron County at the tip of Texas to Orange County near the Louisiana border. Marine-related industries and activities thrive in this area, often prompting important questions about marine resources and the effects of various uses on the environment. The Sea Grant Marine Advisory Service, a group of nine specialists and seven county agents, regularly is called on to respond to these questions.

Quality seafood processing, safe recreation, and profitable and ecological fishing techniques are a few of the unique concerns generated in a marine environment. Issues like these are important to a variety of people — fishermen, tourists, coastal community residents and anyone who wants to enjoy a seafood platter or a day at the beach.

Problems, questions and ideas from people who use and enjoy marine resources are brought to the Texas A&M University Marine Advisory Service (MAS) for solutions, possible answers and suggestions of new ways to use and preserve the marine environment.

"MAS transfers research knowledge from the University and technical information from other agencies to the public through its agents and specialists," says Ranzell Nickelson, MAS project group supervisor and seafood technology specialist.

Marine agents, he explains, live and work in coastal communities. They find out about local problems and needs firsthand. They talk to people on the waterfront and in meetings, as individuals and in groups. They offer workshops and youth education programs. They author publications and help with fishing tournaments. They are a local contact for people who need information or assistance with marine-related problems. Agents, supported by Sea Grant, the Texas Agricultural Extension Service and local county governments, work to see that the latest information about marine technology is available to improve the quality of life along the coast.

When faced with a particularly complex, technical problem, agents can turn to another MAS group for help — the marine specialists. Each specialist is an "expert" in a specific marine area. This group includes an economist, and specialists in recreation, marketing, fisheries, marine business, consumer education, seafood nutrition and seafood technology. Like agents, specialists are in constant contact with many segments of the population. They conduct workshops and short courses, attend meetings, and publish newsletters and advisory bulletins. Specialists and agents research issues, then determine the best ways to get the information to the general public.

The problems have been varied in the past two years. Sometimes issues come up because of outside forces. Rising fuel costs, hurricanes and other unanticipated critical problems create concerns that demand immediate attention. Still other marine problems are always in need of updated solutions — vessel safety, ways to catch and market underutilized fish species, or ways to map obstructions on the ocean floor.

By early 1981 MAS was well aware that the cost of diesel fuel had been rising so steadily that it made up nearly 50 percent of the total operating costs for some shrimp boats. With other costs rising too, high fuel bills seemed capable of dampening, if not sinking, some fishermen's hopes for profitable shrimping and commercial fishing along the Texas coast.

MAS economist Nelson Swartz had been working on a series of computer programs for small and medium-sized fishing operations. One program, "Decision to Fish," could compute the number of pounds of shrimp a fisherman needed to land on a given day to pay the actual cost of the fishing trip. Ice and labor figured into the cost, but diesel bills proved to be the most compelling factor. The programs emphasized the impact additional increases in fuel prices would have on potential fishing profits, and a worried National Shrimp Congress realized that energy conservation and fuel efficiency were becoming primary concerns of the nation's shrimp fleet. They contracted a three-phased project to help operators learn to cut fuel consumption. Swartz' computer programs had laid the groundwork; the new project would include library searches, mail and telephone surveys, and case studies to uncover ways to reduce fuel consumption by using new and existing technology. The information will be used to compile a directory of manufacturers, suppliers and installers of fuel-saving devices; to publish a brochure that will outline fuel conservation and fuel efficiency technology adaptable to existing fishing vessels; and to present a series of workshops along the Gulf Coast to help operators better understand alternative methods to improve fuel efficiency.

While boat operators consider fuel conservation and money-saving tactics, such as reducing hull friction or making engine adjustments, MAS marine business specialist Dewayne Hollin has been working to try to save the industry money from another angle — safety. Injuries to crew members not only result in human suffering, but also in lost work time and repair costs. More serious accidents can lead to the loss of an entire vessel. An average of 12 vessels, valued at between $150,000 and $350,000 each, are lost each year to accidents in the Gulf. Safety inspections, maintenance programs and safety training for crew members can cut those losses according to Hollin.

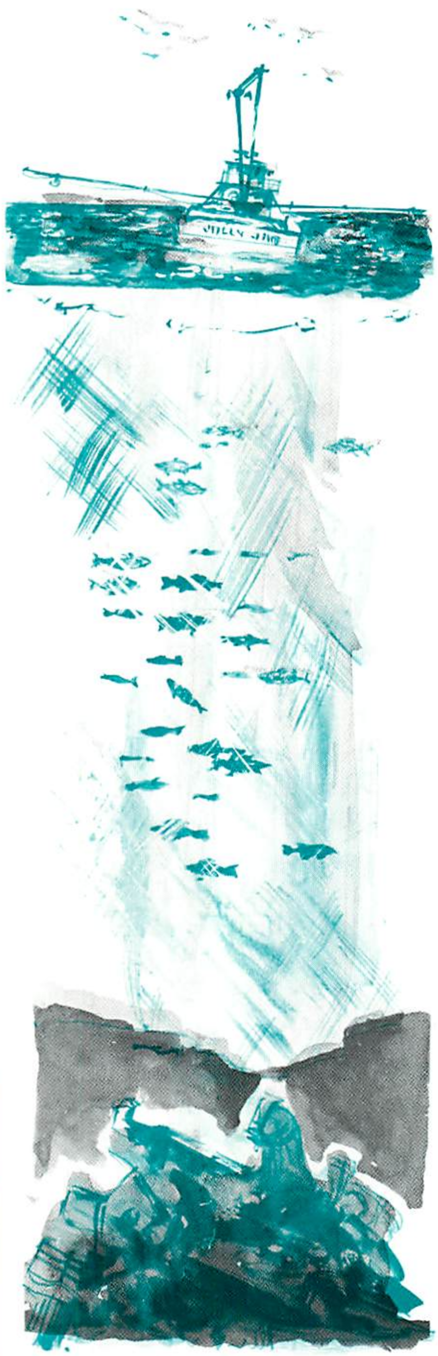
But how does that information get to vessel operators and owners?

MAS sponsored a fishing vessel safety and insurance seminar to review legal problems, costs in processing claims and benefits of well-planned safety programs. Hollin developed a safety checklist for vessel operators to complete before leaving port and distributed it to more than 150 vessels. He also gave a slide presentation on vessel safety at the Texas Shrimp Association meeting.

Hollin's work points out dangers aboard fishing vessels. MAS marine fisheries specialist Gary Graham has spent several years mapping dangers beneath the Gulf waves. Remains of wrecked vessels, pipelines and rocks lurk along the bottom of the Gulf, ready to ensnare fishing gear. Every Texas shrimp boat has an estimated $20,000 worth of fishing equipment that could be caught by obstructions and lost each year. With about 4,000 trawlers shrimping in Texas Gulf waters each year, it can be a costly problem.

Graham, with the help of coastal fishermen, compiled a list of known hangs and obstructions in the Texas/Louisiana Gulf with corresponding Loran A radio-navigation system readings so fishermen could locate dangerous areas to avoid when trawling. Fishermen needed new readings in 1981 when Loran C replaced Loran A as the government-approved radio-navigation system for U.S. coastal waters. Graham developed a computer program to convert the old readings to Loran C coordinates, and the program and a portable computer were sent to coastal communities so fishermen could update their data. Shrimpers in Texas and Louisiana continue to send Graham new hang readings and MAS publishes these regularly.

Traditionally, 90 percent of the Texas commercial fishing industry has been based on shrimping, so shrimpers' problems have been high on MAS priority lists. But, since Texas shrimpers find themselves without incomes during the off-season, MAS fisheries specialists have been evaluating and testing other species that are plentiful in Gulf waters. Changing species requires different rigging and gear, and MAS agents and specialists have investigated longline fishing possibilities along the Texas



coast and demonstrated the feasibility of fishing for swordfish and tuna. MAS offered fishermen information about gear, handling techniques and the biology of these alternate species. In 1980 the swordfish/tuna catch added up to nearly $2.5 million worth of products never before landed by Texas fishermen. Approximately 40 Texas vessels were rigged for longlining, and several continued finfishing during the traditional shrimp season. Studies to develop other new sources of food and profit in the Gulf continue. The most recent evaluations and demonstrations are being done with shark.

Once new catches are identified, fishermen need a market. MAS consumer education, seafood nutrition and marketing specialists work to help determine uses and markets for new species. A food quality and safety lab on the Texas A&M campus houses research in handling and processing techniques, where researchers also can analyze fish quality. The lab analyzes an average of 800 food samples each year.

Seafood specialists helped fishermen and fish buyers and sellers by publishing *A Directory of Texas Seafood Wholesalers*. This lists potential markets, sources of seafood products and available products. It also includes purchasing and processing information and lists delivery areas for each wholesaler.

Consumer education specialist Annette Reddell Hegen produces a series of recipe cards for shellfish and finfish each year. Distributed free to the public through retail food stores, the recipe cards are designed to help consumers learn to prepare and enjoy a variety of seafood dishes. Specialists also often work directly with the public, demonstrating how to cook, handle and store species; shark was the focus of demonstrations throughout the state in 1981. Other times, specialists work with segments of the public interested in a particular aspect of seafood — workshops may be targeted for home economics teachers, commercial fishermen, retailers or seafood lovers.

Sport fishermen contact MAS for game fish recipes. They also are likely to meet agents and specialists at the more than a dozen Texas saltwater fishing tournaments held each summer along the Gulf Coast. MAS staffers serve as judges and officials and help determine fish species and freshness. These tournaments not only generate revenues for coastal communities, they also provide MAS agents and specialists an opportunity to meet more local residents.

Sometimes MAS personnel directly aid an area in need. When Hurricane Allen's 12-foot tides leveled sand dunes along the southernmost part of South Padre Island, a marine extension agent, along with local 4-H agents, led a county beach cleaning patrol in a beach restoration project.

Sand dunes create a buffer zone between waves and man-made structures further inland. The sand itself is stabilized by plants whose root systems hold it in place, slowing erosion. When plants are ripped away by wind or wave action, dunes disappear. After the hurricane, the patrol collected 300 unsold or unused Christmas trees to stake into place along the beach. The trees trapped drifting sand until it accumulated into a dune again. The project, patterned after a successful experiment by Brazoria County marine agent Charles Moss, provided a model for private landowners with dune problems. The total cost of the project was $2.25 for twine — the trees and stakes were donated.

Other coastal communities have asked the Marine Advisory Service for help in park acquisition and development. MAS recreation specialist Ken Pagans works with city managers, park directors, recreation superintendents, commissioners' courts and others to explain techniques of obtaining parkland through donations and federal loans. Working with more than 50 groups in the last two years, Pagans has helped generate more than $9 million for marine-related parklands. He often is contacted by local agents for help with parklands projects.

This cooperation between agents and specialists enables MAS to carry out its charge of transferring knowledge and technical information to the public. Cooperation also can help MAS develop a broad view of marine issues and potential answers.

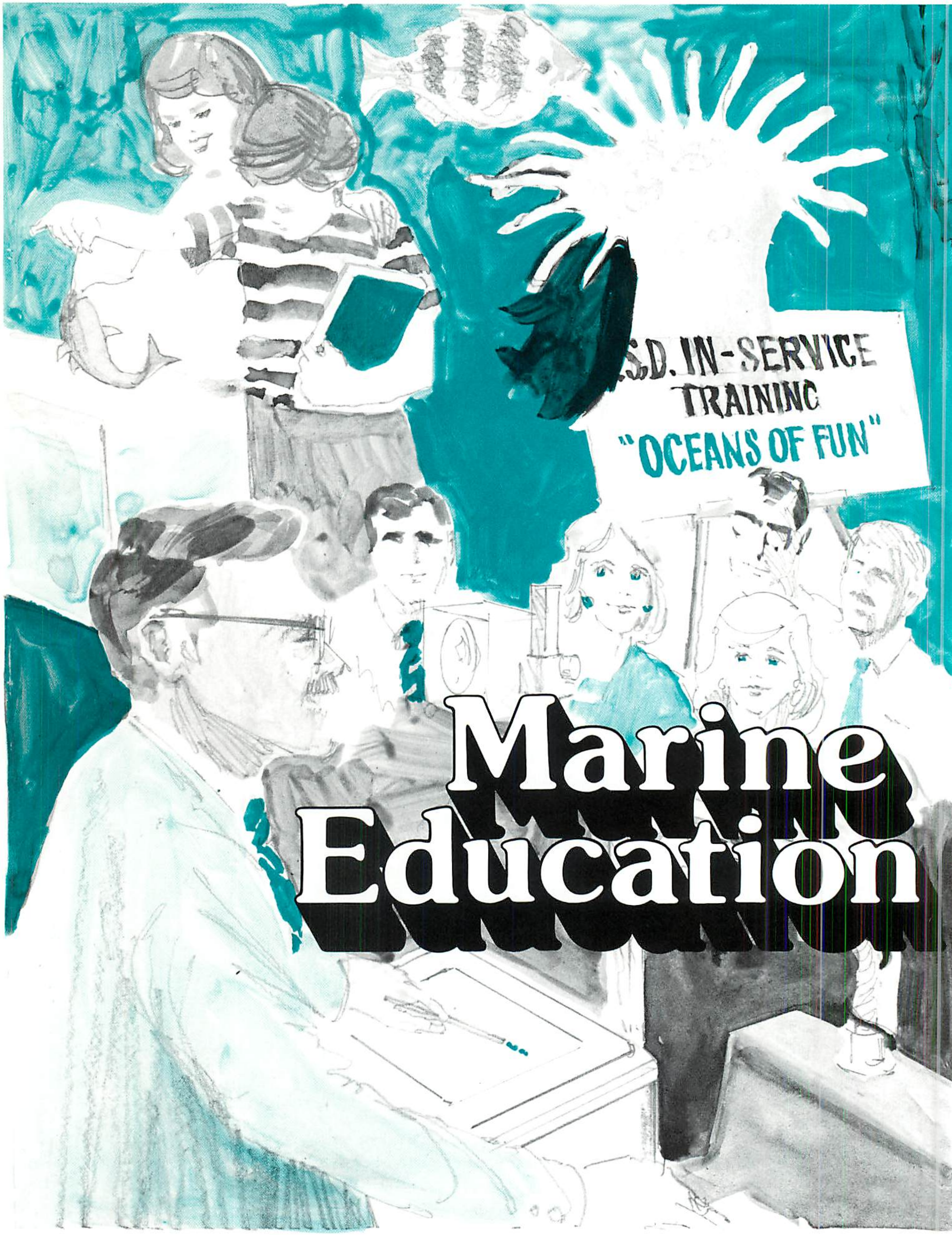
"We've been in this business about 10 or 12 years," Nickelson says, "but we've really begun to concentrate on long-range planning and common efforts in the last two years. Agents need time to react to immediate problems — to put out 'brush fires' in their local area — but we need to make time to work together, to look at the marine future and to identify ways to prepare for it."

He said, for example, there is potential for an expansion of the blue crab industry in Texas, but Texans will need information to realize that potential. Agents and specialists, by discussing the possible expansion, can begin to identify areas for research and information-gathering: What is the status of the industry now? What are the problems it faces? What additional information is needed about crabs?

"If we identify areas such as the blue crab potential, each agent and specialist can contribute his or her own special knowledge, whether it concerns the geography of an area or technical knowledge about biology or processing," says Nickelson. "After research and testing, the information can be transferred to the public."

MAS is patterned somewhat like the agricultural system, according to Nickelson, but with a different emphasis. Marine agents and specialists work with food hunters, not food growers. While agricultural agents are interested in cultivation techniques, pest management and other land farming concerns, marine agents and specialists concentrate on fishing techniques, species characteristics and uses, seafood processing and other marine resource issues that affect everyone.

"We serve a variety of publics," Nickelson says, "because we deal with a common resource — the marine environment."



Marine Education

Sea anemones, hermit crabs, sea chanties, serpent kings, little mermaids. These are just a few of the ingredients of Texas A&M Sea Grant's successful marine education program. It is successful not because of the number of publications produced, but rather because of the numbers of students and teachers who have been introduced to the marine environment.

Texas has hundreds of miles of coastland, but it also has deserts, plains and mountains. The children who live in the latter areas are as far removed from the marine environment as children in Kansas or Iowa or any other midwestern state. These children often know the sea only from television or movies; they seldom have an opportunity for firsthand knowledge.

Those who have guided the Texas A&M marine education effort, such as current coordinator John Hunt, believe a textbook, by itself, can supply only part of the answers. Students need to see marine animals first hand, to touch them and watch them before the words in a book become real.

The Texas A&M Sea Grant marine education program has concentrated on filling this need. With *Children's Literature — Passage to the Sea* elementary students can make their own signal flags, track hurricanes and build Noah's ark or an Indian longboat while being introduced to some of the best marine-related literature available today. *Investigating the Marine Environment and Its Resources* takes junior and senior high school students through a progression of learning activities about the Texas Gulf coast which involve all subjects — science, social studies, language arts, music and art. *Marine Organisms in Science Teaching* takes living organisms such as shrimp, crabs, killifish and barnacles out of the ocean and into classrooms throughout the country.

These books are only the beginning. One of the highlights of the past two years has been *Fairy Tales of the Sea*, which, according to Hunt, is the "only known collection of international fairy tales that use the sea as a central theme. There is an accompanying teacher's guide for use in the middle school, but the reader is a beautiful book — anyone, any age, will enjoy it."

Books and other curricular materials, such as learning center activities, career-oriented brochures and teacher guidelines for implementing a marine education program were an original priority.

"Everyone knew it wasn't just a matter of sitting in an office and writing a book," Hunt says, "but first something had to be put on paper before anyone could start going to the schools and asking why marine-related examples weren't included in the regular curriculum. Regular textbooks didn't include these examples, and unless a teacher was located along a coast, she didn't know where to turn for assistance."

The effort began in 1977 when Violetta Lien, Department of Educational Curriculum and Instruction research associate, was asked to develop a three-week mini-course for junior high teachers. That mini-course outline grew into *Investigating the Marine Environment and Its Resources*, published in its final form in 1980, which includes all the sciences plus social studies. Lien used Texas examples in her book to make the material particularly relevant for the state's schools.

"Although I wrote with Texas schools in mind," Lien says, "I soon discovered that schools outside the state have no problems adapting it to their needs."

Another built-in adaptation advantage was that Lien kept both the traditional and non-traditional teacher in mind. *Investigating* includes a set of specific learning outcomes for each lesson, a teacher's guide and more than 100 teaching and learning activities organized by topics. The 21 topic clusters feature science, social studies and language arts activities that use marine resources along the Gulf Coast.

"Traditional teachers use mainly the readings and questions," Lien says, "while the less traditional ones expand this with role-playing and simulations and by combining art with science. Teachers can pick and choose depending on their teaching style and subject interest."

This traditional/non-traditional style carried over into subsequent materials, but it quickly became apparent that a more pressing need had to be met.

"We couldn't stop with just providing materials for students," Hunt says. "We found that many teachers, particularly those in inland areas, were just as unfamiliar with the ocean and its inhabitants as their students.

"We surveyed Texas teachers to see what their preparation was," Hunt recalls. "The results confirmed our suspicions. Ninety percent of the teachers had had no formal training in marine education, and an additional seven percent had completed no more than six semester hours. Sixty percent had attended only one half-day inservice workshop while the remaining 40 percent had not had even that opportunity."

A new plan quickly evolved as the marine education staff worked to educate the educators. Thirty-nine workshops now are available through the Texas A&M Sea Grant program, lasting from a half to a full day and covering all aspects of marine education for teachers, supervisors and administrators. These workshops take place at individual schools, during districtwide inservice training days, or at regional or national education meetings. The workshops include both in-school and field study opportunities.

From September 1979 through August 1981, more than 6,000 teachers in Texas, California, Connecticut, Delaware, Florida, Louisiana, Maryland, Massachusetts, Michigan, Missouri, New Jersey, New York, North Carolina, Ohio, Oregon, Rhode

Island, South Carolina, Virginia, Washington and Wisconsin attended one of these workshops. More than 8,000 elementary and secondary students also were introduced to marine education in special programs ranging in length from one day to a full week.

The teacher workshops begin with the basics, first explaining the concept of marine education. Science teachers, for example, will be taken through an introductory activity from *Marine Organisms in Science Teaching.*

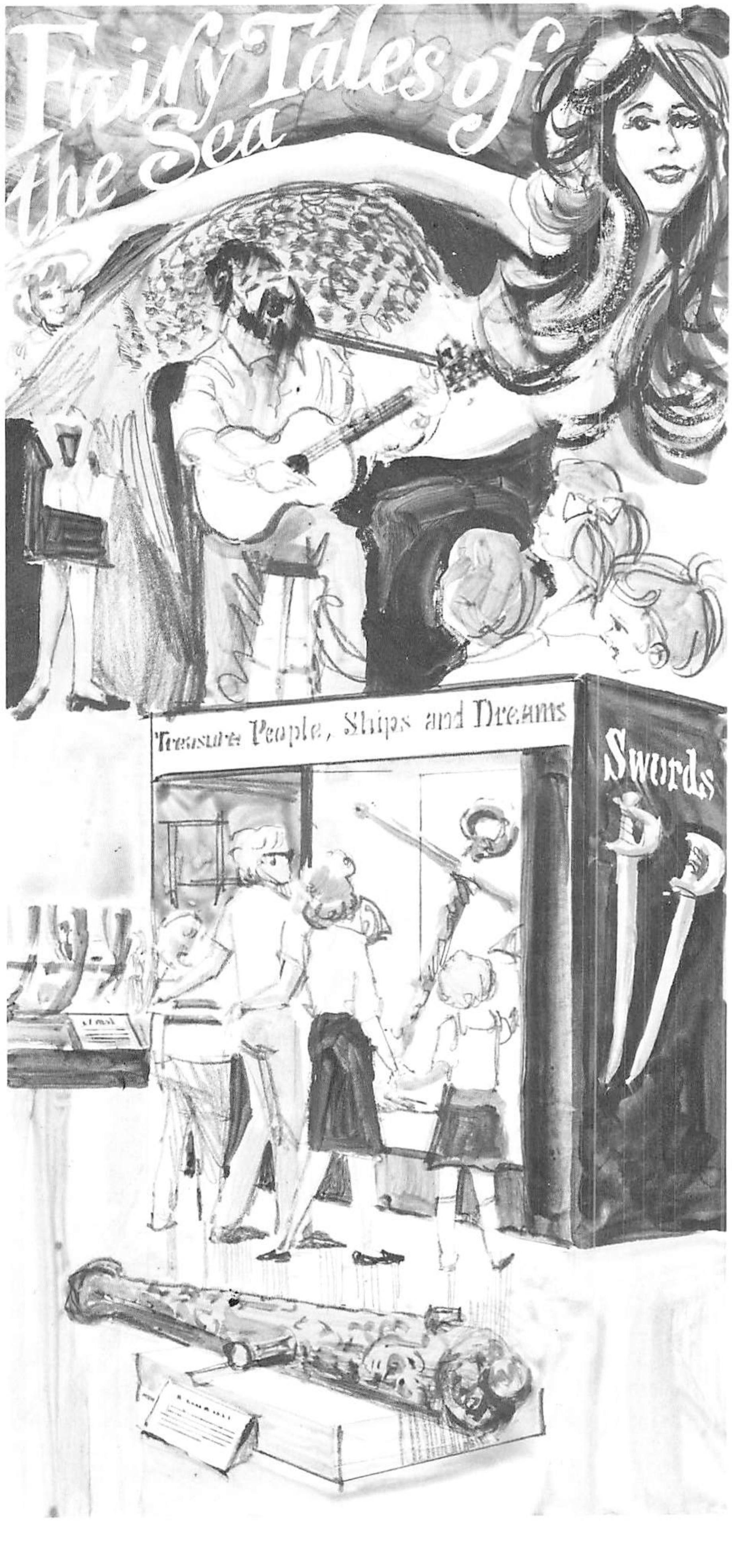
"I generally begin with a sea anemone investigation," Hunt says, "and when I first show teachers a live anemone I often get as many varied responses from the teachers as I get from the students. For example, I have been told on various occasions that a sea anemone is a plant, a relative of a slimy slug or an upside-down mushroom with hairy arms."

As Hunt explains in the workshop, this demonstration is an introduction to the inquiry method of scientific discovery, a basis for any detailed laboratory investigations.

"Marine" is not just science, as Hunt is quick to point out, so workshops for other subject areas concentrate on infusing marine-related examples into existing material. This includes using *Fairy Tales of the Sea* to teach the language arts skills of listening, reading, speaking and writing, and using sea chanties on whaling, transportation, fishing and exploration to supplement a social studies curriculum.

Teacher assistance doesn't end with the workshops. A quarterly newsletter, *Marine Education,* provides current research findings, reviews of current marine-related books, general news items and a marine fact sheet with suggestions for classroom activities. Since it began in February 1980, *Marine Education's* subscription list has increased to more than 4,000, including educators in Australia, Canada, Colombia, France, Italy and Singapore.

Hunt and his staff also work closely



with the Texas Education Agency, which supervises the 1,100 school districts in the state. TEA issues instructional guides for each course taught in the public schools, and the Texas A&M marine education staff has helped revise the science guides that will be implemented in 1982.

With these revisions, instructional guides for physics, chemistry, geology, meteorology, astronomy and oceanography now include relevant marine examples, and a totally new guide has been written for secondary marine science courses.

In-school programs for students are structured much like those for their teachers. These are complemented by one-day programs at the Texas A&M campus, one for high school students and another for the elementary level.

The sixth, and final, Children's Literature of the Sea Seminar in 1981 featured sea chanties and sea stories, interspersed with humorous skits about sea animals for nearly 700 central Texas elementary students. Composer/musician John Langstaff, author Jean Fritz and the Gulf of Maine Aquarium's Mr. and Mrs. Fish (Jeff Sandler and Deb Hall) combined to make marine education an enjoyable experience for the participants.

Two weeks after this elementary-level seminar, nearly 800 senior high students and their teachers attended the second annual Marine Education Symposium. The one-day event offered an opportunity for students to hear their choice of three of 27 scientists and marine specialists.

The Marine Education Symposium will continue, according to Hunt, while the concept of the elementary seminar is being changed.

"We hope to make this more of a statewide effort, expanding the emphasis to include creative dramatics, music and activities with live marine organisms as well as literature," Hunt says.

Some of the material used for public school students and teachers, and printed in *Marine Education*, comes from another area of Sea Grant-supported education. This, a special university-level program to encourage inquiry into promising marine-related areas, provides marine fellowships to Texas A&M graduate students.

As a competitive fellowship program, this project supports those students most capable of conducting research under the direction of faculty advisors and most likely to pursue productive careers in marine research and ocean management. Five Fellows were selected in both 1979-80 and 1980-81, four supported by State of Texas funds and one by National Sea Grant funds.

During the two years, six Fellows, Leo Bernard, Tonalee Carlson, Wendy Keeney, Julie Ambler, Thomas Soniat and Robert Taylor, pursued degrees in the Department of Oceanography. Two others, Jane Ojeda and Leroy George, were in the Department of Wildlife and Fisheries Sciences. Donald Keith, a nautical archaeologist in the Department of Geography, was selected as a Fellow for both years.

As part of their contribution to the enrichment of marine activities at Texas A&M, the Fellows organized lecture series on broad issues of coastal and ocean management. In 1979-1980, they organized a three-part series on "The 1980's: A Decade of Energy from the Sea," and a similar series in 1980-1981 discussed "Remote Sensing of the Marine Environment." The Fellows also co-sponsored a traveling exhibit "Treasure, People, Ships and Dreams," a display of 1554 Spanish shipwreck artifacts from the Texas Antiquities Committee.

Whatever the educational level, either students or teachers, Hunt sees a touch of irony in marine education.

"Americans depended on marine resources for so many years, then we seemed to forget the sea was there. Now we are trying to help our children rediscover three-fourths of our world.

"Our program is committed not only to teaching all ages of people about the sea, but also to making them realize the ways in which the ocean contributes to their well-being."

Mariculture

Holstein. Ring a bell? This famous cattle breed symbolizes 9,000 years of animal domestication. Mariculture research funded by the Texas A&M Sea Grant Program has put shrimp next in line for this "man-made" evolution.

The best shrimp today's money can buy may be puny compared with what shrimp farms will be raising 10 years from now.

For thousands of years we have bred food and work animals to meet our needs. The most important advances in livestock breeding have occurred in the last 200 years, producing quality lines for special uses. New methods of animal husbandry, nutrition, veterinary science and herd management have steadily improved production since World War II.

Shrimp farming hasn't come quite this far, but the Texas A&M shrimp mariculture program is working on it. The program, partly funded by the University's Sea Grant College Program, is the largest in the United States. Shrimp harvested at the Texas A&M facility near Corpus Christi are competitive in quality with shrimp harvested from the Gulf of Mexico. The value of the shrimp produced in the ponds ranges from $1,500 to $4,000 per acre, greater than that of corn, sorghum or cotton. And that value will increase — once the shrimp is "domesticated."

The success of the Texas A&M program has brought shrimp mariculture to the brink of viability as a commercial industry according to Addison Lawrence, director of the mariculture effort.

"Shrimp mariculture is like any kind of farming," says Lawrence. "It could be more productive if we raised an animal more suited to captivity. Now we basically raise a wild animal."

The Texas A&M effort concentrates on four species — *Penaeus setiferus* and *P. aztecus*, natives of the Gulf of Mexico, and *P. vannamei* and *P. stylirostris*, from the Pacific coast of Mexico and Central America.

Domestication hasn't been the primary thrust so far. Instead, it has been basic research — technology development and attaining independence from wild populations, goals easily achieved for most plants and land animals. Not so for shrimp.

Shrimp are hatched in the open Gulf or ocean. The larvae migrate to less salty tidal bays and rivers where, in protected natural nurseries, they undergo a complex metamorphosis before reaching the adult stage. The first step in the Texas A&M program was to simulate these varied environments.

In the pioneer phase of the program, egg-bearing female shrimp, collected in the wild, were brought back to the hatchery to spawn. The eggs hatched, and when the larvae were large enough they were transferred to ponds where they grew until harvest.

"A breakthrough came in the summer of 1979 — the first spawning of *Penaeus setiferus* in captivity," says Lawrence. "Tests of different diets, salinities, daylengths, temperatures and physical conditions finally gave us the near-perfect balance for spawning. We also found that cutting off one of the female's eyestalks removes a gland that produces a hormone that inhibits spawning."

Two other breakthroughs occurred in 1981. Two crops of *Penaeus stylirostris* were raised in one warm South Texas growing season without artificial heat. During the same season, an immunization technique previously used only in the laboratory proved successful in the shrimp ponds.

"*Penaeus stylirostris* postlarvae, slightly dehydrated by immersion in high-salinity water, were placed in a dilute solution containing an extract of killed *Vibrio* bacteria," says Donald Lewis, acting head of the Department of Veterinary Microbiology and Parasitology at Texas A&M and the scientist who developed the technique. "The live bacteria cause a wide range of disease symptoms in shrimp, and sometimes even cause death. The vaccine diffuses into the postlarvae, which then develop immunity." Higher production in the ponds stocked with vaccinated shrimp and lab tests on harvested live shrimp proved that the immunity endured throughout the growing season.

Spawning in captivity and overwintering of adults have released mariculturists from dependence on wild stocks. Two crops per year doubles production, and immunity increases it further. These milestones have brought shrimp mariculture to the verge of commercial reality. Although the basic technology needs refinements and research will continue, the scientists can begin to concentrate on other aspects of shrimp farming. A foremost research target is domestication by genetic selection.

Taste and texture, the main characteristics that determine whether or not people will eat seafood, undoubtedly will be two traits that shrimp breeders and seafood technologists will try to improve in mariculture. Some artificial selection has inadvertently begun. It's only natural to choose the best, biggest shrimp as "seed" for the next crop.

Disease is a particular threat in a closed mariculture system. Usually all animals in a pond are members of the same species so disease can run rampant through the population. Stress compounds the problem. Stress results from crowding and changes in environmental conditions. In the ponds, the shrimp population is much denser than in nature. Fluctuations in temperature and salinity, normally buffered in the huge water volumes in the Gulf, are accented in the small, closed facilities.

Disease resistance is another especially desirable trait. Immunization works, but it is not inherited. Nor is it free. Artificial selection someday will be important in developing disease-resistant shrimp, but natural selection already is doing its part. There is no choice. Individuals highly susceptible to disease are weeded out as part of the natural mortality in the ponds. Only the strong survive.

Fisheries Research

Gulf butterfish. Sand seatrout. Longspine porgy. Ever heard of them? You will soon. Sea Grant fisheries research in 1979-1981 examined new species and new management plans to safeguard U.S. fisheries.

Even if you don't like seafood, don't underestimate what it does for the U.S. economy. In 1980, U.S. fishermen caught 6.5 billion pounds of fish and shellfish — worth $2.2 billion — in U.S. waters. This didn't meet Americans' demands, however, so we imported another 2.7 billion dollars' worth.

Fisheries in the Gulf of Mexico — and all over the world — are hurting. Soaring operating and maintenance costs have put many fishing boats on mothballs. Some experts say that many traditional fisheries are either fully exploited or overfished. Development and pollution tax the valuable estuaries used as nurseries by commercially important species. While fisheries falter, economically and biologically, the demand for seafood increases.

During 1979-1981, the Texas A&M Sea Grant Program focused its fisheries research on alternatives — development of new fisheries, better management of all fisheries, and rehabilitation of the faltering ones. The laboratory for these studies was the Gulf of Mexico, but the work is of worldwide relevance.

Wallace Klussman, an administrator of Sea Grant's Marine Advisory Service and head of the University's Department of Wildlife and Fisheries Sciences, is among the more optimistic fisheries scientists.

"We have a good opportunity for a 'wild crop' fishery as far down the road as I can see," he says. "Things are changing, though. Increasing costs and overfishing are two of the problems, and management policies are critical to the health of our fisheries.

"Groups like the Gulf and South Atlantic Fisheries Development Foundation and the Gulf of Mexico Fisheries Management Council are developing long-range plans for our fisheries within the 200-mile limit." Under the Fishery Conservation and Management Act of 1976, only U.S. vessels can fish in a band 200 miles off the U.S. coast, unless previous agreements have been reached with other countries. Off Texas, the nine miles closest to shore are the state's domain.

In Sea Grant-funded research in 1979-1981, Wade Griffin, associate professor of agricultural economics at Texas A&M, examined management alternatives for the Texas shrimp industry.

"When it adopted the 200-mile jurisdiction, the U.S. government set up eight councils to manage fisheries," Griffin says. "The Gulf of Mexico Fisheries Council is in charge of managing fisheries of the Gulf."

Shrimp is the most valuable U.S. seafood, and the Gulf shrimp fishery accounts for 83 percent of the sales. But even in the Gulf, shrimp stocks are fully exploited and a number of alternate management measures have recently been implemented.

"A new strategy was used in 1981," Griffin says. "In previous years, there was a size restriction on shrimp harvests. Shrimpers had to discard shrimp smaller than '65-count tails'." This means that a pound of shrimp, heads removed, would contain about 65 shrimp tails. "The shrimp fishing season is now closed in the Gulf, between June 1 and the second week in July, a measure coordinated by the Council and the state. When it opens in July, there is no size restriction on the catch. The rationale behind this is that after that period most shrimp are bigger than 65-count, heads-off size. Under the old restriction, the smaller shrimp were dead by the time they had been culled and thrown back into the water anyway. The new regulation allows sale of all shrimp caught after the closure."

Another thrust of Griffin's work was development of a computer model of the bioeconomics of the shrimp fishery in cooperation with William Grant, associate professor of wildlife and fisheries sciences. The model predicts shrimp landings under whatever management conditions the user imposes on the "fishery." In setting up the model, Griffin incorporated landings data published by the National Marine Fisheries Service and cost and returns data.

"We also surveyed the literature and talked to biologists to get population parameters," he says.

The model first provides a "baseline" estimate of shrimp landings. By choosing certain management options, the operator can test new management policies and predict how they would affect landings.

"With the model we can assume closure of any part of the fishery," Griffin says. "This lets me estimate what would actually happen. We can shut down the 'computer fishery' during June and early July and compare the landings to the baseline."

The model gave an estimate remarkably close to actual landings for 1981. It also can eliminate size restrictions, increase fishing efforts, add and remove fishermen from the industry and compare profits.

"The model has been used by FAO (The Food and Agricultural Organization of the United Nations) in studies of squid, cuttlefish and other cephalopod mollusc fisheries off Africa and was important in establishing the Tortugas pink shrimp sanctuary off Florida in the Gulf," Griffin says. "It also is applicable to finfishes, as long as there are no parent/stock relationships, that is, if fishing this year doesn't affect next year's crop." Shrimp, with a high reproductive capacity and a short lifespan, fall into this category. So do a number of common but lesser known fishes of the Gulf.

A shrimp trawl hasn't been designed that snags only shrimp, and it probably never will. In the Gulf, shrimp account for only one-tenth of the weight of the "shrimp" catch. Each year, Texas shrimpers dump almost 500 million pounds of bycatch over-board. These fish hauled in with the shrimp belong to a complex of species that share the bottom habitat with shrimp — groundfish. There are no markets for these mainly unknown fish. They are nutritious and delicious, though, according to Sea Grant seafood specialists. Sports fishermen agree — and they should know. Groundfish make up about 30 percent of the recreational catch in the Texas Gulf.

In a Sea Grant-funded study, Mark Chittenden has taken a very close look at groundfish. Chittenden, associate professor of wildlife and fisheries sciences at Texas A&M, studied the population dynamics and life histories of such groundfishes as the sand and silver seatrouts, longspine porgy, Gulf butterfish, croaker and banded drum. Klussman describes the value of this basic research.

"The goal of many fisheries management plans has been maximum sustainable yield," he says. Maximum sustainable yield (MSY) is achieved for a species when yearly landings are the highest that can be sustained by nature from year to year.

"MSY is difficult to determine until different variables have been defined for a species," says Klussman. "These variables include standing crop, recruitment, available age classes and the dominant age class. For example, the croaker has a short lifespan and a high recruitment rate. Therefore, it can withstand a strong fishery."

The same is true for other groundfishes. Chittenden's work has shown that most species in the complex have similar population patterns that would support a strong fishery with little danger of stock depletion.

"Only two-year classes were ever present at the same time," Chittenden says. "The lifespan seldom exceeds two years, and in most species annual mortality rates are more than 90 percent. These fishes appear very resistant to overfishing."

In a companion study, John Nichols, professor of agricultural economics at Texas A&M, analyzed biological, harvest, marketing and economic information on a number of species that could support new fisheries for Texas.

"We initially did an overview of about 40 popular alternatives," Nichols says. "We surveyed the literature, talked to members of the fisheries industry, biologists and Sea Grant marine extension agents. We gathered information on biological availability, product characteristics, effects and marketability. Using these criteria, we sorted the species by overall suitability for development." Eight species were rated "high priority" by Nichols' system, and another 11 fishes were judged of secondary potential.

Not surprisingly, several of Chittenden's groundfish turned up on these lists. Other more familiar ones also appeared — swordfish and several kinds of shark, for example.

"In Phase II of the study, we looked at several species in detail," Nichols says. Swordfish longlining during the shrimp off-season has been considered one way for shrimp fishermen to survive the energy crunch.

"We found that swordfish has potential, but its populations vary by year and season," he says. "There's a good market for it, but it's on the East Coast. The swordfish is more susceptible to overfishing than, say, the groundfishes. We also looked at several tunas. The problem with tuna is that there are no processing facilities for it in Texas. The grouper/snapper/tilefish group, which inhabits offshore reefs, also has potential. Of course, the snapper has a good market in Texas, but the tilefish market is best developed on the East Coast. Transportation costs would affect prices received by fishermen."

"For all the larger deepwater fishes, such as the swordfish, tuna, shark and tilefish, we need more biological information before we can formulate management plans," Klussman says.

"The swordfish and shark have very different population dynamics than the groundfishes. They're big predators, like mountain lions. They're at the top of the food chain, and they have long lifespans and low reproductive rates — the opposite of seatrouts, for example," Klussman continues. Therefore, caution is necessary because overfishing is more likely.

Although market expansion is mainly the concern of Sea Grant's Marine Advisory Service and not its scientific researchers, marketing problems will have to be overcome if Nichols' and Chittenden's "new fishes" are to support a fishery in the Texas Gulf. Croaker once had no market in Texas, but now is sold in many supermarkets throughout the state. Other species will follow in the croaker's wake. That's easier said than done, and Klussman summed up the problem.

"Americans are extremely selective in choosing seafoods, probably a result of our affluence," he says. "Typically, people in Third World countries appreciate a fish much more than we do, and those countries are studying their fisheries carefully and evaluating their management. As the U.S. population increases, we may begin to look at fisheries like this to an increasing extent."

Environmental Quality

The burgeoning population along the Texas coast brings construction, development and, of course, pollution. In 1979-1981, environmental quality research focused on these pollutants, examining their behavior in Texas waters, perfecting techniques to measure them, and paving the way for environmental planners and policymakers.

Human waste takes many forms these days. Besides traditional sewage, auto exhaust, industrial emissions and mining wastes add to the pollution load. Belched into the atmosphere, rinsed from city streets and flushed into that ultimate disposal, the ocean — or in the case of Texas, the Gulf of Mexico — pollutants are trapped in marine sediments, concentrated in saltwater animals and carried to remote places. Living pollutants — viruses — survive sewage treatment; even bacteria escape when torrential rains flood treatment plants.

Inshore waters — the final outfall of rivers — are the recipient of these human byproducts. These waters tend to accumulate pollutants for the same reasons that they are so productive. Estuaries, the tidal bays, rivers and marshes where the sea meets the land are prime locations for industry and shipping. Because of these activities, they receive relatively heavy pollution.

In addition to their natural beauty, estuaries are important to the seafood industry because they are nurseries for many fish and shellfish. Some species use estuaries only part of their lives, but others are permanent residents. Estuarine organisms experience drastic extremes in environmental conditions. Every day low tide exposes intertidal plants and animals to the air, sun and predators for hours at a time. Runoff from land floods estuaries with fresh water, and tides bring in very salty water. Estuarine animals have evolved many ways to adapt to these natural changes — shells, camouflage, tough skins, spines and special salt-regulating organs — but the balance is delicate, and pollution compounds natural stresses.

Corpus Christi Bay is part of the state's estuarine system. As a major Texas port, the Bay receives pollution from many sources.

"We studied hydrocarbon levels in the open Gulf of Mexico for three years and found it to be very clean," says Pat Parker, professor of chemistry and marine studies at The University of Texas Marine Science Institute in Port Aransas. "We felt it was important to find out whether a semi-closed system such as Corpus Christi Bay accumulated high levels of hydrocarbons."

His primary concern was polycyclic aromatic hydrocarbons (PAHs), compounds containing three or more benzene "cycles." The benzene groups have implicated many PAHs as carcinogens. In 1979-1981 these compounds were the subject of environmental studies in a Sea Grant-funded project led by Parker.

"PAHs are found in crude oil," Parker says, "but they also are produced by combustion."

Combustion that is 100 percent efficient produces primarily carbon dioxide and water, and no PAHs, but no combustion is perfect. Cars produce PAHs, and in Corpus Christi at least one factory's purpose is incomplete combustion to produce carbon black.

"Carbon black is just soot — the same thing you'd scrape from a chimney," Parker says. "It's used to make inks and is added to rubber in tires. The factory produces carbon black by incomplete combustion of whatever hydrocarbon material is cheapest at the time. These days they probably burn cheap oils, but in the past they used natural gas and petroleum." Inefficiency is ensured by a limited oxygen supply, and soot is the result.

When the study began, Parker hoped to track PAHs from the plant to nearby waters and fields. Due to stringent emission controls instituted by the EPA 10 years ago, however, PAH concentrations around the factory were very low. They have been diluted by rains and degraded by bacteria according to Parker.

To determine the presence and concentrations of individual PAH compounds, the researchers first extract a sample with organic solvent. The PAH is then separated from the solvent, concentrated and injected onto a gas chromatographic column.

The gas chromatograph basically is an oven containing the column. The column leads to a detector, and gas flows constantly through the column toward the detector.

A few microliters of the concentrated extract is injected onto the column at a low temperature. The solvent evaporates rapidly and is flushed from the column by the gas, leaving behind the solid PAHs. The temperature of the oven, under computer control, then increase at a set rate, and the PAHs are vaporized one by one, in the same order each time. The order depends on the boiling point of each PAH and on its affinity for the column coating. As a compound is gasified, it is flushed by the gas through the column to the detector. The flame ionizes the compound, giving it an electrical charge which is detected and amplified as an electrical signal. The signal is transmitted to a chart recorder, which produces a peak on a graph. A sample contains many compounds and the resulting graph, which may have many peaks, is called a gas chromatogram. Each PAH has a characteristic "retention time" — the time between injection and the appearance of the peak. By comparing retention times and peak sizes of a chromatogram from a standard mixture, the chemists can identify the PAHs in the sample and calculate their concentrations.

Parker also investigated PAH levels in sediments from the Bay and adjacent waters, including a marina and the Corpus Christi ship channel.

"PAHs were readily detectable, but concentrations were very low," he says. "Also, we were able to generalize about the sources of the PAHs in all three areas." Sediments from each area had a different "suite" of compounds, characteristic of different sources of pollution.

"The highest PAH concentrations were found at the marina site," Parker says. "The compounds in the samples were combustion products, probably from automobile exhaust rather than components of crude oil, and probably came from particulate matter washed into the water from city streets.

"The sediments in the ship channel had a different PAH composition that points to airborne particulates or runoff from plants along the channel. We found very low PAH levels in the Bay. Although all three areas had more PAHs than the open Gulf, the concentrations were not alarmingly high."

More selenium than is deemed safe by the EPA is found in some Texas estuaries. Selenium has been associated with cancer, and is toxic to animals in large quantities. Paradoxically, in trace quantities, it is a required nutrient for all animals and plants. Jerry M. Neff, formerly a professor in the Department of Biological Sciences at Texas A&M, studied the behavior of selenium in a laboratory "estuary."

"Selenium is associated with sulfur deposits along the coast and is discarded from the sulfur refining process," Neff says. "The ore is melted with steam. When the steam condenses and the water is discarded, it contains large amounts of selenium. This explains the high levels in some Texas estuaries.

"The emphasis of our work was to see if selenium can be accumulated in estuarine plants and animals and if it can be passed through the food chain."

A simple estuarine food chain includes both producers (phytoplankton) and consumers (herbivorous and carnivorous animals). Some pollutants, most notably DDT, increase in concentration with each step in the food chain. Selenium posed a potential threat to seafood consumers, an upper link in this chain.

Neff's study examined phytoplankton, oysters, rotifers, shrimp and killifish, consumers that spend at least part of their lives in estuaries. The species were studied separately because if all were placed together, most of the experimental subjects would have been eaten by the others.

The phytoplankton study provided information about the uptake of selenium salts by the tiny plants. Also, the selenium-laden plankton were used as food in assays of the animals Neff studied.

When contaminated algae are placed in tanks with other organisms some of the salts dissolve in the water and levels of the compounds in all parts of the experimental ecosystem had to be accounted for. Substances in seawater interfere with usual analytical procedures for metals, so they worked with salts containing Se-75, a radioisotope of selenium that emits low levels of radiation. Se-75 can be measured with an instrument similar to a Geiger counter: the count indicates the amount of selenium in the sample.

"Se-75 let us work at the parts-per-billion level," Neff says. "It's a very accurate method, and sometimes we analyzed the live organisms and returned them unharmed to the tanks. And there's no interference with the radioisotope."

Se-75 also allowed easy measurement of selenium levels in water, which varied because of dissolution from contaminated phytoplankton and uptake by organisms. In this way Neff could track the selenium salts in the entire system.

Neff found evidence of slight bioaccumulation in the simple food chains he studied. For example, there was a 30-fold increase between phytoplankton and oysters, miniscule when compared to a fat-soluble organic pollutant such as DDT.

Not all pollutants are chemical. Twenty percent of the nation's shellfish beds are closed to harvesting because coliform bacteria that live in the human intestine are present in the sediments, water and shellfish. This is evidence of contamination by sewage. The bacteriological tests used to determine the fitness of shellfish beds, however, do not indicate virus levels. Many enteric viruses — those that multiply in the gastrointestinal tract — survive sewage treatment. Most fecal coliforms are harmless, but shellfish contaminated by enteric viruses have caused epidemics all over the world. In this country at least, they are harvested from beds labeled "safe" after bacteria counts revealed low levels of fecal coliforms.

In a Sea Grant-funded study, Joseph Melnick and his associates are evaluating bacteriological indicators of the quality of shellfish beds and developing ways to determine virus levels in the areas. Melnick, chairman of the Department of Virology and Epidemiology at Baylor College of Medicine in Houston, says viral pollution is a complex problem.

"Human feces contain more than 110 types of enteric viruses which may cause diseases such as meningitis, diarrhea and hepatitis," Melnick says. "When a city discharges sewage effluent into a river, the waste enters the water supply of the next city downstream. Viruses adsorb onto sediment particles, which eventually settle out of the water. But sediments are stirred up by storms, boats and swimmers, and the viruses can reappear in the water without new contamination."

They may be ingested by shellfish that feed by filtering suspended particles from the water.

Melnick and his colleagues are developing virus assays that can be used in conjunction with the coliform assay to evaluate the safety of shellfish beds more thoroughly.

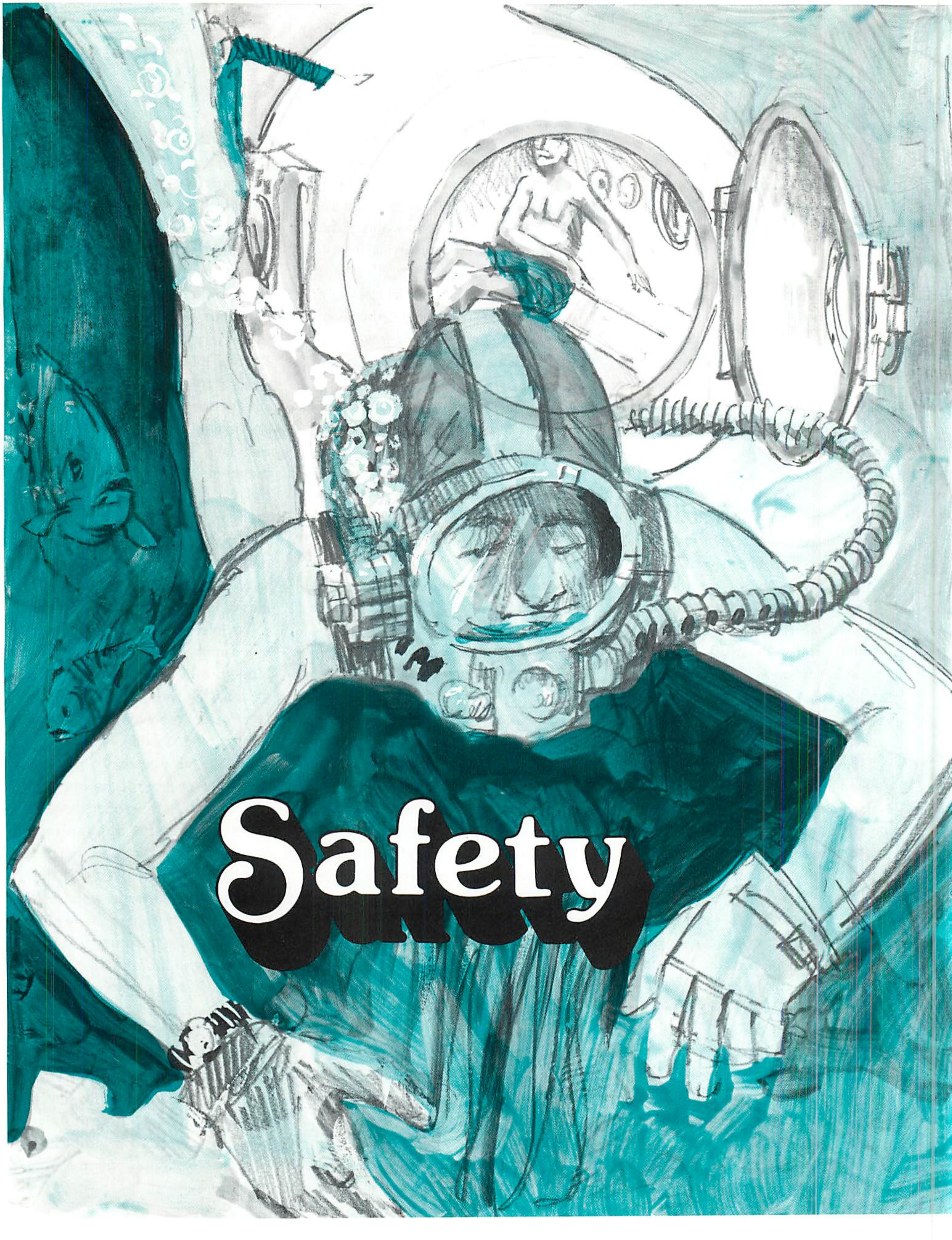
Measuring bacterial levels in a sample is easy because bacteria can multiply using nutrients from the laboratory growth medium. Viruses, however, can multiply only in the nucleus of a living cell. In Melnick's laboratory, most enteric viruses can be grown in a culture of monkey kidney cells which are easily grown in tissue culture.

Although they are numerous enough to cause diseases, viruses in environmental samples have been diluted by sewage treatment and by estuarine waters. They must be concentrated by filtration and chemical manipulation. Then, two types of viral assays are done for each sample. The first simply proves whether or not the viruses are present.

"The monkey kidney cells in the culture are primarily epithelial cells, similar to those in the intestinal lining," says Sagar Goyal, one of Melnick's associates. "Normal epithelial cells are polygnonal in shape. When infected by viruses, however, they get rounder, more opaque and granular. When the kidney cell culture is innoculated with an environmental sample, these cellular changes indicate the presence of viruses."

To determine how many viruses are in a sample, the virologists grow the kidney cells in a gelantinous agar medium. The cells form a solid, cloudy layer across the agar surface, and the culture is innoculated with a sample. If it contains viruses, they will multiply within the cells and cause the cells to split apart (lyse) in about three days. Lysis causes the appearance of "plaques" — clear spots where the cells have been destroyed — in the cell layer. Each plaque represents one viral unit from the innoculum. The number of plaques can be used to calculate virus concentrations in the sample.

Plaquing takes between one and two weeks. One goal of Melnick's project is to develop a faster biochemical test based on antigen-antibody reactions. This test would be especially useful for human rotavirus, the cause of diarrhea that kills millions of malnourished Third World children each year. Rotavirus will not grow in cell cultures.


Safety

The sea lures thousands of recreational swimmers and divers to Texas waters, and as coastal development accelerates, more commerical divers are on the scene. Drowning and "bends" are two dangers these aquarians face. Sea Grant research in 1979-1981 examined the safety problems encountered by both these groups.

A compact car, its personalized license plates bearing the word HYDROX, is parked in front of Texas A&M's hyperbaric laboratory.

"The problem with water is that it demands respect," says the car's owner William Fife, director of the lab. "One of the main causes of diving accidents is attitude. Too many men and women try to be too macho — or macha," he says, speculating on the feminine ending of the Spanish adjective, "and you can't afford to do something stupid in the water." Most diving accidents and deaths take place during recreational dives, because of poor planning, carelessness or "plain stupid" mistakes, he says.

Fife leads a study of diving safety funded by the University's Sea Grant College Program.

"Sea Grant really supports most of the things we do here at the laboratory," says Fife. The lab has been the site of diving and related medical research since it opened in 1968. Its functions include hyperbaric (high-pressure) oxygen therapy for treating skin grafts, gas gangrene and other conditions. The thrust of the Sea Grant work, however, is to reduce the number of diving problems and deaths caused by decompression sickness, commonly known as the "bends." If a diver ascends too fast, nitrogen, dissolved in the blood, comes out of solution and appears as bubbles in the tissues or bloodstream. This can cause decompression sickness, which can produce blood clots in the spinal cord or lungs, causing serious complications or death.

There are hyperbaric chambers of different sizes at the lab that are used to simulate dives and pressures experienced by divers. The smaller chambers simulate dives deeper than 1,800 feet for dogs and sheep and as deep as 4,000 for mice. The chambers large enough for humans can sustain only enough pressure to simulate a 300- to 400-foot dive.

"Most problems in sport diving can be avoided because modern equipment works well if properly maintained," Fife says. "But even though they have done everything right, sometimes divers still get decompression sickness."

Fife's research concentrates on commercial diving safety. Between 15 and 20 commercial divers die each year worldwide, and many more are injured. Although companies usually don't publicize these problems, they sometimes confide in Fife privately. Off the record, one company reported 12 deaths in one year. The problem seriously threatens their businesses and employees. In Texas the booming offshore industry has a high demand for divers.

"When an offshore rig shuts down it costs about $75,000 an hour. If divers can correct the problem they go to work at once." Divers may die from injuries not directly resulting from the dive, but Fife's study addresses decompression sickness caused by improper ascent.

Diving interests, including the U.S. Navy and the National Institute of Occupational Safety and Health (NIOSH), publish decompression tables that divers use to plan a safe ascent. Depending on the depth and duration of the dive, the diver must stop periodically during the ascent to allow the body to purge itself of excess nitrogen, preventing bends. The tables tell the diver at what depths, and for how long, to stop. Physicians also need the tables to treat decompression sickness and injuries that occur during dives. For deep, prolonged dives, however, the tables are not accurate.

"Parts of these tables have been printed surrounded by boxes," Fife points out. "They give approximate depths and durations of stops on ascents from deeper, longer dives, to give the diver a certain margin of safety, but they aren't exact. For example, if a diver wants to stay at 160 feet for two hours, he can't plan a safe ascent using these tables."

With animals as subjects in simulated dives the researchers have developed decompression tables to supplement the faulty one. Tables for each breathing mixture are different because gases behave differently at great depths.

Air or nitrogen/oxygen mixtures can be used for shallow dives, but for deeper dives, the high percentage of nitrogen in these mixtures causes nitrogen narcosis. This condition gives the diver a lightheaded feeling, and the researchers refer to such dives as "one-" or "two-martini" dives depending on the degree of nitrogen narcosis.

"At those depths we can use mixtures of helium and oxygen, but for very deep dives, even helium causes problems. The diver may experience tremors, and the high density of the helium makes breathing more difficult." Fife then explains his license plate.

"We developed 'hydrox' in this laboratory, a non-explosive mixture of hydrogen and oxygen. Hydrogen is lighter, cheaper and, unlike helium, renewable." Hydrogen and oxygen are produced by the electrolytic decomposition of water.

Hydrox has spurred inquiries from diving firms in Canada, Sweden, Brazil and other nations with no native source of helium. Fife's in-house "divers" have logged more than 6,000 hours on hydrox to test the mixture and to prepare decompression tables.

The project also focuses on diving problems unique to women. As more women become divers, concern has mounted that in pregnant women the fetus may be susceptible to decompression sickness even though the woman may not be harmed.

"The woman's lungs filter small bubbles from the bloodstream," says

Fife. "In the fetus, however, circulation is different — the lungs are not functional. A blood vessel shunts blood around them directly into the arterial system, which is very dangerous." Unchecked by passage through the lungs, the bubbles could cause decompression sickness and its complications in the unborn.

"Earlier studies of this problem used pregnant dogs, and dog fetuses seemed more resistant than the mother," he said. "Researchers assumed that human fetuses would not be threatened by decompression sickness. This reasoning may have been faulty, because circulation and gas exhange across the placenta are more efficient in dogs than in humans. We repeated the studies using sheep, in which exchange between mother and fetus is more like that in humans."

The work proved that the fetus was indeed susceptible to decompression sickness in some instances when the mother felt nothing. Most physicians now recommend that pregnant women should not dive. Recent studies suggest that short dives to less than 40 feet may not endanger the fetus, but Fife says he still would not want a member of his family to dive while pregnant.

The decompression tables and the discovery of hydrox have already gained international importance. A new course in diving safety is being added to the biology curriculum at Texas A&M, and Fife has conducted many seminars to make his findings known to diving experts. A diving safety book, to be published in 1982, will include a chapter by Fife about the woman diver.

Without SCUBA gear, swimmers are limited to relatively shallow water and the swimmer's safety depends more on "good sense" than on technical information. Too many people either lack or don't use good sense, however. Alcohol and drug use, improper clothing or choice of swimming area, unsafe toys and just plain carelessness have made drowning the second leading cause of accidental death of Americans between the ages of 1 and 44 according to Jim McCloy, director of the Coastal Zone Laboratory of Texas A&M University at Galveston.

McCloy leads a Sea Grant-funded study of water-related deaths in Texas, where about 600 people drown each year. The study had fairly simple beginnings and was originally an effort to pinpoint where, how, when and why people drown in the state. It turned into much more.

Checking the records of the Texas Parks and Wildlife Department, the Texas Department of Health and county medical examiners across the state, McCloy faced huge volumes of data on drownings — age, sex and race of victims, drug and alcohol use, time of day, the most dangerous places. Before he could code this information into the computer for analysis, he had to put it into a standard format. To simplify future work, McCloy devised a standard form for reporting aquatic accidents and deaths.

"With the help of the Texas Parks and Wildlife Department we devised a reporting form that is now used statewide," he says. "We are now working with USLA (United States Lifesaving Association) on a coast-to-coast reporting system that will allow easy comparison of drowning incidents at beaches in different areas." Because the Sea Grant project enabled McCloy to handle such data, the USLA named him its statistical coordinator and provided him with similar data from beaches across the country.

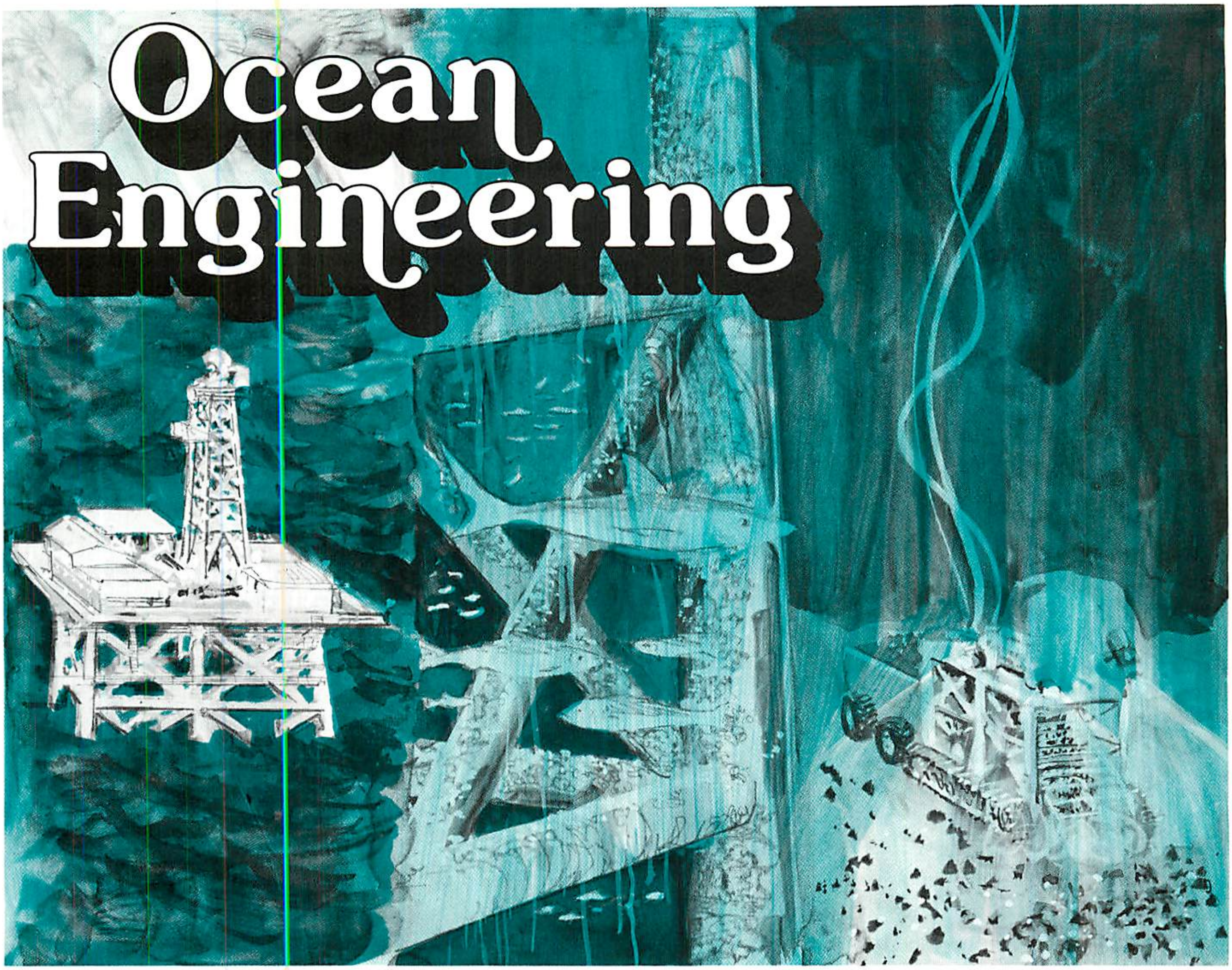
Lack of water safety standards on the various beaches was a significant factor in the drownings. McCloy lives in Galveston, whose beaches flunked the USLA's beach safety test with the lowest possible score. Serious deficiencies in the beach patrol compounded the problem.

"Most beach communities are small towns that don't burden themselves with passing laws defining the number of lifeguards required on their beaches," he says. And the standards that do exist are not uniform and apply to different types of beaches.

"The American Camping Association recommends one guard to 10 bathers, but they usually are concerned with quiet-water, limited access beaches. At big ocean beaches one lifeguard may be responsible for hundreds of bathers, sometimes as many as a thousand."

In April 1980 McCloy hosted the Conference to Develop Guidelines for Open-Water Recreational Beach Standards. Supported by funding from Texas A&M Sea Grant, the conference was sponsored by the American Camping Association, the Council for National Cooperation in Aquatics and the USLA. Water safety experts from across the country met in workshops to discuss standards and to draft guidelines for lifeguard qualifications, training, management and equipment.

That year, McCloy used the Galveston beach to test the guidelines drawn up at the conference. With financial help from the Galveston Park Board of Trustees, the Galveston County Sheriff's Department and the Galveston-based, philanthropic Moody Foundation, the beach patrol became part of the sheriff's department and was completely revamped. New, sophisticated equipment, expansion of the lifeguard force, training sessions led by USLA experts, and a Sea Grant-produced educational brochure about beach safety have made Galveston beach one of the best protected beaches in the country.



Most Texans have seen the maze of oil rig construction on land. At sea, the solution to this maze is complicated by deep water, waves, wind, currents and transportation problems. Yet man's machines protrude from the ocean, scour the sea bed and float atop the water in the perpetual quest for energy and raw materials. One target of Texas A&M Sea Grant's research in 1979-1981 was solving the unique problems faced by offshore industries.

"Construction of offshore platforms in the Gulf of Mexico began in the early 1950's and accelerated greatly during the seventies," says John Herbich, head of the ocean engineering department of Texas A&M's Department of Civil Engineering. "Very extensive progress has been made in the last 30 years."

Oil platforms are just one type of offshore structure in the Gulf. Herbich named more. Pipelines funnel oil and gas to land and flush municipal and chemical wastes to offshore disposal areas. Brine is pumped from onshore salt domes that are being hollowed into huge storage tanks for the nation's petroleum reserve. Jetties, piers and seawalls still don't complete the list.

"Engineers must make these structures as strong as possible, but because of high costs, economics dictate the final decisions in some cases," Herbich says. "If the structures can be designed in terms of the natural forces that they must withstand, the costs decrease and safety increases." In a Sea Grant-funded study, Herbich has been collecting and analyzing wave data from the Gulf — information vital for sound design of onshore and offshore structures.

"The first problem in offshore design is consideration of wave characteristics, the current regime and the frequency of hurricanes and tropical storms at the site," he says. "When we began the wave data study, the government operated only one wave gauge in the Gulf, and it was soon discontinued. The petroleum industry operates many wave gauges, but the data are exclusive property of the companies and thus generally not available to us."

Herbich moored two Waverider buoys in the Gulf about 11 miles offshore in 60 feet of water, one off Port Mansfield, the other off Matagorda Peninsula. Every six hours, for 20 minutes, the buoys transmit data on wave height and wavelength to a receiver and tape recorder mounted on offshore platforms. The data tapes are delivered to Herbich, who feeds the information into a computer. The results are wave spectra, showing the number of waves with the same period and height. The raw data also are used to calculate forces that would act on a structure in the vicinity of the buoys.

"Combining this information with historical data tells engineers the probability that a certain type of wave will hit a structure in that area," he says. "This is important to planners who must decide where to place offshore pipelines and other structures."

Fatigue is another important element in the design of offshore structures. "Monitoring the performance of existing offshore structures needs more attention," Herbich says. "The ocean is a natural laboratory that engineers can use to assess the effects of stresses on ocean structures. They also must consider corrosion rates and the effects of biofouling."

Biofouling is the growth of marine organisms on virtually any object left in the sea. In a Sea Grant-funded project, John Bockris, professor of chemistry at Texas A&M, and his associates are working on a solution to biofouling. The project has investigated the problem as it affects OTEC — ocean thermal energy conversion.

OTEC is similar to steam-powered generation of electricity, but it uses ammonia vapor instead of water vapor. A ship or barge with pumps, turbines, pipes and liquid ammonia floats on warm seas, areas where there is a great difference between surface and bottom water temperatures. Warm surface water is piped through compressed liquid ammonia, producing high-pressure ammonia gas that operates turbines, generating electricity. Another pipe brings very cold water into the system from the deep ocean, condensing the ammonia, which is then recycled.

Marine growth on the pipes stops the transfer of heat, drastically reducing the system's efficiency. The first stage of this biofouling is bacterial growth inside the pipes. Previous attempts to kill the bacteria have used chlorine gas, but the amount of chlorine needed to stop biofouling of OTEC pipes exceeds EPA water quality requirements.

Bockris has devised a safe method to reduce biofouling; he uses the electricity produced by the OTEC facility itself.

"Our method involves applying electricity to the pipe surface," he says. "Oxygen dissolved in the pipe's water is electrochemically converted into hydrogen peroxide which poisons certain bacterial enzymes, preventing the cells from settling."

Working with glass slides coated with tin oxide, the researchers allow bacteria to settle on the glass in a beaker, then pulse the surface with an electrical charge of known strength and duration.

"We have reduced the bacterial concentration on the plates by 99 to 99.9 percent using only a few microwatts per square centimeter," Bockris says. His experiments are continuing, using metal alloys instead of glass and flowing water to simulate the OTEC production environment more closely.

Energy is just one of the sea's resources. There are minerals, too, and manganese deposits represent one of the more recent discoveries.

"Manganese nodules form on the sea floor," says John Flipse, professor of ocean engineering at Texas A&M. Would-be miners of the Gulf bottom, however, should forget manganese nodules, explains Flipse.

"Anywhere there's oil, there are no manganese nodules," he says. "Oil formation requires sedimentation, and manganese nodules grow under the opposite regime. Off Georgia and Florida, for example, the Gulf Stream scours the bottom, providing a great environment for nodule growth." Most nodules containing enough metals to make mining profitable in the future, however, are found far offshore in the Pacific Ocean, at depths greater than 13,000 feet. It is both difficult and expensive to gather the nodules from the sea floor and bring them to the surface.

Flipse is studying these deep ocean mining costs in a study funded by Sea Grant. In an earlier Sea Grant study at the Massachusetts Institute of Technology, engineers developed a computer model to predict these costs. Flipse, and other users of the model, noticed serious shortcomings stemming from the validity of the data used in the computer program, not from the model's structure itself.

Flipse's familiarity with the realities of ocean mining, a result of his experience at the industrial research and development level, gave him insights into the problem that the MIT pioneers did not have. In developing an alternate model, Flipse removed duplications and omissions, increasing the credibility of the model output.

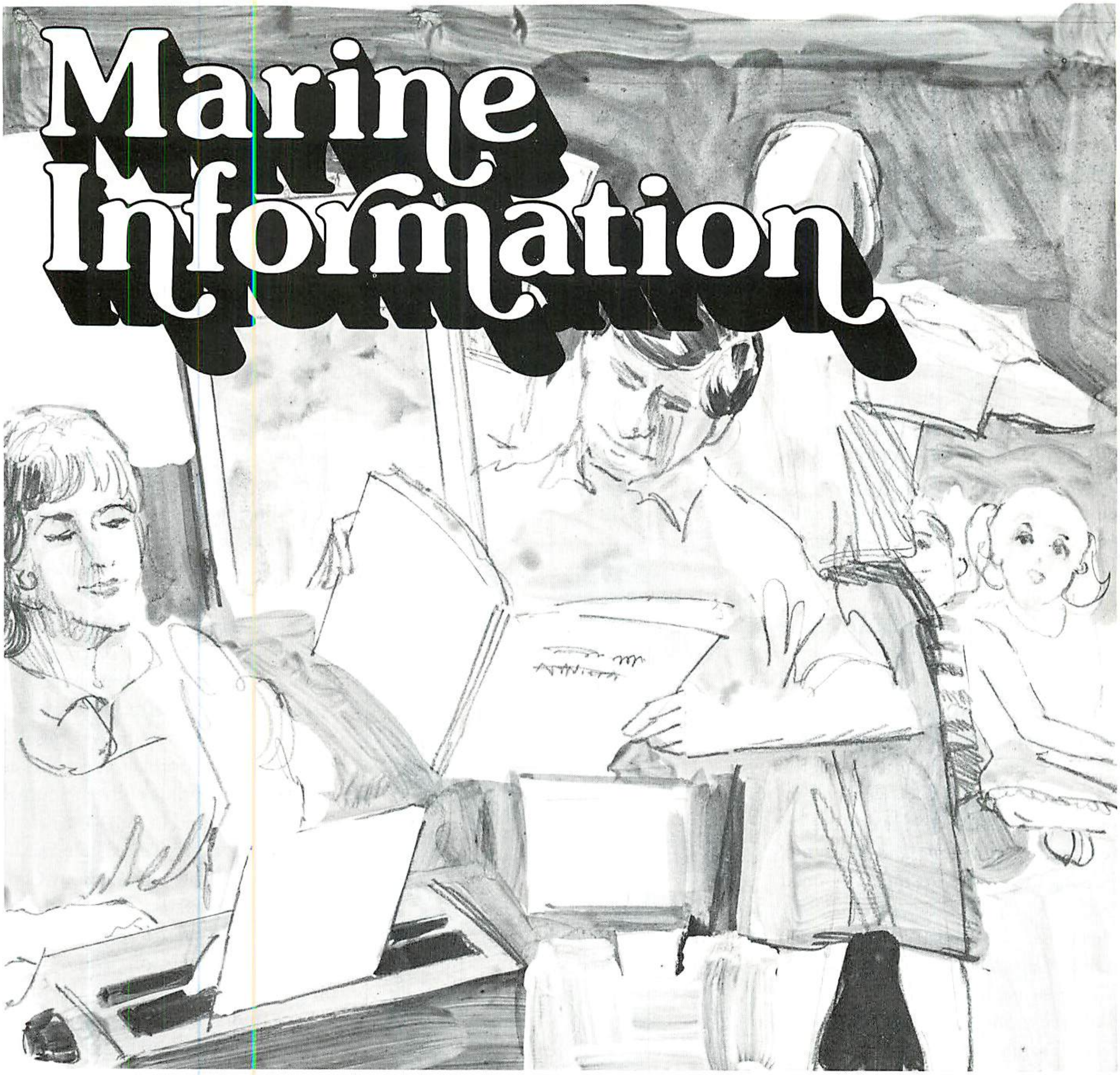
"This model is not unique in determining payout on investment," he says. "What is unique is that it accurately defines and prices a deep ocean mining project from inception to sale of metals." A payout model need not be specific to one resource, but in Flipse's analysis the choice of a manganese nodule mining project makes it unique.

"We took a detailed, practical approach to the problem," he says. "We wanted to include as many technical, business and regulatory options as possible. By considering essential variables, we developed a more realistic model."

The user selects such data as equipment capabilities, depreciation schedules, permitting costs, metal prices and taxes. The model determines whether or not a hypothetical firm can make profits under the specified conditions.

"We plan to investigate a four-metal project — including nickel, copper and cobalt in addition to manganese — to consider economic and technological developments in our ongoing work," Flipse says.

Marine Information



The common thread that runs through all Sea Grant-supported activities — the diverse research projects, the marine education program and the Marine Advisory Service — is a dedication to providing information about the marine and coastal environment that will help people enjoy its delights safely, use its resources wisely, harvest its bounties profitably, unlock its mysteries and appreciate its beauties.

The role of the Marine Information Service (MIS), a small team of public information and public relations specialists, is to publish the results of Sea Grant-supported work in the form most useful to those who need it. By issuing news releases to both print and electronic media, exhibiting at important marine-related meetings and publishing reports and periodicals, MIS "gets the word out" to a wide variety of audiences who can benefit from the abundance of information produced by the research, education and advisory arms of the Texas A&M Sea Grant College Program.

Two quarterly periodicals are published by MIS. *The University and the Sea* presents the results of Sea Grant projects in layman's language in a magazine format to some 2,000 subscribers. *Marine Education* is a newsletter which provides some 4,000 teachers (most in Texas) with news, background information and tips on using marine examples in the classroom.

In the two-year period 1979-1981, a total of 72 new publications were published by MIS. Many "publics" were served by them, and some highlights of the biennium are noted here.

Those who ultimately must make

the decisions about how our coastal environment will be used — government officials, planners, legislators — were provided with information ranging from hurricane evacuation planning, to the current status of the Law of the Sea negotiations, to erosion on densely populated Galveston Island. Sea Grant researchers Carlton Ruch and Larry Christensen co-authored two reports, *Hurricane Message Enhancement* and *Hurricane Watch . . . Hurricane Warning — Why Don't People Listen?*, about their research on what causes people to respond or not respond to warnings about impending hurricanes. Ruch also authored a document for use by emergency preparedness officials, *Hurricane Relocation Planning for Brazoria, Galveston, Harris, Fort Bend and Chambers Counties (Texas).*

Educators, who daily influence the attitudes and understanding of thousands of future voters and wage earners, continued to be a prime target of Sea Grant publications. Staff of the marine education program and the Marine Advisory Service wrote a total of eight new publications for use by teachers, counselors and students. Among them were the highly popular *How to Set Up and Maintain a Saltwater Aquarium, Vocational-Technical Marine Career Opportunities in Texas, Marine Organisms in Science Teaching,* and *Fairy Tales of the Sea* and its accompanying teacher's guide.

Many Texans make their livings, either directly or indirectly, from the sea, and several publications provided them with valuable information. A bilingual Spanish/English flip chart used words and illustrations to show first aid measures to deal with accidents that can occur on fishing vessels. Developed by Marine Advisory Service fisheries specialist Russell Miget, the first aid chart recently won the Grand Award for public service literature in Southwest District of the Council for the Advancement and Support of Education (CASE) competition. When the Coast Guard changed the approved marine navigation system from Loran A to Loran C in late 1981, MAS fisheries specialist Gary Graham updated a previous Sea Grant publication he had authored on the subject. The Marine Information Service published the new book, *'Hangs' and Bottom Obstructions of the Texas/Louisiana Gulf: Loran C,* in time for the switch to the new system. Publication of two references — *Directory of Texas Seafood Wholesalers* and *Directory of Texas Shipyards* — made things easier for both buyers and sellers, and revealed the size of these two important Texas marine industries as well. Another

publication about the fishing industry, *Marketing Alternatives for Fishermen,* has been popular with both economists and the fishermen themselves.

But some Texans just want to enjoy what the state's coast has to offer — food and fun! Marine Advisory Service seafood consumer education specialist Annette Reddell Hegen saw to it that gourmets and novices alike had plenty of new seafood recipes to try. MIS published several new seafood brochures, including *Texas Fish Recipes, Sauces for Seafood, Swordfish Fare,* and *Make It With Mullet.* Reddell also authored a 40-page cookbook entitled *Shrimp in Microwave Cookery.* As well as being popular with homemakers, 9,500 copies of the book were used in a statewide promotion of shrimp conducted by the advisory service as part of a nationwide seafood campaign.

The bilingual Spanish/English brochure *Have Fun! But Know the Dangers of the Beach* was developed by MIS in cooperation with the Galveston County Medical Society Auxiliary and Sea Grant project leader James McCloy and his associate James Dodson. This was used by the Auxiliary as part of a beach safety campaign. Boaters also found valuable information in the directory *Marinas Along the Texas Coast,* compiled by MAS marine business specialist Dewayne Hollin.

Scientists and engineers read the latest results of Sea Grant supported research in numerous technical reports and conference proceedings published by the Marine Information Service, as well as in the reprints of the 59 journal articles distributed in 1979-1981.

Attendees at the Texas State Fair in Dallas, the Offshore Technology Conference in Houston, the National Marine Education Association meeting in Galveston, and several other events throughout the state learned more about the marine environment through exhibits prepared and staffed by the Marine Information Service.

These are only the highlights of MIS' activities during 1979-1981. A complete listing of publications during that period (including journal article reprints) follows. To order any of these, or to request a complete list of program publications since 1969, a program directory, or any other information about the Texas A&M Sea Grant Program, write or telephone:

Marine Information Service
Sea Grant College Program
Texas A&M University
College Station, Texas 77843
(713) 845-7524

BUSINESS

Texas Charter Fishing — Bay and Gulf. *Steven A. Woods and Robert B. Ditton*, September 1979. 4 pages. TAMU-SG-80-504.

Directory of Texas Shipyards. *Dewayne Hollin*. August 1980. Revised November 1981. 24 pages, 1 map. TAMU-SG-80-507.

Coastal Texas: Center of Marine Industry Development. *Dewayne Hollin*. In **The Texas Business Executive,** Fall/Winter 1979. 8 pages, 6 tables. TAMU-SG-80-811.

COASTAL AND OCEAN ENGINEERING

Proceedings of the Eleventh Dredging Seminar. *J. B. Herbich (comp.)*. October 1979. 400 pages. $12. TAMU-SG-80-103. NTIS—PB-80-225-683.

Proceedings of the Twelfth Dredging Seminar. *J. B. Herbich (comp.)*. August 1980. 400 pages. 12 photographs and many figures. $10. TAMU-SG-80-112.

The Potential Cost of Deep Ocean Mining Environmental Regulation. *John E. Flipse*. July 1980. 50 pages, 2 figures. $2. TAMU-SG-80-205. NTIS—PB-80-225-451.

Simultaneous Wave and Current Forces on a Cylinder Near the Bottom Boundary. *David A. Knoll and John B. Herbich*. May 1981. 85 pages, 6 tables, 44 figures. $5. TAMU-SG-81-203. NTIS-PB-81-243-990.

Electrochemical Inactivation of Marine Bacteria. *H. P. Dhar, J. O'M. Bockris and D. H. Lewis*. In **Journal of the Electrochemical Society,** Vol. 128, No. 1. January 1981. 3 pages, 3 figures. $1. TAMU-SG-81-817.

DIVING AND SAFETY

Hurricane Message Enhancement. *Carlton E. Ruch and Larry B. Christensen*. January 1981. 140 pages, 43 figures, 18 tables. $5. TAMU-SG-80-202. NTIS—PB-81-243-677.

Emergency First Aid/Primeros Auxilios: Emergencias. *Russell J. Miget*. March 1981. 16 pages, 49 illustrations. TAMU-SG-80-503.

Hurricane Watch . . . Hurricane Warning — Why Don't People Listen? *Carlton Ruch and Larry Christensen*. May 1980. 4 pages. TAMU-SG-80-508.

Guidelines for Establishing Open-Water Recreational Beach Standards: Proceedings of a Conference, April 16-18, 1980, Galveston, Texas. *James M. McCloy and James A. Dodson (comp.)*. August 1981. $5. TAMU-SG-81-116.

Guide to Fishing Vessel Safety. *Dewayne Hollin*. September 1981. TAMU-SG-81-503.

Have Fun! But Know the Dangers of the Beach (¡Divertase! Pero Conozca los Peligros de la Playa) June 1981. 8 pages. TAMU-SG-81-505.

Hurricane Relocation Planning for Brazoria, Galveston, Harris, Fort Bend and Chambers Counties (Texas). *Carlton Ruch*. June 1981. 183 pages, 21 tables, 17 figures. $5. TAMU-SG-81-604.

The Effect of Social Influence on Response to Hurricane Warnings. *Larry Christensen and Carlton E. Ruch*. In **Disasters,** Vol. 42, No. 2, 1980. 8 pages, 10 figures, 3 tables. $1. TAMU-SG-81-809. NTIS—PB-81-199-895.

ECONOMICS

Economic Impacts of Recreational Boat Fishing in the Houston-Galveston Area of the Texas Coast. *Robert B. Ditton, Alan R. Graefe and Gary Lapotka*. September 1980. 46 pages, 3 figures, 16 tables. $2. TAMU-SG-80-206. NTIS—PB-81-140-980.

Groundfish Trawler Profitability. *John P. Warren and Wade L. Griffin*. In **Marine Fisheries Review,** August 1979. 8 pages, 2 figures, 10 tables. TAMU-SG-80-801.

Costs and Returns Trends in the Gulf of Mexico Shrimp Industry, 1971-78. *John P. Warren and Wade L. Griffin*. In **Marine Fisheries Review,** February 1980. 7 pages, 4 figures, 5 tables. TAMU-SG-80-817.

EDUCATION

Children's Literature — Passage to the Sea: A Guide for Teachers. *Norma Bagnall*. February 1980. 56 pages, 4 questionnaires, 22 pages of illustrations/patterns. $2. TAMU-SG-80-401.

Vocational-Technical Marine Career Opportunities in Texas. *Dewayne Hollin*. March 1980. 22 pages, 7 photographs. TAMU-SG-80-402. NTIS—PB-80-206-071.

Marine Organisms in Science Teaching. *John D. Hunt (ed.)* September 1980. 198 pages. $4. TAMU-SG-80-403.

Indoor-Outdoor Workshops in Marine Education. September 1980. Revised September 1981. 12 pages. TAMU-SG-80-404.

Mini-Learning Centers Set 1: Language Arts. February 1981. 5 activity folders. $5. TAMU-SG-81-401.

Fairy Tales of the Sea. *Elizabeth Cowan and Karen Davis (comp.)*. February 1981. 152 pages, 9 original illustrations. $4.50. TAMU-SG-81-402.

Fairy Tales of the Sea — Teacher's Guide. *Donna Wiseman*. February 1981. 28 pages. $2. TAMU-SG-81-403.

How to Set Up and Maintain a Saltwater Aquarium. *Russell Miget*. June 1981. 8 pages, 7 illustrations. TAMU-SG-81-504.

Marine Education Through Children's Literature. *Norma Bagnall*. In **Current/The Journal of Marine Education,** Vol. 1, No. 2, Winter 1980. 4 pages. $1. TAMU-SG-81-801. NTIS—PB-81-115-313.

Without Losing the Wonder: An Interview with Jan Adkins. *Norma Bagnall*. In **Language Arts,** May 1980. 7 pages. $1. TAMU-SG-81-802.

Theodore Taylor: His Models of Self-Reliance. *Norma Bagnall*. In **Language Arts,** January 1980. 6 pages. $1. TAMU-SG-81-803.

Children's Literature: Visions of Wonder and Enchantment. *Norma Bagnall*. In **Marine Technology,** October 1980. 4 pages. TAMU-SG-81-807.

ENVIRONMENTAL QUALITY

Galveston Island — A Changing Environment. *Arthur R. Benton, Jr., Carolyn A. Clark and Wallace W. Snell*. January 1979. 46 pages, 9 photographs. $2. TAMU-SG-80-201.

Failure of Indicator Bacteria to Reflect the Occurrence of Enteroviruses in Marine Waters. *Charles P. Gerba, et al.* In **AJPH,** November 1979. 4 pages, 2 tables. TAMU-SG-80-805.

Field Evaluation of Methods for the Detection of Enteric Viruses in Marine Sediments. *C. P. Gerba, E. M. Smith, G. E. Schaiberger and T. D. Edmond*. In **Special Technical Publication 673, American Society for Testing and Materials, 1979.** 11 pages, 4 tables, 2 figures. TAMU-SG-80-806.

Bacterial Indicators and Environmental Factors as Related to Contamination of Oysters by Enteroviruses. *Charles P. Gerba, Sagar M. Goyal, Irina Cech and Gregory F. Bogda*. In **Journal of Food Protection,** Vol. 43, No. 2. 3 pages, 1 table. $1. TAMU-SG-80-812. NTIS—PB-81-112-393.

Stability of Simian Rotavirus in Fresh and Estuarine Water. *Christon J. Hurst and Charles P. Gerba*. In **Applied and Environmental Microbiology,** January 1980. 5 pages, 3 figures. TAMU-SG-80-814.

Relationships Between Environmental Factors, Bacterial Indicators, and the Occurrence of Enteric Viruses in Estuarine Sediments. *Raymond L. LaBelle, et al.* In **Applied and Environmental Microbiology,** Vol. 39, No. 3, 1980. 9 pages, 3 tables, 3 figures. $1. TAMU-SG-80-815. NTIS—PB-80-209-372.

Influence of Estuarine Sediment on Virus Survival Under Field Conditions. *Raymond L. LaBelle and Charles P. Gerba.* In **Applied and Environmental Microbiology,** Vol. 39, No. 4. 7 pages, 3 figures, 2 tables. $1. TAMU-SG-80-816. NTIS—PB-81-119-216.

Distribution of Viral and Bacterial Pathogens in a Coastal Canal Community. *Charles P. Gerba, Sagar M. Goyal, Eric M. Smith and Joseph L. Melnick.* In **Marine Pollution Bull.,** Vol. 8, 1977. 4 pages, 1 figure, 3 tables. TAMU-SG-80-819. NTIS—PB-81-102-303.

Development of a Quantitative Method for Detecting Enteroviruses in Estuarine Sediments. *Charles P. Gerba, Eric M. Smith and Joseph L. Melnick.* In **Applied and Environmental Microbiology,** August 1977. 6 pages, 9 tables. TAMU-SG-80-820. NTIS—PB-81-102-436.

Occurrence and Distribution of Bacterial Indicators and Pathogens in Canal Communities Along the Texas Coast. *Sagar M. Goyal, Charles P. Gerba and Joseph L. Melnick.* In **Applied and Environmental Microbiology,** August 1977. 11 pages, 7 tables, 6 figures. TAMU-SG-80-821. NTIS—PB-81-106-395.

Prevalence of Human Enteric Viruses in Coastal Canal Communities. *Sagar M. Goyal, Charles P. Gerba and Joseph L. Melnick.* In **Journal Water Pollution Control,** October 1978. 10 pages, 5 tables, 1 figure. TAMU-SG-80-822. NTIS—PB-81-102-345.

Concentration of Enteroviruses from Large Amounts of Tap Water, Treated Sewage, and Seawater. *Charles P. Gerba, et al.* In **Applied and Environmental Microbiology,** March 1978. 9 pages, 4 tables, 3 figures. TAMU-SG-80-823. NTIS—PB-81-106-403.

Characterization of Sewage Solid-Associated Viruses and Behavior in Natural Waters. *Charles P. Gerba, Charles H. Staff and Marc G. Abadie.* In **Water Research,** Vol. 12. 7 pages, 8 tables. TAMU-SG-80-824.

Role of Sediment in the Persistence of Enteroviruses in the Estuarine Environment. *Eric M. Smith, Charles P. Gerba and Joseph L. Melnick.* In **Applied and Environmental Microbiology,** April 1978. 5 pages, 4 figures, 1 table. TAMU-SG-80-825.

Detection and Occurrence of Enteric Viruses in Shellfish: A Review. *Charles P. Gerba and Sagar M. Goyal.* In **Journal of Food Protection,** September 1978. 12 pages, 3 tables. TAMU-SG-80-826.

R+ Bacteria in Estuarine Sediments. *Saga M. Goyal, Charles P. Gerba and Joseph L. Melnick.* In **Marine Pollut. Bull.,** Vol. 10, 1979. 3 pages, 2 tables. TAMU-SG-80-827. NTIS—PB-81-102-295.

Transferable Drug Resistance in Bacteria of Coastal Canal Water and Sediment. *Sagar M. Goyal, Charles P. Gerba and Joseph L. Melnick.* In **Water Research,** Vol. 13. 8 pages, 7 tables. TAMU-SG-80-828. NTIS—PB-81-102-279.

Human Enteroviruses in Oysters and Their Overlying Waters. *Sagar M. Goyal, Charles P. Gerba and Joseph L. Melnick.* In **Applied and Environmental Microbiology,** March 1979. 10 pages, 5 tables, 1 figure. TAMU-SG-80-829. NTIS—PB-81-102-352.

Influence of pH, Salinity, and Organic Matter on the Adsorption of Enteric Viruses to Estuarine Sediment. *Raymond L. LaBelle and Charles P. Gerba.* In **Applied and Environmental Microbiology,** July 1979. 9 pages, 3 tables, 11 figures. TAMU-SG-80-830. NTIS—PB-81-102-428.

Indicator Bacteria and the Occurrence of Viruses in Marine Waters. *Charles P. Gerba.* In **Aquatic Microbial Ecology.** 8 pages. TAMU-SG-80-834. NTIS—PB-81-102-410.

Type and Strain Dependence of Enterovirus Adsorption to Activated Sludge, Soils and Estuarine Sediments. *Charles P. Gerba, Sagar M. Goyal, Christon J. Hurst and Raymond L. LaBelle.* In **Water Research,** Vol. 14, 1980. 2 pages, 1 table. $1. TAMU-SG-81-805. NTIS—PB-81-199-481.

Thermostabilization of Enteroviruses by Estuarine Sediment. *Pei-Fung Liew and Charles P. Gerba.* In **Applied and Environmental Microbiology,** Vol. 40, No. 2, August 1980. 4 pages, 5 figures. $1. TAMU-SG-80-808. NTIS—PB-81-194-698.

Phytogeograpy of South Padre Island, Texas. *Robert I. Lonard and Frank W. Judd.* In **The Southwestern Naturalist** 25(3), November 14, 1980. 10 pages, 2 tables. $1. TAMU-SG-80-813. NTIS—PB-81-199-879.

Accumulation of Glutamate in Sea Anemones Exposed to Heavy Metals and Organic Amines. *Margaret R. Kasschau, Merton M. Skaggs and Edward C. M. Chen.* In **Bull. Environm. Contam. Toxicol.** 25(1980), 6 pages, 2 tables, $1. TAMU-SG-81-815. NTIS—PB-81-197-956.

Uptake and Survival of Enteric Viruses in the Blue Crab Callinectes sapidus. *Thomas W. Hejkal and Charles P. Gerba.* In **Applied and Environmental Microbiology,** Vol. 41, No. 1, January 1981. 5 pages, 3 figures, $1. TAMU-SG-81-816.

The Terrestrial Flora of South Padre Island, Texas. *Robert I. Lonard and Frank W. Judd.* July 1981. 74 pages. $4.95. TAMU-SG-81-824. Order from Publications Department, Texas Memorial Museum, The University of Texas at Austin, 2400 Trinity, Austin, Texas 78705.

FISHERIES

Proceedings of the Fourth Annual Tropical and Subtropical Fisheries Technological Conference of the Americas. *Ranzell Nickelson II (comp.).* September 1979. 254 pages. $10. TAMU-SG-80-101.

Simulations of the Effects of Fishing on the Atlantic Croaker, Micropogon Undulatus. *Mark E. Chittenden, Jr.* In **Proceedings of the Gulf and Caribbean Fisheries Institute,** 29th Annual Session, 1977. 19 pages, 4 tables, 6 figures. TAMU-SG-80-831. NTIS—PB-81-104-978.

Composition of the Ichthyofauna Inhabiting the 110-Meter Bathymetric Contour of the Gulf of Mexico, Mississippi River to the Rio Grande. *Mark E. Chittenden, Jr. and Donald Moore.* In **Northeast Gulf Science,** December 1977. 9 pages, 1 table, 1 figure. TAMU-SG-80-832. NTIS—PB-259-595. See TAMU-SG-76-210, this section.

Age Determination, Reproduction and Population Dynamics of the Atlantic Croaker, Micropogon Undulatus. *Michael L. White and Mark E. Chittenden, Jr.* In **Fishery Bulletin,** Vol. 75, No. 1, 1977. 15 pages, 9 figures, 2 tables. TAMU-SG-80-833.

Proceedings of the Fifth Annual Tropical and Subtropical Fisheries Technological Conference of the Americas. *Ranzell Nickelson II (comp.).* September 1980. 256 pages. $10. TAMU-SG-81-101.

Abstracts of the Sixth Annual Tropical and Subtropical Fisheries Technological Conference of the Americas. *Ranzell Nickelson II (comp.).* April 1981. 26 pages. TAMU-SG-81-113.

"Hangs" and Bottom Obstructions of the Texas/Louisiana Gulf: Loran C. *Gary L. Graham.* November 1980. 120 pages, 55 double-page charts. $5. TAMU-SG-81-501.

The Comparative Reproductive Physiology of Sea Turtles. *David W. Owens.* In **Amer. Zool.,** 200(1980). 15 pages, 6 figures, 4 tables. TAMU-SG-81-810. NTIS—PB-81-177-230.

Immunoenzyme Microscopy for Differentiating Among Systemic Bacterial Pathogens of Fish. *D. H. Lewis.* In **Can. J. Fish. Aq. Sci.** 38:463-466 (1981). 4 pages. $1. TAMU-SG-81-819.

MARICULTURE

Bio-Engineering Economic Model for Shrimp Mariculture Systems. *C. M. Adams, W. L. Griffin, J. P. Nichols and R. W. Brick.* May 1980. 125 pages, 7 figures, 4 tables. $4. TAMU-SG-80-203. NTIS—PB-80-223-308.

The Role of Bacteria in the Uptake of Hexoses from Seawater by Postlarval Penaeid Shrimp. *Frank L. Castille, Jr. and Addison L. Lawrence.* In **Comp. Biochem. Physiol.,** Vol. 64A, 1979. 7 pages, 2 tables, 4 figures. TAMU-SG-80-804.

Application of a Bio-Economic-Engineering Model for Shrimp Mariculture Systems. *Charles M. Adams, Wade L. Griffin, John P. Nichols and Robert E. Brick.* In **Southern Journal of Agricultural Economics,** July 1980. 7 pages, 2 figures. TAMU-SG-80-835. NTIS—PB-81-102-378.

Aquaculture in Texas: A Status Report and Development Plan. *Robert R. Stickney and James T. Davis.* August 1981. 103 pages, 2 tables, 6 figures. $8. TAMU-SG-81-119.

Summary of Shrimp Mariculture Data at Texas A&M University, 1969-1978. *M. A. Johns, H. W. Holcomb, D. L. Hutchins and W. L. Griffin.* May 1981. 130 pages, 202 tables. $5. TAMU-SG-81-603. NTIS—PB-81-243-974.

Mixed Infection in Columnaris Disease of Fish. *J. E. Marks, D. H. Lewis and G. S. Trevino.* In **Journal of the American Veterinary Medical Association,** Vol. 177, No. 9, November 1980. 4 pages, 1 table, 6 figures. $1. TAMU-SG-81-811. NTIS—PB-81-199-861.

Ultrastructural Localization of Peroxidase Activity in Neutrophil Leukocytes of Ictalurus Punctatus. *M. Samuel Cannon, Hilton H. Mollenhauer, Anita M. Cannon, Thomas E. Eurell and Donald H. Lewis.* In **Canadian Journal of Zoology,** Vol. 58, No. 6, 1980. 4 pages, 2 figures. TAMU-SG-81-812. NTIS—PB-81-182-628.

A Comparison of the Capabilities of Juvenile and Adult Penaeus Setiferus and Penaeus Stylirostris to Regulate the Osmotic, Sodium, and Chloride Concentrations in the Hemolymph. *Frank L. Castille, Jr. and Addison L. Lawrence.* In **Comp. Biochem. Physiol.** Vol 68A, 1981. 4 pages, 2 tables. $1. TAMU-SG-81-818.

An Ultrastructural Study of the Leukocytes of the Channel Catfish, Ictalurus Punctatus. *M. Samuel Cannon et al.* In **J. Morphol.** 161:1-23 (1980). 23 pages, 1 table, 12 figures. $1. TAMU-SG-81-820.

Maturation and Reproduction of Penaeus Setiferus in Captivity. *A. L. Lawrence et al.* In **Proc. World Maricul. Soc.** 11:481-487 (1980). 7 pages, 3 tables, 1 figure. $1. TAMU-SG-81-821.

Winter Culture of Penaeus Vannamei in Ponds Receiving Thermal Effluent at Different Rates. *G. W. Chamberlain et al.* In **Proc. World Maricul. Soc.** 11:30-43 (1980). 14 pages, 2 tables, 5 figures. $1. TAMU-SG-81-822.

Estimation of Shrimp Populations in Experimental Ponds Using Mark-Recapture and Stratified Random Sampling Methods. *David L. Hutchins, George W. Chamberlain and Jack C. Parker.* In **Proc. World Maricul. Soc.** 11:142-150 (1980). 9 pages, 3 figures, 2 tables. $1. TAMU-SG-81-825.

The Role of Sulfate Exclusion in Buoyancy Maintenance by Siphonophores and Other Oceanic Gelatinous Zooplankton. *Robert B. Bidigare and Douglas C. Biggs.* In **Comp. Biochem. Physiol.,** Vol. 66A. 5 pages, 2 tables, 1 figure. TAMU-SG-80-818. NTIS—PB-80-225-501.

RECREATION

Access to and Usage of Offshore Liberty Ship Reefs in Texas. *R. B. Ditton, A. R. Graefe, A. J. Fedler and J. D. Swartz.* In **Marine Fisheries Review,** September 1979. 7 pages, 3 photographs, 5 figures, 4 tables. $1. TAMU-SG-80-803.

Marinas Along the Texas Gulf Coast — A Directory. *Malon Scogin and Dewayne Hollin.* February 1981. 16 pages, 1 map, 6 charts. TAMU-SG-81-502.

Predicting Marine Recreational Fishing Patterns From Boat Characteristics and Equipment. *Robert B. Ditton, Alan R. Graefe and Anthony J. Fedler.* In **Transactions of the American Fisheries Society** 109 (1980), 5 pages, 1 figure, 4 tables. $1. TAMU-SG-81-814. NTIS—PB-81-197-782.

RESOURCES MANAGEMENT

Survey of the Steamboat Black Cloud. *Robert M. Adams et al.* October 1980. 47 pages, 15 figures, 4 photographs. $3. TAMU-SG-81-201. NTIS—PB-81-140-998.

Law of the Sea — Background and Status, August 1981. *Elizabeth Carnahan.* August 1981. 8 pages, 3 diagrams. TAMU-SG-81-506.

The Coastal Upwelling Ecosystems Analysis Program as an Experience in International Cooperation. *Lauriston R. King.* In **Ocean Development and International Law Journal** 9:269-288, 1981. 20 pages, 4 figures. $1. TAMU-SG-81-823.

SEAFOOD MARKETING

Marketing Alternatives for Fishermen. *John P. Nichols, et al.* May 1980. 46 pages, 6 tables. $2. TAMU-SG-80-204. NTIS—PB-80-223-381.

Directory of Texas Seafood Wholesalers. *Mike Lang.* June 1980. Revised May 1981. 20 pages. TAMU-SG-80-511.

SEAFOOD PREPARATION

Sauces for Seafood. *Annette Reddell.* November 1979. 6 pages. TAMU-SG-80-501.

Texas Fish Recipes. *Annette Reddell.* September 1979. 6 pages. TAMU-SG-80-502.

Shrimp in Microwave Cookery. *Annette Reddell.* March 1980. 40 pages, 40 shrimp recipes. $2. TAMU-SG-80-505.

Make It With Mullet. *Barbara Rowland and Annette Reddell.* June 1980. 6 pages. TAMU-SG-80-509.

Swordfish Fare. *Barbara Rowland and Annette Reddell.* June 1980. 6 pages. TAMU-SG-80-510.

SEAFOOD TECHNOLOGY

Edwardsiella Tarda in Freshwater Catfish and Their Environment. *Lawrence E. Wyatt, Ranzell Nickelson II and Carl Vanderzant.* In **Applied and Environmental Microbiology,** Vol. 38, No. 4, October 1979. 4 pages, 3 tables. $1. TAMU-SG-80-802.

Stability of Adenosine Deaminase and Adenosine Monophosphate Deaminase During Ice Storage of Pink and Brown Shrimp from the Gulf of Mexico. *Wai Lun Cheuk, Gunnar Finne and Ranzell Nickelson II.* In **J. of Food Sci.** 44(6), 1979. 4 pages, 4 figures. $1. TAMU-SG-80-807.

Fatty Acid Stability of Gulf of Mexico Brown Shrimp (Penaeus aztecus) Held on Ice and in Frozen Storage. *Nestor R. Bottino, Martha L. Lilly and Gunnar Finne.* In **J. Food Sci.** 44(6), 1979, 2 pages, 3 tables. $1. TAMU-SG-80-808.

Presence, Growth and Survival of Yersinia enterocolitica In Oysters, Shrimp and Crab. *S. S. Peixotto, G. Finne, M. O. Hanna and C. Vanderzant.* In **Journal of Food Protection,** Vol. 42, No. 12. December 1979. 8 pages, 10 figures, 3 tables. $1. TAMU-SG-80-809. NTIS—PB-80-174-659.

Effects of Sampling Procedures on Salmonella Recovery from Fresh Water Catfish. *Lawrence E. Wyatt, Ranzell Nickelson II and Carl Vanderzant.* In **J. of Food Protection,** Vol. 43, No. 1, January 1980. 3 pages, 1 table. $1. TAMU-SG-80-810.

Shelf-Life Studies on Carbon Dioxide Packaged Finfish from the Gulf of Mexico. *Harrel Banks, Ranzell Nickelson II and Gunnar Finne.* In **J. Food Sci.,** Vol. 45, No. 2, 1980. 5 pages, 13 figures. $1. TAMU-SG-80-813. NTIS—PB-80-209-380.

Minced Fish Flesh From Nontraditional Gulf of Mexico Finfish Species: Bacteriology. *Ranzell Nickelson II, Gunnar Finne, Mary O. Hanna and Carl Vanderzant.* In **J. Food Sci.** (45)5, 1980. 6 pages, 9 tables. $1. TAMU-SG-81-804. NTIS—PB-81-192-825.

Minced Fish Flesh From Nontraditional Gulf of Mexico Finfish Species: Yield and Composition. *Gunnar Finne, Ranzell Nickelson II, Annette Quimby and Nina Connally.* In **J. Food Sci.** 45(5), 1980. 4 pages, 1 figure, 4 tables. $1. TAMU-SG-81-806. NTIS—PB-81-180-920.

SEA GRANT PROGRAM

Sea Grant College Program/Texas A&M University/Directory — 1979-1980. September 1979. 16 pages. TAMU-SG-80-603.

Sea Grant College Program Annual Report 1978-79. *Amy Broussard (ed.).* July 1981. 20 pages. TAMU-SG-81-115.

Sea Grant College Program/Texas A&M University/Directory — 1980-1981. March 1981. 12 pages. TAMU-SG-81-602.

Program Summary

Marine Advisory Services	Year Begun	Year Completed
Marine Fisheries and General Extension, Ranzell Nickenson II and Wallace Klussman	1968-69	Continuing
Education and Training		
Marine Fellowship Program, George Kunze	1975-76	Continuing
Increasing the Participation of Minorities in the Marine Sciences at Texas Southern University, Rudolph R. Schwarzer	1979-80	Continuing
Development and Dissemination of Marine Education Materials, K-12, Delmar Janke and Violetta Lien	1977-78	1979-80
Marine Resources Reference Center, James DeShaw	1977-78	1979-80
Marine-Related Children's Literature, David H. Stewart and Norma Bagnall	1977-78	1979-80
Development and Dissemnation of a System for Providing Living Marine Materials and Activities for Grades 4-12, John Hunt and Gary Wolfe.	1979-80	Continuing
Dissemination of K-12 Marine Education Materials and Programs in Texas, David W. David and John Hunt	1980-81	Continuing
Mariculture		
Shrimp Production Systems, Hoyt Holcomb	1968-69	Continuing
Maturation of Penaeid Shrimp: Dietary Lipids, Brian S. Middleditch	1977-78	Continuing
Penaeid Shrimp Maturation and Reproduction: Nutritional and Culture Requirements, Addison L. Lawrence.	1977-78	Continuing
Shrimp Mariculture Data Documentation and Economics, Wade L. Griffin	1977-78	1979-80
Microbial Diseases of Shrimp, Donald Lewis	1977-78	Continuing
Economics of Commercial Shrimp Mariculture, Wade L. Griffin	1980-81	Continuing
Fauna of a Submerged Disposal Area, George A. Bryan, Jr.	1979-80	1980-81
Studies on Preservation of Algal Cultures by Storage in Liquid Nitrogen, Greta Fryxell	1978-79	1979-80
Fisheries Research and Seafood Technology		
Economics of Production and Marketing in the Commercial Fish Industry, Wade L. Griffin	1977-78	Continuing
Saltwater Boat Fishermen: A Statewide Survey of Activity Patterns, Characteristics and Motivation, Robert B. Ditton	1979-80	Continuing
Life History Studies on Redfish (*Sciaenops ocellata*) and Red Snapper (*Lutjanus campechanus*), Connie R. Arnold	1979-80	Continuing
Development of Assessments of the Life Histories, Population Dynamics and Effects of Fishing on Gulf of Mexico Fishes, Mark E. Chittenden, Jr.	1978-79	Continuing
Nutrition and Biology of the Oyster Parasite *Perkinsus marinus (Dermocystidium mariunum)*, Alfred R. Leoblich III	1979-80	Continuing
Imprinting in Marine Turtles, David W. Owens	1979-80	Continuing
Seafood Technology, Gunnar Finne	1977-78	Continuing
Assessment of Fishery Development Opportunities in the Western Gulf of Mexico, John P. Nichols	1978-79	Continuing
Social and Economic Characteristics of Texas Gulf Coast Shrimpers, Robert Lee Maril	1979-80	Continuing
Comparative Study of the Marine Recreational and Commercial Fishing Constituencies and Industries in Texas, Robert B. Ditton	1979-80	Continuing
An Investigation in the Nature and Extent of Customary Fishing Rights and Practices in the Texas Bays, Gary D. Libecap	1979-80	1980-81

	Year Begun	Year Completed
Development of a Simulation Model of Brown Shrimp Growth and Survival in the Galveston Bay System, William E. Grant	1979-80	1980-81
Coastal and Ocean Engineering		
Prevention of Biofouling by Electrochemical Pulsing Techniques, John O'M. Bockris	1978-79	Continuing
Ocean Mining Costs, John E. Flipse	1978-79	Continuing
Wave Data Bank for the Texas Coast, John B. Herbich	1977-78	1979-80
Methods for Large Scale Planting on Dredged Materials, Carl H. Oppenheimer	1977-78	1979-80
Evaluation of the GPS System as a Civil Marine Navigation System in the Coastal Zone, Tom Rhyne	1978-79	Continuing
Environmental Quality		
Accumulation and Transfer of Nutrients and Selenium in an Estuarine Food Chain, Jerry M. Neff and James Dee	1977-78	1979-80
Assessment and Control of Viral Pollution of Marine Resources, Joseph L. Melnick	1978-79	Continuing
Flux of Polycyclic Aromatic Hydrocarbons in the Corpus Christi Bay System, Patrick L. Parker	1979-80	Continuing
An Investigation of the Sediment Contribution from the Brazos River to the Nearshore Marine Environment: A Pilot Study, David W. McGrail	1978-79	1979-80
Marine Extracts and Biomedicinals		
Potential Drugs from Marine Organisms, Alfred J. Weinheimer	1979-80	Continuing
Safety in the Marine Environment		
The Effects of Diving on the Pregnant and Non-Pregnant Female/Saturation Air Diving, William P. Fife	1977-78	Continuing
Water-Related Fatalities in Coastal Texas, James M. McCloy	1979-80	Continuing
Model Hurricane Flood Emergency Relocation Plan, Carlton E. Ruch	1979-80	Continuing
Marine Information Services		
Marine Information Services, Laura Colunga	1969-70	Continuing

Program Budget 1979-80

Program Area (Texas A&M University Categories)	NOAA	Matching	Total
Program Management and Development	190,000	149,000	339,000
Marine Advisory Services	380,000	451,671	831,671
Marine Information Services	125,000	89,640	214,640
Marine Education and Training	126,900	77,127	204,027
Mariculture	238,500	230,172	468,672
Fisheries Research and Seafood Technology	330,900	142,832	473,732
Coastal and Ocean Engineering	100,000	40,549	140,549
Environmental Quality	96,700	52,705	149,405
Marine Extracts and Biomedicinals	25,000	20,039	45,039
Safety in the Marine Environment	129,000	72,996	201,996
Totals	$1,742,000	$1,326,731	$3,068,731

31

Program Budget 1980-81

Program Area (Texas A&M University Categories)	NOAA	Matching	Total
Program Management and Development	202,650	161,649	364,299
Marine Advisory Services	409,900	503,400	913,300
Marine Information Services	140,000	114,780	254,780
Marine Education and Training	153,700	42,812	196,512
Mariculture	286,700	215,961	502,661
Fisheries Research and Seafood Technology	334,850	154,236	489,086
Coastal and Ocean Engineering	247,900	19,747	267,647
Environmental Quality	95,500	47,394	142,894
Marine Extracts and Biomedicinals	29,100	21,200	50,300
Safety in the Marine Environment	72,500	26,197	98,697
Totals	$1,972,800	$1,307,376	$3,280,176

Amy Broussard, *editor;*
Jim Raatz, *design;*
Rita Arnold, Amy Broussard, Laura Colunga, Bland Crowder, *contributors*

TAMU-SG-82-118
5M June 1982
NA81AA-D00092
M6801PM