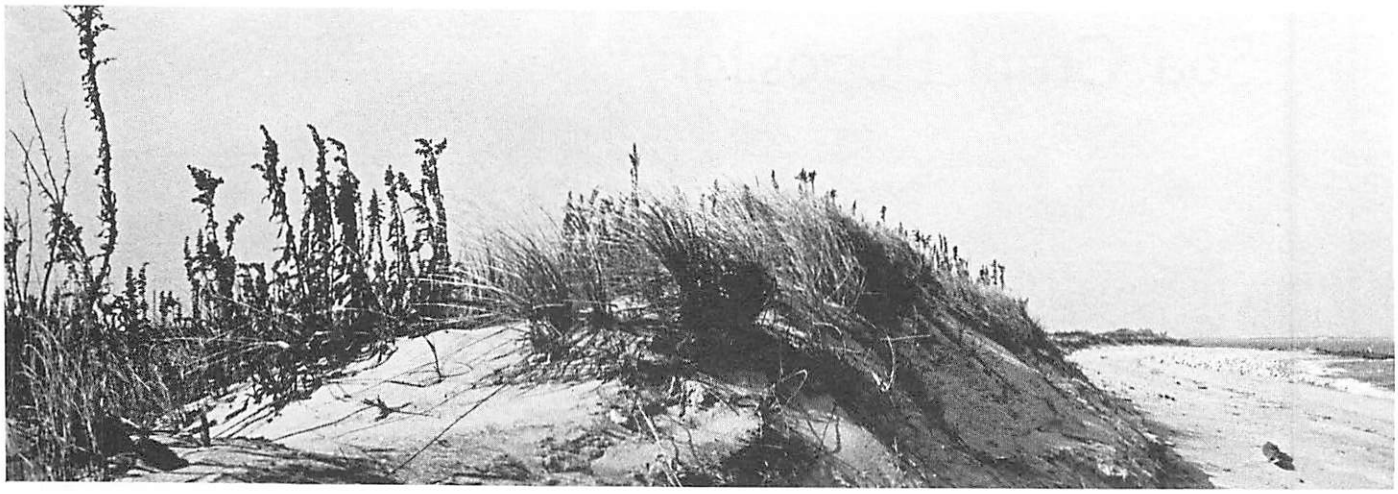
annual report 1974-75

DELAWARE SEA GRANT PROGRAM

university of delaware

Delaware Sea Grant Program 1974-75



THE SEA GRANT CONCEPT IN DELAWARE

In 1968 the term **Sea Grant** was not very familiar to anyone in Delaware. But now, seven years and several success stories later, **Sea Grant** means alot to a great many Delawareans. Sea Grant means a potential food-producing industry for the state. . .it means honest, accurate fishing reports recorded daily. . .it means marine teaching materials in Delaware's classrooms. . .it means understanding how valuable the state's wetlands are. . .and it means more.

Created by Congress in 1966, the National Sea Grant Program is committed to fostering the best possible use and development of the nation's marine resources. Sea Grant, at work in almost every U.S. coastal state, brings together universities, industries, and state and local governments in a cooperative effort. Because the challenge of understanding the complex coastal and ocean system is so great, Sea Grant tackles that challenge in three ways — through **research, education,** and **advisory services.**

Delaware's approach to this three-pronged Sea Grant plan is based on its commitment to serve first the most critical needs of the state. The program, revised and reviewed continuously, is a direct response to high priority marine resource problems facing the state and region. Priorities are established primarily by the Delaware Sea Grant Advisory Council, composed of representatives of industry, education and government. The Council members, with different perspectives, share a common interest in using and protecting the state's marine resources.

Delaware Sea Grant projects are clustered according to themes. During the 1974-75 year, Sea Grant **research** was undertaken in five areas: Food Resources; Tidal Wetlands; Recreation; Human Effects on Delaware's Estuaries; and Coastal Zone Use and Development. **Education** projects focused on developing the graduate curriculum in the University of Delaware's College of Marine Studies, where the Sea Grant Program is administered. As the link between researcher and user, the **advisory service** plays an important role in the program. Through advisory service, as the Sea Grant outreach arm, Delawareans who use the ocean, bay, marsh or beach, whether for business or pleasure, can apply research results to the task of improving their relationship with the sea.

During 1974-75, 64 people were involved in Delaware Sea Grant. Thirty-one faculty, 16 professionals and 17 graduate students worked together in meeting the needs of Delaware and in moving closer to the goal of best possible use and development of the state's marine resources.

THE FY75 NATIONAL SEA GRANT PROGRAM

Total Sea Grant funds:	$21,707,650
Total multiple project grants:	26
Total single project grants:	25

Distribution of funds

• Research	61.5%
• Education	6.2%
• Advisory Services	20.8%
• Program Management	11.5%

The National Sea Grant Program is part of the National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

MESSAGE FROM THE DIRECTOR

This report on the Delaware Sea Grant Program covers the period September 1, 1974 through August 31, 1975 – the seventh year of Sea Grant program participation for Delaware and the fourth year of institutional status.

Last year's annual report described a difficult year, but looked to 1974-75 with optimism. It is clear now that the optimism was well founded. The year brought success to the Delaware program in several different ways.

The first measure of success is program accomplishments. Specifically, progress was made in:

- Developing closed system mariculture. Growth rates were accelerated for both the oysters and clams and the algae grown as food for the shellfish. Both accomplishments mean reduced capital cost for a future commercial operation.
- Developing the commercial application of chitin (pronounced kite - in) for films, fibers, and coagulants. Patent applications have been filed.
- Defining the value of Delaware's wetlands so that the detailed mapping now in progress through the Department of Natural Resources and Environmental Control can provide valuable management information.
- Identifying and cultivating salt-tolerant, seed-bearing food plants.
- Providing information on the frequency, severity, and economic impact of storms that sometimes bring catastrophe to coastal communities.
- Undertaking a comprehensive evaluation of Delaware's small bays where intense development pressures are creating a need for rational decisionmaking to conserve a valuable resource.

- Developing the Center for the Study of Marine Policy and strengthening the marine affairs curriculum in the College of Marine Studies.
- Furthering the advisory service work, which not only extends to the marine recreational community, but also provides increasing service to coastal industries and to the commercial and sport fishing communities. The Fishermen's Hotline was called over 98,000 times last summer!
- Informing the public about crucial issues such as outer continental shelf development through a "Decisions for Delaware" report series.

The second measure of success in the 1974-75 program is the participation of outstanding people. This year, the Sea Grant Advisory Council built on its 1973-74 success by re-examining the high priority problems confronting Delaware. A cohesive group of legislative leaders and citizens worked long and hard under the chairmanship of **Paul Felton** to refine program goals and review program content for responsiveness to state and regional needs.

Important additions were made to both the scientific and professional support staffs of Delaware's Sea Grant Program. Of particular note were the additions of **Dr. Ellis T. Bolton** (Carnegie Institution of Washington Professor of Marine Studies) and **Dr. Robert G. Dean** (Professor of Coastal Engineering). **Dr. Carolyn A. Thoroughgood** was named director of the Marine Advisory Service and **Kathi Jensen** arrived from Texas A&M University to manage communications and publications activities.

The third measure of program success is the confidence expressed through financial support. As might be expected, first-class accomplishments and the efforts of a diverse group of talented people led, quite naturally, to confidence at both the national and state levels. Federal support increased to $695,000 and state support totaled $210,000. This, coupled with non-federal matching funds from industry and the university, raised the total level of Sea Grant effort in Delaware to $1,250,000.

In summary, 1974-75 was a year of positive accomplishment and continued building of a solid base of person power for future growth.

William S. Gaither
Director

RESEARCH

FOOD RESOURCES

Happy as a clam. If it is possible to elevate a clam's mood by speeding up its growth, the ones in Delaware's mariculture laboratory ought to feel exalted. Not only has the Sea Grant research team there managed to grow the hard clam *(Mercenaria mercenaria)* to market size several times faster than nature does, but they've also shed some light on the problem of what-kind-of-food-promotes-the-fastest-growth.

The past year has been one of achievement in many aspects of Delaware's mariculture effort. Eventually, the team hopes to produce successfully, on algae and/or synthetic foods, desirable, fast growing, good-tasting clams and oysters, free of toxins and pathogens, in a controlled environment seawater system, at reasonable cost, unhampered by legal constraints, using natural sources of energy, and recycling organic wastes. Some of these long-range goals have been met — the animals **are** fast-growing; they **are** growing in a controlled environment seawater system, and they **are** eating algal food. The other goals (and refinement and improvement of the first ones) are the major focus of the mariculture work now.

While the technical feasibility of raising bivalves in a recirculating system has been demonstrated, the economic feasibility must still be worked out. System optimization and cost reduction efforts by **G. Pruder, E. Bolton,** and their associates, are leading to an economically feasible

system. Progress has been made in several areas — improved oyster growth rate, reduction of the cost of adding the nutrient nitrogen, and an improved method of water quality maintenance and waste removal (a foam fractionation device).

Fed a constant diet of four different algal species, the clams in the Lewes laboratory grew to market size (shell length of 1-1/2") in 14 months, nearly twice as fast as the researchers had been able to achieve previously. The American oyster *(Crassostrea virginica),* which shares the experimental spotlight with the clam, was just a bit slower in its growth rate, taking 24 months to reach market size in the lab compared to 36-60 months in nature. Seven other bivalves were fed this same diet and also showed remarkable growth.

The quantity of algae required to feed oysters depends on the desired rate of growth, the number and size of oysters being grown and the type of algae. According to **Pruder's** research, the best estimate of the number of cells of algae required to support vigorous growth of small oysters (0.5 g total weight) at 26-28° C is 10×10^8 cells per gram of oyster weight (including shell) per day.

The problem of developing an optimal food for the oysters and clams received considerable attention during the past year. In his research on feeding rate efficiencies, **Dr. C. Epifanio** found that the animals change their feeding rates relative to what they've already consumed.

In another food study, **Epifanio** discovered a way of simplifying the total maricultural process: he found that the clams and oysters grew just as fast when they were fed one particular algal species as when they were fed the four-species diet. This was a significant discovery — growing a single species is much easier than growing four.

The growth-promoting algae, *Thalassiosira pseudonana,* was studied by **Dr. R. Srna** to see how salinity, light and nutrient concentration affected its growth rate. Results made it possible to increase the density of the algae in culture and to increase its rate of growth to four times faster than is ordinarily achieved. An automated technique for culturing *Thalassiosira* was also developed by **Epifanio** and put into operation.

Dr. J. Sharp tackled the problem of food production for the bivalves by studying variations in the cellular chemistry of algae — specifically how chemical differences in various growth stages of the algae can affect its nutritive value.

Using a "continuous culture apparatus," **Sharp** maintained two algal species in the log growth phase. (The two species are maintained in a stable state in the culture medium by adding nutrients and removing algae and wastes.) He found that by doing this (controlling the culture conditions) one species could be favored over the other. Although both species were in the same growth phase, one of them took in nutrients at a faster rate than the other, thus achieving an overall faster growth rate.

Dr. R. Srna's work involved devising methods for control of growth and production of specific species of algae. Ultrasonic treatment was applied to selectively destroy undesirable algae and bacteria in the *T. Pseudonana* culture. A nutrient limitation technique was used so that two species of algae having considerably different growth rates could be harvested from the same culture. A continuous seeding technique has been proposed as a method of stabilizing the productivity of mass algal facilities in response to variable environmental factors. **Srna** also derived and demonstrated equations that predict the amounts of inoculum (number of algal cells) that must be introduced into a single culture so that appropriate growth will take place. Several patent applications, refereed publications, and technical reports result from this work.

Addition of nutrients, trace metals and vitamins to seawater to enhance the growth of desired algae is common laboratory practice. In the Delaware laboratory growing algae is part of the overall mariculture system, so the type and quantity of material added to the system must replace that used or discarded by the system to avoid unsatisfactory build-up or depletions. The Delaware team concentrated on identifying and satisfying the specific nutrient needs of *T. pseudonana,* since it was found to be a good, growth-promoting food for the oysters and clams. Nitrogen as a nutrient is an important consideration, because the nitrogen added in the Delaware system is from commercially available chemicals. The economic significance of depending upon commercial chemicals was considered — the cost depends on the particular chemical purchased. (Ammonia is much less expensive than nitrate.) However, the potential exists to recycle the nitrogen and so further decrease cost.

A foam fractionation device which maintains water quality and removes undesirable liquid and solid wastes, is under active development by **G. Pruder** and his associates. The device is based on a similar one developed by the National Fisheries Center.

Preliminary studies have begun in cooperation with the research department of a major food in-

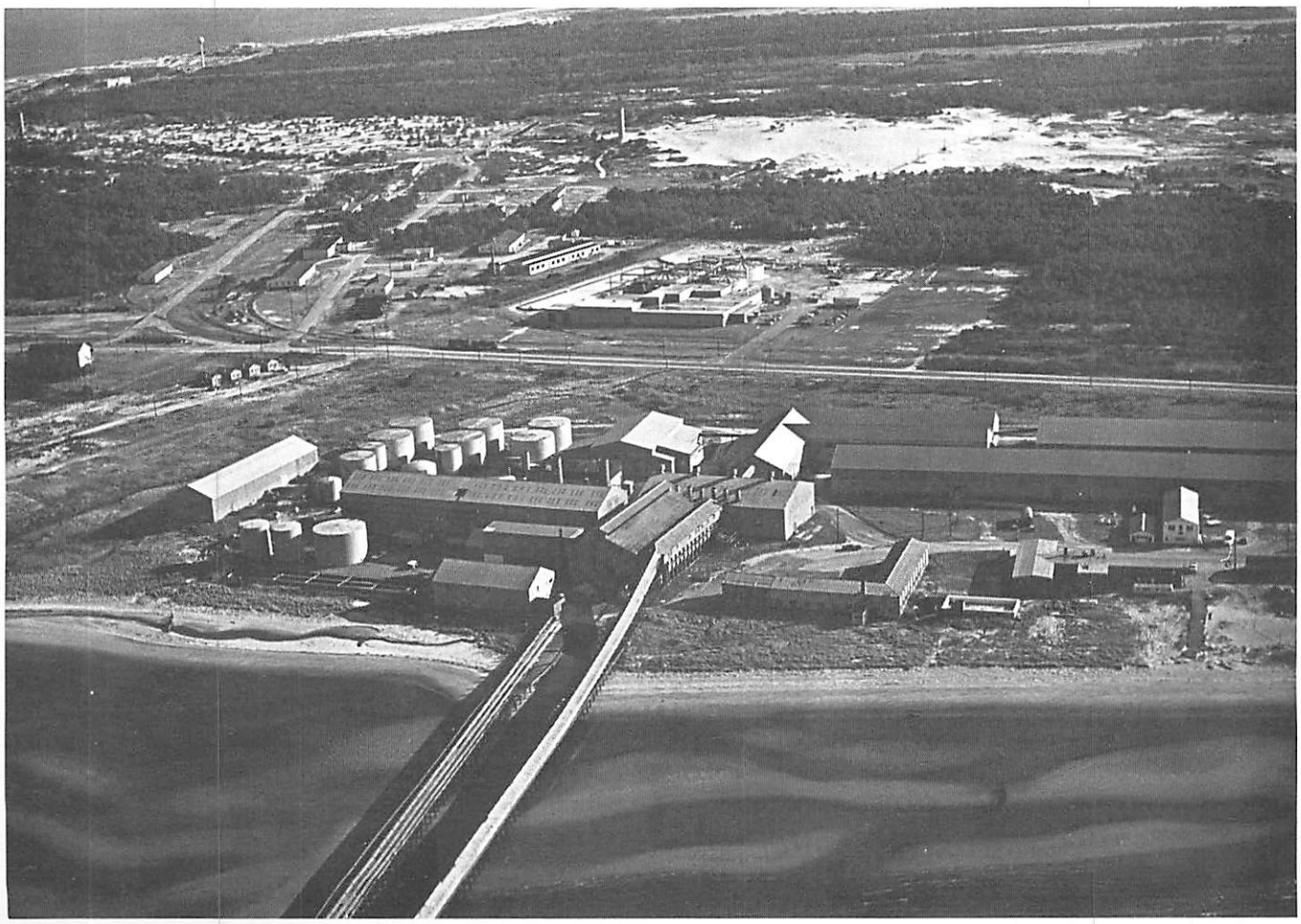
dustry to determine the biochemical basis for the varying food values of different algal species. The expected goal is the development of a synthetic formulated diet for bivalves. Delaware Sea Grant researchers have already done some testing of six formulated diets for larval and juvenile bivalves. A high death rate occurred among all the larvae that ate synthetic foods, probably caused by decomposition of uneaten food particles, fouling of the water and subsequent blooms of bacteria.

One way of dealing with these processes that foul the water and products of the fouling processes is ozonization, a technique that has been studied by **Dr. E. Bolton.** Ozonization is the bubbling of gaseous ozone through artificial or natural seawater, and is a method of sterilizing the water — getting rid of pathogenic bacteria, viruses, or dinoflagellate toxins that may be present. **Bolton** found that ozone treatment produces halites and halogen gas and may remove from the water metals that are necessary to sustain marine life. Although ozonization can help purify an environment for the shellfish in the recirculating system, it is not yet a foolproof technique. **Bolton's** recommendation is that ozonization be used for purification only when no other safe, practical means is possible and that further research be done. In fact, he is continuing studies of ozonization of various mariculture fluids, and is working to scale up the use of ozone from bench-top model experiments.

Any bacteria present in a recirculating seawater system are critically important to the well-being of the system. Based on this knowledge, a microbiology laboratory was established during the past year as part of the mariculture project to provide information on what bacteria are present and the roles they play.

Dr. J. Noble-Harvey has developed a technique for concentrating viruses from the seawater used to culture shellfish. So far, no human viral pathogens (disease-producers) have been isolated. Even though dirt brought in by such vehicles as people and air could cause bacterial contamination of the seawater, according to the microbiologists,

The University of Delaware Mariculture Laboratory, in the foreground, is a two-story, 10,000-square foot, converted oyster depuration plant located at the mouth of Delaware Bay in Lewes.



"there seem to be no bacteria pathogenic for humans associated with cultured shellfish and they should meet Public Heath Service standards for marketing."

A potentially beneficial bacterium has been identified by **Dr. R. Srna** and **K. Smith.** They performed a bacteriological examination of shellfish collected in lower Delaware Bay and found nitrifying bacteria on the shell and in the mantle cavity. This bacterium substantially reduces the concentration of toxic ammonia in seawater and thus may be useful in decreasing the amount of that chemical in the mariculture system.

As a commercial enterprise, mariculture could run into legal constraints. Anticipating that, Delaware Sea Grant took on the task of analyzing just what those constraints might be. **J. Bockrath** completed an analysis of the fishery laws of Delaware, Maryland and Virginia that might affect closed system mariculture industries. For example, there are restrictions on methods of harvesting mollusks, ground leasing, time of harvest, who can harvest, etc. **Bockrath** looked at residency requirements, cull law (regulating the return of undersized animals and excess shell material to beds) size requirements, and methods of harvest. Legal stopgaps in each state for both clams and oysters were identified and possible solutions or alternatives were offered. An article in the Fall, 1975, William and Mary Law Review reports his results.

Delaware's work with chitin, the cellulose-like material found in crab and shrimp waste, is now in its third year, and in the last 12 months, great strides have been made. Chitin is emerging as a potential new marine resource instead of a waste product, benefiting the seafood processing industry. (Potential uses of chitin include surgical sutures, food wrap, film, and pharmaceuticals.) Sea Grant has played more than just a small part in this. Two firms are already making chitin and its derivatives in pilot facilities on the Gulf and West coasts in anticipation of commercial manufacture. The greatest potential for the Delaware-Maryland-Virginia region is in the crab meal animal feed industry — where the opportunity exists to extract the valuable chitin and at the same time upgrade the protein feed. At the University of Delaware, efforts have concentrated on converting the hard-to-handle chitin to high strength films and filaments. Using new solvent and regeneration techniques, **Dr. P. Austin** and **F. Rutherford** are working with the chitin's highly organized crystalline structure (the type found in nylon, polyester, and polyethylene).

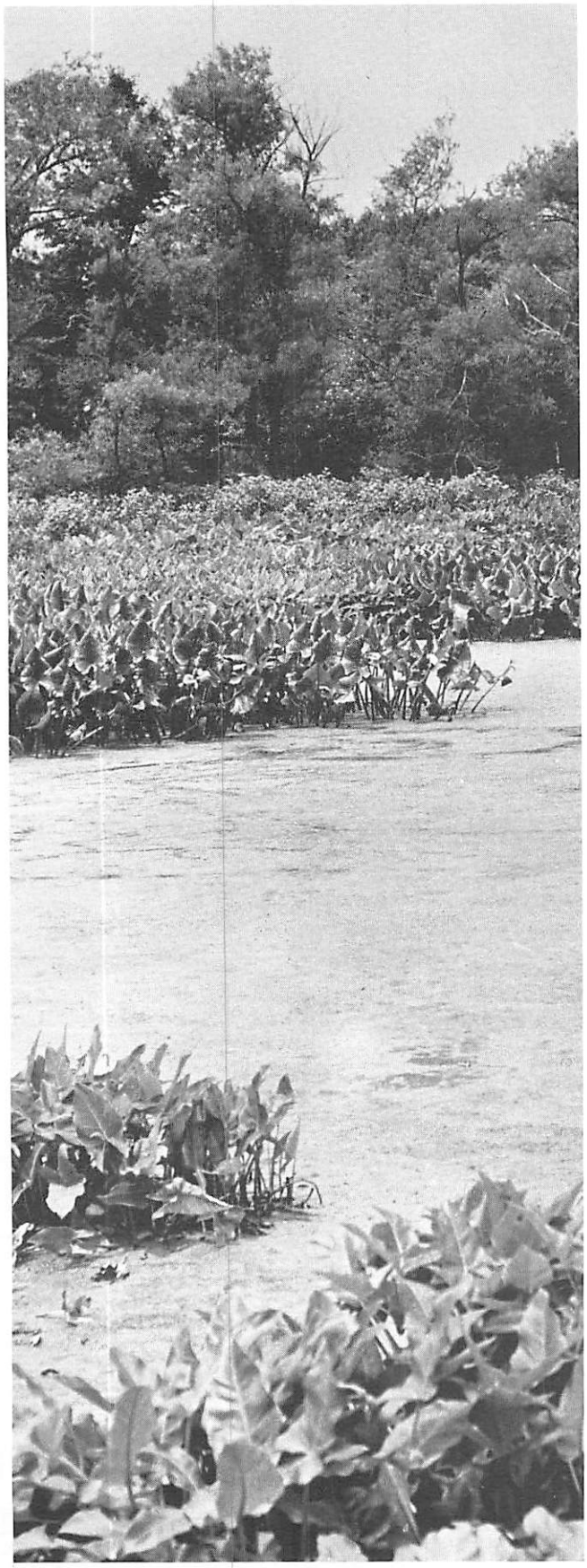
A possible application is that of absorbable surgical sutures. The advantages are the body's acceptability of chitin and chitin's slow biodegradability. Sutures represent a high value-in-use outlet with a market of $50 million annually. Based on **Austin's** work, a major hospital supply company is actively exploring this field. Results of these studies were reported at the April, 1975, meeting of the American Chemical Society and were subsequently published in the Society's symposium series.

Chitin is also one of the few known wound-healing accelerators, but the preparation of consistently active products has remained a problem. New techniques for dissolving and purifying chitin discovered during Delaware's investigations led to the evaluation of a series of samples by a New York-based pharmaceutical company. The company reports that all samples show some activity in their tests. Four U.S. patent applications resulting from this Sea Grant research are being processed.

TIDAL WETLANDS

Although only 10% of Delaware's surface area can be considered tidal wetlands, that 10% may be more important than many people recognize. Scientists don't have all the answers to questions posed by these complex wetlands, yet decision-makers are faced with the reality of managing the use of such areas. How will they know which marshes are most productive? If they decide to build on parts of the wetlands, what will be the environmental consequences? Can we turn the wetlands into a potential food resource for man and/or animals, based on the valuable productivity that is so evident? Answers to these questions are the focus of two long-term projects that the Delaware Sea Grant Program outlined this past year. The foundation work was done during this first year.

Dr. F. Daiber's major intent is to analyze in detail the potential contribution of a salt marsh ecosystem to the marine environment and to analyze how man's activity can alter this contribution. The end result of this five-year study will be a tidal marsh ecosystem model which will provide criteria for the management of Delaware's coastal zone. The model will help in determining the ecological value of a specific area or region of salt marsh — it will help in answering the question "how much salt marsh do we need?"



Daiber's first year of baseline work involved the study of primary production; nutrient and energy flow within the marsh ecosystem; and nutrient and energy flow interactions between marsh and adjacent areas.

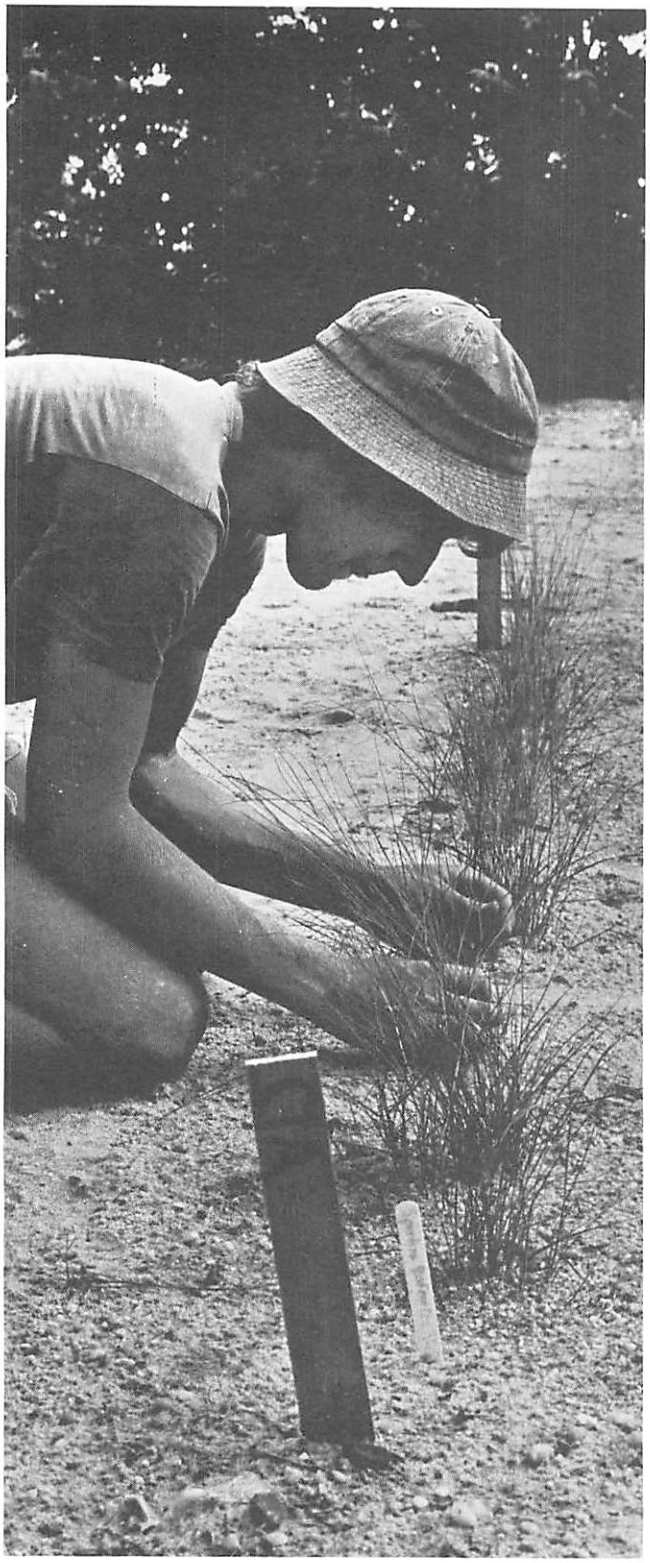
Water chemistry and plant production sampling were done. Above ground and subsurface organic production is being assessed. One unexpected result of the productivity investigation was the large number of diamondback turtles found in the Canary Creek marsh area. It was estimated that during July and August there were 3280 turtles or 120,000 grams for each kilometer of creek. Year-round fish residents were identified for the same area — white perch, mummichog, eel, toadfish, striped killifish, sheepshead minnow and naked goby.

Dr. G. F. Somers is involved in an intriguing search for food plants that will tolerate salt water for irrigation. Investigators are concentrating on halophytes — plants that are already at home in a salty soil environment, and on plants that show promise of being cultivated as food plants. The research plan grew out of a halophyte-oriented conference held in June, 1974, at the University of Delaware. Experts from around the world gathered to share ideas on the feasibility of developing a new food crop in this manner. The implications of such an undertaking are well worth considering: the wetlands or lands contiguous to them into which salty water could be pumped could become a new source of food for a protein-starved world, and the use of salt water to grow food means that fresh water would be conserved for other purposes. Plants now growing in tidal wetlands may prove useful for inland saline areas also.

Research began this year with the selection of over 100 lots of seeds from about 50 plant species. The seeds were tested for germination both in the laboratory and in the field (on an old sand dune). **Somers** found that in the laboratory, many of the species would germinate when exposed to fluctuating temperatures, but on the sand dune, irrigated with seawater from the Broadkill River, (which empties into the Delaware Bay), there was not much success in germinating. The ones that did respond included the common cord grass, *Spartina alterniflora.* Considerably more success was obtained when seedlings were transplanted. They tolerated sprinkler irrigation with saline water. Surprisingly enough, the native wild prickly pear, *Opuntia humifusa,* seemed to do quite well in the most saline water that the investigators used. It showed vigorous

growth and produced an abundance of edible fruits.

In choosing the species for their investigation, **Somers** and his researchers are using these criteria: vigor of growth in salty environments, yield of fruit or edible portion, general characteristics of the edible portion, and the potential for adaptation to commercial production.

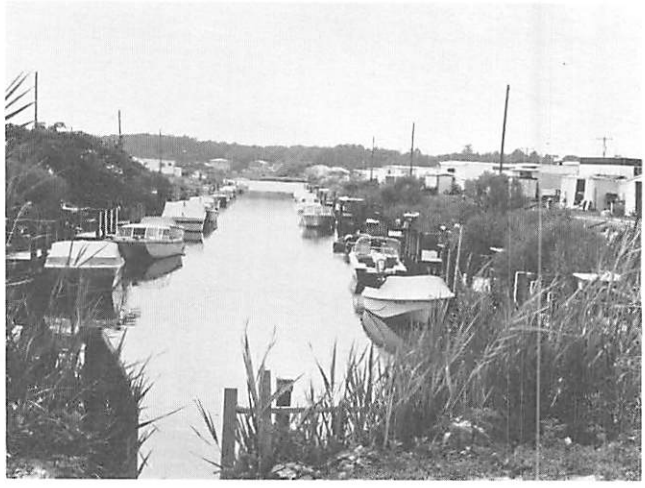


HUMAN EFFECTS ON DELAWARE'S ESTUARIES

Delaware's southeast corner is largely composed of three small bays — Rehoboth, Indian River and Little Assawoman Bays. Much of the state's water-based recreation is concentrated in this area, and since 1945 it has experienced a rapid growth in recreational facilities. Specifically, second homes and marinas are on the increase. All this development has not gone unnoticed. Many coastal property owners resist more and more people and buildings crowding them. Yet some of the community leaders see the need for a moderate rate of development, both in industry and recreation. Obviously, the small bay community is more than moderately interested in land use and development policy.

These are some of the findings reported by **Dr. P. Jensen** and his associates in a preliminary comprehensive review of the small bay area of Delaware. The review, completed this year, includes a look at current economic activity, attitude of community leaders, legal and regulatory constraints on development, and an annotated bibliography of area research.

Understanding the small bay ecosystem is a basic prerequisite to any kind of management program for the area, and so the major purpose of this review was to pinpoint future research needs and to provide information necessary to plan that research. Results indicated that before a wise management plan could be drawn up, more information had to be obtained on basic hydrodynamics, nonpoint waste sources such as agriculture and urban runoff and water quality dynamics. A research program was then designed with the help of this Sea Grant project. Delaware Sea Grant researchers will soon be working with support from the Environ-



mental Protection Agency (through the Sussex County Areawide Wastewater Management Program) and the Delaware Coastal Zone Management Program to analyze the impacts on water quality of various development activities.

Eventually, through research and the planning process, a development policy will result that satisfies the majority of interests in the area and assures water of suitable quality for all designated purposes.

RECREATION

Much of the leisure-time activity that takes place along Delaware's shoreline is concentrated in the small bays area — Rehoboth, Indian River and Little Assawoman Bays. With the exception of fishing and boating, which remained the same, participation in all forms of outdoor recreational activity increased in Delaware from 1972-73 (the latest statistics available).

The pressure on these and other areas to provide adequate support facilities for recreation is building. We need alternatives.

A two-year program initiated this year seeks to provide the basis for developing those alternatives. **Dr. R. Rothman,** a sociologist, and his associates, undertook two major activities in the first year of this project. First, they surveyed facilities in other states to determine what additional kinds of recreational activities could potentially be introduced in Delaware. The second phase involved a state-wide survey of recreational activity and de-

mand. A probability sample of 800 Delaware households was interviewed during July and August. These surveys essentially answered three questions — 1) what do Delawareans do for recreation? 2) what do they **want** to do? and 3) what types of recreational activity (other than what is already present) would be feasible in Delaware? Statistical analysis of all the data is still on-going.

When the final report is written, these data will be the basis for projecting recreational activity in Delaware. Workshops will then be held with legislators, county, state and local planners, and the state department of economic development to discuss methods for exploiting feasible alternatives.

COASTAL ZONE USE AND DEVELOPMENT

Conflict in the coastal zone. To build, to preserve, to play — it's bound to get touchy somewhere along the line. And if it's not because of conflicting land uses, then it has to do with the eternal battle of man vs. nature. There's no easy winner.

Delaware has felt the conflict just as other coastal states have. Long a favorite playground for Delawareans and visitors, the Lewes-Rehoboth-Bethany Beach coastal strip has also felt the prsure of local environmental and conservation groups who want to preserve and protect the coastal area. The Delaware Bay coast, more extensive than the ocean coast, is dotted with industrial sites — from Wilmington south to Lewes. Most of the rest of the marshy bay coast is devoted to wildlife refuges and preserved areas. So, here too there are groups competing for limited land.

Making optimum use of the coastal zone, a basic tenet of Sea Grant, is the concern of one of Delaware's functional research groups. This year, the focus was on two aspects of coastal zone use and development — the interrelationship between specific forms of land use, and coastal erosion.

Drs. M. A. Tayfun and C. Y.Yang have been engaged in studies leading to the prediction of potential damage probabilities along Delaware's coast. The most important input for predicting damage potential is information on extreme high tides and storm waves, since damages are measured by the extent of flood tide and the erosion of beaches. In the first year of this two-year project, Tayfun and Yang made aerial field observations of the coastal damages of the December, 1974, storm. A preliminary prediction was made of annual extreme wave and tide distributions for Delaware coastal waters. For a more critical prediction of storm tides, a random simulation model is being developed.

Present and potential residents of the coastal zone must have a plan of action in the event of storms and high tides — the information from this study will lead to the possible establishment of just such a flood prevention, protection and emergency action program.

Dr. R. A. Dalrymple has concentrated on beach erosion and other problems at Indian River Inlet, a stabilized inlet on the bay-mouth barrier system of Delaware's Atlantic coast. Since the construction of the parallel jetties in 1938, the inlet has interferred with the natural littoral (shoreline) processes — sand from the northward littoral drift has been impounded by the south updrift jetty and in large ebb and flood tidal shoals. The result has been severe beach erosion northward of the inlet. The goal of this study was to determine the sediment movement patterns, the rates of sediment movement, and the tidal hydraulics of Indian River Inlet and to examine methods of bypassing sand around the inlet.

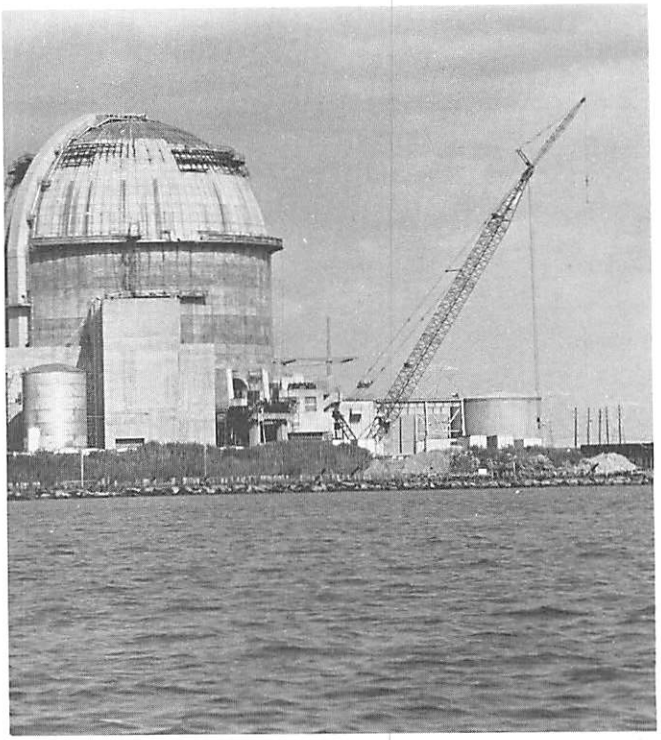
During the first year of this two-year study, Dalrymple, assisted by G. Lanan, a graduate student, collected and analyzed historical charts of the inlet to calculate volumes of eroded or impounded sand. They also conducted two hydrographic surveys of the inlet and offshore bathymetry (September, 1974, and April, 1975) and conducted a sand tracer study.

The major benefits of this study will be recommendations to the state and the Army Corps of Engineers to reduce beach erosion and minimize the cost of inlet maintenance.

A better understanding of the natural forces at work in the coastal zone has resulted in an increased number of storm protection alternatives. Meteorologists can now predict with a fair amount of certainty the long-run probability that a specific coastal area will be hit by a certain-sized storm. Geologists know how to prevent the erosion of sand dunes — so important to storm protection. But, with increased development, population, property values, and building costs, the damages likely to result from a coastal storm are greatly multiplied. The last major storm that struck the Delaware coast was in 1962, and that caused $16.6 million worth of damages. There is certainly no question that improved storm protection is necessary — and the approach should be in terms of cost-effectiveness.

According to his year-long study on the economics of storm protection, Dr. L. Anderson says that the key to improving protection in Delaware is to use historical weather data to evaluate the cost-effectiveness of long-run protection methods (like building barricades or embankments, maintaining sand dunes, and adopting building codes and zoning laws). The answer is not to increase the lead time provided by existing storm warning systems, he says — protection measures that would be effective against large coastal storms require more time than could possibly be provided by any improvements in existing systems.

The model that Anderson developed can be used to compare the increased cost of building with the expected value of damage reduction that would result. One prediction, using this method, is that more restrictive zoning or building codes may cost more than they would save. Anderson



used the method to analyze a proposed Army Corps of Engineers protection plan for the Delaware coast and concluded that the plan should produce savings from storm damage in excess of costs.

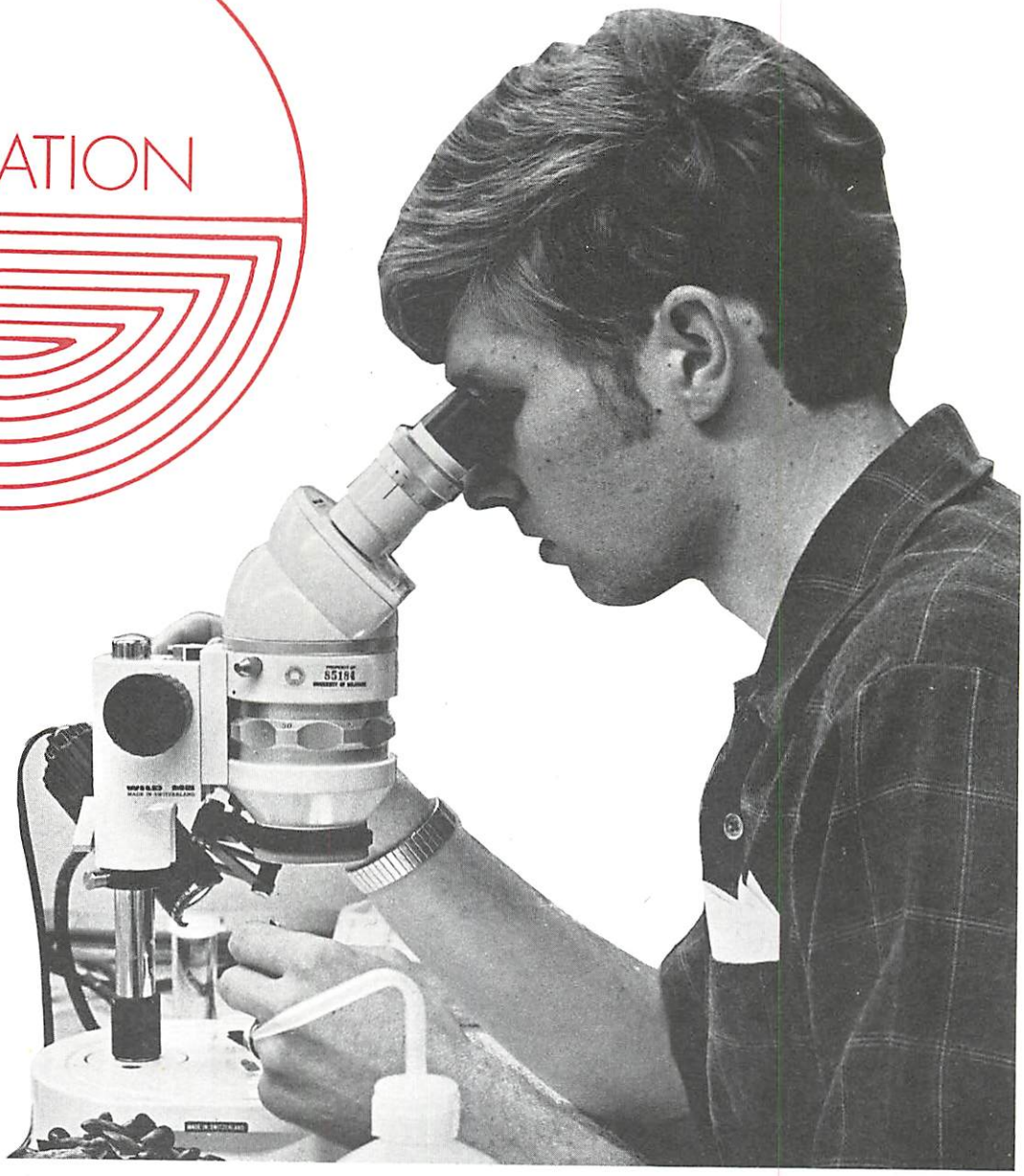
Charged with the task of assessing the ways in which **industry, conservation,** and **recreation** can co-exist in Delaware's coastal environment, **J. M. Goodman** and a five-person research team set out to develop some answers. The team, composed of three sociologists, one economist, one ecologist, and one system engineer, first developed definitions of what constitutes an increase or decrease in industry, conservation and recreation. Then, to look at the question of how desirable a certain industrial or recreational opportunity would be, economic and socio-economic variables were identifed. A model was created to show how these certain opportunities would interact when the conservation element was introduced.

The next step is evaluating the impact of that interaction and the necessity for any corrective action. Specifically, four industrial development opportunities or options were hypothesized: 1) an onshore support base for outer continental shelf activity; 2) a nearshore/offshore terminal in Delaware Bay close to Dover Air Force Base; 3) a nearshore/offshore power plant near the mouth of the Chesapeake and Delaware Canal; and 4) a large-scale industrial park in Lewes, providing business opportunities in fisheries (for example, mariculture companies, fundulus/menhaden-exploiting companies, fishermen's cooperative, etc.)

These four options have been applied to the model and the resultant data will be used to evaluate the environmental impact of the options. Although the principal investigator is no longer with the University of Delaware, there are plans to tackle that evaluation. Analysis of the data is still taking place, and much of it depends on research results of another on-going study. The investigators need up-to-date information on soil properties, natural hazard potential, relative abundance of habitats, etc. **Dr. F. Daiber's** Sea Grant research project on nutrients and energy flow in Delaware tidal marshes will provide this valuable information.

$16.6 million in damages resulted from the December, 1962, storm that swept the Delaware coast.

EDUCATION



MARINE EDUCATION

Marine education. It's the key to making wise use of our nation's oceans and coastal zone. Without it we couldn't.

That's why Delaware Sea Grant is involved in helping to educate and train the scientists, professionals, and technicians who will be among the marine problem solvers of the future.

But before the professional education and training, there exists a specific awareness of the marine environment and its uniqueness. Creating that awareness on the part of the general public and the nation's school children is also very much a part of marine education.

Delaware's education efforts have focused on developing and enhancing the graduate education program in the College of Marine Studies. Within the past three years, the marine affairs discipline in the college has, with the help of Sea Grant, developed an integrated marine affairs curriculum and a Center for the Study of Marine Policy. The college has also acquired a professor of international law and organization, a professor of coastal zone law and policy, and a professor of marine resource economics.

With an eye toward strengthening the curriculum by adding a marine transportation dimension, a

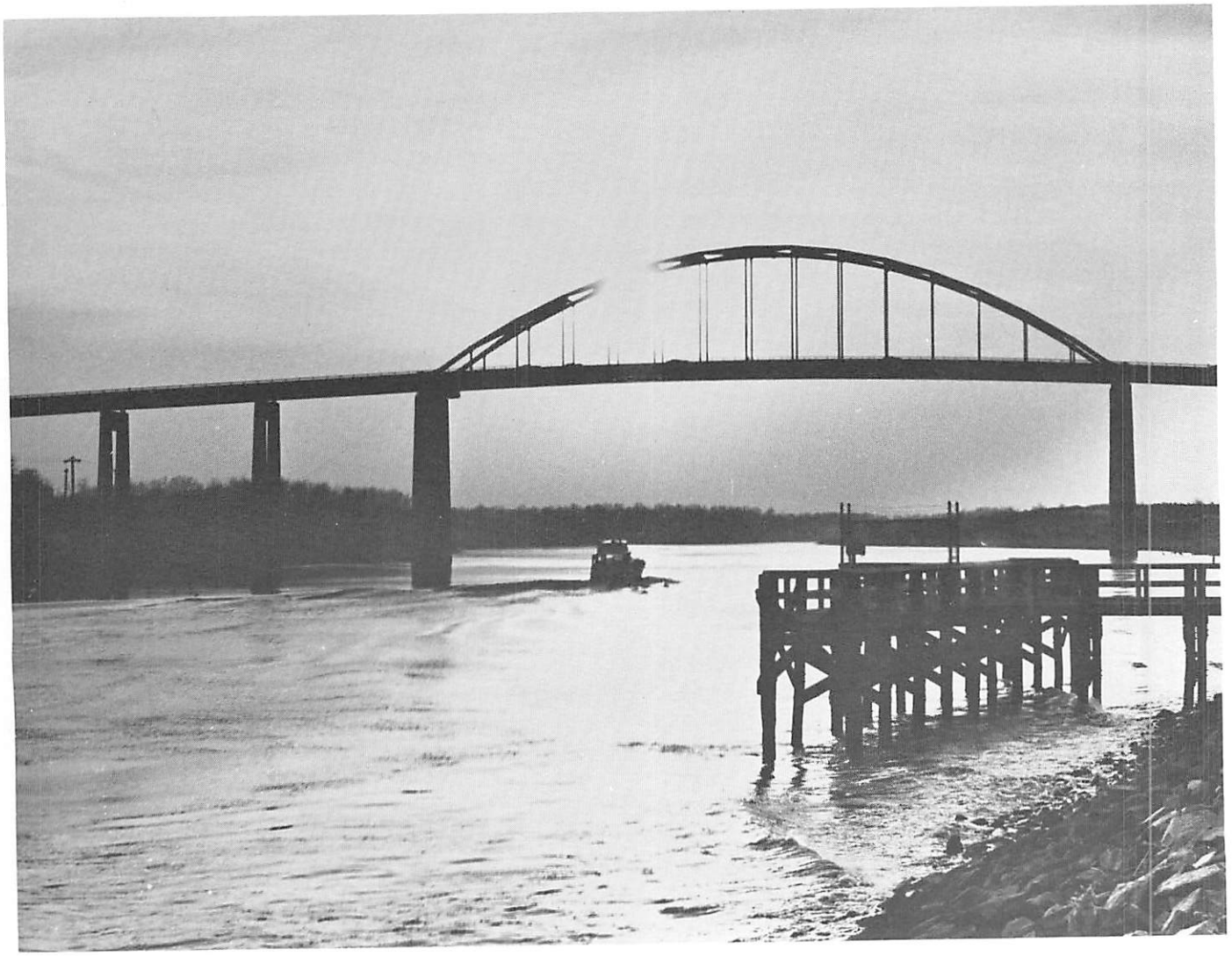
survey of marine transportation courses was undertaken during the past year. More than 50 institutions in the U.S. and Canada were contacted, including schools of law and public administration and maritime academies. Information sought included course material, syllabi, required texts, average enrollment, and level of students attending the courses. The survey showed a wide range of program and course offerings. The most comprehensive approach to the study of marine transportation, the investigators found, is offered at the maritime academies, at MIT and at Rutgers University.

Dr. G. Mangone and **S. Truver** have concluded that marine transportation can no longer be approached as an isolated subject in which the interest begins and ends at the port. The intermodal aspect of marine transportation must be considered. They believe that their study shows some of the strengths and weaknesses of how marine transportation is taught at various educational institutions and that an analysis of the information gathered will help in furthering the broad concept of marine transportation.

Another boost for the marine affairs discipline was the development of curriculum material on marine and coastal zone law and policy. Designed specifically for graduate students who are concentrating in marine science or engineering, the material was collected and organized by **J. Bockrath** with the help of a marine affairs graduate student. During the course of the research, information and materials were exchanged with the marine affairs program at the University of Rhode Island.

Much of the material and the method of presentation was evaluated in two courses taught during the year, "Concepts in Marine Affairs" and "Legal Aspects of the Coastal Zone."

Stemming from this work is a paper, "Law and Marine Science: Problems and Ideas in Interdisciplinary Teaching," accepted for publication by the Journal of Environmental Education.



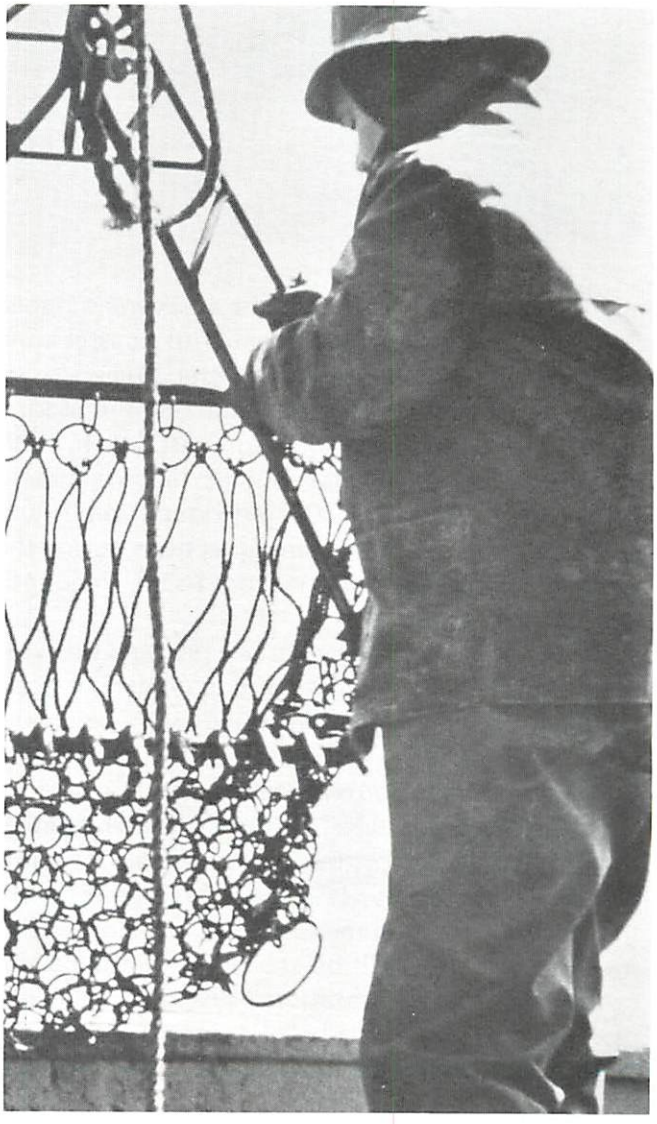
ADVISORY SERVICE

Fred Sturgis owns a campground on the Broadkill River just outside of Lewes, Delaware. When he decided to build a marina on his property, the U.S. Army Corps of Engineers said he needed a permit to do it. But before Fred could apply for the permit, he had to know the answers to some questions — what kind of soil did he have? how much would he have to dredge? how big an area would he need for spoils? To get the answers, Fred turned to the Delaware Marine Advisory Service specialists. They took soil samples, analyzed them, and gave him answers based on their findings. The Corps of Engineers issued the permit and Fred was on his way to a new marina.

That whole scenario is typical of the Delaware Marine Advisory Service modus operandi — advisory specialists communicating on a personal level with the people who use the ocean's resources. As the total Sea Grant effort in Delaware has grown, the variety and size of audiences reached by the Advisory Service has greatly expanded. Just as important, the researchers involved in Sea Grant have addressed themselves to an ever-increasing complexity of problems and the user groups have developed an increasing variety of needs. **Dr. Carolyn A. Thoroughgood** was appointed director of Delaware's Advisory Service this year and has worked closely with advisory specialists in providing a full range of services to users of the state's marine resources.

Over the past year, for example, Delaware specialists found that the state's clammers were looking for ways to supplement their businesses, that coastal zone residents are concerned about the possible effects of an offshore oil operation, and that the few commercial lobstermen in Delaware were having trouble keeping the lobsters alive after catching them. Response to these situations varies. Sometimes all it takes is the specialist working with the individual, sometimes university scientists and researchers get involved, sometimes an advisory service publication provides the information. Delaware's advisory service specialists have held numerous meetings with different user groups in the state, including watermen, restauranteurs, industry representatives, and coastal zone residents.

In efforts to educate the public about the state's marine resources, the Delaware Advisory Service conducted 32 guided tours and field trips of the university's marine research facilities; presented lectures to 51 civic and educational groups,



and held six career day programs at several schools; developed a clearinghouse manual of coastal zone management related research at the University of Delaware; prepared and sold the 68-unit Marine Environment Studies curriculum materials to both Delaware and out-of-state schools (approximately 30 complete sets and 700 individual units); and sponsored a series of six public lectures during the summer for residents and visitors to the Rehoboth Beach/Lewes area.

One of the Advisory Service projects this year was aimed at implementing a commercial scale planting of hard clams. Working with personnel from the mariculture laboratory, **R. Keck** and **D. Maurer** reared approximately 2.6 million juvenile hard clams to setting size (1-2 mm) and then planted them at various densities in a protected one-acre plot in Delaware Bay. It will be three years before the clams reach commercial size, but during this period other plots will be started so that the clams can be harvested in a rotational system. Availability of clam larvae seems to be no problem – the mariculture lab can produce sufficient larvae but it is not geared to handle a large quantity of the clams from larval size until they are ready for planting. That means more facilities will probably be needed to hold the clams during this time.

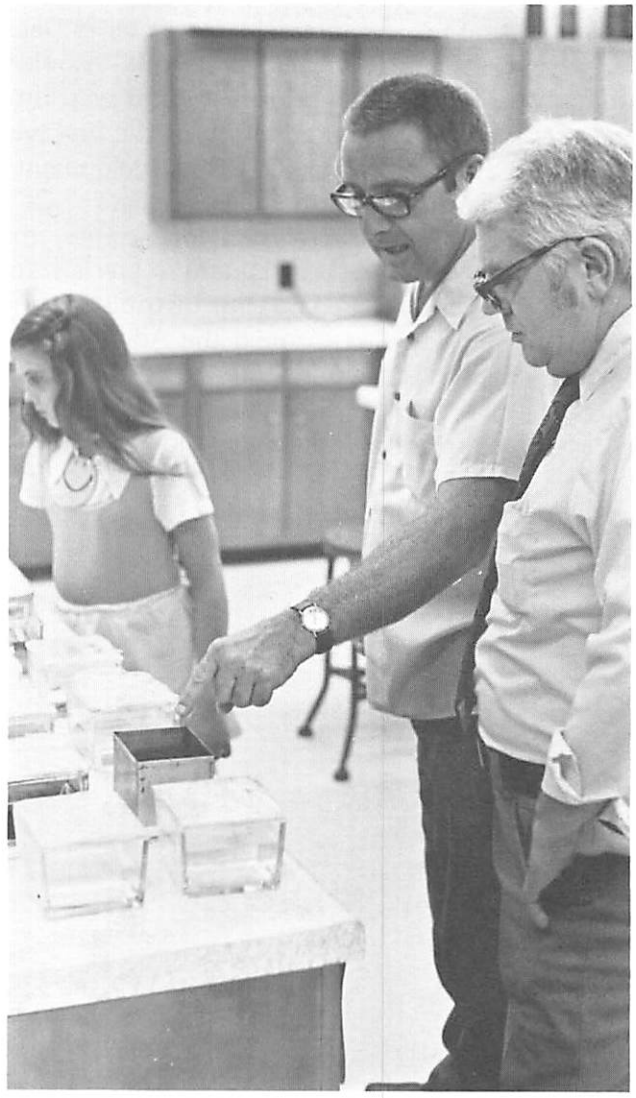
Right now there are mariculture-reared clams only on the one-acre plot. Keck plans to monitor the growth, death rate and condition of the clams in that plot and hopes to start a second one next year. Local watermen worked with the advisory service on this project, especially in gathering data on optimum planting densities, growth, survival techniques, etc. Eventually, they hope to come up with a practical method of planting that could be used by the State of Delaware or by the Delaware Watermen's Association as a management tool. Or perhaps the state could institute a lease program where commercial clammers are required to plant clams based on harvest and lease size. One commercial clammer from New Jersey was provided with extra clams and he in turn is providing the advisory specialists with growth and death rates.

The "Fishermen's Hotline" initiated in 1972 by **H. Seymour**, a marine advisory specialist, has become a household word up and down the Delaware coast. The daily one-minute recorded tele-

phone message can be dialed toll-free from any point in Delaware from May to October and is a source of local fishing, weather and tide conditions. **Seymour** gets his information from area bait dealers, marina operators, and party boat captains. He's usually right on target, and maybe that's why his Hotline was called more than 98,000 times last summer.

Working with state government agencies has always been a major thrust of the Delaware Advisory Service program, and that was no exception this past year. Delaware specialists cooperated with the Department of Natural Resources and Environmental Control in developing plans for improving shellfish harvest in Delaware waters. At the same time, the state's Coastal Zone Management program, based in the State Planning Office, began some in-depth projects and cooperation with the advisory service.

Three conferences were held for which the Delaware Advisory Service provided assistance. A Marine Transportation Seminar was held in conjunction with **Dr. G. Mangone's** project to develop marine transportation as an area of study in the College of Marine Studies. Delaware's Advisory Service and Maryland's Advisory Service co-sponsored a regional Middle Atlantic States Marine Advisory Service planning meeting attended by representatives from New York to Florida. In April, 1975, a National Symposium on Marine Transportation Management, sponsored by the U.S. Coast Guard and organized by the University of Delaware was held in Philadelphia. Along with the Center for the Study of Marine Policy, the Advisory Service provided program coordination and produced the symposium proceedings.



A capability in **communications** is vital to the success of any advisory service program and to the Sea Grant concept in general. Many of the communications techniques employed in the Delaware program are directed toward specific publics — educators, sports fishermen, industries, vacationers, etc. Marine Advisory Service bulletins on flounder, flytraps, and pea crabs (done as a cooperative publication with the Virginia Institute of Marine Science) were produced this year, as was a series of guides to recreation along the Delaware coastline.

Several exhibits were also prepared for various conferences and workshops. The report series **Decisions for Delaware** (designed to be non-technical situation reports on high-priority topics) was initiated this year with the production of the first two reports — "Sea Grant Looks at OCS Development" and "Sea Grant Looks at the Legal Aspects of OCS Development." Marine Environment Studies, the interdisciplinary set of curriculum materials for grades K-12 was also prepared for distribution and sales are being handled through the Advisory Service. A brochure describing the Advisory Service and its functions and a catalogue of Sea Grant publications are now available. Besides the public information aspect, Delaware Sea Grant communications involves disseminating technical information in the form of technical reports. The Advisory Service prepares abstract announcement/order forms for all Sea Grant technical reports.

Delaware's Marine Advisory Service continues to serve as the outreach arm of the Sea Grant program, involving not only the advisory specialists, but also researchers, in getting down to the actual people-to-people interaction that is characteristic of advisory service work. They are working to meet the challenges of Sea Grant, to increase the visibility of Sea Grant, and above all, to establish in Delawareans a real awareness of the marine environment.

PROGRAM DEVELOPMENT

	FY73	FY74	FY75
PROGRAM MANAGEMENT	C	C	C
FOOD RESOURCES			
Mariculture Demonstration, R/A-4	C	C	C
Controlled Environment Mariculture, R/A-5	C	C	R
Water Chemistry Support To Demonstration Project, R/A-7			N
Phytoplankton Kinetics Studies, R/A-6			N
Legal Aspects of New Product Development for Mariculture, R/L-1			N
Microbiology of Closed System Mariculture, R/F-1			N
New Species for Mariculture, R/A-1	T		
New Food Resources, R/B-2	C	T	
Utilization of Chitin, R/N-4	N	C	C
CZ USE AND DEVELOPMENT			
Factors in Coastal Storm Damage, R/C-1	R/T		
Shoreline Rates of Change, R/G-1	T		
Shoal Development Processes, R/G-2	R/T		
Port Development, Management, R/T-3	N/T		
Local Convective Flow, R/T-2	C	T	
Economic Changes in the CZ, R/E-1	C	T	
Analysis of CZ Industry, R/E-2	R/T		
CZ Land Use Patterns, R/E-3a	N	T	
Redevelopment of Degraded Salt Marshes, R/N-5		N/T	
CZ Co-existence Alternatives, R/M-6		N	C
Management Model for Coastal Flood Planning, R/E-6			N
Beach Erosion Control at Indian River Inlet, R/T-5			N
Statistical Prediction of Tides, Waves R/T-4			N
TIDAL WETLANDS			
Role of Algae in Tidal Marsh, R/N-3	T		
Blue-Green Algal Viruses, R/W-1	C	T	
Nutrient Flux, Energy Flow and Production in Salt Marshes, R/B-2			N
Search for Salt Tolerant Food Plants, R/B-12			N

C=Continuing T=Terminated

N=New R=Restructured

PROGRAM DEVELOPMENT

	FY73	FY74	FY75
RECREATION			
Seashore Recreation Options, R/S-1	T		
Ecological Warning System, R/W-2	T		
Local Control of Biting Flies, R/W-4	T		
CZ Recreation Development Opportunities, R/SE-3			N
HUMAN EFFECTS ON DELAWARE ESTUARIES			
Ecology of Small Bay Complex, R/T-12			
EDUCATION			
Marine Affairs Curriculum, E/T-2	N	T	
K-12 Marine Environment Studies, E/Z-1	T		
Marine Technician Training, E/T-3	N/T		
Curriculum Development, CZ Law and Policy, E/T-5			N
Marine Education, E/T-4			N
ADVISORY SERVICES, A/I-1	C	C	C
Test Planting of Hard Clams, A/I-2			N
Public Information, A/I-5	C	C	C
Coastal Zone Development, A/I-7	C	C	C
Recreation and Tourism, A/I-8	C	C	C
Commercial Fisheries, Seafood Industry, A/I-9	C	C	C
Public Education, A/I-10	C	C	C

C=Continuing T=Terminated

N=New R=Restructured

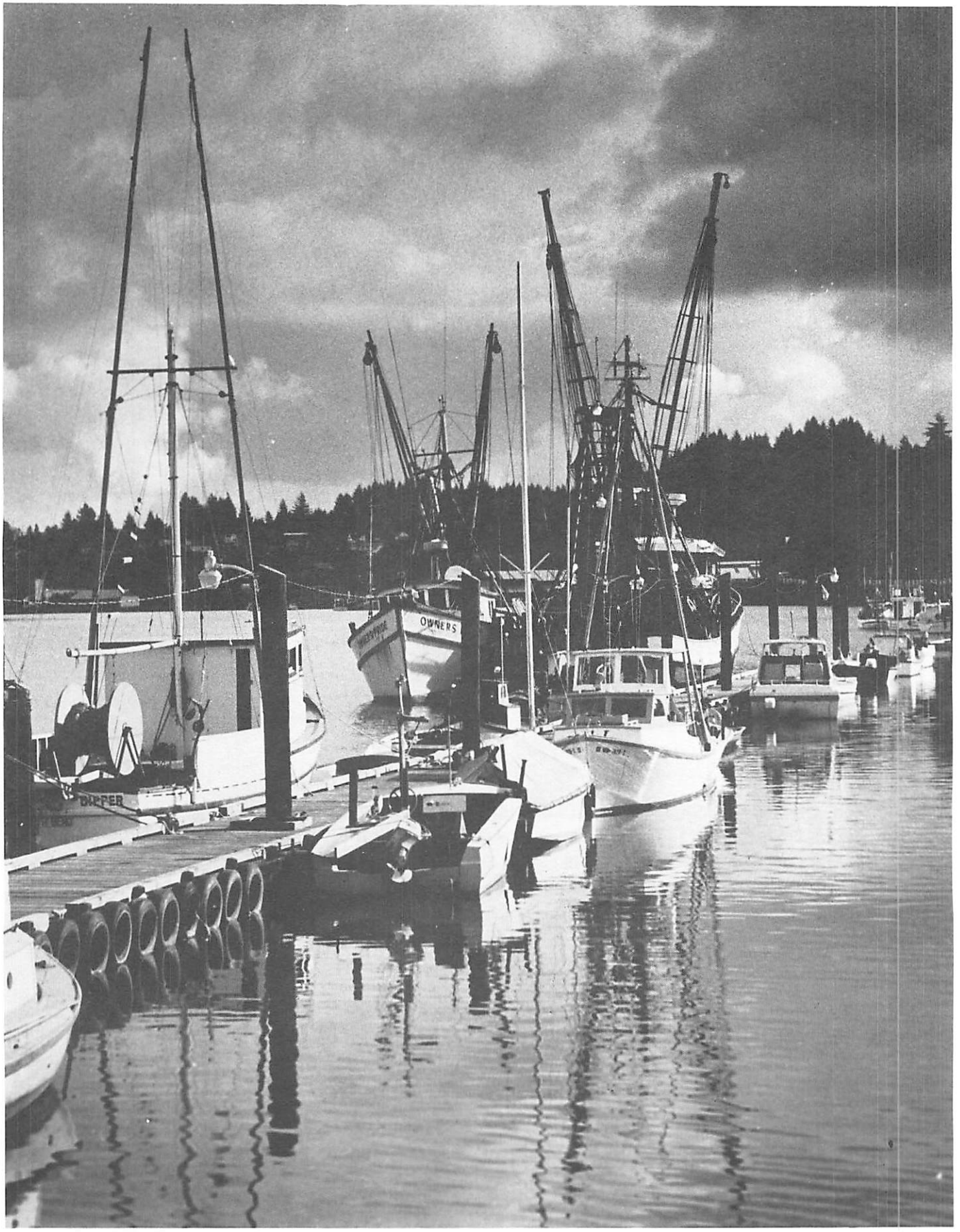
BUDGET

OFFICE OF SEA GRANT CATEGORIES

	Sea Grant	Matching
PROGRAM MANAGEMENT		
Administration (Including Information and Publications)	$ 97,566	$138,656
MARINE RESOURCES AND DEVELOPMENT		
Aquaculture	$153,788	$146,765
Marine Biomedicinals & Extracts	14,176	9,062
MARINE TECHNOLOGY RESEARCH AND DEVELOPMENT		
Ocean Engineering	$174,203	$ 56,228
MARINE ENVIRONMENTAL RESEARCH		
Coastal Zone Management Decisions	$ 16,492	$ 78,907
Ecosystems Research	99,101	73,986
MARINE EDUCATION AND TRAINING		
College Level	$ 27,953	$ 24,122
ADVISORY SERVICES	$111,735	$ 29,500
TOTAL	$695,014	$557,226

UNIVERSITY OF DELAWARE CATEGORIES

	Sea Grant	Matching
PROGRAM MANAGEMENT		
Administration (including Information and Publications)	$147,566	$163,656
RESEARCH		
Food Resources	$239,286	$109,917
Tidal Wetlands	103,863	60,434
Recreation	--	38,920
Human Effects on Estuaries	--	25,545
Coastal Zone Use & Development	64,611	105,132
EDUCATION	$ 27,953	$ 24,122
ADVISORY SERVICES	$111,735	$ 29,500
TOTAL	$695,014	$557,226


OWNERS

PUBLICATIONS

MARICULTURE

Hartman, Michael, Charles E. Epifanio, Gary Pruder and Richard Srna
Farming the Artificial Sea: Growth of Clams in a Recirculating Seawater System. (From: Proceedings of the Gulf and Carribbean Fisheries Institute, 26th Annual Session, October, 1973.) **DEL-SG-2-75.**

Dwivedy, Ramesh C.
A Proposed Method of Waste Management in Closed Cycle Mariculture Systems Through Foam Fractionation and Chlorination. (From: Proc. of the Natl. Shellfisheries Association 64, 1974.) **DEL-SG-8-75.**

Srna, Richard F., and Anne Baggaley
The Feasibility of Utilization of Solid Waste Material from the Cultivation of Shellfish as a Marketable Product. **DEL-SG-12-75.**

Srna, Richard F., Anne Baggaley and John E. Ewart
Kinetic Response of Perturbed Marine Nitrification Systems. (From: Journal Water Pollution Control Federation, Washington, D.C. March 1975.) **DEL-SG-13-75**

Epifanio, Charles E., Richard F. Srna and Gary Pruder
Mariculture of Shellfish in Controlled Environments: A Prognosis. (From: Aquaculture, Vol. 5, 1975.) **DEL-SG-16-75.**

OUTER CONTINENTAL SHELF DEVELOPMENT AND COASTAL ZONE MANAGEMENT

Goodman, Joel M.
Decisions for Delaware: Sea Grant Looks at OCS Development. **DEL-SG-1-75(1).**

Goodman, Joel M.
The Delaware Coastal Zone Experience. (From: Environmental Law, the Lewis & Clark Law School – Northwestern School of Law, Chicago, Ill. pp. 727-740.) **DEL-SG-18-75.**

Mangone, Gerard J. and Jerry Homer
Decisions for Delaware: Sea Grant Looks at the Legal Aspects of OCS Development. **DEL-SG-1-75(2).**

MARINE GEOLOGY

Kraft, John C., Robert E. Sheridan, Roger D. Moose, Richard N. Strom, and Charles B. Weil
Middle-Late Holocene Evolution of the Morphology of a Drowned Estuary System: the Delaware Bay. (From: Memoires de l'Institut de Geologie du Bassin d'Aquitaine, No. 7, 1974). **DEL-SG-4-75.**

Weil, Charles B., Roger D. Moose, and Robert E. Sheridan
A Model for the Evolution of Linear Tidal-Built Sand Ridges in Delaware Bay. (From: Memoires de l'Institut de Geologie du Bassin d'Aquitaine. Proceedings of the Intl. Symposium on Interrelationships of Estuarine and Continental Shelf Sedimentation, Bordeaux, France 1973.) **DEL-SG-5-75.**

Swain, Frederick M.
Biogeochemistry of Humic Compounds. (From: Proceedings of Intl. Meeting on Humic Substances, Nieuwersluis, 1972.) **DEL-SG-15-75.**

PROGRESS REPORTS

Stearns, K. I. (ed.)
Sea Grant Annual Report 1973-74. **DEL-SG-11-75.**

MARINE BIOLOGY

Somers, G. Fred
Seed-Bearing Halophytes as Food Plants. (Proceedings of a Conference.) **DEL-SG-3-75.**

Sulkin, Stephen D., and Charles E. Epifanio
Comparison of Rotifers and Other Diets for Rearing Early Larvae of the Blue Crab, *Callinectes Sapidus* Rathbun. (From: Estuarine & Coastal Marine Science (1975) 3.) **DEL-SG-7-75.**

Logan, Dennis, and Don Maurer
Diversity of Marine Invertebrates in a Thermal Environment. (From: Journal Water Pollution Control Federation, Vol. 47 No. 3, March 1975.) **DEL-SG-9-75.**

Kinner, Peter, Don Maurer, and Wayne Leathem
Benthic Invertebrates in Delaware Bay: Animal Sediment Associations of the Dominant Species. (From: Intl. Revue der Gesamten Hydrobiologie, 59, May 1974.) **DEL-SG-10-75.**

Leathem, Wayne and Don Maurer
The Distribution and Ecology of Common Marine and Estuarine Gastropods in the Delaware Bay. (From: The Nautilis, Vol. 89 (3), July 1975.) **DEL-SG-19-75.**

Ralph, R. D.
Blue-Green Algae of the Shores and Marshes of Southern Delaware. **DEL-SG-20-75.**

MARINE ECONOMICS

Agnello, Richard J., and Lawrence P. Donnelley
The Interaction of Economic, Biological and Legal Forces in the Middle Atlantic Oyster Industry. (From: Fishery Bulletin, Vol 73, No. 2, 1975.) **DEL-SG-17-75.**

ADVISORY SERVICE

Anderson, Roger
The Pea Crab. (joint publication with the Virginia Institute of Marine Science.)

Catts, E. Paul, and Elton J. Hansens
To Build a Better Fly Trap. (From: The Delaware Conservationist, Spring, 1975.) **MAS-8.**

Seymour, Howard
Weakfish — Catch a Queen for Dinner. (second printing.) **MAS-3.**

Smith, Ronal W.
Try Flounder — The Ocean's Platter. **MAS-7.**

Delaware's Sea Grant Advisory Service. (second printing.) **MAS-1.**

Marinas of Delaware's Coastline (first in a series of recreation guides to the Delaware coast.)

Editorial:	Karin Danberg
Design:	Lorraine Turner/Lois Butler
Photos:	Delaware State Highway Dept., page 14
	Karin Danberg, pages 1, 19, 24
	Frank Danberg, page 16
	Kathi Jensen, pages 3, 10, 12, 13, 20
	Al Pione, pages 5, 7, 15
	Dick Stewart, page 18
	Jonathan Taylor, pages 2, 11, 17
	Larry Thornton, page 9
Composition:	Pamela Duncan