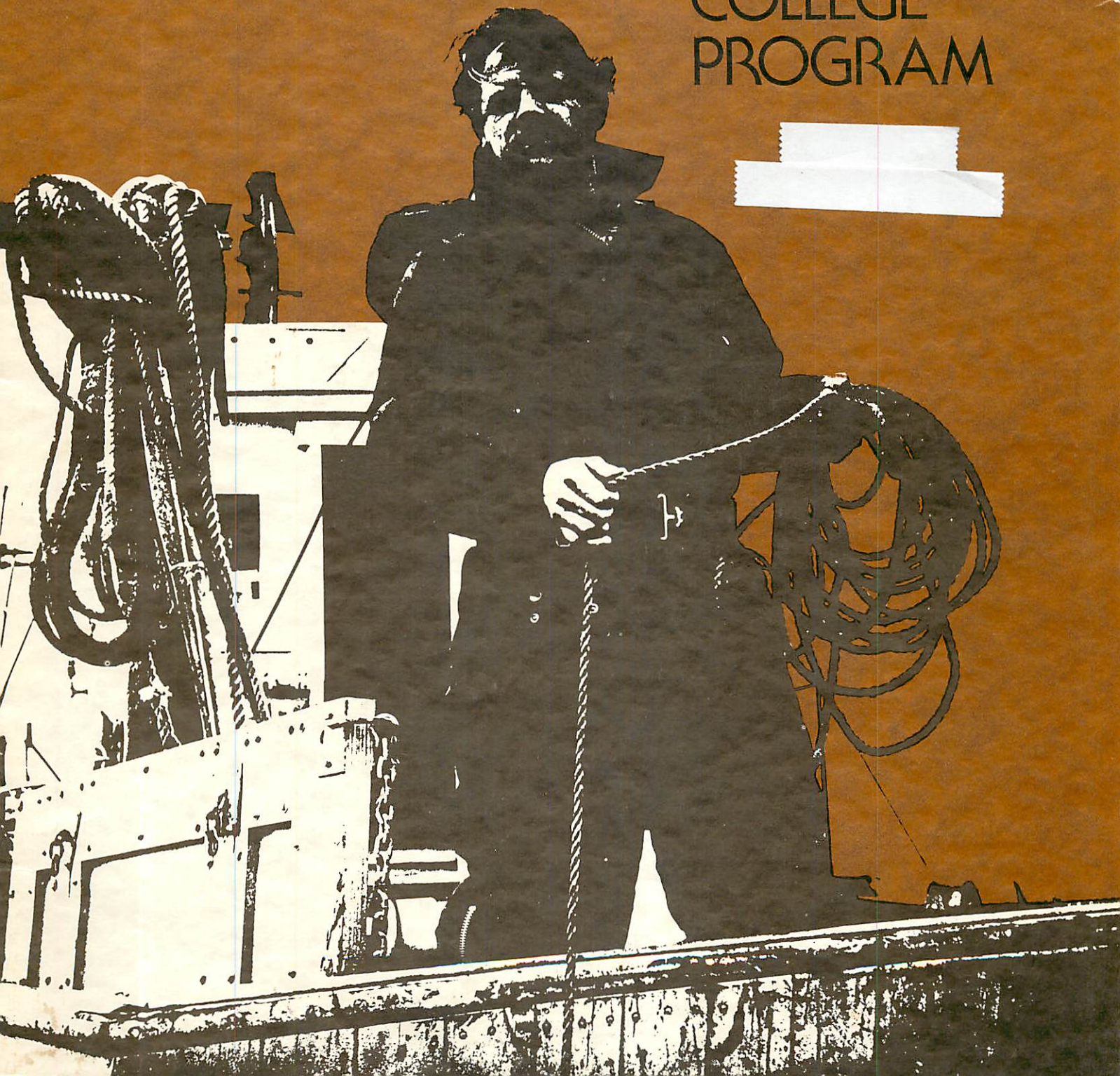
Annual Report 1976-77

DELAWARE SEA GRANT COLLEGE PROGRAM



Sea Grant in Delaware

A decline in natural oyster production was Sea Grant's first challenge in Delaware. The year was 1968 and the state was more than just a little concerned about what was happening in Delaware Bay. Over the past 50 years pollution, sedimentation, storms, and a disastrous oyster disease had nearly wiped out the once plentiful shellfish beds. Something had to be done. Here was an opportunity to take action. So, armed with $155,000 to investigate *controlled* oyster production, the Sea Grant program went to work in Delaware.

Almost a decade later, Sea Grant is still at work, and now with *more* challenges to face. In 1977, the Delaware Sea Grant College Program reflected nine years of growth and maturity. The early work, focusing on revitalizing the state's oyster industry, had helped to lay the groundwork for today's closed-cycle mariculture research. But the development of food resources and marine products is just one area of effort. Projects were also carried out this year in the areas of tidal wetlands, coastal and offshore engineering, coastal zone management, education, and advisory services.

The Delaware Sea Grant College Program is managed by the College of Marine Studies and involves investigators from most of the other nine colleges at the University of Delaware. Over 95 faculty, research staff and students were part of the Sea Grant work in Delaware this year.

Contents

From the Director

This report covers the activities of the Delaware Sea Grant College Program during its ninth year of operation. In those nine years, the program has proceeded through all of the Sea Grant developmental steps, beginning with project support in 1968, expanding to a coherent area program in 1970, achieving institutional status in 1971 and being designated as the nation's ninth Sea Grant College in 1976. As the program has matured, it has also developed stability in its research directions so that productivity and accomplishments have increased. While stability is desirable from one point of view, it can be stifling to new initiatives if care is not taken to solicit and encourage new ideas and research. Ideally the program should be a mix of projects ranging from mature to new and exploratory.

In our program, the controlled environment mariculture research is our most mature and widely recognized. Two established areas of research are just now beginning to reach their period of prime productivity. These are the tidal wetlands and halophytes research and the coast, bay and shelf engineering studies. A new area concerned with extracting useful energy from the sea and the introduction of new materials to cope with the marine environment economically and effectively is just now emerging. These researches contribute new knowledge and at the same time advance the university's and Sea Grant's primary mission -- education at all levels. The University of Delaware has pioneered the development and introduction of new educational materials at the kindergarten through 12th grade levels. It has contributed to undergraduate and graduate level programs and it has reached the general public through a wide variety of marine advisory service activities.

At the national level, the influence of a new director, Dr. Ned Ostenso, is being felt. His objective is to continue to improve the quality of Sea Grant-conducted research and its effectiveness in transferring new knowledge to marine resource managers.

During the 1976-77 Sea Grant year two initiatives were undertaken by the program management group.

One, the wave energy research, is reported on in its functional group, Coastal and Offshore Engineering, in this annual report. This project, which examines wave energy as a renewable resource, has produced data indicating that 1,000 gallons/day fresh water output can be achieved from a 15-foot diameter buoy at a cost slightly greater than that found in suburbia.

Another initiative was the Atlantic Offshore Program -- a comprehensive plan to obtain vital information for the nation to protect and use its Atlantic offshore resources. The first step in this regional effort was to identify priority problems of commercial significance to the nation. This was accomplished at a May, 1977, "users" workshop initiated by the Delaware Sea Grant College Program. We worked closely with the Delaware congressional delegation and 17 other East Coast senators and representatives as well as with the 14 other East Coast Sea Grant institutions. The report of the May workshop was published by the Delaware Sea Grant College Program.

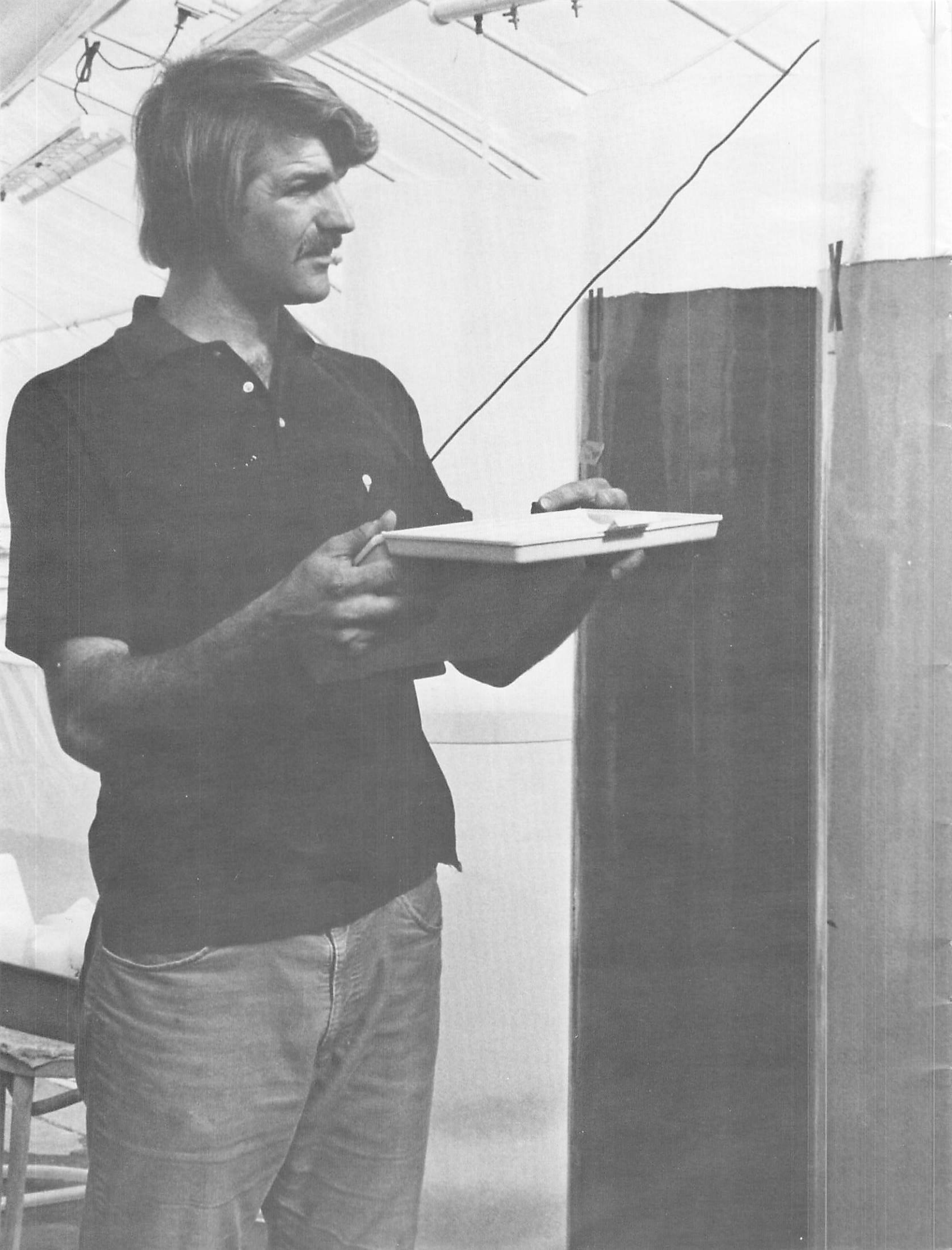
The second step -- developing a preliminary technical and scientific plan to solve or shed light on the user problems -- was carried out at a second workshop in September, 1977. We expect the Delaware Sea Grant College Program to play a leading role in the Atlantic Offshore Program as it moves ahead.

In the coming year I look forward to continued growth and improvement in the Delaware Sea Grant College Program. I also look forward to Delaware's increasingly active leadership role in marine affairs along the entire Atlantic coast. As the coastal zone management plans of each tidewater state are completed and adopted, the next step of raising our eyes to the important effect of offshore commercial development will begin. Here, the Sea Grant programs are well prepared to help the states define and satisfy their information needs for wise resource management.

William S. Gaither
Director

FY77 Sea Grant Budget

	Sea Grant	Matching
Program Management		
Administrative and Supporting Services	$ 93,900	$ 66,200
Decisions for Delaware	33,500	
New Initiatives	30,000	
Atlantic Offshore Program Workshop	3,000	
Marine Resource Development		
Aquaculture	174,600	140,800
Living Resources	45,000	2,000
Marine Biomedicinals	30,300	17,600
Socio-Economic and Legal Studies		
Marine Economics	8,500	3,800
Marine Technology Research and Development		
Ocean Engineering	210,400	116,300
Marine Environment Research		
Environmental Models	116,000	39,000
Research and Studies in Direct Support of Coastal Management Decisions	14,700	6,100
Marine Education and Training		
Secondary Program and Other	94,300	16,400
Advisory Services		
Agent Activities and Communications	57,600	141,400
Total	$911,800	$549,600



Mariculture

Delaware Sea Grant scientists and engineers have designed a unique closed cycle mariculture system for growing oysters and clams. All aspects of the animals' existence, from larval stage to maturity, can be controlled. Nine years of research have gone into the system and now oysters are growing to market size in 36 weeks there, compared to 36 months in nature. Maricultured clams grow to market size three to five times faster than do wild clams.

Much of the mariculture work at the University of Delaware during 1977 focused on the planning of a prototype system for the controlled production of clams and oysters. Construction of a new laboratory began near the end of the year and is scheduled to be completed in 1979. It is partially supported by a $1.2 million grant from the federal Economic Development Administration. Other funds are being sought from private and industrial sources.

The 21,000 square feet of space will house laboratories, hatcheries, an algal seed culture room, offices and conference and exhibit areas as well as a greenhouse complex. Once operable, the new mariculture laboratory will for the first time, allow a complete, detailed analysis of capital, materials, operations, and energy costs of a prototype so that the feasibility of commercialization can be judged.

In the new facility, researchers will be able to grow 100-200 bushels of mollusks per year. The recirculating system that operated during this ninth year of Sea Grant research had the capacity of four bushels per year. This smaller system has been operating for over a year at 90% recycle, i.e., 10% of the water is removed and replaced with make-up water every day. A companion flow-through system is also in operation (100% of the water is made up daily). Oysters in the recycling system continue to grow well in comparison to those in the flow-through system. Certain steps in processing the seawater, such as charcoal adsorption and acidification, prevent the algae cells from clumping and microbes from getting into the recycling system.

Several chemical and microbiological factors in the recirculating seawater were monitored but no serious effects from manipulating the system were discovered. Two hundred data points were collected every week, constituting the largest body of data in existence on controlled environment shellfish culture systems.

Research on trace metals and minerals in the four-bushel system showed that no toxic amounts of trace metals accumulate in either the recirculating or flow-through system over time. However, significant increases in copper, cadmium, manganese and iron were found in the algae and oyster tissue cultured in the flow-through system.

Investigators have studied the rates at which the oysters take in calcium from the water and algae, and now they're looking at the effects that fluctuations in calcium concentration can have on calcium transport and amino acid metabolism in the oyster.

Nutritional studies of algae revealed that the poor food value of *Phaeodactylum tricornutum* could be related to the fact that oysters take in practically none of the vital nutrient nitrogen, when fed the *Phaeodactylum.* However, results of studies with *Isochrysis galbana* point to a more promising future for that algae as a source of nutrition.

In a cooperative study with the Campbell Institute for Food Research (CIFR), six species of algae were harvested from different phases of growth and analyzed by the CIFR for their chemical composition. There may be potential correlations between food value and algal composition.

Artificial foods were also considered and in one study, researchers discovered that commercially available yeast can be used in place of up to 50% of the algae necessary in the diet of at least three species of commercial shellfish.

Of all the parts of an oyster, what's *inside* the shell is probably more important than the shell itself, to most people. But at Delaware, the mariculture team knows that the shell can't be ignored in the overall research plan. The structure and chemical composition of an oyster shell can reveal

much about how the animal is growing. This year, biologists grew oysters in three different places (a river, a flow-through system, and a recycle system) to see if differences in environment would show differences in the shell.

According to results of the studies, several factors could be indicative of environmental conditions:

- shell shape and coloration
- the extent and distribution of chalky deposits on the shell
- the size and structure of prismatic scales
- the size and shape of prisms at the growing edge of the valve, and
- the banding of the ligament

The value of these features as environmental indicators will be tested by microscopical analysis during the next year.

What are the economic implications of all this? A complete macroeconomic analysis of a potential mariculture firm was developed this year. One result of this was a deeper appreciation of the sensitivity of the total cost to changes in project design. The research also showed how use of economic analysis can make the choice of optimal design easier by identifying bottlenecks to profitability. One important bottleneck is the cost of growing algae. Some of the proposed methods of supplying various combinations of nutrients were costed out so that the biologists could focus on the lower cost alternatives.

Underway now are several other studies that will help in the development of the commercially viable prototype:

high density feeding under intensive culture (oysters thrive on algal diets 1000 times as dense as natural diets)

advantage of early vs. late setting spat (all spat of a spawn can be grown rapidly if the food supply is adequate)

clam planting (hard clams marked indelibly with fluorescent tetracycline are being planted in one of Delaware's small bays. At the harvest stage, they should reveal survivability and growth rate in prepared areas of Rehoboth Bay and lead to management tools for recreation and commerce.)

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Dr. Gary Pruder
College of Marine Studies

Dr. Charles Epifanio
College of Marine Studies

Dr. Lowell Sick
College of Marine Studies

Dr. Melbourne Carriker
College of Marine Studies

Dr. Lee Anderson
College of Marine Studies;
College of Business and Economics

Mr. Kevin Smith
College of Marine Studies

Development of Chitin

Seafood waste from crab and shrimp processing contains protein, which can be converted into animal feed, and chitin (kite'n), a tough cellulose-like material that may soon be considered a new marine resource.

Development of chitin as a marine resource has been a goal of the Sea Grant work at the University of Delaware for the past few years. As a result of earlier solvent and filament studies under this program, chitin is being evaluated for surgical sutures by a commercial firm. Crab meal plants on the east coast have been encouraged by this and other research and are considering the possibility of recovering chitin from crab waste.

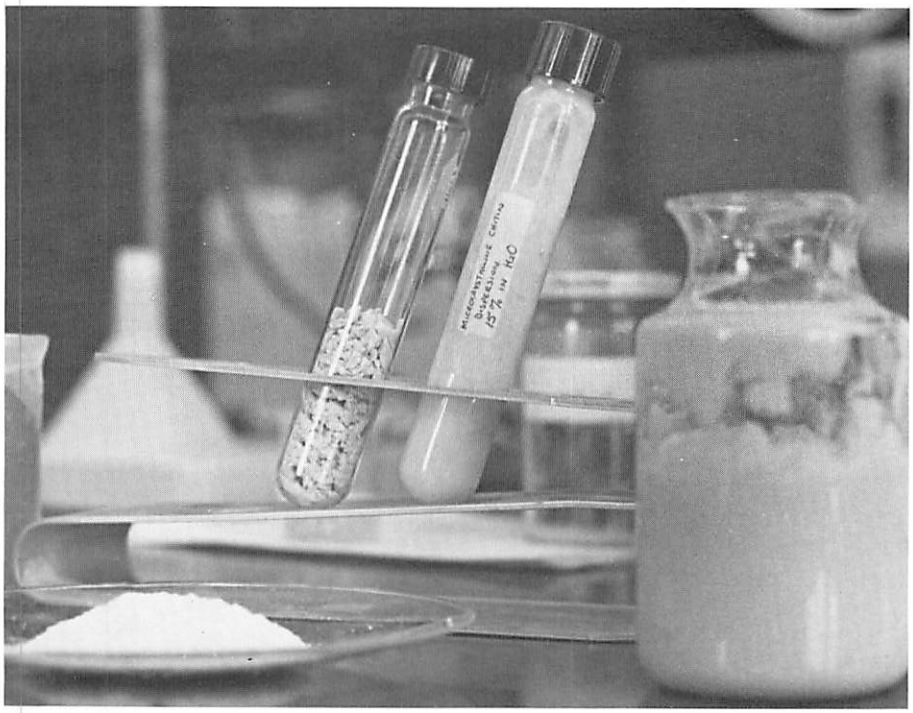
Chitosamine, the building block of chitin, has the important biological effect of promoting the growth of bacteria that aid digestion of milk sugar lactose. A chitosamine product has been developed that is very effective and a commercial firm is preparing quantities for further tests. Studies have been started on using it to improve the digestion of whey, a surplus by-product from cheese-making. Initial tests are encouraging.

Microcrystalline chitin, a new physical form, has been prepared as a mayonnaise-like dispersion in water by using an ultra-high speed blender that shears the molecules and forms the microstructure. The product will be tested in the whey program and as an accelerator for wound healing (native chitin has been found effective in this).

To promote the fledgling chitin industry a vigorous patent and publication program has been pursued at Delaware. The First International Conference on Chitin and Chitosan, held in April, 1977, in Boston, was co-sponsored with the Massachusetts Institute of Technology. New industrial contacts have been established. The whey program is being conducted in a separate project, directed by Dr. John Zikakis in the College of Agricultural Sciences.

Dr. Paul Austin
College of Marine Studies

Dr. John Zikakis
College of Agricultural Sciences



Tidal Wetlands

Delaware Salt Marsh Ecosystems

After three years of investigation, marsh biologists in the Delaware Sea Grant College Program are getting much closer to answering the question "how much is a marsh worth?" The effort is a five-year one aimed ultimately at developing a model that will help decisionmakers determine the biological contribution of a known area of salt marsh to the Delaware Bay ecosystem.

Primary production estimates are continually being evaluated—samples have been collected monthly. Experimental work will begin on water level regulation and nutrient additions. Estimates of marsh surface contours and primary production were determined beforehand.

Canary Creek marsh is the site of the studies. A continuing analysis of nutrient flux in the marsh was started three years ago. In addition, nutritional studies were initiated on the mummichog (*Fundulus heteroclitus*). The growth data and protein content of individual fish are now being analyzed.

During the summer the investigators gathered baseline measurements of the use of certain experimental ditches as spawning sites by the mummichog. They found some clutches of eggs in cordgrass but most were found in empty ribbed mussel shells. The scientists plan to add the analysis of this phenomenon to next year's work.

Another finding this year had to do with bacterial activity. Iron sulfide (the chemical compound that causes the normal black color of the marsh) was discovered as a possible food of certain sulfur bacteria. These bacteria simultaneously convert carbon dioxide into organic matter, much as plants do. They're also very numerous and grow quickly. The investigators believe organic matter formed during iron sulfide metabolism may be important in the food chain of some microscopic animals in the marsh.

Nitrogen fixation—the conversion of nitrogen gas to ammonia—is done solely by bacteria. This process in relation to water content, salinity, and organic content of mud, has been studied and fixation rates are very high in the Lewes marsh. In fact, the rates are probably high enough to account for all the nitrogen the marsh plants need in a year. This finding is significant, particularly in light of the long search for the identity of the nitrogen source for marsh vegetation.

Research efforts have focused on assessing nutrient flux rates between the marsh and bay ecosystems and on the population ecology of some characteristic marsh fauna. The nutrient studies have resulted in two years of baseline data that provide information necessary for the next phase of this five-year investigation. That will include the experimental manipulation of parts of the marsh to determine nutrient uptake rates and cycling times.

The population dynamics and productivity of resident species like the diamond-back terrapin, fiddler crab, ribbed mussel, and mud snail continue to be examined. Work with the terrapin has revealed a large, stable population in the marsh waterways, likely to be important in marsh energetics.

Dr. Franklin Daiber
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Dr. Victor Lotrich
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Dr. Lawrence Hurd
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Dr. Malcolm Taylor
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Dr. David Smith
School of Life and Health Sciences; College of Marine Studies

Halophytes as Potential New Food Crops

The possibility of eating orach instead of lettuce in your salad may not be as wild an idea as it seems. Delaware Sea Grant scientists have been working to find or develop seed bearing plants that will tolerate salinities similar to coastal or estuarine water and that could be used as food for man or domesticated animals. They have focused on *halophytes* (plants that already grow in salty soil).

Halophyte researchers concentrated on three species in their work this year: smooth cordgrass,

seashore mallow, and orach. Since the start of this project three years ago, candidate plants have been considered in light of five criteria:

—Does it grow in a saline habitat naturally?
—Does it produce abundant seeds?
—Does it produce large seeds?
—What are its potential food attributes?
—What is the potential for adapting it to managed production?

After examining more than 70 species using those criteria, the investigators chose to focus on the cordgrass, orach and mallow.

Smooth cordgrass is the dominant species in most salt marshes in the eastern U.S. It's very productive and it's better understood biologically than other tide marsh grasses. The seeds contain 10-12% protein. A major problem that plagues scientists though, is the disease ergot, a particular menace to cordgrass that can be very disastrous to the yield of the seed. To cultivate this grass successfully as a cereal crop, Delaware investigators feel that a selection of resistant strains will be needed or control measures will have to be developed.

Work was begun this year on selecting superior strains of smooth cordgrass. There is some evidence that it is a self-pollinated plant, but for the most part it is cross-pollinated. More work on this will be important in planning for further selection.

This year, cordgrass seeds from several different sources (ranging from Maine to Virginia) were grown in the greenhouse and then transplanted to outside flood-irrigated plots. Definite differences were found in the plants—differences that cannot be accounted for solely by the salinity of the surrounding soil. The genetic differences are something the investigators intend to exploit.

Seashore mallow, in contrast to smooth cordgrass, is a minor component of the salt marsh, but it tolerates moderate salinity levels and will mature into a seed-producing plant in one season. It belongs to the same family as the common vegetable okra. Seashore mallow seeds contain about 33% protein, and do not shatter (ripen and drop off) as badly as those of other wild plants. Studies on seeds from different Delaware marshes indicate there is a natural variation in salt tolerance.

Orach is frequently seen along the edge of eastern salt marshes and is definitely edible as a salad green or pot herb. Seed protein content is about 15%. It tolerates spray or flood irrigation with very salty water (about 25-32 parts per thousand). The standing crop of orach at the end of the growing season this year was 5.7 tons per acre. Average yield of seed was more than 1000 pounds per acre.

Orach seeds from several different localities have been collected, and they show much variation in characteristics and seed size.

The amino acid content of the top three candidates is encouraging. For smooth cordgrass, the balance of amino acids compares favorably with that of wheat gluten. For seashore mallow and orach, the balance is comparable to that of casein.

Lambs quarters, saltmeadow cordgrass and seashore saltgrass were given only minor attention this year, but each has characteristics that indicate they may grow well in other areas. Delaware scientists are now pursuing a plan to collaborate in studies with the University of Arizona and Sonora University in Mexico, and these species will be tested there.

Dr. G. Fred Somers
School of Life and Health Sciences;
College of Marine Studies

Coastal and Offshore Engineering

Coastal Barriers and Adjacent Wetlands

Delaware's coasts continue to erode. The only major area of Delaware's shoreline where sand is deposited rather than eaten away is in the Lewes Harbor region and at the tip of Cape Henlopen. Rates of erosion along the coastline vary from about one meter per year to about 10 meters per year. These statements come after completion of a two-year research project on the geologic structure, evolution and destruction of Delaware's coasts.

Geologists found that higher rates of erosion are occurring along the Delaware Bay shoreline than the Atlantic Ocean shoreline. This agrees with observations based on coastal surveys dating back to 1831.

Field studies were carried out in the coastal zone all year. Particularly emphasized were the analysis of storm overwash features and the interrelationships of these features with the vegetation and swamps behind the coastal barriers. The floral evolution and the recovery of marsh flora destroyed by storm overwash damage were systematically analyzed.

The storm overwash process is the major cause of coastal erosion on the Delaware Bay shoreline. That is also basically true of the Atlantic Ocean shoreline. However, along the ocean coast several defensive structures have been put up — groins, jetties, and artificially built up dunes. Therefore, most coastal erosion tends to be from littoral drift north toward Cape Henlopen and from removal of sand into the deeper offshore area. Much sand is blown from the beach-berm area onto the dunes, but the most significant erosion continues to be to the north of the Indian River Inlet jetties. Much of the sediment eroded from the coast is ultimately deposited in the flood tidal delta of Indian River Inlet in Indian River Bay.

Three technical reports are planned to disseminate the results of the field and laboratory work.

Dr. John C. Kraft
College of Arts and Sciences;
College of Marine Studies

Beach Erosion Control at Roosevelt Inlet

Delaware's coastline features two major inlets, linked via the Intracoastal Waterway. Roosevelt Inlet serves as the northern entrance to the Waterway and lies on the extreme southern edge of Delaware Bay, approximately three nautical miles west of Cape Henlopen. Indian River Inlet lies at about the mid-point of Delaware's Atlantic Coast, eleven nautical miles south of Cape Henlopen. These two inlets are coupled by the Lewes and Rehoboth Canal and the Rehoboth and Indian River Bay systems.

Like most tidal inlets along sandy coastlines, these inlets have resulted in significant erosion on the adjacent beaches. Roosevelt Inlet currently traps about 11,000 cubic meters of beach sand per year, most of which is deposited in lobe-like shoals along both banks. This quantity, although seemingly small, has resulted in major downdrift erosion along Lewes Beach, Delaware.

Roosevelt Inlet was cut and stabilized in 1937 to provide a dependable entrance to the newly dredged Lewes and Rehoboth Canal. The inlet channel was dredged to a depth and width of two meters and about 61 meters respectively, and stabilized by the construction of twin steel sheet pile jetties about 520 meters long and 153 meters wide.

Studies were done to identify and document the various past and present coastal processes. These studies include hydrographic surveys, beach profiles, current measurements, sand tracer experiments, collection and comparison of past and present charts and aerial photographs, as well as the documentation of all dredging and beach nourishment activities for each inlet. One major point of interest uncovered by these studies was the net littoral drift reversal in the vicinity of Roosevelt Inlet. Before 1900, littoral drift passed rather freely around the then blunted Cape Henlopen along the ocean to the bay beaches in a north by westerly direction. As the Cape advanced into the mouth of the Delaware Bay (perhaps aided by the construction of two detached hooked breakwaters near its tip) less sand was able to reach the bay beaches from the

east resulting in a net drift reversal (now west to east). Second, the major northeast storm of March, 1962, was found to have caused significant damage to the already deteriorated steel sheet pile jetties. Analysis of shoaling rates in the inlet showed an eightfold increase following 1962. Analysis of accretion rates along the updrift jetty revealed a rapid decline in sand retention also following 1962. An overview of the various trends and processes has resulted in a sand budget analysis, a useful and pertinent tool in planning maintenance and bypassing schemes.

A numerical model was developed, encompassing all the bays and waterways from Indian River Inlet to Roosevelt Inlet. This one-dimensional model provided a basis for simulating the tides and cross-sectionally averaged currents at any location within the system. The tides and currents predicted by the model were compared with measured field data and gave quite accurate results. The model predicted the location of the tidal division line, but more important, it predicted a mean southerly flow through the entire system (also evident in the field measurements). This net flow, although only about 10% of the total flow through Roosevelt Inlet, is shown to cause a significant bias in the portion of tidal power available for sediment transport. In fact for Roosevelt Inlet a flood tidal bias exists, resulting in a strong tendency for this inlet to trap and confine sand within its throat. At the opposite end of the system an ebb tidal bias exists resulting in a dominant ebb tidal shoal forming at Indian River Inlet. Considerable loss to the flood tidal shoals in Indian River Bay has also been noted since 1936.

Concepts of stability and equilibrium were also analyzed for both inlets. Indian River Inlet was found to be quite stable against closure, its cross-section increasing over time. On the other hand, Roosevelt Inlet shows a tendency toward closure from its presently maintained channel dimensions.

Methods for the maintenance and/or redesign of Roosevelt Inlet were developed during the course of this study. Design recommendations were derived from historical analysis of the techniques that did and did not succeed at these inlets. The jetties at Roosevelt Inlet need to be made more sand tight — steel sheet piling has deteriorated well beyond its effectiveness and should be replaced by more substantial materials. Sand bypassing should be continued on a periodic basis to help alleviate downdrift erosion.

A technical report has been prepared on this study.

Dr. Robert A. Dalrymple
College of Engineering;
College of Marine Studies

Coastal Erosion Induced by Rip Currents

Beach erosion is widely recognized as a serious problem in Delaware, particularly as winter storms have moved significant amounts of beach sand offshore. How the sand is transported and the magnitude of this process, however, are not entirely clear to coastal engineers.

They *do* know that rip currents (mistakenly called undertows in the past) are responsible for much of the beach erosion. Rip currents take beach sand with them as they flow seaward from the surf zone, but the currents are not entirely understood, either. If the offshore bottom varies regularly along the beach, then regularly spaced rip currents can occur, but the question remains, "Why would the bottom be regularly spaced?"

Coastal researchers know that large storms cause sand bars to form in the vicinity of the breaker line. These bars tend to trap water between them and the shore and allow it to flow out where there are breaks in the bar. Because large storms cause beaches to recede the most (at least temporarily), Sea Grant coastal engineers focused on the configuration of the beach area after a large storm.

For these barred coastlines a theoretical model was developed to predict the mean flows and the rip current spacing (the spacing between the breaks in the bar). This model has been tested successfully in a small laboratory basin; however, because of the model's flat offshore topography, severe problems were encountered with wave current interaction. Further modeling work is being planned for the next year in the Civil Engineering Department's new wave basin.

Dr. Robert A. Dalrymple
College of Engineering;
College of Marine Studies

Shoreline Erosion Due to Extreme Storms and Sea Level Rise

A three-year project was started this year to develop a better understanding of shoreline response to increased storm tides and waves. From the results of the first two years of study, recommendations and guidelines can be formulated to help in designing, planning for, and managing the coastal zone.

During the first two years of research, the main emphasis has been on onshore-offshore sediment transport in the nearshore zone. This kind of movement usually is significant during storms and results in extensive erosion and structural damage. Much of the slow but pervasive erosion occurring along the shorelines of the world is due to sea level rise, resulting in onshore-offshore sediment transport.

Over 500 beach profiles from the Atlantic and Gulf coasts were analyzed and compared to predicted profiles. From the predicted profile, the investigators developed in graphic form the response of natural and seawalled beaches to storm tides and waves of unlimited duration. With a predicted profile, it's also possible to examine shoreline erosion associated with a slow sea level rise. Both these capabilities should be effective in evaluating the erosion susceptibility of an area.

Barrier islands — low-lying, elongated, sandy strands — make up much of the outer shoreline along the Atlantic and Gulf coasts. During high tides and waves, sand is eroded from the outer shores of these islands and moved landward, where part of it is left on the island, increasing its height. The remainder of the eroded material is deposited in the bay, extending the island boundary toward the mainland. This process is called *overwash* and the first known wave tank tests of it were conducted under this Sea Grant project as an M.S. thesis topic. The student measured the rates of sand transported by overwash for various wave and tide conditions. A predictive relationship was developed. Future plans include applying and evaluating the results against full scale conditions.

A second series of wave tank tests was carried out to quantify the role of the *storm bar* — a result of eroded beach sand that is deposited as an elongated feature near the location of breaking waves.

A storm bar is sometimes regarded as a major feature of the "defensive posture" that the beach profile adopts against the storm tides and waves. By sacrificing some of the beach to build the bar, the beach is protected because much of the wave energy is dissipated on the bar, and further beach erosion is limited.

The purpose of these wave tank tests was to determine the volumes of sand eroded from the beach for given storm wave heights. Results seem to be a reasonable extension of previous work in which wave conditions for the formation of a storm bar were established.

In the second year of this project, the engineers plan to concentrate on the alongshore movement of beach sand.

Dr. Robert Dean
College of Engineering;
College of Marine Studies

Wind-Induced Effects on Coastal Sand Dunes and Structures

One of the best forms of natural protection along a shoreline is the sand dune, built up by wind and drifting sand. But dunes can also be eroded by the same forces that build them. By studying wind velocity, beach profile, existing dunes and the effects of wind on dunes, Sea Grant researchers hope to provide important information to help control that erosion. Knowing how to build and stabilize coastal dunes depends on a good understanding of how wind moves sand along a dune surface.

In the first year of this three-year project, a numerical model was developed to calculate the force generated by wind along a dune surface. The calculated shear stress on a symmetrical dune, confirmed in the laboratory study, shows an increase near the top of the dune. Based on this shear stress, rates of sand movement along the dune surface were evaluated so that a region of wind erosion and deposition along the dune surface could be calculated.

When the research is completed, coastal planners and managers will be able to use the results in designing the most effective method of either installing fences for dune building or planting grass for dune stabilizing. Information will be available so that a stable dune shape can be calculated, and so that the effect of building a structure near the top of the dune can be evaluated.

Dr. Ronald Lai
College of Marine Studies

Dr. Jin Wu
College of Marine Studies;
College of Engineering

Energy From Sea Waves

Researchers from the Colleges of Marine Studies and Engineering this year began testing a system they hope will lead to harnessing the power of sea waves to produce fresh water.

The system they have designed and are testing consists of a sea wave-activated pump that powers a salt-removal unit by direct hydraulic energy.

Inhabitants of underdeveloped islands and coastal communities would benefit from this type of desalination unit. Fresh water could be produced for drinking, small scale farming and/or food processing. Fish storage facilities might also be possible, based on the same basic design.

A two-part buoy is being developed. One part, anchored below the water surface, contains the pump. The other part, floating on the surface, sends the energy of the waves to the pump.

Data from the first year of research indicate that freshwater output from a 15-foot diameter buoy should be about 1000 gallons per day. Estimates suggest that the cost would be only a bit higher than what most suburban U.S. homeowners pay for water. Reduction in energy cost and introduction of innovative designs for inexpensive organic high-pressure pumps contributed to the relatively low projected cost of producing fresh water.

Two more years of testing and research should conclude in a detailed design, with engineering specifications.

Dr. C. Michael Pleass
College of Marine Studies

Coastal Zone Management

Assessing Local Governmental Capacities Related to Onshore Impacts from mid-Atlantic OCS Development

How will the coastal towns in Kent County, Delaware, or Atlantic County, New Jersey, cope with potential onshore needs of outer continental shelf (OCS) oil and gas exploration? More specifically, how will local governments respond to OCS exploration, development and production?

These questions were the starting point of a Sea Grant project carried out by investigators from the College of Urban Affairs and Public Policy.

The study was done to assess local governmental planning activities related to offshore development. Research focused on Kent and Sussex Counties in Delaware, Wicomico and Worchester Counties in Maryland, and Atlantic and Cape May Counties in New Jersey. Through interviews with city, county and state elected officials and study of public documents, reports, and newspaper files, the researchers found that coastal cities and towns tend to have limited planning capacity in terms of professional staff and dollars spent in general planning, and particularly in coastal development planning. When planning is done, most cities use private planning consultants.

Given these low levels of expenditures to begin with, the study found that there weren't many incentives for local governments to do anticipatory planning to assess costs and benefits of OCS development. This was in part due to uncertainty among local officials about whether their areas would be targeted for onshore development, and its timing and extent if it were to occur. The inherent ambiguity of the situation led most governments to take no action. When communities *did* respond, it tended to be in one of two forms. Some communities tried to recruit firms to establish support bases for OCS activity on the assumption (without direct study) that this would enhance the local economy. Others were able to oppose the establishment of OCS support facilities, often joining in coalition efforts with other governmental units, with a very small expenditure of resources.

Initiative of communities was further inhibited by little effort at the state level to include city and town governments in the development and administration of state-wide coastal management plans. Most of the interaction took place between state and county governments. Consequently, in cases where local initiative did exist for coastal planning, it was at the county level for both OCS development and general coastal management.

Recommendations that resulted from the study include:

- Coastal cities and counties should become more involved in coastal planning and management at both local and state levels. Federal and state planning systems should improve procedures for including preferences of local areas in coastal decisions.
- Cities and counties need to have a greater committment to coastal planning in general. Policies toward onshore facilities should be part of an overall set of priorities for a community's shoreline.
- Information on OCS development provided to state governments should be shared with cities and towns.
- The extensive role of private planning consultants in local coastal zone planning should be recognized in the development and administration of state coastal zone management programs.

The data and recommendations will be made available to regional, state, county and local governments to assist in planning and managing onshore impacts from OCS development.

Dr. Robert Warren
College of Urban Affairs and Public Policy; College of Marine Studies

Education

Distribution of Coastal Oceanic Awareness Studies

Delaware's primary effort in the field of public marine education, Project COAST (Coastal Oceanic Awareness Studies), continued this year with eight mid-Atlantic school districts introducing COAST materials into their existing curricula. Altogether, approximately 220 teachers and 7,330 students in Delaware, Maryland, New Jersey, and Virginia were involved. Tests were given to grades 4, 8, and 12 to measure basic knowledge and understanding of marine environment concepts. Results revealed a low level of marine environment awareness among students generally, and thus a need for increased attention to marine education.

In addition to disseminating the 85 COAST learning experiences, several other activities were undertaken:

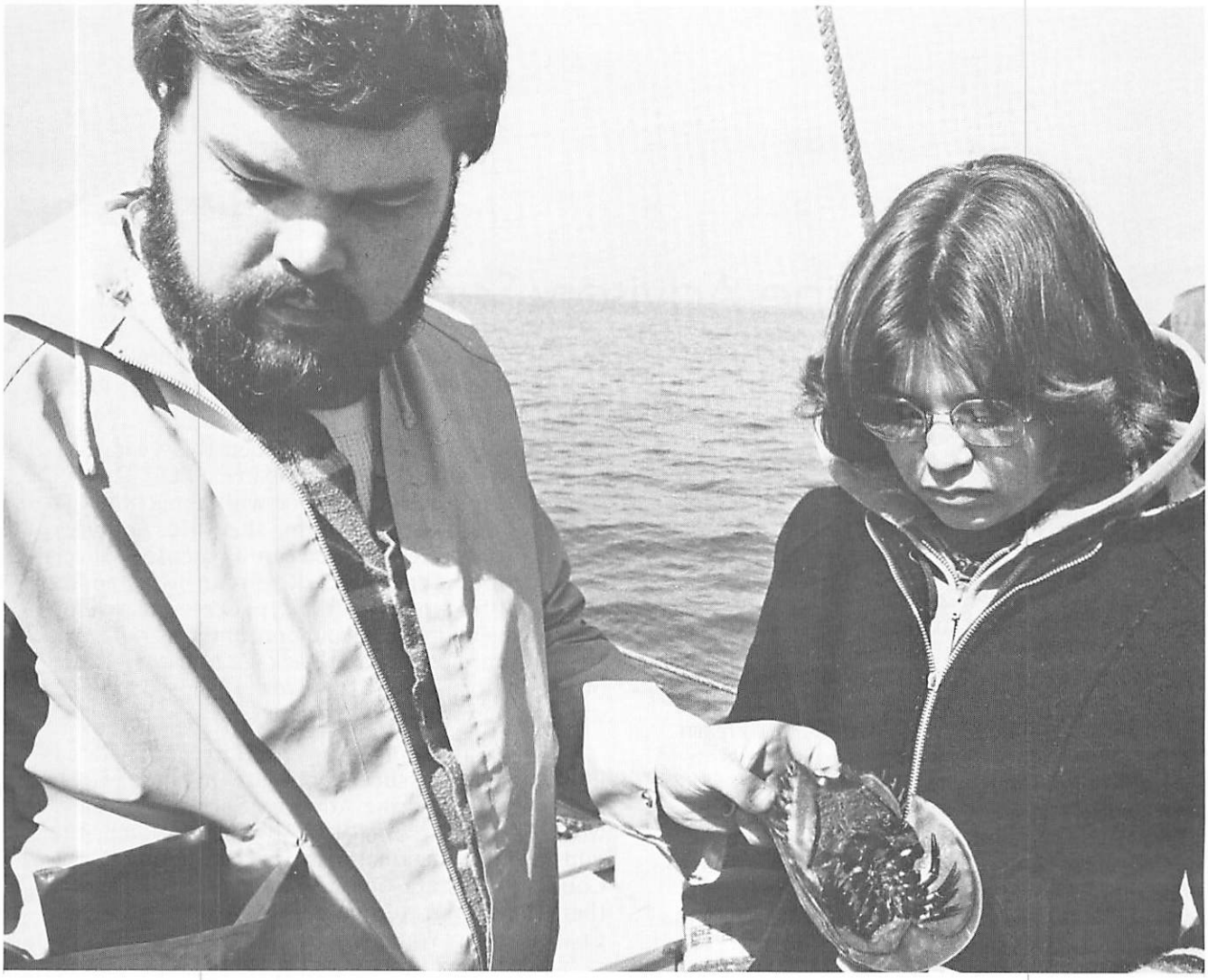
- More than 30 new or modified lessons were prepared to enrich, extend and refine the COAST collection.
- A catalog, "Audio-Visual Aids, Games, and Art for Marine Environment Studies," was prepared for marine educators. The catalog lists reviewed 16 mm films, filmstrips and prints of marine art. Over 100 prints are now part of a collection which the Project COAST personnel can make available for use by schools.
- In cooperation with the National Marine Education Association (NMEA) a 115-item "Catalog of Curriculum Materials for Marine Environment Studies, Elementary and Secondary" was published and distributed at the second national meeting of the NMEA, held in August, 1977, at the University of Delaware. The conference was co-sponsored by the NMEA, Project COAST, and the University of Delaware Sea Grant College Program. About 150 marine educators from across the country attended.
- Project COAST personnel also annotated and catalogued over 300 children's books on the marine environment to help teachers incorporate marine studies into reading and language arts ("A List of Books on the Marine Environment for Children and Young People"). "An Annotated Bibliography of Periodical Sources for Marine Environment Studies, Newsletters, Bulletins, Journals, and Magazines" was also prepared.
- A full-time marine environment coordinator was appointed in Cape Henlopen (Delaware) school district and a graduate assistant in the University's College of Education was retained to work with the COAST testing program. Supplemental grants from the Office of Environmental Education of the U.S. Department of Health, Education and Welfare, and from the DuPont Educational Aid Committee, helped to make these appointments possible.

Dr. Robert Stegner
College of Education

Development of a National Sea Grant Policy on Marine Education

The need for a clear statement about the importance of marine education in the U.S. has been raised several times over the past few years. A conference sponsored by the Oceanic Society was convened in 1976 to review Sea Grant's role in marine education. At that conference, Harold L. Goodwin (formerly with the Office of Sea Grant) was requested to draft a statement, "Introduction to Marine Education." This draft would provide the basis for discussions of the need for marine and aquatic education among educators in many parts of the country.

To gather the opinions of a broad spectrum of people in education, primarily those not already committed to the water world, a project was started and based at the University of Delaware, with funding by Sea Grant. Twenty-six workshops, coordinated at Delaware, were conducted in 16 states to gather the educators' thoughts and suggestions on marine education. More than 1300 people participated, including teachers, principals, state and local administrators, marine advisory service personnel, and the general public. A revised draft of "Introduction to Marine Education" was used as a point of departure for participants as



they debated and worked on the development of a comprehensive statement. The book *Americans and the World of Water,* edited by Harold Goodwin, provided a resource on water-related topics. With chapters by E. R. Pariser, Joel Hedgpeth, John Craven, Peter Fong, Robert Stokes, and Gerard Mangone, it was published by the Delaware Sea Grant College Program especially for participants in the workshops, although it has been in great demand elsewhere.

Project personnel have interacted with the National Advisory Committee on Oceans and Atmosphere, the U.S. Office of Education, the National Marine Education Association, the Education Committee of the Marine Technology Society, and the Education Council of the Sea Grant Association. The introductory statement was presented at the Offshore Technology Conference and copies were supplied to the Education Committee of American Geological Institute.

Some conclusions were reached: without question both fresh and salt water need to be included in any educational experience. The vital importance of fresh water in inland as well as coastal areas, cannot be denied. There is really no noticeable difference in attitude about the importance and usefulness of marine and aquatic education between those already involved and those new to the concept. Teachers expressed the need for suitable quality resource materials and the need for more background. There is a need for a water emphasis in the social sciences and humanities. Revising textbooks to achieve a balance that would include the world of water as well as the worlds of land and air was suggested.

One result of the workshops was a move by participants in many locations to organize into associations of marine and aquatic education.

From the workshops and the agency interactions, general recommendations have been made and should lead to unified action. The statement on the need for marine and aquatic education is now being published. It will be distributed to educators, institutions, and public officials throughout the U.S.

Mr. James G. Schaadt
College of Marine Studies

Marine Advisory Services

Much of the contact between Sea Grant and its constituents comes through the Marine Advisory Service (MAS) component. Through publications, slide-tape presentations, public meetings, conferences, and the work of advisory and communications specialists, Delawareans have been getting answers to their questions and learning more about the sea and its resources.

About 30 school, civic, service and professional groups visited the College of Marine Studies Lewes Complex this year to hear advisory specialists speak about various topics. Specialists traveled to seven schools in the state with information on marine education and career opportunities. Twenty groups went to sea on the *R/V Wolverine* to learn about oceanographic research and to see marine flora and fauna in its natural state.

Delaware's MAS works with specific publics to help them get the information they need to do their job, pursue their hobby, or solve their problem. In May, 1977, a one-day workshop on marine insurance was hosted by the MAS. Response from area businessmen was encouraging enough to plan for another workshop in the fall of 1977.

A hard clam planting program, designed to revitalize Rehoboth and Indian River Bay hard clam fisheries, was begun three years ago and has indicated that commercial scale planting was not very successful — the survival rate was only 9.2%. But the advisory specialist and the biologist involved think the success of planting may relate to *where* it is done. They recommend that more work be done on water and bottom characteristics at successful sites. Future cooperation is possible between the state Department of Natural Resources and Environmental Control and the MAS.

The highly regarded Fisherman's Hotline was again a welcome service to sport fishermen in Delaware and to those nearby who travel to the First State to fish. Recorded daily by Sea Grant marine advisory specialist Howard Seymour, the Hotline operated from May to November for the sixth consecutive year. Several area radio stations taped the 90-second message so that their listeners could hear where the fish were biting, what bait was good, and how the weather and tides were affecting fishing. Radio station broadcasts of the Hotline helped to get the message to many more people than was possible through telephone calls. A goal for next year will be to expand the number of stations that are aware of the Hotline and might broadcast it.

Cooperative work continued this year with the International Paper Company (IPC). The IPC supplied the Advisory Service with a machine that packages fresh fish to prolong shelf life. Analyses of this process were carried out by advisory specialists and food technologists. If fish can be stored fresh instead of frozen for 30 days, packers can save on expensive energy costs and consumers can have a fresher, more convenient package to use. Because of the importance of this work, funds are being sought to continue it.

Sea Grant's increasing visibility in the state is illustrative of the success of many of these efforts. Sea Grant and Marine Advisory Service personnel worked with the Shellfish Advisory Council, the mid-Atlantic Regional Fisheries Management Council, the state Coastal Management Program, the Delaware Watermen's Association, and the Coastal Sussex Water Quality Management Program.

Several exhibits were prepared and displayed for the Delmarva Watermen's Association Conference, the Assateague Sportfishing Expo 77, the Delaware State Fair, National Nutrition Week, and the University of Delaware Farm and Home Field Day.

Through the efforts of the marine advisory service and Project COAST (Coastal Oceanic Awareness Studies), educators from four states (Delaware, Maryland, Virginia and New Jersey) and the District of Columbia have been using COAST materials and marine advisory publications in the classroom. In-service training programs were held for about 500 teachers in Delaware.

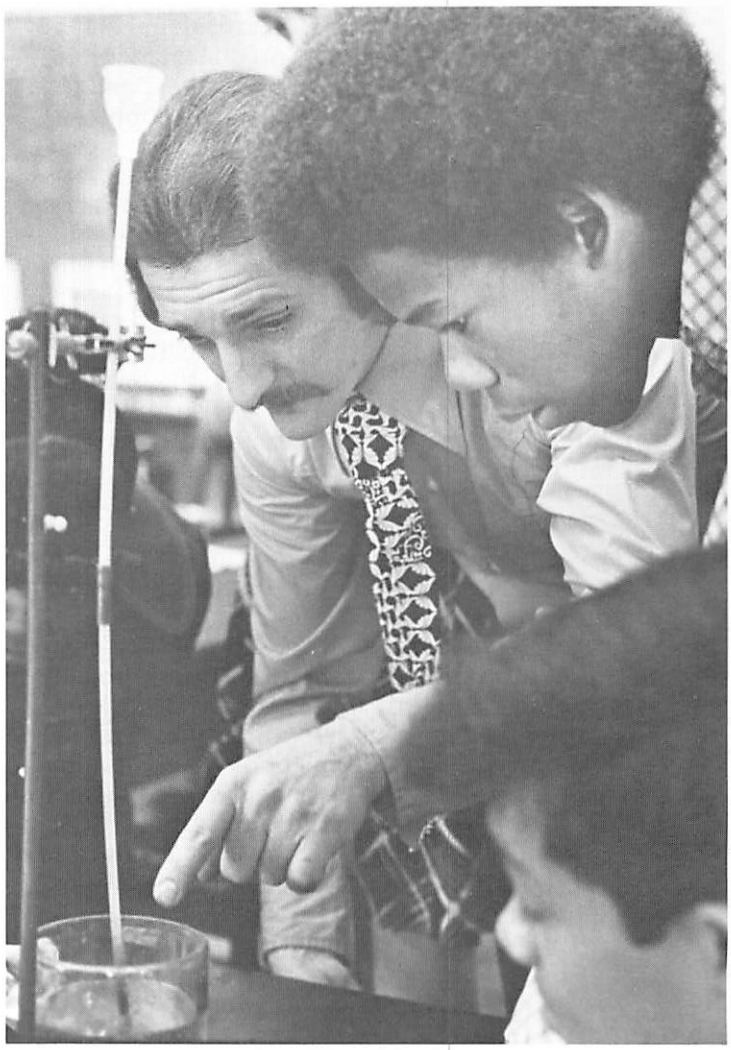
A popular MAS educational activity is the half-day-long trip at sea aboard the University's *R/V Wolverine*. This year over 525 students and close to 200 teachers had a chance to see firsthand oceanographic research techniques. A teaching unit based on the day at sea experience was written for the COAST materials so that teachers could set up lessons.

Advisory specialists have worked with the Delaware Department of Public Instruction and the Department of Parks and Recreation (DPR) on incorporating marine educational materials into their

programs. Possible programs were discussed for gifted students to research various problems in the coastal zone. The DPR has set up nature trails near the Lewes Marine Studies Complex and the MAS has been working with teachers on the flora and fauna of the area so they can instruct their students.

In the area of coastal zone management, Delaware's advisory specialist has worked on the analysis of water quality on the Broadkill River, Rehoboth Bay, Indian River Bay and Little Assawoman Bay. The work has been in cooperation with the Coastal Sussex Water Quality Management Program and the Delaware Coastal Management Program. Using a water quality model developed for the project, the effects of future changes in population and waste effluents were analyzed. The results of the study are a significant component of the proposed water quality management plan for coastal Sussex County.

Another task was the study of the water-based recreation potential of the New Castle County Delaware River shoreline. Preliminary work indicates there is significant untapped recreation potential of the area now that shoreline environmental problems are being controlled. One recommendation will be to develop a shoreline nature study area as well as a multiple activity park.



COMMUNICATIONS

A major tool in carrying out marine advisory activities is communications. Sea Grant's communications group supports both advisory and research efforts as well as carries out a separate project.

Eighteen technical reports and journal article reprints were edited and produced this year. A comprehensive marine publications catalog was compiled and produced. Included were all publications published by the College of Marine Studies. The third report of the Decisions for Delaware series, *Sea Grant Looks at Oil Spills,* was published and has been well-received.

Two newsletters were continued as a result of very positive responses to a reader survey. *OCS Update,* in its second year, informs interested citizens of the latest developments in the search for oil and gas on the Atlantic continental shelf. 91% of *OCS Update* readers rated it useful in their business or profession. *Seadrifts,* also in its second year, is a monthly compilation of marine-related clippings from area newspapers. 25% of *Seadrifts* readers read at least half of each issue.

Preliminary work was done on a new *SeaTalk* radio program format. *SeaTalk,* a specific project of the Sea Grant public information effort, began last year as 30-second public service announcements (PSAs), sent as written scripts to about 30 area radio stations. Plans for the coming year are to expand the PSAs to 60 seconds, to produce them internally and to mail four PSAs on tape each month.

Venturing further into electronic media, an educational color videotape on the mariculture program at Delaware was begun this year and the final product is expected to be ready soon. The tape will also be transferred to 16mm film so that it can be used in the classroom and for workshops and conferences where film equipment is available.

A brochure describing the mariculture research, *A Seafood Greenhouse,* was written and produced.

Three advisory bulletins were revised and reprinted to meet the continual requests for them: "Common Seashells"; "Delaware vs. the Sea"; and "The Horseshoe Crab." A new advisory bulletin on blue crabs was written and produced, in cooperation with the marine education advisory specialist.

Two more pamphlets in the Delaware Seafood series were published: on *crabs,* and *clams.* Pamphlets on lobsters, oysters, and underutilized species are forthcoming.

Americans and the World of Water, a reference text for the National Marine Education Project, was published and distributed by the Delaware Sea Grant College Program. The initial press run of 3000 is nearly depleted. The books were used by participants at 26 workshops held across the nation to discuss the need for marine education.

At the national level, Delaware continued to chair the National Sea Grant Communications Committee.

Dr. Carolyn Thoroughgood
College of Marine Studies;
College of Human Resources

Mr. Howard Seymour
College of Marine Studies

Mr. Ralph Williams
College of Marine Studies

Mr. William Hall
College of Marine Studies

Ms. Kathi Jensen
College of Marine Studies

Ms. Karin Danberg
College of Marine Studies

Dr. Paul Jensen
College of Marine Studies

Mr. Richard Keck
College of Marine Studies

Survey of the U.S. Clam Industry

With funds from the National Marine Fisheries Service (NMFS) funneled through Sea Grant, Delaware investigators did an extensive survey of the U.S. clam industry. The survey was eventually included in a report by NMFS, "The Molluscan Shellfish Industries and Water Quality – Problems and Opportunities," published in August, 1977.

More than 14 species of clams are commercially harvested in 18 different states but only four species account for 99% of the volume and dockside value of the total U.S. clam catch. In the clam survey report, major and minor clam species are reviewed with respect to the history, current status and expected future of each commercial fishery. Also, the investigators discussed industry problems at all levels and made recommendations for resource management.

Dr. Kent Price
College of Marine Studies;
School of Life and Health Sciences

Mr. Theodore Ritchie
College of Marine Studies

Publications

Coastal Engineering

Lanan, G. A. and R. A. Dalrymple. A Coastal Engineering Study of Indian River Inlet, Delaware. DEL-SG-5-77.

Klemas, V., et al. Delaware Bay Ice Conditions, 1977. DEL-SG-9-77.

Coastal Zone Management

Agnello, R. J., et al. Coastal Zone Recreational Activity and Potential Demand of Delaware Residents. DEL-SG-8-77.

Agnello, R. J., et al. Final Report: New Castle County Delaware River Shoreline Study. DEL-SG-18-77.

Biggs, R. B. Decisions for Delaware: Sea Grant Looks at Oil Spills. DEL-SG-13-77.

Murray, J. J., et al. A Case Study of a Comprehensive Marine Transportation System for the Delaware Valley Region. DEL-SG-12-77.

Education

Goodwin, H. L. Introduction to Marine Education.

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Project COAST. A List of Books on the Marine Environment for Children and Young People.

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_____. Audio-Visual Aids, Games and Art for Marine Environment Studies.

_____. Catalog of Curriculum Materials for Marine Environment Studies, Elementary and Secondary.

Mariculture

Epifanio, C. E. and J. Ewart. Maximum Ration of Four Algal Diets for the Oyster *Crassostrea virginica* Gmelin. (From: Aquaculture, Vol. 11, 1977). DEL-SG-14-77.

_____ and C. A. Mootz. Growth of Oysters in a Recirculating Maricultural System. (From: Proceedings of the National Shellfisheries Association, Vol. 65, 1976). DEL-SG-2-77.

Pruder, G. D., et al. Hatchery Techniques for a Controlled Environment Molluscan Maricultural System. DEL-SG-15-77.

Marine Biology

Islam, M. N. and R. A. Lea. Development of a Sardine-Like Product from the Mummichog *(Fundulus heteroclitus)*. (From Journal of Food Science, Vol. 42, No. 3, 1977). DEL-SG-17-77.

Winget, R. R., C. E. Epifanio, T. Runnels, and P. Austin. Effects of Diet and Temperature on Growth and Mortality of the Blue Crab *Callinectes sapidus*, Maintained in a Culture System. (From: Proceedings of the National Shellfisheries Association, Vol. 66, 1976). DEL-SG-16-77.

Marine Economics

Agnello, R. J. and L. P. Donnelley. Externalities and Property Rights in the Fisheries. (From: Land Economics, Vol. 52, No. 4, November, 1976). DEL-SG-3-77.

Marine Geology

Allen, E. A. Petrology and Stratigraphy of Holocene Coastal Marsh Deposits Along the Western Shore of Delaware Bay. DEL-SG-20-77.

John, C. J. Internal Sedimentary Structures, Vertical Stratigraphic Sequences and Grain-Size Parameter Variations in a Transgressive Coastal Barrier Complex: the Atlantic Coast of Delaware. DEL-SG-10-77.

Weil, C. B. Sediments, Structural Framework and Evolution of Delaware Bay, a Transgressive Estuarine Delta. DEL-SG-4-77.

Physical Oceanography

Mooers, C. N. K. and C. A. Parker. New York Bight: Physical Oceanography and Meteorology. Summary of an Informal Workshop. DEL-SG-6-77.

_____, ed. East Coast Ecosystem Dynamics: Summary of an Informal Workshop. DEL-SG-7-77.

Program Administration

Delaware Sea Grant College Program Annual Report, 1975-76.

Marine Publications, 1977.

Gaither, W. S., ed. Atlantic Offshore Users Workshop, May, 1977: Proceedings. DEL-SG-11-77.

_____. Proposed Atlantic Offshore Program, September, 1977. DEL-SG-19-77.

Advisory Services

Aprill, G. H. Common Seashells of Delaware. MAS-5 (revised printing).

Hall, W. R., Jr. Delaware's Blue Crab. MAS-11.

Kraft, J. C. Delaware vs. the Sea: Are We Losing the Battle? MAS-4 (revised printing).

Lewis, A. The Horseshoe Crab. MAS-6 (revised printing).

A Seafood Greenhouse. Pamphlet describing Delaware's closed cycle mariculture system.

Delaware Seafood. Series of six pamphlets of cooking and buying hints, and recipes for different seafoods found along Delaware's shoreline (finfish, crabs, oysters, clams, lobsters, and underused species).

OCS Update. Regular newsletter on mid-Atlantic oil and gas development.

Seadrifts. Monthly compilation of marine-related news clippings from local and regional newspapers.

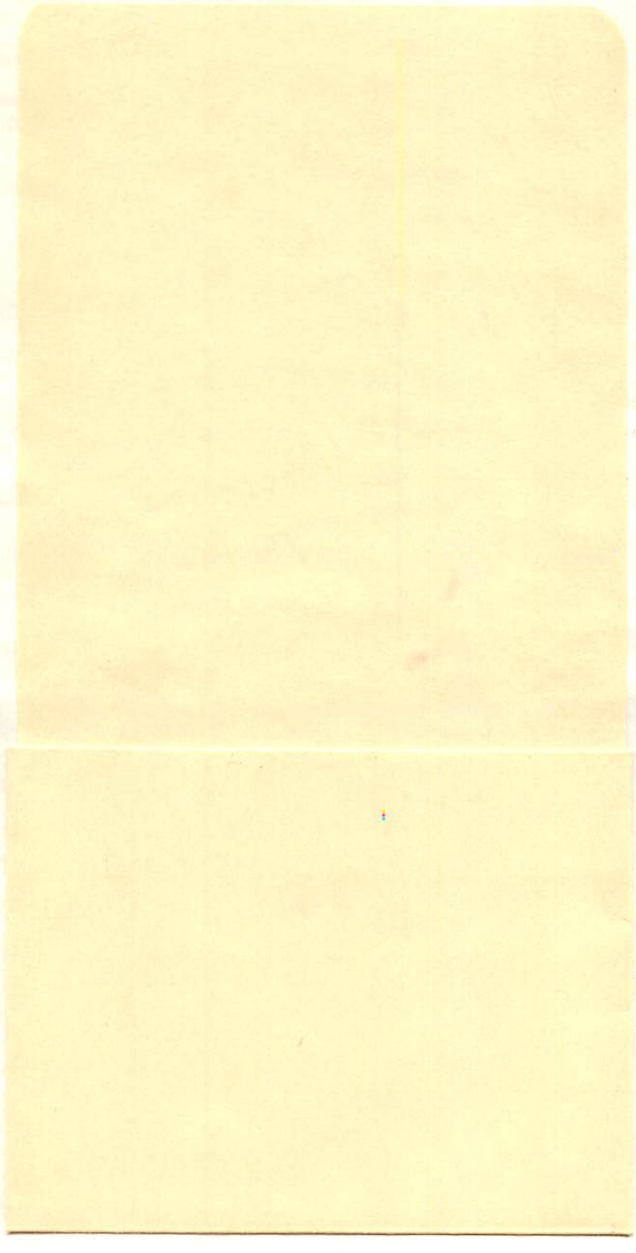
Program Development

	FY75	FY76	FY77
Program Management	C	C	C
Development of Food Resources and Marine Products			
Commercial, Closed-System Mariculture (Bolton)	C	C	C
Controlled Environment Mariculture (Pruder)	C	C	C
Shellfish Nutrition in Closed-System (Epifanio)	C	C	C
Trace Metal Requirements, Closed-System (Sick)			N
Ultramorphology of Shell Biosynthesis (Carriker)			N
Economic Aspects of Closed System (Anderson)			N
Microbiology of Closed System (Smith)	N	C	C
Purification by Ozonization (Bolton)		N/T	
Phytoplankton Kinetics Studies (Sharp)	N/T		
Legal Aspects of New Product Development (Bockrath)	N/T		
Water Chemistry Support (Srna)	N	T	
Research and Development Services (Srna)		N/T	
Crab Waste Chitin Development (Austin)	C	C	C
Tidal Wetlands			
Nutrient Flux, Energy Flow, Production (Daiber)	N	C	C
Halophytes as Potential New Food Crops (Somers)	N	C	C

	FY75	FY76	FY77
Coastal and Offshore Engineering			
Coastal Zone Coexistence Alternatives (Goodman)	T		
Management Model for Coastal Flood Planning (Anderson)	N/T		
Beach Erosion Control at Indian River Inlet (Dalrymple)	N	T	
Statistical Prediction of Tides, Waves (Tayfun, Yang)	N	T	
Coastal Engineering Assessment of Delaware Coast (Dalrymple)		N/T	
Geologic Structure Evolution, and Destruction of Coastal Barriers (Kraft)		N	C
Beach Erosion Control at Roosevelt Inlet (Dalrymple)			N
Shoreline Erosion Due to Extreme Storms and Sea Level Rise (Dean)			N
Coastal Erosion Induced by Rip Currents (Dalrymple)			N
Wind-Induced Effects on Coastal Sand Dunes (Lai)			N
Recreation			
Coastal Zone Recreation Development Opportunities (Rothman)	N/T		
Coastal Zone Management			
Local Governmental Capacities Related to Onshore Impacts from OCS Development (Warren)			N

N=New T=Terminated C=Continued

	FY75	FY76	FY77
Education			
Marine Education (Mangone)	N	T	
Curriculum Development, Coastal Zone Law and Policy (Bockrath)	N/T		
Symposium on Fisheries Management (Anderson)		N/T	
Marine Environment Curriculum Study Test (Stegner)		N/T	
Evaluation of Marine Environment Studies (Stegner)		N/T	
Coastal Oceanic Awareness Studies (Stegner)		N/T	
Distribution of Marine Environment Studies (Stegner)			N
Advisory Services			
Management (Thoroughgood)	C	C	C
Test Planting of Hard Clams (Keck)		N	C
Public Information (K. Jensen)	C	C	C
Coastal Zone Development and Management (P. Jensen)	C	C	C
Recreation and Tourism (Williams)	C	C	C
Commercial Fisheries (Seymour)	C	C	C
Add-on Projects			
Survey of U.S. Clam Industry (Ritchie, Price)			N/T
National Marine Education Policy (Schaadt)			N
Wave Energy (Pleass)			N



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