University of Delaware

Sea Grant Annual Report

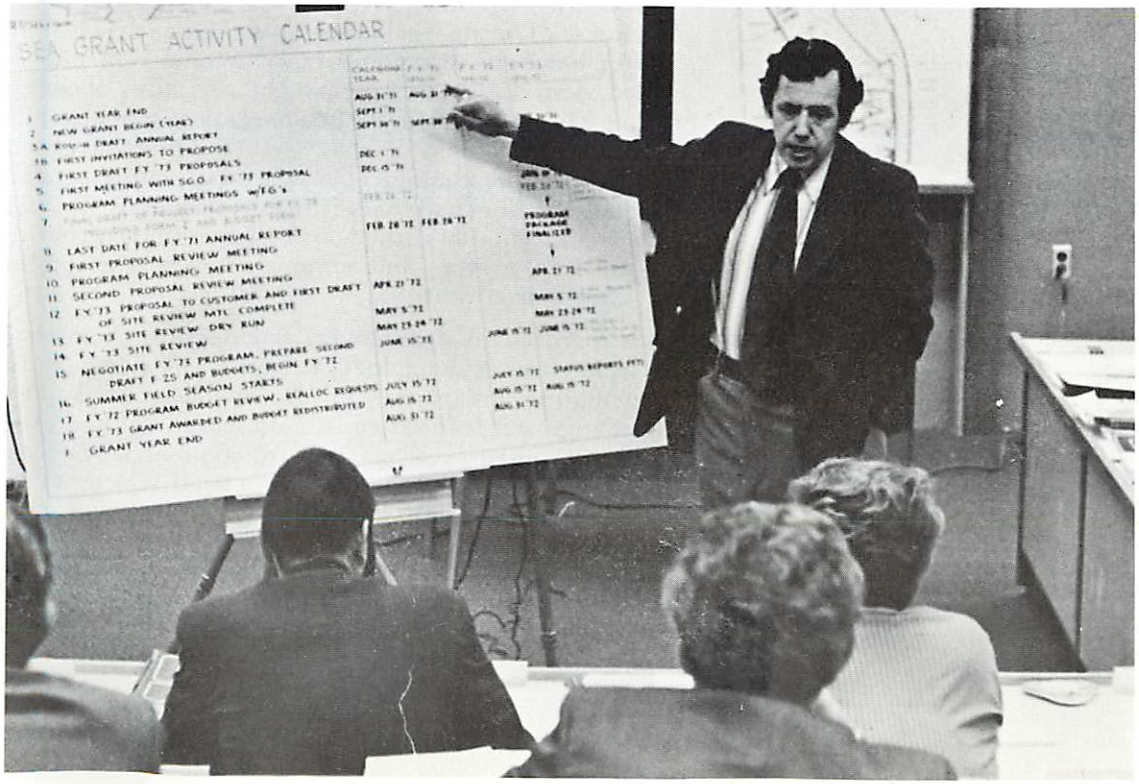
1971 - 72

Sea Grant

The National Sea Grant Program was created on October 15, 1966, with the signing of Public Law 89-688, *The National Sea Grant College and Program Act*. The purpose of the Act is to accelerate national development of marine resources, including their conservation, proper management, and maximum social and economic utilization. The term "Sea Grant" was chosen to emphasize the parallel between the present needs of the nation in the marine environment and the need for development of the land at the time of the Morrill Act of 1862, which established the Land Grant Program. The Sea Grant Program follows the pattern of the Land Grant Program only to a limited extent: it provides the means through which scholars and institutions of higher education can apply their knowledge and talents to the practical needs of the nation and the world, and it includes the Land Grant concept of advisory services through which scientific research results may be most directly applied to real problems.

The National Sea Grant Program, originally assigned to the National Science Foundation, was transferred to the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, the President's Reorganization Plan #4, in October 1970. Within NOAA, the Program is administered by the Office of Sea Grant.

Cover: *Frank Danberg*
Concept: *Anne Ritchey*



UNIVERSITY OF DELAWARE

SEA GRANT ANNUAL REPORT 1971-72

Director's Message

The Sea Grant program is a corner-stone of the University of Delaware's total marine studies development. It is unique among Federally sponsored programs for several reasons.

- It is problem-focused at the state, regional and national levels.
- It requires one-third non-Federal matching to secure a grant.
- It emphasizes information transfer through an advisory services program.

The University of Delaware made a positive commitment to the Sea Grant concept by establishing the College of Marine Studies in 1970. This interdisciplinary, professional, graduate school is dedicated to education and research into human marine problems in our estuaries, the coastal zone, and on the continental shelf. The College was also created to provide a "home" for the Sea Grant program in the University of Delaware community. This means providing leadership, a management structure, and a solid working base from which the Sea Grant problem solving approach can be shared with other units in the University, with regional industry, and with government.

At the University of Delaware, a Sea Grant project began in September, 1968. A Delaware marine problem—declining oyster production in the Delaware Bay—was attacked head on. This attack was based on established biological strength that had been created nearly 20 years earlier to conduct research on Delaware's marine resources. During the past three years of research, oyster hatchery techniques have become well understood. Also during this period, the pressures of population have been felt by more natural oyster grounds being closed because of pollution. This human related problem is not unique to Delaware but will effect the viability of shellfish harvesting everywhere. It was this realization that turned our research to the problem of growing oysters and other marine species under "poultry house" control.

This approach involves biology, engineering, chemistry, nutrition and epidemiology, to name a few important contributing disciplines. It also involves a planned team approach focused equally on a well defined problem, "Is closed cycle mariculture commercially feasible?" It was the asking of this question which set in motion the unification of all mariculture research into a single laboratory supplied by a local marine industry. This laboratory is now beginning operation and is well equipped and staffed to solve this significant problem.

Mariculture is not all that the Sea Grant program is about. During the developing years of 1968 through 1971, Sea Grant program support increased and a more comprehensive and complete program of research, education and advisory service evolved. In August, 1971,

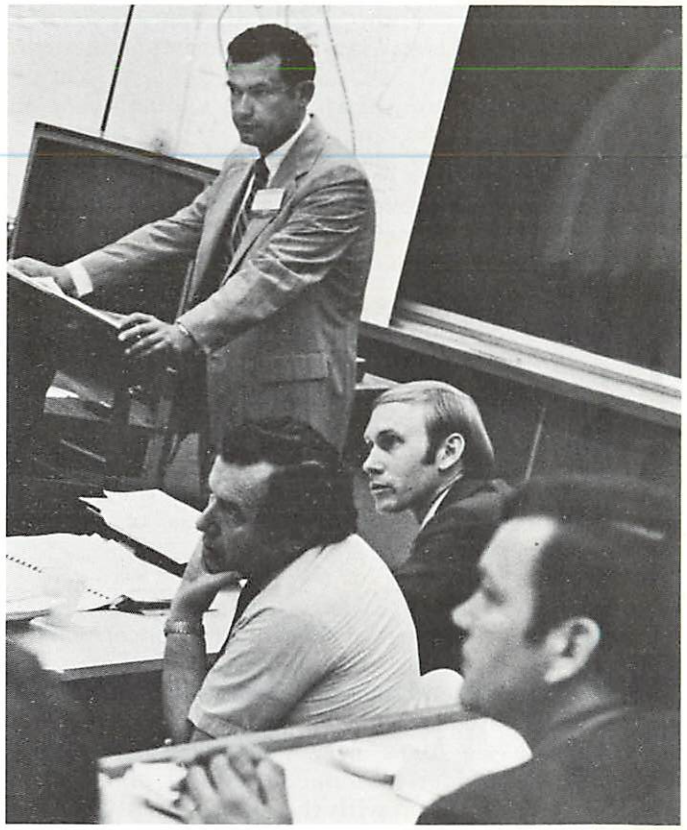
the University of Delaware was named the nation's 12th Sea Grant Institution. This was both a recognition of marine program breadth, depth and competence at Delaware and a commitment from Sea Grant program continuity via annual funding. As the program has grown, so have its well defined thrusts. In addition to the focus on mariculture (on food from the sea), other functional research groups were; System Engineering for Development Options, Socio-Economic Aspects of Coastal Zone and Marine Resource Development, Environmental Impact, and Coastal Zone Management.

In addition, in education at the university level, a graduate ocean engineering laboratory course was developed. At the K-12 level in secondary education, a marine environment curriculum development was begun.

The Advisory Service program, possibly the most important of all Sea Grant activities, was placed on firm footing as a full partner with the established Cooperative Extension Service which services agriculture so well. Work has begun in several areas including a sport fisherman's cooperative to build an offshore fishing reef.

The Sea Grant program represents approximately 30% of the University of Delaware's marine activities. Other programs are sponsored by the National Science Foundation, the Office of Naval Research, the National Aeronautics and Space Administration, the Delaware River Basin Commission, and the Delaware Department of Natural Resources and Environmental Control, to name a few. These are in addition to a growing university budget and large state appropriations for land acquisition and new facility construction for marine studies.

The College of Marine Studies and the Sea Grant program are contributing both leadership and knowledge to the solution of several important marine problems confronting the State of Delaware. These include participation in, and contribution to, the Governor's Task Force on Marine and Coastal Affairs as well as the publication of its 464 page final report, on July 1, 1972. The Sea Grant Director was named Chairman of the Delaware Bay Oil Transport Committee and the Associate Director to the State Planner's Advisory Board. The Director of Marine Advisory Services was named to chair a principal subcommittee of the Governor's Wetlands Action Committee.



These are but the outlines of the Sea Grant program at the University of Delaware during the program's first year as a Sea Grant Institution. Two additional years remain before Delaware is eligible to be considered for designation as a Sea Grant College. The 1971-72 year was a sound beginning to achieve that goal.

W. S. Gaither

William S. Gaither
Director

Introduction

This report summarizes the Sea Grant program activity of the University of Delaware for the period September 1, 1971 to December 31, 1972 including the first year of institutional status and the University's fourth year of participation in the program.

Program Guidance

The Delaware program has been structured around the general theme of improved understanding and rational development of the marine resources of the region within very general national program guidelines.

The program is therefore designed to be responsive to needs as defined by the following sources.

- Dialogue with state and regional agencies
- The Delaware Sea Grant Advisory Council, representative of special interest constituencies
- Feedback from concerned elements of the general public through information channels of Marine Advisory Services, and
- The findings of research

The Need

As with many other areas of the country, concerns with regional marine resources and coastal zone management locally transcend questions of economic exploitation. In Delaware, industry, recreation and conservation interests vie for a very limited resource on a regional scale. Understanding of natural phenomena and of man's interaction with the environment is either limited or non-existent, placing the marine and coastal zone resource manager in an extremely difficult position from a policy formulation and decision-making viewpoint. Under such circumstances, in the balance, the need for a broad base of knowledge and understanding far outweighs the need for "things," a premise which is reflected in the make-up of the Delaware Sea Grant program.

Program Administration

The Delaware Sea Grant program is administered through the College of Marine Studies (CMS), a graduate academic unit of the University. The research program is organized into functional groups. This provides flexible management organization. Disciplinary and program approaches are combined, as necessary, to make the most of the total investment.

Educational projects and Advisory Services round out the program.

RESEARCH PROGRAM

Research was a major and important aspect of the Sea Grant program during 1971—72. Five functional groups participated in this activity and the results are summarized elsewhere in this report.

The five functional groups and their leaders are:

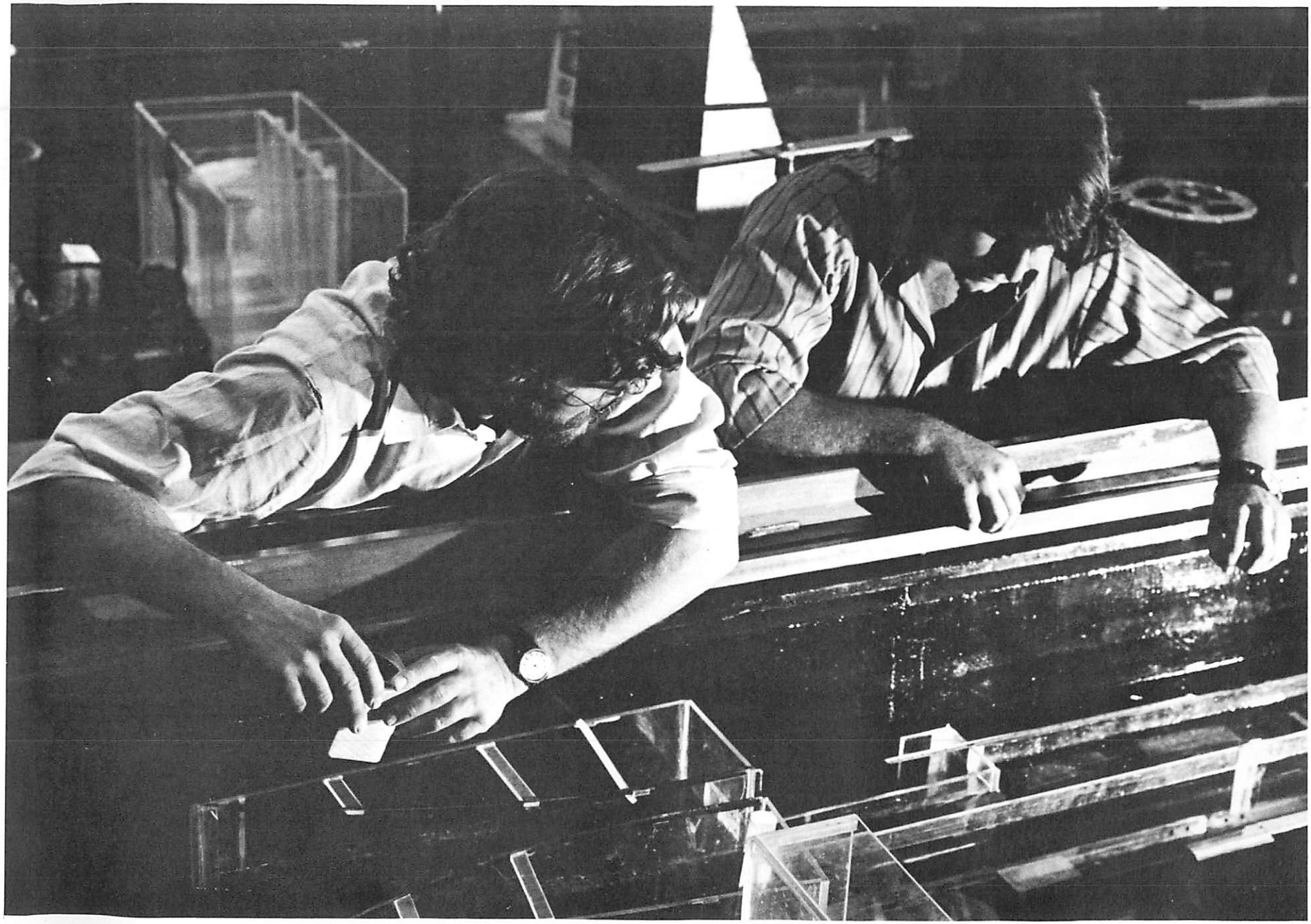
- Food from the Sea: A group of projects whose objective is to explore the technical and economic feasibility of re-developing the shellfisheries of Delaware through closed cycle mariculture and to identify newly exploitable resources. Dr. K. S. Price is the Functional Group Leader.

- System Engineering for Development Options: A group of projects aimed at defining engineering strategies for use in the coastal zone with minimum resulting environmental degradation. Dr. R. Richards is the Functional Group Leader.

- Socio-Economic Aspects of Coastal Zone and Marine Resource Development: A group of projects with the dual objective of evaluating the impact of socio-economic developments and the socio-economic structure that follows exploration of the physical and aesthetic properties of the coastal zone. Dr. R. Agnello is the Functional Group Leader.

- Environmental Impact: A group of projects which develops an improved understanding of natural and man-induced interactions with the coastal zone. Dr. R. B. Biggs is the Functional Group Leader.

- Coastal Zone Management: Projects which seek to improve the decision maker's understanding of coastal zone phenomena, and to provide these decision makers with actionable choices. Mr. J. M. Goodman is the Functional Group Leader.



FOOD FROM THE SEA

During the past 50 years the decline of all fisheries, including shellfisheries, in Delaware Bay has been dramatic. Recent causes include the MSX epidemic, natural disasters such as tropical storms, and the closure of shellfish beds due to pollution. There has also been evidence of a long-term trend which, since about 1890, has seen the crop fall from an annual average of 22 million pounds to scarcely more than ½ million before the onslaught of the previously mentioned, and more recent depredations.

The Delaware Food From the Sea projects are seeking ways to re-establish fisheries as a viable economic force in the development of the Middle Atlantic Region.

Mariculture Demonstration Project

Project No. R/A-4
Principal Investigator:
Dr. C. Epifanio
Co-Investigators:
Dr. M. Hartman
Mr. G. Pruder
Dr. R. Srna

The objective of the Mariculture Demonstration Project is to establish, on a pilot plant scale, the technical and economic feasibility of closed-cycle mariculture. The term closed-cycle means that the system recycles the primary process fluid (sea water) with minimum make-up for evaporation. It was felt that although most of the process components had been studied individually with oysters as the experimental animal, it remains to be proven that the sum of the parts would be viable. The design approach is intentionally conservative in order to maintain close control of a process which obviously still has many unknowns. Supportive research programs explore some of the higher risk design options.

Major Accomplishments of FY 72

- Definition of Research Plan
- Activation of Controlled Environment Recirculation Sea Water System and Process Facilities

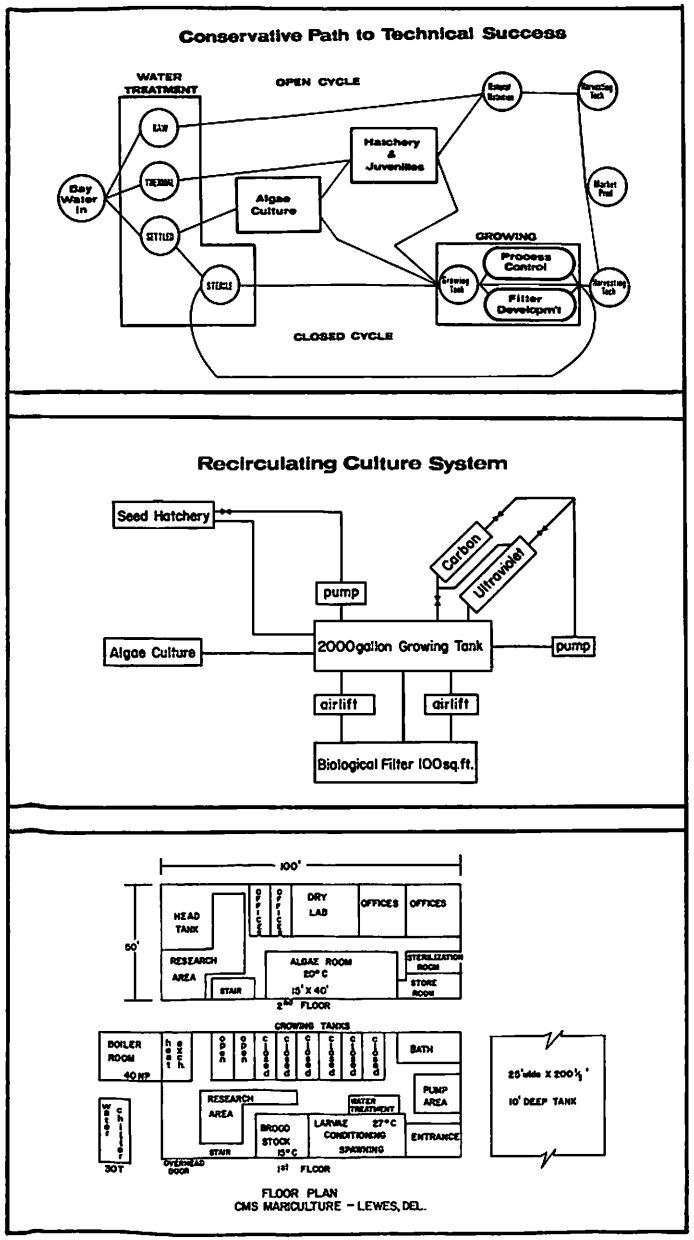
Define fast safe path to technical success for bivalve molluscs.

Large scale team research in science requires that some tested management methods be employed to assure the efficient integration and distribution of research effort. It has become apparent that mariculture research at the University of Delaware is such a program, and has reached a level of complexity such that PERT-type methods for managing many of the large government and industrial research programs would be of great value to the research team.

The technique, modified considerably to meet the special needs of the program, defined the lowest risk path to technical success in the controlled environment culture of bivalve mollusks: It appeared likely that a program could be completed within two to three years. Research projects underway, or in the planning stages have been assigned priorities based on imminent utility to the Demonstration Project (rather than on potential long-term benefits) and their importance in immediately traversing that "safest" path to technical success.

Although a milestone chart in the classical PERT mold is useful, the accompanying process-flow diagram is

more valuable for the purposes of tracking the progress of the demonstration projects. The major subsystems of concern to the project are those identified below.



Identify project accomplishments required along the path

The first 2,000 gallon closed-cycle culture system contains 50,000 oyster spat introduced after 3 weeks of filter conditioning. The spat are fed a cultured algae mix for 8 hours per day during which time filters are bypassed; during the remaining 16 hours filtered and treated water flows past the spat at 5 gpm.

Two Phase Water Quality Program; baseline monitoring and recirculating system management.

A program has been established for the routine analysis of the chemical status of the recirculating water culture. Since it appears from the literature that the quantitative relationships between the variables in a recirculating system have not been developed, the purpose of the chemical analysis is:

1. To define quantitatively the system components and system interactions which affect the quality of the growing environment.
2. To define and maintain water treatment subsystem performance.
3. To help monitor the health and viability of the recirculating culture system.

The table below summarizes the monitoring program.

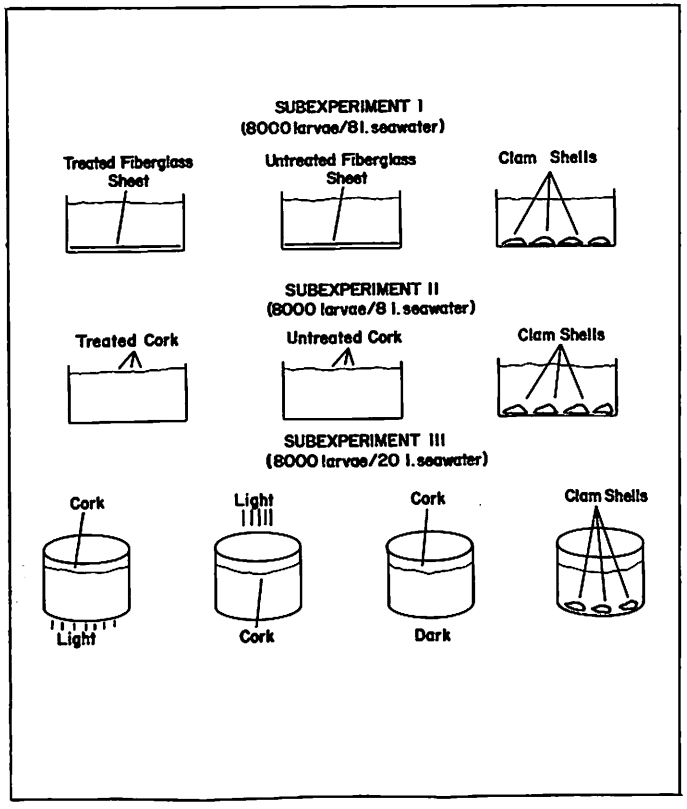
Chemical Monitoring of Recirculating System

Chemical Component	*Method*	*Effect on System*
Inorganic ions and salinity	Ion specific electrodes	Evaporation and codistillation in system will change total salinity and ionic make-up of seawater.
Heavy metals	Atomic absorption spectrometry and flame photometry	Potential build-up of these metals in shellfish
pH and alkalinity	Ion specific electrodes	Low pH indicates degradation of system
Sulfide ion	Ion specific electrode	High concentration indicates reducing environment and degradation of system
Nitrogen containing nutrients	Ion specific electrode and Diazo reaction with colorimetry	High ammonia = biological filter defunct High nitrite = potential toxicity Increasing nitrates = system working well
Phosphates	Standard colorimetric technique	Increasing phosphates = eutrophicating system Long term problem. Potential blooming of unwanted algae.
Dissolved O_2	YSI oxygen meter	Levels below saturation indicated degrading system. Levels going into biological filter should be higher than those coming out of biological filter in healthy system.
Dissolved organics	Wet oxidation	High COD indicates degrading system with much substrate for bacterial or fungal growth. Also oxygen sink.

In this first year of designing and equipping the closed-cycle Mariculture Demonstration project, there remain some process developments which should be completed that may have a significant influence upon process design parameters and process options for demonstration start-up. The design of the hatchery process and larvae nutrition are the two principal factors requiring continued investigation.

Oyster Spat Attractant

Preliminary results from two replicates show that a 10% oyster glycogen coating appears to promote single spat oyster set on floating cork and fiberglass approaching that on natural shell cultch.



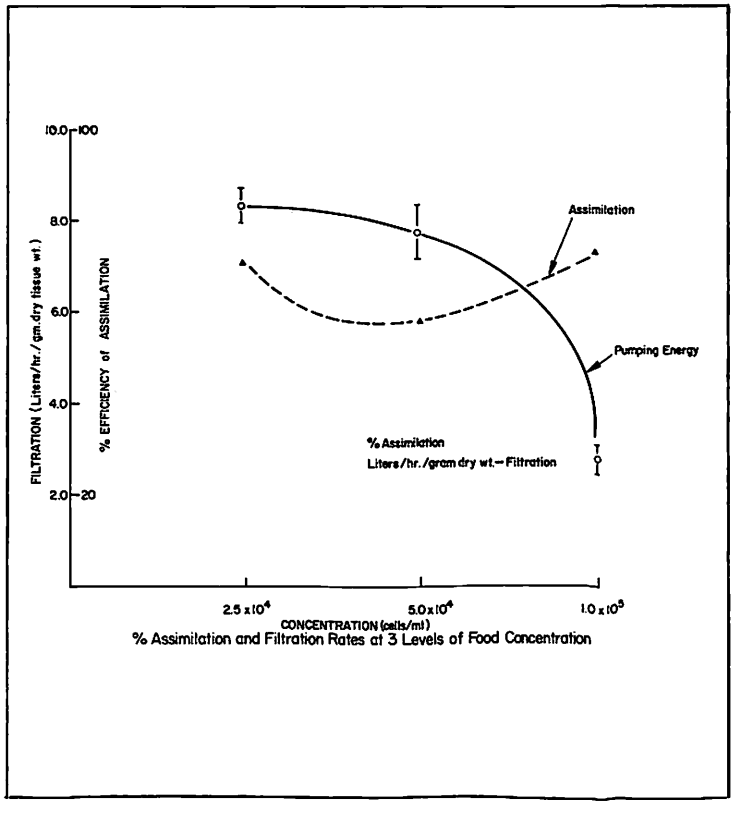
Shellfish Development and System Engineering for Mariculture

Project No. R/A-1
Principal Investigator:
Dr. C. Epifanio
Graduate Students:
C. Langfoss
C. Mootz

Oyster Energy Budget

Consumption=
- Production plus
- Respiration plus
- Feces plus
- Urine

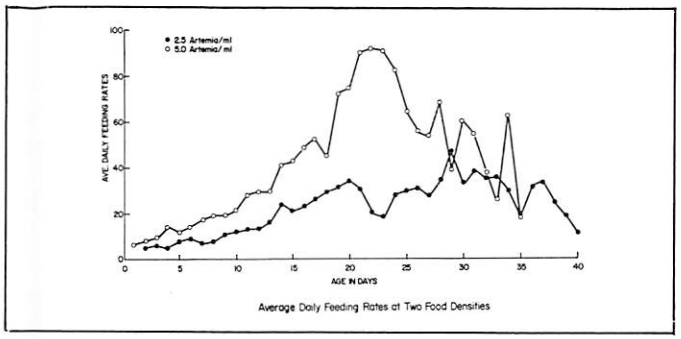
The energy portioning by oysters in 12 hour runs at three levels of algae concentration *(Phaeodactylinn tricoputiun)* indicates efficiences of assimilation ranging from a low of 58% at a concentration of 5 x 10^4 cells/ml to about 70% at 2.5 and 10 x 10^4 respectively. Over the same range of concentrations, filtration effort markedly decreased as cell concentrations reached 10 x 10^4 cells/ml.



% Assimilation and Filtration Rates at 3 Levels of Food Concentration

Energy Budget for Crab Larvae

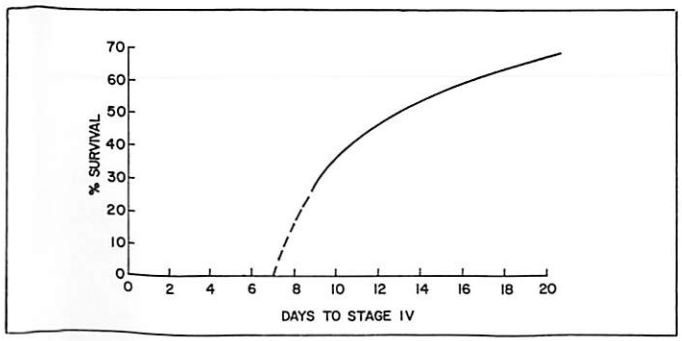
Feeding rates of Florida Stone Crabs for four densities of Brine Shrimp have been completed as a first step toward determining the cost of the mass culture of crab larvae for mariculture use. Gross growth efficiencies of as much as 31% have been recorded for periods up to 1st crab stage at a feed density of 5 shrimp/ml.

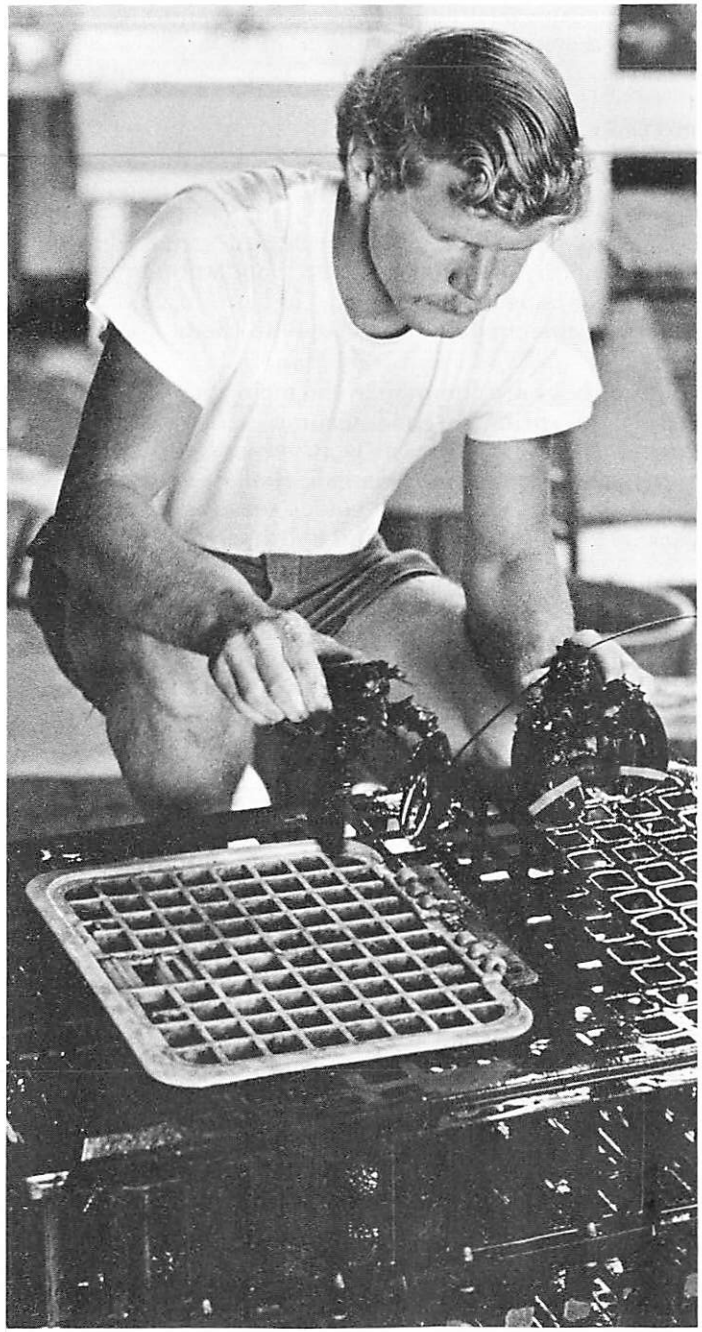


Average Daily Feeding Rates at Two Food Densities

Lobster Culture

There is a reasonable chance that overfishing of the limited Delaware lobster habitat will diminish the present lobster population. The mass culture of young lobsters for stocking the area or for mariculture therefore warrants investigation. Preliminary studies show a trade-off between time for larval development and percent survival which should be pursued if economical exploitation of the resource is to be achieved. Newly hatched Brine Shrimp seem to be a particularly good food for lobster larvae.





The Potential of the Mummichog as a Fodder Species

Project No. R/B-1
Principal Investigator:
Dr. V. Lotrich
Graduate Student:
William H. Meredith

The estuarine tide marsh is often referred to by ecologists as a highly productive area in a biological sense. Its productivity is ascribed to the presence of many steps in the food chain between marsh plants and commercially valuable species which find their way to the dinner table. Among those species thought to be important links in the food chain is the mummichog *(Fundulus heteroclitus Linnaeus).*Populations of the animal appear to have a limited distribution range. Thus it seems conceivable that a given population might be locally contained,*in situ,*for the benefit of a commercially valuable predator confined with them.

Mummichogs are common in the major tidal creeks only from late spring to mid-autumn. Their occurrence during the rest of the year is as yet undetermined, but many can be found in the small, shallow tributaries of the main creek during the colder seasons (probably in close association with the mud bottoms).

Population dynamics and bioenergetics of the mummichog are being studied to determine if a harvestable potential exists in tide marsh creeks (salinity 6-24$^{o}/_{oo}$). The usable biomass for man will depend upon two factors: 1) The quantity and importance of the mummichog in the salt-marsh ecosystem and, 2) The economic feasibility of rearing and capture methods. This project is presently concerned with the first aspect.

Present population estimates are applicable only to the summer months. Results from a mark-recapture program for estimating population size, gave a mean of 33,000 fish per km of bank; the estimates decrease upstream as the creek becomes less saline. The mean weight of a 600 fish sample was 8.0 gm. Thus, the standing crop of mummichogs in the one km stretch of tidal creek in June is estimated at 264 kg, or, 264,000 calories of energy per km.

Through mark-recapture techniques, a summer distribution range of about 36 meters per individual has been determined. The adaptive value and mechanisms for maintaining this small home range have not been discovered, but the implications for suitability of rearing are obvious. This limited range breaks up and expands during the colder seasons. However, individuals have been noted returning to the same geographical location in the main creek as in a previous summer once the narrow home range is again established. No extensive immigrations or emigrations were noted once the summer range was formed.

They appear capable of withstanding crowding and confinement without affecting growth rate.

Common late May through early October

Usable biomass

The large numbers are well adapted to withstand onslaughts of predation.

Estimated at 264,000 calories of energy per km of stream bank

With a distribution range of 36 meters per individual

The large numbers of mummichogs are well adapted to withstand either constant or temporal onslaughts of predation by marsh birds, blue crabs, diamondback terrapins, white perch, summer flounders, and American eels without drastically reducing the standing crop. The American eel *(Anguilla rostrata Lesueur)* is not evident in the tidal creeks during the summer, but in early fall swarms into the creeks and consumes sizeable numbers. The significance of this food resource to the eel population is not known. More extensive predation studies will be done to determine its importance in the marsh food web.

Approximately 122 fish were entrapped in a pen extended 4 meters out from the creek bank 36 meters in length (the bank was used as one side of the pen); and 2 meters in depth. During low tides, the usable portion of the penned area for the fish was decreased by almost 60%. This produced a highly concentrated population of fish, practically a swarming mass. However, the mean growth increment of this high density population did not vary from the mean growth increment of unpenned fish after a seven week confinement period. Thus, it appears that mummichogs can withstand crowding and confinement and do not have their growth rate affected as long as a free-flowing current is not prohibited. The application of this fact to rearing possibilities or stocking of pens with predators holds promise.

SYSTEM ENGINEERING FOR DEVELOPMENT OPTIONS

The ability of man to cope with the engineering aspects of development problems in the coastal zone requires an understanding of the natural processes at work. More specifically, knowledge of the location and makeup of areas subject to unusual erosion or accretion, and their susceptibility to storm damage or unusual sediment accumulation, is important to an understanding of how tidal marsh sand dunes or sediment accumulations are damaged by engineered structures and devices which modify flow regimes, topography, ambient light levels or flushing patterns.

In light of these observations, the approach taken to developing projects within this group has stressed an early understanding of the naturally prevailing conditions followed by engineering studies of development options which must co-exist with that environment.

The coastal zone attracts development and industry for many reasons. Its shoreline is aesthetically pleasing and attractive recreationally. It is attractive to industry as the sea presents easy access to raw materials, a source of cooling water, and a sink for the disposal of wastes.

It is not surprising that engineers who deal with this attractive, dynamic but fragile environment have adopted either of two extreme strategies for development work: Avoidance of the zone or complete modification by filling or dredging.

If a more rational approach is to be taken to construction in the coastal zone, there is evidently a need for some sort of help to be provided for designers of coastal zone structures such as a design-aid handbook combining methods, aids, illustrations and commentary.

Meteorological and Human Factors in Coastal Storm Damage

Project No. R/C-1
Principal Investigator:
Dr. J. R. Mather

Storm damage to the coastal zone area is a subject of considerable significance to the state of Delaware with its extensive coastline. Studies of this subject have provided a detailed catalog of storms from the past 30 years. At the same time, land-use maps have been prepared from aerial photos made over the past two decades which point out potential high damage areas. Preliminary field studies, interviews, and low-level aerial overflights have provided the framework for more in depth studies. Traverses and observation points extending from shoreline to inland control points have been established to test the variability of damage within specific hazard zones.

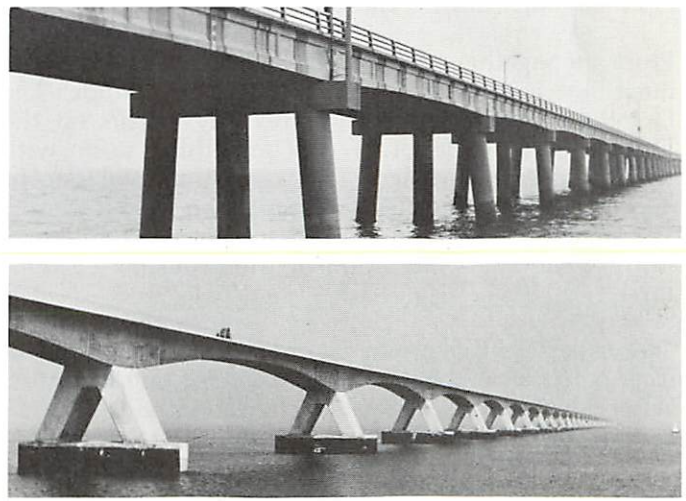
Convective Flow Near the Bay and Ocean Floor

Project No. R/T-2
Principal Investigator:
Dr. F. A. Costello

Temperature and velocity around a submerged heated body were investigated through the use of a laboratory model simulating a nuclear reactor on a submerged habitat. Purpose of the experiment was to determine the effect of water depth on the various flow fields. Existing theories for prediction of plumes and jets resulting from these submerged bodies were also examined. As a result, it was shown that thermally induced artificial upwelling is important in the deep ocean for power dissipations such as would characterize power stations. Another finding was that there is a deficiency in predictive techniques for the flow region where the plume impacts the ocean surface.

Design Strategy in a Coastal Environment

Project No. R/T-1
Principal Investigator:
Dr. R. Richards, Jr.



Comparison of marine viaducts: Chesapeake Bay bridge and tunnel (top), Oosterschelde Bridge (bottom).

SOCIO-ECONOMICS OF COASTAL ZONE AND MARINE RESOURCE DEVELOPMENT

Social and economic forces are both a beginning and an end to marine resource development. Therefore, it should be easy to understand that changes of many types may result because of the action of these forces. At the macroscopic level, for example, the local life style of the Coastal Zone Community may be markedly affected by development options. In contrast, at the microscopic level, the engineering-economic study of development opportunities may show widespread effects, with but minor local disturbances.

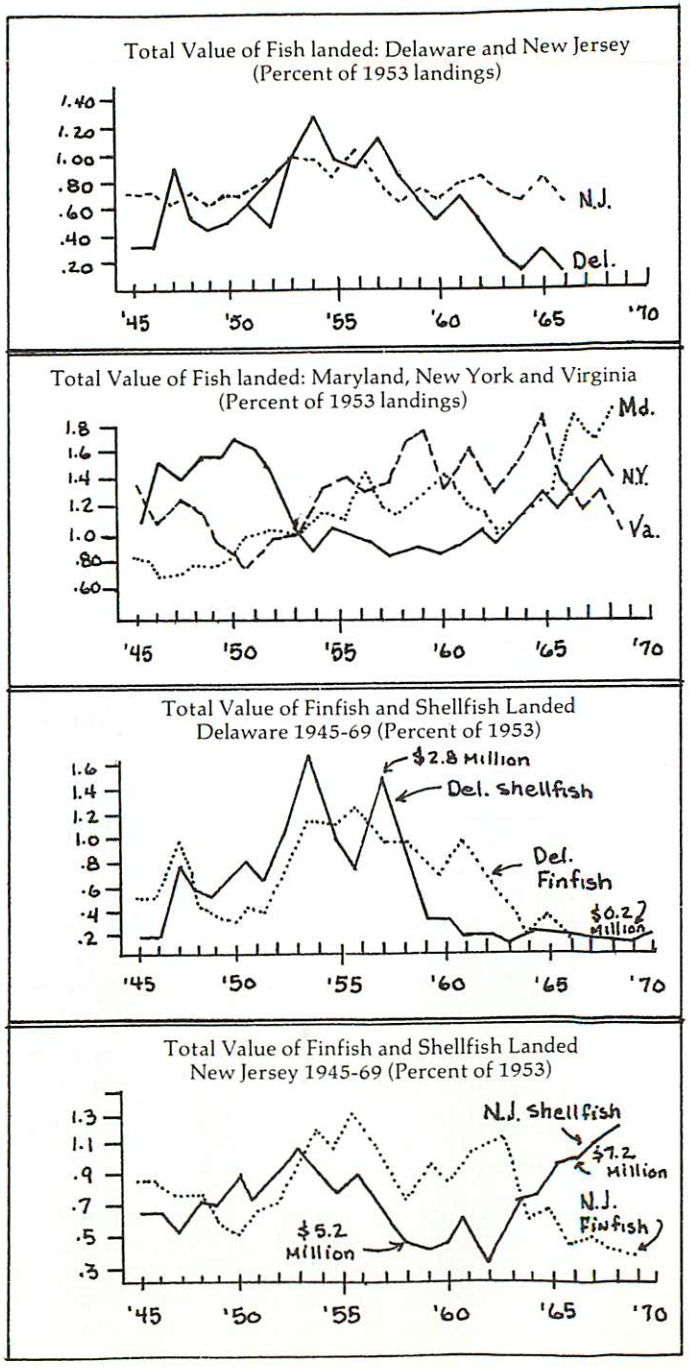
Delaware's Commercial Fishery

Project No. R/E-2
Principal Investigators:
Dr. R. Agnello
Dr. L. Donnelley

From Virginia north to New York, the states bordering the estuaries, sounds, and ocean have experienced significant changes in the value of their commercial fisheries landings during the period from 1945 to 1969.

From among these states, New Jersey's experience is most like that of Delaware's except in magnitude. The fact that landings for both states rely in part on the Delaware Bay undoubtedly has something to do with their similar experience. This partial mutual dependence suggests that a close comparison of differences and similarities between the fisheries of the two states can provide some indication of the problems encountered.

The projects in this group examine this broad spectrum of possible socio-economic and techno-economic interaction within a regional perspective to provide governmental and industrial planners and economic development agencies with information needed to intelligently guide the future of their respective constituencies.



Shellfish rather than finfish account for a large part of the differences in landings for the two states. The finfish series of data illustrate virtually identical trends, with both states having attained their highest yield in 1956 and having since decreased significantly. The decline, however, has been larger for Delaware since menhaden, which had accounted for just about all of Delaware's finfish catch, whether measured by weight or by value (92%), had almost completely disappeared from Delaware's offshore waters by 1966. Although menhaden had also been the principal finfish for New Jersey, it had not dominated the catch to the same extent.

New Jersey and Delaware show similar drastic decline in finfish due to loss of menhaden.

Oysters, crabs, and clams account for almost the entire output of Delaware's shellfish industry; for New Jersey the list also includes Northern lobster and scallops. In absolute terms, Delaware's maximum postwar shellfish catch of 9.874 million pounds for 1957, was only seven percent of the mid-Atlantic region's total catch.

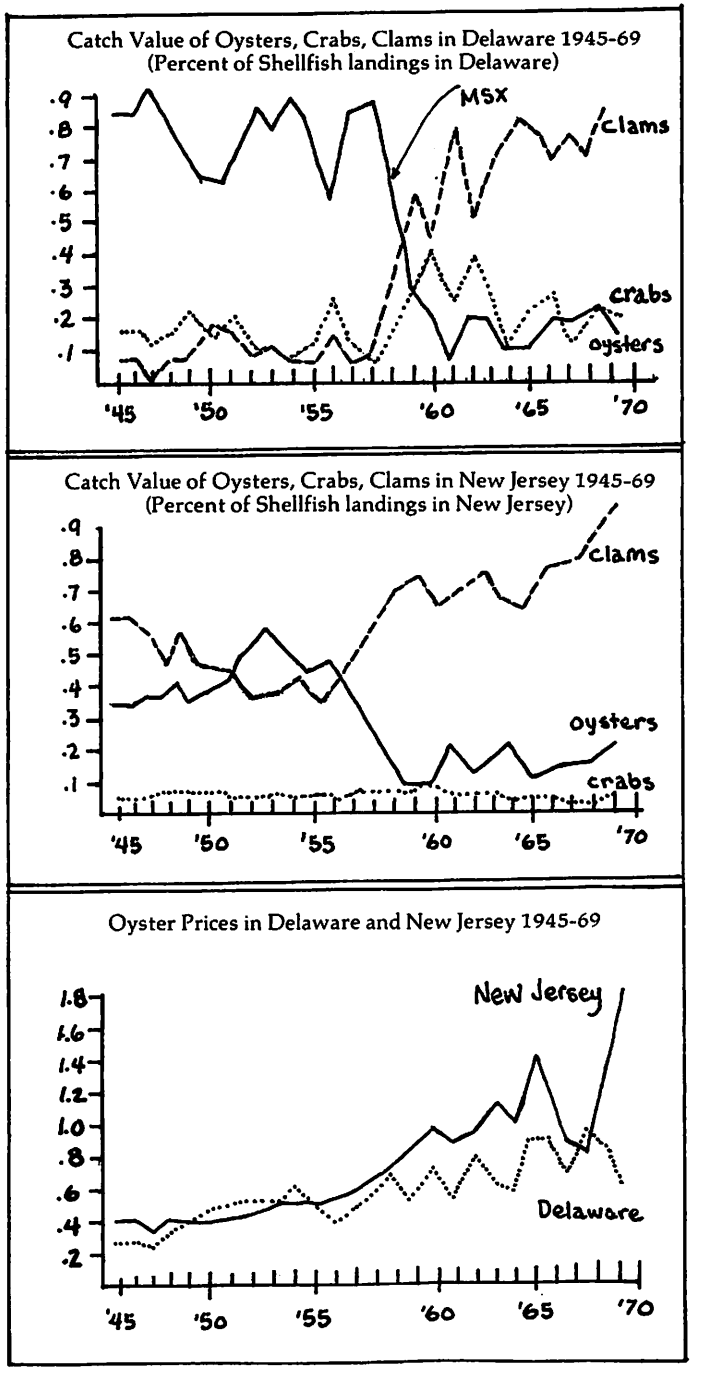
Shellfish, in particular oysters, account for the disparity in the trends of New Jersey's and Delaware's commercial fisheries. Historically, oysters have been Delaware's most important commercial shellfish, comprising 81 percent of the value of commercial shellfish production in 1958.

Whereas both states suffered setbacks in production during the 1950's due mainly to MSX disease of oysters, New Jersey has since recovered and, until very recently, Delaware's industry has continued to contract.

New Jersey and Delaware suffered shellfish production setbacks during 1950's because of MSX oyster disease. By 1968 New Jersey had recovered; Delaware had not.

Other factors influencing the oyster stock include the general worsening of the water quality in Delaware Bay, and nonreplenishment of cultch or substrate.

Some evidence also points to overfishing and to declining marketability of the oyster. The latter is the subject of continuing study.



ENVIRONMENTAL IMPACT

Enviromental impact is a subject of growing national concern. Along with population growth and improved technology has come the recognition that man,as an animal and through his institutions, has the potential for destroying the environmental resources so essential to his well-being.

There are, of course, many aspects of environmental impact that must be understood if we are to manage effectively the use of limited and sensitive resources. Characteristics of ecosystems and processes, methods for measurement and monitoring, and institutional arrangements for regulation and control are all essential to sound management.

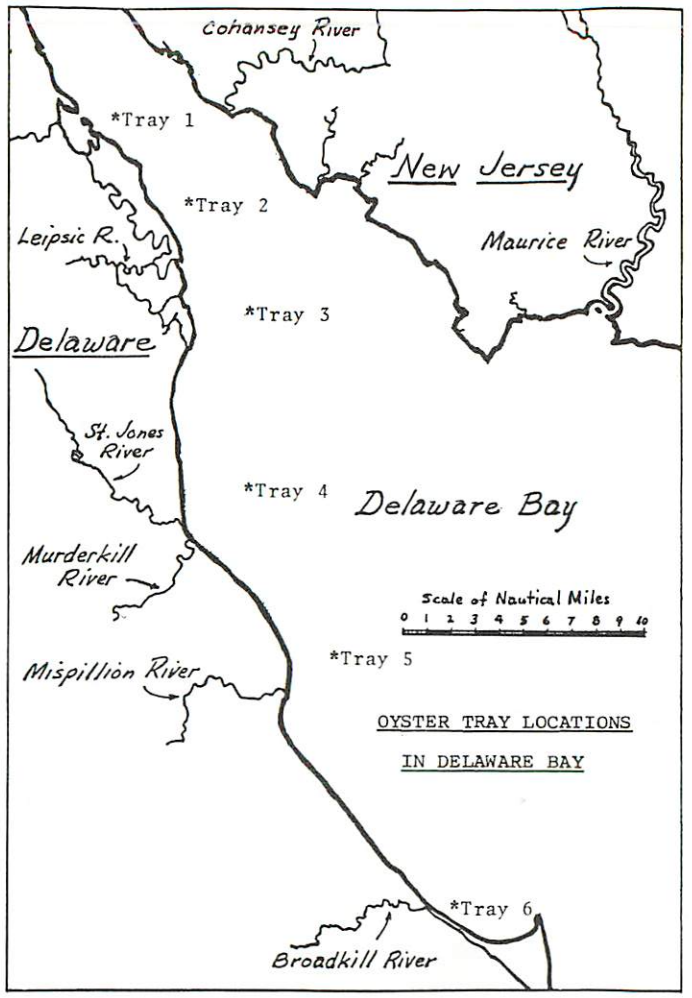
This series of projects examines a number of ecosystem characteristics and aspects of impact for a variety of natural and man-related uses of the coastal zone.

A saline habitat, such as is found in tidal marshes of the Atlantic Coastal Plain, might be expected to pose severe constraints upon plant growth because of the high concentrations of sodium and chlorine ions in the sea water which periodically floods them. It has been known for many decades that calcium is required for normal growth of higher plants and in upland soils, clays are the major reservoirs. The high concentration of sodium in sea water might be expected to largely displace calcium from exchange sites on the clays in marsh soils. Therefore this reservoir might be largely depleted. Hence calcium nutrition of marsh-inhabiting plants which are very significant in the food web of the estuary because of their vigorous growth, is something of an enigma.

The approach to examining the cycling of calcium in a tide marsh which is taken here is to examine various pools with which this ion might exchange. Blue-green algae which are ubiquitous in tide-marshes might fill this possible role.

The Role of Algae in Nutrient Cycles in Tidal Marshes

Project No. R/N-3
Principal Investigator:
Dr. G. Fred Somers



Bioaccumulation of Metals

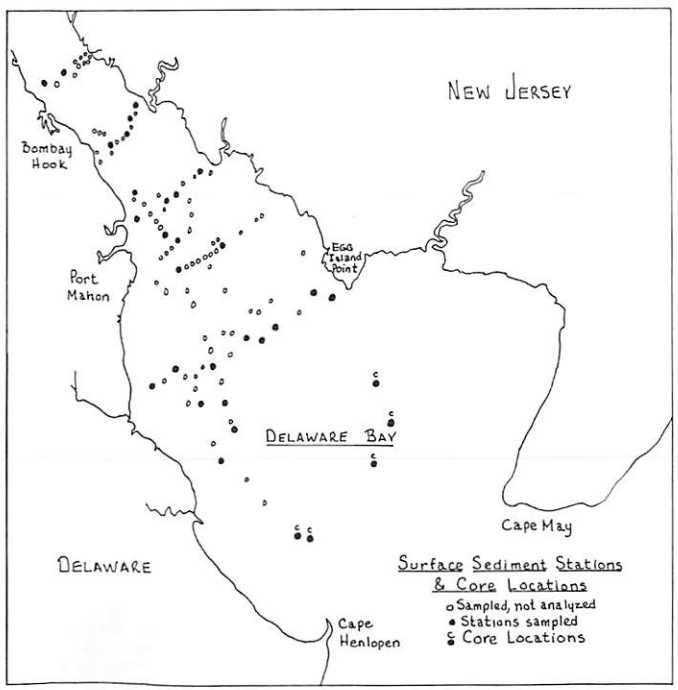
Project No. R/W-2
Principal Investigator:
C. A. Lesser

The presence of environmentally active trace metals in varying concentrations in the sediments of Delaware Bay leads to questions concerning their presence in commercially valuable shellfish, and their rate of accumulation in these animals. Might it be possible, in fact, to use such animals as part of a system which warns of impending danger to the ecosystem?

Non-metallic trays loaded with oysters have been placed at selected sites within the bay in order to gain an answer to these questions.

Comparisons between test and control sites after a single 24 day test span lead to the preliminary conclusion that the oyster responds significantly to changes in copper and zinc within that period. However, much remains to be done to determine the oyster's sensitivity as an indicator species.

From the distribution of organic residues in a relatively small number of samples taken from Delaware Bay, it appears that the main reservoir of organic matter lies in the middle bay area. This area must supply food for benthic organisms throughout the middle and lower bay areas. Widespread dredging or filling in the middle part of the Bay might exert an imbalance in the food chain of Delaware Bay that would prove detrimental to resident shellfish and game fish populations. From a single deep core taken in the Wilmington Canyon, it appears that the continental slope environment is more favorable than either middle or lower Delaware Bay for the accumulation and preservation of settled organic matter.



Biogeochemistry of Sediments of Delaware Bay

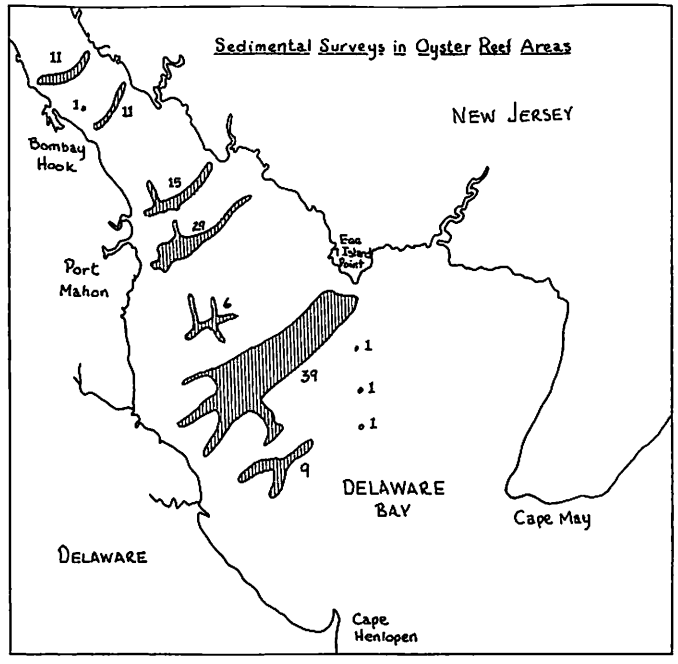
Project No. R/G-4
Principal Investigator:
Dr. F. M. Swain

A sedimentological survey of the oyster reef areas of Delaware Bay resulted in the observation that fine grained sediments, possibly carriers of extraneous materials, are concentrated to a large extent on the Delaware side of the bay making it more susceptible to pollution from upriver sources.

Environmentally active extraneous materials, such as trace metals, pesticides, etc., may be biochemically removed from sediments by living organisms including commercially valuable filter feeding animals such as oysters and clams. As a result of the application of inorganic techniques that approximate natural processes, an atlas of the distribution of environmentally active materials has been produced identifying potentially dangerous growing areas.

Trace Metal Environments Near Shell Banks in Delaware Bay

Project No. R/G-3
Principal Investigator:
Dr. R. B. Biggs



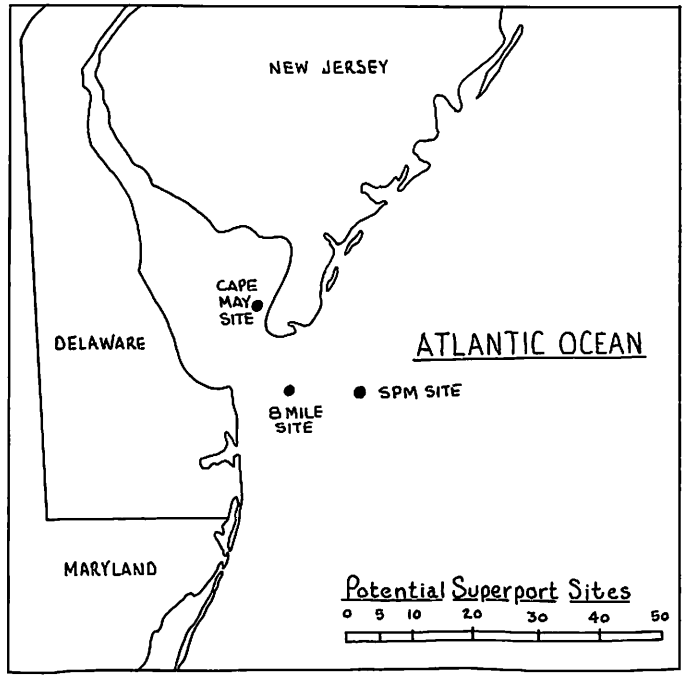
The questions of "Why and where superports?" are a national concern with strong local economic, social and environmental impact. Initial reactions to the superport questions range from total acceptance to outright hostility, frequently with little basis in fact. In order to improve understanding on this subject there have been numerous studies undertaken by Federal agencies including the U.S. Army Corps of Engineers, the Maritime Administration of the Department of Commerce, state agencies with jurisdictional authority over potential port sites and academic institutions in these same geographical areas. Delaware is among those areas which have studied the question in greater depth.

Summary Results

1. Developed informed scientific opinion on probability effects on important ecological and commercial species.
2. Defined areas particularly susceptible to harmful effects.
3. Described spread and fate of oil spills.
4. Ranked proposed sites in terms of environmental vulnerability.

Environmental Vulnerability of the Delaware Bay Area to Supertanker Accommodation

Project No. R/O-1
Principal Investigators:
Dr. D. Maurer
Dr. H. Wang



COASTAL ZONE MANAGEMENT

The management of the coastal zone is a problem of natural concern as borne out by the Coastal Zone Management Act of 1972. As stated in the Act, ". . . present State and institutional arrangements for planning and regulating land and water uses in the coastal zone are often inadequate to deal with the competing demands and the urgent need to protect natural systems in the ecologically fragile area." In part, these inadequacies stem from a lack of perception of problems related to coastal zone development, the absence of priorities for required problem solutions and a lack of adequate understanding of natural and social processes which relate to use of the coastal zone resource. The two projects described in this section are designed to resolve some of these difficulties for Delaware while simultaneously developing a methodology with transfer value.

The coastal zone is recognized as an area of conflict. It is a limited resource subject to development pressures which, if satisfied indiscriminately, could adversely affect conservation or recreational values. Just how important are these issues in the eyes of decision makers who represent the various constituencies of the coastal zone? A first step has been taken in developing an understanding of these issues in Delaware.

Perspective of Coastal Zone Development Issues

Project No. R/M-1
Principal Investigator:
J. M. Goodman

An informal survey of various state constituencies was made to determine unresolved issues and various areas of consensus. The survey included the following:

Participants 100
Respondents 25

Represented Constituencies

State Exec Dept.	*Civic Clubs*	*Trade Unions*
State Legis.	*LWV*	*Small Businessmen*
Local Chambers of Commerce	*Conservation Groups*	*Educators*

Typical Unresolved Issues

- Whether people believe coastal zone recreational use is or is not as destructive as industrial use of the coastal zone.
- Whether industry, conservation and recreation are incompatible in the coastal zone.

Typical Areas of Consensus

- Very important to improve use and quality of marine environment,

but

- Improving use and quality is low on list of priorities compared to health, welfare, unemployment and defense.
- Acceptability of industrial development in coastal zone *would not* depend upon deriving sufficient income to balance state's budget.
- The cost of establishing and maintaining the desired quality of the marine environment should be recovered from taxes and increased prices.

Management agencies and public policy-decision makers at local, state, and Federal levels require a continuous supply of sound information in order to implement resource management policy. All too often their decisions are delayed for years while awaiting the results of studies that are conceived and executed under pressures for immediate results. The concept of the coastal zone laboratory offers the prospect for satisfying information requirements in an expeditious manner, through well conceived research programs.

Top Seven Research Priorities

- Development of coastal recreation centers
- Development of predictive models for Delaware Bay
- Rehabilitation of shellfish industry
- Management of sportfish habitats
- Development of organizational structure for coastal zone
- Creation of financial incentives for coastal zone development
- Identification strategies for engineering development in a coastal environment

The first major step is to understand the coastal development objectives and priorities envisioned for the State of Delaware and Mid-Atlantic region by the Delaware government, regional development bodies, and civic and business leaders. The principal input was derived from the administrative branch of the state government consisting of ten departments, particularly the Department of Natural Resources and Environmental Control. Additionally, significant recommendations were available from special advisory bodies to the Governor such as the Task Force on Marine and Coastal Affairs whose report detailed information on the present status, trends and problems relating to the coastal zone and recommendations concerning its future use.

Inventory of Capability and Organization Concepts for a Coastal Zone Laboratory in Delaware

Project No. R/M-3
Principal Investigator:
Dr. K. S. Price

Partial preliminary plan for U. of Del. Marine Studies facilities at Lewes, Del.

First

Understand coastal development objectives and priorities

Second

Inventory current tasks, facilities, and functions supportive of research and tech services activities.

and

Analyze research and tech service activities necessary to support research priority and program options.

and

Compare inventory and analysis to predict requirements for changes in funds, facilities, and manpower.

Third

Develop cooperative research and management program

The laboratory functions necessary to support alternative research, monitoring and management requirements have been analyzed for the state and region based on identified problems and development objectives. From problem definition, available management information for the problem was compared to the information required; this determined the research needed. The research needs were compared to the total research capability of the state and region in order to predict requirements for additional funds, facilities, and manpower.

As a pilot study the College of Marine Studies and the State Department of Natural Resources and Environmental Control embarked on planning for a cooperative research and management program for FY 74. The results are summarized in the Table below.

Pilot Study

- Survey of Marine Studies expertise
- Listing of CZ Management problems
- Listing of cooperative research projects
- Top priority projects
- Joint budget proposal
- Executive and legislative review

EDUCATION PROGRAM

In the words of the Sea Grant Act of 1966, the educational component of the Sea Grant program has as a primary goal ". . . to develop the skilled manpower, including scientists, engineers, and technicians, and the facilities and equipment necessary for the exploitation of the resources." The process of attaining the objective can be viewed from many perspectives, two of which are pursued in the Delaware program.

One approach is to raise the general level of awareness and understanding of the unique marine environment among the population as a whole, thus prompting the emergence of special interests in the area and the desire to pursue them on a career basis.

A second approach is to provide the specialized curricula necessary to train professionals wishing to pursue career objectives in this area.

There remains much to be done to further the attainment of the program objective.

The process of educating the public to the qualities and significance of the marine environment may take any of a number of forms. It is the hypothesis of the study that this educational process can best be achieved if consideration of the environment is made an integral part of every learning experience during the formative years of public schooling. A set of lesson plans is being prepared to carry out this type of program.

K-12 Marine Science Curriculum Study

Project No. E/Z-1
Principal Investigator:
Dr. R. E. Stegner

The training of the manpower necessary to assure the continued development of national marine resources requires the creation of educational programs with an appropriate balance of classroom, laboratory and field experience. The Delaware Ocean Engineering curriculum initiated in 1968 reached a point in its development which warranted the addition of a laboratory program. A description of the facilities is included in this section.

Ocean Engineering Coursework

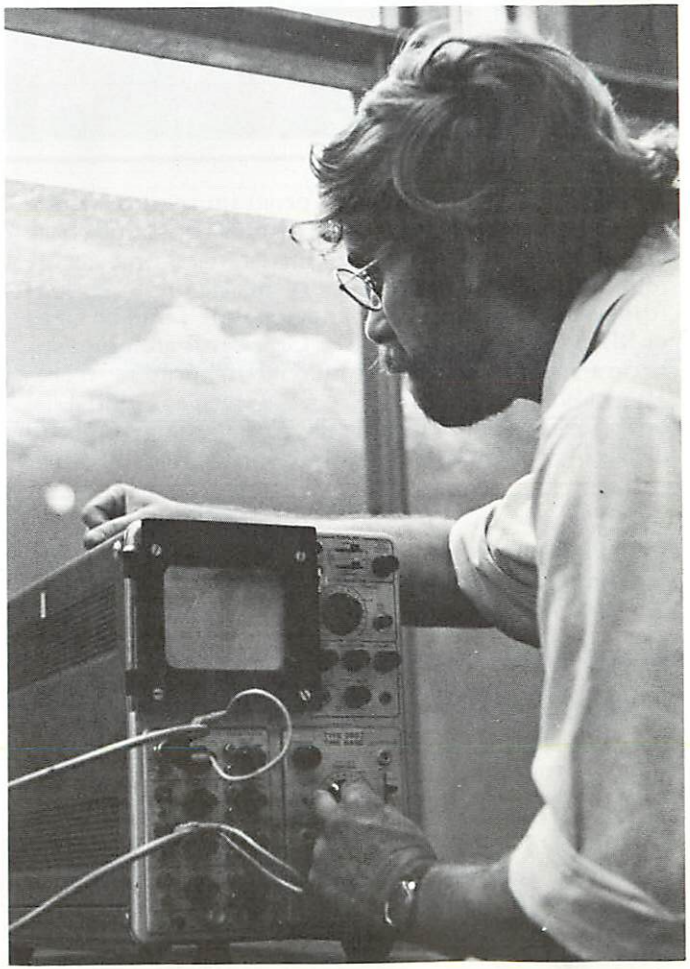
Project No. E/T-2
Principal Investigator:
Dr. F. E. Camfield

Principal Laboratory Equipment

- Marine soils testing equipment
- 120′ Wave & tow tank with electronically controlled hydraulically driven, piston type wave plate
- 80′ Glass walled wave tank

Principal Laboratory Models

- Tilting-tray tidal model
- Breakwater wave diffraction
- Energy transmission through piling arrays
- Wave transmission over submerged bars
- Wave action on moored buoys



ADVISORY SERVICES

Extension agents assist in construction of artificial offshore reefs.

A complete Marine Advisory program requires three ingredients; interested user groups, a sound base in research, and a vehicle for transferring information. In Delaware, Advisory Service is a person-to-person program as evidenced by the familiar sight of MAS Field Agents and Sea Grant research investigators meeting with commercial fishermen, recreation and transportation representatives, industrial operators, planners and development groups to discuss problems and programs for the coastal zone.

Town Hall Meetings
- Fisheries regulation and enforcement practices

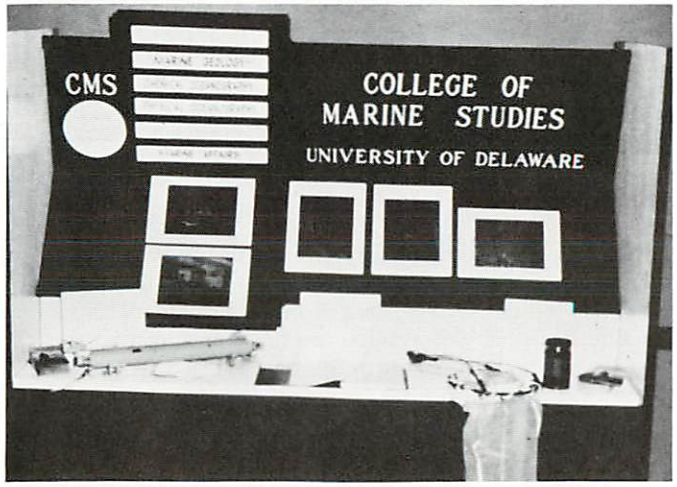
Public Marine Education
- Field trips
- Lectures
- Literature
- Media programs

For the Sport Fisherman
- Artificial reefs
- Fishing hotline

Legislative Liaison

Problem Solving

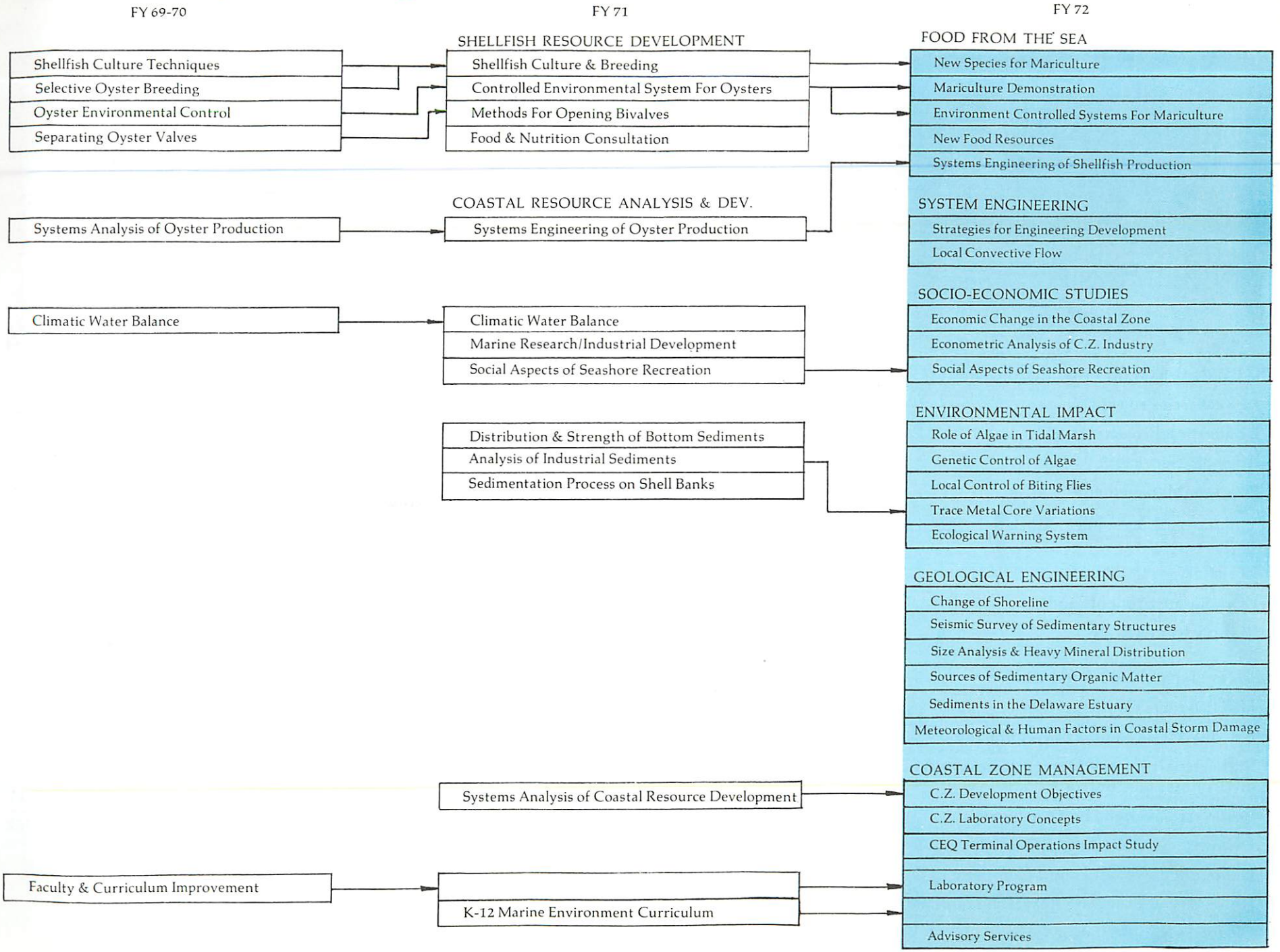
Students inspect specimen on field trip.



Portable display units appear around the state.

The Marine Advisory Service this year took a major step forward in the level of its activity. The Service now operates in conjunction with the University's Cooperative Extension Service, its land grant counterpart in the College of Agriculture. This step has made available to marine agents resources, expertise and knowledge developed over many years of land grant program activity and is particularly appropriate in light of the strong agri-marine tradition of Kent and Sussex counties.

Sea Grant Program Development



Program

The FY '71 Sea Grant Program consisted of:

- 25 Research Projects
- 2 Education Projects
- Advisory Services &
- Program Management

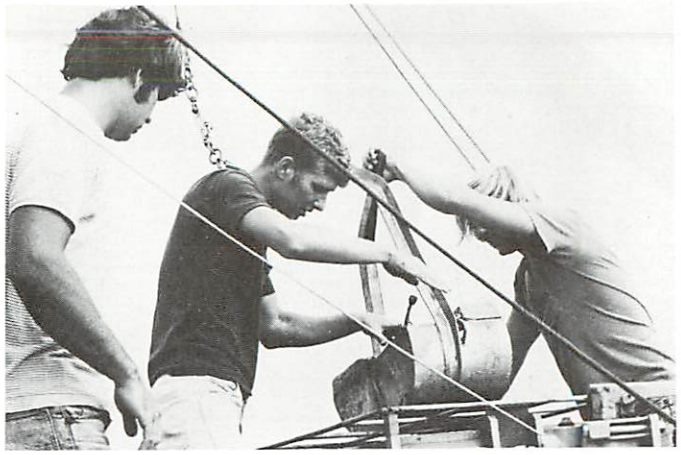
The number of personnel associated with the program included:

- 43 Faculty
- 17 Graduate Students and
- 17 Professional Staff

Funding

Sources of matching funds included:

- Fish Products Company
- E. I. duPont de Nemours & Company
- State Department of Natural Resources and Environmental Control
- Delaware River and Bay Authority
- Delaware River Basin Commission
- Delmarva Power and Light Company
- University of Delaware Research Foundation
- Delaware State Planning Office



Budget

	Sea Grant	Matching
Program Management	$ 80,174	$ 48,782
Research:		
• Food From the Sea		
Aquaculture	224,516	78,522
Commercial Fisheries	8,588	3,670
• Engineering	31,603	14,476
• Environmental Interaction	116,366	58,521
• Coastal Zone Management	53,915	66,828
• Education		
K-12 Curriculum Development	18,014	14,106
Ocean Engineering Graduate Studies	34,331	23,320
• Advisory Services	48,993	14,497
	$616,500	$322,722

Publications

The publications released during the grant year resulting from continuing or prior year programs are listed below:

Annual Progress Report for 1971 — DEL-SG-1-72

Industrial Development and the College of Marine Studies Operations in Lewes, Delaware
Frederick R. E. Durr — DEL-SG-2-72

Sedimentation on Shell Banks in Delaware Bay
Robert B. Biggs — DEL-SG-3-72

Institutional Proposal for FY-1973, 2 volumes — DEL-SG-4-72

Systems Engineering of Oyster Production. Optimization of an Oyster Production System in the Presence of Uncertainty
Frederick A. Costello and Brent L. Marsh — DEL-SG-5-72

Instrumentation and Technique to Control the Environment for Shellfish Nutritional Studies
R. C. Dwivedy
Presented at the Annual Meeting of the American Society of Agricultural Engineers, June, 1972 — DEL-SG-6-72

Design Strategy in a Coastal Environment: Potential Improvements in Civil Engineering Design Techniques For Coastal Zone Projects
Rowland Richards, Jr. and David G. Elms — DEL-SG-7-72

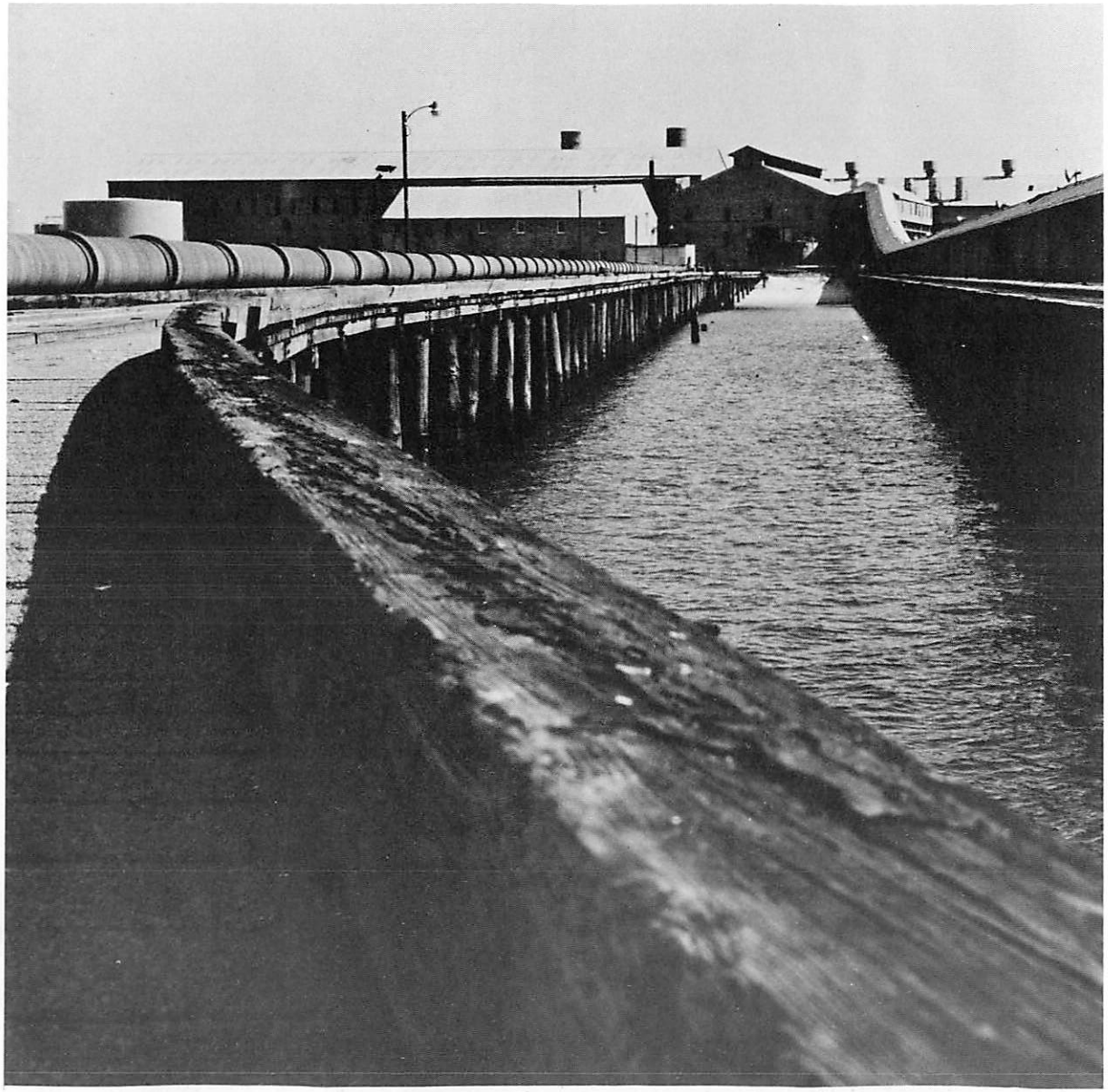
Biogeochemistry of Sediments of Delaware Bay
Frederick M. Swain — DEL-SG-8-72

Trace Metal Environments Near Shell Banks in Delaware Bay
Frederick Bopp III and Robert B. Biggs — DEL-SG-9-72

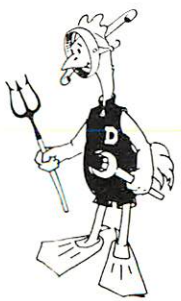
Trace Metal Baseline Studies on the Murderkill and St. Jones Rivers, Delaware Coastal Plain
Frederick Bopp III, Frederick K. Lepple Robert B. Biggs — DEL-SG-10-72

Comparative Carbohydrate Geochemistry of Bay, Salt Marsh, and Deep Gulf Sediments
Frederick M. Swain and J. M. Bratt — DEL-SG-11-72

Trace Metals in Cores from the Great Marsh, Lewes, Delaware
Richard N. Strom and Robert B. Biggs — DEL-SG-12-72



All mariculture research is unified in a single laboratory building (two-story building left of center) supplied by a local marine industry and with direct access to sea water.



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UNIVERSITY OF DELAWARE
SEA GRANT ANNUAL REPORT 1971-72

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