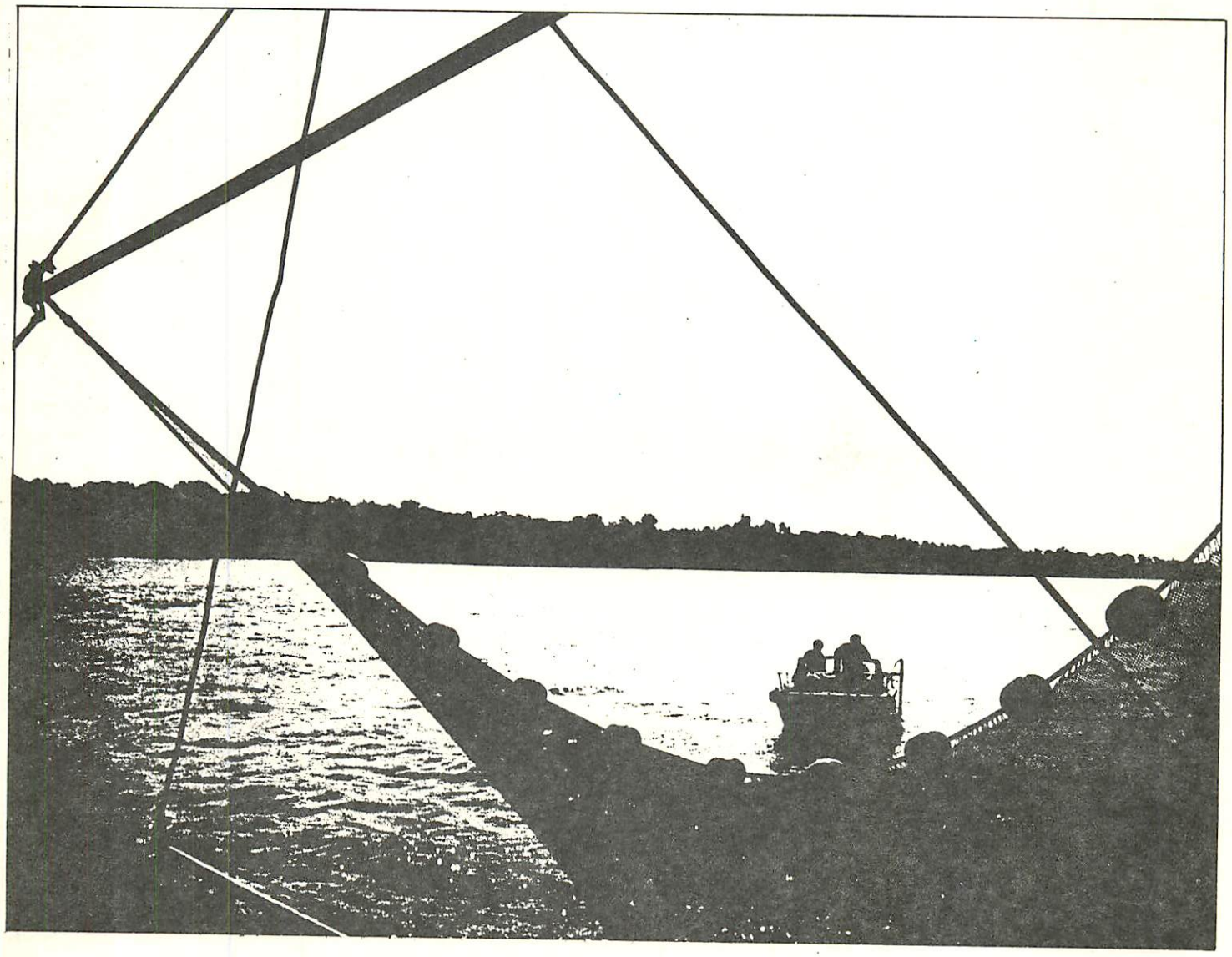
SEA GRANT ANNUAL REPORT 1973

A Report on the Virginia Institute of Marine Science
Sea Grant Program for January 1-December 31, 1973



VIRGINIA INSTITUTE OF MARINE SCIENCE
Gloucester Point, Virginia 23062

SEA GRANT ANNUAL REPORT 1973

A Report on the Virginia Institute of Marine Science
Sea Grant Program for January 1-December 31, 1973

Special Report No. 65
in Applied Marine Science and Ocean Engineering

Compiled and Edited by
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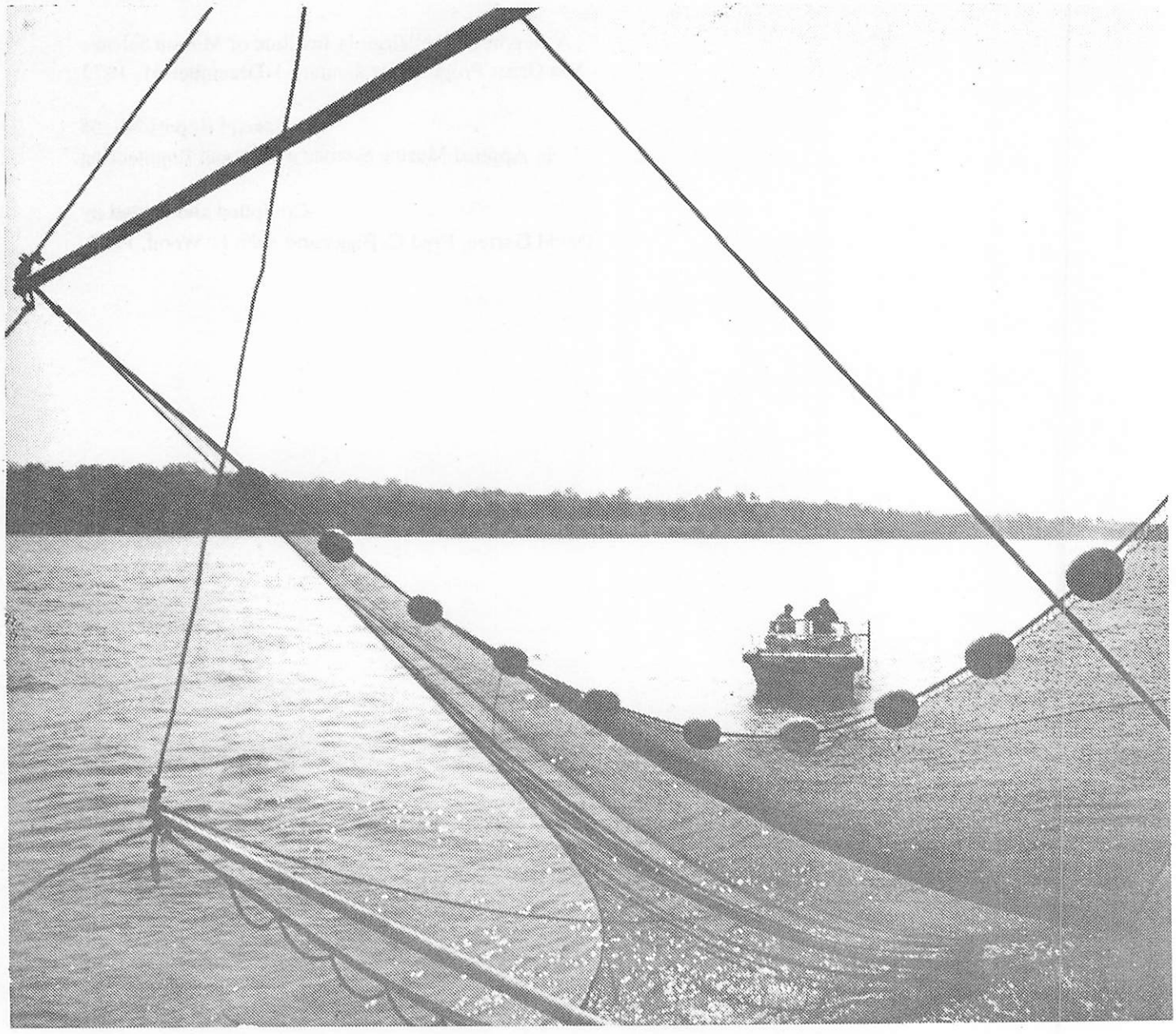
Sea Grant Program

VIRGINIA INSTITUTE OF MARINE SCIENCE
Gloucester Point, Virginia 23062

Dr. William J. Hargis, Jr., Director



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Introduction

During 1973 Sea Grant support made possible a continuation of work that yielded tangible and refreshing results. We were especially gratified to see the growing numbers of representatives from various marine resource-use industries appear at workshops and seminars and to observe the increasing numbers of personal inquiries for information, consultation, publications and other facets of the advisory services.

A commercial oyster seed hatchery developed with assistance of the Sea Grant-supported mariculture program is now in production at Colonial Beach, Virginia, and others are being planned in this state and in Maryland.

Studies were completed during the report year that describe the minimum water depth and flow necessary to sustain high soft crab yield in crab shedding tanks. This information should help make more soft crabs available for market, improve profits to the crab shedding industry and lower consumer costs for the product.

Through continued research findings on the biology and distribution of rock crabs, interest in utilizing this potential resource is increasing among lower Bay fishermen, and information on other underutilized species is being acquired.

Progress on work concerning the mariculture and controlled production of oysters, clams and scallops continued during the report year. Selective breeding methods to produce oyster strains that exhibit rapid growth rates, disease resistance and other desirable characteristics have been successful, and progeny are being obtained that may further enhance the economic feasibility of shellfish mariculture. Sea Grant has provided a great deal of impetus and financial assistance to these important and productive projects.

Other developments during 1973, such as the batch culture of three newly-isolated species of algae for use as food for oyster larvae, brought additional benefits to the commercial seed-producing industry.

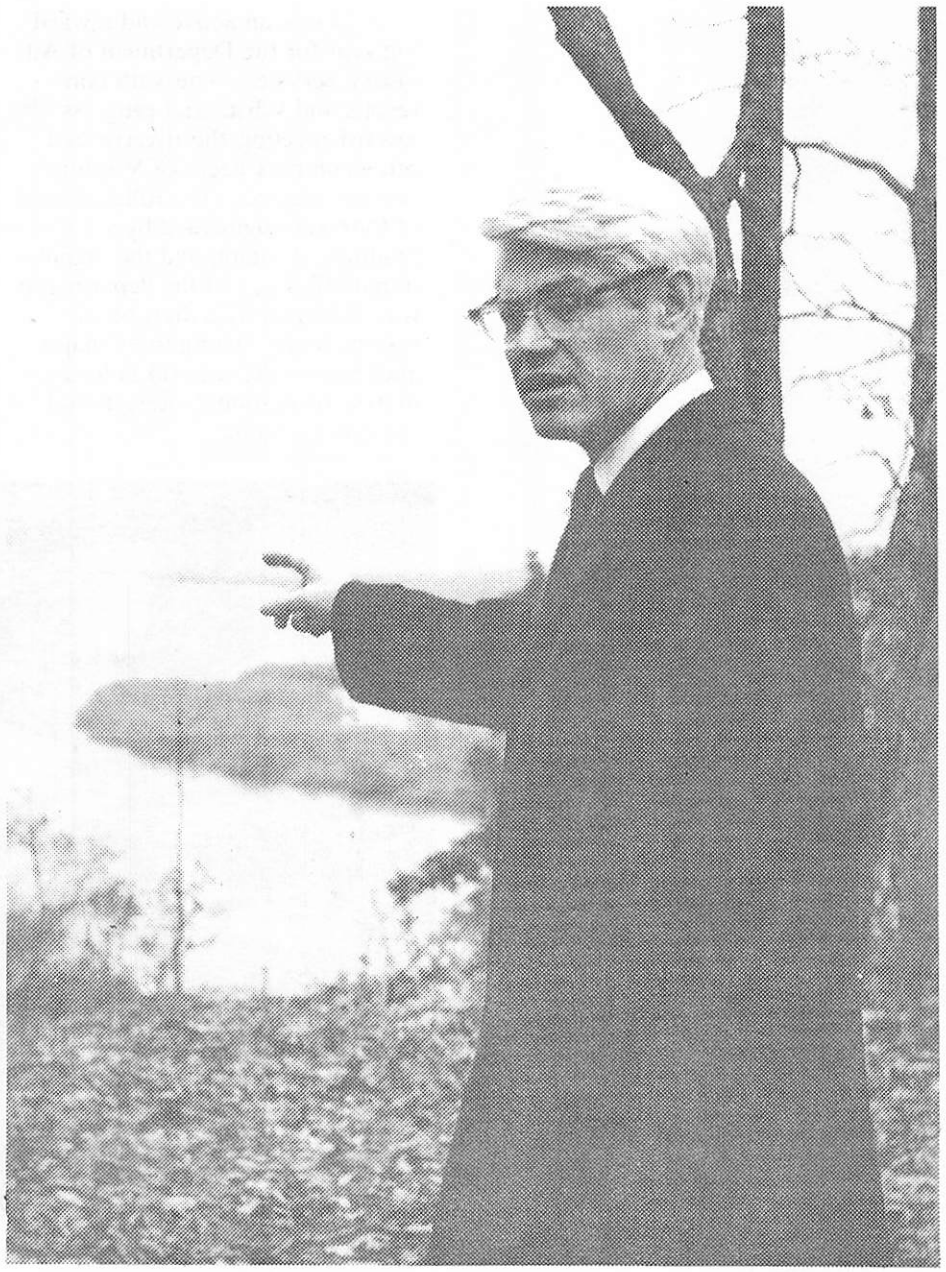
Sea Grant-funded studies to develop commercially applicable methods for growing clams and scallops from egg to market size were concluded at the close of the report year with most objectives successfully fulfilled. The final objective, to ascertain the economic feasibility of the methods as developed, will be the focus of continued work on mariculture of these species.

During 1973, Sea Grant support, along with considerable assistance and interest from the NASA-Langley Research Center in Hampton, Virginia, was applied to a study of ocean wave refraction for Virginia's coastline. Shoreline histograms of wave heights, wave energy and wave power gradient, along with shelf contour maps of wave heights and bottom orbital velocities, were being formulated for approximately 30 different periods and directions. Data derived illustrates how knowledge of refracted wave forces at a site is useful especially in shoreline defense programs and in the construction and maintenance of coastal and offshore structures.

Through the continued research and advisory programs described in this report, managers and users of estuarine environments and resources in Virginia have benefitted, and the Sea Grant Program, with VIMS, has received justification of its support.

Dr. William J. Hargis, Jr.

Dr. Hargis, director of the Virginia Institute of Marine Science since 1969, is principal investigator and overall program manager of VIMS' Sea Grant Program.



Advisory Services
Marine Extension Activities

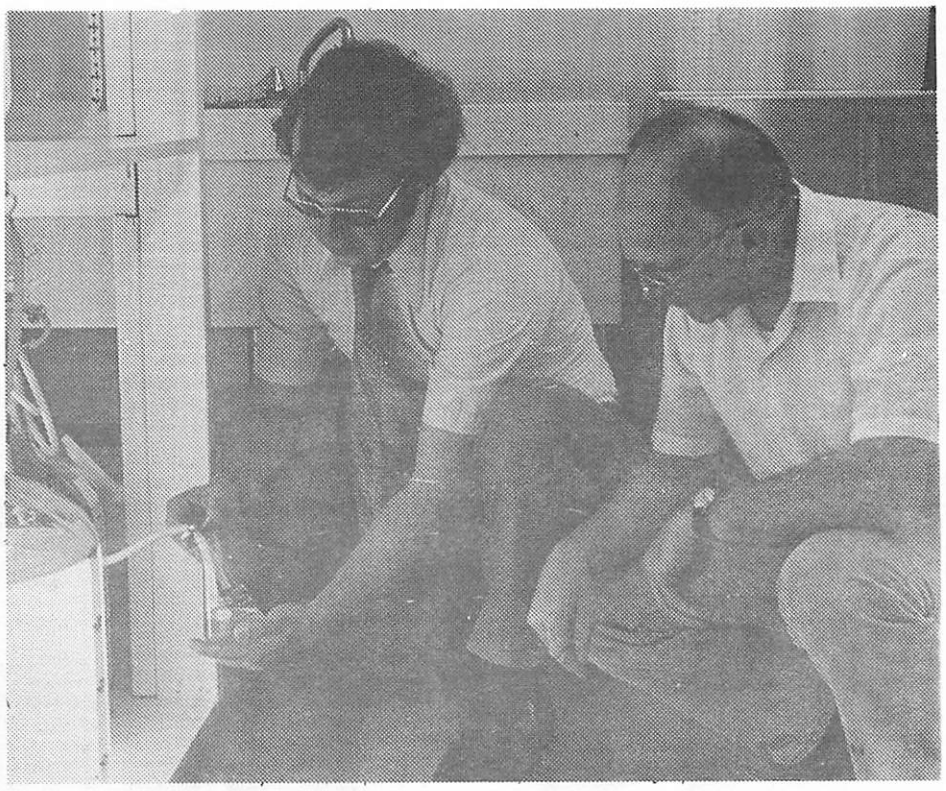
1973 was an active and rewarding year for the Department of Advisory Services—one with concrete results and substantial progress toward meeting the diverse and often complex needs of Virginia's coastal audience. The fulltime staff of four was augmented by a graduate assistant, and the organizational efficiency of the department was increased by a division of responsibility among three major audiences—the seafood industry, marine recreational interests and the general public.

Planned activities for 1973 included several workshops and seminars. Advisory Services sponsored an Oyster Industry Workshop which attracted more than 100 participants from industry, state and federal agencies and institutions, and the press. The two-day program reviewed the legal and political framework of the industry, technology of oyster production, economics, and state programs of interest to industry.

Advisory Services also developed and hosted a workshop on anti-pollution regulations governing the boating industry in Virginia. The responsibilities and policies of pertinent state enforcement agencies were summarized for industry representatives; regulations governing holding tanks, overboard discharge of wastes, sanitary and sewage facilities, and condemnation buffer zones were discussed in detail. A summary of workshop proceedings was published as a *Marine Resource Information Bulletin* special report (August 22, 1973).

A Menhaden Fishery Technical Workshop, sponsored by Advisory Services in cooperation with the menhaden research staff of the NMFS Atlantic Estuarine Fisheries Center, reviewed methods of estimating fishing effort in Atlantic and Gulf menhaden fisheries and presented forecasts of catches. Industry personnel, some from as far away as Louisiana and New Jersey, participated in the discussions and made valuable suggestions regarding future research needs.

Two wetlands seminars entitled "Land Use Controls in Wetlands Areas" were presented during 1973. The seminars, sponsored by the Marshall-Wythe Institute of the College of William and Mary, the VIMS Department of Advisory Services and the VIMS Chesapeake Research Consortium (NSF-RANN) Program, were designed for state and local government officials responsible for management of Virginia wetlands. Economic concepts pertinent to planning use of coastal resources were presented by an advisory specialist.



A preliminary customer survey of marinas, developed at the request and with the cooperation of the Virginia boating industry, was conducted during September. Questionnaires used in the survey were developed jointly by the Tidewater Marine Trades Association and the Advisory Services staff.

The questionnaires, distributed to 50 marinas in coastal Virginia, were developed with three objectives in mind: (1) to determine the views of industry's clientele regarding adequacy of existing services and facilities, (2) to provide information which could be translated into business opportunities, and (3) to compile data on the industry's impact upon the economy of Virginia.


NOOK

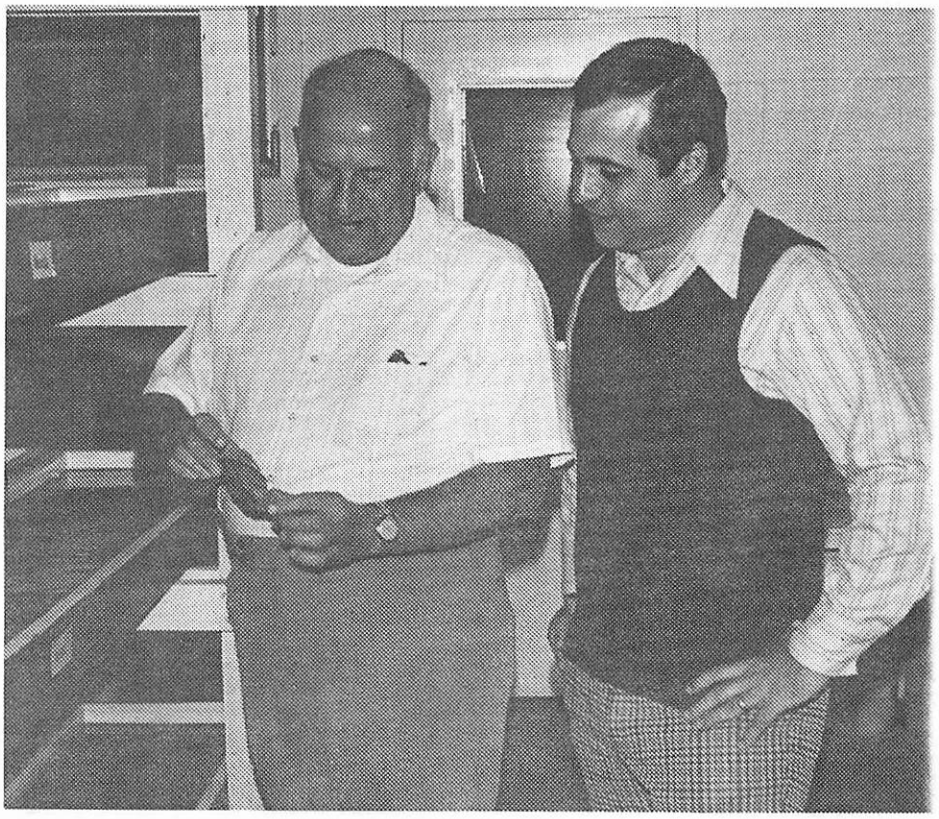
Industry personnel conducted the on-site customer interviews and sent the completed questionnaires to the Department of Advisory Services for compilation and analysis. Results of the preliminary survey were favorable and indicated that the boating industry of Virginia could be adequately characterized by this procedure with only slight modification of survey methods and format.

In addition to workshops, seminars and the customer survey, other activities during 1973 included talks by advisory specialists on a range of subjects including the future of the seafood industry, aquaculture, artificial fishing reefs, and the surf clam industry. A new exhibit emphasizing VIMS Sea Grant Advisory Services was developed and displayed on several occasions.

Substantial activity also took place in the informal part of the Advisory Services program. Person-to-person contacts numbered in excess of 5,000 which serves to indicate the importance placed upon this portion of the overall program. Personal contacts formed the basis of all major planned activities and were important in problem identification, establishment of priorities, and development of strong rapport with pertinent audiences. In many instances the informational needs of clients could be met on the spot; on other occasions more time was necessary to develop a reply.

Verbal and written responses to requests for information and assistance represented a cross-section of coastal zone subjects such as biology and ecology of marine fish and shellfish, fishing gear and techniques, economics, pollution legislation and regulations, aquaculture, marine sanitation devices, fuel allocation, federal sources of financing, seafood processing equipment, raw-product supply sources, and catch statistics.

Advisory specialists also attended workshops conducted by other organizations to stay abreast of regional and national developments of interest to major audiences. Noteworthy among those attended were sessions on the Occupational Safety and Health Act, Boating in New England, Business Management, and the National Marine Advisory Service. During the year staff members were also active participants in several boat and sport shows and meetings held by industry trade associations, civic clubs and professional associations.



Advisory Services
Publications; Information and Education

"Advisory services" is a general term for the variety of means whereby results of scientific research or engineering development are communicated to those who will apply the results to obtain economic or social benefits, and the problems and needs of marine-based industry are learned.

In conjunction with personalized extension services, conferences, workshops and seminars developed by the Department of Advisory Services, the Department of Information and Education helped further the program objectives through publications, public information, and mass media techniques.

Through its Sea Grant publications program, VIMS disseminated marine information to a broad cross-section of users, developers and managers of coastal resources.

These included commercial and recreational fishermen, marine engineers, marina operators, coastal miners, public administrators, legislators, educators, students, the mass media, and the general public.

The editor of the *Marine Resource Information Bulletin* strived to put information on marine resource utilization, development and enjoyment directly into the hands of people who needed it. The *Bulletin* covered a broad range of subjects and although much of the information was original material, the scope of the publication was broadened to include related developments from other sources, especially from other Sea Grant programs.

In addition to 12 regular issues of the *Bulletin,* four editions were distributed as special reports. These included the 1972 annual summary of oyster spatfall on shellstrings in Virginia rivers, boat pollution regulations announced by the State Water Control Board, a summary of proceedings of the boating industry workshop sponsored by VIMS Department of Advisory Services, and a report on fishing vessel fuel allocation problems which was distributed in cooperation with the National Marine Fisheries Service.

At the close of the report year the *Bulletin* was reaching nearly 3,600 persons, including mailings to 39 states and 14 foreign countries.

Marine Resources Advisory Series No. 7, "Rock Crab: A Potential New Resource", was produced and distributed in November 1973. *Sea Grant Annual Report 1972,* documenting Sea Grant activities at VIMS for calendar year 1972, also was produced and distributed by the Advisory Services publications unit.

Newspapers, television and radio, which provide an inexpensive and effective way of reaching the public, were an important phase of the Advisory Services. News releases were distributed regularly to more than 650 recipients, including newspapers, technical periodicals, radio and TV producers and interested agencies and individuals.

Publications and informational services were often aimed at specific audiences as well as the general public. A number of categories of special users have been compiled and mailing labels were available for each category or any combination. New categories added during 1973 were Wetlands Boards, Wetlands Contractors, Saltwater Sportfishermen, and Tidewater Planning Districts. Other categories were News Release, News Media, Sea Grant, MRI Bulletin, Virginia General Assembly, Wholesale Dealers in Fishery Products, State Agencies, Shellfish Shippers, Oyster Ground Leasers, Boat Docks and Marinas, and Sport Fishing Facilities. "Address Correction Requested" was printed on each of the publications mailed

out and we constantly strive to keep the mailing lists as current as possible.

During the report year 376 requests for *Bulletin* and *Advisory* subscriptions, publications and informational services were processed by the Advisory Services publications unit. As in the past, most of the requests were from industry, governmental agencies and the news media.

VIMS' exhibit at the Parade of Progress, held November 3 through 11, 1973, at Hampton Roads Coliseum, resulted in an additional 217 requests for subscriptions to the *Bulletin*. Considered the most extensive exhibit effort in which Institute personnel have ever been involved, the theme was VIMS' research, advisory and education programs, with emphasis on Sea Grant, wetlands and fishery programs.

Exhibits were also provided for the Mid-Atlantic Boat Show and the Gloucester County Fair, and 58 programs on marine science subjects were presented throughout Virginia, as well as in some other states.

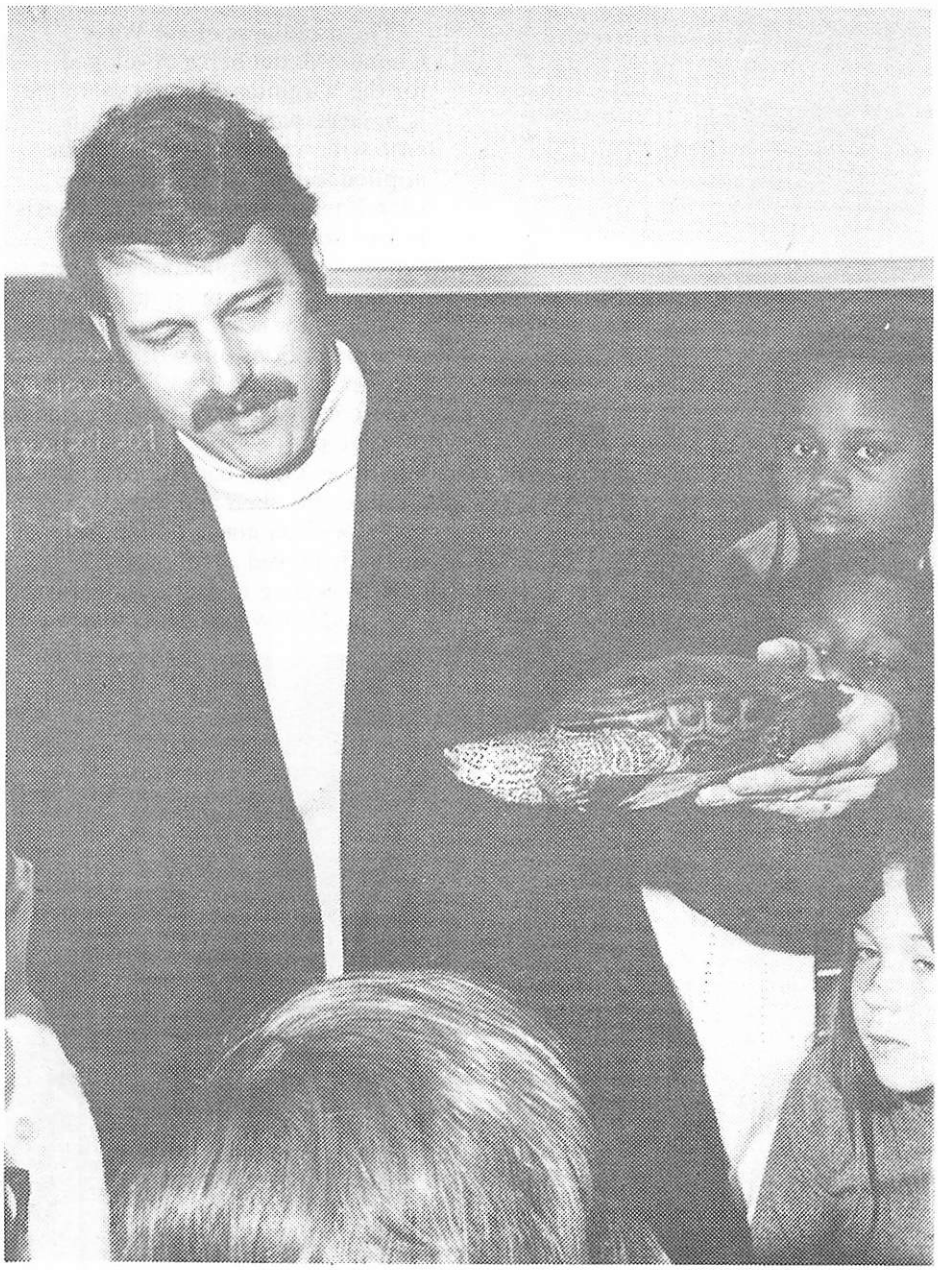
Nine new 16mm films, new 16mm and 35mm projectors, and a film loop projector were added to the audio-visual inventory. Heavy demand for this material continued at VIMS and free loans to schools and other groups increased dramatically.

Demand for educational services grew faster during the year than did our capabilities, as more school groups began to rely on VIMS as a resource center for a variety of needs in marine science. One information officer provided programs for over 5,000 visitors at VIMS and assisted in the production of educational television lessons on studying the river bottom and fish reproduction, including information on research at VIMS. Almost 500 individual requests for marine science information were answered.

Collecting trips to nearby salt-marshes and on VIMS beach were in demand during the warmer months. Slide programs, films, lectures, laboratory tours, and 12 demonstration cruises on VIMS research vessels provided a comprehensive Education Program. Especially popular were demonstrations on establishing a saltwater aquarium which were paired with a collecting trip to provide the marine animals. Some aquaria were set up in schools and loaned to classes for several months.

Aquaculture Bibliography

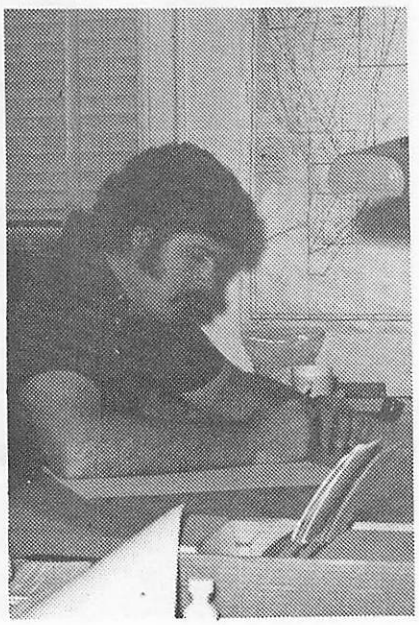
VIMS has worked with the Environmental Data Service (EDS), NOAA, U. S. Department of Commerce, in developing a national bibliography of aquaculture. During 1973 an initial thesaurus was developed and 382 articles were indexed for use in the initial retrieval program. In addition to indexing the articles, VIMS, through its Marine Environment and Resources Research and Management System (MERRMS), provides EDS with microfiche of all indexed articles not protected by copyright and for which copyright privilege can be obtained. This is a continuing project.



Study of Ocean Wave Refraction for Virginia's Coastline

The usefulness of the Wave Climate Model being developed for the Virginian Sea and shoreline is in large part dependent on the ease with which such data can be applied to particular shelf and shoreline problems. Thus, emphasis in this study was shifted to the synthesis and applications of the voluminous data previously generated. These wave data, consisting of computations of 19 different wave parameters for 124 distinct wave conditions (i.e., combinations of wave period, approach direction, height, and tidal conditions) calculated for the shelf and shoreline, and stored on magnetic tape, is being displayed as follows:

- Shoreline histograms of wave heights, wave energy and wave power gradient (Fig. 1). The spectral analyses of these frequency distributions suggest strong periodicities in increased wave heights and wave energy in the order of 3 to 5 mile spacing along the shore. This spacing is related to the various shelf relief elements.
- Shelf contour maps of wave heights and bottom orbital velocities (Fig. 2). Contoured maps of these two parameters show a strong correlation with the highly irregular sea floor bathymetry, i.e., higher parametric values associated with topographic highs. However, there are several notable exceptions of which potential users and exploiters of the continental shelf need to be aware.



These two types of displays, shoreline histograms and shelf contour maps, are being constructed for approximately 30 different wave periods and directions. (At $400 per diagram, plus program development costs, this represents approximately $20,000 in computer costs, which are being borne completely by NASA-Langley Research Center, Hampton, Va.). With the aid of specially computated wave height nomographs for these two types of displays, a wide variety of shoreline and shelf wave heights, energy, and bottom velocities can be easily determined for any input deep water wave heights up to 30 feet.

A major part of the program is to make this information available to user agencies, industry, government agencies and other interested segments of the public. Three Special Reports in Applied Marine Science and Ocean Engineering (SRAMSOE) and five scientific papers have resulted during the year's effort. The first SRAMSOE (No. 39), a four foot multicolored bathymetric map of the Virginian Sea contoured at 12 foot intervals out to the 492 foot depth, and at 100 foot intervals out to 1000 feet, was compiled from 60 original hydrographic sounding sheets and other data. Approximately 1000 copies were distributed within six months; all except for the official Sea Grant mailing list were distributed in response to direct requests to VIMS.

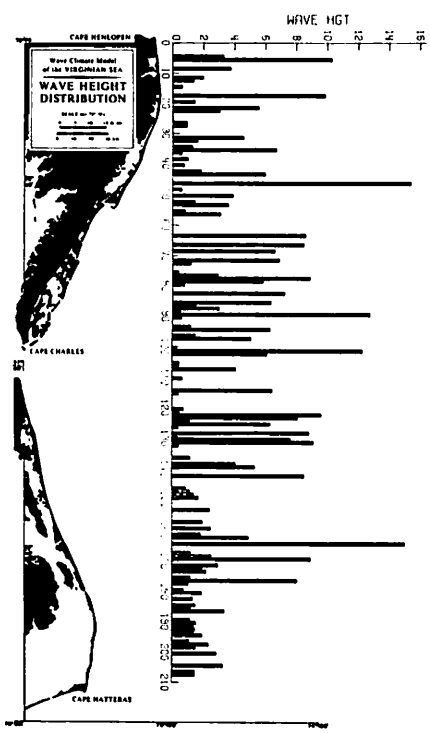


Figure 1. Histograms of shoreline wave heights for waves from the east with a period of 8 seconds for deep-water wave heights of 6 feet.

The second SRAMSOE (approximately 150 pages), in press at the close of the report year, contains a detailed description of the Virginian Sea Wave Climate Model along with 70 wave refraction diagrams. A review of the shelf geomorphology is also presented in this document since the most important influence on the wave climate of this shelf is the interaction between the ocean waves and the various shelf relief elements.

A third SRAMSOE is in preparation and will contain the shoreline histograms and shelf contour maps of wave heights, wave energy, power gradient, and bottom orbital velocities. These data are being related to historical shoreline changes and known shelf sediment distribution.

The presentation and analysis of data derived from the Wave Climate Model further substantiates the general recognition that ocean wave refraction plays a dominant role in controlling the distribution of wave energy over the continental shelf and along the coasts. Furthermore, these data illustrate how knowledge of a specific refracted

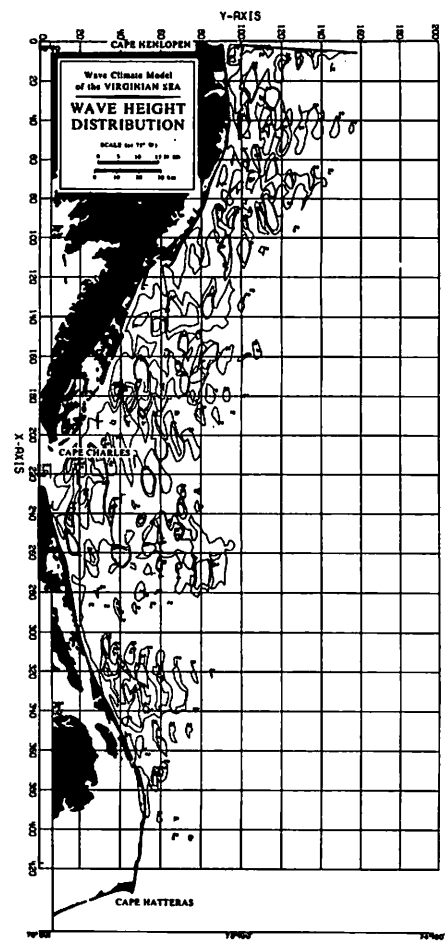


Figure 2. Shelf wave height distribution for waves from the east with a period of 8 seconds for deep-water wave heights of 6 feet.

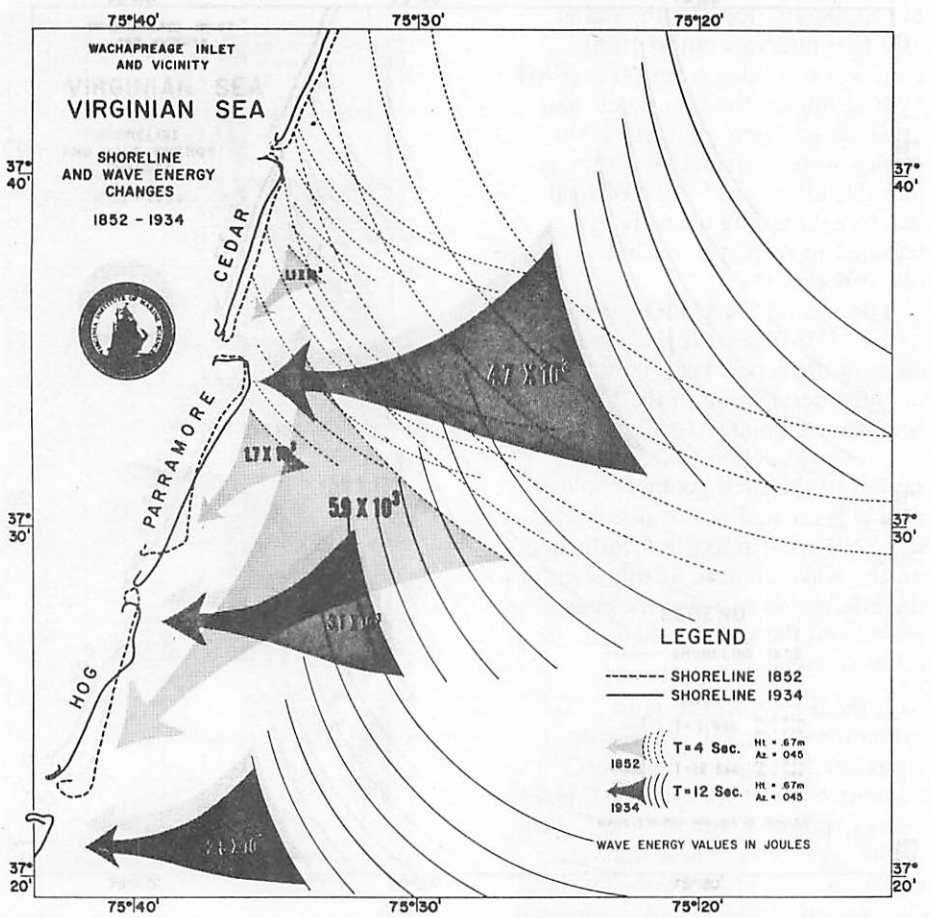


Figure 3. Schematic summarizing relationships between historical changes in both wave energy distributions and shoreline changes.

wave input at a site is critical to the successful implementation of shoreline defense programs, knowledge of continental shelf sedimentation processes, and construction and maintenance of coastal and offshore structures.

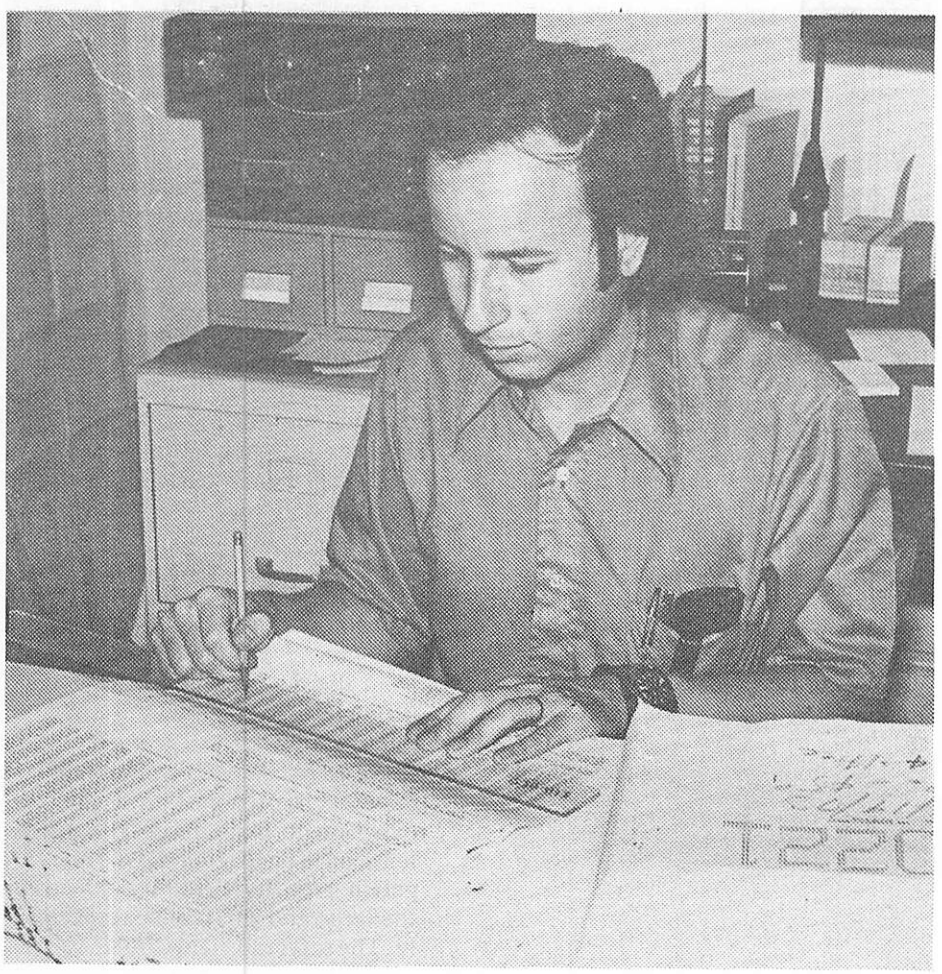
Among the numerous potential user agencies for this information are VIMS, NASA-Langley, the U. S. Army Corps of Engineers, U. S. Geological Survey, U. S. Fish and Wildlife Service, Virginia Marine Resources Commission, Commonwealth Division of Planning and Community Affairs, Highway Department, shipping, fishing and recreational boating industries, local, Commonwealth and federal legislatures and agencies, and numerous industries.

In order to encourage optimum usage of these voluminous data, a variety of techniques and procedures were developed. One successful technique compared the shoreline energy distributions in both 1852 and 1934 with the historical shoreline changes during the same time interval, for the dynamic barrier island shoreline along 20 miles of Eastern Shore of Virginia adjacent to Wachapreague Inlet.

The two wave energy distributions were derived by using the 1852 and 1934 U. S. Coast and Geodetic Survey bathymetric surveys as input to the model. The results of this study, which is being published in *Recent Advances in Estuarine Research,* are summarized in Figure 3. Note that "erosional"

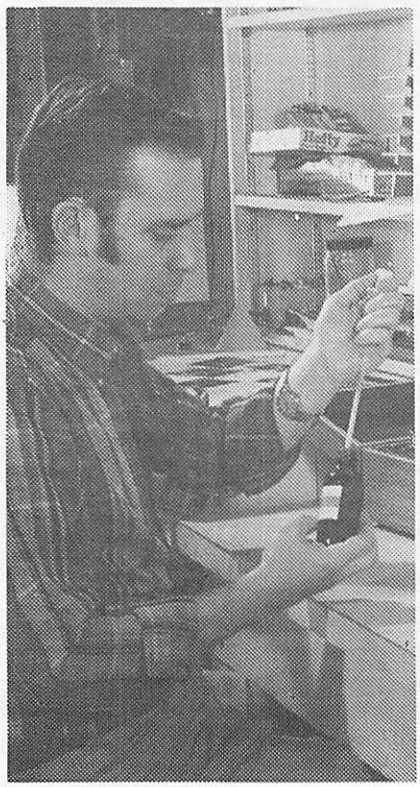
short steep waves in 1852 (T = 4 sec) tended to concentrate their energy on the southern portion of the barrier islands, resulting in the observed historical erosion, while the northern portions of the islands have been built seaward by the longer, less-steep waves (T = 12 sec). This effect is reinforced as the offset increases. Note also that the scale of historical change agrees directly with the scale of wave energy distribution.

The data strongly suggest that predictive capability for future shoreline changes in certain areas may be possible using these techniques. This capability would be a most welcome addition to the planning tools available to coastal zone managers.



Improvement of Fisheries for Crustaceans

Sea Grant-funded research on crustaceans during 1973 represented continuance of effort required to meet two long-term objectives: (1) to identify the intrinsic and extrinsic conditions necessary for increasing the commercial production of the soft stage of the blue crab *(Callinectes sapidus),* and (2) to determine the potential for commercial exploitation of the rock crab *(Cancer irroratus).*



Soft Blue Crabs

Initial plans for the summer of 1973 called for improving the recirculated seawater system for holding and shedding blue crabs. However, unforseen delays in acquiring certain key components forced a temporary diversion of attention to problems of an open-flow system.

The variety of seawater systems in commercial shedding operations is overwhelming and few recommendations on depth of water in tanks, flow rate, and turnover time have been made to industry. The 1973 research program considered these parameters in relation of soft blue crab yield in terms of percent molt.

A pair of tiered fiberglass tanks was used in this study. York River seawater (16-20 ppt, 23-28°C) was pumped into the top tank which acted as a settling basin to remove sediment. The water was gravity-fed into the bottom tank which was partitioned into a deep reservoir at one end and four parallel bins at the other. Turnover of 22 to 44 times the deep and shallow bin volumes, respectively, was realized from the 840 gal/hr flow rate through the system.

Only advanced stage peeler crabs (pink to red sign) from the York River were used in this 55-day experiment. Daily biomass equivalents of 90 and 160 crabs/100 gallon capacity were maintained in the large and small bins, respectively. The soft crab yields, 66-75%

molt, were not only the same for both sets of conditions, but they were economically feasible. A yield of this magnitude represents 2.5 soft crabs produced for each peeler lost.

These results dramatically illustrate that the same yield was obtained under conditions of two different water depths, one of which was much more shallow than any employed by industry. Several applications can be made of these results. Lowering the water depth conserves water. Lowering the depth of water to 4 inches and increasing the number of holding tanks would allow more peeler crabs to be handled and the volume of soft crab production would be increased. The same pumping system can produce more crabs. Further, those shedding plants experiencing high mortality because of marginal pump capacity should be able to increase soft crab yield by decreasing the height of water in each tank, thereby increasing the water turnover rate. New plants can be designed around these recommended water depth and turnover rates.

A manuscript describing the details of this research has been prepared for publication by Paul A. Haefner, Jr., Robert Harris and James Lesofsky.

Blue Crab Physiology

Two studies on oxygen consumption provide hard data emphasizing that generous amounts of dissolved oxygen must be available to peeler and molting crabs, particularly in confined holding tanks. This becomes increasingly critical as the size of the peeler decreases and as the temperature increases.

A study to evaluate the effects of sex, weight, salinity and temperature on the oxygen consumption of hardshell crabs was completed in 1973 by Chae Laird, a graduate student.

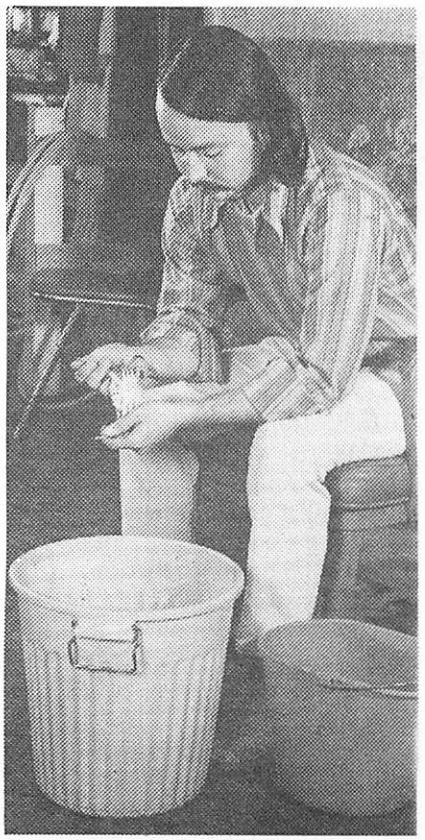
Weight-specific oxygen consumption decreased with increasing wet weight of crabs (weight range 1 to 7 ounces). Sex had no effect on consumption over this weight range.

Acclimation to 10 ppt and 30 ppt salinity had no effect on the consumption of warm (24°C) acclimated crabs. For cold (10°C) acclimated crabs simultaneous acclimation to 10 ppt produced higher oxygen consumption rates than acclimation to 30 ppt.

While oxygen consumption increased with experimental temperature from 10 to 25° C, consistent increases were exhibited only by cold acclimated crabs. The oxygen consumption of warm acclimated crabs increased greatly with increase in experimental temperature from 10 to 17.5°C, but was independent of temperature from 17.5 to 25°C.

The blue crab was observed to regulate oxygen uptake independent of the available oxygen supply down to an average critical level of 2.5 mg O_2/liter. This level was unaffected by sex and weight.

A study of oxygen consumption of blue crabs before, during, and after molting was the basis of a research report by Elizabeth G. Lewis. The methods used by Laird in his thesis research on hard crabs were applied to crabs progressing from pink and red sign peeler stages to the papershell stage.



The most significant finding was that total oxygen consumption was relatively high in peeler crabs. High demand was followed by a decrease in oxygen consumption for crabs molting. Post-molt (papershell) crabs consumed more oxygen than either the pre-molt or molting crabs. These results imply that oxygen uptake is virtually blocked during the time that the crab is molting the chitinous covering of the gills. The increased utilization following the loss of the old cuticle may reflect an adaptive mechanism of hyperventilation which aids in removal of an "oxygen debt" accrued during molting.

Rock Crab

Field studies on the biology of rock crabs and other decapod crustaceans of commercial importance were given added impetus by participation in a cruise aboard the University of Miami's research vessel *Columbus Iselin*. The cruise mission, supported by an NSF grant (GA-37561) to Dr. J. A. Musick, was a trawl net survey of the Norfolk Canyon and adjacent slope and shelf off the coast of Virginia. Information on reproduction, molting, distribution, and relative abundance in relation to water temperature and depth were collected for all decapods, including the rock crab *(Cancer irroratus)*, jonah crab *(Cancer borealis)*, red crab *(Geryon quinquedens)*, American lobster *(Homarus americanus)* and a portunid crab *(Bathynectes superbus)*.

Numerous sources of data were utilized in preparation of a manuscript, "The seasonal distribution, reproduction and molting in the rock crab, *Cancer irroratus* Say, in the Mid-Atlantic Bight", by P. A. Haefner, Jr. The most important sources of data were the paper of Musick and McEachran (1972); cruises of the *Columbus Iselin* 73-10, *Blesk* 71-4, and *Eastward* 73-1; and the theses of Shotton (1973) and Terretta (1973) which were completed during the report year.

Cancer irroratus is contagiously distributed (distributed in groups rather than uniformly) within depth and temperature ranges of 300-1000 fathoms and 3 to 22°C, respectively, but it is most abundant at those depths at which the bottom temperature is 4 to 14°C. The normal sex ratio among crabs smaller than two inches is 1:1. Among larger crabs the ratio varies with depth. The males are found deeper than 120 fathoms while the females are found in shallower water.

The crabs migrate inshore during the fall and move offshore in the spring. The increased inshore population in winter is due primarily to the presence of male crabs which are actively molting at that time. Molting also occurs offshore in June but with equal incidence between the sexes and among smaller crabs. Ovigerous crabs have been collected from September to June; larvae from May to October.

Two potential fisheries exist for this species. Crabs molting in Chesapeake Bay during the winter provide a source of soft crabs. Large, hard rock crabs are vulnerable to the seabass pot fishery off the coast of Virginia. Neither resource has been adequately exploited at this time.

VIMS *Marine Resources Advisory Series* (No. 7) on the rock crab was released to the general public during the report year. A manuscript on the jonah crab is being readied for publication. An article on the distribution and abundance of red crabs was being prepared during the report year and was published just after the close of the year (Haefner and Musick, 1974). Graduate student thesis research on the biology of the portunid crab *(Bathynectes superbus)*, collected from Norfolk Canyon and the adjacent slope, has been initiated.

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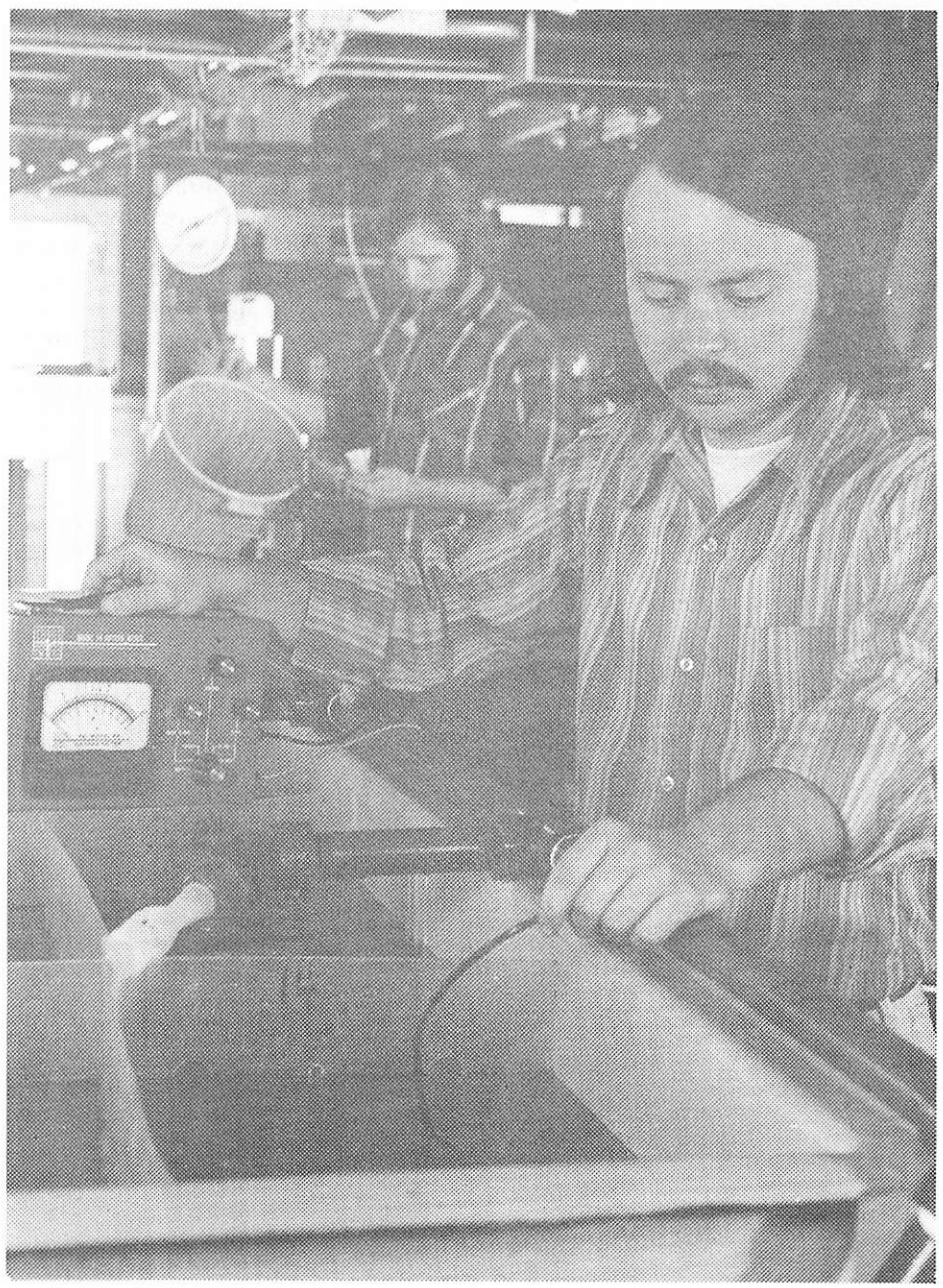


Production of Superior Oysters

Selection and testing of several laboratory-bred strains of oysters as broodstock for mariculture activities continued in 1973 from a disease-resistance program initiated in 1964. All strains except wild control lots are resistant to the protozoan disease caused by *Minchinia nelsoni* (MSX). Emphasis has been shifted to rapid growth, meat yield and shell shape.

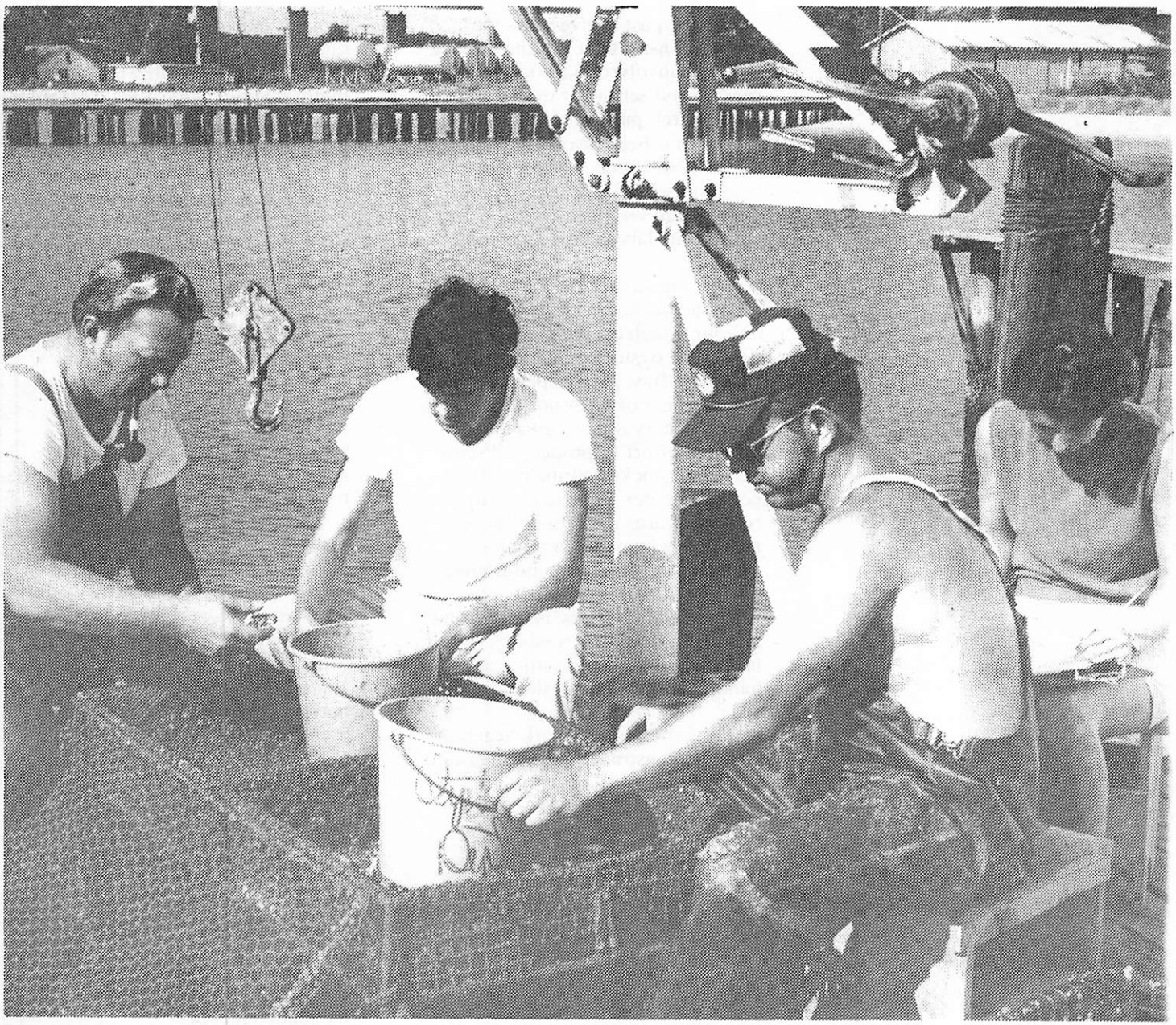
The objective was to select inbred strains that exhibit vigor and heterosis when used in hatcheries as broodstock to produce F1 progeny. Progeny testing for two or three years in trays in natural waters involved nearly 100 lots of oysters in 1973. Many pair matings from third and fourth generation selections were included among 30 new yearclass lots during the report year. Inbreeding depression was evident in many sibling lots.

Outcross of most strains have yielded progeny that reached market size in 13 to 18 months. Oyster growth is greatest during May and June in Virginia waters because of favorable temperatures and food supplies. Therefore if early harvesting is to be attained, it is important that spat be obtained by May 1. This is possible only in hatcheries.

The effects of Hurricane Agnes and dinoflagellate blooms that seem to accompany excessive runoff and high nutrient levels interfered with oyster growth in 1973. There was a six-week period of no oyster growth in April and early May. These events are warnings that control of mariculture beyond the hatchery and nursery stage may become necessary for oysters.

Intensive inbreeding has exposed certain strains that exhibit strongly cupped shells, exceptional growth, and some degree of sterility. The genetic characterization of these selected strains is urgently needed.

A reduction of laboratory bred lots from 1966 to 1972 yearclasses was necessary, with retention of the most promising strains. Selections from the F2 generation of strains appear to be most promising as broodstock for outcrosses in hatcheries. These are available at various ages for present use.



Management of Larvae— Supply of Algal Food

For the past twelve years the Virginia Institute of Marine Science has been involved in the spawning, rearing and setting of oyster larvae for research purposes. Much of this activity has been Sea Grant supported. In 1969 a major effort was begun to spawn southern oysters, *Crassostrea virginica,* and to rear and set the larvae on a year-round basis.

The appearance during 1957 of an oyster pathogen, *Minchinia nelsoni,* which caused mass mortalities in the oyster populations in Delaware Bay, gave impetus to the development of laboratory and later hatchery oyster culture in a research effort to produce "disease resistant" stocks. During this latter period, greater emphasis was directed towards the refinement of techniques involving a reliable method for fattening, conditioning and spawning of supposedly refractory adult oysters, isolation and mass culture of new foods for oyster larvae rearing, larval setting and handling of juvenile oysters or free spat.

The experimental work begun in 1969 demonstrated that oysters can be spawned upon demand at any time during the year; that larvae can be reared to setting in 9 to 13 days; that a combination of local algal species can be isolated and grown in culture for use as food, and that free spat will grow to a suitable size for planting in three months.

Free spat, manipulated to set on sheets of plastic from which they can be easily removed, have many potential benefits to both the laboratory and commercial shellfish hatcheries. Costly handling and washing of bulky shells used as cultch may now be eliminated. In addition, free spat allows the production of oysters uniform in both size and shape which can be shipped anywhere in large numbers for relatively little cost.

The methods developed by VIMS for successful fattening, conditioning and spawning of the southern oyster during periods when populations cannot reproduce in nature because of low temperatures, or for controlling spawning to obtain gametes upon demand during the natural spawning season, has given greater flexibility and a promise for more efficient production of oyster spat.

Once techniques were developed to efficiently produce large quantities of seed oysters, the scientists then turned their attention to application of this knowledge to the design of a commercial hatchery which could operate on a year-round basis and produce sufficient quantities of oyster seed for planting on a commercial scale.

Hatchery procedures and the design of new hatchery equipment for fattening, conditioning and spawning Chesapeake Bay oysters in four to six weeks were developed from experimental laboratory

designs and adapted to a hatchery built with the advice of VIMS by a seafood producing firm located at Colonial Beach, Virginia.

The hatchery operation, which began in January 1973, required modifications of some of the procedures developed in the laboratory, but the project has demonstrated that a commercial oyster hatchery can produce sufficient quantities of oyster seed for planting on a commercial scale.

The special significance of the project is the ability to manipulate conditions to yield "ripe" oysters at any time during the year, especially during the first five months of the year when ambient bay water temperatures are too low to allow "natural" development of gonads in oysters. Design of new tanks to hold the broodstock populations, to control temperature, the rate of water flow, and rate of feeding starch and algae have made this manipulation possible. VIMS' hatchery design and methods are described in "Translations of mariculture research into a commercial oyster seed hatchery" by Dr. John L. Dupuy, reprinted as VIMS Contribution No. 581 from Marine Technology Society 9th Annual Conference Proceedings.

Isolation and successful batch culture of three new species of local estuarine algae for use in combination as food for oyster larvae and the demonstration of growth to setting of the larvae in 9 to 12 days have not only given the ability to operate a hatchery on a year-round basis, but also have enabled the placement of oyster hatcheries in a greater number of geographical locations.

In addition, a new method developed to obtain free spat has proven particularly adaptable to areas where fouling and heavy sediment occur. This method, coupled with the design of free spat holding tanks to obtain seed oysters in two to three months, gives promise for the establishment of an efficient hatchery operation where these problems exist.

Improvement of Fisheries for Molluscs

Sea Grant-funded studies begun in 1968 to develop commercially applicable methods for growing clams and scallops from egg to market size were concluded at the close of the report year.

Despite the economic importance of the hard clam, *Mercenaria mercenaria,* and the bay scallop, *Argopecten irradians,* there have been few attempts of even rudimentary culture of these two species. Methods for conditioning, spawning and growing the embryo and larval stages are described in the literature, but little work has been done on the methodology and economics of growing these species to a marketable product.

This study was initiated with several objectives:

- To investigate the technical feasibility of culturing these two species.
- To test various methods and ascertain those that are commercially feasible.
- To develop and test a methodology of culturing these species to market size.
- To critically evaluate the above methods, including their costs, to see if they were economically feasible.

A critical review of the literature, supplemented by interviews with other investigators indicated that these species could be induced to spawn and the larvae could be grown to setting. Literature indicates considerable research on culturing hard clams was carried out with little or no success. Little information, except for natural history data, was available on growing scallops beyond setting.

Experimental work carried out at the Wachapreague branch laboratory on Virginia's Eastern Shore demonstrated that culture of these two species is technically feasible. However, few of the problems of culture beyond setting have been solved.

Most larval culture is based on growing unicellular algae to feed the larvae or on using rough filtered or raw seawater. Several pelecypod species have been successfully grown by the Glancy method. This method consists of clarifying raw seawater by centrifugation using a clarifier or cream separator and storing the supernatant seawater in aerated tanks in a solarium or greenhouse.

In reviewing the larval culture methods, it was decided that growing unicellular algae required considerable space and costly equipment. It also requires considerable trained technician time per unit of food. The cost per unit of food would be excessively high. It was also apparent that unicellular culture had many inherent pitfalls and problems.

The Glancy method seemed less expensive and more reliable. Preliminary tests indicated food grown by this method produced excellent survival and fast larval growth. Using the Glancy method, over 200 million clams were grown and set in a nine-month period.

It was apparent that growing post set to market size was the most critical problem and required our greatest effort.

Hard Clams

Review of the literature indicated that many methods of growing clams had been attempted with varying degrees of success. Without some form of predator protection most juvenile clams planted in natural waters were lost. Culture attempts using various methods of predator protection had generally been abandoned due to high costs of maintaining and cleaning boxes, screens, trays and floats, or had failed because of fouling, smothering of clams, or washing out by waves or current.

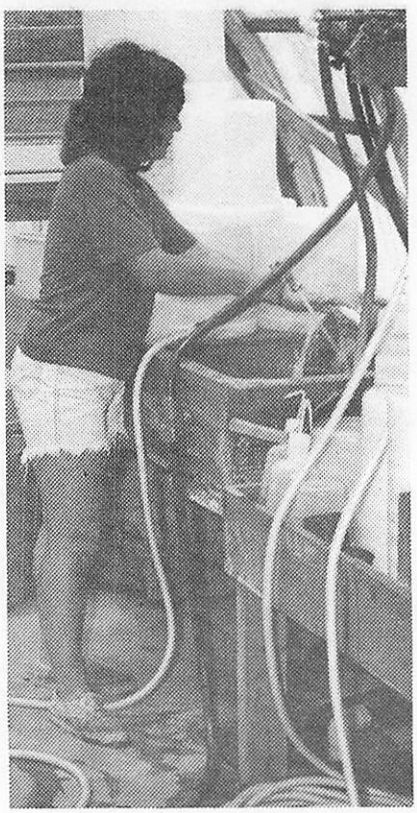
Growing clams in predator-controlled ponds or tanks was apparently not feasible since clams failed to grow in restricted waters. Growing clams in tanks or flumes dependent on pumped seawater was too costly to be commercially feasible.

The most productive methods suggested from this study were:

1. Collect clams from various geographical areas when the

gonads are ripe or nearly ripe. This eliminates the expense of refrigerated holding facilities (to prolong the spawning period) and heated conditioning facilities (to develop the gonads for spawning). Geographic selection from Long Island Sound, native Virginia clams, and North Carolina clams make spawners available for 9 to 10 months.

2. Spawn using the thermal shock and sperm stimulus method generally used in pelecypod culture.
3. Grow larvae using Glancy method.
4. Grow post set in tanks of flowing unfiltered seawater until they are 3 to 5 mm in width (approximately 3 to 5 weeks).
5. Move to protected nursery area.
6. Thin out nursery areas and expand or transplant clams.



The protection used in this study was stream-bed gravel, stone, crushed marl or shell aggregate one to three inches thick spread on the planting area. The juvenile clams burrow through this material into the bottom. The aggregate offers a good degree of protection from predators, requires no cleaning or maintenance, is easy to install, is relatively inexpensive and is reusable. The gravel, stone or marl worked best in this area since shell often collected a heavy set of oyster spat, making it difficult to harvest the clams.

The first experiments using this protection method on 3 to 10 mm clams yielded 86 to 92% survival while controls yielded 0 to 16% survival.

Subsequent trials gave erratic results. Indications were that where strong currents or wave action prevailed, the clams were washed out and lost. Laboratory tests indicated that clams 3 to 5 mm in width were moved by laminar flow currents as low as 18 cm/sec. Not until clams were 20 mm in width could they withstand ½ knot currents (25 cm/sec).

Simple current baffles were designed and tested. The most effective were simply panels of ¼ inch mesh plastic screen 24 inches high that were placed around small 7 to 10 foot square aggregate-protected plots. Clams could be planted in these small nursery plots at high densities (300 per sq. ft.), then transplanted, or a series of small plots could be used to grow clams to little neck size without thinning at densities of 50 per sq. ft.

Bay Scallops

In reviewing the literature there was no mention of attempts to culture this species, although transplanting was often recommended to supplement wild stock in given areas of the northeast.

The first objective of this research was to establish the feasibility of growing this species to market size and to determine whether or not the Glancy method could be used for larval culture. Since scallops have the ability to swim, they were grown in floats, pens, or cages.

Results of the study indicated that bay scallops could be cultured and would reach market size in a relatively short time (6 to 7 months). The larvae were reasonably hardy and could be grown using the cultured water of the Glancy method. In addition, adults from local waters and from North Carolina could be spawned from

February to November with little or no conditioning.

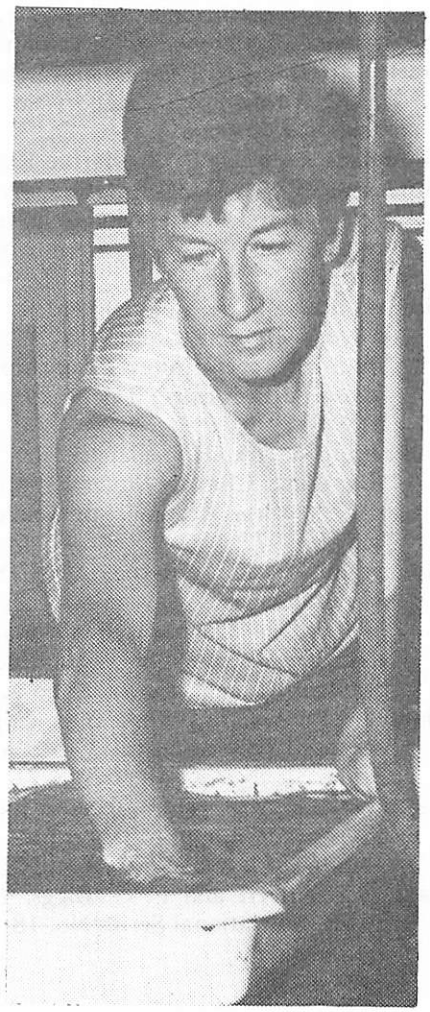
Further research yielded considerable natural history and culture information. Experiments were carried out on different types of holding tanks, pens, and floats. Experiments were also carried out on depth and densities. Meat yields were volumed and weighed from each experimental group. Some preliminary selection of stocks were made and some self-fertilization and sibling crosses were tried.

VIMS' method for culturing bay scallops is:

1. Spawn adults using thermal shock method and sperm stimulus if necessary.
2. Grow larvae in cultured water (Glancy method).
3. Hold post-set juveniles in flowing sea water in tanks with multiple vertical partitions. A suitable screen at the outlet is necessary to catch the scallops caught in the overflow.
4. When scallops are 10 to 13 mm in width, move to 10 x 10 x 7 ft. high pens in nature where they are grown to market size.

Cost estimates of the VIMS method of growing clams and of scallop culture were presented to Sea Grant.

During the course of this study cooperative experiments were made with over 36 commercial watermen from Virginia, Delaware, Maryland, New Jersey and New York. More than 30 million clams and 2 million scallops were furnished to various individuals and agencies to use to conduct experiments. Experiments using part of the methods described have been carried out in eight states on the Atlantic Coast and in the Virgin Islands with assistance from VIMS' Sea Grant programs.



Future Studies

Plans are being laid to do a complete cost analysis on the culture of these two species. To do this accurately, an attempt will be made to grow approximately two million of each species to market size. These will be sold to local packers and profits compiled. The objectives of this study are to accumulate accurate economic data to use as a demonstration unit. Further use will be decided upon, but the unit could be used for a nursery for stocking public areas.

In making the literature search for the previous studies, an excellent bibliography has been accumulated. If funds become available, an annotated bibliography will be completed for *M. mercenaria.* After this is completed, consideration will be given to completing the same for *A. irradians.*

A project was initiated to test the feasibility of a put-and-take fishery for scallops. Approximately 30;000 juveniles (1,000 tagged) were released in Bradford's Bay on Seaside of the Eastern Shore. It is hoped that these scallops will be harvested by commercial fishermen and returned to VIMS so that information on growth, survival, and movement can be obtained.

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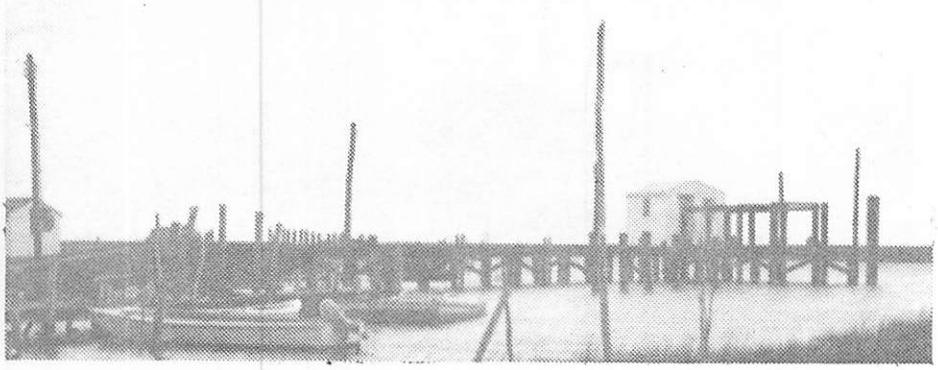

Sea Grant Activity Budget—1973

	NOAA Grant Funds	VIMS Matching Funds	Totals
Marine Resources Development			
Aquaculture—Molluscs	$104,200	$ 81,800	$186,000
Information Base	10,000	—	10,000
Marine Technology Research and Development			
Commercial Fisheries—Technology	52,700	28,300	81,000
Marine Environmental Research			
Applied Physical Oceanography	35,000	18,700	53,700
Advisory Services			
Extension Programs and Other Advisory Services	110,500	38,500	149,000
Program Management and Development			
Program Administration	22,600	13,900	36,500
Totals	$335,000	$181,200	$516,200