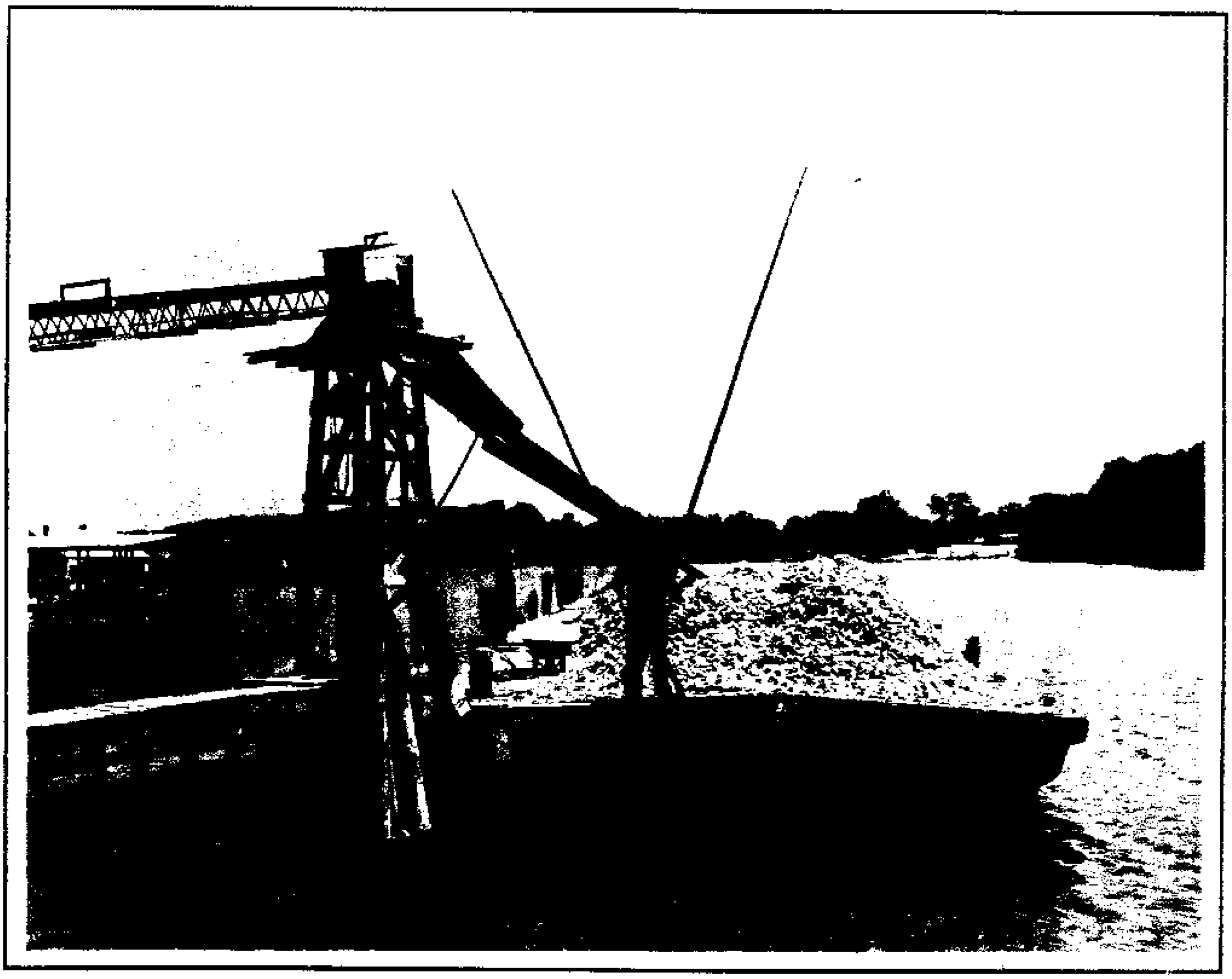
Marine Aquaculture In the Commonwealth Of Virginia



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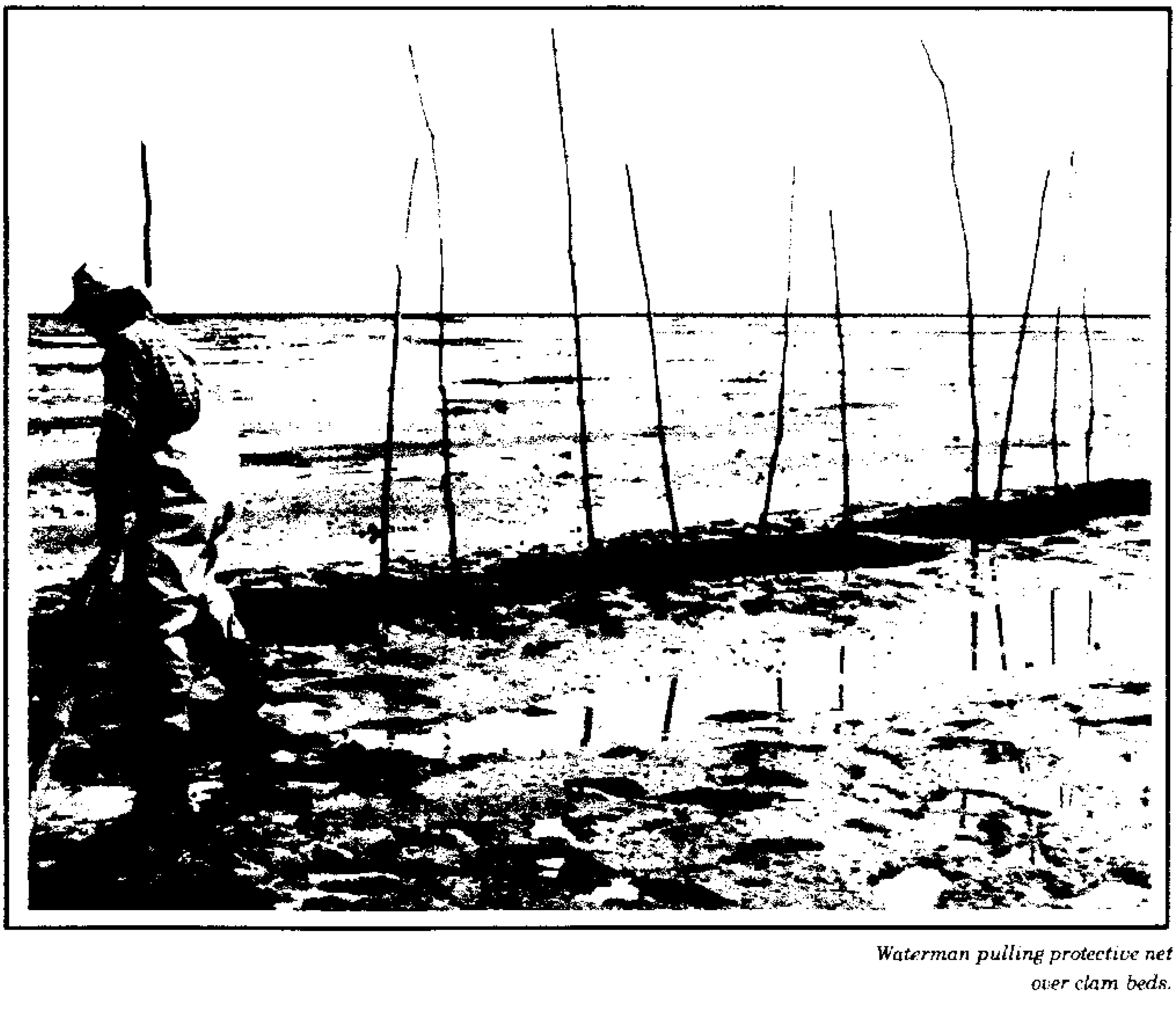
Marine Aquaculture, A Status Report

By
Michael Oesterling



Waterman pulling protective net over clam beds.

Aquaculture, broadly defined as the controlled cultivation and harvest of aquatic plants and animals, has experienced a resurgence of activity throughout the United States. "Marine aquaculture" has been used to distinguish the culture of marine or estuarine organisms from freshwater aquaculture. As the supplies of traditionally utilized fisheries (i.e. wild stocks) approach maximum exploitation, cultured products can help meet increasing consumer demand for high quality seafood.

Although aquaculture has had a long history in Virginia, the Commonwealth initiated an aquaculture development task force in the late 1980s. Initially envisioned as an agricultural diversification activity, this program has broadened its scope to encompass the promotion of all aspects of aquaculture, including coastal marine aquaculture activities. Virginia marine aquaculture activities focus on three species, oysters (*Crassostrea virginica*), hard clams (*Mercenaria mercenaria*) and soft shell blue crabs (*Callinectes sapidus*).

Future culture activities are expected to concentrate on several species. The bay scallop (*Argopecten irradians*) figures predominantly. An ongoing, experimental program has made it possible to identify several options for final grow-out, and has enabled methods to be fine tuned for commercial applications.

Other animals which may figure into Virginia's marine aquaculture future include the ribbed mussel (*Guekensia demissa*); the surf clam (*Spisula solidissima*); and the softshell clam (*Mya arenaria*). ✣

Crassostrea virginica, The Virginia Oyster

Virginians have cultivated the oyster since the mid-1800s, initially in a frontier-style without regulation and then in a legally-managed fashion. The actual development of a leasing system did not occur until the late 1800s when private individuals began growing oysters on barren public bottoms. The need for an organized system arose from the difficulties in determining what was a barren bottom. As a result of these controversies, the Virginia General Assembly in 1892 passed an act entitled "An Act to Protect the Oyster Industry of the Commonwealth." This marked the beginning of the dual management system for the public oyster fishery and the private oyster culture industry.

As a result of the 1892 Act, all the naturally-producing oyster grounds of the time were delineated and set aside for the public trust. These "Baylor Grounds," named after their surveyor, comprise 243,000 acres of public oyster harvesting grounds. Any areas not included within the Baylor Grounds are available for private leasing. Interestingly, Lt. Baylor, in his report to the Virginia Governor in 1893, urged encouragement of leasing and private oyster planting as a way to preserve the oyster industry.

It did not take long for leasing to become a major factor in the oyster industry. By 1900 almost 48,000 acres were already under lease. The subsequent years showed steady increases: 1927, 59,500 acres; 1944, 70,600 acres; 1955, 127,000 acres; and in the record year of 1967, 134,500 acres. Since 1967 there has been a decline of acres under lease to 1990 when 108,500 acres are currently leased for shellfish production. The Virginia Marine Resources Commission is charged with administering the leasing system and is responsible for rent collection. Virginia has one of the most liberal leasing policy of any shellfish producing state.

The exclusion of an area from the original Baylor Survey meant oysters did not, at the time, occur there naturally. Thus, the leaseholder had to manipulate the grounds in some manner in order to make them productive. This usually meant one of two things. If the lease was in an area where a natural strike of oysters could be expected, but did not have any oysters, most likely the bottom was too soft to support the weight of oysters. As a consequence, the leaseholder needed to stabilize the bottom, usually with oyster shells, to encourage naturally-occurring oyster larvae to settle on his grounds. Areas with bottoms solid enough to support the weight of oysters, but where no oysters occurred, did not receive a natural set of oysters. Leaseholders of these grounds would have to plant seed oysters from other locations on their ground. From this developed the most prevalent method of oyster culture in Virginia, harvesting seed oysters from one area and transplanting them for growth in another area. Most of the private oyster planters in Virginia still use culture techniques for growing oysters which have remained unchanged since the turn of the century.

Indeed, the most common oyster culture technique in Virginia is the transplanting of wild-harvested seed to private growing grounds. The amount of seed planted per acre depends on bottom stability and growth characteristics of the area. Plantings vary from about 500 bushels of seed per acre for hard bottoms, to 750 bushels for soft bottoms stiffened with shell in order to compensate for the inevitable losses associated with such bottoms. Planting as high as 1,000 bushels of seed per acre, or higher, does occur. However, these plantings are on grounds with a long history that has shown them able to support this density of oysters. Oyster planters hope for at least a one-for-one return on planted seed versus market oysters. Prior to 1980 the private grower paid little attention to his grounds between the time the seed was planted and the time mature oysters were harvested, some 2 or 3 years later. Now, however, because of increased disease activity, private planters monitor the condition of their growing grounds more closely and may routinely have their oysters tested for disease presence.

Oyster hatchery at the Virginia Institute of Marine Science.

Other methods for growing oysters have been attempted. During the late 1930s the Chesapeake Corporation investigated using a tray and rack system to grow oysters in the York River. Trays containing approximately 1/2 bushel of oysters were supported off the bottom on short wooden stakes. At one time over 11,000 trays stretched for 3 miles along the shore of the York River. However, in 1942 this project was discontinued, probably because of high labor costs to maintain the trays/racks and to handle the oysters. Subsequent studies using a similar tray system demonstrated that oysters cultured this way grew much faster than those grown on adjacent bottom; tray culture could produce a well-shaped, high quality oyster in shorter time than required for bottom culture. However, at that time large scale tray culture was economically impractical.

Sometime in the early 1950s oyster planters began placing wire mesh bags full of oyster shell on the bottom in hopes of receiving a good set. This practice began after shellfish biologists had been using shell bags to monitor the set and survival of oysters. After the onset of MSX (*Haplosporidium nelsoni*) and a decline in setting intensity, the use of shell bags increased in Virginia. An estimated 100,000 shell bags—each holding about 1/2 bushel of shells—were set in the Great Wicomico and other Virginia rivers by 1971. The use of shell bags today has all but disappeared, again presumably because of the cost in constructing and handling shell bags.

The severely depressed condition of the entire Virginia oyster industry is well known. This applies to both the public and private sectors. This century's peak production from private grounds—3,347,170 in 1959—fell to only 47,247 bushels in 1991.

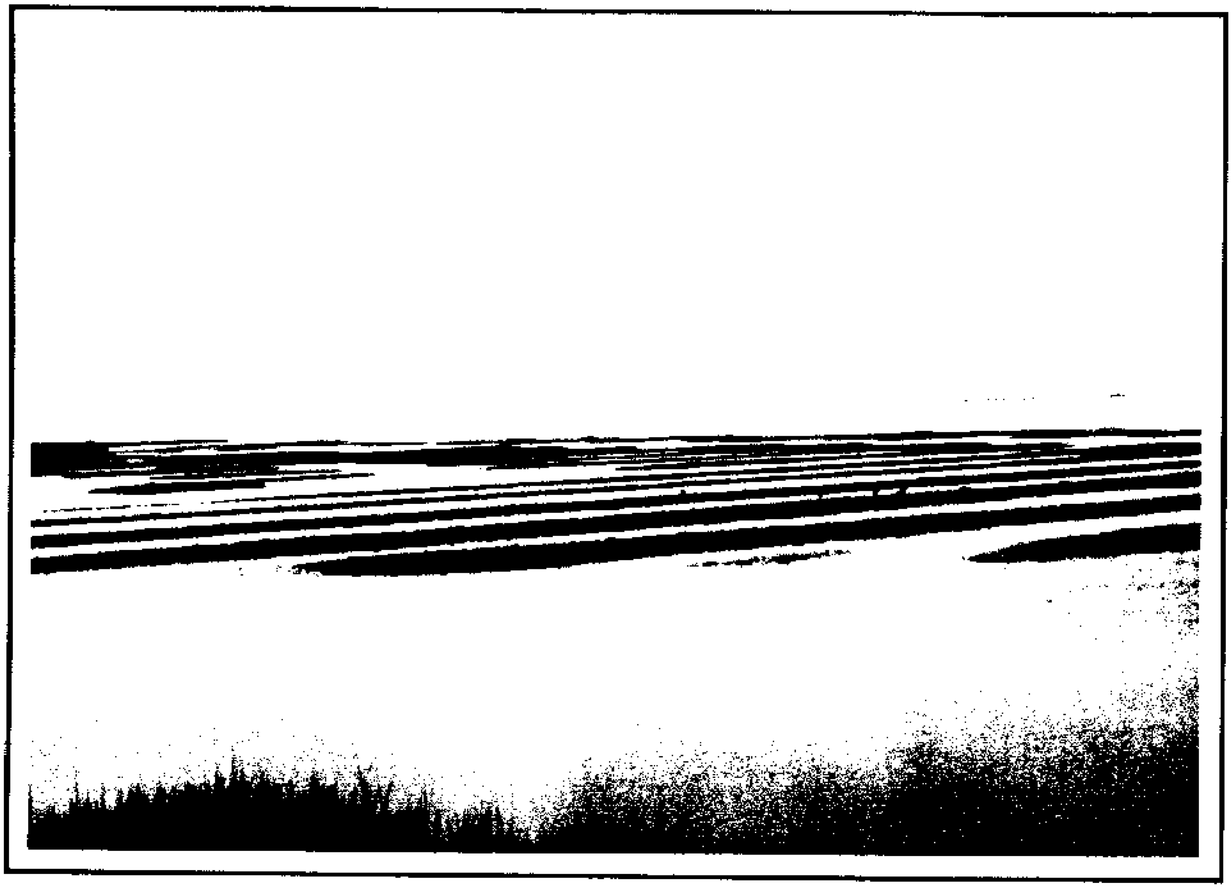
The advent of the oyster pathogen MSX in Chesapeake Bay in the early 1960s wrought great changes in the oyster industry. Not only were the traditional high salinity growing grounds no longer productive, but the supply of natural seed oysters was drastically reduced. This lack of a consistent production of natural seed supplied the impetus for investigations into the development of hatcheries to supplement natural seed production. By the late 1960s the Virginia Institute of Marine Science (VIMS) was actively researching alternative methods of oyster culture and established an oyster hatchery at its Gloucester Point facility.

During the 1970s the oyster industry recovered somewhat from the initial devastation of the previous decade. This period experienced weather conditions that were unfavorable for the oyster pathogens and allowed for increased oyster production. Oyster processors acquired shellstock from other oyster-producing states permitting them to maintain their supply of raw materials for shucking and contract fulfillment. Oyster planters had learned from past experiences how to manage around MSX, or had developed new growing grounds outside disease-impacted areas. These all combined to lessen the urgency for the development of alternative culture technology or hatchery implementation.

Three periods of drought occurred during the 1980s, once again crippling the oyster industry. The practices of transplanting seed had essentially spread the oyster pathogens throughout Virginia waters. During the drought periods, areas previously relatively unaffected by MSX or Dermo (*Perkinsus marinus*) were ravaged by the diseases. Dermo became particularly destructive, spreading to areas never before impacted by diseases, in particular the seed grounds of the James River and the oyster growing grounds in the Virginia tributaries of the Potomac River. Production of both market oysters and seed plummeted during the 1980s causing another plea from oyster growers for assistance. The concept of hatcheries to help alleviate seed shortages or to supply heartier stocks of oysters resurfaced. Additionally, during this time frame a shift in marketing strategies for oysters was occurring. Past production concentrated on producing oysters for shucking, essentially bulk sales. With shortages in supply, processors began to switch their sales from shucked product and concentrated on the more lucrative half-shell market. Emphasis was placed not on volume (shucked) but on a per-piece (half-shell) market. As a result of this shift in market strategy and stock reductions, culture techniques designed to produce an oyster that could survive the oyster pathogens and satisfy the half-shell market became important.

The severely depressed condition of the entire Virginia oyster industry is well known. This applies to both the public and private sectors. This century's peak production from private grounds—3,347,170 in 1959—fell to only 47,247 bushels in 1991. This decline is the result of

Oyster beds at Chincoteague, Virginia.



many intertwined factors. Contributing to the current situation are an increased activity of the oyster pathogens MSX and Dermo; an increase in predators such as the cownose ray, *Rhinoptera bonasus*; lowered oyster reproductive success; overharvesting; and economic considerations (high money interest rates, seed cost or availability, cost of labor).

While the picture may be bleak, the oyster culture industry of Virginia is not dead; even at record-low harvest it remains a million dollar business, with a 1991 dockside value of $970,000. Research is continuing at VIMS in hopes of rejuvenating oyster culture in Virginia. One current research direction focuses on the use of off-bottom culture as a means of augmenting, not replacing, traditional on-bottom culture. Through cooperative research projects involving private culturists, VIMS seeks to improve off-bottom culture techniques designed for the production of single oysters (cultchless) destined for the half-shell market. Coupled to this aspect of the project are investigations regarding broodstock selection for desirable traits (i.e. fast growth, proper shell shape, disease resistance), the potential for genetically manipulated oysters (triploids, etc.) and descriptors for predicting best growth areas. While there is great interest in the VIMS activities within the private sector, this aspect of oyster culture is still in the research and development phases. At this point less than a dozen individuals are involved in actively attempting off-bottom culture. An ultimate goal of these projects is the opening of a private hatchery to supply cultchless seed oysters necessary for off-bottom culture. ✥ ✥ ✥

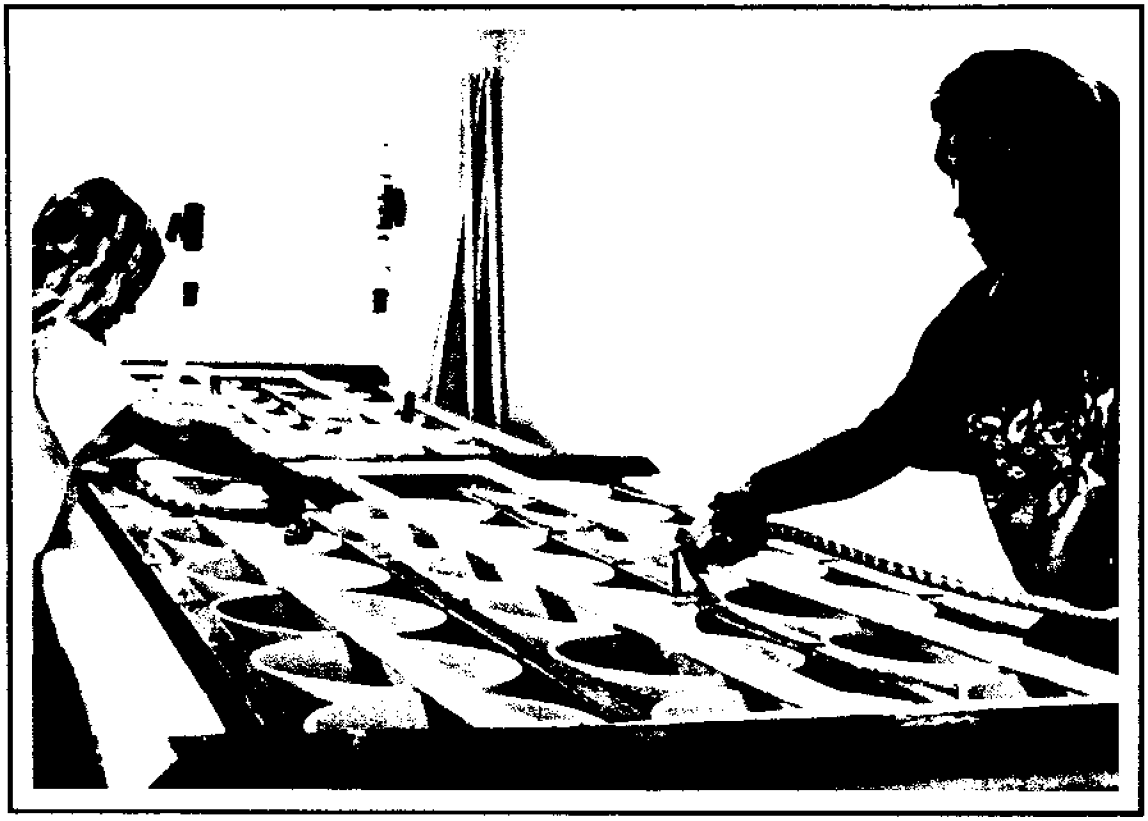
Mercenaria mercenaria, The Hard Clam

The hard clam is an important seafood to Virginia. In 1991 reported landings placed hard clam meats seventh in importance by poundage (1.1 million pounds) and fourth by value ($4.1 million) of all Virginia edible seafood. Unfortunately, it is not possible to separate out any contribution to these landings from clam culture activities. However, based upon discussions with field representatives from the Virginia Marine Resources Commission and with clam farmers, in all likelihood these numbers reflect only wild-harvested animals and not cultured clams.

Similarly, the acreage of leased bottom under clam culture is unknown. This is because there are no separate provisions for clam leases. The Code of Virginia states that all provisions relating to leasing of oyster grounds shall also apply to clams, but no distinction in purpose (i.e. oyster or clam culture) is required in the leasing procedure.

Even though clam culture in Virginia is not as old as oyster culture, crude forms of husbandry, such as moving clams from one area to another for storage or holding in other structures, has been practiced for decades. Only within the past 20-30 years has true commercial culture of hard clams become a reality. The single most important factor leading to commercial clam culture has been the development of hatchery techniques for seed production since, unlike oysters, commercial quantities of wild seed are seldom available. Coupled to this was the development of the capabilities to protect small seed clams from predators. Currently, the technology for hatchery, seed nursery and field grow-out has advanced to the point where manuals are available to assist the clam culturist.

Algae culture: food for larvae and juvenile clams.



Routine maintenance at a commercial hard clam facility.

The cylinders in which the animals are grown are downwellers. Water flows from top to bottom in a downweller.

Virginia's Eastern Shore was the site of the first commercial clam hatchery in the U.S. In 1956, using methods developed by the U.S. Bureau of Commercial Fisheries (now the National Marine Fisheries Service), Richard L. Kelly set up a clam hatchery in an oyster house in Atlantic, Virginia. The production from this hatchery/nursery was reasonably successful, but sporadic. Unfortunately, field plantings were complete failures, most likely due to predation. As attempts were being made to improve field planting success, Mr. Kelly died and his work was not continued.

The problem of predator control in the field grow-out phase of clam culture was investigated by researchers at the VIMS Wachapreague Laboratory. After years of experimentation, VIMS scientists developed techniques for successful grow-out systems and with these developments, clam culture was poised for rapid growth.

Although a strong potential for financial success exists, commercial clam culture developed somewhat slowly. Clam culture has been hindered by biological/environmental, social/regulatory, or economic reasons. Environmental impediments arise from the biological needs of the hard clam for appropriate water quality, proper substrate, absence or reduced presence of predators and water current flow patterns. Regulatory restrictions have delayed clam culture development as well. Imposed restrictions on harvesting gear that makes the use of efficient gear illegal (see Section 28.1-128.01 Code of Virginia, relating to the use of hydraulic dredges) and a general lack of legislative incentives for expansion (for example, tax credits) have contributed to the slow growth of clam culture. A major stumbling block to growth has been financial limitations, a reluctance for private lending institutions to fund culture activities. Additionally, potential clam culturists do not have access to publicly supported programs. As a consequence, many clam culturists must begin on a very small scale and slowly expand as additional resources become available. In only a couple of cases has a clam culture facility been adequately capitalized to permit large-scale hatchery, nursery and field grow-out.

Despite these constraints, Virginia currently has approximately 32 clam culture facilities, including the largest, totally-integrated operation in production in the East. These clam culturists have field plantings ranging from a few thousand to tens of millions. Total harvest production is unknown, although a reasonable estimate would approach 30 million littleneck clams in 1991. At this level of production, cultured clams have exceeded the value of the wild harvest! With the continued expansion of hard clam aquaculture within the Commonwealth, the importance of cultured clams to the Virginia seafood industry will grow.

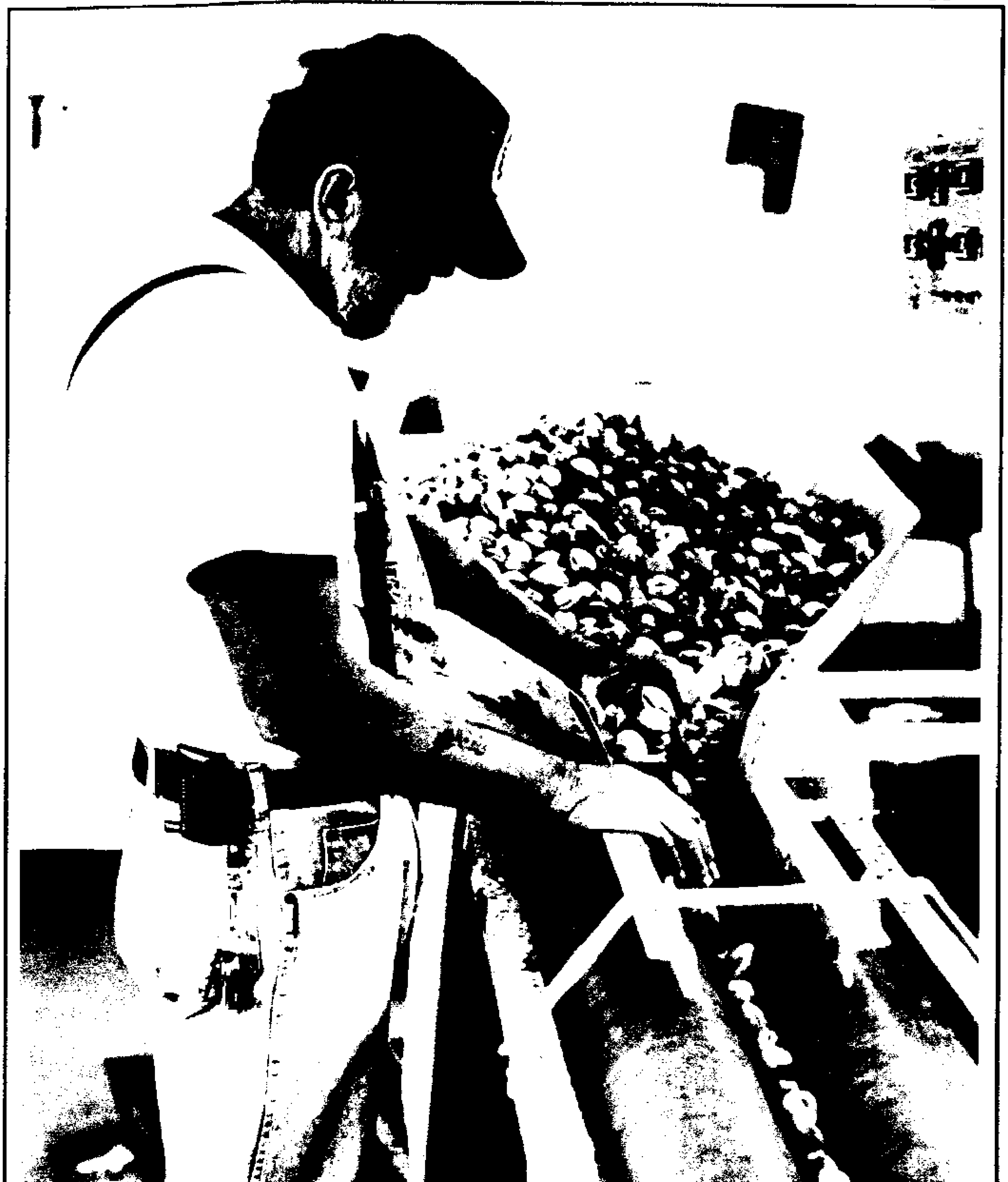
This is not to say that everything is known about hard clam culture. Producers must still identify the best suited methods for grow-out in their particular area. Work continues on refining the entire process, from broodstock selection to spawning, nursery and final grow-out. Clam culture is still a time consuming, labor intensive venture that continues to be improved upon.

Both cultured clams and oysters compete in the marketplace with the wild harvested product. Because of little investment on the part of the harvester, in most cases wild clams/oysters can be "produced" at a lower cost than cultured and thus can be sold cheaper. Many buyers are interested only in the "bottom line"—not in the superb quality and other traits of a cultured product. In some respects, clams and oysters are commodity items, prices varying with supply and demand. Culturists can be caught in this price shuffle if they do not effectively market their product or are unable to withstand financial hardships to withhold the product from the market until prices become more favorable.

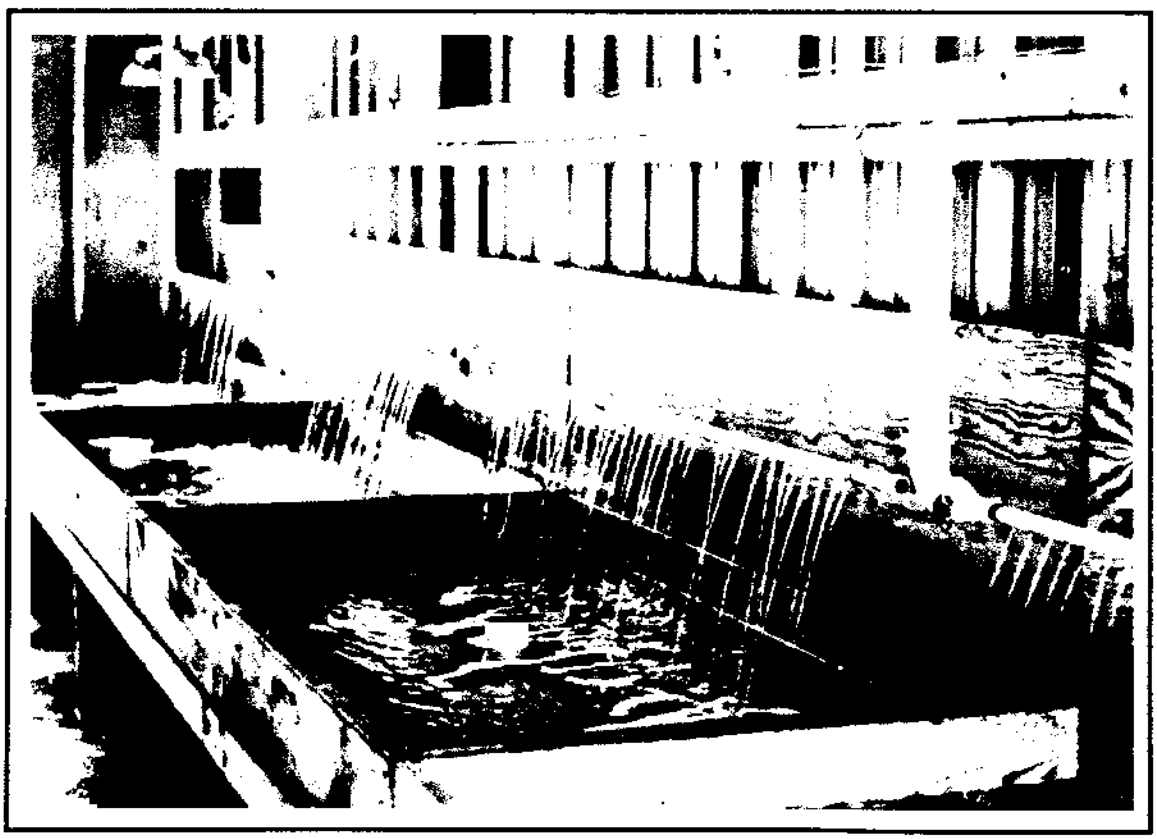
This competition is not restricted to only wild harvest. Both clams and oysters are cultured in other parts of the U.S. and compete for the same markets as Virginia producers. The answer to this competition is not necessarily increased production, but may be more efficient cost effective procedures or innovative marketing which creates a perceived premium for Virginia products. ✣ ✣ ✣

Upwellers at a hard clam facility. Seawater is pumped from a nearby source into the upwellers. The direction of the water is from bottom to top in an upweller.

Clams being graded.



"Buster" crab backing out of its shell. Once out of the old exoskeleton, the wrinkled, soft shell crab will absorb water and in several hours to several days its new shell will completely harden.



Shedding facility for soft shell crabs. After a crab molts, it will remain soft if it is removed from the water.

Callinectes sapidus,
The Soft Shell Blue Crab

Soft-shell crabs have been produced commercially in Virginia for well over 100 years and may be the earliest form of aquaculture in the United States. Soft-shell crabs are not a separate species of crab, but are blue crabs (*Callinectes sapidus*) that have shed (molted) their hard outer shells in preparation for growth. The hard exoskeletons of blue crabs do not allow for continual size increases associated with fishes and other animals. In order for a crab to grow, this hard shell must be shed; a soft, pliable crab emerges, expands its soft new shell, and "grows into" its new body. At this time, when the crab emerges from its old shell, it is known as a soft-shell crab or, more simply, a "soft crab." Within hours the crab will again return to its previous hardened state. However, if the crab is removed from the water shortly after molting, it will remain soft and can be sold as a soft crab. Today, the soft crab represents a major Virginian fishery; in 1991, more than 1.4 million pounds of soft-shelled crabs were commercially produced with a dockside value of $1.7 million.

Initially, soft crabs were probably caught in a very haphazard manner, being readily scooped up by foraging Indians and later by English settlers. It was not until hundreds of years after the arrival of the white man that the mass production of soft crabs was attempted. The soft crab industry began in Crisfield, Maryland, and quickly spread to Virginia.

The loosely controlled shedding of crabs began in the 1850s when wire enclosures were staked out in the shallows of the tidal zone. These pens were filled with hard crabs which were fed and watched closely for molting. This method was difficult to manage; numerous crabs were lost to cannibalism or died as a result of wide variations in temperature, salinity or water quality.

As these early crab shedders handled more and more crabs, they learned to examine hard crabs for unique signs which indicated a premolt condition (peeler crab). Experienced producers began to equip their crab pens with floating boxes to house and protect those crabs nearer to shedding. These floating boxes ("floats") were successful in decreasing mortality and increasing soft crab production. In time, producers used more floating boxes and became less dependent on crab pens which required extra care. Soft crab production began to be more dependent upon a selective harvest of peeler crabs. Through these trial and error modifications of the earliest floats, we arrived at the design and construction still in use today.

More reliance on floats meant that producers were no longer restricted to the shallow tidal waters of crab pens. Floats could be moored in deeper waters where there was better water quality. The crab pen with its floats evolved into "shanties" or "soft crab houses." When adequate water depth was available or protection offered, many float operations became centered around shore-based crab houses.

Of the methods used to produce soft crabs, floats are the least expensive to construct, maintain and operate; however, disadvantages outweigh advantages in a float operation. To begin, there is the need for expensive waterfront property conducive to the siting of many moored floats. Due to the very nature of float construction, crabs are confined to the upper few inches of water; at these depths, crab mortalities in floats can occur from rapid temperature and salinity shifts as the result of heavy rainfall. Additionally, many float operations are located in pro-

Soft shell blue crab being wrapped for shipment.

tected areas where, unfortunately, water circulation may be poor. Without proper circulation, dissolved oxygen can be depleted and water temperatures can rise to lethal levels. Crabs held in floats also are exposed to predation by animals both in (eels, bull minnows, etc.) and out (raccoons, herons, otters) of the water. Essentially there is no control over environmental factors.

However, perhaps the greatest drawback to a float operation is the physical difficulty and discomfort associated with tending a group of moored floats. Removal of soft crabs, dead peelers and empty shells from the floats, as well as culling crabs generally has to be done from a skiff, with the operator bending over the gunnel; in other words, back-breaking work.

The desire for convenience, more than any other factor, led to the next major development in shedding facilities—the shore-based float or tanks. It was not until the 1950s, almost 100 years after the inception of the soft crab industry, that crab shedders began to "leave the water" and investigate shore-based tanks as a better and easier method to produce soft crabs.

These shedding tanks were simple troughs or shallow tables used to hold running water pumped from an adjacent brackish water supply and then returned overboard. These flow-through systems were easier to manage than floats. Initially just sited in the open along the shore, they soon were housed to provide shade and protection from rain and predators. The foremost advantage, however, is the ease with which they can be worked; no more hanging over the gunnel of a boat. In many cases, shedding tanks are at waist level where little bending is required. Onshore, soft crabs are better protected from predators; no more eels or bull minnows, and tanks that are housed are safe from raccoons, birds and poachers. Finally, there is some limited control over the environment. More stable temperature and salinity can be achieved by drawing water from greater depths. Also, housing keeps tanks out of direct sunlight and protects them from rainfall.

Unfortunately, these flow-through systems still require waterfront property and water of good quality and depth. There is also an increase in both construction costs and operational expenses over an in-water float system.

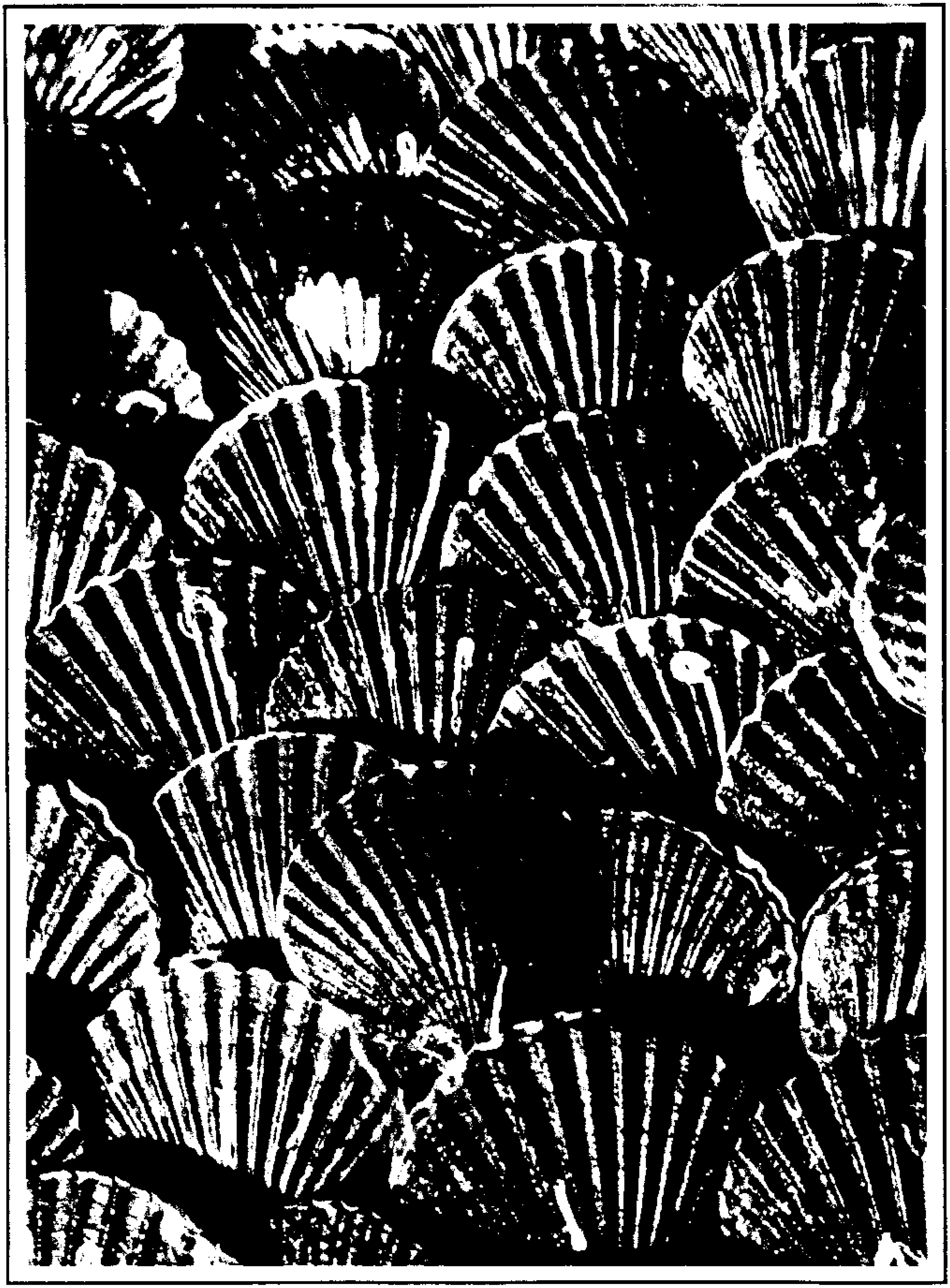
During the past decade a great deal of interest has been generated over the use of recirculating water (closed) systems for crab shedding. Closed systems offer several advantages over traditional methods. They provide the opportunity to shed crabs completely away from the waterfront or, in areas of reduced water quality, they offer a viable method for producing soft crabs. Foremost among the advantages is better control over environmental factors: salinity can be maintained at a constant level; water temperatures may be manipulated as the season dictates; there are no dangers from waterborne pollutants or silt; water clarity can be increased; and tanks can be maintained and kept cleaner easier.

However, a closed system has disadvantages as well. They are more complex and costly to build and maintain than a flow-through system. Unlike flow-through systems, production cannot be readily stopped and restarted. And, with no overboard discharge, constant attention is required for the control of potentially toxic wastes added to the system by the normal bodily functions of the crabs. The buildup of toxic substances resulting from these waste products is the primary limiting factor in a closed system.

Soft crab production continues to be a growth fishery in Virginia. It offers the full-time hard crab fisherman the possibility for expanding his income by utilizing the peeler crabs he harvests in his own shedding operation. As the reliability of closed systems improve, more watermen will take advantage of this income generator. ✤ ✤ ✤

Blue crabs en masse to market.

Bay scallops.



The Future

With Virginia's history in mollusk culture and its geographic location, it is likely that new culture activities will focus on this group of animals. Indeed, there are current efforts by VIMS to initiate a bay scallop (*Argopecten irradians*) culture industry. The program actually is building on basic information developed by VIMS scientists in the early 1970s.

The bay scallop is considered to be suitable for marine aquaculture for a number of reasons: 1) it has a high market value; 2) there is a high level of consumer recognition and acceptance; 3) natural populations experience fluctuating stock abundance; 4) they have rapid growth to market-size; and 5) hatchery techniques for spawning and rearing larvae/juveniles have been successfully demonstrated. When VIMS scientists first investigated bay scallop culture, two major impediments were identified as constraints to further development. One was the need for better grow-out methods. And secondly, the economics of producing bay scallops for the shucked meat market did not look favorable. At that time, only the scallop adductor muscle was utilized. Recently, however, interest has developed in using the entire animal, similar to oysters or hard clams, as either a half-shell animal or as a cooked whole animal. These animals command a premium price in the market, making the economics of the culture much more favorable.

The current VIMS research is addressing the other problem of field grow-out. This project has investigated several options for final grow-out and has been successful in identifying potential commercial methods. At this point, private growers are being assisted in experimental plantings in order to assess the practicality of bay scallop culture at their locations and in conjunction with their existing culture activities.

The blue mussel (*Mytilus edulis*) already supports a thriving culture industry around the world, and closer to home, the state of Maine. Unfortunately, Virginia is at the southern edge of its distribution. As a result of this, production of blue mussels would be tenuous, some years being successful, others disastrous. It also requires a high salinity environment which would limit its production within Virginia to the seaside of the

Graduate student counting juvenile scallops to volumetrically determine the total number of animals which were grown.

Bay scallops were initially "set" in mesh bags. Here, a graduate student is removing scallops so that the animals can be transferred to upwellers.

Eastern Shore and the extreme lower part of Chesapeake Bay.

However, there is a native mussel, the ribbed mussel (*Guekensia demissa*), that could possibly be utilized as a culture animal. It is already harvested for personal consumption by many coastal inhabitants. The propensity for the ribbed mussel to grow partial buried in the substrate sometimes results in animals with an off-flavor. This could be alleviated by culturing these animals "off-bottom" using methods similar to those already in place for the blue mussel. Additionally, the ribbed mussel has a wider range of tolerances for salinities which would permit it to be grown in more locations around the state. In order for the ribbed mussel to be grown commercially, work must be done to identify acceptable growing methods, including both larval/juvenile and market-size animals. Some market promotion would also be required, but should not be too extensive as the ribbed mussel should be able to benefit form the wide acceptance of the blue mussel.

Efforts are currently underway elsewhere evaluating the culture potential of the surf clam (*Spisula solidissima*). This species has potential applications in Virginia, as well. Results from other regional research should be watched closely for successful implementation of culture technology for the surf clam. It would be a simple matter to transfer to Virginia the technology developed elsewhere.

Another species currently under investigation for culture, is the softshell clam (*Mya arenaria*). In actuality, it is cultured for public reseeding programs in Maine. Thus, the spawning, hatching and rearing of seed-sized animals is already being practiced. It would only require one additional step, field grow-out methods, to make the transition from public restocking to private culture. In all likelihood, existing methods to culture other clams could be modified to accommodate softshell clams. Virginia has had exploitable populations of softshell clams in the past. However, the potential areas to grow softshell clams may be environmentally limited.

An area that has been receiving increased amounts of attention, is the cultivation of marine fishes. In many respects this area is far behind the culture of mollusks. For some of the species being mentioned, there are still basic biological questions that need to be answered. These include fundamental information on larval requirements, broodstock acquisition, growth parameters and nutritional needs. In most cases these species are attractive to culture because of high market value and dwindling natural supplies. There may also be regulatory roadblocks in culturing these species. In particular, the questions of water column usage and siting of in-water culture facilities (i.e. pens or cages) must be addressed prior to any commercialization attempts. Species that have been mentioned as having potential for Virginia include the black sea bass (*Centropristis striata*), summer flounder (*Paralichthys dentatus*) and weakfish (*Cynoscion regalis*). ✣ ✣ ✣

Sources of Additional Information and Assistance

With so much interest focused on aquaculture, it is not surprising that there are numerous sources of information and assistance. Some of these are written manuals, articles or books; other sources provide individual consultation services. Many times, however, the process of locating these information sources seems difficult. These are several starting points for anyone desiring culture information.

The Virginia Sea Grant College Program offers assistance and information to everyone interested in coastal resources. Virginia Sea Grant is a partnership of universities, industry and government dedicated to promoting the wise use and management of our marine resources. Virginia Sea Grant is federally funded by the National Oceanic and Atmospheric Administration, with additional support from universities and industry. Through the Sea Grant Marine Advisory Program individuals can receive assistance in developing economic plans for aquaculture ventures or learn about the current technology and procedures for marine aquaculture operations. Many Advisory Program personnel have experience in culturing a particular species of interest, so they may be able to provide first-hand information. Or, by using the national Sea Grant network, they can identify the appropriate source of information.

Virginia Sea Grant
Madison House, 170 Rugby Road
University of Virginia
Charlottesville, VA 22903
(804) 924-5965

During the 1992 session of the Virginia Legislature, the Aquaculture Development Act was passed officially designating the Virginia Department of Agriculture and Consumer Services as the lead agency to assist in the development and promotion of aquaculture within the Commonwealth, and it created an Aquaculture Advisory Board to help oversee this development. Within the Department an aquaculture program manager was assigned to coordinate the duties of the Advisory Board. One of the major roles of the aquaculture program manager is to serve as a contact point for those interested in aquaculture. The aquaculture program manager can then refer the inquiry to the appropriate information source within the state.

Aquaculture Program Manager
Virginia Department of Agriculture and Consumer Services
P.O. Box 1163
Richmond, VA 23209
(804) 371-6094

The Virginia Institute of Marine Science of the College of William and Mary is charged with providing the citizens of Virginia with research, education and advisory services concerning the marine resources of the Commonwealth. Housed within the Institute is the Department of Marine Advisory Services which functions as the outreach arm of the Institute and works in conjunction with the Virginia Sea Grant Marine Advisory Program and other state agencies and universities. Advisory Service personnel provide advice and conduct research on various aspects of marine aquaculture ranging from business management and economics to production technology. Each year, Advisory Service personnel either sponsor, conduct or participate in seminars, workshops or conferences, sharing their expertise. In addition, personnel conduct demonstration projects, many times in cooperation with industry partners, that are designed to show prospective culturists current technology.

Marine Advisory Program
Virginia Institute of Marine Science
College of William and Mary
P.O. Box 1346
Gloucester Point, VA 23062
(804) 642-7165

The Aquaculture Information Center of the National Agriculture Library serves as a focal point for those interested in obtaining literature about aquaculture. This reference service is designed to guide users to pertinent references that can then be accessed through a library (bibliographic services). Information can also be obtained regarding U.S. Department of Agriculture research activities in aquaculture, as well as how to access limited availability articles and other literature contained within the National Agriculture Library.

Aquaculture Information Center
National Agriculture Library
Room 304
Beltsville, MD 20705
(301) 504-5558

The volume of written materials available pertaining to marine aquaculture is too numerous to list in this limited space. Many books, journals or manuals on different aspects of marine aquaculture can be found in libraries throughout the state. Research libraries, such as the one at the Virginia Institute of Marine Science, are open to the general public during normal working hours and are the best starting points for background information searches. Armed with a bibliographic listing from the Aquaculture Information Center or other sources, one can amass a great deal of useful information at any of the colleges or universities within the Commonwealth. ✣ ✣ ✣

Seed clams.

Waterman planting seed clams.

On the cover: Historical photo of an oyster seed barge, loaded with shell for planting. The waterman is holding 20-foot long shaft tongs.

On the right: Waterman tending clam beds.

Virginia Sea Grant
Marine Advisory Program
Virginia Institute of Marine Science
Gloucester Point, Virginia 23062

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