Shellfish Aquaculture Development in Maryland and Virginia

Economy, Employment, Environment

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Credits:

- Engravings, p. 4 & 15 – Harpers magazine, c. 1800s.
- Figure, page 6 – G. E. Krantz, "*Oyster Culture in Maryland 1979*", MD Sea Grant proceedings. 1980. Out of print.
- Chesapeake Bay satellite photo, p. 7 – National Aeronautics and Space Administration, http://veimages.gsfc.nasa.gov/234/MODIS1000018.jpg
- Graphs, pages 20-22 – from "*Economic Implications of Alternative Management Strategies for Virginia Oysters and Clams*", Darrel Bosch, Nicolai V. Kuminoff, Anna Harris, Jaren C. Pope, Kurt Stephenson, and Pam Mason. Virginia Tech. December 2008. 116 pp.
- Photo, p. 30 – Donald Meritt, University of Maryland
- Extension hierarchy diagram, p. 32 – Bennett, Claude and K. Rockwell, Program Development – Overview of the Seven Levels, University of Nebraska Lincoln, http://citnews.unl.edu/TOP/english/overviewf.html

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An Industry Survey for NOAA Directed Funding to Expand Oyster Aquaculture

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Executive Summary

This project was initiated by Dr. Jamie King of the NOAA Chesapeake Bay Office (NCBO) to help guide future NOAA investment in advancing oyster aquaculture in Virginia and Maryland. This was seen as a logical step in placing more of these important filter feeders in waters affected by disease, overharvest, and poor management choices for decades. Aquaculture offers an opportunity to use the private sector to aid solution of a public sector environmental problem. While the two states involved are vastly different in their historical treatment of aquaculture, both suffered catastrophic losses in the resource during the past half century. Both states recognize the need to rebuild these stocks.

The project was organized to address issues of: 1) hatchery production; 2) research and demonstration projects; 3) education; 4) public policy, and; 5) marketing and economics. During the course of the project, many exciting developments were taking place in both states that should aid in furthering the important partnerships that can make the vision of restoring oysters to the Chesapeake and coastal bays a reality. NOAA is well positioned to target funds where they can best be used to assure a bright future for oyster aquaculture as it develops to become an important part of the overall restoration effort. As a science agency using state-of-the-art technology and with a wealth of knowledge about the region built upon decades of effective work, NOAA has been and will continue to be a major partner in the matrix of agencies, groups, and organizations that share the mission of restoring these keystone bivalves to one of America's principal estuaries.

Oyster Cages in Virginia

This project used the Sea Grant Extension Programs, another resource of NOAA with extension organizations in both states, to gather information from those best positioned to define problems requiring solution. During the course of eighteen months, meetings and discussions were held with growers, scientists, resource managers, and others concerned with the oyster problem and interested in enhancing oyster aquaculture. Input to the project ranged from one-on-one meetings and telephone conversations with those knowledgeable about the problems and possible solutions to a state

aquaculture conference with multi-state representatives. The project was able to take advantage of industry surveys that provided timely information across the greatest period of decline for aquaculturists, and enhanced by a broad-scale survey of Virginia producers.

From the information gained, problems were identified and recommendations developed that, if instituted, would continue NOAA's mission of aiding in the restoration of this important national resource. These are discussed in the following areas:

Hatchery Production

- Breeding and Selection
- Disease Transmission and Biosecurity
- Hatchery Development
- Sea Grant Regional Shellfish Culture Specialist
  - Short Course Training
  - In-service Training

Research and Demonstration

- Remote Setting Technology
- Field Verification
- Production Methods
  - Advanced Structure Design
  - Alternative and Innovative Cultch
- Sonar Mapping Application

Education

- 4-H programs
- Targeted Extension Education
- Undergraduate Internships

Public policy

- State Legal and Regulatory Review
- Lease Program Assistance

Marketing and Economics

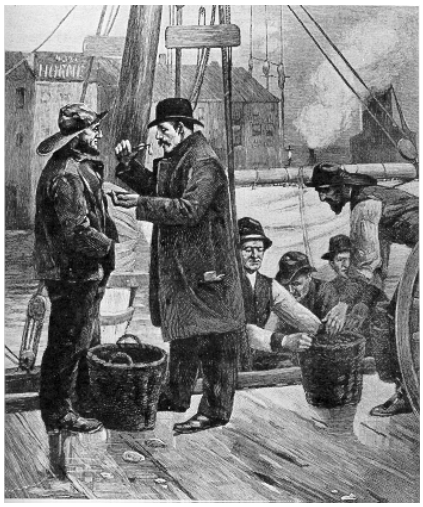
- Growth Tracking and Analysis
- Business Planning Assistance
- Finance Information

Additionally, the report concludes by noting areas where NOAA can provide continued leadership through the application of the science and technology that the agency has become noted for. This could further aid in the advancement of the shellfish aquaculture industry while gaining better information on issues of site development, management, and productivity.

Industry Background

Oysters have been an integral part of the life of the Chesapeake Bay, as well as the people who came to settle its surrounding territory. They provided sustenance for native population as well as those who came from Europe in the 1600's.

At the beginning of the colonial period, oysters were used as food, often for survival due to their abundance and availability. Later, harvesters began marketing them to others. This led to an industry that relied on hand devices to harvest animals from reefs that had formed over centuries from oysters settling upon and attaching to each other. Captain John Smith, and other early English explorers and settlers, remarked how these reefs were so abundant that oysters rose out of the water and posed a hazard to navigation for vessels.



Oysters were important historically

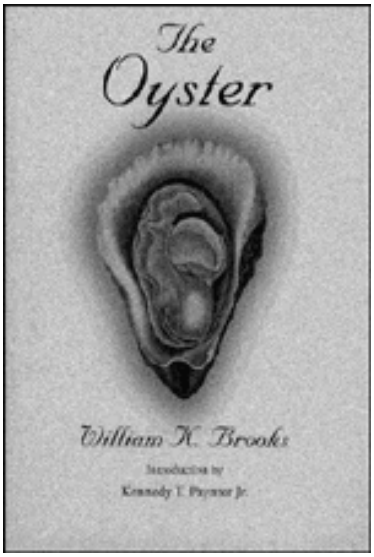
After the Civil War, seafood dealers from the New England region saw the rich oyster deposits in the Chesapeake and sent their technologically advanced vessels to harvest them. These boats used towed dredges that were able to harvest more oysters in a shorter time than the hand tongs used by local watermen. In New England, this gear had brought about depletion of local oyster beds and caused shortages of oysters in the marketplace. By using the new gear on Chesapeake Bay oyster reefs, the habitat was slowly but inexorably changed. Three-dimensional reefs, formed by oysters setting and growing on top of older oysters, were torn down and spread out by the action of the dredges. Structures that previously rose to the surface were reduced to low-relief profiles, with resultant changes in habitat.

This clash of technology inevitably led to conflict between participants. The "Oyster Wars of the Chesapeake" ensued with vessels sometimes engaging in armed conflict as tongers and dredgers opposed each other, fighting to harvest from the rich oyster grounds. As in other such conflicts, politics intervened. In 1868 the Maryland legislature funded the Oyster Navy, a system of armed patrol boats that were the forerunner of the Natural Resources Police. The organization was charged with collecting license fees, enforcing fishing restrictions, and protecting private oyster grounds.

Science and Oysters

Scientists noticed the Bay and the rich stock of oysters that existed there. William K. Brooks, Ph.D., a biologist at the Johns Hopkins University, was an early researcher with interest in oysters. He not only studied the animals, but was familiar with those who harvested, processed, and marketed them as well.

In 1891, Brooks wrote a popular treatise on the industry entitled "The Oyster". It included a history of the regional industry and references to historical attempts to culture the animal back to the Roman Empire. The book included survey information about oysters throughout the Bay. These were taken from data collected by himself and Lt. Winslow of the U.S. Navy, an early oceanographer whose interest in oysters helped drive conservation efforts. Brooks' book included sepia-tone renderings of oysters taken during his survey trips that showed their abundance.



The late 1800s and early 1900s brought about the cataloging of natural oyster populations throughout the bays. The resultant information became known as Baylor grounds in Virginia, while the Yates survey in Maryland led to the designation of Natural Oyster Bars on state charts. Both of these designated areas encompassed historical levels of approximately 250,000 acres in each state. These were charted with the intention that all other grounds would be available for lease by state citizens. Charles Yates, for example, was convinced that within a few years the 250,000 acres of natural bars he had charted would be joined by 100,000 to 300,000 acres of leases in Maryland alone. Yates was to be greatly disappointed.

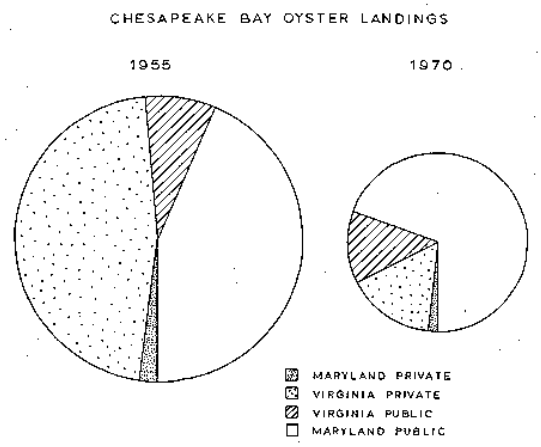
After the Baylor Survey of 1894, Virginia residents actively pursued private aquaculture while Maryland's commercial watermen actively fought against it. These divergent pathways continued throughout the twentieth century. Virginia eventually listed over 100,000 acres under lease, with nearly that amount under lease today in the Chesapeake and coastal bays. The state's rich natural seed grounds in the James River provided juvenile oysters for growers to plant and improve their grounds. Maryland, on the other hand, placed a continuous stream of barriers in the way of growers. They were prevented from having access to seed and, over time, the legislature banned leasing in most areas of the state best suited for production, at the demand of commercial harvesters.

Disease Epizootics

In the 1950s, a significant event struck the Eastern oyster industry in Delaware Bay when the disease that became known as "MSX" first expressed itself in a massive epizootic. It has been effectively demonstrated that the organism came from the Pacific Northwest, although there are several theories of how it may have arrived. The parasite was devastating to *C. virginica* with mortality of over ninety percent (90%) occurring in newly exposed stocks.

Further epizootics occurred throughout New Jersey and along Mid Atlantic coastal bays, killing commercial aggregations of oysters in seaside Maryland and Virginia and entering the Chesapeake Bay. It progressed northward, destroying oysters in Virginia and advancing into Tangier Sound in Maryland. Above that point, the disease wavered due to the salinity limits required for it to be effective. MSX combined with Dermo, a southern disease first noted in Virginia in the 1940s, to destroy natural reefs as well as private grounds.

Between 1955 and 1970, the annual harvest evolved as a result of disease mortality. Formerly, Virginia had been the largest contributor to oyster production. Virginians valued private cultivation over public harvest. Private growers were therefore the largest contributors to oyster production in the Chesapeake Bay. That changed when initial epizootics were over. Maryland, with its emphasis on the harvest of public resources, became the new leader in regional harvest. The state had a low salinity “defense” for over a decade that seemed to keep disease from affecting oysters in many areas of Maryland.



Shift in Chesapeake Bay Oyster Production Pre and Post MSX

In the 1980s, however, drought conditions moved the salinity wedge, the oceanic water entering the estuary, elevating salt levels in more northern areas of the Bay. Conditions that favored MSX and Dermo came to exist in areas that had not been previously affected. Dermo may have been introduced when oysters from the Gulf coast, brought to the Chesapeake for shucking, were

placed overboard during a period of low market demand. This was common practice in an industry that understood little about biosecurity. It became devastating to local oysters.

In the late 1970s, while Virginia's production languished, Maryland watermen urged the state to move oysters from the lower Bay, where there was continued reproduction, to the upper Bay. Against scientific advice and with pressure from elected officials bowing to the wishes of harvesters, many diseased animals were moved to locations where disease had not been previously seen. The results were disastrous, as heavy parasite loads in the infected oysters created new areas of disease. This was especially prevalent in drought years when salinity levels rose throughout the Bay. Over the course of a couple of decades, populations of oysters in Maryland plummeted as well.

Chesapeake Bay Region

During the 1980s, oysters heavily laden with the disease parasites were moved into most areas of the upper bay. Within a short time mortality began to express itself, principally from Dermo, which not only killed in salinity ranges known previously but also evolved to kill at lower levels. The Maryland harvest, like Virginia's in the previous decades, began to plummet. Today there are only remnants of the once great oyster industry. Remaining processing plants largely rely upon shellfish shipped in from other states to stay in business and only a few hundred public harvesters still remain in the largely defunct industry.

Pathways to Productivity

The oyster industry has fallen to low production levels. In recent years, however, oysters have become recognized not only as a valuable commercial shellfish but as an important component in estuarine ecosystems. These bivalves pump significant quantities of water during their lives. They use the abundant phytoplankton as food for growth and reproduction, binding unwanted material in mucus for deposition as "pseudofeces". This action helps utilize phytoplankton that results from nutrient runoff into the Bay, removing particles from the water that retard sunlight penetration and causing turbidity that prevents the submerged aquatic vegetation, that is so important to a properly functioning ecosystem, from reestablishing.

The propensity of oyster larvae to set on other shells causes them to form reefs. These structures provide habitat for other benthic organisms and attract

pelagic animals that use the reefs for food and protection. Therefore, the overall benefit to the Bay through biofiltration and diversity is recognized as being more important than just commercial landing statistics. The question, however, is how to increase the abundance of these important bivalves.

The principal options for increasing oysters are:

- Conserve and manage natural stocks with the hope that, over time, selection will develop disease resistance in the populations
- Develop techniques to grow oysters in disease-prone areas so that animals reach market size before disease causes significant mortality
- Develop strains to survive disease through:
- Breeding and selection
- Other genetic modification
- Introduce non-native species not susceptible to current diseases

Each of these pathways has potential risks and benefits. Natural resistance is uncertain and will likely require a long time to develop and support widespread populations of resistant animals. In the meantime, techniques are available to grow oysters faster than the diseases can kill them. Breeding and selection has led to lines that perform better in this area as well, while triploid technology has generated oysters that focus their energy on growth rather than reproduction for accelerated production.

The last option, introducing non-native species, has been investigated with two different species (*Crassosstrea gigas* and *C. ariakensis*) for almost two decades and was the subject of a recent EIS by the US Army Corps of Engineers and other federal and state agencies, including NOAA. While science has not definitely ruled out the use of one of these, social and political constraints, coupled with likely legal challenges, will likely remove this as a viable option for restoration of depleted natural populations in the foreseeable future.

Crassostrea ariakensis, the Suminoe Oyster

Along with these options, there is recognition that private cultivation can contribute to the overall solution by providing an input of large numbers of oysters. There are many benefits of developing an effective aquaculture

industry. First, private capital is used for production rather than relying on the public funding that ebbs and flows according to public sector priorities and demands. Second, private culture places product in the marketplace in response to market demand rather than by government sanctioned seasons. Third and perhaps most important, is the fact that oysters use the abundant phytoplankton caused by nutrient inputs to the Bay. They use this for growth and reproduction while depositing waste at the benthos, aiding water clarity. Removing oysters and shipping them to market transfers nutrients to other areas and thereby assists in cycling one of the proximate causes of the decline of water quality.

Aquaculture is a form of agriculture and, as such, bears many similarities to terrestrial culture. To be successful, the business must:

- Increase survival
- Protect from predators
- Manage health
- Maximize growth rates
- Develop uniformity
- Grow for market demand
- Develop product continuity

NOAA and the Chesapeake

Federal organizations, including forerunners of NOAA line agencies, have had long and distinguished involvement with the Chesapeake and coastal bays of Virginia and Maryland. This included early mapping of the bays, while the latter half of the 19th century saw government professionals, including naval officers, engaged in mapping oyster bars and conducting biological surveys for density of the animals on bottom.

After the disastrous MSX epizootics of the 1950s and 60s had affected the oyster populations of the Mid Atlantic, a fisheries service laboratory was established in Oxford, MD for the purpose of researching the disease. This "lab that MSX built" was instrumental in furthering information on shellfish diseases throughout the years. It continues today as the Sarbanes Cooperative Oxford Laboratory as a partnership between NOAA and the State of Maryland, with a staff of professionals continuing to provide needed services. The NMFS has long maintained a presence throughout the fishing industry with its statistical reporting service that has tracked the rise and decline of various industry segments. Their Financial Assistance Division was instrumental in financing and reconstructing fishing vessels through several

programs over the years. These were always known for their professionalism and ease of use in relation to other government programs. The group provided excellent service to the industry, and could be of great benefit in helping to rebuild a shellfish aquaculture industry with modern vessels.

Coastal Zone Management (CZM) programs have had a long record of effectively engaging groups in planning of shoreline regions. They remain an important part of the overall management strategy today, with their demonstrated ability to reach many public groups that can play a part in determining how and where shellfish aquaculture will develop. CZM advisory groups already include members of shoreline county planning and zoning offices who can be play an important part of decisions that not only affect tidewater leases but also the shore bases that are critical to a marine industry.

Sea Grant Programs were established in both states in the early 1970s, usually beginning with extension or advisory services to provide links between academia and industry. From an early focus on commercial fishing and the seafood industry, the programs evolved into aquaculture as it became apparent that there was great potential for development in that area. Both states had institutions that became Sea Grant Colleges as they progressed through the stages of recognition established by the National Office of Sea Grant (NOSG).

The establishment of the NOAA Chesapeake Bay Office (NCBO) in 1992 was significant in that the agency provided a single location for a matrix of line agencies dedicated to helping turn around the decline of the Bay. While other federal agencies have created offices aimed at these bay programs, the NOAA office has been perhaps the foremost in engaging others in dedicated efforts. From a small beginning with a few personnel, the office has grown to over twenty employees, with an office with a smaller presence at VIMS. The NCBO has emerged as a group that involves many players in bay restoration, while providing a staff of NOAA professionals who are conversant with the many aspects of the bay's problems. Whether managing earmark funds provided to projects such as the Oyster Recovery Partnership, engaging minority institutions in programs to interest non-traditional audiences in marine and estuarine sciences, and aiding citizen restoration efforts important in educating groups about the importance of bivalves, the NCBO presence has been notable for its wide-ranging accomplishments.

Along with the line agencies, with their continued service to the states, NOAA has been designated to administer important programs supported with special funds. Of these, the Oyster Disease Research Program (ODRP) has had a distinguished history of funding excellent research aimed at discovering

causes and transmission mechanisms of diseases and developing solutions. This program is at the core of success in finding ways to understand and manage diseases and has provided funds through competitive grants that have led the way in many areas of progress. Funding this program is a priority for industry expansion.

Within the Chesapeake region, NOAA has provided administration for various earmark funds designed to encourage public-private partnerships for oyster restoration. These have included a $2 million earmark through NOAA to the Virginia Institute of Marine Science to support monitoring of planted sites and research into the development of disease resistant animals. A pilot project with private growers was implemented in cooperation with the Virginia Marine Resources Commission to train growers in remote setting and production of spat-on-shell and gather input data on survival and growth rates. This portion of the project included larval production by private and public hatcheries, remote setting of larvae on shell, with this spat-on-shell planted by growers at restoration sites.

Maryland tonger harvests on Managed Reserve

In Maryland, earmark funds provided through NOAA to the Oyster Recovery Partnership supported hatchery production of spat-on-shell, establishment and expansion of sanctuaries, and development of the concept of managed reserves. Reserves are areas incorporating ecological benefits of oyster reefs with economic benefits of monitored harvests when sixty percent (60%) of the oysters on the reef reached four inches or more. Areas were “bar cleaned” by commercial watermen to remove existing diseased oysters and planted with disease-free hatchery seed. Monitoring included survival, growth, and disease status. Due to the fact that the oysters were usually an additional year older and most were one-third larger before harvest was allowed, the ecological benefits of these larger oysters aided the environment while rotational and monitored harvests kept local harvesters employed. A harder to measure benefit of this concept was the educational value of involving harvesters and scientists *in situ* during the design, implementation, and monitoring phases of it. In fact, many of the watermen involved with these have changed their attitudes about aquaculture.

Project Development

In 2006, it was decided that a project should be undertaken to identify the best methods for NOAA to target funds for development of oyster aquaculture in Virginia and Maryland. It was recognized that this would enlarge the biomass of oysters in the Chesapeake and coastal bays to help rebuild the industry, provide employment, and generate economic activity while aiding ecological goals of biofiltration and nutrient transfer. Initial consultations were held between representatives of NCBO, the National Office of Sea Grant (NOSG), the Maryland Sea Grant Extension Program (MSGEP), and the Oyster Recovery Partnership (ORP), for an assessment of available information and identification of areas to be covered in the study. These included:

1) Hatchery production
2) Research and demonstration
3) Education
4) Public policy
5) Marketing and economics

The project was led by the MSGEP, with coordination and assistance from their colleagues at the Virginia Sea Grant Marine Extension Program (VSGMEP). The goal was to gather information from and about the aquaculture industry in the two states, and to develop recommendations for targeting funds to areas best suited for measurable gain. The project included:

Oyster hatcheries will be critical components

- developing historical data on industry problems and needs
- using individuals and groups to identify and prioritize problems
- developing recommendations on funding to develop aquaculture

The project had active input from the VSGMEP and it would not have been possible to have generated the required information without the assistance and guidance of that staff. They participated in targeting groups and developing meetings that provided relevant information, as well as reviewing findings and recommendations for the report. In addition to growers, other interest groups including scientists, university faculty, resource managers, other extension professionals, and processors were included in the project in order to gain broad worthwhile input.

Contact with industry was coordinated between the Virginia and Maryland Sea Grant Programs. Extension professionals have been associated with many of the groups included in the project for years, which helped gain trust from the industry for the project as it assisted in gathering accurate information. The format included individual and group meetings, regional and statewide gatherings, and mailed surveys. Together, they combined to elicit a great deal of information that led to useful recommendations for priorities. As those in extension know, the proof of any project lies in the long-term application of the results rather than just a count of how many meetings were organized or how many attended. The goal was to generate recommendations for measurable increases in production.

At the beginning of the project, a color double-fold brochure was produced in cooperatively by MSGEP and NCBO that explained the objectives and provided contact information in both states. It was entitled *"Shellfish Aquaculture Planning Project: a collaborative effort to explore shellfish aquaculture development in the Chesapeake Bay region"*. These brochures were used throughout the course of the project in mailings and other distribution, and were used at all meetings held in conjunction with it. This was a good way of showing the various aspects under investigation, as well as describing the ultimate uses of information derived from the project.

Results

Historical information relating to the size, production, and identified problems in the oyster industry was gathered to define a baseline. The project was fortunate to have had strong background information that was able to be included for a temporal look at the industry.

Maryland Industry Surveys

There were two principal formal surveys of Maryland leaseholders over the years. Since that state consisted almost entirely of oyster growers, it provided a strong means of assessing the needs of the industry both during a period of normal production as well as after catastrophic declines of the 1980s and 90s.

1979 Conference Survey

In 1979, at the first known conferences held for oyster growers, a survey questionnaire was included with the conference materials. This instrument measured the status of the industry in Maryland at that time and defined problems faced by them. Respondents were asked about future plans based

upon assumptions about future availability of seed and shell. Ninety-nine (99) surveys were returned and the results revealed an industry that recognized its problems but was optimistic about the future. This was at a time when MSX and Dermo had not yet had a significant impact on the upper Bay and many growers were still in business.

Half of those attending held between twenty-five and one hundred acres, while 44% held smaller amounts of less than twenty-five acres. A few (6%) were among the industry leaders, holding more than one hundred acres of leased ground.

Oyster nursery, 1980, Nanticoke MD

There were an equal number of old and new entrants into the industry with 39% having held leases less than five years and 37% reporting as having possessed them for more than fifteen years. They were actively planting seed that showed that they were serious about their business. While some planted at low levels (<100 bushels to the acre), there were some at the upper end of the scale planting at rates exceeding 1,500 bushels per acre. The majority fell into the mid-range more normally found in the industry at that time.

These planting figures were reflected in the ultimate harvest data. While some growers reported harvests exceeding 1,500 bushels per acre, the majority of harvest fell between fifty and five hundred bushels. Survey respondents reported infrequent natural spatfall on their leases, which led to optimism about the future of hatcheries in the Chesapeake Bay region.

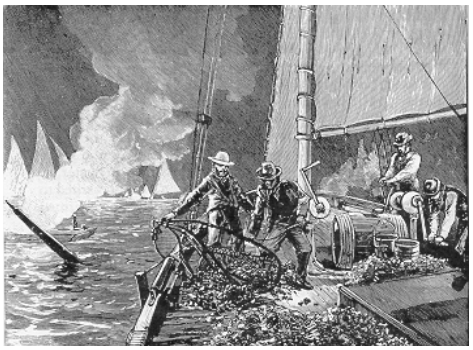
Of the nine choices (with one open-ended) provided to the growers, the top five problems defined by them in the 1979 survey were:

- Lack of seed sources (27%)
- Theft of their product from leased grounds (18%)
- Lack of development capital (17%)
- Pollution (13%)
- Mortality (11%)

Marketing was not considered a problem by growers. This contradicted opinions held by watermen and some packers that the market for oysters was

limited. Those who believed this argued that the way to manage the industry was to restrict supply to keep prices inflated.

A problem noted by growers was theft. This had long been a factor in Maryland. The smaller size of most Maryland leaseholds made the cost of full-time private patrols, found in larger operations in areas like Long Island Sound, economically unfeasible. The problem continues in Maryland to this day, as evidenced by the interest voiced by pro-aquaculture committees in recent years. Virginia, with its long history of oyster culture, does not seem to find this a significant problem.



Oyster pirates on the Chesapeake, 1800s

Those responding to questions regarding future plans saw a bright path. In questions about business expansion eighty-two percent (82%) said they would be financially able to farm their leases if shell was available at $.60 per bushel and seed for $3.50 per thousand, both realistic prices at that time. Shell cost was based upon that dredged from Upper Bay deposits at that time and seed prices were those asked by James River producers and followed by local hatcheries.

Questions about educational programs elicited a one hundred percent affirmative response that future conferences should be held. As a result, these programs were held for five years and then expanded into a multi-day annual aquaculture conference supported by six Mid Atlantic states (MD, VA, DE, NJ, PA, and WV) that was conducted until 1995.

2002 Industry Survey

In the latter part of 2002, the MSGEP and Maryland Department of Natural Resources (MDNR) sought information on shellfish aquaculture through a mailed survey. The survey was conducted by the Opinion Research Center at the University of Maryland. It consisted of a two-round mailed instrument with a mid-point reminder card. That is, there was an initial mailing to all leaseholders that included a cover letter explaining the included survey, and a postage-paid return envelope. Surveys were coded for anonymity. The initial mailing was followed in two weeks by a postcard reminder asking the recipients to complete the survey. Two weeks later another copy of the survey was sent to those who had not responded with a letter asking them to do so. Survey instruments were returned to the Opinion Research Center and only spreadsheet information was forwarded for analysis.

For the 2002 survey, there were 799 separate leases that totaled 7,524 acres. These were held by 313 individuals after duplicate addresses for leases were accounted for. 114 (36.4%) responded to the survey. From the initial profile it was found that over 70% derived no income from their grounds, which had become unproductive following the epizootics. Only about 9% reported that they had 20% of their income derived from leased ground at that time. This was largely related to several key points:

- Viable seed was, by that time, not available from James River or Maryland seed areas
- Not enough hatcheries were producing seed that could live and return a profit to growers
- Seed expense was too great for growers who were earning little from their leases
- Disease had affected leases causing it to be futile to grow where mortality killed the crop

Problems defined by leaseholders as being primary concerns

Response (%)				
Category	**Always**	**Sometimes**	**Rarely**	**Never**
Death of oysters	38.8	19.8	4.3	2.6
Seed availability	28.4	12.1	7.8	6.0
Lack of financing	21.6	16.4	2.6	12.9
Theft of product	19.0	18.1	6.9	8.6
Water pollution	17.2	12.1	14.7	8.6
Bottom type	11.2	11.2	12.9	12.9
Poor / slow growth	6.0	12.1	18.1	12.9
Available markets	0.9	8.6	12.9	17.2
Market price	2.6	12.1	13.8	15.5

When asked what would most help their productivity and enable them to return to growing oysters successfully, the highest ranked were:

1) Having native oysters able to survive disease
2) Availability and cost of cultch to prepare grounds
3) Availability of natural or hatchery seed
4) Protection from theft

When asked about research priorities that would best assist them, they ranked the two highest as:

1) Higher survival of seed
2) Growing methods for disease-prone areas

One grower summarized the situation well when he noted that the principal need was to "Find an oyster that will live … to reach market size."

Extension programs were favored by many of the respondents as means of learning about new ideas, techniques, and equipment. Field days (36%), workshops (34%), and evening programs (26%) were favored over other techniques for disseminating information. The topics favored most were disease monitoring (52%), production methods and equipment (44%), remote setting for spat production (34%), and protecting leases from theft (34%), and hatchery operations (28%). There was interest in having web-based information and many had used internet information sources on aquaculture production.

> *"Find an oyster that will live … to reach market size"*
>
> *-Maryland grower*

Virginia Industry Surveys

Virginia has both ongoing studies of their industry development, as well as a standalone project that was beneficial to this project. Data derived from these provided an excellent way to track the recent increase in production, as well as investigate the needs and outlook of the industry as it strives to overcome the issues of disease and begin to grow once again.

Virginia Sea Grant Annual Survey

Industry surveys have been conducted by Tom Murray and Mike Oesterling of the Virginia Sea Grant Marine Extension Program since 2006, when they began by incorporating data from 2004 and 2005 in their first study. These have provided an excellent way to track growth in the industry and they have had a response rate that included the largest producers. This has allowed the accumulation of data representative of 90% or more of Virginia's production.

From the mid 1980s, the Virginia shellfish aquaculture industry developed through hard clam aquaculture. This was pioneered by Cherrystone Aquafarms, an outgrowth of a long-time family oyster business, and led to production by others that brought the state to the forefront of cultured clam output in the nation. VIMS annual surveys have tracked these increases in production. In addition to the hard clam industry, they have shown recent advances in oyster planting as genetic lines and methods have led to animals that survive to market in the face of disease pressure. These lines, enabling oyster production even in areas of high disease prevalence, offer expectation

that a new industry will emerge to again provide benefits to the economy, employment, and environment of their state.

This Situation and Outlook Report has emerged as a highly respected source of data on current production and planted inventory for future growth of the industry. The fact that there is a strong rate of response that is characteristic of the majority of that state's production makes it a well regarded survey.

Data derived from the Virginia Sea Grant survey has measured:

	2005	2006	2007
Number of Oysters Planted	6,158,000	16,098,000	18,456,000
Number of Oysters Sold	843,842	3,145,282	4,800,900
Seed Sold by Virginina Hatcheries	20,400,000	26,204,850	26,724,000
Employment (full time / part time)	143 (72 / 71)	167 (79 /88)	86 (30 / 56)

The most recent report notes, however, that "the near tripling of oyster plantings, which occurred from 2005 through 2006, tapered during 2007. One reason for the diminished rate of expansion is the shortage of viable oyster seed from existing hatcheries." This observation confirms the information gathered in this project from direct discussions and surveys of the industry.

> *"One reason for the diminished rate of expansion is the shortage of viable oyster seed from existing hatcheries"*
>
> *-VIMS Annual Shellfish Survey*

The VIMS study noted that 2008 should see a large increase in planted oysters, with estimates up to 25 million animals. Growth in sales was accompanied by stable prices for cultured oysters in concert with the expansion of sales. This would point to markets available for aquaculture products and the advantage that aquaculture has over wild harvest by being able to sell items according to market demand rather than open season.

While a decline in employment listed in the oyster segment of the survey was noted, it was speculated that this might be attributed to efficiency in production or difficulty in estimating labor and time because most businesses are relatively small scale and often conducted with other ventures that make estimates variable and difficult to separate accurately. However, it should be pointed out that most oyster aquaculture occurs in rural areas where any increase in employment is highly valued.

Virginia Tech Survey

In 2008, the Virginia Coastal Zone Management Program (VCZM) funded an investigation of the "Economic Implications of Alternative Management Strategies for Virginia Oysters and Clams". The study group in the Resource Economics Department at Virginia Tech coordinated this mailed study with the VSGMEP and the VMRC to obtain use of the best address information, as well as for assistance in developing the survey instrument. The PI for this project was fortunate to be able to participate in the survey by having questions inserted into the instrument leading to information needed for this work. In a conference call and email traffic, the survey was developed and modified to provide the most significant input by Virginia growers. This allowed the project to obtain a far wider input of information than would otherwise have been possible through local meetings alone.

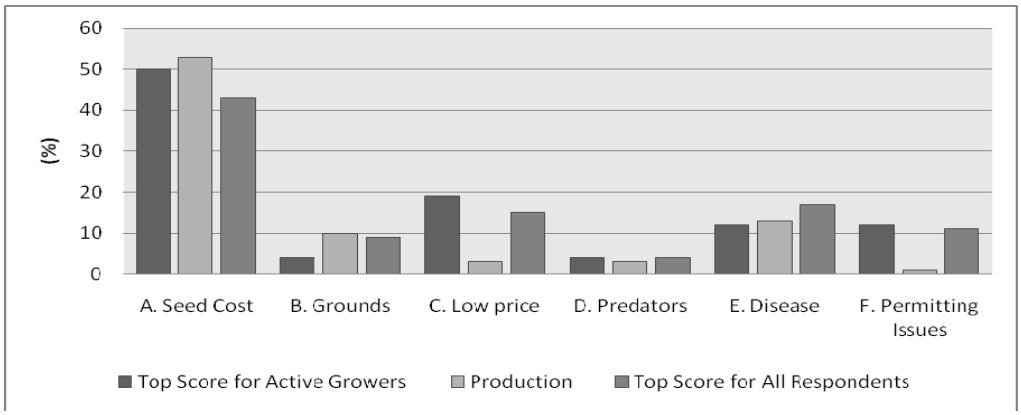
Floating upweller (FLUPSY) in Virginia

Of the policy alternatives called for in the Virginia Tech study, those investigating the need for "research and development programs" and "various financial incentives to increase production" were deemed to be in line with the needs of this project. Hence, the initial intent to survey for ideas to advance state R&D programs was broadened to include this NOAA study involvement.

The surveys were sent to 150 shellfish growers from a mailing list provided by the Virginia Marine Resources Commission. There was a response from 65. This was a 43% response rate that represented 95% of the estimated annual production in Virginia. The survey went to both oyster and hard clam growers, although in some instances the same individuals raised both species.

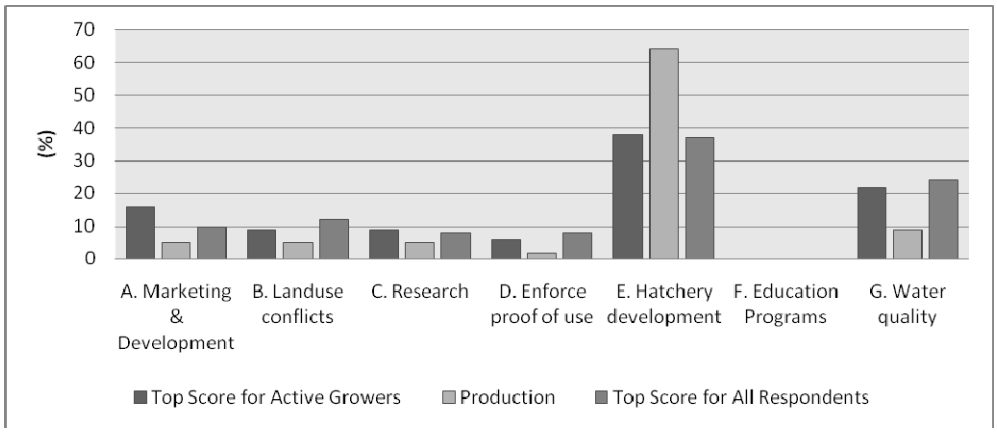
The results of the survey were summarized by the Virginia Tech faculty in tabular and graph form. That is, they calculated the top score and mean for both "Active Oyster Growers" and "All Respondents".

A defining question was asked about the factors constraining the growers' ability to expand his or her current production by ranking various factors. This was meant to investigate and identify barriers to expanding oyster production in Virginia water. These included: a) availability/cost of seed; b) availability of grounds; c) lack of market/low price; d) predation (rays, crabs, etc.); e) disease (MSX, Dermo); f) permitting issues/land use conflict.



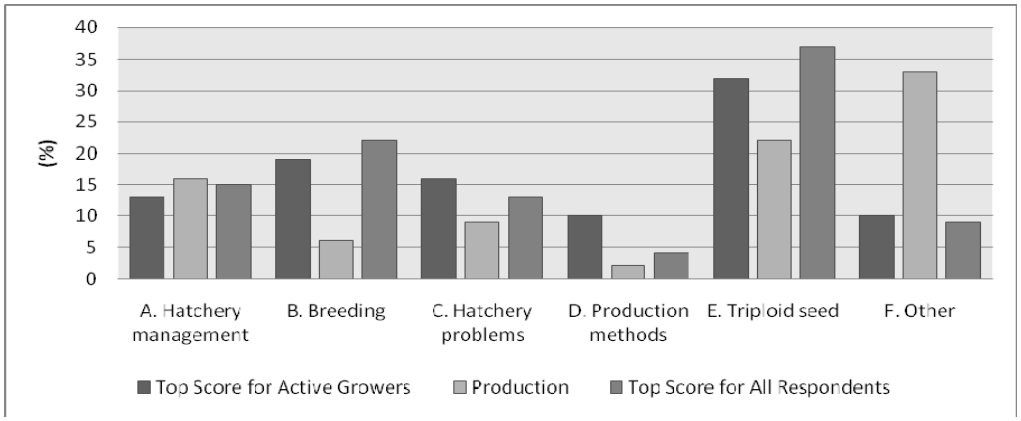
Factors constraining ability to expand production

To get to needs of growers to enhance their industry, several questions were included. The first asked for information regarding types of assistance that could best be provided by state agencies and NOAA. These included: a) assist with marketing and the development of value added products; b) assist in minimizing conflicts with surrounding landowners and recreational users; c) fund research and demonstration projects targeting defined industry problems; d) enforce 'proof of use' requirements to ensure that leased grounds are being used for oyster production; e) assist with seed production by aiding the development of hatcheries; f) support educational programs for technical training and extension programs; g) protect and enhance water quality.



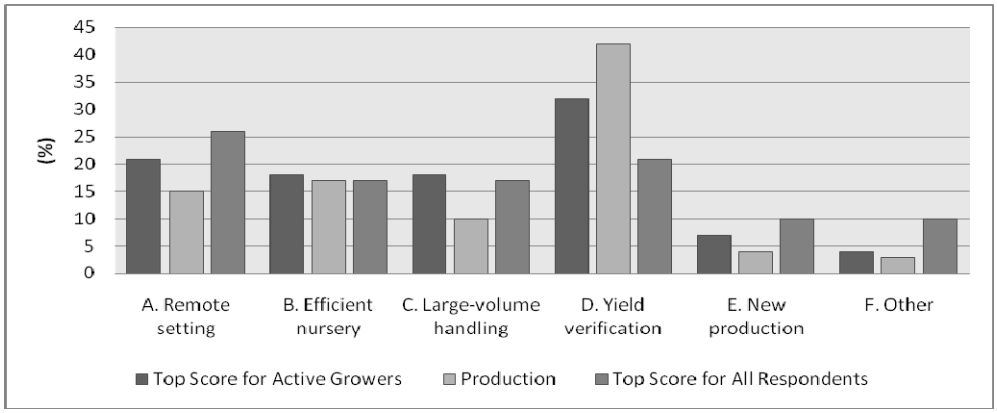
Assistance requirements of oyster growers

With the need for larvae and seed noted, a question was included asking how agencies and NOAA could develop this component to expansion by ranking categories. These included: a) assist with training programs for hatchery managers and technicians; b) provide support for long-term breeding and genetic research; c) develop technology for solving hatchery problems; d) support research for new production methods; e) help provide greater access to triploid seed; f) other (specify). The results were:



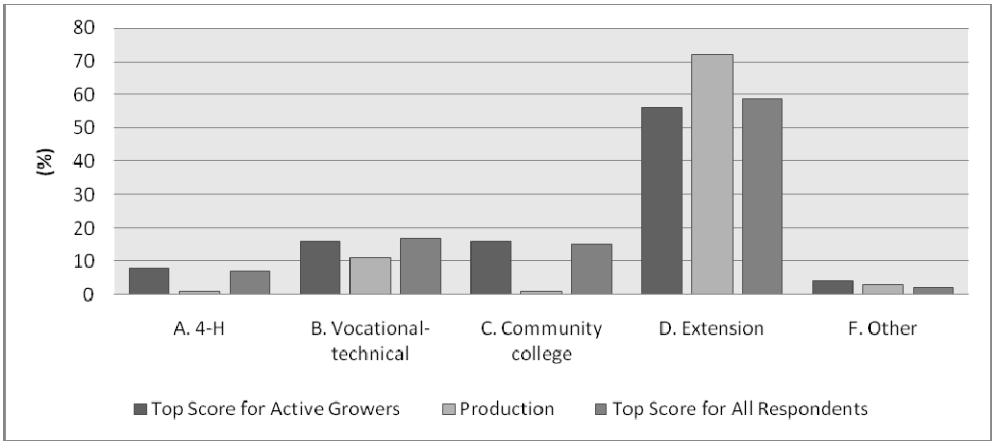
Agency / NOAA support for larvae and seed production

As part of the NOAA study, the need existed to get input on various types of support most beneficial for research and demonstration projects. These included: a) expand and enhance remote setting systems; b) develop more efficient nursery systems; c) develop methods for large-volume material handling; d) support yield verification (field trials for genetic lines); e) develop new production methods and equipment; f) other. The results showed that yield verification, or field trials, were preferred for support.



Requested support for research and demonstration projects

The project area on education programs led to inclusion of a question on the best ways to support this. The respondents were asked what agencies and NOAA could do to provide support to providing educational programs for development of the industry. Categories included: a) 4-H and Youth programs (including high school clubs, FFA, and others); b) vocational-technical school programs; c) community college programs; d) extension programs; e) other. Clearly, in this, extension programs were the most popular with growers.



Requested support for educational programs

Individual and Group Meetings

The initial design of this project was to engage in individual and group meetings with those in the oyster industry. This was envisioned as proceeding from small regional meetings in each state to a bi-state effort, but delays in funding the project placed this concept out of synchronization. It is difficult to gather producers at certain times of the year due to the operations involved in running seafood and aquaculture businesses. For this reason, some steps in gaining information through meetings alone were reevaluated and modified to get the best input from growers through the input of surveys, such as the Virginia Tech project previously reported.

Planting oysters in the Patuxent River

Growers

Meetings with growers were held with both individuals and groups. These included discussions with those using traditional bottom culture techniques and those utilizing off-bottom methods

for growing oysters. In all discussions, copies of the color brochure explaining the project were provided to the participants and discussions followed the five topic areas defined in the project. These were mailed to many growers as a preliminary step in meeting with them, so that they would be aware of the project and its goals.

Often it was necessary to explain what NOAA, as a federal agency, was not legally able to do. It was also apparent that there is a lack of knowledge regarding the breadth of services included within NOAA line agencies. Most participants recognized the services provided by NWS, NMFS, and the Sea Grant programs, but the functions of agencies like NOS or NESDIS were rarely known.

Bottom Culture

Growers working with bottom culture focused quickly on problems of disease and seed. It was seen as critically necessary for the overall development of the industry for adequate sources of larvae and seed to be available. Some growers had investigated out-of-state sources for seed but what was most desirable was that from selected lines or triploid technology. The supply of those oysters is currently constrained. This remains the most needed area for development in future, with strong support noted for increased development of hatcheries and the trained personnel that will be necessary to staff them.

For bottom culture to be successful there will need to be large-scale material handling advances that can deal with the volume of shell needed to plant hundreds, if not thousands, of acres. This material handling will increase capital cost of operating the business but should provide considerable savings in labor, which is always a significant input. It was noted that some of these methods have been worked out for large-scale restoration projects and could be further refined and adapted for business.

Oyster floats, St. Mary's County

Off-bottom Culture

Those working with off-bottom, or surface floats, had different ideas about problems. Float aquaculture is currently more difficult to develop as a business due to the length of time that it often takes to get permits. While bottom culture is dealt with at the state level, water column leases are handled by the US Army Corps of Engineers (ACE), as the agency responsible for navigable

waterways. Also, different ACE districts tend to treat aquaculture differently and the Chesapeake Bay is divided by two of them. The Norfolk District has an excellent reputation for trying to work with growers but the Baltimore District, which handles Maryland growers, has a less than stellar one. It was pointed out by several growers in Maryland that their operating permits had taken many years of frustrating work in order to get the necessary approval to operate.

There was a great deal of interest in the development of more highly refined methods for testing waters for approval as growing areas. This derives from the location of many of these operations in nearshore waters that are either unclassified or listed as restricted. Oysters are then required to be relayed to approved waters prior to being sold for human consumption. It was pointed out that more refined and accurate assessments of the harmful organisms would both aid the industry as well as the consumer.

> *"Nutrient credits could provide an additional income stream for industry development while aiding the Bay"*
>
> *- Maryland off-bottom grower*

Interestingly, float culturists frequently voiced the idea that growing at the surface prevented disease epizootics. While this seems a popular myth in the industry, it has been disproven by those who experienced severe mortality from disease, often at considerable expense. The need for good monitoring and biosecurity procedures are still necessary, as is the need for strong, disease resistant seed.

Off-bottom growers noted an interest in the concept of 'nutrient trading', in which they might be paid for growing oysters that would not necessarily go into the human consumption area. Rather, they would be paid by those who were placing nutrients into the bays as a means of mitigation. This concept has been widely discussed but so far has not been implemented.

Issues facing growers using different types of gear:

Off bottom culture	**Bottom culture**
Access to growing waters	Cultch/methods of bottom preparation
Ease/speed of permitting	Aged cultch for remote setting
Good quality cultchless seed/larvae	Better volume production methods
More accurate sanitation surveys	Faster growing oysters
Labor-saving growout equipment	Disease resistant oysters

Virginia Aquaculture Conference

In addition to the multiple meetings with small numbers of growers, the project was able to take advantage of a statewide aquaculture conference planned in Virginia in November 2007. This was the first time that such an activity had been organized since the multi-state Mid Atlantic conference had terminated in 1995. This conference provided an excellent opportunity to have growers from both states meet in a dedicated forum to address topics of concern. While this would have been scheduled as the wrap-up to the project, the timing made it necessary to take advantage of the opportunity while additional meetings and data gathering continued afterwards. In effect, this did serve as a means of verifying the facts that had, in many instances, already been gathered. It also allowed growers and others from the bi-state area to meet and discuss their common concerns. Project funds helped support this session. It was advertised to Maryland producers through targeted mailings and assistance was provided for speakers to aid in its success.

Conference organizers at the VSGMEP aided this effort by providing a focus on shellfish on the first day, Friday, November 16, 2007. The program was entitled "Commercial Oyster Culture Using Spat-On-Shell" and included four speakers covering development of aquaculture on the West Coast, and efforts to adapt and expand techniques in the Chesapeake region.

Virginia cage culture

The program concluded with an open discussion entitled "*So, What Do You Think? A Round Table Discussion to Prioritize Development Needs*". Over 150 attended the session, with growers from both states attending. The program was moderated by the PI and a recorder, experienced in shellfish aquaculture, taking notes. The session began with an overview of the project and a brief description of the types of development needs that NOAA would be able to address. It then proceeded through the range of topics, gaining input from the audience on their industry needs.

The following points were made by growers at the conference:

Hatchery technology:

- There are not enough hatcheries in the region now and, as they are developed, they should be private. Public hatcheries are useful to get industry going but their long-term role is for research and development of lines, and maintenance of broodstock needed by private hatcheries, which should in turn be able to help support research financially.
- There are not enough trained hatchery personnel and it is an ongoing task to recruit and train new ones. Frequently, state hatcheries train staff only to have them leave for higher paying jobs in the private sector. While this is a logical sequence, it could perhaps be more formalized to train personnel for industry while supporting the public hatcheries needed for research.

Protection:

- Theft is a problem, especially in Maryland, where there needs to be a concerted effort to develop or adapt technology to aid enforcement. NOAA, with its NMFS enforcement personnel, could provide assistance, especially where product crosses state lines, since federal violations might be more useful in deterring lawbreakers.

VIMS Shellfish Culture Forum

Education:

- Possible need for some community college training programs but they should be careful not to outrun the job market. Perhaps support should be provided for a single program or for a few courses but these should also be in cooperation with industry for field experiences. It was noted that two community colleges on the West Coast currently support that industry but provide courses in growout rather than hatchery operations.
- A 4-H program was developed in MD in 1981 and had a national award winner, but concluded with the disease epizootics that killed the industry. Clubs have been tried in VA but without success in finding leaders. While this could be a program for the future, it would require state and funding support.

- Any educational efforts should be designed to show youth that there is a future in the industry. Training should include science so that they know how to conduct simple experiments and understand water quality and other data.

Research and Demonstration

- The key for successful R&D is long-term funding. This is definitely necessary when developing genetic lines, where a ten-year horizon is considered minimal. There were questions about whether this was within the means of NOAA or would be more likely to find funding in USDA, where animal agriculture recognizes that fact.
- Among the needs are better equipment; specifically, sturdiness in handling gear and density-dependent growth improvements that can increase production and cut input costs.
- Work that NOAA has funded in restoration projects could be useful in adapting to private culture. This has often required large-volume handling methods and mechanization of the process that could bring useful ideas to growers, if they were better disseminated.

Public Policy

- VA CZM program has assisted in developing an environmental code of practices in order to prevent conflicts. This is viewed as a proactive approach by growers, especially necessary in areas where there are a great many riparian owners who do not understand the benefits of shellfish aquaculture.
- Current Best Management Practices exist in MD from direction of the legislature. While voluntary, they could form a set of mandatory standards if the industry is allowed to develop.
- The most critical need seen for shellfish growers, environmental NGOs, and shoreline property owners is in the establishment of good water quality. This aids both the environment and the economy.

Marketing and Economics

- While most growers are interested in the high value half-shell trade, the basis of the industry was always large volume shucked product. There is room for both in the marketplace.
- Pacific growers have moved towards “green” marketing of their shellfish with certification sought from groups like the Food Alliance and World Wildlife Fund to enhance their market penetration and profitability.
- It would be helpful to develop and adapt quality-enhancing methods and equipment such as *Vibrio* reducing products such as the post harvest treatment for *V. parahaemolyticus* being used in other areas. Quality assurance programs can result in publicity that helps drive marketing efforts.

Hatchery Operators and Staff

Meetings and discussions with current hatchery operators and staff generated a range of ideas for supporting and expanding this important component to industry expansion. Virginia tends to have a hard time keeping staff, especially managers, due to demand from current hatcheries for trained personnel. While many of these hatcheries are producing clams, there is a growing demand for oysters, with a steady increase in output in that state. While vexing to those charged with running the public facilities, there was the recognition that this movement from public to private was beneficial for the industry and a normal part of growth. This led to discussions of how the process of training and industry movement could be formalized into program elements. In Maryland, where there is currently only one private hatchery, this outward movement has not yet become a problem, although there is recognition that public hatcheries should have a role in training staff for the private sector.

UM Horn Point hatchery staff operations

The current public (i.e. institutional) hatcheries in the region are part of a consortium that has developed lines that are now being grown successfully in high disease locations. This group, that includes institutions in New Jersey, Delaware, Maryland, and Virginia, has developed pricing for their lines that will eventually lead to industry financial support for these activities through the payment of royalties. Unfortunately, the current small size of the oyster aquaculture industry will mean that these activities will need to be supported by government funds for some time until there is sufficient production to begin to continue development on a self-sustaining basis.

There were discussions regarding the proper role of public hatcheries so as not being seen as stifling development of private sector hatcheries. This is a continuing issue with private producers who see public sector hatcheries as being, essentially, state supported competition. Often this is more perceived than real but nonetheless can become an issue when private hatchery operators complain to elected officials. Public hatcheries participating in industry development projects have taken care to set their prices competitively with

those in the private sector and do not normally seek competitive sales. On the other hand, it is recognized that public hatcheries are, at this time, better able to carry out the development of new lines and refining of the triploid technology that can help rebuild an industry. Clearly what is most needed is an ongoing relationship between public and private for the benefit of each.

It was pointed out that it is often difficult for entrepreneurs to begin new hatcheries. There are many factors involved in site identification, permitting, design, and operation faced in developing them. A great deal of knowledge about these issues resides within operators of institutional hatcheries. While willing to share this, they are time constrained in being able to go on-site with new operators to provide the commitment required for minimizing problems and ensuring success. The concept of a "circuit riding" specialist was discussed at length. This would provide a trained hatchery consultant who would deliver knowledge and services to new hatchery operators developing his or her business. It was suggested that this position would make the most sense being placed with existing extension staff with the person tasked with working between states to provide service.

Hatchery filtration bank

Institutional hatcheries are expected to provide many services in the bi-state area. They maintain genetic lines of oysters, work with non-native species in quarantine systems, provide larvae and seed to restoration projects, aid in training and providing advice to private hatchery operators, and participate in research projects that require shellfish. As such, they must be viewed as important parts of a program that will be needed to reach success in developing oyster aquaculture.

Ongoing meetings between institutional hatchery staffs in the two states have been held semi-annually for two years. These have allowed the personnel to better know each other and to share problems and solutions that occurred throughout production seasons. As the industry grows, it was thought that this model might well be expanded to include private operators and their staff. Ongoing interaction between professionals is a recognized method of continuing education.

Other Input

In the course of conducting the meetings for this project, a number of other groups and individuals were consulted for their ideas. These were either directly involved in oyster aquaculture or peripherally connected but with implications for success in aiding development.

4-H and Youth

The education part of this project included investigation into programs for long-term industry development. In agriculture, a key part has been the commitment to leadership development. This has been carried out by the 4-H and Youth area for almost a century. It involves young people in industry, often raising animals and plants as they learn modern techniques, while building the leaders of tomorrow through programs such as public speaking.

Youth programs build for the future

A 4-H project was begun in Maryland in 1980 coupled with an oyster aquaculture development project. It provided trays of hatchery oysters to young people to grow in different areas of a county to find where they grew best. One earned a trip to the National 4-H Congress with her project. A political leader was impressed enough with it to get a law passed authorizing 4-H clubs to obtain up to ten acres of leased bottom for aquaculture projects. However, when epizootics killed many of the oysters in that area, the club disbanded. Currently, the only known 4-H project in the nation actively teaching oyster aquaculture is in Washington. Attempts to form clubs in Virginia have been unsuccessful due to the inability to attract leaders.

It must be recognized that developing programs in oyster aquaculture would be a major step forward in training the next generation of aquatic farmers. Discussions with state 4-H leaders provided background on the best methods for building these. USDA currently envisions priorities as being in science, engineering, and technology with an emphasis on entrepreneurship. This would make oyster aquaculture a prime candidate for developing programs that can lead the industry forward. They recommended that leaders from Washington be brought to the area to discuss the club on the West Coast and to see what could be provided in developing similar programs here.

It was apparent that there will need to be funding provided to efforts to build these programs. There were suggestions that perhaps NOAA and USDA could work together to build these, using expertise and funding from each.

Community Colleges

Local technical colleges have provided excellent training for many years on a variety of subjects. Often, they are very responsive to new or developing industries in their area and react with program offerings that are developed in consultation with industry. There are two community colleges offering programs for shellfish growers in the Pacific Northwest, plus others in North Carolina, Florida, and Mississippi that include hatchery operations.

In the Chesapeake region, there are no current programs operating. One was planned for phased implementation at Rappahannock Community College in Virginia but is not now in existence. It was to begin by offering short courses to prospective growers and then develop into a two-year program. It was supported by a survey conducted of the industry that showed interest in various topics.

After discussions with industry and community college administrators, it is clear that there needs to be a stronger industry prior to instituting courses at this level. In fact, one of the principal drawbacks in aquaculture training is that the training often outruns the job market. The opinion was voiced by several that there needs to be a demonstrated market survey done prior to initiating degree programs. In the case of aquaculture, the skills needed for success as a grower can frequently be gained from technical courses already offered by many community colleges, such as construction techniques. For hatchery training, it is considered more advantageous for people to work at a hatchery to gain skill and knowledge. It was regarded as too soon to pursue development of courses of this type.

Undergraduate Training

It became apparent that there was interest in assisting undergraduates in learning more about shellfish aquaculture, and encouraging them to participate in activities to gain skills useful in the industry. In that regard, it was mentioned that many undergraduates had worked either full time during summers at institutional hatcheries or had part-time jobs throughout the school year. This allowed them to use their science education in a practical manner while learning skills that, in some instances, provided them with jobs after graduation. For others, they used this interest and training to further their education in graduate school, choosing biological science majors in many cases.

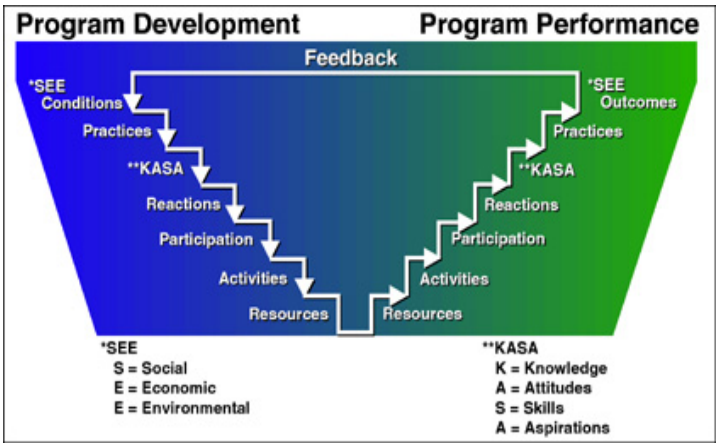
As with community college curricula, there was not thought to be enough of a demand at this time to create programs aimed at formalizing undergraduate

education in shellfish aquaculture. However, offering job and training opportunities to undergraduates in the operation of hatcheries provided a very unique and worthwhile method of gaining people who were interested in this field of endeavor. Several opinions about formalizing programs of this type were expressed, especially in discussions with minority institutions. NOAA already has done excellent work in bringing scientific offerings to these schools, and it was hoped that prior work could provide a model for developing minority participation in the shellfish aquaculture industry.

Extension Education

Outreach has been an integral part of both the Land Grant and Sea Grant systems since their earliest years. Extension provides the formal educational process by which research is gotten to the field and problems derived from industry needs are in turn gotten to the scientists who can solve them. Currently there are only a few extension professionals in both states whose time and activities are largely focused on shellfish aquaculture.

From industry surveys and discussions with producers, it is apparent that there is significant support for enhanced services. This will be more necessary as the industry builds. Extension faculty will be called upon to plan and conduct educational programs, implement demonstration projects in cooperation with industry, and aid in feeding back the results to the scientific community.



Bennett and Rockwell - Extension program hierarchy

Extension education builds on a logical process of planning, implementation, and evaluation. It seeks ultimately to reach goals that have measurable impacts. That makes these programs ideal for being able to report results that are increasingly being demanded by elected officials to determine the effectiveness of funding. Programs move from marshalling resources and conducting activities through measuring changes in the knowledge, attitudes, skills, and aspirations of those being taught. Adopted practices are then chronicled and actual outcomes, often in economic terms, are determined.

Discussion

It can be seen from the information provided that while the two states cataloged their natural oyster populations at about the same time, creating leasing programs in an attempt to develop aquaculture, they traveled divergent pathways from that point. Virginia adopted laws and practices that encouraged oyster aquaculture while Maryland engaged in a century-long demonstration of how to discourage private culture. When the prospect of disease entered the picture, both states eventually succumbed to their devastating effects – Virginia because of conditions that allowed the parasites to thrive and then Maryland, which moved diseased oysters throughout the Bay leading to epizootics. So the historical argument over whether a public or private oyster fishery is better has brought the industry to the point where they have neither.

In recent years, however, recognition of the ecological benefits of oysters has brought about research into how to create animals that survive MSX and Dermo. Breeding and selection programs have developed lines that survive to reach the size and quality demanded by both state laws and market demand. Research into non-native oysters that can survive diseases has led to a body of knowledge on new growing methods and triploids. The development of triploid technology has allowed the production of oysters that focus their energy on growth rather than reproduction. These have had success in not only reaching market size quickly but in offering product that is readily acceptable in the market. This has led to interest in rebuilding the industry which must be done largely through aquaculture.

This project grew out of the recognition that more oysters in our bays would provide biofiltration benefits while aiding in cycling the result of the nutrients that continue to flow into them. While this project was being carried out, there were other ongoing initiatives that often included oyster aquaculture, in part or full, in their charges. Among these recent drivers were:

- Virginia producers working towards Best Management Practices (BMP) and Code of Practice (COP) for their industry
- Virginia Coastal Zone Management (VCZM) efforts to minimize user conflict in shellfish growing water
- Virginia Marine Resources Commission project training growers in remote setting and growout with oyster lines and triploid technology
- Maryland Aquaculture Coordinating Council (ACC) development of BMPs and Aquaculture Enterprise Zones (AEZ)
- Establishment of a Maryland Oyster Advisory Commission (OAC) to recommend ways of restoring oysters and rebuilding industry
- Demand by the Governor of Maryland for revision of century old lease laws to spur aquaculture production

If a single issue has pervaded the industry for years it is seed. From Maryland growers highlighting it as their key issue in 1979 to growers in both states recognizing it as a critical need in this decade, it is apparent that there will need to be significant resources devoted to enhancing delivery of larvae and seed if the industry is going to be successful. There is little chance that an effective oyster industry can be developed without aquaculture without it.

Hatchery technology and remote setting procedures have led the way in the Pacific Northwest for development of successful aquaculture businesses. Lessons learned from that area can be applied to development on this coast. Indeed, it was from that area that remote setting was brought to the Chesapeake in 1981, with ten Maryland growers eventually using it to produce seed prior to the epizootics that led to the collapse of the industry midway in that decade.

> *"It's all about overcoming disease"*
>
> *- Oyster grower in group meeting*

Recent NOAA funded demonstration projects in Virginia have shown growers how to use remote setting, with hatchery larvae of selected lines and triploids, to successfully produce oysters. These efforts have combined genetic development with field verification to obtain data on how these lines perform. This type of work needs to be expanded into both states, with continuing feedback on performance provided to the consortium developing these lines. As one geneticist pointed out, we would likely one day have lines that are optimized for many of our river systems, as seed companies do for agriculture.

The VIMS Annual Industry Survey confirms that industry expansion will be constrained by the availability of seed. While that state has several private hatcheries either in production or getting ready to produce oysters, it will not be an easy path to generate the volume of material that will be needed for large-scale expansion to occur and be sustained. Maryland has only one private hatchery and would need to see significant demand for larvae and seed before others might reasonably be expected to develop. However, production of larvae and seed within the Chesapeake system would not be problematic for growers to purchase since there are few constraints on movement within that system at present.

The Virginia Tech (VT) survey confirmed the facts that seed costs and availability of hatchery products were among the highest on growers list of concerns. Therefore, targeting funds at development of these areas should be a priority.

Pollution control and water quality is a topic that has been identified both temporally and spatially. Growers, perhaps more than any other group, understand the need for good water quality in order to support their business. This has two facets – the first being water quality necessary to support the animals themselves, especially during their sensitive younger stages, and the second is the water quality necessary for production of animals free of pathogens that can harm consumers. Float producers are particularly interested in finding better ways in which health agencies can assess human pathogens since their oysters are frequently subjected to relays for depuration prior to harvest, which increases cost and lowers profit.

Triploid seed is of great interest in Virginia but has not, to any substantive degree, been grown in Maryland to date. The growth rate of these animals seems to be worth their cost in trials and being able to compact a growth cycle by a matter of years, while extending marketability during summer, would argue that the economics would be attractive in an industry where growth cycles of three or more years were common. This seed should likewise be used throughout the bays in broad-scale demonstration projects using field verification techniques to obtain useful financial information on their benefits.

> *"The problem by far is availability and cost of seed"*
>
> *-Virginia grower from Virginia Tech survey*

Verification trials were among the highest rated areas requested for support in the VT study. Along with remote setting, nursery efficiency, and volume handling, it is apparent that there is a great deal of anticipation for rebuilding a large oyster industry but questions about how best to do so. While some of these questions of materials handling have been addressed by the large-scale restoration projects in Maryland, the solutions may not be as economically viable when applied to the private sector. Additional work clearly needs to be carried out in this regard to increase setting efficiency, minimize labor, and obtain the best lines of oysters for optimizing production.

This project has shown a high demand for extension services. With programs already operating in both states, these could and should be considered as a means of providing enhanced service to the industry. Whether this occurs through the addition of career positions or through short-term contracts would remain a matter of defining the expertise required and determining how best to integrate it into the programs. Sea Grant extension programs have long been associated with aquaculture and would be able to effectively gauge the needs of the industry and implement programs designed to bring research-based educational programs to them.

While not as highly rated in the survey as in individual and group meetings, consideration should certainly be given to developing the next generation of growers and hatchery operators. Most people involved in aquaculture have not been part of 4-H or FFA activities, but these remain models of successful programs for having young people obtain technical knowledge and education while building leadership skills so that they can become the next generation of industry leaders.

> *"Pair students with operating facilities"*
>
> *-Virginia grower from Virginia Tech survey*

There is not the same interest in opening new grounds in Virginia as there is in Maryland. This is because Virginians had move aggressively into aquaculture and leased a great deal of ground decades ago, taking advantage of natural seed and that from the James River grounds. Maryland is only now playing catch-up, with a movement to revise archaic leasing laws, develop enterprise zones, and move in the direction of attracting private capital.

Maryland is actively pursuing legislative approval for Aquaculture Enterprise Zones (AEZ) that will provide quick access to water column and surface waters for aquaculture. While AEZs have been discussed in Virginia, not as much interest exists. This could be because of inherent differences in their definition. In the VT survey, AEZs were explained as being new areas in which aquaculture would be zoned, rather than areas that would be made attractive to the private sector through a variety of benefits. In essence this is the difference between being forced somewhere and having the option of locating because of perceived benefits. Some of the benefits of locating within an AEZ being investigated in Maryland include: speed of entry into business; targeted financial assistance programs; targeted enforcement of private property rights; and priority for training programs.

Triploid C. virginia

There will be differences in growout methods tried in each state. This has been noted already in the development of bottom cages in Virginia that seem attractive for the production of triploids. Various types of floats have been used in both states. There is a great deal of development that could be done for all growout methods, however, and NOAA is positioned to be able to fund projects that can have great benefits in future production. It has been noted, for example, that floats have cut wave action and not only brought about cessation of erosion in areas, but have actually led to accretion of the shoreline. This could lead to the development of stronger gear able to withstand higher forces in areas of high erosion. This could make it possible to grow oysters while combining other environmental benefits. Perhaps, if successful, aquatic vegetation could then be planted along the protected shoreline in an integrated process designed to combine aquaculture and stabilization.

In all methods, there will need to be a continuing effort to find more efficient methods to locate and operate hatcheries, further develop selected oyster lines, verify the results, produce seed, grow oysters, and manage grounds. This will require directed funding for projects that can lead to research-based solutions in cooperation with industry for the overall benefit of the bays.

Recommendations

The following areas are recommended for NOAA consideration in building programs to support development leading to a strong oyster aquaculture industry in the Chesapeake and coastal bays of Virginia and Maryland:

I. Hatchery Production

Overview - there are three private hatcheries in Virginia and one in Maryland that produce oyster seed. Two other hatcheries should begin production in Virginia in 2009 while two clam hatcheries located in that state also have the potential to diversify into oysters. While the principal intent of most of these is seed production for vertically integrated operations, some sales to outside growers take place. Public hatcheries are in operation at the University of Maryland's Horn Point Lab and the Virginia Institute of Marine Science. In addition, there are shellfish nurseries in each state that provide oyster seed.

It is recognized that hatchery capacity will need to be expanded. Existing public hatcheries will provide a way to assist with developing a successful industry, but additional production will be required to reach goals that are envisioned by many state and federal organizations that have been working to increase oysters in the bays.

A. <u>Breeding and Selection</u>: Disease has remained a principal problem in increasing oysters to the region. While genetic programs and the development of triploid technology have created the opportunity to raise oysters in high disease locations, there is a critical need to provide long-term funding for continued development of lines and to hold and maintain sufficient numbers of broodstock for industry access. Currently, these lines are part of a consortium of regional institutions that includes the Virginia Institute of Marine Science College of William and Mary, Rutgers University, the University of Delaware, and the University of Maryland. While the consortium has a schedule of fees designed to aid continued development, it is unlikely that these fees will support the range of activity needed for industry expansion. Agriculture recognizes that long-term funding is necessary for this type of research and development, and that advances in technology and improved lines produce benefits that extend to other species as well.

> *Recommendation: NOAA should provide support to the program of breeding and selection and triploid technology by providing long-term dedicated funding for genetically improved stocks.*

B. <u>Disease Transmission and Biosecurity</u>: NOAA's ODRP has been a mainstay in developing information on the causes and nature of oyster diseases, and is considered a success in bringing the best science to these problems. MSX and Dermo are in the process of being managed for aquaculture through the production of fast growing stocks developed through breeding programs. However, research is still needed into aspects of these diseases as well as projects in biosecurity to assure that other diseases are not brought into this, or other, production theatre or transferred between regions. This requires both research and outreach components for ultimate success.

> *Recommendation: NOAA should continue support for oyster disease research, concentrating on methods for minimizing impact of current diseases while educating industry in biosecurity measures to ensure future safety of stocks.*

C. <u>Hatchery Development</u>: Development of private hatcheries will be a mainstay of production in developing a contemporary industry. This will need to include both small and large scale operations. Current public hatchery operators are unable to provide sufficient time to start-up operators to help them solve all of the problems inherent in this phase of the business. Therefore, the following programs are recommended as necessary for expansion of this important part of the industry:

1. <u>Sea Grant Regional Shellfish Culture Specialist</u>: Many problems arise in the development of new hatcheries, from site selection and choice of equipment and techniques to be used, to the production of algae and care of larvae. Recent innovations in high density production make it possible to raise large numbers of larvae in a significantly smaller footprint that was formerly possible. A regional specialist knowledgeable in the design, construction and operation of oyster hatcheries could provide service on an interstate basis to those seeking to begin shellfish hatcheries. It is envisioned that this person would work with industry to set up hatcheries from the design phase and continue to provide longer term on-site service through the initial staffing and operation.

Recommendation: NOAA should consider supporting a position for a Sea Grant Regional Shellfish Culture Specialist to be integrated within the Sea Grant Extension network to work directly with industry on a long-term basis to aid in the establishment and operation of oyster hatcheries in the bi-state area.

2. <u>Short Course Training</u>: Short course training is recognized as a proven educational method, with courses designed from a few days to several weeks. These are usually provided at sites that allow hands-on training, which has been demonstrated to be the most effective for learning. Short courses have been provided by Sea Grant programs in both states; however these are in need of support and expansion for effective industry development.

Recommendation: NOAA should support long-term development and application of short courses according to an industry needs survey. Program materials and curricula developed through these NOAA supported activities would be available for distribution throughout the national Sea Grant community.

3. <u>In-service Training</u>: Hatchery personnel in Virginia and Maryland have met periodically to share production experiences and discuss problems, which this has been recognized as beneficial. Formalizing these activities by providing support would create ongoing relationships between personnel that would aid efficiency, help to identify common problems, and target potential solutions.

Recommendation: NOAA should provide support for a continuing program of consultation and in-service training for hatchery crews on at least an annual basis. This should include formal identification of problems and solutions with expansion in future to include staff from private hatcheries as industry expands.

II. Research & Demonstration

Overview – Agriculture has long recognized that coordinated research, education, and extension projects provide the best model for industry development. Aquaculture is no different and the role played by NOAA's Sea Grant Programs serves to provide that linkage between the agency and industry, often incorporating research scientists into project at grassroots levels. Solving industry problems can often be done effectively by applying research through demonstration projects. These are aided by the practicality of industry cooperators, and provide a ready and efficient means of educating others through the use of field days, demonstration plots, and fact sheets. This type of diffusion of knowledge is recognized as important in the application of technology. While some projects of this type are currently underway, funding uncertainties could be remedied through directed and expanded federal support. Among the areas identified for NOAA to address through a development project are the following:

A. Remote Setting Technology: Spat production by setting larvae on cultch at a site away from the hatchery is an effective method for production. Systems provided to Virginia growers have been proven successful. This program requires expansion to other producers, especially in Maryland where traditional watermen need assistance in transitioning between wild harvest and aquaculture. Subsidizing equipment and materials on a bi-state basis would help these potential producers gain knowledge about how to become profitable producers and show the benefits of moving from a wild capture to culture fishery.

> *Recommendation: NOAA should provide support for programs, subsidizing equipment and larvae for remote setting production, while building a database of information on setting efficiencies and successful system modifications for industry expansion.*

B. Field Verification: Perhaps the most important feature of any agricultural or aquacultural project is determine what breeding and selection has done to aid production in the growout environment. Developing field verification programs is costly. However, including hatcheries, extension specialists, and industry partners across the range of conditions in the Chesapeake and coastal bays in measuring results of genetic improvements is critical for success in managing improvement. Experimental design will be is necessary to get the best temporal and spatial information that can be used for stronger production.

> *Recommendation: NOAA should provide long-term commitment to field verification projects in both states that can aid in determining the best lines for productivity and profitability and be used to further refine and expand lines for regional production areas.*

C. <u>Production Methods</u>: Innovations in aquaculture need to take into account geographic, hydrologic, socio-political, regulatory, and market factors prevalent in the states. Bottom culture has been the standard method of production for decades but new bottom enclosures and surface floats have been used successfully. However, there is clear need for expanded development of growout systems and management operations. These will require research and development to maximize productivity and profitability.

> *Recommendation: NOAA should develop a funding program for research designed to enhance production, make systems more efficient, and integrate aquaculture into environmentally beneficial areas, such as multi-species projects or those designed to stabilize shorelines from erosion. Engineering, biology, and economics should all be a part of this area of investigation.*

1. <u>Structure Design</u>: Several types of culture equipment are now used in both states, from bottom cages in Virginia to several types of surface floats in both states. Modification of existing equipment and development of new and innovative methods could lead to significant advances in production, the expansion of aquaculture to areas currently seen as unfavorable and minimizing labor costs that are a significant factor in the overall profitability of a business.

> *Recommendation: NOAA should fund projects that would: develop gear for high energy areas; investigate multi-species culture systems to provide increased income; research systems to minimize visual impacts to other users; protect product from theft; decrease biofouling in an environmentally benign manner; lower labor costs, and; increase profitability.*

2. <u>Alternative and Innovative Cultch</u>: The lack of whole oyster shell for cultch has been a problem in developing the industry. While alternatives such as construction materials have been used in some instances, these are often less than ideal, since they are high in cost and inconsistent in supply. They are often criticized as being waste material used in the name of environmental restoration. Creating other methods of stabilizing bottom would help expand production.

> *Recommendation: NOAA should fund projects to develop methods for bottom production that would use more efficient methods of renovating existing shell deposits and investigating the use of new or innovative materials that can aid production while being environmentally benign.*

D. Sonar Mapping Applications: NOAA has been a partner in remapping portions of the Chesapeake Bay for oyster restoration using state-of-the-art technology. The resulting products of side scan sonar and sub-bottom profiling show potential for use in assessing grounds for aquaculture.

> *Recommendation: NOAA should make available products from recent work for use by industry in aquaculture site assessment and develop a project in cooperation with the Sea Grant Extension Programs providing linkage between NOAA technology and its use by industry.*

III. Education

Overview – Educational programs are an important part of long-term industry growth. While there does not seem to be a current market for a formal degree program aimed at shellfish aquaculture at the community or technical college level, this should be an area for future investigation and support and, if necessary, could be provided on a regional basis. Students interested in shellfish aquaculture will continue to pursue degree programs at other institutions in the region that offer the possibility of specializing in this field, through both undergraduate and graduate programs. These are often accompanied by opportunities to work in hatcheries or assist in research projects for field experiences.

It has long been recognized in agriculture that, to effect long-term positive change, it is necessary to educate current, as well as the next generation of scientists, educators, and producers. This off-campus continuing education has been a mainstay of both the Sea Grant and Land Grant systems and provides a strong model for developing aquaculture programs. Recommended programs for support in this area include:

A. 4-H and Youth Programs: These are practical educational programs designed to impart lifelong learning and leadership skills to young people. They were a principal method of getting research into agriculture. There is only one 4-H program in the nation that has been built on shellfish aquaculture but it would be useful as a model and successful programs in the bi-state area could have national applicability. Programs have been attempted in both states but have fallen short of expectations to date.

> *Recommendation: NOAA funds should assist in leveraging Cooperative Extension support for development of youth programs in oyster aquaculture. Discussions with state 4-H leaders should include cooperative funding and support mechanisms with educational materials disseminated nationally after development.*

B. <u>Targeted Extension Education</u>: Both states currently have Sea Grant extension programs that provide educational programs and assistance to the shellfish aquaculture industry. However, with the expansion of interest and the impending changes in law in Maryland, it is envisioned that there will be a large increased in time demanded by the industry for extension support activities. These efforts will be need to be expanded and staffed in order to build a robust shellfish aquaculture industry. Industry recognition of the need for extension in building the industry has been demonstrated in all surveys and discussions during this project.

> *Recommendation: NOAA should provide funding to enhance state extension programs for oyster aquaculture, to include individual and group educational activities, and printed and electronic dissemination of research based information through the Sea Grant Extension Program network.*

C. <u>Undergraduate Internships</u>: Undergraduate work experiences can have a profound impact on the direction of student lives and have led many to learn skills by working in research and applying them in private sector jobs. Providing opportunities for students to engage in shellfish aquaculture under supervision of scientists could help provide career guidance. Students could also work with NCBO in bay mapping and other projects leading to trained personnel available for employment in industry, agencies, or academia.

> *Recommendation: NOAA should establish a program to support undergraduate students working at public and private hatcheries and growout facilities for practical work experiences, and investigate expanding this to include work experiences with NOAA in bay related scientific projects.*

IV. Public Policy

Overview – There are many public policy issues in aquaculture, ranging from the historical to current user conflict. However, it must be stated that increasing the oyster resources of the Chesapeake and coastal bays should be envisioned as a shared public task and responsibility with society-wide ecological benefits. Creating laws and regulations supporting this task requires engaging many groups in the decision-making process.

Along with interest in expanding aquaculture, there have been groups investigating and making recommendations on keeping working waterfronts available for watermen, growers, and others. This will be critical for expanded production since access to water and land-based storage for equipment, along with the processing plants that are traditionally located in these areas will be needed for effective growth.

A. State Legal and Regulatory Review: Several groups have pursued analysis of laws and regulations that currently inhibit industry development. From early in the nineteenth century, the two states diverged in their treatment of shellfish leasing, to the point where Virginia has 100,000 acres leased while Maryland's has dwindled to a mere 7,000. Reforming laws that prevent growth of the industry should be an ongoing project.

> *Recommendation: NOAA should fund projects that support policy analysis directed at aquaculture industry problems. These should include Coastal Zone Management programs, with their involvement in planning and zoning issues and record of public engagement, as well as potential applications involving the expertise of the National Sea Grant Law Center.*

B. Lease Program Assistance: It is often hard for entrants to the industry to find their way through laws and regulations affecting shellfish aquaculture. While bottom leases are often easy to obtain, state and federal barriers can affect water column and surface operations and be difficult to surmount.

> *Recommendation: NOAA should support projects that provide leasing and permit information in a readily obtainable form through print and electronic methods to serve as a national model for other states modernizing their shellfish aquaculture industries. This should be carried out through state extension programs.*

V. Marketing and Economics

Overview – There is a critical need to be able to provide the best possible information to those entering the aquaculture industry on a variety of topics including the best methods of creating and selling oysters, creating brand identification, use of "green" certification programs, and value-added products. While there are many possible programs available that could assist potential producers in building their businesses, little of this information has been aggregated in easily obtained packages. As the industry develops, there is a great need for production data that is consistent between states in order to track progress.

A. Growth Tracking and Analysis: The Virginia Sea Grant Marine Extension Program has been a leader in developing annual information on production of shellfish but this has been done on an *ad hoc* basis with no dedicated funding, and with no similar information available in Maryland.

> *Recommendation: NOAA should assist expanding of the Situation and Outlook project to include both states with a funding stream that will allow tracking of industry growth and development for an accurate assessment on a coordinated and region-wide basis.*

B. <u>Business Planning Assistance</u>: While it is recognized that answers to technical issues are frequently the most sought after by industry, more businesses fail because of financial problems than technical. In renovating its leasing laws, Maryland may be requiring business plans as a prerequisite for applying. All businesses should have proper plans in order to aid success.

> *Recommendation: NOAA should support a bi-state project to assist entrants with developing realistic business plans, aided by information produced through Aquasim and other risk analysis software programs.*

C. <u>Finance Information</u>: Programs are available at the local, state, and federal level that can aid in financing various aspects of aquaculture projects. However, there are no central locations that have gathered information on these as they apply to shellfish aquaculture. Access to capital has been noted in several parts of this study as needed for industry development.

> *Recommendation: NOAA should support a project to create a database for financial assistance information that can lead producers toward the most appropriate funding sources and agencies that best suit the needs of their operations. This could be provided through on-line database and decision-making tools.*

<u>Other – Application of Scientific Technology</u>

While not within the initial scope of the project outline, it was apparent from discussions with many growers and allied groups that there is great interest in the application of scientific technology that could help development of shellfish aquaculture. One suggestion was specifically included in item II.D. – Sonar Mapping Applications, where they recognized that advanced bottom profiling information being used for oyster restoration could be applied to aquaculture. This information could aid growers in finding grounds for development into productive growout areas by showing the amount of shell available and the sediment overburden requiring removal for bottom leases.

In fact, it will likely be areas that were natural oyster bars in Maryland that are placed into production, if the draft law being drafted for the legislature is passed. Using existing bottom with shell already emplaced would not only aid in getting it back into production but would mitigate the contentious problem of reopening the dredging of fossil shells in the upper Chesapeake. However, knowing what areas would be most efficient to place into production would require information for proper decision-making.

NOAA, as a scientific agency, has many products and services that are seen as useful. The principal ones are those of the National Weather Service with its

variety of products for agricultural and marine users, as well as forecast information that can assist future planning. Marine charts provided for well over a century have been a staple of successful navigation and a key source of bottom information. Aside from those, it is recognized that there are many useful products that could be applied to industry needs, interests, and problems.

All line agencies are represented in the states of Maryland and Virginia, where the NOAA presence includes many activities, and its national headquarters. The NCBO combines line agencies in a matrix that provides interaction with constituent groups and governmental agencies. Sea Grant Programs in Maryland and Virginia have effective outreach programs tied to cutting-edge research and frequently interact with NOAA professionals.

NCBO should work with the Sea Grant Extension Programs and members of the oyster aquaculture industry to identify areas where NOAA science and technology could support industry development. These meetings could generate ideas for the application of NOAA science to industry problems. One such project mentioned by a grower in Maryland was to develop a tool for modeling fecal coliform dynamics in near-shore waters. This would be useful in locating shellfish growing operations that would meet NSSP guidelines without the onerous and often expensive task of relaying oysters for depuration prior to commercial sale.

Using state-of-the-art systems that NOAA scientists have at their disposal and applying them to shellfish industry problems would provide a model for application to other areas in the nation. This would continue to show the agency as one that is responsive to the need for responsible aquaculture that can be useful in expanding economic opportunity and creating employment while protecting the environment.

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For information about this project, interested persons may contact the author of this report:

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