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An Investigation of Impediments to Commercial Shellfish Mariculture in Virginia

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AN INVESTIGATION OF IMPEDIMENTS TO COMMERCIAL
SHELLFISH MARICULTURE IN VIRGINIA

A Thesis

Presented to

The Faculty of the School of Marine Science
The College of William and Mary in Virginia

In Partial Fulfillment

Of the Requirements for the Degree of
Master of Arts

by

ROBERT CHARLES NEIKIRK

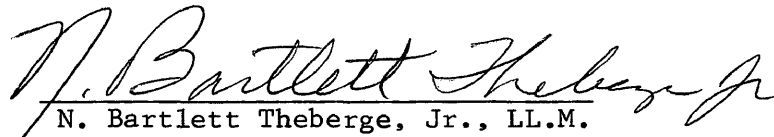
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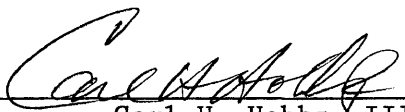
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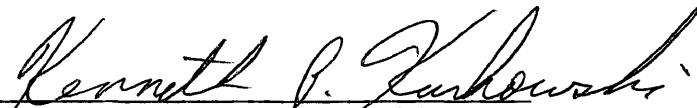

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TABLE OF CONTENTS

	<u>Page</u>
ACKNOWLEDGMENTS .	iv
LIST OF TABLES. .	v
ABSTRACT. . . .	vi
INTRODUCTION. . . .	2
LITERATURE REVIEW .	7
METHODS .	13
RESULTS	19
DISCUSSION.	28
Regulatory Impediments	29
Impediments Associated with multiple use of the Coastal Zone .	46
Environmental Impediments. .	53
Technical Impediments. .	59
Financial Impediments. .	64
SUMMARY	67
APPENDICES.	71
LITERATURE CITED. .	85
VITA. .	89

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LIST OF TABLES

<u>Table</u>		<u>Page</u>
1.	Number of surveys distributed an returned. .	21
2.	Compiled survey results. .	22
3.	Virginia survey results.	23
4.	Summary of identified impediments. .	26

ABSTRACT

A nationwide survey of shellfish mariculturists was used in conjunction with a literature review and review of state and federal laws and regulations, to identify impediments to commercial shellfish mariculture development. The results of the survey and reviews were utilized to identify likely impediments to commercial shellfish mariculture in Virginia and to develop recommendations to address the identified impediments, should Virginia wish to pursue efforts to enhance development of this industry.

This study suggests there are state laws, regulations, and policies which act as impediments to commercial shellfish mariculture development in Virginia. Many of the identified regulatory impediments result from the applicability of laws and regulations designed to manage and protect the natural resources and more traditional uses of the coastal zone.

Because this study relied heavily on subjective input from individuals representing the mariculture industry and did not involve individuals who may have attempted to enter the industry and failed, it may not accurately identify all of the actual impediments to the industry's development. However, the study should provide valuable input into any comprehensive state effort to enhance shellfish mariculture development in the Commonwealth of Virginia.

AN INVESTIGATION OF IMPEDIMENTS TO COMMERCIAL
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INTRODUCTION

Some forms of aquaculture, the propagation and rearing of aquatic species in controlled or selected environments, date back to 5000 B.C., yet, aquaculture has only recently gained significant attention in the United States. This recent national attention may be due, in part, to declining harvests of some naturally occurring, traditionally abundant, commercially important fisheries, the high market price of certain gourmet species, as well as, the commercial success of a limited number of aquaculture operations around the country.

The terms "aquaculture and "mariculture" are used widely throughout this paper. Both terms refer to the propagation and rearing of aquatic species in controlled or selected environments. However, whereas aquaculture includes freshwater and marine culture of organisms, mariculture refers only to the culture of marine and estuarine organisms. This paper deals primarily with the mariculture of oysters and clams.

In 1980 Congress signed the National Aquaculture Act into law (P.L.96-362). The Act declared the promotion of aquaculture to be in the national interest and declared the development of aquaculture in the United States a national policy. The legislation also established the Joint Subcommittee on Aquaculture, a federal interagency board

developed to assist the Secretaries of Agriculture, Commerce, and Interior in the coordination and promotion of aquaculture in the United States. Finally, the Act called for the development of a National Aquaculture Development Plan. Over forty million dollars was authorized to be spent on this initiative during a three year period, however, no allocations were ever made.

In 1985, in the wake of a growing five billion dollar seafood trade deficit, the National Aquaculture Improvement Act was attached as a rider to the Food Securities Act of 1985 and was signed into law. This act replaced the earlier act, declared the Department of Agriculture to be the lead agency for aquaculture development and provided for the establishment of a National Aquaculture Information Center within the Department of Agriculture. In 1987 Congress appropriated three million dollars to the U. S. Department of Agriculture for the establishment of four regional aquaculture information and demonstration centers. The centers are located in the states of Hawaii, Mississippi, Massachusetts, and Washington. Recently, a fifth center was founded with headquarters located in East Lansing, Michigan and Ames, Iowa. Virginia is in the southern region administered by the aquaculture center located in Stoneville, Mississippi.

It is difficult to determine if the National Aquaculture Development Program, has had a significant affect on aquaculture development in the United States. Nevertheless, the aquaculture industry in the United States has grown in recent years. Total

aquaculture production in the United States was 281,160 metric tons in 1986, up from 183,851 metric tons in 1983 (USDA, 1988). Commercial aquacultural production of catfish in freshwater bodies has increased nearly five-fold between 1980 and 1988 (USDA, 1988). Various forms of oyster culture and salmon culture are well developed on the West Coast. Clams, mussels, oysters, and shrimp are among the species that are cultured commercially, with varying degrees of success, along portions of the East Coast.

Successful aquaculture development has not been uniformly distributed throughout the United States; some states' aquaculture industries are much more developed than others (Joint Subcommittee on Aquaculture, 1983). This is true even among different states that possess similar environmental conditions and are well suited for the culturing of the same species. Apparently, a few states may have enhanced their aquaculture industries through the development of ambitious aquaculture initiatives and have gained an industry advantage over less ambitious states.

Virginia, a coastal state controlling a large portion of the Chesapeake Bay and Eastern Shore and possessing over five thousand miles of tidal shoreline, has vast areas potentially suitable for mariculture development. The extensive series of shallow, well-protected lagoons along Virginia's Eastern Shore are ideal for many forms of mariculture, including oysters and clams. The Eastern Shore is composed mainly of small fishing and farming communities and is generally free of large industry. The Eastern Shore is also close to

large urban areas including, Hampton Roads, Richmond, Baltimore and Washington D.C., where extensive markets could be revitalized or further developed to accommodate a variety of aquaculture products.

The Commonwealth's seafood industry is currently experiencing declining harvests of many of its commercially important traditional fisheries. A shocking example of this is the decline of Virginia's oyster harvests from an average of 3.5 million bushels annually prior to 1960 to less than 283,000 bushels in 1989 (Virginia Marine Resources Commission, 1989). In fact, large numbers of oysters are imported from out of state and processed in Virginia to keep processing plants open and to supply traditional markets. Enhanced development of mariculture in Virginia could promote economic development and augment the traditional seafood industry. In addition, since mariculture generally requires clean waters, it may provide an additional economic incentive for the protection of the Commonwealth's estuarine environment.

The Virginia Institute of Marine Science (VIMS) has conducted an exhaustive study of clam mariculture and operates a clam mariculture demonstration and research facility on the Eastern Shore. Innovative hatchery and grow-out techniques refined by scientists at VIMS have demonstrated the technical feasibility of such operations in Virginia (Castagna and Kraeuter, 1977 and 1981; Castagna, 1983[a]). In addition, continuing studies at VIMS related to oyster culture, including the development of oyster strains which exhibit a resistance to the oyster disease *Haplosporidium nelsoni* (MSX), acquired immunity in oysters to *Perkinsus marinus* (Dermo), experiments related to remote

setting, and investigations into the feasibility of introducing non-native species of oysters, may further enhance the feasibility of oyster mariculture in Virginia.

The technology apparently exists to support the successful development of commercial hard clam and oyster mariculture in Virginia. Yet, it appears that the development of such operations in the Commonwealth may be hampered by a variety of legal, policy, and institutional constraints (Joint Subcommittee on Aquaculture, 1983). Apparently, many of these constraints exist in Virginia because the practice of mariculture has generally been overlooked and overshadowed by traditional fishing interests at the policy-making level (Office of the Secretary of Commerce and Resources et al., 1981). This thesis was conducted to identify impediments to the development of commercial shellfish mariculture in Virginia and to develop recommendations for the removal or mitigation of the identified impediments.

Literature Review

The aquaculture industry has received only minimal financial and legislative support in recent years. Despite this, the successful cultivation of a limited number of species including clams, oysters, crayfish, and catfish in the United States has provided some credibility to the aquaculture industry and has generated interest among the private sector. For example, catfish aquaculture production has increased from 19 million pounds in 1976 to 280 million pounds in 1987 and over 2,000 catfish farms were in operation in 1988 (USDA, 1988). Independent studies (Jago, 1981; Aquaculture Committee of Sea Grant Directors, 1982; and The Joint Subcommittee on Aquaculture, 1983), have identified a number of species which may be ideal candidates for commercial aquaculture in the United States.

Some marine molluscs, including a few species of oysters and clams, appear to be especially well suited for mariculture development. These species' high fecundity, hardiness, low position in the food web, ability to be reared in high densities, relatively rapid growth rates, and consumer popularity, are characteristics identified by Mann (1984) and Webber and Riordan (1976), which make molluscs particularly well suited for aquaculture development.

Successful laboratory culture techniques for oysters, mussels, clams, and scallops were pioneered by William Firth Wells approximately 70 years ago (Wells,1933) and further refined during the 1960s (Loosanoff and Davis,1963 and Walne,1964). Castagna (1983[b]) conducted a review of more recent bivalve culture methods and Burrell (1983) reviewed the state of mollusc culture in the United States.

Manzi et al. (1980) and Castagna and Kraeuter (1981) developed experimental hard clam aquaculture techniques and have transferred this knowledge to the field for verification of the viability of these techniques. Castagna and Kaeuter (1977 and 1981) described low cost open field grow out and predator exclusion techniques which have demonstrated impressive results. Manzi (1985) and Manzi and Castagna (1989) reviewed the current state of clam aquaculture in the United States. Huner and Brown (1985) reviewed current status and techniques of crustacean and mollusc aquaculture in the United States. Financial data compiled from the Virginia Institute of Marine Science's experimental clam aquaculture facility (Castagna, 1983a) and from the Trident Farms clam aquaculture facility (Brown et al., 1983) indicated that the transfer of these techniques to commercial operations may be economically feasible.

Commercial aquaculture development does not necessarily have to displace traditional harvesting techniques. Kvaternik et al. (1983) conducted an economic study involving a price flexibility analysis of the Virginia hard clam fishery which indicated that an increase in clam supply would result in only a slight decrease in price. If managed and

marketed carefully, the study suggests that clam aquaculture and the traditional hard clam fishery may coexist and perhaps could even benefit one another through the expansion of markets. Glude (1983) and Capps et al. (1989) reviewed the status of the mollusc market in the United States and concluded it could be expanded to accommodate increases in supply. Additionally Capps et al. (1989) suggested that advantages could be taken of peaks in demand if landings could be controlled.

As aquaculture technology advanced and commercial aquaculture became more feasible in the United States, a question arose regarding how this new water use would fit into the complex set of traditional rules and regulations governing water rights and utilization.

Kane (1970) identified a number of potential conflicts between aquaculture and more traditional water uses. He identified potential conflicts involving riparian rights, navigation, fishing, recreation, and water quality. This project involved numerous case studies and extensive reviews of Federal and Florida statutes.

Smith and Marshall (1974) identified aquaculture as a different form of water use because it requires exclusive use of an area, a financial investment, and legal protection for that investment. They also recognized and discussed the jurisdictional overlaps involving local, state, federal, and international claims to water rights with which the aquaculturist may be confronted.

McCutcheon (1976) investigated the potential legal conflicts between aquaculture and more traditional Canadian and International uses of the seas. He specifically reviewed conflicts between aquaculture and navigation, riparian rights, fishing, and some additional water uses. Wildsmith (1982) also investigated legal conflicts regarding aquaculture development in Canada and developed a model aquaculture development plan for Nova Scotia. Many of the conflicts identified by McCutcheon and Wildsmith, while based on Canadian laws, are applicable to the United States because of America's strong ancestral legal ties to English common law.

Bockrath and Wheeler (1975) reviewed the fisheries statutes of Maryland, Delaware, and Virginia to determine their applicability to certain aquaculture technologies. They specifically investigated the applicability of these laws to aquaculture technologies which utilized closed-water systems. They concluded that advances in aquaculture technology place new stresses on laws which were designed originally to accommodate a single circumstance and that the applicability of these laws to new technologies is often a result of chance wording. Furthermore, they concluded that Maryland and Virginia need to adopt new statutes if they wish to encourage aquaculture development.

Some states have developed specific aquaculture legislation designed to address water use conflicts associated with aquaculture and to aid in the development of aquaculture in those states. Owen (1978), conducted a comparative study of aquaculture legislation in California, Florida, and Maine. She concluded, broadly drafted legislation is more

likely to accommodate new aquaculture technologies. She also noted the law tends to be reactive rather than initiating and technology must generally be proven economically feasible before the law recognizes and accommodates a new technology such as aquaculture.

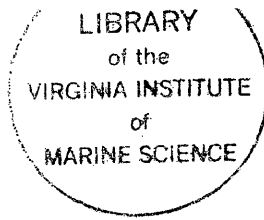
A number of studies have been performed to identify how potential legal conflicts and other biological, economical, and regulatory barriers may act to constrain the aquaculture development (Landy, 1975; Bowden, 1981; Aspen Research and Information Center, 1981; and Shupe, 1982).

Trimble (1972) conducted an assessment of the potential for aquaculture development in Hawaii and developed recommendations to enhance the development opportunities in the State. These recommendations included: land and water use plans, legislative changes, and a stepwise program for aquaculture development. A comprehensive study similar to Trimble's has not been conducted for Virginia.

The federally appointed Committee on Aquaculture (1978) reviewed the status of the United States aquaculture industry, identified constraints, and made recommendations to address the constraints and enhance development of the industry. The Aspen Research and Information Center (1981) identified some broad constraints to general aquaculture development in the United States in a study conducted for the Fish and Wildlife Service. This study identified 120 federal statutes and programs which could impede aquaculture development. The

study was broad in scope, however, and failed to identify constraints to specific aquaculture technologies and offered few recommendations for the mitigation of the identified impediments. In a report to the Secretary of Education and the Governor, the Virginia Institute of Marine Science's Marine Advisory Service (1984) identified lack of investment capital as a significant constraint to aquaculture development and suggested this lack of capital may be due, in part, to the long lead period between the start of a project and a return on the investment.

Although no money was ever allocated to carry out the provisions of the National Aquaculture Act of 1980, The National Aquaculture Development Plan was developed by the Joint Subcommittee on Aquaculture in 1983 with funds from other sources. The development plan which was called for in the Act, identified industry constraints including burdensome state and federal laws, multiple use conflicts, and inadequate transfer of information. The plan also provided a summary of species which hold a potential for aquaculture development in the United States including marine species of oysters, clams, mussels, shrimp, and salmon.



METHODS

This study was conducted in three consecutive phases. First, likely candidates for enhanced commercial mariculture development in Virginia were identified. Once potential species had been identified, impediments to the commercial culture of these species were compiled. Finally, recommendations to remove these impediments and enhance the potential for the commercial culture of these species were developed. This section describes the techniques that were used to complete these steps.

A literature review was conducted to identify likely candidates for commercial mariculture in Virginia, given a favorable regulatory climate. Nutritional, hydrodynamic, climate, salinity and substrate requirements were reviewed along with growth rates, hardiness, potential yields, and susceptibility to existing predators in Virginia. Also carefully considered were the existence of established culture techniques, current market value, and demand for the product.

After the more likely species and culture techniques had been identified, Virginia and Federal laws were reviewed to identify potential impediments to the commercial application of these mariculture systems. Special attention was given to harvesting restrictions, pollution abatement requirements, permitting and leasing

regulations, residency restrictions, and potential conflicts with navigation and other established public and private rights.

The literature review identified shellfish mariculture as holding the greatest potential for mariculture development in the Commonwealth. The results which lead to this determination are presented in the results section. The remainder of the methodology deals specifically with shellfish mariculture.

A general understanding of the impediments to various forms of shellfish culture was obtained during the literature review and the review of State and Federal laws. However, before recommendations could be developed to alleviate these impediments, a more complete list had to be developed and an understanding of the relative importance of each constraint was needed. Therefore, a two-part survey was developed to identify and rank what those persons involved in commercial mariculture believe are the most important constraints to the further development of the industry.

Although the shellfish mariculture industry is underdeveloped in Virginia, there are numerous commercial facilities in other coastal states. Therefore, to obtain information from the development efforts of these other states, the survey was conducted nationwide with the replies keyed to the respondent's state.

The Delphi survey technique described in Delbecq et al. (1975) was utilized to identify constraints that may not have been revealed in

a survey of the small number of Virginia shellfish aquaculturists and also to provide an insight into the effectiveness of other states' initiatives to enhance aquaculture development.

A mailing list for the survey was compiled from the facilities listed in the National Aquaculture Directory (Ayers, 1984), which identified clams or oysters among the species cultured at a facility. Due to the large number of oyster and clam facilities listed for Washington, a subsample of 100 was randomly selected from over four hundred entries listed in the Washington section of the directory. Additional facilities, which were noted in aquaculture related journals, were added to the mailing list. The survey list of facilities for Virginia included individuals interested in commercial aquaculture who have solicited assistance from VIMS' advisory services programs as well as those who have expressed an interest in obtaining oyster larvae from VIMS' oyster hatchery. A list of individuals who responded to the survey from Virginia is provided in Appendix 1.

The survey was conducted in two parts. The first mailing asked the respondents to answer several questions about their facility and to list under the appropriate heading; Technical, Economic, Regulatory or Other, in no particular order, what they felt were the major constraints to the development of their aquaculture operation (Appendix 2). The survey returns from this first mailing were compiled to create a national list of clam and oyster aquaculture constraints.

The second mailing asked the respondents to select and rank, from a list of the twenty-seven constraints identified from the first survey, what they felt were the ten most important constraints to the development of their aquaculture operations (Appendix 3). The questionnaire instructed the respondents to assign the most important constraint a ranking of ten, the next most important constraint a nine, and continue until the least important of the ten constraints was assigned a value of one.

The results from the second mailing were grouped by state and tallied. A total vote for each constraint was obtained by adding the individual rankings assigned to each item. Thus, if a constraint received the ranks of 10-6-8-6, the total vote would be thirty. Once a total vote was obtained for each of the twenty-seven constraints, they were arranged in order, by state, and assigned a rating of one to twenty-seven. The constraint receiving the highest total vote was assumed to be the most important constraint in that state and was assigned a rating of one. After the constraints had been rated for each state, all of the replies were collectively tallied to obtain a national constraint rating.

The rating system facilitated the comparison of the relative importance of each constraint in each of the states included in the survey and provided an insight into the effectiveness of various state initiatives to alleviate a particular impediment.

Due to the subjective nature of the survey and the numbers it generated, no complex statistical tests were conducted on the data. The survey was not designed for such tests and would not likely fit the assumptions and rules for any statistical testing. The survey was designed merely to provide a list of impediments to shellfish mariculture development and to indicate the relative importance of each impediment in a variety of coastal states.

The state laws and regulations of neighboring coastal states and states with more developed mariculture industries were reviewed in conjunction with the survey results to gain an insight into the effectiveness of various initiatives to enhance aquaculture at the state level. This review was conducted to identify legislation and initiatives which have been effective in other state's mariculture development efforts and which could potentially be adapted to enhance mariculture development in the Commonwealth.

A list of constraints to shellfish mariculture development which might be removed or mitigated through legislative, regulatory, or policy changes at the state level in Virginia was compiled from the survey and the legislative reviews of other states. Various alternatives to address these constraints were developed along with a number of beneficial and detrimental impacts which might be associated with each alternative.

The various alternatives and associated impacts were presented during personal interviews to individuals representing state agencies,

industry, commercial mariculture facilities, and other groups which might be affected by any of these alternatives. The interviews were intended to identify additional alternatives to address the constraints and to gain an understanding of the concerns various groups may have regarding any proposed recommendations. The names and addresses of all individuals contacted and cited as personal communication are provided in Appendix 4.

The information collected from the literature reviews, reviews of state and federal laws and regulations, the Delphi survey, and the personal interviews was used to compile a list of constraints to shellfish mariculture development in Virginia. Various alternatives for the removal or mitigation of each of the identified constraints were also developed and are presented along with a number of potential benefits and detriments which might be associated with their implementation.

RESULTS

The literature review indicated that oysters and hard shell clams likely possess the greatest immediate potential for mariculture development in Virginia. This conclusion was based on the following technical and socioeconomic factors. The culture techniques have been thoroughly studied and the culture techniques are well established for both species. The Virginia Institute of Marine Science has conducted a great deal of research related to oyster and clam mariculture and has adapted and developed culture techniques which are directly applicable to Virginia's environmental conditions (Castagna and Kraeuter, 1981). The traditional Virginia oyster fishery has been ravished by the oyster diseases Haplosporidium nelsoni "MSX" and Perkinsus marinus "Dermo". The Virginia hard clam fishery has been placed under increasing fishing pressure as a result of fishermen switching their efforts from oysters to clams (Randy Owen and Lewis Gillingham, VMRC; personal communication). Well established markets exist for both species and Virginia's traditional fisheries have been unable to meet market demands (Capps et al., 1989) and (VMRC, 1989).

The survey was conducted during October through December of 1986. Three hundred and three questionnaires were mailed out during the first portion of the survey and sixty responses were received, for a return rate of twenty percent. Twenty five questionnaires were returned

undelivered and twelve were returned by individuals who indicated that they were not involved in aquaculture. These thirty seven individuals were subsequently removed from the mailing list. Therefore, two hundred and sixty six questionnaires were mailed out in the second portion of the survey. Of these, sixty four responses were received, giving a return rate of twenty four percent for the second portion of the survey. Table 1 presents the number of survey forms distributed and returned by each state.

The compiled results of the survey are summarized in Table 2. The twenty seven constraints were developed in the first portion of the survey and the corresponding rankings were assigned from the results of the second mailing. The constraints in this table are listed in an order which corresponds to the national ranking, which is a compilation of all of the returns. The corresponding rankings for Connecticut, California, Washington, and Virginia are listed along side for comparison. The low numbers of returns received from the other states surveyed, did not justify the development of additional state specific lists. However, the replies from these states are reflected in the national compilation list and were important in the development of the twenty seven constraints which were utilized in the second portion of the survey.

Table 3 presents the rankings of the constraints identified by the Virginia respondents. Included in this table is the total score received for each constraint. Although statistical tests were not conducted on this data, the scores are helpful when making comparisons

Table 1. Number of surveys distributed and returned.

STATE	<u>FIRST MAILING</u>			<u>SECOND MAILING</u>		
	#SENT	#RETURNED	%RETURNED	#SENT	#RETURNED	%RETURNED
Virginia	18	11	61%	18	10	56%
California	40(7)	10	25%	33	14	42%
Connecticut	70(3)[4]	14	20%	63	12	19%
Deleware	1	1	100%	1	0	0%
Florida	4(1)	1	25%	3	1	33%
Hawaii	10(1)[1]	0	0%	8	2	25%
Louisiana	1	1	100%	1	1	100%
Maine	5	1	20%	5	2	40%
Maryland	1	1	100%	1	1	100%
Massachusetts	1	1	100%	1	1	100%
New Hampshire	9	1	11%	9	1	11%
New Jersey	2(1)	0	0%	1	0	0%
New York	9	2	22%	9	3	33%
Oregon	28(3)	2	7%	25	3	12%
Rhode Island	1	1	100%	1	0	0%
South Carolina	1	1	100%	1	0	0%
Texas	2	0	0%	2	0	0%
Washington	100(9)[7]	12	12%	84	13	15%
Total	303	60	20%	303	64	24%

() represent the number of survey forms returned "undelivered"

[] represent survey forms returned by individuals who indicated they were not mariculturists

Table 2. Compiled survey results. A ranking of "1" indicates the most important constraint identified by the respondents. Independent rankings are given for Connecticut, California, Washington, Virginia, and all respondents

<u>RANK</u>					
<u>CT</u>	<u>CA</u>	<u>WA</u>	<u>VA</u>	<u>ALL</u>	
1	4	10	5	1	Poor or variable water quality.
4	1	12	14	2	Lack of affordable investment capital.
8	5	2	7	3	Difficult and time consuming to obtain necessary leases, licenses and permits.
2	3	10	9	4	Lack of available coastal property which is affordable and appropriate for aquaculture development.
12	14	12	1	5	Antiquated laws and regulations designed to manage the natural fisheries which are inappropriate for aquaculture.
9	2	5	17	6	Lack of understanding by the investment community of the benefits and risks associated with different types of aquaculture operations.
14	8	4	3	7	Resistance to development by private property owners and traditional fishermen.
11	7	5	10	8	Lack of coordination between local, state and federal agencies.
5	17	19	2	9	Excessive costs associated with predator and disease control.
6	16	7	8	10	Ineffective measures to control theft of product.
15	13	16	6	11	Apathy of state regulators toward the aquaculture industry.
10	10	9	15	12	Health department regulations are too burdensome and inappropriate for some types of aquaculture.
18	6	22	12	13	Lack of technical research which is practical to the aquaculturist.
18	19	1	27	14	Excessive state taxes on labor and property.
3	19	8	20	14	Difficulty in entering into market and competing with the large companies.
21	22	17	4	16	Lack of rights to the water column and surface.
12	23	15	10	17	Poor understanding of private property rights.
7	12	24	17	18	Lack of insurance to cover losses due to storm damage.
16	15	17	15	18	Too few sources of specialized seed.
26	10	3	25	20	Other constraint(s) not listed above.
24	9	14	17	21	Lack of low cost equipment to clean, sort and grade products.
24	18	22	22	22	Lack of veterinary services and pathological laboratories for quick analysis of diseases.
23	25	20	26	23	Lack of approved antibiotics and other disease preventative drugs.
22	21	24	22	24	Lack of affordable manufactured feed.
17	24	20	20	25	Difficulty in obtaining and meeting hiring regulations for teens and temporary help.
20	26	24	24	26	Difficulty in obtaining scientific and technical information.
27	27	24	13	27	Excessive costs associated with raising phytoplankton for food.

Table 3. Virginia survey results. A ranking of "1" indicates the most important constraint identified by the respondents. The total vote received is indicated in parenthesis.

RANK (TOTAL VOTE)

- 1 (77) Antiquated laws and regulations designed to manage the natural fisheries which are inappropriate for aquaculture.
- 2 (61) Excessive costs associated with predator and disease control.
- 3 (44) Resistance to development by private property owners and traditional fishermen.
- 4 (40) Lack of rights to the water column and surface.
- 5 (39) Poor or variable water quality.
- 6 (31) Apathy of state regulators toward the aquaculture industry.
- 7 (30) Difficult and time consuming to obtain necessary leases, licenses and permits.
- 8 (29) Ineffective measures to control theft of product.
- 9 (26) Lack of available coastal property which is affordable and appropriate for aquaculture development.
- 10 (24) Poor understanding of private property rights.
- 10 (24) Lack of coordination between local, state and federal agencies.
- 12 (21) Lack of technical research which is practical to the aquaculturist.
- 13 (19) Excessive costs associated with raising phytoplankton for food.
- 14 (17) Lack of affordable investment capital.
- 15 (15) Health department regulations are too burdensome and inappropriate for some types of aquaculture.
- 15 (15) Too few sources of specialized seed.
- 17 (10) Lack of insurance to cover losses due to storm damage.
- 17 (10) Lack of understanding by the investment community of the benefits and risks associated with different types of aquaculture operations.
- 17 (10) Lack of low cost equipment to clean, sort and grade products.
- 20 (9) Difficulty in entering into market and competing with the large companies.
- 20 (9) Difficulty in obtaining and meeting hiring regulations for teens and temporary help.
- 22 (8) Lack of veterinary services and pathological laboratories for quick analysis of diseases.
- 22 (8) Lack of affordable manufactured feed.
- 24 (4) Difficulty in obtaining scientific and technical information.
- 25 (3) Other constraint(s) not listed above.
- 26 (1) Lack of approved antibiotics and other disease preventative drugs.
- 27 (0) Excessive state taxes on labor and property.

and judgements regarding the relative importance of two or more constraints.

Many of the constraints identified in the survey also were independently identified in the literature review and the review of the Virginia Code. The survey results help to confirm that these constraints are indeed perceived by those in the industry to be impeding the development of commercial shellfish mariculture in Virginia. Those constraints receiving a total vote of less than ten were considered not to be presenting a serious problem to mariculture development at this time and were not further investigated. This break point was arbitrarily chosen, however, a constraint which received a total vote of ten or less received less than two percent of the possible vote. Some of the lesser constraints are, however, addressed in the recommendations to address the more significant impediments.

One possible constraint identified in the review of the Virginia Code was not identified in the survey. This is the sections of the Virginia Code referred to as residency requirements which mandate nonresidents may not take shellfish from Virginia waters for market or profit (28.1-122 Va. Code Ann.) and may not lease shellfish planting ground from the State (28.1-109[2] Va. Code Ann.) The applicability of these laws to fish and crabs were struck down as unconstitutional in Douglas v Seacoast Products Inc., et al.(1977) and Tangier Sound Watermen's Assoc., et al. v. Douglas (1982). The importance of these residency requirements to shellfish mariculture is more fully discussed in the results section.

The survey results of the individual states were compared along with the aquaculture development efforts taken by those states to gain an understanding of the effectiveness of various initiatives to remove impediments within the respective states. These comparisons were used to help develop recommendations to remove or mitigate impediments within Virginia. The results of this portion of the study are presented, where appropriate, in the discussion section.

After the constraints had been identified through the survey and literature review, a number of interviews were conducted with representatives of regulatory agencies, aquaculture industry, and a variety of user groups which may be affected by certain initiatives to enhance shellfish mariculture development in the Commonwealth. These interviews provided valuable insight into the importance of the various impediments and the feasibility of implementing certain initiatives to remove the impediments. They also provided some additional alternatives to remove or mitigate some impediments and provided comments on possible opposition and problems associated with implementing the initiatives. Although this information was quite valuable to the development of this paper, the information is difficult to quantify and present in this section due to the subjective nature of the interviews. Much of the information collected from these interviews is presented in the discussion section.

A list of the impediments which were identified in the study and further evaluated to make recommendations to address them, are grouped by category and presented in Table 4. Each of these impediments are

Table 4. Summary of identified impediments

1. Regulatory Impediments
 - a. Laws and regulations designed to manage the traditional fishing industry which adversely impact shellfish mariculture
 - b. Residency Requirements which discourage mariculture investment by nonresidents of Virginia
 - c. Health Department regulations which may be inappropriately applied to mariculture operations
 - d. Lack of coordination within the regulatory review process
2. Leasing and Permitting Impediments
 - a. Inability to lease the water column
 - b. Inability to quickly modify encroachment permits in response to changing conditions or experiments and new technologies
3. Impediments Associated with Multiple Use within the Coastal Zone
 - a. Poor understanding of how mariculture will be viewed to affect private and public water rights
 - b. Resistance to mariculture development by commercial fishermen and private property owners
 - c. Lack of available coastal property which is affordable and appropriate for mariculture development
 - d. Ineffective measures to control theft of the cultured organisms
4. Environmental Impediments
 - a. Poor or variable water quality
 - b. Problems associated with predator and disease control
5. Technical Impediments
 - a. Inadequate sources and inability to utilize specialized oyster and clam seed
 - b. Lack of technical research which is practical to shellfish mariculture
 - c. Excessive costs associated with raising phytoplankton as a food source for the cultured shellfish
 - d. Gaps in predator and disease control technology
6. Financial Impediments
 - a. Lack of affordable investment capital
 - b. Marketing problems

described and presented in the discussion section along with various alternatives to remove or mitigate them. Where actions have been taken in other states, the success or failure of these actions are also presented. In some instances a variety of alternatives are presented along with their associated potential benefits and detriments.

DISCUSSION

This study identified a number of real and potential constraints to the development of shellfish mariculture in Virginia. The majority of these impediments appear to exist because the practice of aquaculture is a relatively new use of Virginia's commonly owned waters. As such, the practice of mariculture must compete with more traditional water uses and rights including: navigation, fishing, recreation and even aesthetics. Many of the laws which govern and protect these traditional water uses act to impede the development of mariculture (Owen, 1971; McCutcheon, 1976; and the Joint Subcommittee on Aquaculture, 1983).

Although a few states have developed significant mariculture industries, Virginia's mariculture industry has been slow to develop. This slow development may be due, in part, to the fact that Virginia has traditionally been blessed with vast seafood resources and has a long history of traditional commercial seafood harvesting. Only recently have the harvests of many of these fisheries suffered from serious declines. As a result, Virginia has only just begun to investigate developing alternate seafood production techniques; and to date, there have been few governmental initiatives to enhance the development of the industry. In contrast, the West Coast has developed a significant shellfish mariculture industry through innovative

culturing techniques and the importation of nonnative species. Therefore, despite Virginia's natural environment which is well suited for a variety of mariculture activities, I believe the lack of state initiatives to remove existing impediments to aquaculture development coupled with Virginia's typically conservative government and strong history of private property rights may be acting to constrain development of mariculture in the Commonwealth.

The constraints identified in this study and deemed to be important impediments to the development of the shellfish mariculture industry are grouped by type and individually discussed in this section. An effort was made to follow a similar format in the discussion of each constraint to allow for an easier review of this material.

First, a description and the history of the constraint are presented. Then, the relative importance of the constraint is discussed. Finally, recommendations for the removal or mitigation of the impediment are suggested. Where appropriate, examples of other state's initiatives are presented along with the potential benefits, detriments and opposition which might be expected to be associated with each recommendation.

Regulatory Impediments

There are a wide array of statutes and regulations intended to manage and protect the natural resources and traditional uses of the

Commonwealth's waterways, which act as constraints to shellfish mariculture development. Many of these regulatory impediments need to be carefully studied so that their applicability to mariculture can be modified to enhance shellfish mariculture opportunities (Joint Subcommittee on Aquaculture, 1983).

Laws and regulations designed to manage the traditional fishing industry which may adversely impact shellfish mariculture.

The Commonwealth has a long history of commercial shellfishing. As a result, there are 94 individual code sections directly related to managing the shellfish industry (28.1-82 through 28.1-164 Va. Code Ann.). Although the intent of these laws is to manage the naturally occurring stocks of oysters and clams, shellfish mariculture operations may inadvertently be affected by the wording in some of these statutes. For example, laws and regulations concerning size and season restrictions or harvesting gear restrictions can adversely affect a shellfish mariculture operation.

Currently there are no size or season restrictions on the harvesting of clams or oysters taken from privately leased shellfish grounds. However, since the Marine Resources Commission has statutory authority to develop regulations to manage these fisheries (28.1-23 Va. Code Ann.), the possibility of restrictions remains a concern to many culturists. Representatives from the Marine Resources Commission's Fisheries Management Division indicate that it is unlikely that any regulations concerning size and seasonal restrictions would be adopted

in a manner which would affect privately raised shellfish (Randy Owen and Lewis Gillingham, VMRC; personal communication). It appears therefore, that size and seasonal restrictions are only a potential problem and mainly only a problem of perception.

Other fisheries laws and regulations directly impact clam and oyster aquaculture activities. Specifically, laws which prohibit the harvesting of oysters on Sunday or at night (28.1-139 Va. Code Ann.) or clams on Sunday or at night (28.1-139.1 Va. Code Ann.) and which prohibit the use of the hydraulic escalator dredge to harvest shellfish (28.1-128.01 Va. Code Ann.) are applicable to privately reared oysters and clams. These laws are important management tools for regulating the taking of naturally occurring shellfish, however, they may not need to be applicable to privately reared shellfish.

The actual and potential applicability of laws and regulations, designed to manage the traditional oyster and clam fisheries, to shellfish mariculture was identified as an important constraint to the development of the industry. Unlike the traditional fishermen, the aquaculturist incurs an expense in raising the organisms to market size. In order to offset these expenses and obtain the widest possible profit margin, the culturist must harvest the product at the most appropriate size and time and in the most efficient manner possible. I believe unreasonable barriers which prohibit such activities may provide an unnecessary disincentive to enter the industry.

The hydraulic escalator dredge is one of the most efficient pieces of harvesting gear for hard clams. Austin and Haven (1981) indicated the dredge can harvest at least 70 to 100 clams per minute from productive grounds which is approximately eight times faster than current patent tong methods and damaged fewer clams than the present techniques. Ken Kurkowski with VIMS indicated that the hydraulic escalator dredge is capable of harvesting at even faster rates, especially in areas where clams are abundant (personal communication). In 1981 the Virginia legislature enacted a law which prohibited the use of hydraulic escalator dredge to harvest clams (28.1-128.01 Va. Code Ann.). This law was enacted mainly as a management tool to prevent overharvesting of natural clam population. There was also a fear that the dredge's operation could adversely affect the marine environment, mainly from the associated siltation. Studies conducted by the Virginia Institute of Marine Science, however, indicated that the environmental affects associated with the hydraulic escalator dredge were similar to traditional harvesting methods(Austin and Haven, 1981).

The prohibition against the use of the hydraulic escalator dredge to harvest clams was identified in the survey to be one of the most important impediments to the development of clam mariculture in Virginia. Since the survey, however, some clam mariculture facilities have incorporated predator exclusion devices into their grow out operations such as trays and nets, which limit the ability to harvest the clams with a hydraulic escalator dredge. Therefore, since necessary predator exclusion devices limit the practical use of the dredge, its prohibition may not be as important of a constraint to

mariculturists using these types of predator exclusion devices. Nevertheless, nearly all of the culturists surveyed believe it would be beneficial to allow the hydraulic escalator dredge to be used to harvest aquaculturally reared clams from privately leased shellfish ground.

The State should consider legislation which exempts mariculture products from laws and regulations designed solely to manage natural stocks. Similar legislative action have been taken in states including California and Florida. I believe the State should also consider a legislative change which would allow for the carefully regulated use of the hydraulic escalator dredge to harvest mariculturally reared shellfish from privately leased shellfish grounds. These initiatives, particularly the hydraulic dredge legislation, may draw objection from the traditional commercial fishing industry who may view such steps as providing an unfair advantage to the mariculture industry.

Residency requirements

The State of Virginia has a long standing policy of attracting business investments to the State, yet throughout much of the Commonwealth's history, the Code of Virginia has contained laws which prohibit nonresidents from taking fish or shellfish from the State waters for market or profit(28.1-122 Va. Code Ann.), and which prohibit nonresidents from leasing shellfish planting grounds from the State(28.1-109[2] Va. Code Ann.). These laws were presumably enacted to preserve the commonly owned, naturally occurring, fish and shellfish

for the citizens of Virginia and they have been challenged in court on several occasions. As a result of these court challenges, the applicability of these laws to finfishing and crabbing have been struck down (Douglas v. Seacoast Products Inc., et al.[1977] and Tangier Sound Watermen's Assoc., et al. v. Douglas[1982]).

These residency requirements may have a detrimental affect on the development of shellfish mariculture in Virginia. The mariculture industry is still considered an experimental high risk investment by most traditional lending institutions and most full scale mariculture operations require significant investment capital. As with other business ventures, I believe it is important that potential investors, regardless of their residency, be allowed to enter into the mariculture industry.

Residency requirements were not specifically identified in the survey, yet, problems associated with securing investment capital was identified as an important constraint. The residency requirements may have an adverse impact on the development of the shellfish mariculture industry by limiting nonresident investment. I believe the State should consider legislation to remove the applicability of these laws to mariculture operations and should actively encourage nonresident investment in the shellfish mariculture industry. Virginia would be expected to profit from investment in mariculture, regardless of the residency of the investor, through increased tax revenue and employment opportunities.

Health department regulations

The Department of Health's Division of Shellfish Sanitation is responsible for enforcing laws and regulations designed to protect public health by assuring the quality of shellfish taken from the waters of the state for consumption. Some aquaculturists identified these regulations as overburdensome and inappropriate for mariculture. As such, they felt they act as a constraint to the development of shellfish mariculture. For example, the Health Department is currently considering requiring holding permits for mariculture structures such as, oyster racks, even if the structures are in open shellfish waters and the shellfish have never been exposed to condemned waters (Mike Oesterling, VIMS; personal communication). Holding permits are required for relaying oysters from polluted grounds to clean waters for depuration, however, there necessity for mariculture structures in clean waters is unclear and may be unnecessary.

The Health Department's regulations must meet the standards of the National Shellfish Sanitation Program and many are necessary to protect public health and product quality and are inflexible. One of the mariculturists (Chip Petre; personal communication), felt that the Health Department needed review the applicability of their regulations to aquaculture facilities to determine if they are all necessary and that this information should be made available to the local inspectors, who may not be familiar with shellfish mariculture facilities.

A number of productive shellfish growing areas are classified as condemned or seasonally condemned for the direct marketing of shellfish. Although it is unlikely that an aquaculturist would intentionally decide to grow out clams in condemned waters, it is possible that already planted grounds could be reclassified as condemned before the culturist could harvest the planted shellfish. I believe, increased efforts to develop and permit innovative depuration techniques such as, containerized relaying and depuration facilities should be encouraged to offset this potential problem. This action would parallel current Virginia Marine Resources Commission (VMRC) and Health Department actions, support the Chesapeake Bay Oyster Management Plan, and benefit the traditional fisheries as well as the mariculture industry by reducing the costs associated with cleansing and marketing clams harvested from polluted waters.

Impediments associated with the regulatory process

Just as the applicability of individual regulations can adversely affect mariculture, the regulatory process itself can impede the development of the shellfish mariculture industry. The lack of coordination among the regulatory agencies such as VMRC, the Virginia Water Control Board, and the Virginia Department of Health, with respect to mariculture activities was identified in the survey to be an impediment to the development of the industry.

Constraints within the regulatory process involve the lack of coordination and knowledge among the agencies with respect to what

permits are necessary from all levels of government and a perceived apathy on the part of the regulatory agencies with regard to the development of the mariculture industry. These problems appear to stem from the fact that mariculture is a new use of the resources over which these agencies have jurisdiction, and as such, mariculture does not fit well into these agencies' existing regulatory programs. Additionally, most of the people within these agencies only have a limited knowledge of the benefits, detriments, and associated needs of the industry. The mariculturist is therefore, left to sift through a maze of regulations and hope that he has obtained all the necessary permits and authorizations to conduct his operations legally. Obviously, this process can be both costly and time consuming and was identified as an important constraint to the development of the industry.

There are, of course, shellfish mariculture facilities currently operating in Virginia. The numbers are small, however, and many of the regulatory agencies have not strictly enforced their regulations; taking a wait and see attitude, since the industry is small and conflicts have not arisen. It is likely that many of these facilities do not possess all the permits required by law. For example, any facility utilizing structures in the waters of the State including, trays, rafts, stakes, nets, and fences is required to obtain a permit from the VMRC under section 62.1-3 of the Code of Virginia. To date however, only one VMRC permit has been issued to an aquaculturist for such structures. The necessity to permit structures such as nets and trays placed in proximity to the bottom and not excluding other activities has not been determined, however, as the industry grows and

conflicts arise this issue will have to be addressed (Tony Watkinson, VMRC; personal communication).

Problems associated with the regulatory review process have been addressed in some other states through legislative actions to adopt lead agencies tasked with coordinating permitting efforts and providing relevant information to the regulatory agencies and prospective culturists. An effort to coordinate the permit review process for mariculture activities would likely prove to be beneficial to the development of the mariculture industry in the Commonwealth (Joint Subcommittee on Aquaculture, 1983).

Virginia is fortunate to have a well coordinated permit review process in place for many activities requiring permits in the coastal zone, nontidal wetlands and nontidal rivers and streams throughout the State. An applicant needs only to submit a single local state federal joint permit application to the Marine Resources Commission. The Marine Resources Commission acts as a clearing house and sends copies of the application to the U. S. Army Corps of Engineers, all involved State agencies and the local wetland board, if applicable. This process could be adapted to help streamline aquaculture permitting through slight modifications to the permit application, perhaps through the addition of an appendix for aquaculture activities and the creation of a list of all agencies desiring or required to review and comment on aquaculture applications. The lead agency could be responsible with coordinating this streamlining effort.

I believe it is unlikely that any groups would oppose such coordination efforts. However, some existing mariculture facilities may view such efforts unfavorably because they may be required to comply with previously unenforced regulations. In fact, one mariculturist, who wished to remain anonymous, believes that once all the agencies begin to review and enforce all applicable regulations, compliance will become more difficult. If the industry is to be encouraged to grow, however, I believe the regulatory agencies will have to strictly enforce all applicable laws and regulations and that the industry will be best served if the requirements are identified and complied with from the outset.

Constraints associated with leasing and permitting structures in State Waters

All the beds of the bays, rivers, creeks and the shores of the sea channelward of mean low water and not conveyed by a special grant or compact are the property of the Commonwealth (62.1-1 Va. Code Ann.). Virginia does have a mechanism in place which allows for the leasing of tracts of the subaqueous bottom for the purpose of growing and propagating oysters and clams (28.1-109 Va. Code Ann.). This leasing system was originated to allow for the transplanting of oysters from good seed production areas such as, the James River to better grow out areas such as the Rappahannock River. This leasing authority is also applicable to the growing of clams (28.1-110). There are currently 111,554 acres of privately leased shellfish grounds in Virginia (VMRC, 1989). Although the shellfish ground leasing program was not

specifically designed for true egg to market mariculture activities, some entrepreneurs have used it for such.

One of the shortcomings of Virginia's shellfish ground leasing program, as it relates to mariculture, is it does not allow for the leasing of the water column and surface. The lease confers no special rights to utilize the waters above the bottom. This is unfortunate for mariculturists, because many forms of mariculture require the use of the entire water column and many bottom culture techniques become more productive when the system is expanded to include the water column. These three-dimensional systems more efficiently utilize the water resource, help to reduce some forms of predation, avoid certain problems associated with the resuspension of sediments, and allow for easier handling and harvesting. The structures associated with these systems include rafts, trays, pens, fences, and nets and depending upon their placement, they may require a permit from a variety of agencies including the Marine Resources Commission, U.S. Corps of Engineers and a local wetland board.

All encroachments in, on, or over the State owned subaqueous lands which are not specifically authorized in the Code of Virginia require a permit from the Marine Resources Commission (62.1-3 Va. Code Ann.). Therefore, all the structures necessary for three-dimensional aquaculture which are placed channelward of the mean low water mark are required to be permitted by the Marine Resources Commission. The Marine Resources Commission permit specifically states in its standard conditions that, "it grants no authority to encroach on the property

rights of others, including riparian rights and the permitted activity shall not interfere with the rights vouchsafed to the people of Virginia concerning fishing, fowling, and the catching and taking of oysters and other shellfish in and from the bottom of areas and waters not included within the terms of the permit".

The lack of special rights to the water column and surface was identified in the survey as an important constraint to shellfish mariculture development in Virginia. This constraint ranked low in other states which permit the leasing of the water column such as California, Florida, Connecticut, and Washington.

Activities which are permitted under section 28.1 of the Virginia Code, the section which regulates coastal fishing activities, are specifically exempted from the permitting requirements contained in section 62.1-3. Therefore, fishing structures such as gill nets, pound nets, and crab pots do not require permits for encroachment over state owned bottom lands. It could be argued that these fishing structures are analogous to many mariculture structures because they also have the potential to interfere with riparian rights, navigation, fishing, fowling, and hunting, and they also require an exclusive use of a particular area. However, mariculture activities are not currently regulated under section 28.1 and the VMRC has been reluctant to regulate mariculture activities solely under this section (Robert Grabb, Randy Owen, and Lewis Gillingham, VMRC; personal communication).

Aquaculture structures can be permitted under the existing system, in fact, the VMRC issued a permit to Mr. Andrew Teeling in 1990, which authorized him to place 100 rafts, designed to grow oyster off-bottom, in a small tidal creek on the Eastern Shore. These permits may not provide the necessary exclusiveness to provide protection from other uses of the waterway such as boating related activities, and the permit does not provide much flexibility to allow the culturist to experiment with other structures as they become necessary, such as, wave baffles and predator exclusion fences and nets. Under the existing permitting system, the addition of new structures or design modifications would require a new permit or at least, a permit modification with the full public interest review required by law.

Some states including, California, Connecticut, Florida, South Carolina, and Washington have developed statutes which allow for the leasing of the water column for mariculture activities. North Carolina issued its first aquaculture related water column lease in 1989 (Walter Clark; personal communication). In general, these leases are either in predetermined aquaculture zones or individuals may request aquaculture leases in other areas through a application and public interest review process. Within the aquaculture lease the individual may construct and utilize a variety of structures within the water column. The leaseholder is typically given nearly exclusive use of the area often with the exception that public access must be allowed to the extent that it does not interfere with the culture operation.

Water column leases provide the mariculturist with a better degree of protection from other competing water uses and allows the necessary flexibility to experiment with different types of structures in a timely fashion as they become necessary. Additionally, other nearby activities requiring permits are often more critically reviewed with regard to their potential impact on existing mariculture leases.

A mariculture leasing program could be administered in Virginia, but would likely require authorization in the state code. I believe the system would likely be administered by VMRC since they currently regulate leasing of shellfish growing bottoms, marine and estuarine fisheries, and issue permits for encroachments in, on, or over state owned submerged lands. Mariculture water column leasing responsibilities would include, identifying and declaring mariculture lease zones, review of lease applications, collection of fees, collection and maintenance of records and production data, and the review and granting of authorization to utilize a variety of structures within these leased areas. Appropriate lease fees and product taxes could be used to help offset the costs of the program.

To assure that the state receives a fair price for the leased land and to fairly distribute the leasable areas, a closed bidding system could be utilized. Closed bids are currently utilized in Florida and after the term of the lease expires, often ten years, the lease is put to closed bid again but the existing leaseholder is granted first right of refusal.

A mariculture leasing system could be beneficial to the industry (Mike Pierson, Chip Petre, and Glen Tyler; mariculturists; personal communication). The needs of the mariculture industry may not fit well into the existing permitting and leasing structure and a better system may be necessary to encourage mariculture development (Tony Watkinson, VMRC; personal communication).

The selection and determination of aquaculture lease zones would have to be conducted carefully. The areas would have to meet the environmental requirements for mariculture and should be in areas which only minimally impact traditional public uses. The areas should not adversely impact naturally productive fish and shellfish areas or environmentally sensitive areas such as, beds of submerged aquatic vegetation (Tony Watkinson, VMRC; personal communication). The areas should also be located away from areas more likely to be developed in the near future.

There are thousands of acres of ungranted State owned lands on the Eastern Shore which border tidal water bodies and may be suitable for mariculture (Bart Theberge, VIMS; personal communication). The State should consider reviewing and declaring certain waters which are bordered by these lands as mariculture lease zones. These areas are unique because they are not subject to upland development pressure and there would be no potential conflicts with riparian rights since there are no individual riparian property owners (Bart Theberge, VIMS; personal communication).

A variety of opposition to a mariculture leasing system is possible and will likely depend on the location of the sites proposed for mariculture zones. Zoning of particular areas for mariculture lease zones could have significant impacts on other uses of the waterway and the adjacent upland. If mariculture zones prohibit certain otherwise permitted activities on adjacent upland, it may be considered a taking (Andrew Heatwole, Va. Assoc. of Realtors; personal communication). Local governments, developers, and private property owners may object to the designation of certain areas for mariculture, particularly if more lucrative development alternatives could be impacted by the designation. Boaters and recreational fishermen may object to zones sited in traditionally popular fishing and boating areas because these uses could be somewhat restricted. Commercial watermen may object to the concept in general due to potential market competition and could be expected to vehemently oppose the designation of mariculture zones in any traditionally productive fishing or shellfishing areas (Randy Owen, VMRC; personal communication).

To avoid unnecessary opposition, aquaculture zones will have to be carefully selected and the positive aspects associated with mariculture development will need to be made clear to the general public. The benefits which should be explained to the public include, increased employment and taxes, habitat enrichment associated with the structures and related organisms, water quality improvement associated with the filtering activity of the shellfish, and potential recruitment benefits to wild stocks due to the reproductive activity of the aquaculturally reared species.

Impediments Associated with Multiple Use of the Coastal Zone

Some of the impediments identified in the study are related to how mariculture will be accommodated into the system which governs the existing user groups of the coastal zone. The more traditional uses of the water such as, fishing, navigation, and recreation have coexisted for years, and a variety of laws, regulations, and general practices have evolved to limit conflicts between these uses. Mariculture is a more recent use of the waters and the uncertainty associated with with how it will be accommodated by the existing laws, regulations, and even the other users of the waters, can act as a constraint to the development of the industry.

Poor understanding of how mariculture affects private and public water rights

The riparian property owner, an owner of property which borders on a body of water, is afforded a variety of statutory and common law rights. These rights include, the right to a reasonably unaltered flow of water past his property, the right to ingress and egress, the right to wharf out, the right to a reasonably unobstructed view of the waters in front of his property, and the right to open a channel to reach navigable waters. These rights are not absolute or without limitation, however, it is apparent that an aquaculture facility could potentially infringe upon some of these rights.

There are also broad public water rights, including the common law right of navigation and and Virginia statutory rights to fish, fowl and take shellfish from the waters of the State.

The VMRC issues permits for the encroachment of structures over the State owned submerged lands. When reviewing an application for a permit, the VMRC is mandated to consider the anticipated impacts of the proposal on these private and public rights. The VMRC permit does not, however, grant the permittee authority to encroach on the property rights of others. Therefore, even if a mariculturist receives a permit from the VMRC to encroach over the submerged land, he may still face litigation if there is a dispute over the impact of the project on another's private or public rights.

An example of this problem was realized in early 1990. Despite an adjacent property owner's objections, the VMRC voted to approve, in a modified form, an applicant, Mr. Andrew Teeling's request to place 400 floating oyster trays in Butcher Creek, a Chesapeake Bay tributary in Accomack County on Virginia's Eastern Shore. The adjacent property owner was concerned that the project would infringe upon his riparian rights and would adversely affect navigation within the creek. A few days after the VMRC decision to approve the request, the property owner threatened the permittee with litigation. Unable to afford the costs or time associated with a court challenge, the prospective mariculturist reluctantly agreed to move the trays to another, less desirable location.

The uncertainties associated with how mariculture activities will be interpreted, by regulatory agencies and the courts, to affect private and public rights was identified as an important constraint to mariculture development in the Commonwealth.

Many of the uncertainties associated with the affects of mariculture facilities on private and public rights will likely be resolved through case law. There are, however, some initiatives the State could pursue to help mitigate this constraint. Initiatives which encourage and direct mariculture development in appropriate, sparsely developed areas may help to reduce the potential for conflict. This initiative could take the form of zoning aquaculture lease areas, which was discussed in the leasing and permitting section of this paper. In the absence of aquaculture development zones, prospective mariculturists should be instructed to investigate potential public and private rights conflicts when siting a mariculture facility.

Resistance to mariculture development from commercial fishermen and private property owners

As a result of potential conflicts with riparian rights and perhaps some misconceptions with the nature of the business, there is a concern that certain private property owners may resist development of the industry. In addition, since mariculturally reared oysters and clams may directly compete with traditionally harvested oysters and clams in the marketplace, it is expected that there may be resistance to mariculture development expressed by some sectors of the commercial

fishing industry. This resistance to mariculture development could affect the enactment of certain initiatives to enhance the mariculture industry and was identified as an important constraint in the survey of Virginia mariculturists.

Resistance to mariculture development might be partially addressed through the previously explained, careful siting of facilities to reduce potential conflicts. Additionally, to promote mariculture development in the Commonwealth, Virginia could consider paralleling national and other states' efforts to promote the development of the aquaculture industry by declaring aquaculture development to be public policy. A State policy to promote mariculture development would parallel the State aquaculture initiatives which have, to date, concentrated on freshwater aquaculture promotion, and would support a number of the initiatives contained in the Chesapeake Bay Oyster Management Plan in which, Virginia agrees to investigate alternate oyster production techniques. The State policy to promote mariculture development could be based on the anticipated public benefits associated the industry including, increased tax revenue and employment and an economic incentive to maintain superior water quality.

Lack of available coastal property which is affordable and appropriate for mariculture development

The siting of a mariculture facility is one of the most important factors dictating the success or failure of a mariculture venture. A site must be located which is appropriate for the construction of a

hatchery, a nursery, and associated support buildings. If not directly on the water, it should be located close to the water and appropriate right of ways must be secured to connect the facility with the water to supply water and allow for water discharge associated with hatchery and nursery operation. The site must have access to water with the appropriate environmental attributes including, temperature, salinity, and pH. The water also must be free of contaminants which are detrimental to the growth and development of the shellfish.

The number of sites which are ideally suited for mariculture development are limited. In addition, the requirements for an aquaculture facility often overlap with the ideal requirements for other water related activities and coastal development. These other potential uses may raise the value of the property to the point that mere economics discourage the lands development as an aquaculture facility.

This particular impediment can be a difficult problem to address through state initiatives. It doesn't make economic sense for an individual to develop a parcel of coastal land as an mariculture facility if more lucrative opportunities such as, waterfront communities or marinas are feasible. In addition, the pressures on other forms of coastal development surely will increase as the coastal zone becomes more populated.

A possible alternative to address this constraint is again related to the careful siting of these mariculture facilities. Mariculture

development could be encouraged in areas which are suitable for mariculture, but, which for some reason are not suitable for more intense forms of development. For example, many of the tidal creeks and coves in Virginia which are suitable for mariculture are bordered by low lands with poorly drained soils or wetland areas. Current environmental regulations and mere construction related problems may prohibit intense development of these areas. Conversely, these areas may be able to support a mariculture facility with only minimal adverse impacts to any environmentally protected areas. Additionally, since shellfish mariculture is a water dependant activity which is generally nonpolluting and efficiently utilizes the natural resources while providing an economic incentive to maintain and protect those resources, its development may fit well into Virginia's coastal zone management efforts (Keith Buttlesman, Council on the Environment; personal communication).

Ineffective measures to control the theft of the cultured organisms

Once the cultured shellfish are moved from the protected onshore facilities to the open growout areas, they become increasingly susceptible to unintentional harvesting and theft. The shellfish are especially vulnerable because they typically are planted in high densities, which allow for large numbers of shellfish to be taken in a short period of time.

The threat of theft and the costs associated with measures to help control it, was identified as an important constraint in most of the

states surveyed. The Virginia mariculturists interviewed had not yet had a theft problem, but see the potential as a serious concern. Since mariculturists in states with more developed shellfish mariculture industries such as, Washington, Connecticut, and California indicated that theft was an important constraint, this particular problem may be difficult to address through states initiatives.

Fortunately, as a result of Virginia's traditional shellfish planting history, there are laws in Virginia which specifically address the theft of oysters and clams. Section 28.1-137 of the Code of Virginia declares that it is a larceny to "take, steal or carry away, without permission of the owner, oysters, clams, bedded or planted, oysters deposited by any person making up a cargo for market, shells or seed planted for the formation of oyster beds by the State or any person, firm or corporation". Although not specified, one would assume that this section would also apply to shellfish removed from permitted mariculture structures. It might be beneficial to the mariculture industry, however, to amend this section to specifically include shellfish taken from permitted mariculture structures or from within the confines of a mariculture lease, if the State does initiate a mariculture leasing program.

The VMRC's Law Enforcement Division has full police power and may be able to provide some assistance in patrolling mariculture growout areas. However, since many of these growout areas may be located in remote and shallow creeks and coves, the bulk of the surveillance effort will be left up to the culturist and will have to be considered

a business related expense. The mariculturists interviewed indicated that the ideal situation is to be able to watch the growout areas from your residence, but when this is not possible surveillance equipment or even genetic markers may have to be used if a problem develops.

Environmental Impediments

Virginia is blessed with abundant water resources and over 5000 miles of tidal shoreline. As a result, there are vast areas which are potentially suitable for shellfish mariculture development. Unfortunately environmental concerns may be impeding this development in many of these regions. The two primary environmental constraints identified in this study were, concerns of poor or variable water quality and problems associated with predators and disease.

Constraints associated with poor or variable water quality

A shellfish mariculture operation is particularly susceptible to poor or variable water quality. Typical contaminants which can adversely affect a mariculture facility include, industrial wastes, pesticides, leachates from antifoulant paints and sewage. During the hatchery and nursery phases, the organisms typically are held in extremely high densities and often are already in a stressed condition and particularly susceptible to poor water quality.

In addition to disease and mortality problems associated with poor water quality, a mariculturist must also be concerned with the affects

of water quality on the marketability of the shellfish. If for some reason the waters become contaminated by sewage or some toxic compound, the shellfish may be determined to be unsafe for human consumption. The mariculturist would then be faced with either having to relay the shellfish to a clean area for depuration or may not be able to market them at all. Obviously the economic impacts associated with either of these alternatives could be devastating to the industry.

Although the mariculturist could face significant hardship as a result of a decrease in water quality, it could be difficult to recover damages. The pollution could be associated with a permitted discharge or the source could be associated with a number of nonpoint sources discharges and difficult to trace. It is not apparent if current permitting programs would totally protect the mariculture industry (Martin Ferguson, State Water Control Board; personal communication).

Even in situations where the source of pollution can be identified, Virginia case law does not provide much protection to a leaseholder from damage to his leased shellfish planting grounds and the associated shellfish. In Darling v. City of Newport News (1919) an oysterground leaseholder was denied compensation for the contamination of his leased oyster beds which resulted from a municipal discharge. The Court ruled "an oyster planter takes his right to plant and propagate oysters on the public domain of the Commonwealth... subject to the ancient right of riparian owners to drain the harmful refuse of the land into the sea, which is the natural sewer provided therefor by nature".

Problems associated with poor or variable water quality were identified as an important constraint by respondents in all the states surveyed. Unfortunately, water quality problems are one of the most difficult impediments to address. In addition, since the coastal zone is being subjected to increasing residential and industrial development pressure, the problems associated with water quality will likely continue to grow. Water quality problems will likely continue to be a risk associated with the mariculture industry, yet, the State could pursue some initiatives which reduce the mariculture industry's vulnerability to pollution.

The State could specifically declare products propagated through aquacultural techniques to be the private property of the culturist. This has been done in California and may aid the culturist in attempts to recover damages from water pollution, through the Court system. Mariculture facilities could be directed into appropriate waterbodies with existing good water quality through a mariculture lease system or the development of mariculture lease zones. Mariculture would be given a priority use in the regions and activities which would adversely impact water quality in these areas could be discouraged through the permit system. This approach has been taken in in Florida's revised aquaculture lease rule.

The regulatory agencies could be directed to carefully weigh the anticipated adverse effects of a proposal on any existing mariculture facilities or any areas determined to be particularly well suited for mariculture development. A legislative declaration of a public policy

to enhance mariculture development in the Commonwealth may aid these efforts.

Constraints associated with predator and disease control

A variety of predator and disease organisms are present in Virginia and unless they are somehow avoided or controlled, these organisms can significantly affect the success of a mariculture venture. Although these predators and diseases naturally affect wild populations of oysters and clams, mariculture operations are particularly susceptible due to the typically high densities in which the cultured organisms are kept.

The hatchery and nursery phases of shellfish mariculture are susceptible to a wide array of disease organisms including various species of bacteria and viruses. However, if the culturist is careful to avoid the introduction of predators into these controlled systems, predation is not usually a significant problem during the onshore phases of shellfish mariculture.

Once the shellfish are transplanted into the natural environment, either at an intermediate nursery stage or for final growout, they become susceptible to a wide array of predators and remain vulnerable to the previously mentioned disease organisms. The predators which can present significant problems to shellfish mariculture in Virginia include numerous species of crabs, rays, starfish, birds, certain fish, raccoons, and even other molluscs including, whelks and drills.

Mariculture efforts to raise the native oyster Crassostrea virginica are plagued by the same diseases which have devastated the Chesapeake Bay's natural oyster stocks. Both of these diseases, Haplosporidium nelsoni "MSX" and Perkinsus marinus "Dermo", thrive in higher salinity areas, requiring salinities of approximately 15 parts per thousand to produce infections, and do not typically cause significant mortality until the oyster's second summer of life (Andrews, 1979).

Predator and disease control problems were identified as a serious impediment to shellfish mariculture by the Virginia respondents to the survey. As with water quality problems, predation and disease are difficult to address through state mariculture development initiatives. However, there are some activities the state could pursue and encourage to help address some of the problems associated with predation and disease.

Many of the diseases which infest on shore hatcheries and nurseries are preventable or treatable if the proper steps are taken by the culturist. A fledgling mariculture company likely will be operating on a tight budget and may not be able to afford to hire the necessary experts or to obtain the equipment necessary to diagnose the early presence of some diseases. The State could initiate a program similar to the agriculture extension program to provide technical and diagnostic services to the culturist. The Virginia Institute of Marine Science has provided assistance to many private culturists in the past, but if the industry is to be encouraged to grow, these services

may have to be expanded. Aquaculture extension services are provided in some other states and typically are administered through the respective agriculture departments.

Once the shellfish are transplanted to the field for growout, there are preventative measures the culturist can take to help reduce predation. A variety of nets, stones, trays, and fences can be employed to exclude many predators. In addition, floats and racks can be employed to get the organisms off the bottom which may reduce some forms of predation and reduce problems associated with resuspended silt. These floats and racks also serve to increase water circulation and the filtering efficiency of the shellfish which may promote more rapid growth. Increased growth rates may be especially important for the cultivation of oysters in attempts to raise the oysters to market size before the onset of MSX or Dermo.

As was mentioned in the leasing and permitting section, predator exclusion structures which encroach in on or over the State owned subaqueous land require a permit from the VMRC. Because these predator exclusion structures are often experimental and may change from season to season, I believe the State should consider developing a list of structures which are suitable for placement on and above grounds leased for mariculture purposes on an as needed basis.

Technical Impediments

Despite the vast amount of existing information and continuing research on clam and oyster biology and mariculture, there still are some technical problems which may be impeding development of the industry. The specific areas identified by the Virginia survey respondents were: the lack of specialized oyster and clam seed, a lack of technical research which is practical to the mariculturist, excessive costs and problems associated with raising phytoplankton for supplemental food, and problems associated with predator and disease control.

Inadequate sources of specialized oyster and clam seed

Oyster and clam seed is widely available from hatcheries across the the nation. However, some of the Virginia respondents to the survey indicated that additional research needed to be conducted on exotic and genetically altered shellfish to develop new strains and species which are better suited for commercial mariculture in Virginia. They specifically indicated a need for faster growing and disease resistant shellfish. They further suggested that once the organisms are developed and approved for introduction into Virginia's waters, that the Virginia Institute of Marine Science should help to supply seed and broodstock to culturists.

VIMS has and continues to conduct a great deal of research related to the development of disease resistant oysters and faster growing

strains of clams. In addition, hatchery reared oysters have been provided to private oyster planters in a remote setting program and hatchery reared clams selected for superior growth have been provided to prospective clam culturists

An ongoing VIMS investigation of the resistance of the Japanese Oyster Crassostrea gigas to the oyster diseases MSX and Dermo was recently temporarily set back in April, 1990. The VMRC took a cautious approach towards a VIMS request to conduct overboard experiments on the exotic oysters and required an environmental impact statement be prepared before the Commission will decide whether to approve the request. This issue provided an interesting insight into the controversial nature of requests to place nonnative species into Virginia's waters. Scientists, watermen, regulators, and the general public were interestingly divided on the issue. The controversial nature of nonnative species will likely play an important role in the development of exotic and genetically altered species for use by the Virginia mariculture industry.

The primary thrust of existing studies to develop disease resistant oysters are primarily aimed at rejuvenating the State's natural oyster stocks, however, this research should also be directly applicable to mariculture. The State should consider funding programs to provide broodstock of any approved superior strains or exotic species of shellfish to the mariculture industry.

Lack of technical research which is practical to shellfish mariculture

This particular constraint did not rank very high in the survey and both of the culturists interviewed felt that the basic information regarding the culturing of oysters and clams was available and that they had received considerable assistance from VIMS. Nonetheless, two culturists did indicate the lack of technical research as a constraint to the development of the industry.

Many of the problems which arise in a mariculture operation come about suddenly and may be site specific. Some culturists, especially those new to the business and without a great deal of experience may not have the resources on hand to deal with these problems in an expedient manner.

Some states have developed aquaculture extension services which provide expert advice to culturists. An extension program in Virginia may help to provide necessary technical advice in a timely manner and may help to mitigate this impediment. Mason Carbaugh, Commissioner, Virginia Department of Agriculture and Consumer Services, indicated that their experience working with agriculture growers and producers might put them at an advantage in developing a program of assisting culturists by providing information, marketing assistance and other services (personal communication).

An additional problem associated with the lack of practical research may be related to the accessibility of valuable existing and

new information to the culturist. To encourage mariculture development, the State may wish to consider developing an aquaculture information center and develop programs to disseminate relevant information related to clam and oyster mariculture.

Excessive costs and technical problems associated with raising phytoplankton

Most mariculturists utilize cultured phytoplankton to feed the larvae during the hatchery and sometimes nursery phases of their operation. A few culturists indicated that problems and costs associated with raising the phytoplankton were constraints to the development of the industry. This constraint only ranked fifteenth in the Virginia portion of the survey and ranked low in the overall survey, as well. However, it apparently has provided problems for some culturists.

There are well developed techniques to produce phytoplankton in a cost efficient manner. However, one of the mariculturists suggested that more guidance was needed in this aspect of the business and suggested that it would be helpful for VIMS to provide specific species for starting cultures of phytoplankton.

Mike Castagna, Associate Director of VIMS' Eastern Shore Laboratory, pointed out, that specific strains of phytoplankton are available from repositories such as the University of Texas at Austin's Culture Collection of Algae (personal communication). He indicated the

state might more wisely spend its money on the development of a formulated food supplement (personal communication).

Constraints associated with predator and disease control technology

Constraints associated with predator and disease control were discussed in the section on environmental impediments, but, since additional research may result in technical advances to control some of these problems, the author felt it would be beneficial to discuss the technical aspects of this constraint in this section.

Problems associated with predator control may be able to be addressed through innovative predator control techniques and special growout systems. In addition many hatchery borne diseases may be controlled if properly diagnosed and treated or prevented through the application of preventative techniques. Research directed toward developing disease resistant strains of oysters and strains of oysters which grow fast enough to reach market size before being killed by MSX and Dermo are avenues of research which may be particularly valuable to the enhancement of oyster mariculture in the Commonwealth.

Problems associated with predator and disease control were identified as very important constraints to the development of the shellfish mariculture industry in Virginia. State initiatives to mitigate these constraints should encourage continued research in the areas of innovative predator exclusion techniques, development of disease resistant stains of oysters, and exotic species of oysters

which may be suitable for mariculture. Much of this research, particularly that associated with the development of disease resistant oysters, would benefit the traditional fishing industry as well.

As with other technical advances related to mariculture, any new information developed related to predator and disease control should be made readily available to those in the mariculture industry. Efforts to disseminate this information could be accomplished through the previously discussed mariculture extension program and a mariculture information center. The extension program would likely be especially valuable since many predator and disease problems are site specific.

Financial Constraints to Shellfish Mariculture Development

Financing a mariculture venture is generally an expensive proposition, and due to the nature of the business, it may be years before there are any returns on the initial investment. In addition most commercial lending institutions consider aquaculture to be a high risk venture due to the lack of a proven track record. Therefore, if loans are available, they are often quite costly.

The lack of affordable investment capital was identified as a moderately important constraint to mariculture development by the Virginia survey respondents. This constraint was identified as very important in the overall survey and it was expected that it might rank higher in Virginia. However, the survey may have been biased towards the existing operations in Virginia which are primarily privately

funded and the individuals may not have sought a great deal of outside capital.

Two aquaculturists interviewed had different opinions regarding state initiatives to help secure more affordable loans for aquaculture ventures. One culturist, who wished to remain anonymous, felt that the business is a risky venture and inexpensive loans would result in many individuals defaulting on their loans. He further indicated that adequate investment capital is available through venture capital groups and private individuals (personal communication). The other culturist felt that the potential benefits to the state warranted initiatives to help identify and secure affordable investment capital for mariculture ventures (Chip Petre; personal communication).

Some other states have paralleled federal initiatives and have declared aquaculture a form of agriculture and have directed their respective agriculture departments to identify and aid aquaculturists in securing loans through applicable agriculture programs. Virginia should consider declaring mariculture a form of agriculture and directing the Department of Agriculture and Consumer Services to assist mariculturists in identifying and securing loans through applicable agriculture programs. Care should be taken to ensure that only qualified individuals who are aware of the risks associated with the mariculture industry are given loan assistance. Earlier this year, the Virginia Aquaculture Task Force took a positive step in addressing financial constraints by requesting the Department of Taxation to determine if mariculture facilities are exempt from sales tax.

Recently, the Department of Taxation did declare mariculture facilities exempt from sales tax.

The Department of Agriculture and Consumer Service (VDACS) appears receptive to promoting mariculture as a form of agriculture and aiding in identifying and securing loans. The Commissioner of VDACS, Mason Carbaugh, also suggested that the Virginia Agriculture Credit Committee, an organization which assists in developing new agricultural ideas and programs for providing adequate agriculture credit to producers, could have a role in reviewing the special financial needs of mariculture (personal communication).

SUMMARY

Commercial shellfish mariculture development could benefit Virginia through increased tax revenue, increased employment, possible reduced pressure on natural shellfish stocks, and by providing an economic incentive to maintain superior water quality. Although certain mariculture techniques for oysters and clams have been demonstrated to be commercially viable and Virginia has vast water resources potentially suitable for the culture of shellfish, Virginia mariculture development lags behind many coastal states. It appears that commercial development may be constrained by a variety of impediments in Virginia. Many of these impediments appear to be legal and political, rather than scientific and technical.

This study identified many real and potential constraints to commercial shellfish mariculture. Because this study relied heavily on subjective input from individuals presently involved in the mariculture industry and did not consider input from persons who may have attempted a mariculture business and failed, it probably does not accurately identify all of the impediments to shellfish mariculture in Virginia. However, the study should provide valuable input into any comprehensive state effort to enhance development of shellfish mariculture in the Commonwealth of Virginia. The following is a summary of recommended initiatives to remove or mitigate the identified impediments:

- 1) Seek legislative action to develop a state policy to enhance aquaculture development and declare a lead agency for aquaculture development which is tasked with providing:
 - A. Funding Assistance
 - B. Marketing Assistance
 - C. Educating regulators and the general public on benefits associated with aquaculture development.
 - D. Coordinate the regulatory review of mariculture operations
 - E. Develop a state aquaculture enhancement plan
- 2) Seek legislation to exempt mariculture products from laws and regulations designed to manage the traditional fisheries.
- 3) Seek legislation which would allow the carefully regulated use of the hydraulic escalator dredge on privately leased ground to harvest shellfish raised and reared through mariculture techniques.
- 4) Seek legislation which removes the applicability of residency requirements to oyster and clam mariculture.
- 5) Seek legislation to create a mariculture leasing program administered through the Marine Resources Commission which includes:
 - A. Ability to lease the water column
 - B. Closed bid system

- C. Minimum of 10 year leases with provision which allows current the leaseholder to have first right of refusal on subsequent bids
 - D. Provision which provides for critical agency review of proposed activities which could adversely affect an existing lease.
 - E. Designation of specific mariculture lease areas
 - F. Provision which requires proof of active use of the lease
-
- 6) Seek legislation to declare aquaculturally reared plants and animals to be the private property of the culturist
 - 7) Seek legislation to amend section 28.1-137 of the Virginia Code to specifically include the taking of mariculturally reared oysters and clams as larceny.
 - 8) Develop a mariculture extension service to provide individual culturists with on site technical advise.
 - 9) Develop a mariculture information center to assist in disseminating appropriate information.
 - 10) Develop a disease diagnostic center to provide assistance in addressing mariculture related disease problems.
 - 11) Consider declaring mariculture a priority use of certain waterfront property in the Virginia Coastal Zone Management Plan.

- 12) Direct the Health Department to review carefully the applicability of their regulations to shellfish mariculture and remove any unnecessary regulatory burdens which would not compromise the program.
- 13) Encourage efforts of the Health Department and VMRC efforts to develop and permit advanced depuration and relaying techniques.
- 14) Encourage the Shellfish Enhancement Task Force to continue efforts to open previously condemned shellfish waters.
- 15) Encourage additional research in mariculture related fields with special emphasis on:
 - A. Development of specialized strains of shellfish
 - B. Exotic species which might be appropriate for culture in Virginia
 - C. Prevalent shellfish diseases
 - D. Innovative predator exclusion techniques

APPENDIX 1

APPENDIX 1

Names and addresses of Virginia survey respondents

Mr. Weston Conley RCV Seafood Inc. Morratico, Va. 22523	Traditional oyster processor and grower interested in obtaining hatchery reared oyster seed
Mr. Lake Cowart S. L. Cowart Seafood Co. Lottsburg, Va.	Traditional oyster processor and grower interested in obtaining hatchery reared oyster seed
Mr. Richard Daiger Potomac Seafood Co. RFD #3 Montross, Va. 22520	Traditional oyster processor and grower interested in obtaining hatchery reared oyster seed
Mr. Skipper Garrett F. L. Garrett and Sons Bowlers Wharf, Va. 22560	Traditional oyster processor and grower interested in obtaining hatchery reared oyster seed
J. C. Walker Brothers Box H Willis Wharf, Va. 23155	Clam mariculturists
Mr. Jack Miles J. H. Miles and Co. Box 178 Norfolk, Va.	Traditional oyster processor and clam grower interested in obtaining hatchery reared oyster seed
Mr. Cranston Morgan W. F. Morgan and Sons Weems, Va. 22576	Operated an oyster hatchery until predation and disease problems forced them to discontinue the hatchery
Mr. Bill Nickel Lower Bay Mariculture, Inc. RFD #1, Box 262 Melfa, Va. 23410	Clam mariculturist
Dr. Mike Pierson Cherrystone Aqua Farms Cheriton, Va. 23316	Manager of clam mariculture facility

Mr. Pete Terry
H. M. Terry Co.
Willis Wharf, Va. 23486

Traditional oyster processor
and grower who also plants
and harvests seed clams

Mr. Glen Tyler
Basic Foods Corp.
Box 108
Parksley, Va. 23421

Clam mariculturist

Mr. Thomas Shackelford
Shackelford Thomas Seafood Co.
Severn, Va. 23155

Traditional oyster processor
and grower interested in
obtaining hatchery reared
oyster seed

APPENDIX 2

APPENDIX 2
First Questionnaire of Two-Part Delphi Survey

Gentlemen,

By now I hope you have received an introductory letter describing the purpose of this survey. It is designed to identify constraints to the development of commercial aquaculture. The project is specifically designed to identify impediments in Virginia and hopefully to develop recommendations to alleviate these regulatory and policy constraints.

The reason I am surveying operations in states other than Virginia is two-fold. Firstly, I hope to identify and remove impediments which have not yet surfaced in Virginia but which may present unforeseen problems to the aquaculturist as the industry develops. Secondly, by comparing what are and what are not constraints in different states and then by studying those states' laws and regulations, I hope to identify various mechanisms to remove or mitigate those constraints.

Although this project is designed to identify aquaculture constraints in Virginia, I would like to stress that I believe the results of this study will help other states to develop or further develop their own aquaculture industry. I hope you will be willing to participate in this survey by answering the questions on the attached sheet. Please complete and return the following questionnaire in the enclosed envelope for analysis by September 8. If you have any questions regarding this survey please contact me at the address listed below. Thank You.

Sincerely,

Chip Neikirk
VIMS
Gloucester Pt., Va. 23062
(804) 642-7110

The following information is needed to group the responses of this survey. Please take a few moments to answer the following questions about your facility. If you feel uncomfortable answering any of the following questions, please feel free to leave it blank or give me a call. Thank you.

- 1) Name address and phone number of the aquaculture facility.
- 2) Position of the respondent (owner, manager, technician) and address if different than the aquaculture facility.
- 3) Is the facility presently in operation? If no please explain.
- 4) Species cultured at your facility (list only brackish and marine species).
- 5) Does your operation include a hatchery?____ a nursery?____ an open water grow out?____ a land based grow out facility?____
- 6) Do you hold a lease which includes submerged bottoms?____ How many acres of submerged bottoms do you presently hold?____
- 7) Do you hold a lease which gives you special rights in the water column?
- 8) Does your lease provide you with any specific rights to the water surface?
- 9) Is your facility incorporated?
- 10) How many full-time people are employed at your facility?
- 11) How many years has your facility been in operation?
- 12) Approximate annual production?
lbs.____ gross dollar value ____
- 13) Approximate annual production hoped for in the future?
lbs.____ gross dollar value ____

- 14) What do you consider to be your target market?
retail or wholesale? geographic location? _____
- 15) Does your operation utilize intensive or extensive culture techniques?
note: intensive culture refers to expensive culture techniques which often require the culturist to provide food and habitat for the cultured species. Example - high flow raceways with supplemental feeding and water temperature control.
extensive culture refers to less expensive culture techniques that usually rely heavily on nature to provide food and habitat.
example - pond culture of a species without supplemental feeding.
- 16) Does your operation utilize a closed water (re-circulating) or an open water (pumps water in at one end and out at other) circulation system?
- 17) Any additional information which you feel would be helpful in describing your facility.

SURVEY QUESTION

Please list what you feel are or were constraints to the development of your aquaculture facility. These constraints may be technical, economic, or regulatory in nature and they do not have to be listed in any particular order. Please feel free to cite an example from your own personal experience if it will help clarify a particular constraint.

TECHNICAL

ECONOMIC

REGULATORY

OTHER

APPENDIX 3

APPENDIX 3
Second Questionnaire of Two-Part Delphi Survey

Directions for final questionnaire.

- 1) Please review the following list of constraints which were identified during the first questionnaire. Comment on any items you wish. Feel free to contact me to answer questions or make clarifications on any of the items.
- 2) Select the ten items which you feel are most important to your aquaculture operation. Assign a value of "10" to the most important. Assign a "9" to the next most important , and so on, until the tenth item (the least important of the ten) is assigned a value of "1".
- 3) Please return your response in the self addressed, stamped envelope by December 2.

LIST OF AQUACULTURE CONSTRAINTS

- _____ Lack of insurance to cover losses due to storm damage.
- _____ Excessive costs associated with predator and disease control.
- _____ Difficult and time consuming to obtain necessary leases, licenses and permits.
- _____ Resistance to development by private property owners and traditional fishermen.
- _____ Lack of affordable investment capital.
- _____ Ineffective measures to control theft of product.
- _____ Lack of technical research which is practical to the aquaculturist.
- _____ Lack of coordination between local, state and federal agencies.
- _____ Difficulty in obtaining scientific and technical information.
- _____ Lack of available coastal property which is affordable and appropriate for aquaculture development.
- _____ Poor or variable water quality.
- _____ Lack of low cost equipment to clean, sort and grade products.
- _____ Antiquated laws and regulations designed to manage the natural fisheries which are inappropriate for aquaculture.
- _____ Lack of veterinary services and pathological laboratories for quick analysis of diseases.
- _____ Lack of affordable manufactured feed.
- _____ Too few sources of specialized seed.
- _____ Lack of understanding by the investment community of the benefits and risks associated with different types of aquaculture operations.
- _____ Health department regulations are too burdensome and inappropriate for some types of aquaculture.
- _____ Lack of approved antibiotics and other disease preventative drugs.
- _____ Lack of rights to the water column and surface.
- _____ Excessive state taxes on labor and property.
- _____ Difficulty in obtaining and meeting hiring regulations for teens and temporary help.
- _____ Apathy of state regulators toward the aquaculture industry.
- _____ Poor understanding of private property rights.
- _____ Excessive costs associated with raising phytoplankton for food.
- _____ Difficulty in entering into market and competing with the large companies.
- _____ Other constraint(s) not listed above.

Please feel free to comment on any of the items by using the space below and the back of this page.

APPENDIX 4

APPENDIX 4

Names and addresses of individuals cited as personal communication

Mr. Keith Buttleman, Administrator
Council on the Environment
903 Ninth Street Office Building
Richmond, Va. 23219

Mr. Mason Carbaugh, Commissioner
Virginia Department of Agriculture and Consumer Service
P. O. Box 1163
Richmond, Va. 23209

Mr. Michael Castagna, Assoc. Director and Scientist in Charge
Eastern Shore Laboratory
Virginia Institute of Marine Science
Wachapreague, Va. 23480

Mr. Walter Clark
Ocean and Coastal Law Specialist
Box 8605
North Carolina State University
Raleigh, N. C. 27695

Mr. Martin G. Ferguson, Jr., Permits Program Manager
Office of Water Resource Management
State Water Control Board
Box 11143
Richmond, Va. 23230

Mr. Lewis Gillingham
Fisheries Management Specialist
Virginia Marine Resources Commission
Box 756
Newport News, Va. 23607

Mr. Robert Grabb, Chief
Habitat Management Division
Virginia Marine Resources Commission
Box 756
Newport News, Va. 23607

Mr. Ken Kurkowski, Manager
Oyster Hatchery
Virginia Institute of Marine Science
Gloucester Point, Va. 23062

Mr. Andrew Heatwole, Vice Chairman
Virginia Assoc. Of Realtors
Tidewater Board of Realtors
808 Newtown Road
Virginia Beach, Va. 23462

Mr. Mike Oesterling
Aquaculture Specialist
Virginia Institute of Marine Science
Gloucester Point, Va. 23062

Mr. Randy Owen
Fisheries Management Specialist
Aquaculture Program Manager
Virginia Marine Resources Commission
Box 756
Newport News, Va. 23607

Mr. Mike Pierson, Manager
Cherrystone Aqua Farms
Cheriton, Va. 23316

Mr. Chip Petre
Intertidal Marine
421 Messick Road
Poquoson, Va. 23662

Mr. Bart Theberge, Chairman
Department of Ocean and Coastal Law
Virginia Institute of Marine Science
Gloucester Point, Va. 23062

Mr Glen Tyler
Basic Foods Corp.
Box 108
Parksley, Va. 23421

Mr. Tony Watkinson, Deputy Chief
Habitat Management Division
Virginia Marine Resources Commission
Box 756
Newport News, Va. 23607

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