# APPENDIX C

# DEVELOPMENT OF ASSESSMENT SCENARIOS FOR AQUACULTURE ALTERNATIVES (4 AND 5)

## Note to Readers of Appendix C

Appendix C describes how representative scenarios for the development of an expanded aquaculture industry in Chesapeake Bay were developed for use in assessing the environmental consequences of Alternatives 4 and 5. The assessment scenarios described in this appendix were created for evaluation purposes only and are not recommended plans for implementing the aquaculture alternatives. The scenarios were constructed assuming that future aquaculture operations would employ methods currently being used by oyster growers within Chesapeake Bay. The analyses of the aquaculture alternatives in the PEIS were not intended to compare different aquaculture methods or techniques or to determine the most cost-effective or most productive methods of culturing Suminoe or Eastern oysters.

## 1. 0 Introduction

The PEIS for oyster restoration evaluates two alternatives that involve aquaculture:

- Alternative 4 - Establish and/or expand State-assisted, managed or regulated aquaculture operations in Maryland and Virginia using the native oyster species.

- Alternative 5 - Establish State-assisted, managed or regulated aquaculture operations in Maryland and Virginia using suitable triploid, nonnative oyster species.

The PEIS is intended to provide information to assist the lead agencies to select the most appropriate broad courses of action for restoring the ecological and economic functions of oysters throughout the Bay and to help Federal and State agencies and private organizations to work coherently and consistently toward a common restoration goal. The scope of the PEIS is to evaluate the potential effects of the proposed action and each alternative in as much detail as is possible despite considerable uncertainty about how each action might be implemented. Hypothetical implementation scenarios were developed for the proposed action and all alternative actions to provide a context for identifying the general kinds and ranges of potential consequences of each action. This appendix describes how scenarios were developed for the two aquaculture alternatives. The assessment scenarios described here are for evaluation purposes only; they are not recommended plans for implementing the aquaculture alternatives. Supplemental, site-specific NEPA analyses will be required if specific plans for implementing one or both of the aquaculture alternatives are proposed in the future.

The following factors were considered in developing the aquaculture assessment scenarios. Each factor has a range of options or a range of magnitudes. Such ranges are acknowledged, and their implications are addressed in the PEIS to the extent possible with the information available to date.

- The total number of oysters that might be produced annually in a full-scale oyster aquaculture industry in the Bay (expected to be the same for Alternatives 4 and 5)
- Techniques to be used for cultivating oysters (e.g., suspended from floats, placed on hard bottom); cultivation techniques are expected to differ between Alternatives 4 and 5
- The locations in the Bay at which such operations might be established (expected to be the same for Alternatives 4 and 5)
- The size of a typical operation (i.e., number of oysters produced annually by an individual grower); expected to be the same for Alternatives 4 and 5
- The area a typical operation might occupy and habitat in which it might be located; area and habitat are expected to differ between Alternatives 4 and 5 because of differing culture methods and different times required for native and nonnative oysters to reach market size

The foundation for developing the aquaculture scenarios was the output of an economic demand model for the oyster industry in the Chesapeake Bay region developed by Dr. Doug

Lipton, of the University of Maryland, and described in Appendix D of the PEIS. The model was used to project the maximum, economically viable oyster industry that could develop in the region. In addition to estimating the maximum economically viable annual production of oysters, the model also provided information about the anticipated size of oyster-producing firms. The experience of commercial oyster growers in Maryland and Virginia provided the basis for defining other elements of the scenario, such as locations for new or expanded aquaculture operations and cultivation techniques. Mr. A.J. Erskine of the Bevans Oyster Company, Cowart Seafood Corporation, was the primary source of information about oyster aquaculture in Virginia. Mr. Don Webster of the Maryland Aquaculture Coordinating Council was the primary source of information about oyster aquaculture in Maryland. The outcomes of an aquaculture workshop (Attachment A) organized by the PEIS Project Delivery Team and held on February 1, 2006, also provided information for developing the aquaculture assessment scenarios. Participants in that workshop identified a large number of environmental, economic, and social factors that would influence how and where aquaculture operations might be implemented. The simplified scenarios developed here cannot account for all of those factors or interactions among them, but they provide a rough basis for comparing outcomes among alternatives. The probability that an industry of the size defined for this assessment scenario would develop within 10 years (i.e., the evaluation period for the PEIS) is very small due to numerous limiting factors discussed in Sections 5.1.5 and 5.1.6 of the PEIS; nevertheless, scenarios that represent large-scale aquaculture provide a basis for assessing the maximum effects, both economic and ecological, that might result from such an industry.

## 2.0 Quantification and Delineation of Factors

***Maximum Aquaculture Production*** – The oyster economic demand model projected that the mean maximum economically viable annual production of oysters (including cultivated and wild caught) would be 2.6 million bushels (range – 1.7 to 5.4 million bushels), including oysters cultured for both the half-shell and shucking markets (Appendix D). As a simple means of accounting for wild-caught oysters, future wild harvest was assumed never to exceed the most recent total, Bay-wide, wild harvest of oysters. Average Maryland harvest for the period 2002-2006 was 104,000 bushels. In Virginia, annual harvest from public waters over the same period was 34,400 bushels, giving an average, Bay-wide, wild-caught total of 138,400 bushels. Subtracting that average from 2.6 million bushels, the maximum economically viable production from aquaculture would be about 2.46 million bushels. Assuming 275 oysters/bushel[1], the total number of oysters produced through aquaculture annually would be 676.5 million.

***Size of Operations*** – There is tremendous uncertainty regarding how big full-scale aquaculture operations might be in the future. The assessment scenarios assume the average operation size that Dr. Lipton used for the oyster demand model: 676,900 oysters annually. Assuming the maximum production noted above, 1,000 average operations would account for the total production. Actual operations could be larger or smaller than the average, and the evaluation in the PEIS addresses that variability. Sections 5.1.5 and 5.1.6 of the EIS describe numerous limiting factors that could preclude the development of an industry of the maximum

[1] Dr. Lipton used 275 oysters/bushel in his analysis. Mr. Jim Wesson of VMRC indicated that the number of oysters per bushel ranges from 250 to 500 in Virginia, depending on the size of the oysters. Mr. Chris Judy indicated that 300 oysters/bushel may be typical in Maryland. For consistency, 275 oysters/bushel is assumed throughout the aquaculture discussions.

size, either within the 10-year assessment period for the PEIS or beyond. Nevertheless, assuming an industry of the maximum size in the assessment scenario affords the greatest degree of contrast between the aquaculture alternatives and other actions, which facilitates identification of major differences in possible outcomes.

***Method of Cultivation*** – The method of cultivation is a significant factor for determining the kinds of effects that might result from aquaculture. Participants in aquaculture trials using triploid *C. ariakensis* implemented by the Virginia Seafood Council in 2007 used primarily off-bottom cages deployed in either intertidal or subtidal habitats; several used Taylor floats, and a few used long-line bags. Floats could be used in soft-bottom areas. The assessment scenarios assume that all nonnative oysters would be cultivated using confined methods. Based on current practice and input from Mr. Erskine, the assessment scenario for Alternative 5 assumes that two-thirds of operations would use some kind of off-bottom cages or on-bottom confinements (bag lines), and about a third of operations would use floats. This is consistent with the discussions at the aquaculture workshop. Confined methods would not be required to cultivate native oysters (diploid or triploid), and the most likely method of cultivation for Alternative 4 would be directly on the bottom. Although the rate of recovery of oysters cultivated on the bottom would be less than for confined oysters, operational costs would be lower for on-bottom cultivation. However, on-bottom aquaculture requires more area than confined culture. Both Mr. Erskine and Mr. Webster indicated that spat-on-shell, on-bottom cultivation provides some protection from predation at some increase in cost. Dr. Lipton addressed the cost differences between methods in his economic evaluation of the aquaculture alternatives (Sections 5.6.2.5 and 5.6.2.6).

On-bottom aquaculture requires some preparation of leased beds, primarily addition of shell or other hard substrate. Mr. Erskine and Mr. Webster indicated that such preparation generally would not involve excavation, only placement of new material on top of old material within the footprint of existing beds. Oysters produced by on-bottom cultivation are most likely to be harvested by hand-tonging, although mechanical dredging would be permitted on private leased beds.

Off-bottom cages require hard bottom to ensure that cages do not sink into the substrate, but the hard bottom does not need to be shell. This offers a greater degree of flexibility in locating aquaculture operations than the use of on-bottom aquaculture. Also, some oyster growers have suggested that the use of floats to keep oysters near the surface reduces their susceptibility to diseases. Floats afford substantial flexibility in siting an aquaculture operation because anchors can be set over any kind of bottom; however, floats are subject to damage from wind and waves and must be placed in sheltered areas. In addition, icing of floats during cold winters can cause damage, and continued fouling of the structures requires substantial maintenance for cleaning.

***Area Required*** – The area required for the maximum aquaculture production would differ between Alternatives 4 and 5; however, production figures from different sources vary widely and are certain to be influenced by site-specific conditions. The range of areas that might be required and how different factors might influence those ranges is presented here. The objective is to try to come up with figures that allow area requirements of the different aquaculture methods to be compared reasonably.

One important factor for assessing how much area might be required for aquaculture production is the length of time that oysters need to be in the water before they reach market size. Mr. Erskine indicated that triploid *C. ariakensis* reach market size in less than one growing year (as little as 9 months). Thus a new cohort equal in size to the maximum production could be deployed and harvested each year. In contrast, triploid *C. virginica* grown off-bottom in cages in Virginia waters reach market size in 12 to 18 months. Mr. Erskine and Mr. Webster indicated that triploid *C. virginica* on-bottom may reach market size in 18 to 28 months; the scenario for Alternative 4 assumes 24 months. For diploid *C. virginica*, Mr. Webster (2007) and Mr. Erskine indicated that average time for an oyster to reach market size is three years. The consequence of these different cultivation times is that only a single cohort of *C. ariakensis* would have to be in the water in any single year (i.e., the number of oysters in the water would be equal to the number of oysters harvested each year), but two or three cohorts of *C. virginica* would have to be in the water in any given year in order to yield the same annual production, which would require twice or three times as much area.

The aquaculture workshop in February, 2006, provided information about the amount of area needed for different levels of production of the native oyster but did not provide area information for triploid *C. ariakensis*. Participants at the workshop estimated that producing 5 million bushels (1,375 million oysters) of diploid *C. virginica* in floats would require 2,000 to 5,000 acres (275,000 to 688,000 oysters/acre) depending on suitability of sites for the off-bottom operation (i.e. high algal concentrations would allow for more floats at a specific site). In the VSC trials, 1/8 acre was required for 65,000 triploid *C. ariakensis* oysters in Taylor floats (520,000 oysters/acre). This figure is consistent with estimates from the workshop for *C. virginica*. Mr. Tommy Legget of the Chesapeake Bay Foundation indicated that a project recently completed with Bevans Oyster Company and VIMS produced 947 bushels of triploid *C. virginica* oysters in 18 months on ½ acre of bottom (i.e., 1,897 bushels/acre or 522,000 oysters/acre). If that level of production could be realized in various locations in the Bay, the amount of area required to meet the maximum production would be an order of magnitude less than the required area estimated using other data.

Mr. Erskine indicated that he is producing 50,000 triploid *C. ariakensis* in about 1/3 to 1/2 an acre (100,000 to 150,000 oysters/acre) using off-bottom cages; however, he indicated that the spacing of cages in his trial was greater than would actually be feasible in commercial production to reduce the potential for unintended reproduction and production of diploids. Other VSC trials using off-bottom cages suggest that about ¼ acre was required to produce 75,000 oysters (300,000 oysters/acre). Mr. Erskine suggested that this figure would be reasonable to assume for triploid *C. ariakensis* production.

Production figures for on-bottom culture of *C. virginica* were obtained from Webster (2007). Pre-disease, on-bottom culture often produced approximately 500 bushels/acre (137,500 oysters/acre), and sometimes produced as many as 1,500 bushels/acre (412,500 oysters/acre). More recently (2002), highest production was approximately 100 bushels/acre (27,500 oysters/acre).

The widely varying figures provided by individuals involved in oyster aquaculture in the Bay are a result of the different culture techniques, the different kinds of oysters being grown, and the characteristics of the growing sites. At best, the area estimates provided here are very rough, order-of-magnitude estimates that are useful primarily for illustrating the scale of difference in area requirements.

The figures just discussed were use to develop estimates of the hypothetical total areas required to achieve the maximum annual aquaculture production of 2.46 million bushels (for reference, the total acreage of tidal waters in Chesapeake Bay is 2,978,163):

- For diploid *C. virginica* grown on bottom, assuming 100 bushels/acre (27,500 oysters/acre) and 3 years to market size, 3 times 24,600 (2.46M/100), or 73,800 acres of hard bottom would be required.
- For triploid *C. virginica* grown on-bottom, assuming 1,900 bushels/acre (552,500 oysters/acre) and 2 years to market size, 2 times 1,295 (2.46M/1,900) or 2,590 acres of hard bottom would be required.
- For triploid *C. ariakensis* grown off-bottom in floats, assuming 1,891 bushels per acre (520,000 oysters/acre) and 1.5 years to market size, 1.5 times 1,301 acres (2.46M/1,891) or 1,952 acres of area would be required (not necessarily hard bottom).
- For triploid *C. ariakensis* grown off-bottom in cages, assuming 1,091 bushels per acre (300,000 oysters/acre), 2,255 acres (2.46M/1,091) of hard bottom would be required.

*Location* – Although a significant amount of oyster aquaculture is occurring in Virginia portions of the Bay (private production was 25% to 40% of total oyster production in the last 3 years, J. Wesson, VMRC, pers. comm.), levels of production in Maryland are very low. Given this background and the fact that Virginia has substantial existing infrastructure to support aquaculture, the assessment scenario assumes that after 10-years, 80% of the maximum aquaculture production would occur in Virginia waters and 20% in Maryland waters.

Current aquaculture operations in Virginia provide a basis for speculating about potential locations for expanded operations. Mr. Erskine provided his assessment of the likely locations of such operations within the Bay and the proportion of production that might occur in each, as indicated in the figure below[2]:

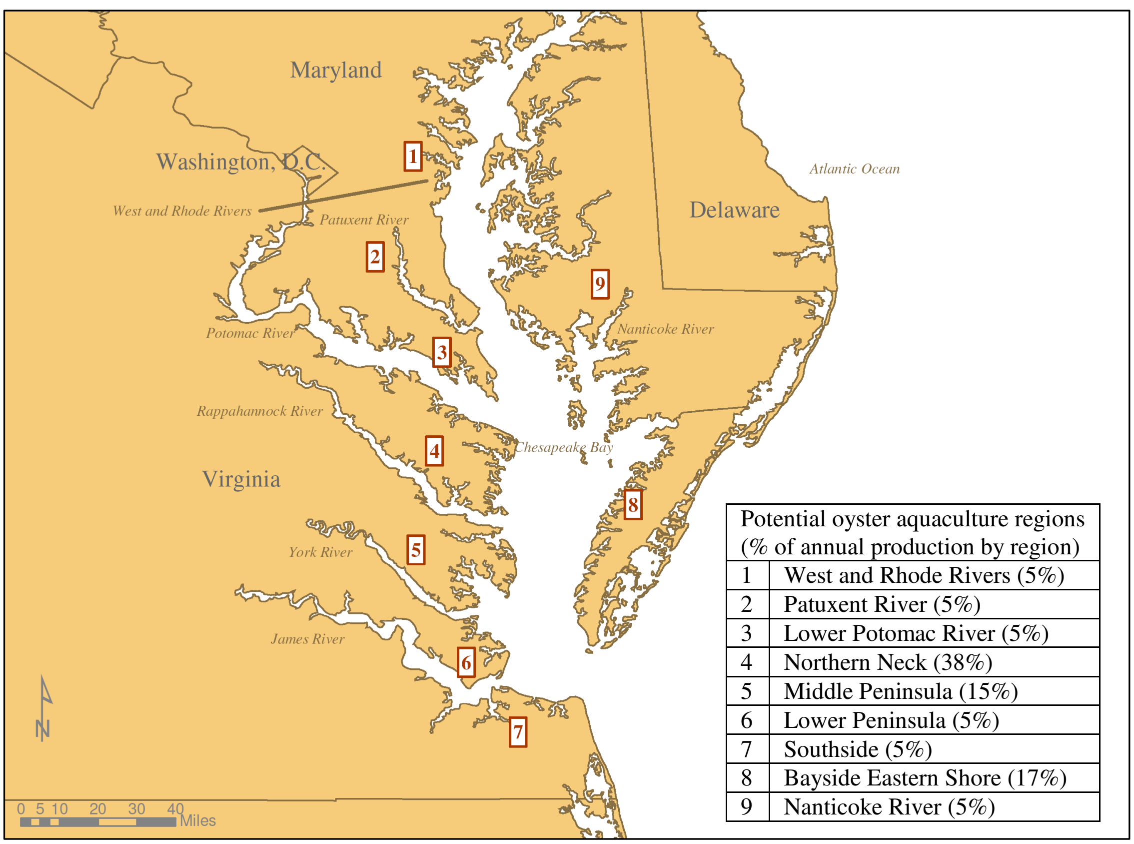
- Northern Neck – Likely sites are the lower Potomac Tributaries such as the Yeocomico and Coan rivers and the Little Wicomico, where there is a deep tradition of oystering, and substantial undeveloped areas where aquaculture conflicts would be minimal.
- Middle Peninsula – Likely sites are the lower and middle Rappahannock River, Mobjack Bay and tributaries; strong tradition of oystering; more development so acceptable locations more limited than Northern Neck
- Lower Peninsula – Likely locations would be the lower, middle and upper James River, the Paquoson River and Back Bay; strong oyster tradition but high level of shoreline development would limit activity here

[2] Both Mr. Erskine and Mr. Webster indicated that significant aquaculture may occur in ocean-side bays; those locations are not addressed here.

- Southside – Likely locations would be Lynnhaven, Broad Bay, and Elizabeth and Nansemond rivers; highly developed, but some aquaculture operations being developed

- Bayside Eastern Shore – Likely locations would be Pocomoke Sound and nearby areas; rural and current clam aquaculture operations would provide some infra-structure.

Potential locations for expanded aquaculture in Maryland cannot be defined based on current operations. Webster (2007) described the numerous legal and regulatory obstacles that expanded operations may encounter, which are summarized in Section 5.0 of this appendix. Webster (2007) described the concept of Aquaculture Enterprise Zones (AEZ) being developed by the Maryland Aquaculture Coordinating Council, which plans to submit an AEZ plan to the 2009 General Assembly as part of a comprehensive legislative package concerning aquaculture in Maryland. Upon request, Mr. Webster identified four locations within Maryland's portion of the Chesapeake Bay that might be considered for inclusion in the AEZ plan: West/Rhode rivers; Patuxent River; Lower Potomac River; and Nanticoke River. The aquaculture assessment scenario assumes that the 20% of maximum annual oyster production that would occur in Maryland would be divided equally among those four locations and that all regulatory obstacles were overcome. The need to resolve those issues is addressed in the PEIS. An additional limitation is that the compact establishing the Potomac River Fisheries Commission prohibits aquaculture in the Potomac River mainstem. Legislation would be required in both Maryland and Virginia to amend the compact and eliminate that restriction.



## 3.0 Scenarios

To develop the aquaculture alternatives, the total maximum annual aquaculture production (2.46 million bushels) was apportioned among the nine hypothetical locations according to the percentages in the following table:

| Potential oyster aquaculture regions<br>(% and amount of annual production by region) | | | |
|---|---|---|---|
| | | Bushels | Oysters (M) |
| 1 | West and Rhode Rivers (5%) | 123,000 | 33.8 |
| 2 | Patuxent River (5%) | 123,000 | 33.8 |
| 3 | Lower Potomac River (5%) | 123,000 | 33.8 |
| 4 | Northern Neck (38%) | 934,800 | 257.1 |
| 5 | Middle Peninsula (15%) | 369,000 | 101.5 |
| 6 | Peninsula (5%) | 123,000 | 33.8 |
| 7 | Southside (5%) | 123,000 | 33.8 |
| 8 | Bayside Eastern Shore (17%) | 418,200 | 115.0 |
| 9 | Nanticoke River (5%) | 123,000 | 33.8 |

The area required for such production would differ by species, genetic status (diploid/triploid), and aquaculture method, as summarized in the following tables:

| | Area required for diploid *C. virginica*, on bottom | Hard bottom acres |
|---|---|---|
| 1 | West and Rhode Rivers (5%) | 3,690 |
| 2 | Patuxent River (5%) | 3,690 |
| 3 | Lower Potomac River (5%) | 3,690 |
| 4 | Northern Neck (38%) | 28,044 |
| 5 | Middle Peninsula (15%) | 11,070 |
| 6 | Peninsula (5%) | 3,690 |
| 7 | Southside (5%) | 3,690 |
| 8 | Bayside Eastern Shore (17%) | 12,546 |
| 9 | Nanticoke River (5%) | 3,690 |
| | Total | 73,800 |

| | Area required for triploid *C. virginica*, on bottom | Hard bottom acres |
|---|---|---|
| 1 | West and Rhode Rivers (5%) | 130 |
| 2 | Patuxent River (5%) | 130 |
| 3 | Lower Potomac River (5%) | 130 |
| 4 | Northern Neck (38%) | 984 |
| 5 | Middle Peninsula (15%) | 389 |
| 6 | Peninsula (5%) | 130 |
| 7 | Southside (5%) | 130 |
| 8 | Bayside Eastern Shore (17%) | 440 |
| 9 | Nanticoke River (5%) | 130 |
| | Total | 2,590 |

| | Area required for triploid *C. ariakensis*, on floats | Acres of area (hard bottom not required) |
|---|---|---|
| 1 | West and Rhode Rivers (5%) | 65 |
| 2 | Patuxent River (5%) | 65 |
| 3 | Lower Potomac River (5%) | 65 |
| 4 | Northern Neck (38%) | 494 |
| 5 | Middle Peninsula (15%) | 195 |
| 6 | Peninsula (5%) | 65 |
| 7 | Southside (5%) | 65 |
| 8 | Bayside Eastern Shore (17%) | 221 |
| 9 | Nanticoke River (5%) | 65 |
| | Total | 1,301 |

| | Area required for triploid *C. ariakensis*, with off-bottom cages | Acres of hard bottom |
|---|---|---|
| 1 | West and Rhode Rivers (5%) | 113 |
| 2 | Patuxent River (5%) | 113 |
| 3 | Lower Potomac River (5%) | 113 |
| 4 | Northern Neck (38%) | 857 |
| 5 | Middle Peninsula (15%) | 338 |
| 6 | Peninsula (5%) | 113 |
| 7 | Southside (5%) | 113 |
| 8 | Bayside Eastern Shore (17%) | 383 |
| 9 | Nanticoke River (5%) | 113 |
| | Total | 2,255 |

## 4.0 Aquaculture Infrastructure Needs

The figures presented above provide a relative sense of the total area of particular kinds of habitat that would be required for a large-scale aquaculture industry in the Bay. The purposes aquaculture assessment scenarios assume that large-scale oyster aquaculture would be implemented using only hatchery-produced seed. As of 2006, total hatchery production capacity in Virginia and Maryland combined was 300 million spat. The planned expansion of the hatchery at the University of Maryland's Center for Estuarine Studies (UMCES) will increase the production capacity of that facility to 1 to 2 billion spat per year. Although that production is intended for State restoration programs, information on this and Virginia hatcheries provides a basis for characterizing the number and size of hatcheries that might be required to support a full-scale aquaculture industry.

The number of hatchery spat required to produce the specified number of market-size oysters was the basis for estimating the number of hatcheries that might be required to support the maximum oyster aquaculture industry. The number of spat required for each of the aquaculture alternatives would vary as a function of growth and mortality rates, and thus of the species and the genetic status (diploid, triploid). The number of spat that a hatchery can produce is variable and subject to many factors that can affect the number of eggs that can be fertilized, the percentage of those eggs that attain the eyed-larva stage, and the percentage of those larvae that become spat. Although success at each stage of spat production may vary, Mr. Erskine and Mr. Webster provided some general figures that represent the level of hatchery success that might be expected.

For diploid *C. virginica*, participants at the aquaculture workshop (Attachment A) estimated that 1 billion spat might be expected to produce 1 million bushels. Mr. Webster provided a general overview of the level of spat production that might be required to produce 3.2 million bushels of oysters in Maryland. He anticipated that production would be 80% spat-on-shell, on-bottom cultivation and 20% cultchless, contained cultivation. Some of his general assumptions, which are not species- or ploidy-specific, were that a hatchery would yield about 10% set from fertilized eggs (based on recent production figures); bottom culture would return about 50% survival based on studies of how animals land on bottom and historical figures; and contained culture would yield 70% to 80% of set. He estimated that to produce 3.2 million bushels, hatcheries would have to be able to produce approximately 16 billion spat.

Mr. Erskine provided more detailed estimates broken down both by species and ploidy. To produce 3.2 million bushels (880 million oysters, ignoring the potential wild harvest that would be included in annual production) of diploid *C. virginica*, which would require about 3 years to grow to market size, he provided the following estimates:

- 75-175 billion eggs fertilized
- 80-125 billion eyed larvae set
- 25-50 billion spat planted
- 880 million oysters harvested

For triploid *C. virginica*, assuming 1.5 years to grow to market size, and for triploid *C. ariakensis*, which would have a 9 month grow-out, assuming survival for both triploids is about the same, he provided the following estimates:

- 25-50 billion eggs fertilized
- 15-30 billion larvae set
- 5-15 billion spat planted
- 880 million oysters harvested

Both contributors emphasized that the figures provided were very rough estimates based on recent experience, and that hatchery production rates can vary substantially from year to year. They also indicated that hatchery production efficiencies tend to increase with experience, and that more consistent production would be likely after a hatchery operation is well established. Acknowledging all of these caveats, these figures provide a basis for a general characterization of the hatchery capacity that might be required for a full-scale aquaculture industry. Don Merritt, Manager of the UMCES oyster hatchery, indicated that the expanded hatchery will have a production capacity of 1 billion to 2 billion spat-on-shell, diploid *C. virginica*. Taking a conservative view of the required production just presented, the amount of spat that may be required could range from 15 billion to 50 billion. As a rough generalization, production of spat to operate a full-scale aquaculture industry in the Bay might require from 15 to 25 hatcheries of the size of the UMCES facility; however, the requirement would be much less with increased production efficiency.

A major variable in this kind of an assessment is the rate of survival of deployed spat. Mr. Erskine indicated that survival of containerized triploid *C. ariakensis* can be as high as 90% but often is lower. Survival of containerized triploid *C. virginica* can vary widely but is generally in the range of 40% to 75%. Survival of spat-on-shell (triploid and diploid) also varies but is lower, generally ranging from 10% to 30%. On-bottom plantings are subject to predation (e.g., cow-nosed rays), and recovery is less efficient than for containerized spat, thus reducing the percentage of spat that are ultimately harvested as market-size oysters.

Mr. Merritt. provided an overview of required elements of a successful hatchery. The major components include a cultch aging, washing, and containerization facility; hatchery facilities (where spawning is induced); and setting tanks (where larvae set). A waterfront location, with the facilities in close proximity to a water body with good water quality is optimal. The U. of MD hatchery occupies approximately 5 acres along the shore of the Choptank River.

Despite the fact that the "founder stock" for the current Chesapeake Bay stock of the Oregon strain of *C. ariakensis* consisted of 7 males and 9 females, Mr. Stan Allen of VIMS has indicated that producing large numbers of triploid *C. ariakensis* spat using the substantial numbers of Oregon strain currently available would not be constrained by the availability of diploid brood stock. He indicates that the current number of *C ariakensis* available in Virginia and Maryland would be sufficient to produce the number of spat required for the maximum aquaculture operations. *C. ariakensis* production facilities would have to include biosecurity systems for the diploid brood stock, and the systems required for triploid production, both of which would increase the cost of spat production somewhat beyond the cost of producing diploid *C. virginica* spat. Although these and other related cost factors are discussed in Section 5.6.2 of the EIS, data from which to establish the cost differences is not currently available.

Hatchery facilities may not have to be located in the immediate vicinity of the locations in which aquaculture is occurring because spat can be transported easily; however, the aquaculture assessment scenario assumes that hatcheries are distributed in the same manner as assumed for growing operations.

## 5.0 Regulations Pertaining to Aquaculture

Oyster management actions that involve placing structures in the water, including several alternatives being considered in the PEIS, require Federal permits issued by the U.S. Army Corps of Engineers (USACE). Operations that involve placing shell or other substrate on the bottom (e.g., repletion programs, spat-on-shell aquaculture, or shell placed under cages to prevent sinking) require a permit under Section 404 of the Clean Water Act (33 U.S.C 1344). Off-bottom aquaculture in cages requires a permit under Section 10 of the Rivers and Harbors Act (33 U.S.C 403). The process for approving such permits requires the permitting agency to prepare a formal EIS or environmental assessment according to the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.). The USACE has granted nationwide permits (NWPs) for a variety of activities deemed to have minimal environmental consequences.

The NWPs are designed to streamline the permitting process while ensuring the protection of the environment and natural resources. The USACE prepared and documented the appropriate analyses of environmental effects and a Finding of No Significant Impact (FONSI) for the activities authorized in each of these general permits. Nationwide Permit 4, Fish and Wildlife Harvesting, Enhancement, and Attraction Devices and Activities, authorizes traditional shellfish seeding activities, provided that they do not occur in wetlands or vegetated shallows. NWP 4 does not authorize construction of artificial reef. Nationwide Permit 48, Existing Commercial Shellfish Aquaculture Activities, authorizes the installation of buoys, floats, racks, trays, nets, lines, tubes, and other structures necessary for the continued operation of an existing, permitted commercial aquaculture operation. NWP 48 does not authorize new operations, the expansion of the project area for an existing operation, or the cultivation of species not previously cultivated in the waterbody. Each USACE District may impose conditions appropriate for its region in addition to the general conditions prescribed in the nationwide permits.

In Maryland, three kinds of shellfish aquaculture are practiced: on-bottom, off-bottom, and indoor closed-loop systems. On-bottom aquaculture requires a Shellfish Bottom Lease from DNR. Maryland law permits a lessee to plant and cultivate only the native oyster, *Crassostrea virginica,* (Natural Resources Article, §4-11A-12, Annotated Code of Maryland). Shellfish leases have a 20-year term and are transferable (Natural Resources Article, §§ 4-11A-07 and 4-11A-09, Annotated Code of Maryland). State law prohibits DNR from leasing bottom to non-residents, corporations, or joint-stock companies (Natural Resources Article, §4-11A-05, Annotated Code of Maryland). Local restrictions and regulations also apply. Six counties are closed to new leases: Charles, Kent, Queen Anne's Talbot, Dorchester, and Somerset (Natural Resources Article, §4-11A-05, Annotated Code of Maryland). As stated previously, a permit is required to import shellfish for planting in state waters. The Potomac River Fisheries Commission has management jurisdiction over the Potomac River. The Commission's compact prohibits aquaculture in the Potomac River; however, the Commission is planning to pursue modifications of the compact to permit aquaculture within the river (A.C. Carpenter, pers. comm.). Currently, approximately 7000 acres of bottom are leased in the Maryland portion of Chesapeake Bay (Webster and Merrit 2007).

Off-bottom aquaculture operations in Maryland require (1) a permit from DNR (i.e. Aquaculture Permit), (2) a Tidal Wetlands License, and (3) a lease of State real property from the Board of Public Works (for operations that occupy 500 square feet or more of State wetlands or waterways). Both off-bottom and indoor closed-loop systems for culturing shellfish require an Aquaculture Permit from DNR. DNR will issue permits only for operations that will not adversely affect wild stocks or result in the release of non-native or genetically altered species (Natural Resources Article, §4-11A-02, Annotated Code of Maryland). DNR's aquaculture permits have a term of five years and are renewable. Off-bottom operations may not interfere with pre-existing, on-bottom leases at the same location and are not allowed over charted "natural oyster bottom" or oyster sanctuaries. A Tidal Wetlands License is required for off-bottom operations in navigable waters or if the operations will alter any floodplain or tidal or nontidal wetland. A Tidal Wetlands License is obtained by submitting a joint Federal/State application to the Maryland Department of the Environment (MDE), Water Management Administration. MDE distributes the application to the USACE, which coordinates all required Federal permitting processes (e.g., Section. 404, Section 10, Section 401 Water Quality Certification) while MDE, Tidal Wetlands Division, coordinates with other State agencies (e.g., Chesapeake Bay Critical Areas Commission, Natural Resources Police, Maryland Historical Trust) to resolve any conflicting uses of water ways. A lease from the Board of Public works is required if a significant area of State wetlands or waterways will be used for commercial profit.

Virginia law allows deployment of nonnative triploid oysters on submerged state lands for aquaculture provided the species is included on the State's clean list, or the operator has received written permission from VMRC (VA Code Ann. §28.2-826). Growers in Virginia lease about 100,000 acres of submerged state land. On November 27, 2007, the VMRC approved a new system for licensing growers and requiring them to report their harvests (Lynch 2007). The regulation creating the new system became effective on December 1, 2007 (4VAC201130-10 et seq.). The new permitting regulation specifies a set of criteria for guiding where growers may deploy "temporary protective enclosures" for shellfish. The regulation defines a "temporary protective enclosure" as a cage, rack, tray, or other similar device for holding and protecting oysters or clams and limits the size of such enclosures to 70 cubic feet. The regulation limits growers to an average of 250 enclosures per acre or 250 arrays of structures per acre when enclosures are stacked. Growers are required to place enclosures at least 100 feet from a waterfront property owner's boundary or dock and to keep them out of navigable channels (4VAC201130-10 et seq.).

The USACE, Norfolk District, issues NWPs for qualified existing commercial aquaculture operations in the Virginia portion of Chesapeake Bay. The Norfolk District also issues regional permits for qualified, new aquaculture activities in Virginia waters. Regional Permit 19 authorizes bottom and suspended culturing and harvesting of bivalve mollusks in the intertidal and subaqueous areas of navigable waters, including deployment and maintenance of buoys, rafts, trays, and other equipment. An aquaculture activity is considered eligible for a regional permit if it will have only "minimal adverse effects on existing or naturally occurring beds or populations of shellfish, marine worms or other invertebrates that could by used by man, other mammals, birds, reptiles, or predatory fish" (CENAO-CO-R-03-RP-19). Regional Permit 19 states no other conditions regarding the species of bivalve mollusks that may be cultured. This EIS will assist resource managers in Virginia to evaluate the magnitude of any adverse consequences of growing triploid Suminoe oysters in Virginia waters. If potential adverse effects are deemed to be minimal, the USACE, Norfolk District, could grant NWPs for the use of the Suminoe oyster in existing commercial aquaculture operations in the state, or regional permits for new operations with the species.

# Attachment A

**Evaluating the Potential for Oyster Aquaculture in the EIS**

**PRFC, Colonial Beach, Virginia**

February 1, 2006

**Purpose of Workshop**:
The Environmental Impact Statement that is being developed to evaluate oyster restoration alternatives for the Chesapeake Bay includes two oyster aquaculture alternatives:

> Alternative 4--Aquaculture: Establish and/or expand State-assisted, managed or regulated aquaculture operations in Maryland and Virginia using the native oyster species.
>
> Alternative 5--Aquaculture: Establish State-assisted, managed, or regulated aquaculture operations in Maryland and Virginia using suitable triploid, non-native oyster species.

The challenges facing the establishment of economically viable oyster aquaculture in the Bay are numerous and varied. The federal and state agencies working on the development of the EIS also recognize this, and know that it is going to take a broad range of expertise to adequately evaluate the potential of oyster aquaculture in the Chesapeake Bay. To that end, the cooperating Federal agencies sponsored a workshop on February 1, 2006 to discuss and identify the aquaculture scenarios that should be evaluated in the EIS to fully evaluate the native and non-native oyster aquaculture alternatives, and to identify sources of information that will be useful for conducting those evaluations. The results from this workshop will be forwarded to the Oyster EIS Project Delivery Team, and then to the Oyster EIS Assessment Team consisting of individuals responsible for identifying the economic, cultural and economic risks and benefits of these alternatives.

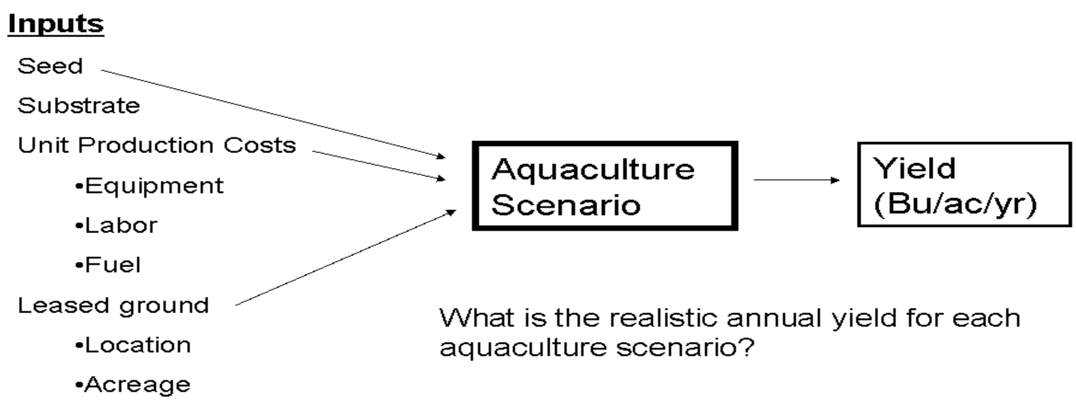
**Workshop Summary**:
Mike Fritz moderated the meeting. Mike welcomed workshop participants and reviewed the purpose of the workshop. A list of attendees is attached.

The group began by reviewing the Purpose and Need statement of the EIS: "The purpose of this EIS is to identify a preferred alternative(s) for establishing an oyster population that reaches a level of abundance in Chesapeake Bay that would support sustainable harvests comparable to harvest levels during the period of 1920-1970. A need exists to restore the ecological role of oysters in the Bay and the economic benefits of a commercial fishery through native oyster restoration and/or an ecologically compatible non-native oyster species that would restore these lost functions.

The Maryland Department of Natural Resources has estimated harvest numbers for the 1920-1970 time period at 2.31 million bushels/year in MD and 2.51 million bushels/year in VA. The EIS will evaluate which alternative(s) or combination of alternatives can supply this level of harvest. It was noted that the Purpose statement does not require oyster populations to be self-sustaining, but only to provide a sustainable level of harvest equivalent to that of the 1920-1970 time period.

A conceptual model for evaluating the aquaculture alternatives was presented to help structure discussions about scenarios and information needs.

Conceptual model for exploring aquaculture alternatives for the EIS




The definition of shellfish aquaculture was then discussed. On-bottom aquaculture is planting seed on bottom and requires the grower to lease bottom. Off bottom aquaculture involves shellfish being contained in a structure and requires state and federal permits for a structure being in the water column.

The group identified the following aquaculture scenarios that should be evaluated:

- diploid *C. virginica*
    - on-bottom and off-bottom
    - wild seed and selectively-bred hatchery seed
- triploid *C. virginica*
    - on-bottom and off-bottom
- triploid *C. ariakensis*
    - on-bottom and off-bottom

There was some general discussion of the ecological benefits of oyster aquaculture. Among the points made were:

- Don Meritt stated that oysters in aquaculture can spawn and there can be ecological benefits. The use of triploids would preclude the spawning so there could be a difference in environmental benefits between diploids and triploids.

- Tom O' Connell stated that the ecosystem impact model being developed by Carl Cerco will examine ecological benefits associated with increased numbers of oysters.
- Donald Webster stated that there is ecological degradation associated with most aquaculture practices but shellfish aquaculture is different in this regard.
- Donald Meritt stated that if you had a wild population established you wouldn't necessarily have to sustain aquaculture with hatchery seed.
- Bob Parkinson added that wild seed might not be desirable since aquaculturalists do selective breeding to improve their strains for shape, rate of growth, and other qualities. Interbreeding with the wild population may dilute those characteristics.
- Tommy Leggett stated that the oysters he cultures usually spawn before he harvests them and are in the water long enough to provide short term ecological services such as nutrient removal through feeding on phytoplankton and providing habitat noting that he sees large numbers of gobies, blennies, skillet fish, oyster toads, polchaetes, and a host of other fouling community organisms, on and in his oyster bags and cages. Mike Fritz summed up the discussion: Will oysters from aquaculture be in the water long enough to reproduce and contribute to ecological benefits?

The group then began outlining the details of each aquaculture scenario, and identifying types sources of information for evaluating each scenario.

**1. Diploid *C. virginica* on-bottom**

General comments:

- Need to define whether utilizing hatchery seed or wild seed from seed beds. Seed was defined as oysters less than 1 year of age. To produce hatchery seed, oysters are spawned in the spring and the seed is put out in the same year. Wild seed is produced during the summer to fall spawning season and the seed are usually moved the following year when they are a year old. Thus, hatchery seed oysters are less likely to spawn during their first summer, while wild seed oysters produced during the previous season are more likely to spawn during their first summer.
- Growth is a function of where you put them (salinity and environmental conditions)

Some data sources to evaluate this scenario:

- Growth and mortality under various environmental conditions
  - MD – Don Webster (1979-2002 data)
  - VA – Jim Wesson and private growers (Bevans, Kellum, Cowart)
- Information on off-setting mortality from disease using managed reserve techniques
  - MD – Ken Paynter

Historic on-bottom aquaculture practices in Maryland:

- There are approximately 7,000 acres of leased bottom in MD. Don Webster indicated that under current regulatory restrictions for leased bottom it would be nearly impossible to obtain more leases in MD.
- Growers typically planted 1 million spat/acre and let it go for 2-3 years
- Yield of 750-1,000 bushels/acre on well-managed bottom

- Best years might yield 1,500 bushels/acre
- Under historic conditions, producing 5M bushels annually would require 5,000 acres of bottom and 5 billion oyster seed per year

<u>Current on-bottom aquaculture practices in Virginia:</u>

- In Virginia, growers plant wild spat on shell. They typically plant 9,000 bushels and get 500 bushels of 3' oysters back (Tommy Leggett)
- Current aquaculture of *C. virginica* on-bottom is located upriver to reduce impacts from disease. The trade-offs from planting seed upriver are slower growth rates because of lower salinity and risk of mortality from freshets. (Tommy Leggett)

<u>Constraints:</u>

- Oyster survival rates for the 2-4 years it takes to get to market size (disease)
- Not enough hatchery seed. Could use wild seed as another source, but there is no consistent place to get wild seed where there isn't disease using traditional practices. If you can't get wild seed, then you must increase hatchery production
- Leased ground location. 26% of the leases that remain in Maryland are in high disease, high salinity waters
- Theft of oysters from leases is a big issue
- Leased ground quality. For example, cost of preparing leased bottom that has become silted over (ORP will provide cost data for bar cleaning).
- Availability of shell or other suitable substrate
- Predation from rays
- Additional seed cost of 7% for disease resistant strains (Stan Allen, personal communication)

**2. Diploid *C. virginica* off-bottom (containerized)**

<u>General comments:</u>

- Lots of different deployment methods associated with containerized, off-bottom aquaculture (i.e., floating, long line with bags, cages near bottom). Each method has different issues associated with it
- Can use either cultchless or spat-on-shell
- Shucking and half-shell markets – different economics
- Use of different selected strains (DEBY, CROSbreed) in different areas could affect growth and mortality rates
- In VA, typically see growth to market size at 2.5 inches in $\leq$2 years

<u>Some data sources to evaluate this scenario:</u>

- Survival to market
  - high disease approximately 50% (Tommy Leggett)
  - low disease 50% (Bob Parkinson)
  - data from Mobjack Bay and Wye River (Ken Paynter)

- Bushels/acre
  - St. Thomas Creek Oysters (Bob Parkinson); 1 float=1,000 oysters=3 bushels of 3 inch oysters— at 33% coverage per acre to accommodate the need for space between floats and to have enough algae per acre of water to support the oysters. To get 5M bushels using these conditions you need 4,000 acres. In reality the actual number may vary between 2000 to 5000 acres depending on suitability of sites for the off bottom operation (i.e. if there is a lot of algae you can have more floats in a particular area).

<u>Constraints:</u>

- Access to grow-out sites
- Location of grow-out sites where the oysters are able to reach market size before disease mortality occurs (no remnant oyster population acting as local disease reservoir).
- Social and aesthetic issues associated with structures in or on the surface of the water column; competition for resources among stakeholders (i.e. waterfront property owners, recreational fishermen, boaters, etc.)
- Poor water quality – unmarketable product or cost to relay and depurate
- Economic/marketing constraints – more geared toward half shell market
- Equipment fragile, can not be used in open water areas. Stronger gear would likely increase costs (The Japanese have been growing oysters in open water of the Pacific Ocean since 1930. Is this approach cost-prohibitive in the Bay?)
- Disease problems may increase over time with oysters densities
- Regulatory issues, especially permit difficulties
- Adequate government staffing (e.g., for monitoring and enforcement) – staffing would need to increase with the expansion of the industry.
- Cost factors: Predation (Bob Parkinson indicated that he has to turn the floats for 48 hours every 3 weeks because of crab predation); Gear fouling; Seed costs.
- Seed (wild or hatchery) availability, as well as other constraints listed for #1.
- Additional seed cost of 7% for disease resistant strains (Stan Allen, personal communication)

### 3. Triploid *C. virginica* on-bottom and off-bottom (containerized)

<u>General Comments:</u>

- Not as valuable ecologically because it won't spawn and contribute to the wild population

<u>Some data sources to evaluate this scenario:</u>

- Mortality, growth rates, seed costs (all are likely to have different numbers than those for diploids)
  - Literature
  - VIMS/VASG – Karen Hudson (biological), Tom Murray (economics)
  - VSC – Mike Congrove
  - Tommy Leggett and AJ Erskine (current triploid C.v. on-bottom project)

Constraints:

- Same as #2 for off-bottom
- Additional seed cost of 5 % for triploidy surcharge. There is an additional 7% surcharge if disease resistant strains are used. (Stan Allen, personal communication)

**4. Triploid *C. ariakensis* off-bottom (containerized)**

Some data sources to evaluate this scenario:

- Mortality, growth rates, seed costs, optimal stocking densities
  - VIMS/VASG – Karen Hudson (biological), Tom Murray (economics)
  - VSC – Mike Congrove
- Taste tests:
  Quantitative Taste Test Studies:
  - North Carolina studies (published)
    - Bishop, Melanie J., and C.H. Peterson. 2005. Consumer rating of the Suminoe oyster, *Crassostrea ariakensis*, during home cooking. *Journal of Shellfish Research*. 24(2): 497-502.
    - Grabowski, Jonathan H., S.P Powers, C.H. Peterson, M.J. Powers and D.P. Green. 2003. Consumer Ratings of non-native (*Crassostrea gigas* and *Crassostrea ariakensis*) vs. native (*Crassostrea virginica*) oysters. *Journal of Shellfish Research*. 22(1): 21-30.

- Qualitative or Informal Taste Tests:
  - ORP taste tests – Charlie Frentz
  - Louis Wachsmuth (west coast) – Rich Bohn

Constraints:

- Possibly more susceptible to Polydora which could affect marketing
- Possibly more predation by blue crabs
- May have lower tolerance to low dissolved oxygen (Ken Paynter ?)
- Shorter shelf life than *C. virginica*
- Marketing and taste tests (e.g., marketing a nonnative oyster versus a native oyster)
- Most likely to be best as a processing (shucking) type oyster
- Regulatory hurdles, especially permit difficulties
- Biosecurity – costs associated with risk mitigation (e.g., preventing reproduction). Need to evaluate feasibility of this scenario both with and without additional costs for biosecurity measures
- Broodstock limitations – lag of 3 years to get a large number of animals for industry use
- Quarantine requirements limit numbers due to space, expensive to hold these broodstock
- Triploid seed cost – 5% surcharge on top of seed cost (Stan Allen, personal communication)

5. **Triploid *C. ariakensis* on-bottom**

   General Comments:
   - Similar to scenario #1 but must utilize triploid *C. ariakensis* on-bottom growth and mortality rates. Seed costs might also be higher
   - For each scenario, there should be an attempt to characterize uncertainty based on the quality of data available

   Some data sources to evaluate this scenario:
   - Mortality and growth rates
     - Luckenbach et al on-bottom project (on-going)
   - Triploid seed cost – 5% surcharge on top of seed cost (Stan Allen, personal communication)

## *Data gathering assignments to obtain some of the needed data:*

Data will be sent to Tom O'Connell and Michelle O'Herron during the next 2 weeks

1. Tommy Leggett:
   - Contact Kellum and Ruark for VA information on # bushels, seed planted, and yield
   - Personal data on survival of diploids and limited information he has on triploids
   - Personal data on grow-out costs and area
   - Cost to get 5 million bushels with 50% mortality
   - Survival to market for high disease areas

2. Donald Webster
   - Growth rates of on-bottom *C. virginica* from growers in MD (1979-2002 data)

3. Charlie Frentz
   - Information on costs of refurbishing bottom planting shell on abandoned leases
   - Cost of cleaning, seed, shell, gear

4. Richard Bohn
   - Number of *C. virginica* harvested from leases in MD
   - Wiegert- West coast model using g*igas* has data on mortality for moving seed

5. A.J. Erskine
   - Number of bushels *C. virginica* spat (wild seed) planted, numbers harvested
   - Triploid *C. virginica* off-bottom
   - Predation data

6. Bob Parkinson
   - Diploid *C. virginica* off-bottom
   - Survival to market for low disease

7. VIMS, VSC data
   - Triploid *C. ariakensis* off-bottom growth and mortality
   - Possible survival difference between triploid and diploid (also in literature)

8. Ken Paynter
   - Growth and mortality
   - Information on off-setting mortality from disease from harvest reserve sites
   - Survival to market data from Mobjack Bay and Wye River

9. Jim Wesson
   - Predation data
   - Growth and mortality data

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