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Project Management for Virginia Seafood Council's Economic Analysis of Triploid C. ariakensis Aquaculture (Year 1 and 2)

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Final Project Report (#FRGP 2003-07)—Year I

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Executive Summary

The Virginia Seafood Council (VSC) project for 2003-2005 focused on industry field trials with genetic triploid *Crassostrea ariakensis*. This entailed deployment of approximately 100,000 *C. ariakensis* at each of ten industry participants' private oyster grounds to test aquaculture grow-out methods and marketability. In addition deployment of genetic triploid *C. virginica* allowed for a side-by-side comparison.

In concert with the VSC industry field trial, the Virginia Institute of Marine Science (VIMS) designed a study "Biosecurity and comparative field trials of triploid *C. ariakensis* with *virginica*" which enabled scientists, industry members, and state and federal agencies to collect and have access to both ecological and economical data.

As a result of damage sustained during Hurricane Isabel in September 2003, two participants, Robert Johnson and Peter Nixon, were unable to participate in the VSC project. Therefore, only eight field sites contain oysters. However, nine growers exist as two growers occupy one field site and are splitting the 100,000 oysters.

Both state (Virginia Marine Resources Commission—VMRC) and federal (United States Army Corps of Engineers—USACOE) permits were obtained by VSC, which contained thirteen and fifteen conditions, respectively. One condition in particular required VIMS to test 3,000 individual triploid *C. ariakensis* for ploidy analysis. It has been demonstrated that the "genetic method" does not produce 100% triploid oysters therefore it is possible that some proportion of diploid oysters may exist. The best possible resolution has been determined to be one diploid oyster among 1,000 triploid oysters. Accordingly, a second spawn of genetic triploid *C. ariakensis* had to be done, thus delaying the original deployment date July 1, 2003 until about October 1, 2003.

C. ariakensis deployed at all sites grew very well and generally obtained market size by the spring of 2004. Despite cooler water temperatures and potentially lower food availability, *C. ariakensis* grew quickly once acclimated to site-specific environmental conditions. Triploid *C. virignica*, deployed concurrently, did not immediately grow like *C. ariakensis*. In fact, *C. virginica* generally grew very little from deployment until the middle spring 2004.

From deployment until late December 2003 no product was marketed nor lost due to mortality. However, some *C. ariakensis* was lost due to winter icing at the following sites: Drewer, Harding, Bevans, Ruark, Crewe, and Mason. Although *C. virginica* experienced little winter icing mortality, it became clear that *C. ariakensis* was more sensitive to severe cold temperatures if exposed.

C. ariakensis was also slowly coming to market during the spring 2004. Higher and moderate salinity sites were marketing hundreds to thousands of *C. ariakensis* primarily for the half-shall market. *C. virginica* was growing but not nearly the rate of C. ariakensis and subsequently was not ready for marketing.

On February 2, 2004 VSC applied for a federal permit extension because the original permit termination date was June 30, 2004 and the trial had a later than expected start date. Unfortunately, if terminated on June 30, 2004 the majority of *C. ariakensis* would not have been marketed. Several state (Virginia, Maryland, Delaware, and Pennsylvania) and federal (EPA, NOAA, USFWS, NMFS, USACOE, and the *C. ariakensis* Ad-Hoc Panel) agencies became involved as a result of the USACOE having to seek input and recommendations.

The new federal permit extension was issued by USACOE on July 1st, 2004 and included nine additional conditions. One condition in particular required the growers to harvest oysters and/or reduce the density of oysters per unit (i.e. cage, bag, or float). This clearly has introduced several aspects of bias into the economic and market analyses. First, the growers were forced to purchase more gear and consequently spend more labor in aquaculturing *C. ariakensis*. Second, growers were forced to harvest standard (smaller) oysters and sell to the market potentially when demand was not high. This scenario increased costs yet reduced returns which will have to be taken into consideration when applying the analysis of economic feasibility of culturing *C. ariakensis* and the supply and demand of the *C. ariakensis* market.

Marketing analysis from December 2003 through June 2004 showed that approximately 204,940 triploid *C. ariakensis* were sold to both the half-shell and shucked markets. Also, from July through August 2004 another 78,950 were marketed in both sectors. Product has been distributed to both novice and experienced oyster consumers, and large and small half-shell and shucked markets. Unfortunately, approximately 61,080 oysters have died due to predation, winter icing, or lack of husbandry.

The cost analysis varies widely from site to site. For example, Sopko, Ruark, and Crewe used primarily older cages to contain oysters, whereas growers such as Mason, Bevans, and Leggett chose to purchase new coated wire cages which range from $1,000 to $4,000 in total initial investment costs. In general, minimal investments have been made in labor, fuel, and other miscellaneous aquaculture costs. Labor appears to be consistent with typical aquaculture techniques, although increased biosecurity and required harvest and splitting of oysters as part of permit extension conditions has significantly increased labor costs.

Conclusions thus far indicate that triploid *C. ariakensis* on a commercial scale (industry based—i.e. several hundred thousand bushels/year) is unrealistic and cost-prohibitive. However, for smaller scale aquaculture farms, i.e. half shell market—possibly 300-900 bushels/year is very realistic and profitable, as this study will demonstrate. Of course, under more liberal and realistic biosecurity constraints, both an aquaculture half-shell and on bottom shucking products may be attainable.

Description of Project

Purpose:

This industry-based field trial was designed to address two main objectives. First was to determine if growing triploid *C. ariakensis* in Virginia's Chesapeake Bay and the seaside of the Eastern Shore was economically feasible for both large and small companies. Second was to produce a market analysis of triploid *C. ariakensis*.

In order to determine economic feasibility each participant has to track their costs

(inputs): fuel, labor, supplies, transportation, shipping, ice, etc. This will then be balanced against the returns (outputs): revenue from oysters sold to half-shell and shucking markets.

Marketing analysis will involve examining the half-shell and shucked market trade. Generally, questions such as consumer acceptance, shuckability, yield, appearance, and taste will be documented as often as possible.

Another objective of this project involves grow-out methods. Several types of gear are being used, which enables a reasonable comparison among grow-out types and growth of *C. ariakensis* in various environments.

Methodologies employed:

Grow-out methods used so far in this project include: floats, off-bottom cages, long-line systems (bags on bottom), re-bar racks, land-based crab shedding tanks, and an experimental raft system. Some of these grow-out systems are part of a separate FRGP grant, but have dove tailed nicely with the overall objectives of this VSC field trial. For example, Shores and Ruark Seafood have grown triploid *C. ariakensis* in an experimental long-line system that was approved for development by a FRGP grant study. In addition, Shore Seafood employed an experimental raft system during the fall and winter to grow-out triploid *C. ariakensis* that was also part of a separate FRGP grant study. Unfortunately, the use of this system had to be temporarily discontinued for summer 2004 due to the close proximity of units (stacks of tray inserts in the raft) and the possibility of reproduction imposed by the conditions set forth in the VSC permit extension document (see attached Appendix 1).

An interesting aspect of this project will be the contrasting marketing schemes employed by each grower. For example, some of the larger shucking facilities will process oysters on site and sell oysters to regular customers. On the other hand, smaller aquaculture farms will sell primarily shell stock oysters to restaurants, hotels, and/or the public. A few aquaculture farms will also sell shell stock oysters but to larger shucking facilities to determine yield.

Summary of Data

Initial (09/29-10/25/03)

Investments:

Bevans spent $3,702.94 in cages, bags, cable ties, and other aquaculture supplies. Twenty-six man-hours were spent constructing cages, sealing bags stocked with oysters, and deployment.

Harding spent $3,421.02 in bags, lines, cable ties, and other aquaculture supplies. It was estimated that the pump to run seawater over the bags contained in the land-based crab shedding tanks cost $120 per month. The pump was on from deployment (October 1st, 2003) until October 25, 2003, which totals $100.00 in electricity. Twenty-five man-hours were spent sealing bags stocked with oysters and deployment.

Ruark spent a total of $9,516.00 in cages, bags, cable ties, anchors, buoys, and other aquaculture supplies. In addition, it was estimated that $1200.00 in labor was invested in deployment of the experimental animals.

Sopko spent $700.00 in cable ties, bags, and other aquaculture supplies. Eight

man-hours were spent sealing bags stocked with oysters and deployment.

Crewe spent $202.50 on used and new mesh bags to contain oysters. Land transportation included 4 trips @ 14 miles each for a total of 56 miles. A total of 13 man-hours were used in order to deploy oysters.

Leggett spent $3,723.00 on new rigid, coated wire mesh cages, $900.00 on mesh bags, $160.00 on clips to close bags, and a total of nine man-hours deploying the oysters.

Drewer spent $15,860.90 on new equipment and aquaculture supplies to grow-out triploid *C. ariakensis*. However, this dollar amount includes some expenses incurred as part of a separate FRGP grant study to build two experimental grow-out raft systems. In addition, a total of 18.25 man-hours were spent deploying oysters.

Hammer spent $1612.00 on bags, ties, and fuel to contain and grow-out oysters. Also 32 man-hours were invested in deploying the oysters.

Mason spent $1600.00 on bags, cable ties, and fuel to contain and grow-out oysters. Also 10.5 man-hours were spent deploying oysters.

Mortality/Growth:

No oyster mortality of either species was associated with transportation to deployment sites or initial planting.

All oysters were deployed at a minimum size of 20mm. Overall, triploid *C. ariakensis* grew extremely well from deployment through mid October 2003. Shell height increases ranged from 10mm at lower salinities and 15-25mm at moderate and higher salinities. Triploid *C. virginica* did not grow significantly during this time period. Minimal increases in shell height were 0-5mm on average across all sites.

Returns:

No product was distributed to the market during this time period.

1st Quarter (10/25-12/17/03)

Investments:

Bevans invested approximately $1,000.00 in more bags, cable ties, and other aquaculture supplies in order to split oysters to allow for growth. Also, approximately 60 man-hours were spent on splitting and redeploying oysters.

Harding did not make further capital investments in supplies during this period. Approximately 53 man-hours were spent splitting, counting, and cleaning oysters.

Ruark did not make further capital investments in supplies during this period. Approximately 25 man-hours were spent moving floats, cleaning, and gear checks.

Sopko did not make further capital investments in supplies during this period. Approximately 15 man-hours were spent moving cages to deeper water for the winter months to avoid freezing.

Crewe did not make further capital investments in supplies during this period. Approximately 9.20 man-hours were spent splitting bags and redeploying oysters.

Leggett did not make further capital investments in supplies during this period. Approximately 45 man-hours were spent splitting bags of oysters, culling out market animals, and cleaning.

Drewer did not make further capital investments in supplies during this period. Approximately 111 man-hours were spent splitting bags of oysters, preparing the experimental raft for deployment, and stocking the raft system for grow-out.

Hammer invested approximately $730.00 on bags, cable ties, fuel and other aquaculture supplies in order to split oysters to allow for growth. Approximately 70 man-hours were spent splitting bags of oysters, cleaning gear, and redeploying oysters.

Mason invested approximately $500.00 on bags, cable ties, fuel and other aquaculture supplies in order to split oysters to allow for growth. Approximately 45 man-hours were spent sieving and redeploying oysters and constructing new gear.

Mortality/Growth:

Growth

The first allotment of triploid oysters distributed to growers on September 29th have grown extremely well at all sites and in all grow-out systems. Initial sizes prior to field deployment ranged from 20-25mm. At the first sampling conducted in early November, oysters ranged from 38-52mm. Essentially, from September 29th to early November, approximately five weeks, all triploid *C. ariakensis* had doubled in length. Almost every grower has chosen to split these oysters at least once. Growers that initially stocked 1500-1000 oysters per bag are currently stocking 600-330 oysters per bag.

At most sites triploid *C. virginica* have increased in shell height. Average initial pre-deployment size was 20-23mm and November sampling revealed shell heights ranging from 25-35mm.

The second allotment of triploid *C. ariakensis* distributed to growers on October 8th has seen appreciable growth. These oysters also were deployed at approximately 20mm and have grown to 30-35mm. Some growers have split this allotment of oysters from 1500 per bag to 600 or even 300 per bag for the winter period. Others have chosen to remain at slightly higher densities for the winter period.

The third allotment of triploid oysters distributed to growers on October 17th has not grown as much as the first two allotments. Stocking densities remain around 2000-1000 oysters per bag. Although this allotment of triploid oysters has not attained the large size other allotments have, they show shell growth. Some animals have grown from the initial deployment size of 20mm to approximately 25-30mm.

In summary, the September 29th allotment grew extremely fast having to be split, at all sites in all systems at least once. Some of these oysters are over two inches long and may be marketed later this winter, according to a few growers. The October 8th allotment of triploid oysters has grown well across all sites and in all systems. A few growers have split these oysters into lower stocking densities for the winter period, but some remain at higher density. The October 17th allotment of oysters has had little shell growth and densities remain 2000-1000 per bag.

Mortality

Bevans experienced a small mortality event (~3%) in triploid *C. ariakensis* was observed on 11/7/03. All oysters at this site are being grown in off-bottom cages. The affected *C. ariakensis* were removed and re-deployed at other grow-out sites that already contained *C. ariakensis* cages. This mortality is most likely due to uncontrollable environmental factors since it was confined to this specific site. No further mortality has

been observed in *C. ariakensis* at any of the other grow-out sites.

Harding experienced no mortality of triploid *C. ariakensis* deployed in crab shedding tanks and taylor floats since October 17th.

Ruark experienced no mortality of triploid *C. ariakensis* deployed in taylor floats since October 17th.

Sopko experienced no mortality of triploid *C. ariakensis* deployed in off-bottom cages since October 17th.

Crewe experienced no mortality of triploid *C. ariakensis* deployed in off-bottom cages since October 17th.

Leggett experienced no mortality of triploid *C. ariakensis* deployed in off-bottom cages since October 17th

Drewer experienced no mortality of triploid *C. ariakensis* deployed in taylor floats and experimental rafts since October 17th.

Hammer experienced no mortality of triploid *C. ariakensis* deployed in taylor floats since October 17th.

Mason experienced no mortality of triploid *C. ariakensis* deployed in off-bottom cages since October 17th.

Returns:

No product was distributed to the market during this time period.

2nd Quarter (12/17/03-03/17/04)

Investments:

Bevans invested approximately $500.00 in supplies and fuel during this period. Approximately 25 man-hours were spent checking cages and general maintenance.

Harding invested approximately $420.00 in bags, long-lines, buoys, cable ties, and fuel to redeploy *C. ariakensis* after the crab shedding system froze on January 26th, 2004. Approximately 67 man-hours were spent splitting bags of oysters, redeploying bags, and constructing long-line systems.

Ruark invested approximately $100.00 in fuel during this period. Approximately 15 man-hours were spent performing inventories, checking floats and bags, and general maintenance.

Sopko invested approximately $50.00 in fuel during this period. Approximately 15 man-hours were spent checking cages and general maintenance.

Crewe invested approximately $50.00 in fuel during this period. Approximately 15 man-hours were spent checking cages, splitting bags of oysters, and general maintenance.

Leggett invested approximately $27.00 in fuel and accumulated 80 land transportation miles during this time period. Approximately 18 man-hours were spent culling, splitting, and redeploying oysters.

Drewer invested approximately $50.00 in fuel and aquaculture supplies during this time period. Approximately 22 man-hours were spent checking on gear and oysters and splitting bags of oysters.

Hammer invested approximately $100.00 in fuel and cleaning supplies during this time period. Approximately 28 man-hours were spent splitting, harvesting, and redeploying oysters.

Mason invested approximately $402.00 in aquaculture supplies during this time period. Approximately 26 man-hours were spent sieving, splitting, and redeploying oysters.

Growth/Mortality:

Growth

Overall *C. ariakensis* continued to increase in shell height throughout this time period. It became clear that although water temperatures were near freezing, *C. ariakensis* remained agape and continued to filter available algae. Low salinity environments ranged in shell height from 40-55mm, moderate salinity sites from 47-63mm, and high salinity sites from 51-67mm.

Shell differences were also becoming apparent according to salinity and environment. Low salinity environments generally had more round, thick, and weathered shells. However, meat to shell ratio observationally appeared to be high. In moderate salinity environments meat to shell ratio visually seemed to remain high, however, shells did not appear to be weathered. In high salinity environments meat to shell ratio appeared to be somewhat lower than other salinities, however, shells were much larger, thinner, and tended to be less round depending on grow-out method. Although oyster meats were plump and in superior condition, the apparent lower meat to shell ratio may be due to oyster meats not equaling the rate of shell growth during age 0-6 months.

Triploid *C. virginica* grew little across all sites during this time period. Toward the middle of March 2004 *C. virginica* began to filter, feed, and grow however, growth estimates were generally about half that of *C. ariakensis*. Although overall shell length, width, and depth of *C. virginica* were much less compared to *C. ariakensis*, it appeared that *C. virginica* shells were thicker and stronger. In addition, *C. virginica* have the ability to completely shut both valves thus protecting the oyster from harsh winter conditions in Chesapeake Bay. It seems that *C. ariakensis* does not have the ability to close completely (possibly due to environmental conditions in its native habitat—warmer annual water temperatures compared to Chesapeake Bay) and therefore remains slightly agape during the cold winter months. Clearly the advantage is winter growth, but the disadvantage is winter mortality if exposed.

Mortality

Bevans experienced a very small amount of mortality (approximately 320 oysters) due to previously high stocking densities in bags.

Harding experienced a small amount of mortality (approximately 500 oysters) due to freezing conditions inside the crab-shedding tanks.

Ruark experienced mortality (approximately 9500 oysters) due to previously high stocking densities in bags.

Sopko experienced no mortality during this period.

Crewe experienced no mortality during this period.

Leggett experienced no mortality during this period.

Drewer experienced a large mortality event during this time period. An estimated 14,004 oysters were killed due to exposure during extremely cold temperatures. The experimental raft systems top two trays became exposed during an ebb tide and a

northeast wind and subsequently 100% of oysters were killed in the top tray and approximately 30-75% were killed in lower trays.

Hammer experienced no mortality during this period.

Mason experienced no mortality during this period.

Returns:

Bevans did not market any *C. ariakensis* during this period.

Harding did not market any *C. ariakensis* during this period.

Ruark did not market any *C. ariakensis* during this period.

Sopko did not market any *C. ariakensis* during this period.

Crewe did not market any *C. ariakensis* during this period.

Leggett marketed approximately 1500 *C. ariakensis* during this period. Most oysters were sold to the half-shell market at approximately $0.25 per oyster.

Drewer did not market any *C. ariakensis* during this period.

Hammer marketed approximately 100 *C. ariakensis* during this period. All oysters went into the half-shell market.

Mason did not market any *C. ariakensis* during this period.

3rd Quarter (03/17/04-06/17/04)

Investments:

Bevans invested approximately $200.00 in aquaculture supplies during this time period. Approximately 189 man-hours were spent splitting bags of oysters, checking gear, and general maintenance.

Harding invested approximately $300.00 in aquaculture supplies during this time period. Approximately 40 man-hours were spent splitting bags of oysters, long-lining bags of oysters, and constructing systems.

Ruark invested approximately $100.00 in fuel and aquaculture supplies during this time period. Approximately 30 man-hours were spent splitting bags of oysters and redeploying on long-line systems.

Sopko invested approximately $50.00 in fuel and aquaculture supplies during this time period. Approximately 20 man-hours were spent splitting bags of oysters and redeploying again in cages.

Crewe invested approximately $25.00 in fuel and aquaculture supplies during this time period. Approximately 28 man-hours were spent splitting bags of oysters, counting market oysters for sale, and general maintenance. In addition, approximately 30 land transportation miles were invested in culturing oysters.

Leggett invested approximately $18.00 in fuel during this time period. Approximately 35.5 man-hours were spent splitting bags of oysters, deploying additional gear, and counting market oysters for sale. Also, approximately 60 land transportation miles were invested in culturing oysters.

Drewer did not make further capital investments in supplies during this time period. Approximately 49.5 man-hours were spent splitting bags of oysters, removing *C. ariakensis* from experimental raft system (per federal permit extension risk mitigation mandate), and redeploying oysters into floats.

Hammer invested approximately $50.00 in fuel during this time period. Approximately 143 man-hours were spent culling oysters, splitting oysters into additional floats, and general maintenance.

Mason invested approximately $402.00 in fuel and aquaculture supplies during this time period. Approximately 70 man-hours were spent sieving oysters, culling market oysters, and constructing additional cages.

Growth/Mortality:

Growth

In moderate and high salinity environments approximately 15-25% of the triploid *C. ariakensis* population quickly became market size (75mm or larger) during this time period. Clearly, the spring phytoplankton bloom coupled with this oyster already being acclimated to feeding and filtering since they remained agape during the winter months, allowed for a significant increase in shell height. For example, at a moderate salinity site triploid *C. ariakensis* averaged 45 oysters per liter in late December 2003 and by March 19th, 2004 the average was 24 oysters per liter. A similar trend was observed in low salinity environments, however a smaller proportion (~ 5-15%) of oysters attained market size. For example, by April 22nd, 2004 oysters grown in a low salinity environment averaged 29 oysters per liter. Comparatively, measurements from November 2003 indicated that one-liter contained approximately 75 oysters.

C. ariakensis shells continued to be thinner compared to *C. virginica* in high salinity environments. This could be due to energy allocation being shunted to shell height growth and less to overall thickness of the shell. Conversely, it appeared that *C. ariakensis* in low and most moderate salinity sites tended to produce a thicker shell. It is important to note that this apparent difference is documented only observationally and has not been proven experimentally.

Triploid *C. virginica* during this time period began to increase in shell height across all sites. Although overall shell length measurements did not exceed, nor equal, *C. ariakensis*, it became clear that *C. virginica* also took advantage of the spring phytoplankton bloom.

In general, *C. virginica* shells continued to be thicker compared to *C. ariakensis* shells across all sites. Morphologically, *C. virginica* tends to have a more curved shell hinge and a less flaky shell bill compared to *C. ariakensis*.

Mortality

Bevans experienced some mortality (approximately 6660 oysters) due to previously high stocking densities in bags and possibly predation.

Harding experienced no mortality during this period.

Ruark experienced some mortality (approximately 6700 oysters) due to previously high stocking densities in bags and lack of husbandry.

Sopko experienced some mortality (approximately 7400 oysters) due to previously high stocking densities in bags and lack of husbandry.

Crewe experienced some mortality (approximately 7500 oysters) due to previously high stocking densities and lack of husbandry.

Leggett experienced no mortality during this period.

Drewer experienced some mortality (approximately 8500 oysters) due to previously high stocking densities and possibly predation.

Hammer experienced no mortality during this period.

Mason experienced no mortality during this period.

Returns:

Bevans did not market any *C. ariakensis* during this period.

Harding did not market any *C. ariakensis* during this period.

Ruark did not market any *C. ariakensis* during this period.

Sopko did not market any *C. ariakensis* during this period.

Crewe marketed approximately 12100 *C. ariakensis* during this period. Oysters were distributed to both the half-shell and shucked markets at approximately $0.20 per oyster.

Leggett marketed approximately 7500 *C. ariakensis* during this period. Most of these oysters went into the half-shell trade at approximately $0.25 per oyster.

Drewer did not market any *C. ariakensis* during this period.

Hammer marketed approximately 20589 *C. ariakensis* during this period. Oysters went into both the half-shell and shucked markets at approximately $0.23 per oyster.

Mason marketed approximately 5500 *C. ariakensis* during this period. Most of the oysters were distributed into the half-shell market at approximately $0.25 per oyster.

4th Quarter (06/17/04-08/17/04)

Investments:

Bevans invested approximately $100.00 in fuel and aquaculture supplies during this time period. Approximately 66 man-hours were spent splitting oysters, culling market oysters, and redeploying.

Harding invested approximately $1200.00 in bags, cable ties, buoys, and line for further development of long-line systems. Additionally, $30.00 was spent in fuel. Approximately 112 man-hours were spent culling market oysters and splitting oysters into the long-line systems.

Ruark invested approximately $50.00 in fuel and aquaculture supplies during this time period. Approximately 44 man-hours were spent splitting oysters from bags into clam-relay cages, culling market oysters, and redeploying into grow-out systems.

Sopko invested approximately $50.00 in fuel and aquaculture supplies during this time period. Approximately 100 man-hours were spent constructing new long-line systems, culling market oysters, and redeploying into grow-out systems.

Crewe invested approximately $35.00 in fuel and accrued 42 land transportation miles during this time period. Approximately 41 man-hours were spent culling market oysters and securing grow-out systems.

Leggett invested approximately $30.00 in fuel and accrued 100 land transportation miles during this time period. Approximately 24.5 man-hours were spent culling market oysters, further splitting bags of oysters, and redeploying into grow-out systems.

Drewer did not make any further capital investments during this time period. Approximately 147 man-hours were spent splitting oysters, harvesting, and redeploying in grow-out systems

Hammer did not make any further capital investments during this time period. Approximately 79 man-hours were spent culling market oysters, further splitting oysters in floats, and redeploying into grow-out systems.

Mason did not make any further capital investments during this time period. Approximately 40 man-hours were spent culling market oysters and further splitting oysters into grow-out systems.

Growth/Mortality:

Growth

Triploid *C. ariakensis* grew very well during this period. Some proportion of oysters from all salinity regimes attained market size. Shell height measurements ranged from 50-95mm. High and some moderate salinity environments realized approximately 30-50% of the population becoming market size, which is reflected in the returns. Low and other moderate salinity sites had a smaller proportion of the population approximately 15-25% attain market size. Although *C. ariakensis* continued to grow throughout the early and middle part of the summer, it seemed that the growth curve was more asymptotic rather than exponential like other quarters. This phenomenon may have been due in part to the warmer water temperatures (>25° C) in July and August 2004.

Unfortunately, federal restrictions issued in the VSC permit extension, mandated that each site remove a certain proportion of these oysters according to their size. This translated into very high harvest rates of the larger *C. ariakensis* ranging from 15000 at lower salinities to almost 60,000 at higher salinities. For growers in the lower salinities not all of their larger oysters were marketable. Typically they harvest and shuck medium and larger oysters (101mm—4 inches or greater), yet the harvested oysters were 65-85mm. Subsequently, oysters were forced into the market at a smaller size and possibly for a lower price.

Triploid *C. virginica* continued to realize a higher growth rate compared with the first and second quarters. Similar to the third quarter shell bill was observed and a larger cup was evident across all sites. Some *C. viriginica* in high and moderate salinities doubled in size and nearly attained three and half inches in shell height. Lower salinities did not quite equal the other salinity regimes, but nonetheless, increased in shell height.

Mortality

Bevans experienced some mortality (approximately 4000 oysters) possibly due to previously high stocking densities in bags, predation, and environmental conditions.

Harding experienced some mortality (approximately 5600 oysters) possibly due to environmental conditions and sedimentation.

Ruark experienced some mortality (approximately 1200 oysters) due to previously high stocking densities in bags and lack of husbandry.

Sopko experienced no mortality during this period.

Crewe experienced some mortality (approximately 2000 oysters) due to previously high stocking densities and lack of husbandry.

Leggett experienced no mortality during this period.

Drewer experienced no mortality during this period.

Hammer experienced no mortality during this period.

Mason experienced no mortality during this period.

Returns:

Bevans marketed approximately 15340 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out as standards yielding approximately 7 pints/bushel.

Harding marketed approximately 18000 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out as standards yielding approximately 7 pints/bushel.

Ruark marketed approximately 27000 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out as standards and selects yielding approximately 10-11 pints/bushel.

Sopko marketed approximately 20600 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out as standards yielding approximately 6-7 pints/bushel.

Crewe marketed approximately 15134 *C. ariakensis* during this period. Oysters were marketed in both the half-shell and shucked markets yielding on average $0.20 per oyster.

Leggett marketed approximately 15189 *C. ariakensis* during this period. Oysters were marketed in both the half-shell and shucked markets at approximately $0.25 per oyster.

Drewer marketed approximately 32200 *C. ariakensis* during this period. All oysters were shucked on site and frozen. Overall oysters shucked-out as standards and selects yielding approximately 11 pints/bushel.

Hammer marketed approximately 24075 *C. ariakensis* during this period. Oysters were marketed in both the half-shell and shucked markets yielding on average $0.25 per oyster.

Mason marketed approximately 58050 *C. ariakensis* during this period. Oysters were marketed primarily in the half-shell market in the mid-Atlantic region yielding on average $0.23 per oyster.

Conclusions

Although not complete this project has demonstrated that culturing triploid *C. ariakensis* is feasible in Virginia waters. There is an initial investment ranging from a few hundred to a few thousand dollars depending on the purchase of new or used grow-out systems. One difficulty is that *C. ariakensis* grow so fast that oysters need to be tended to on a regular basis otherwise crowding and smothering occurs leading to mortality. A modest investment of two thousand dollars can realistically grow-out 100000 triploid *C. ariakensis* and the return can range from $10000 to $30000. Of course there are incidental costs during this process so another one thousand dollars for investment is probably realistic. However, it is clear that a profit can be made with triploid *C. ariakensis* aquaculture. Even though initial investments in gear can be high this is generally a one-time cost and returns from this can be realized for several year classes of oysters.

Preliminarily market returns indicate that this oyster is a solid shucking product. Lower than expected yields may be a function of shucking smaller standard size oysters as opposed to larger count oysters, however, this was mandated by the federal resource agencies involved in negotiating for a permit extension. It is encouraging, however, that

at low and moderate salinity sites yield was as high as 11-14 pints/bushel. Initial responses to shucking *C. ariakensis* are very positive, as it is easy to open and remove the product.

The half shell trade was not as well accepted as the shucking product. A short shelf life seems to be predominant regardless of salinity. Oysters kept dry and in ambient air temperatures only last a day or two. Oysters kept in cool storage (~ 45-50° F) can survive for up to 3-5 days. Although, oysters kept in cold storage (32°F) are subject to a slightly earlier mortality. It does seem that grow-out method may have an effect on shelf life. Oysters that have remained intertidal since deployment, even through the cold winter months, have a longer shelf life.

Several grow-out methods have been employed during the first year of this project. Floats, off-bottom cages, long-line bags, crab-shedding tanks, and off-bottom racks have all been used. Interesting differences and experiences have been observed. For example, long-line bags on bottom seem to expedite the growth of *C. ariakensis*. This may be due in part to the native habitat of *C. ariakensis*, which can be muddy bottom types. In addition, crab-shedding tanks are a very biosecure and effective intermediate step in culturing *C. ariakensis*. Prior to field deployment tanks can be used to increase shell height, possibly avoiding predations from crabs and/or skates. However, oysters need to be removed from tanks prior to freezing conditions otherwise mortality may become a problem. Floats encourage oysters to grow very quickly as they take advantage of surface phytoplankton blooms. In addition, oysters are protected during freezing temperatures as the basket of the float sits a foot or more below the surface.

Recommendations

A more realistic feasibility study of *C. ariakensis* aquaculture could be conducted if biosecurity measures were not so stringent. This project has been subjected to several layers of biosecurity that have unfortunately introduced bias into the analysis. If growers could culture *C. ariakensis* on bottom or in containers but on a less restricted basis, then investment costs would be less and possibly more watermen or industry members could become involved.

In the coming year economic and marketing data will continue to be collected from each grower. Shelf life will be more closely monitored along with winter management of *C. ariakensis* possibly by relocating older oysters intertidally to encourage hardening.

Grow-out systems will also be more closely examined. It is clear that long-line bags on bottom is an extremely effective method to grow *C. ariakensis*, however, the method needs slight improvements with retrieval and bag attachment to the main line. Several variations of off-bottom cages have been used but possibly a more specific analysis of cage type that produces maximum flow and thus food availability might increase growth rate on bottom. Lastly, off-bottom rebar racks although just recently deployed have proven to very effectively grow oysters. It is possible to improve on this grow-out method by increasing the surface area to accommodate more bags and flaring the legs so that the rack doesn't sink completely and submerge the bags of oysters.

Final Project Report (#FRGP 2003-07)—Year 2

A.J. Erskine
Project Manager
Virginia Seafood Council

5th Quarter (08/17/04-10/17/04)

Investments:

Bevans invested approximately $50.00 in fuel and aquaculture supplies during this time period. Approximately 45 man-hours were spent culling and harvesting market oysters, and redeploying sub-markets oysters.

Harding invested approximately $30.00 in fuel. Approximately 112 man-hours were spent culling market oysters and splitting oysters into the long-line systems.

Ruark invested approximately $75.00 in fuel and aquaculture supplies during this time period. Approximately 65 man-hours were spent culling and harvesting market oysters, and redeploying sub-markets back into grow-out systems.

Sopko invested approximately $50.00 in fuel and aquaculture supplies during this time period. Approximately 25 man-hours were spent culling market oysters, and redeploying into grow-out systems.

Crewe invested approximately $5.00 in fuel and accrued 42 land transportation miles during this time period. Approximately 11 man-hours were spent culling market oysters and securing grow-out systems.

Leggett invested approximately $45.00 in fuel and accrued 150 land transportation miles during this time period. Approximately 41.25 man-hours were spent culling market oysters, further splitting bags of oysters, and redeploying into grow-out systems.

Drewer did not make any further capital investments during this time period. Approximately 40 man-hours were spent harvesting and culling market size oysters and redeploying sub-markets back in to grow-out systems.

Hammer did not make any further capital investments during this time period. Approximately 40 man-hours were spent culling market oysters, further splitting oysters in floats, and redeploying into grow-out systems.

Mason did not make any further capital investments during this time period. Approximately 50 man-hours were spent culling market oysters and further splitting oysters into grow-out systems.

Growth/Mortality:

Growth

Triploid *C. ariakensis* grew well during this time period. Smaller, sub-market oysters that were re-deployed into grow out systems and allowed further space to feed and grow did very well. Quickly these oysters became market size towards the end of this quarter. Although water temperatures continued to climb, hydrographic conditions did not inhibit *C. ariakensis* from continuing to grow. Shell bill was evident across all sites but most striking was the overall strength of the shell from various sites.

It seemed as if the oysters were on the asymptotic part of the growth curve, not putting on incredible amounts of shell length, but more shell thickness. Unlike the beginning of this project when oysters were growing so quickly that most of the growth efforts were concentrated in the shell bill region. However, during this quarter the concentration of shell growth was in the width of the oyster also adding to the "cupped" appearance at some sites.

Triploid *C. virginica* grew extremely well at several sites during this quarter. In fact, some sites began to market three to three and a half inch oysters. The growth could be due to the strain of oyster (a cross between two disease tolerant lines) producing hybrid vigor or the environmental conditions observed the last two seasons in which rainfall has been in excess of the average. *C. virginica* began this project with slow, almost non-existent, shell growth but have now put on both cup (thickness) and some shell bill to produce very marketable oysters.

Mortality

Bevans experienced no mortality during this period.

Harding experienced no mortality during this period.

Ruark experienced some mortality (approximately 5280 oysters) due to previously high stocking densities in bags, predation, and some sedimentation.

Sopko experienced no mortality during this period.

Crewe experienced no mortality during this period.

Leggett experienced some mortality (approximately 1042 oysters) possibly due to predation and sedimentation.

Drewer experienced no mortality during this period.

Hammer experienced some mortality (approximately 1650 oysters) possibly predation and some sedimentation.

Mason experienced some mortality (approximately 5280 oysters) possibly due to predation and some sedimentation.

Returns:

Bevans marketed approximately 7500 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out primarily as selects yielding approximately 10 pints/bushel.

Harding marketed approximately 7500 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out primarily as counts yielding approximately 11.5pints/bushel.

Ruark marketed approximately 35720 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out as selects yielding approximately 12.5 pints/bushel.

Sopko marketed approximately 7000 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out as selects yielding approximately 10 pints/bushel.

Crewe marketed approximately 2900 *C. ariakensis* during this period. Oysters were marketed in both the half-shell and shucked markets yielding on average $0.20 per oyster.

Leggett marketed approximately 4189 *C. ariakensis* during this period. Oysters were marketed in both the half-shell and shucked markets at approximately $0.25 per oyster.

Drewer marketed approximately 4000 *C. ariakensis* during this period. All oysters were shucked on site and frozen. Overall oysters shucked-out as standards and selects yielding approximately 11 pints/bushel.

Hammer marketed approximately 5000 *C. ariakensis* during this period. Oysters were marketed in both the half-shell and shucked markets yielding on average $0.25 per oyster.

Mason marketed approximately 13600 *C. ariakensis* during this period. Oysters were marketed primarily in the half-shell market in the mid-Atlantic region yielding on average $0.23 per oyster.

6th Quarter (10/17/04-12/17/04)

Investments:

Bevans invested approximately $125.00 in fuel and aquaculture supplies during this time period. Approximately 65 man-hours were spent culling and harvesting market oysters, and redeploying sub-markets oysters.

Harding invested approximately $110.00 in fuel. Approximately 69 man-hours were spent culling market oysters and re-deploying oysters into long-line systems.

Ruark invested approximately $35.00 in fuel and aquaculture supplies during this time period. Approximately 35 man-hours were spent culling and harvesting market oysters, and redeploying sub-markets back into grow-out systems.

Sopko invested approximately $55.00 in fuel and aquaculture supplies during this time period. Approximately 45 man-hours were spent culling market oysters, and redeploying into grow-out systems.

Crewe invested approximately $10.00 in fuel and accrued 42 land transportation miles during this time period. Approximately 18 man-hours were spent culling market oysters and securing grow-out systems.

Leggett invested approximately $25.00 in fuel and accrued 70 land transportation miles during this time period. Approximately 23 man-hours were spent culling market oysters, further splitting bags of oysters, and redeploying into grow-out systems.

Drewer invested approximately $25.00 in fuel and aquaculture supplies during this time period. Approximately 42 man-hours were spent harvesting and culling market size oysters and redeploying sub-markets back in to grow-out systems.

Hammer invested approximately $25.00 in fuel and aquaculture supplies during this time period. Approximately 62 man-hours were spent culling market oysters, further splitting oysters in floats, and redeploying into grow-out systems.

Mason invested approximately $25.00 in fuel and aquaculture supplies during this time period. Approximately 53 man-hours were spent culling market oysters and redeploying oysters into grow-out systems.

Growth/Mortality:

Growth

Triploid *C. ariakensis* continued to grow but at a much slower rate than previously recorded in this project. Most likely this is due to these oysters attaining the

asymptote of the growth curve. During this quarter, across all salinities, oysters ranged in size from ~80mm (3¼") to 150mm (5⅞"). *C. ariakensis* shell growth was observed in the width of the oyster more so than the bill region. Shells were becoming heavier and physically tougher than previous time periods. Differences in salinity and growth were evident since oysters at high salinities exhibited some shell bill growth but lower and moderate salinities showed more "cupping" and girth shell growth.

Triploid *C. virginica* continued to grow during this quarter. At moderate salinities especially, native oysters reached market size and more were being marketed in the half-shell trade. Growth was more uniform than *C. ariakensis*, but markedly slower. Oysters ranged in size from 55mm to 80mm.

Mortality

Bevans experienced no mortality during this period.
Harding experienced no mortality during this period.
Ruark experienced no mortality during this period.
Sopko experienced no mortality during this period.
Crewe experienced no mortality during this period.
Leggett experienced no mortality during this period.
Drewer experienced no mortality during this period.
Hammer experienced no mortality during this period.
Mason experienced no mortality during this period.

Returns:

Bevans marketed approximately 53380 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out primarily as selects yielding approximately 10 pints/bushel.

Harding marketed approximately 46400 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out primarily as counts yielding approximately 11.5pints/bushel.

Ruark marketed approximately 14600 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out as selects yielding approximately 14 pints/bushel.

Sopko marketed approximately 35200 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out as selects yielding approximately 10 pints/bushel.

Crewe marketed approximately 6660 *C. ariakensis* during this period. Oysters were marketed in both the half-shell and shucked markets yielding on average $0.20 per oyster.

Leggett marketed approximately 14080 *C. ariakensis* during this period. Oysters were marketed in both the half-shell and shucked markets at approximately $0.25 per oyster.

Drewer marketed approximately 40950 *C. ariakensis* during this period. All oysters were either shucked on site or sold to other shucking houses for processing. Overall oysters shucked-out as counts and selects yielding approximately 11-13 pints/bushel.

Hammer marketed approximately 32488 *C. ariakensis* during this period. Oysters were marketed mostly to shucking houses for processing but some went into the local or regional half-shell trade. Shucking yield was approximately 11-12 pints/bushel and half-shell prices averaged $0.23/oyster.

Mason marketed approximately 14432 *C. ariakensis* during this period. Oysters were marketed primarily in the half-shell market in the mid-Atlantic region yielding on average $0.23 per oyster.

7th Quarter (12/17/04-2/17/05)

Investments:

Bevans invested approximately $55.00 in fuel during this time period. Approximately 30 man-hours were spent culling and harvesting market oysters, and redeploying sub-markets oysters.

Harding invested approximately $75.00 in fuel. Approximately 35 man-hours were spent culling market oysters and re-deploying oysters into the long-line systems.

Ruark did not make any further investments during this quarter. Approximately 10 man-hours were spent collecting grow-out gear after complete harvest at the end of last quarter.

Sopko invested approximately $25.00 in fuel during this time period. Approximately 20 man-hours were spent culling market oysters, and redeploying into grow-out systems.

Crewe invested approximately $10.00 in fuel and accrued 22 land transportation miles during this time period. Approximately 9 man-hours were spent culling market oysters.

Leggett invested approximately $20.00 in fuel and accrued 60 land transportation miles during this time period. Approximately 21 man-hours were spent culling market oysters, transporting to markets and redeploying into grow-out systems.

Drewer invested approximately $10.00 in fuel during this time period. Approximately 10 man-hours were spent collecting most of grow-out gear as most oysters were harvested toward the end of the last quarter.

Hammer invested approximately $10.00 in fuel during this time period. Approximately 25 man-hours were spent culling market oysters and redeploying into grow-out systems.

Mason invested approximately $15.00 in fuel during this time period. Approximately 25 man-hours were spent culling market oysters and redeploying into grow-out systems.

Growth/Mortality:

Growth

In general triploid *C. ariakensis* did not grow significantly during this quarter. Some sites exhibited shell growth either along the margin or in the girth region mostly from sub-market size oysters that had been re-deployed for grow-out. Larger triploid *C. ariakensis* put on minimal shell growth as their maximum 1½ year old size was being reached (~160mm). Interestingly, smaller re-deployed oysters did very well during this time period even though shell growth may not be expected during the colder months of December through February.

Triploid *C. virginica* also did not grow significantly during this quarter however this may be due to the growing season for *C. virginica*. It was reported earlier in this project that *C. virginica* tend to grow well from middle spring until middle fall but essentially shut down feeding processes outside of this time period. After 14 months of deployment some sites observed a significant percentage of their triploid *C. virginica* crop (~50-60%) had attained market size (3 inches).

Mortality

Bevans experienced no mortality during this period.
Harding experienced no mortality during this period.
Ruark experienced no mortality during this period.
Sopko experienced no mortality during this period.
Crewe experienced no mortality during this period.
Leggett experienced no mortality during this period.
Drewer experienced no mortality during this period.
Hammer experienced no mortality during this period.
Mason experienced no mortality during this period.

Returns:

Bevans did not market any oysters during this quarter, but sub-markets were re-deployed for continued grow-out.

Harding did not market any oysters during this quarter, but sub-markets were re-deployed for continued grow-out.

Ruark did not market any oysters during this quarter because the entire crop had been marketed at the end of the last quarter.

Sopko marketed approximately 17600 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out as selects yielding approximately 10 pints/bushel.

Crewe marketed approximately 3346 *C. ariakensis* during this period. Oysters were marketed in both the half-shell and shucked markets yielding on average $0.20 per oyster.

Leggett marketed approximately 7040 *C. ariakensis* during this period. Oysters were marketed in both the half-shell and shucked markets at approximately $0.25 per oyster.

Drewer did not market any oysters during this quarter, but sub-markets were re-deployed for continued grow-out.

Hammer marketed approximately 16244 *C. ariakensis* during this period. Oysters were marketed mostly to shucking houses for processing but some went into the local or regional half-shell trade. Shucking yield was approximately 10 pints/bushel and half-shell prices averaged $0.23/oyster.

Mason marketed approximately 7216 *C. ariakensis* during this period. Oysters were marketed primarily in the half-shell market in the mid-Atlantic region yielding on average $0.23 per oyster.

8^{h} Quarter (02/17/04-04/17/05)

Investments:

Bevans invested approximately $20.00 in fuel during this time period. Approximately 10 man-hours were spent harvesting final crop of market oysters.

Harding invested approximately $30.00 in fuel. Approximately 15 man-hours were spent harvesting final crop of market oysters.

Ruark did not make any further investments during this quarter.

Sopko invested approximately $15.00 in fuel during this time period. Approximately 10 man-hours were spent harvesting final crop of oysters.

Crewe invested approximately $5.00 in fuel and accrued 12 land transportation miles during this time period. Approximately 5 man-hours were spent harvesting final crop of oysters.

Leggett invested approximately $10.00 in fuel and accrued 20 land transportation miles during this time period. Approximately 5 man-hours were spent harvesting final crop of oysters.

Drewer invested approximately $5.00 in fuel during this time period. Approximately 5 man-hours were spent harvesting final crop of oysters.

Hammer invested approximately $5.00 in fuel during this time period. Approximately 4 man-hours were spent harvesting final crop of oysters.

Mason invested approximately $10.00 in fuel during this time period. Approximately 10 man-hours were spent harvesting final crop of oysters and collecting off-bottom cages.

Growth/Mortality:

Growth

The few triploid *C. ariakensis* that were re-deployed in previous quarters grew very well and have since reached market size. Most strikingly was growth from lower salinity regions where oysters were deployed in either longline bags on bottom or off-bottom cage or rack systems. During this time, late winter or early spring, three-inch *C. ariakensis* have continued to put on shell bill and thicker shell layers as well.

The triploid *C. virginica* continue to grow well. Overall the crop is continuing to reach market size across a variety of salinities. Although it has been documented in this project that *C. virginica* did not grow during colder water months, the early spring 2005 has seen *C. virginica* populations grow very well.

Mortality

Bevans experienced no mortality during this period.
Harding experienced no mortality during this period.
Ruark experienced no mortality during this period.
Sopko experienced no mortality during this period.
Crewe experienced no mortality during this period.
Leggett experienced no mortality during this period.
Drewer experienced no mortality during this period.
Hammer experienced no mortality during this period.
Mason experienced no mortality during this period.

Returns:

Bevans marketed approximately 12300 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out primarily as selects yielding approximately 10 pints/bushel.

Harding marketed approximately 22000 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out primarily as counts yielding approximately 11 pints/bushel.

Ruark did not market any oysters during this quarter because the entire crop had been marketed.

Sopko marketed approximately 12000 *C. ariakensis* during this period. All oysters were shucked on site and shipped domestically. Overall oysters shucked-out as selects yielding approximately 10 pints/bushel.

Crewe marketed approximately 350 *C. ariakensis* during this period. Oysters were marketed in the half-shell trade yielding on average $0.20 per oyster.

Leggett marketed approximately 500 *C. ariakensis* during this period. Oysters were marketed the half-shell trade at approximately $0.25 per oyster.

Drewer marketed approximately 350 *C. ariakensis* during this period. All oysters were sold locally for half-shell yielding approximately $0.25/oyster.

Hammer marketed approximately 1500 *C. ariakensis* during this period. Oysters were marketed locally for half-shell yielding approximately $0.25/oyster.

Mason marketed approximately 1200 *C. ariakensis* during this period. Oysters were marketed locally for half-shell yielding approximately $0.25/oyster.

Conclusions

This project successfully demonstrated that aquaculture of triploid *C. ariakensis* is both profitable and marketable. Previously it was thought that commercial-scale aquaculture might be unrealistic however VSC has demonstrated that high throughput, tens of millions of cultured oysters, is feasible in the Bay and Eastern Shore of Virginia. Aquaculture can be a very effective means of implementing a "put-and-take" fishery that accomplishes several goals.

Protection from predators such as cow nose rays and crabs is critical to obtaining market size oysters. Over the last several years industry members have come to realize that traditional planting of oysters, those caught on shell, will be readily consumed by predators especially rays. Aquaculture also provides close examination of the oyster crop being grown. Implementation of efficient nursery systems such as floating upweller systems, high volume oyster grading systems and the most effective grow-out methods allows growers to closely monitor their crop and attain market size oysters in the shortest amount of time.

As it pertains to this project, aquaculture of triploid *C. ariakensis*, we have shown that on a moderate scale (i.e. 100,000 oysters per grower) can be profitable regardless of initial investment requirements. A smaller first year profit margin may be realized for someone that must invest in new gear however larger profit margins can be realized for those that already have a considerable amount of gear available. In addition, strong market demand exists for this oyster. Some growers reported that oysters were either specifically asked for or favorably accepted in the competitive oyster market.

As successful as this project was, we also learned a few important lessons. Aquaculture of triploid *C. ariakensis* needs to be monitored closely. This means that

stocking density needs to be tracked and reduced appropriately in addition to regular cleaning of bags and cages. Half-shell oysters that were shipped over several days had a tendency to arrive agape and thus were unsuitable for market. This phenomenon needs to be examined further but may be resolved by simply planting seed oysters intertidally to strengthen the shells of *C. ariakensis* during fluctuations of high and low tide. Infections of *Polydora* were high in both *C. ariakensis* and *virginica*, but transmission dynamics were species specific. This trend should be followed in subsequent years to determine if this was an anomaly or typical infection rates. Similarly, disease infections were either absent or very low in *C. ariakensis* (MSX and *Bonamia* were absent and Dermo was rare or light). In *C. virginica* MSX and Dermo were either low or moderate infections and *Bonamia* was absent.

This project has been instrumental in providing a building block for triploid aquaculture. As state and federal agencies work on native diploid oyster restoration and an Environmental Impact Statement to determine the fate of *C. ariakensis*, the Virginia oyster industry has begun to realize how important and successful aquaculture can be if done properly. One aspect that VSC growers did not obtain from this current project was whether or not a one-year time frame for grow-out could be realized. This is vital if triploid aquaculture is to become a business in Virginia, since annual rotation of crops would determine how many oysters could be cultured in one year across several salinities. It is possible to envision a scenario where low salinity regions need more than 12 months to grow-out *C. ariakensis* and a certain percentage of their crop would be sub-markets. This project has been an example of industry, researchers, state and federal agencies, the press and the public working together to collect information and provide an alternative method of oyster culture that is economically feasible in Virginia waters.