



NOAA CHESAPEAKE BAY OFFICE Non-native Oyster Research



Research
Topic:

*Aquaculture
options:*

*Biological
and economic
factors affecting
aquaculture
production of
native and
non-native
oysters in the
mid-Atlantic*

Quarterly Review
Summer 2005



Background

Decline in abundance of the native oyster, *Crassostrea virginica*, in the Chesapeake Bay has led to the collapse of a formerly productive fishery and the loss of significant ecological services. Two oyster diseases, MSX and Dermo, have contributed at least in part to the decline, and continue to challenge oyster restoration efforts. In response to this situation the State of Maryland and Commonwealth of Virginia have proposed to intentionally introduce a non-native oyster species, *Crassostrea ariakensis*, which has greater resistance to the pathogens responsible for MSX and Dermo. Considerable controversy exists over the proposed course of action and many questions remain about the implications of such an introduction.

In 2003 the U.S. Congress authorized the Army Corps of Engineers to prepare an Environmental Impact Statement (EIS) to examine both the risks and benefits of introducing this species to the Chesapeake Bay. The EIS is being conducted by the Corps as the lead federal agency, with the Maryland Department of Natural Resources (MDNR) and the Virginia Marine Resources Commission (VMRC) serving as lead state agencies. The U.S. Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), and Fish & Wildlife Service (FWS) are cooperating agencies on the EIS.

In 2004 the NOAA Chesapeake Bay Office (NCBO) initiated a 3-year Non-native Oyster Research program funded at \$2M annually to obtain the scientific information needed to evaluate the proposed Asian oyster introduction. The program is aimed at research priorities recently identified by the National Research Council (NRC) and the Scientific and Technical Advisory Committee of the Chesapeake Bay Program (STAC), as well as guidance from the International Code of Practice on the Introductions and Transfers of Marine Organisms.

Research findings are reviewed quarterly at meetings or web conferences sponsored by NCBO and hosted by the Chesapeake Research Consortium. Invitees include scientists conducting research relevant to the EIS, representatives from federal and state agencies, and other interested management groups. These quarterly review sessions are designed to facilitate timely discussions of research results among scientists and managers, and speed the transfer of information to the EIS evaluation process. It must be emphasized that the findings of ongoing research are preliminary. Additional time will be required for the projects to be completed, and the results to be peer reviewed.

Summary reports of all Quarterly Reviews and additional information on NOAA's Non-native Oyster Research initiative are available at <http://chesapeakebay.noaa.gov/>.

Spring 2005 Overview of research topics: Taxonomy, genetics, disease, human health, ecology, interspecific interactions, ecosystem services and functions

Summer 2005 Aquaculture options: Biological and economic factors affecting aquaculture production of native and non-native oysters in the mid-Atlantic

Biological and economic factors affecting aquaculture production of native and non-native oysters in the mid-Atlantic

Why is this research important for the EIS?

There are eight alternatives to the proposed action that will be evaluated in the Environmental Impact Statement (EIS). Two of the alternatives focus on aquaculture:

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.

We need to determine the available data and analyses by which these aquaculture alternatives will be evaluated in the EIS. Assessing these alternatives with respect to feasibility, commercial attractiveness, risk, marketing and demand issues, and potential impacts on current goals to restore oyster stocks in the Bay should provide useful information for choosing among the full set of alternatives.

Many factors affect the prospects for oyster aquaculture in the mid-Atlantic. Evaluations must take into account the biological and economic factors that could affect viability of aquaculture production, and the potential for different aquaculture methods to supply products with suitable characteristics and appropriate prices for the half-shell and shucking markets. In general, the shucking market requires a low-cost, high meat yield, easy shucking oyster. The half-shell market can support a higher price, but requires an oyster with good aesthetic appearance, high meat quality, and long shelf life for distance shipping.

One biological factor is *Polydora*, a bristleworm common in many marine and estuarine environments. The worm affects oysters by burrowing into the oyster shell to form dwelling tubes. High levels of *Polydora* infestation can affect marketability. Another biological factor for caged aquaculture methods is fouling. The settlement of dense aggregations of fouling organisms on aquaculture gear (e.g., bags, cages) reduces oyster growth rates by impeding water flow, and periodic removal of fouling communities increases labor costs and creates additional wear-and-tear on equipment. Economic factors include the costs of labor, equipment, and supplies, as well as the market price that can be obtained for the product.

Presentations:

Jonathan Grabowski (Gulf of Maine Research Institute) – The bioeconomic feasibility of culturing triploid *Crassostrea ariakensis* in North Carolina

Michael Congrove (VSC) – Results from the Virginia Seafood Council’s 2003/2004 *Crassostrea ariakensis* aquaculture trials

Tommy Leggett (CBF) – The feasibility of using triploid *Crassostrea virginica* for Chesapeake Bay aquaculture

Robert Fisher (VA Sea Grant) – Shell disease of *Crassostrea virginica* and *C. ariakensis* in Virginia: *Polydora*, a marketing concern

Some preliminary findings:

Aquaculture of Native Oysters

- There has been relatively little investment for research and development to promote native oyster aquaculture in the mid-Atlantic region. Despite the lack of a concerted R&D effort, a few growers are currently operating financially viable commercial enterprises with native oyster aquaculture. Also, some Virginia growers recently began investing in the development of commercial scale nursery and grow-out systems to support government-funded restoration efforts in addition to commercial production. Overall, there seems to be increasing interest in oyster aquaculture by private industry.
- As demonstrated by existing successful growers, diploid *C. virginica* can be profitably grown in off-bottom aquaculture for the half-shell trade. Profitability of off-bottom aquaculture production for the shucking market is unlikely, due to cumulative labor costs and mortality over the longer time required for diploid *C. virginica* to reach sizes (i.e., meat yield) needed for the shucking industry.
- On-bottom aquaculture will likely be needed to produce oysters for the shucking market, which is a larger share of the market for Chesapeake Bay oysters. In Virginia approximately 90% of oysters go to shucking and packing houses, and the remaining 10% go into various forms of half-shell product.
- Limited studies of triploid *C. virginica* in Virginia have shown better growth rates, survival (i.e., disease resistance), and meat quality relative to diploid natives.
 - The 2003/2004 VSC trial included modest numbers of triploid and diploid *C. virginica* deployed off-bottom in concert with triploid *C. ariakensis* (PIs: Allen, Hudson). Triploid *C. virginica* grew significantly faster and had lower mortality than diploids. Within 18 months some triploids had reached 3-inch market size at 7 out of 8 sites. The percentage of market sized triploids varied among the 7 sites and ranged from 22% to 78% (average 44%). Sites located in higher salinities experienced faster growth, resulting in a higher percentage of triploid *C. virginica* reaching market size. Mortality ranged from 7% to 34% across all sites. (Data available from Karen Hudson, VIMS)
 - In an earlier VIMS study (PI: Calvo), triploid *C. virginica* of the DEBY strain clearly outperformed their diploid counterparts in terms of survival, growth and condition. By 28 months, cumulative mortality was 11% in triploids and 43% in diploids. At that time, 41% of the triploids were market size whereas none of the diploids had even attained 2.5 inches. Condition of triploids and diploids similarly increased in fall 2003 and remained high over the winter and spring 2004. However, while condition decreased slightly in triploids a pronounced decrease was observed in diploids in summer 2004. *Perkinsus marinus* was nearly absent in August 2003 and

its prevalence in triploids and diploids similarly increased to 90-97% in November 2004. In August 2003, prevalence of MSX was 4% in triploids and 40% in diploids whereas no MSX was present in November 2004. Based on the good performance of triploids oyster dealers started to purchase triploid stock at a wholesale price of \$0.25/oyster in fall 2004. (Virginia Fishery Research Grant Final Report available from Tom Murray, Virginia Sea Grant)

- In Delaware Bay, triploid native oysters were evaluated as part of a NOAA ODRP funded study at Rutgers University (PIs: Guo, Ford, Wang and DeBrosse). Natural triploids were produced from Rutgers disease-resistant strains using tetraploids and compared with diploids in off-bottom bag systems. At 26 months of age, triploids were significantly larger than diploids by 12% in shell height, 20% in whole body weight and 34% in meat weight, although there was apparently no additional improvement in survival compared to diploids from disease-resistant strains. Further studies are being conducted to improve the performance of triploids by interstrain hybridization. (Contact PIs for more information).
- Two new projects funded by NOAA to further test triploid *C. virginica* are now getting underway:
 - VIMS and Virginia Sea Grant will conduct a companion trial to the 2005 VSC project, in order to perform a comparative economic evaluation of triploid *C. ariakensis* and triploid, disease-tolerant strains of *C. virginica*.
 - CBF, VIMS, and Bevans Oyster Company will evaluate the performance of triploid *C. virginica* for on-bottom culture, and perform a financial analysis of this cultivation strategy.

The results of all these studies should be used to perform bioeconomic analyses of *C. virginica* (both diploid and triploid) aquaculture for comparison with those now available for triploid *C. ariakensis*.

- Evaluation of the native oyster aquaculture alternative in the EIS should include a thorough examination of current and potential future levels of aquaculture production. To obtain the baseline and projection data needed for such an analysis, a questionnaire survey of oyster growers in the Chesapeake Bay should be conducted. The NOAA Chesapeake Bay Office is prepared to devote resources to accomplish this survey over the next 6-12 months, but will have to draw upon expertise in the aquaculture community (e.g., Sea Grant, academia, private industry) to develop an effective questionnaire.
- Potential expansion of commercial aquaculture production assumes access and leased rights to water column or bottom sites with environmental conditions suitable for oyster cultivation. The regulatory and policy issues associated with availability of oyster leases was beyond the scope of the discussion, but was identified as a key issue affecting aquaculture potential, particularly in Maryland.

Aquaculture of Triploid C. ariakensis

- A bioeconomic analysis based on observed performance of triploid *C. ariakensis* grown in bags on racks in intermediate to high salinities in North Carolina suggests profitability is

possible under certain conditions. Only operations initiated in winter are expected to be profitable. Summer deployments are expected to have negative returns due to biological factors such as *Polydora*, fouling, and mortality (e.g., *Bonamia*, mud crabs). Growers would have to carefully consider season of deployment to realize a profit.

- The 2003/2004 VSC trial included triploid *C. ariakensis* and a smaller number of triploid *C. virginica* grown at 8 sites in Virginia. Growers made an initial investment in gear (e.g., racks, bags, cages), ranging from \$700-\$10,484. Average grower profit from *C. ariakensis* sales was \$10,049 (range \$2,801-\$17,677). Cumulative mortality at sites averaged 5% (range 0-10%) for *C. ariakensis* and 16% (range 8-35%) for *C. virginica*, excluding mortality from documented events such as winter icing.
- The economic results of the VSC trial as reported do not include capital costs, because the growers already had boats and other equipment needed to grow oysters. The project also did not include the full cost of seed production. A rigorous financial analysis must include capitalization and seed prices to reflect the true costs of production. Arguing against the inclusion of capitalization is the fact that the Virginia seafood/oyster industry is currently over-capitalized at a level capable of much greater production with existing assets than currently occurs. An additional analysis that could be conducted with existing VSC data is the financial repayment ability of the pilot operations. It is recommended that additional financial analyses of the VSC trial be conducted for inclusion in the EIS.
- The North Carolina project estimated costs for biosecurity measures that were in place at the time of the study, including netting underneath the racks to capture any oysters that might escape from the bags, at around \$900/year for a 500,000 oyster operation. The cost of obtaining triploid *C. ariakensis* seed was estimated at twice the cost for *C. virginica* hatchery production. The VSC analysis reflected some biosecurity costs, in the form of costs for hatchery seed and additional gear (“Supplies”) necessary to achieve decreased deployment densities as required in permit conditions designed to minimize the risk of reproduction by rare diploids inherently present in triploid cohorts. To fully assess the non-native oyster aquaculture alternative, the EIS evaluations must include all costs associated with any biosecurity requirements likely to be established for triploid non-native oyster aquaculture (the underlying hypothetical assumption being that the proposed action of a diploid introduction is not adopted as the preferred alternative, thus making biosecurity measures imperative). These costs might derive from additional labor, extra gear necessary to reduce deployment densities below those typically used for oysters, biosecurity monitoring, etcetera. However, biosecurity requirements to minimize or mitigate long-term, cumulative risks of triploid non-native aquaculture have not yet been established.
- Some growers in Chesapeake Bay and North Carolina have expressed concerns about the shelf life of *C. ariakensis*. Gaping, shell splintering or cracking, and leaking or “bleeding”, have been noted as undesirable characteristics exhibited by *C. ariakensis* over substantially shorter post-harvest time periods relative to *C. virginica*. Unless solutions are devised, these problems may preclude long-distance shipping and limit *C. ariakensis* marketability to local half shell or shucking markets. Field observations suggest that there is a difference between apparent and real shelf life with *C. ariakensis*, as gaping oysters returned to the water often revive. The distinction between apparent and real shelf life may not be relevant for marketability, as buyers have no way to distinguish between oysters that appear dead versus oysters that really are dead or dying upon receipt of a shipment. Quantitative information is

needed to determine the post-harvest shelf life of *C. ariakensis* under a variety of conditions typical for oyster handling and shipment.

Effects of Polydora

- *Polydora* infestations result in the formation of “mud blisters” on the interior shell surface or knobs within the adductor muscle as the oyster creates extra shell material to wall-off worm penetrations. Given time to deposit sufficient shell material, oysters can seal and cover conchiolin mud blisters on the shell interior to reclaim marketability, but knobs will always remain.
- In general, *Polydora* infestations are a low-to-intermediate salinity, site-specific, summer problem. The worst infestations usually occur at intermediate salinities <25 ppt, but *Polydora* can also be a problem at higher salinities. The upper end of *Polydora*'s salinity range has not yet been well established. Infestations are heaviest in the summer and light to nonexistent in the winter. The precise combination of factors that determine *Polydora* prevalence are unclear. Some low salinity sites have few *Polydora* even during the summer, while other sites at higher salinities can have severe *Polydora* infestations.
- Studies of *Polydora* in Virginia have found that *C. virginica* and *C. ariakensis* experience similar rates of infestation. However, the two species differ in their expression of the infestation. *C. ariakensis* exhibits more mud blisters and knobs than *C. virginica*, presumably because of differences between the species in shell density and thickness.
- Aquaculture operations may be able to manage *Polydora* infestations through a variety of actions. Moving oysters to higher salinity sites decreases the prevalence of *Polydora*, and has the added benefit of increasing oyster growth rates. Strategically timing deployment of oyster spat in late summer or early fall allows for winter grow out when *Polydora* are at low levels (especially for *C. ariakensis* which continues rapid growth during the winter).
- The aesthetic impacts of *Polydora* are most significant for the half-shell market. *Polydora* is problematic for the shucking market only in cases of severe infestation where shell fragmentation, mud blister breakage, and knobs affect shucking.
- It is not clear how the level of infestation, as manifested in the percentage of shell covered by mud blisters, affects market price. In the North Carolina study, mud blister coverage >25% of the shell was considered unmarketable. In Virginia, growers have not reported reduced market price for oysters as a result of mud blisters. The ongoing VSC project documents all oysters sold, buyers they are sold to, and at what price. VSC growers participating in the 2005/2006 trials should also record details in cases where the selling price is significantly lower than average due to mud-blisters or other factors. With multiple different batches of oysters sold to a wide range of buyers, this information could be used to determine the extent to which mud-blisters affect marketability. Market tests could also be conducted by presenting oysters with varying levels of mud blister coverage to several different buyers for comparative pricing, but this activity is not planned as part of any current projects.

Economic Analyses and Supply-Market Price Dynamics

- The EIS should include economic evaluations of the proposed action and each alternative, combining estimates of oyster supply under each scenario with a better understanding of the relationship between oyster supply and market price.
- Addressing the supply and market price question, the National Research Council report states:

Oyster harvests from the Chesapeake Bay have declined to less than 3% of the total U.S. live, fresh, and frozen supply. Therefore, a doubling or even tripling of Chesapeake Bay oyster harvests over several years is likely to have only minimal impact on U.S. oyster prices. This is likely to be the case with the introduction of hatchery-based triploid *C. ariakensis* or with cautious introduction of diploid *C. ariakensis*. Nevertheless, changes in local harvests may influence price in local markets. The market for oysters is dynamic. Prices and sales volume vary across species, production region, seasonal and intergenerational changes, consumers' preferences, product-form innovations, and marketing efforts. It is unlikely that triploid aquaculture or even the introduction of diploid *C. ariakensis* will result in sufficient increases in production volume to contribute to an observable impact on prices in the short term. Media attention associated with the introduction of *C. ariakensis* could lead to increased or decreased consumer demand, depending on the message. However, it must be cautioned that in the event introduction of *C. ariakensis* or recovery of *C. virginica* leads to explosive growth in harvest, the price effect is likely to be negative. (NRC 2004. Nonnative Oysters in the Chesapeake Bay. National Academies Press, Washington, D.C., pages 209-210.)

- The hard clam industry could also be examined as a case study where aquaculture production dramatically increased supply, leading to decreases in market price.
- The EIS should also take into consideration cross effects of combined alternatives. What are the conditions under which aquaculture would be more attractive to watermen than harvesting in the open-access fishery? Could these conditions be sustained if the wild fishery recovered?
- It is hoped that economic studies currently underway by researchers at UMD and VIMS will provide much of the needed information and analyses for the EIS.

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