CRASSOSTREA ARIAKENSIS: PANACEA OR PANDORA?

Dr Mark Luckenbach, Virginia Institute of Marine Science

The introduction of *Crassostrea ariakensis* into Chesapeake Bay has been proposed for both economic and ecological gain. Data exists suggesting that *C. ariakensis* grows significantly faster and is more resistant to the diseases that have devastated the native oyster.[1] However, there is still a great deal of uncertainty regarding species identification, competitive interactions (food and space), ability for larval dispersal, introduction of new diseases, and reef building capabilities.[2] Current knowledge suggests that the most likely outcome of a large scale introduction would be neither panacea nor pandora.

INCENTIVES FOR INTRODUCING *C. ARIAKENSIS*

The introduction of *Crassostrea ariakensis* (the Suminoe or Asian oyster) to the Chesapeake Bay has been proposed due to the decline of the native *Crassostrea virginica* (the Eastern Oyster). This decline can be attributed to many factors including over-fishing, disease, water quality, increased sedimentation, toxins and habitat degradation. Current attempts to restock the bay with *C. virginica* have been relatively unsuccessful due to loss of habitat for oyster spat settlement, continuing disease mortality and decreased water quality.

Economic Gain | **Ecological Gain**

AQUACULTURE

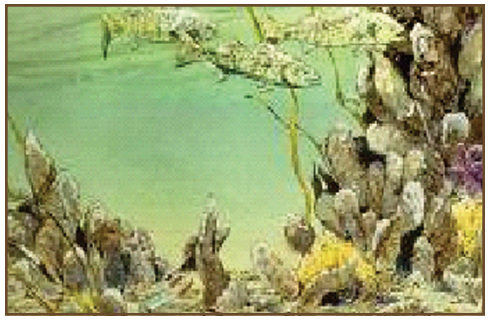
Oysters have been a vital part of the Bay economy and development of aquaculture offers an avenue to recover some of the lost economic value from the fishery. Aquaculture trials with sterile triploids have shown very promising results, with faster growth rates and better survival than the native species. No serious threats have been identified, but while the risks are uncertain they can probably be clarified with further research. Uncertainty remains regarding the potential for an accidental introduction into the wild due to the difficulty of ensuring the sterility of the oysters.

FISHERY RESTORATION

Historically the oyster fishery has been an important part of the region's culture. Restoring a wild fishery would allow traditional fishing to continue. The introduction of a reproductive (diploid) *C. ariakensis* population into Chesapeake Bay in the hopes of restoring a wild fishery faces considerable uncertainty. Despite the greater tolerance of *C. ariakensis* (compared to the native *C. virginica*) to endemic oyster diseases in Chesapeake Bay, it would likely still face limitations due to lack of habitat, poor water quality and high sedimentation rates.

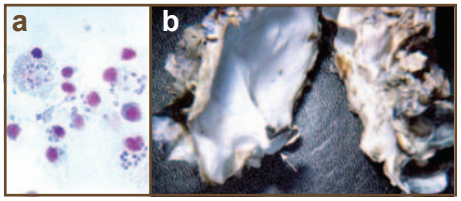
ECOLOGICAL RESTORATION

Oysters are an important filter-feeding organism and reestablishing populations would potentially reduce phytoplankton and suspended sediments in the water, thereby improving water quality. Oyster reefs are also important habitats for many Bay species. Presently, however, there is a very high degree of uncertainty about the potential for *C. ariakensis* to fulfill these ecological goals. We currently have insufficient information about this species to predict either its potential population growth or its capacity to build reefs in the Chesapeake Bay.



C. ARIAKENSIS DOES SUFFER FROM DISEASE

Recurrent large-scale mortalities (80-90% annually) of *C. ariakensis* within their native range in Asia have been documented since 1992.[3] *C. ariakensis* has been found to contract infections of Dermo (protozoan parasite, *Perkinsus marinus*) in Chesapeake Bay. Intensities of this disease have remained low and it is not certain whether it has contributed to any mortality. It is also susceptible to another parasite, *Bonamia* spp., which has been reported in Atlantic waters.[4] In one Chesapeake trial, 90% of *C. ariakensis* were infected with a fungal shell disease compared with only 20% of the *C. virginica*. This raises concerns that *C. ariakensis* could harbor the fungus, increasing its prevalence and potentially infecting the native oyster.[5] *C. ariakensis* has also been found to be susceptible to herpes.[6]



a) Bonamia *spp. b) Abnormal shell growth caused by fungal shell disease.*

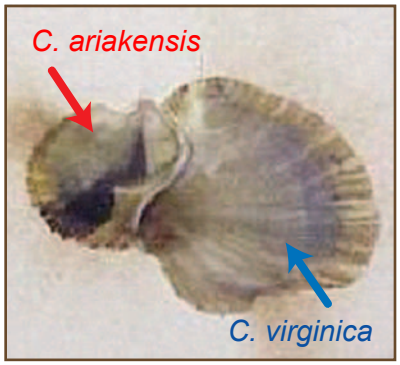
In addition to disease resistance, there are other issues causing mortality of native oysters, such as reduced habitat availability and poor water quality. Specifically, red tide blooms are a common occurrence in Chesapeake Bay and could also cause mortality of *C. ariakensis.*

C. ARIAKENSIS GROWS FASTER ONLY IN OPTIMAL CONDITIONS

Growth trials with triploid (sterile) *C. ariakensis* showed faster growth rates than diploid *C. virginica*. However, sterile organisms often exhibit higher growth rates since resources are not directed towards reproductive effort. These field trials were conducted in an aquaculture setting in which oysters were grown in cages off the bottom in non-space limiting conditions. This makes them less subject to fouling, and predators were excluded.

However, a recent study that examined growth rates of juvenile oysters in crowded conditions showed that *C. ariakensis* grows more slowly. It also suffers greater mortality than *C. virginica,* and its growth rate is even worse when it is crowded with *C. virginica* than with other *C. ariakensis.* This indicates that inter-specific competition for space may be stronger than intra-specific competition for *C. ariakensis*. Therefore the growth advantage of *C. ariakensis* in an aquaculture setting disappears under space limiting conditions. This may be due to their different growth forms.

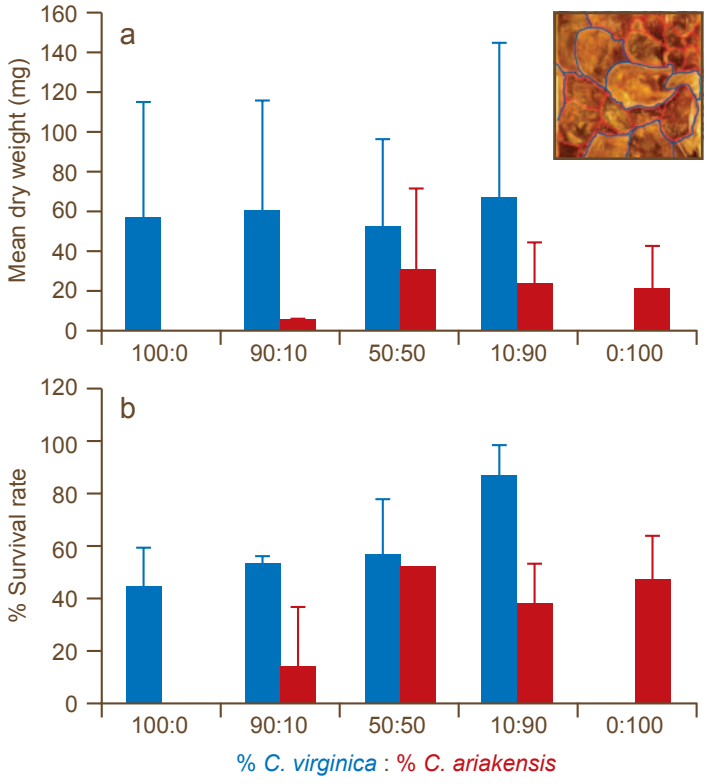
When *C. virginica* individuals grow together they immediately grow up at the margins. In contrast, *C. ariakensis* grow up much more slowly. When *C. virginica* and *C. ariakensis* grow together, *C. virginica* frequently grows up and over *C. ariakensis*, even though *C. ariakensis* may be growing more quickly at first.



Trials show that C. virginica *grows up and over* C. ariakensis.

These results are preliminary because these trials only investigated juvenile oysters up to 12 weeks in age, but this raises doubts about their ability to compete for space with *C. virginica* and produce reefs, one of the key processes required for ecological restoration of the Bay.

Another consideration is that if conditions do allow fast growth rates in *C. ariakensis*, a thinner shell results, potentially increasing susceptibility to predation by crabs.



C. virginica *has faster growth rates (a) and a higher percentage of survival (b) compared to* C. ariakensis *when grown in space limiting conditions. The inset shows the competitive nature of* C. virginica *under space-limiting conditions.*

A LOT IS STILL UNKNOWN ABOUT *C. ARIAKENSIS*

DISPERSAL MECHANISMS UNKNOWN

Little is known about larval recruitment and dispersal of *C. ariakensis*, although some research in progress is suggesting that interesting differences exist with the native oyster. In preliminary experiments with south China stocks of *C. ariakensis,* larvae swam entirely on the bottom, compared with the native *C. virginica* larvae which typically swim near the surface throughout much of their larval life. However, observations of larvae from west coast stocks of *C. ariakensis* suggest that there may be differences between different stocks of this species. This may dramatically affect the dispersal abillity of *C. ariakensis.* If these differences in larval behavior are confirmed, they could have important implications for the dispersal of this species, as well as its susceptibility to predation and low dissolved oxygen. Further research is needed to determine the potential dispersal patterns of *C. ariakensis* in the Bay, as well as determining the best mechanism for introducing the oyster to the Bay.

RESEARCH INITIATIVES

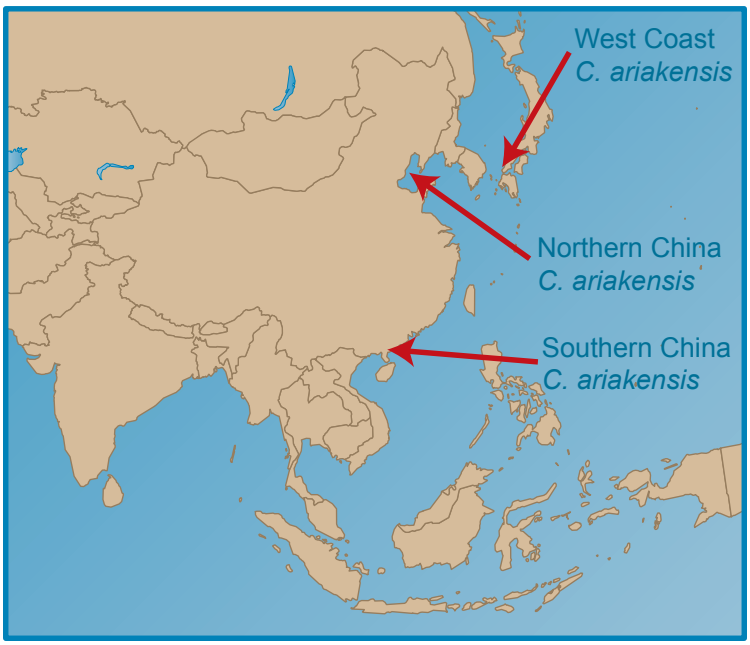
Since the beginning of 2004, multiple research projects investigating *C. ariakensis* have been initiated at various institutions. Below are some of these research projects:

Predation on *C. ariakensis*; Environmental Impact Statements (EIS) concerning the introduction of *C. ariakensis* into Chesapeake Bay; modeling *C. ariakensis* population and larval dispersal; comparing behavioral responses of *C. ariakensis* and *C. virginica* to environmental change; reproduction of *C. ariakensis*; susceptibility of *C. ariakensis* to disease; competitive interactions between *C. ariakensis* and *C. virginica*; behavior and substrate selection by *C. ariakensis* larvae; reef-forming capabilities of *C. ariakensis* in its native China; and assessing the potential of *C. ariakensis* to foul water intake pipes of Maryland power plants.

These research projects, funded primarily by ~$1.6 million from the Maryland Department of Natural Resources (DNR) and coordinated by Tom O'Connell (*toconnell@dnr.state.md.us*), are the result of collaborations between the University of Maryland Center for Environmental Science, Virginia Institute of Marine Science, Maryland DNR, Maryland Environmental Service, University of Maryland College Park, Versar Inc., University of Maryland Biotechnology Institute, Smithsonian Environmental Research Center, Florida Institute of Technology, Chinese Institute of Oceanography and University of Wales.

WHAT ARE WE DEALING WITH?

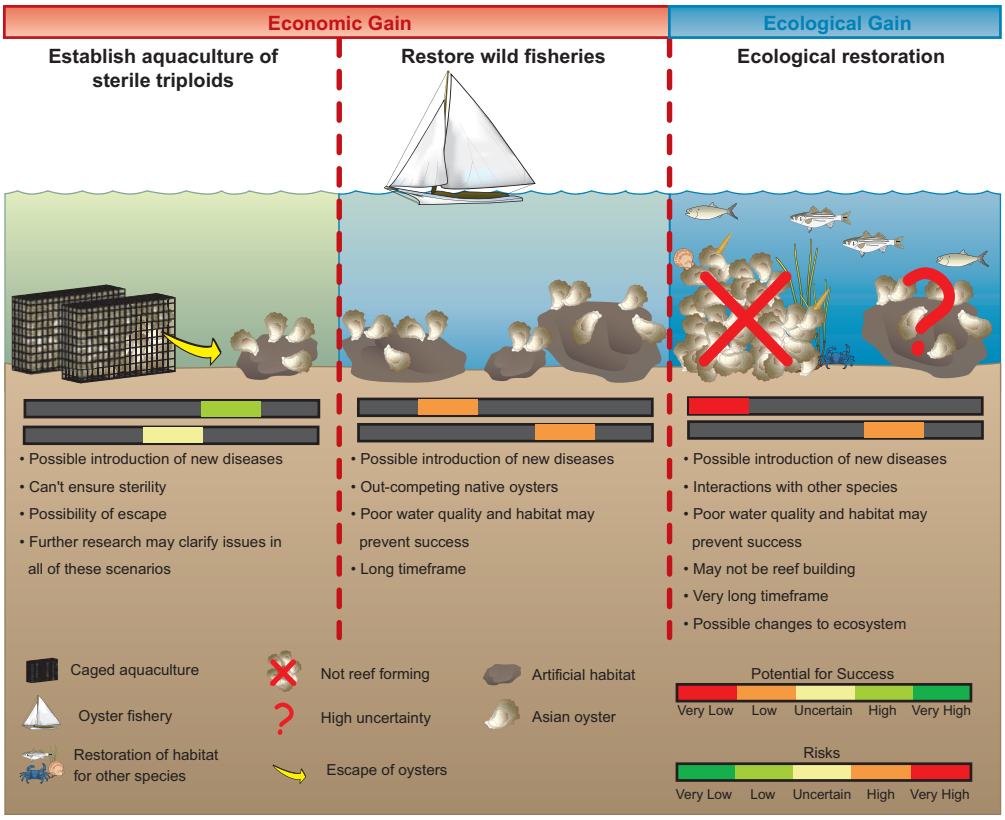
Genetic analysis shows that differences exist between the potential stocks of the Asian oyster (Reece & Zhang, unpub. data). At present it is unknown whether there are merely two or more different stocks, or whether the two genetic types that have been identified are actually two different species. Observed biological differences (i.e. 10% increase in larval size and different swimming behaviors) between stocks could affect their potential for introduction into Chesapeake Bay. This also raises concern as to the reliability of current data which has been collected from studying different stocks. The natural range of the oyster is reported to be from southern Japan along the south China coast through southeast Asia to the western coast of the Indian subcontinent. However, the taxonomy is tenuous in some areas and its actual distribution is not clearly defined.[7] The confirmed range (Japan and China) of *C. ariakensis* is much reduced based on what is known of its tolerances. In much of its native environment in China (and introduced in Japan), it is not the dominant oyster and is on the decline in some areas due to crowding from *Crassostrea gigas.* These same unknown limiting factors may also control its distribution in Chesapeake Bay.



Potential stocks of C. ariakensis *being considered for introduction to Chesapeake Bay.*

The way *C. ariakensis* grows also seems to differ between locations. In its native habitat in the Bo Hai Sea in China it grows on large reefs, but in Ariaki Bay in Japan, where it may have been introduced, it grows primarily on mud flats. This difference in the ability to form reefs may be due to different genetic strains or environmental factors controlling the way it grows. If *C. ariakensis* behaves like a 'rock oyster' (i.e. covering solid substrates but not forming vertical reefs) in Chesapeake Bay, it would form less habitat than the native oyster.

ECONOMIC POTENTIAL vs ECOLOGICAL UNCERTAINTY



Conceptual diagram detailing some of the potential risks and uncertainties of the three possible scenarios for the introduction of the oyster C. ariakensis *into Chesapeake Bay.*

A careful examination of the economic potential for *C. ariakensis* in terms of the demand for oysters, the likely success of caged aquaculture, and the possibility of restoring the wild fishery is needed. Further information is also required about:

- the native range of *C. ariakensis* to determine the occurrence of disease and possible interactions with other species.
- size specific growth rates, mortality and reproduction rates are required to support the development of a demographic model to help determine the likely success of *C. ariakensis* in Chesapeake Bay.
- interactions with other native species, both predators and competitors.

References

1. Calvo GW, Luckenbach MW, Allen SK Jr. & Burreson EM (2000). A comparative field study of *Crassostrea ariakensis* and *Crassostrea virginica* in relation to salinity in Virginia. *Special Report in Applied Marine Science and Ocean Engineering* **No. 360.** Virginia Institute of Marine Science.
2. Rickards WL , Ticco PC & Hayes P (2002). *The Suminoe Oyster,* Crassostrea ariakensis, *in Chesapeake Bay: Current status and near-term research activities.* Virginia Sea Grant College Program. **9 pp.**
3. Wu XZ & Pan JP (2000). An intracellular prokaryotic microorganism associated with legions in the oyster, *Crassostrea ariakensis* Gould. *Journal of Fish Diseases* **23**:409-414.
4. Cochennec N, Renault T, Boudry P, Chollet B & Gerard A (1998). *Bonamia*-like parasite found in the Suminoe oyster *Crassostrea rivularis* reared in France. *Dis. Aquat. Org*. **34:**193-197.
5. Fisher R (2003). *Tidewater Oyster Gardeners Association Newsletter*. Gloucester, VA. **4 pp**.
6. Committee on Non-native Oysters in the Chesapeake Bay, National Research Council (2003). *Non-Native Oysters in the Chesapeake Bay.* The National Academies Press, Washington, D.C. **241 pp.**
7. Carriker MR & Gaffney PM (1996). A catalogue of selected species of living oysters (Ostracea) of the world. *In:* VS Kennedy, RIE Newell & A Eble (Editors). *The eastern oyster* Crassostrea virginica. Maryland Sea Grant Publication. **pp. 2-18.**

Acknowledgements

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