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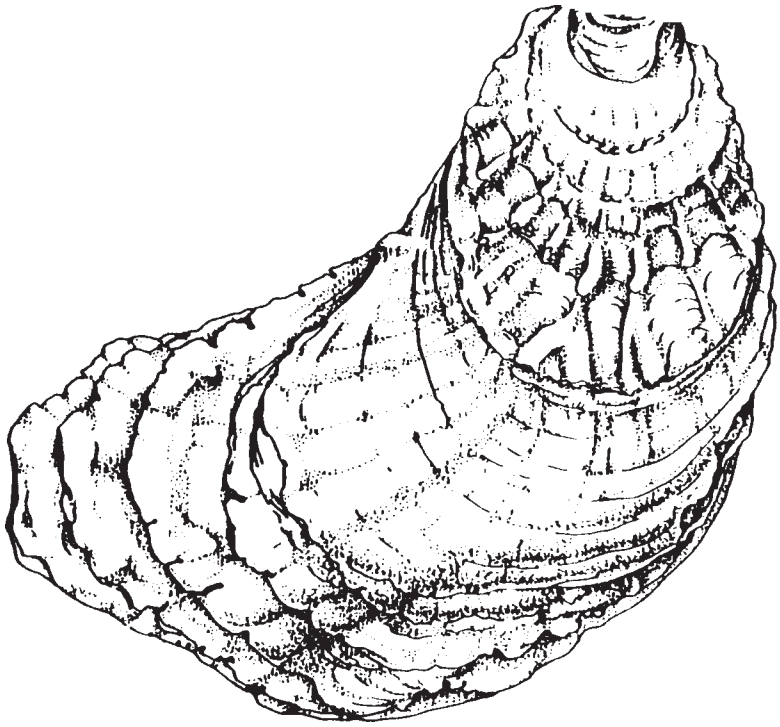

Current Status and Near-Term Research Activities

Sea Grant
Virginia

This publication was supported by funds from
the National Sea Grant College Program
through Virginia Sea Grant College Program grant # NA96RG0025

VSG-02-23

Additional copies of this publication are available from Virginia Sea Grant

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The Issue

The steady and often rapid decline in numbers of living coastal marine resources has been well documented worldwide. Overharvesting, habitat loss, destructive land-use practices, point and non-point sources of pollution, incidental or deliberate by-catch, and overdevelopment of coastal areas have all led to the implementation of a variety of management strategies that have both ecological and socio-economic ramifications.

One management tool employed, if rarely, is the direct introduction of a new species to substitute for a species that has been decimated by human or natural perturbations. The goal is to use a species that not only fills a similar ecological niche as the original but that may also become valuable for human use. However, the introduction of species historically has not always exhibited these positive results.

A current example of this situation is the possible introduction of the non-native C*rassostrea ariakensis* oyster into Chesapeake Bay as a substitute for the native American or Eastern oyster C*rassostrea virginica*. Preliminary research has shown that this foreign oyster is disease resistant, grows faster to market size than the native oyster, admirably performs its water filtering function, and is amenable to human consumption. However, there is still considerable scientific uncertainty as to the effect of this introduction on the Bay ecosystem, including impacts on other organisms. Scientists, coastal managers, industry representatives, policy-makers, and individual shellfishers throughout the region have been weighing in on this issue to the point that it has become controversial at the state, regional and national level.

Background

When Captain John Smith sailed into Chesapeake Bay in the 17th century he was overwhelmed by the sheer abundance of oysters that were present. Today, due to severe overharvesting (beginning in the years immediately following the Civil War) and the effects of pathogenic diseases, a mere fraction of the original historic population of C. *virginica* exists. This situation has had serious ecological and socio-economic repercussions. Apart from sustaining a shellfishing industry (and its associated economic side-effects), oysters and their associated reefs serve several critical ecological functions. They provide important habitat for other forms of aquatic life, and filter algae and particulates from the water column thus improving water quality for all organisms that reside in the Bay (including those consumed by humans). It is estimated that at peak population levels Chesapeake oysters could filter out the entire Chesapeake Bay in four days. Today, it is estimated that over one year is required for the oysters to filter the Bay's volume.[1]

In an effort to rectify this situation, scientists began experimenting with alternative oyster species that play a similar ecological role, and which may aid the restoration of the oyster shellfishing industry. With native C. *virginica* populations already at extremely low levels, scientists at various institutions introduced small lots of C*rassostrea gigas* (the Pacific or Japanese Oyster - the most widely cultured oyster in the world) into eastern U.S. coastal waters in the 1940s and 1950s to see how it would perform. While this oyster possessed

[1] Newell, R.I.E., 1988, Ecological changes in Chesapeake Bay: Are they the result of overharvesting the Eastern oyster (*Crassostrea virginica*)? In: M.P. Lynch and E.C. Krome (eds.), Understanding the Estuary: Advances in Chesapeake Bay Research, Chesapeake Research Consortium Publication 129 (CBP/TRS 24/88), 536-546.

several similarities to C. *virginica* (growth rate, taste) it left behind the deadly oyster disease MSX (H*aplosporidium nelsoni*).[2] This disease spread from Delaware Bay to the Chesapeake Bay and decimated much of the remaining native Virginia oyster population, although oysters in Maryland and Delaware were not as severely depleted. By the 1980s another pathogenic disease, Dermo (caused by the parasite P*erkinsus marinus* – a single-celled protozoan), was also found to be killing oysters at a high rate. The extreme susceptibility of C. *virginica* to MSX and Dermo destroyed most of the remaining oysters in Virginia, devastated the industry, and contributed significantly to the decline of the Bay's water quality.

In response, the Virginia General Assembly in 1995 directed the Virginia Institute of Marine Science (VIMS) to research the possible introduction of the non-native C*rassostrea ariakensis* oyster into Chesapeake Bay. In several laboratory and field trials C. *ariakensis* has been shown to grow rapidly and survive under a wide range of coastal and estuarine conditions, e.g., it is able to tolerate extreme differences in temperature, salinity, dissolved oxygen and the amount of suspended sediments in the water column; and, perhaps most important, is much less susceptible to the diseases that have plagued the native Chesapeake Bay oyster. Finally, a majority of volunteers reported very positive results in taste tests.

Many aquaculturists and commercial fishermen want to move forward with the wide-scale introduction of C. *ariakensis* into the Bay. They point to the following benefits:

- good economic potential for Virginia and the region as a whole, including increased employment and state tax revenue;
- restoration of ecological functions of oyster reefs; and
- improved water quality from oyster filtering functions.

However, many scientists and coastal policy-makers within the states that surround Chesapeake Bay are wary about potential adverse impacts that may accompany an introduction of any non-native species into the ecosystem, and the uncertainties that surround the C. *ariakensis* oyster. The number of unknowns and concerns include:

- whether or not it builds reefs;
- feeding patterns;
- its ability to co-exist with native oysters and other species in the Bay;
- the possibility that it may very well introduce other pathogens into what is left of the native oyster community;
- survival success in the wild;
- possible spread from Chesapeake Bay to other areas;
- it may be illegally introduced by private citizens before conclusive scientific study deems it safe to be placed into the Bay even under controlled circumstances; and
- hurricanes or other storms might displace them into the wild from aquaculture sites and/or hatchery facilities.

Positions/Actions

Given the enormous economic and ecological impact of the Chesapeake Bay watershed on the eastern United States, the historical and cultural significance of the Bay oyster fishery, and the scientific uncertainty surrounding the introduction of C. *ariakensis* into the Bay the issue has attracted much attention, and has become a classic precautionary principle case study. To wit, how much and what type of research needs to be completed before policy-makers decide whether the benefits of C. *ariakensis* introduction outweigh the costs to the degree necessary to move forward with a program of establishing a non-native oyster population.

[2] Burreson, E.M., N.A. Stokes and C.S. Friedman, 2000, Increased virulence in an introduced pathogen: *Haplosporidium nelsoni* in the eastern oyster *Crassostrea virginica*, J. Aquatic Animal Health, 12: 1-8.

One umbrella effort to help reach a conclusion is being performed by the National Academy of Sciences. The NAS, a non-profit institution created to advise Congress on scientific matters, is reviewing the ecological, social and economic issues surrounding the potential introduction of C. *ariakensis* into Chesapeake Bay. The study, funded through several state and federal agencies, and the Virginia and Maryland Sea Grant programs, is slated for completion in May of 2003. The report will focus specifically on the impact that C. *ariakensis* would have on the recovery of native oysters, and its effect on Bay water quality, habitat, other marine life, and the aquaculture industry.

Regionally, the "Chesapeake 2000" agreement (an encompassing set of management strategies designed to achieve resource and ecological goals in the Bay) includes a goal that:

"By 2010, achieve, at a minimum, a tenfold increase in native oysters in the Chesapeake Bay, based upon a 1994 baseline. By 2002, develop and implement a strategy to achieve this increase by using sanctuaries sufficient in size and distribution, aquaculture, continued disease research and disease-resistant management strategies, and other management approaches to restore the native oyster productivity to Chesapeake Bay."

The cost of achieving this goal is estimated at approximately $100 million. In response, the Chesapeake Bay Program Federal Agencies Committee (CBPFAC), signatories to the agreement, stated that:

"there are a number of significant, poorly understood risks and potential adverse consequences associated with introducing C. *ariakensis* into the Chesapeake Bay – worsening disease problems, interspecific competition with the native oyster and other organisms, and detraction of funds and effort from the Chesapeake 2000 commitment to a "tenfold increase in native oysters."

Therefore, the CBPFAC "opposes the introduction of C. *ariakensis* into the Chesapeake Bay unless environmental and economic evaluations are conducted and reviewed to ensure that the risks of introduction are acceptably low."

Another major regional organization, the Chesapeake Bay Foundation (CBF), has taken a similar precautionary track, taking the position that:

"until there is substantial scientifically validated information about the ecological risks and benefits associated with the use of sterile C*rassostrea ariakensis* oysters for aquaculture, a public policy decision to sanction large-scale aquaculture or outright introduction cannot be made responsibly."

Similar attitudes exist at the state management level. The Maryland and Virginia Sea Grant programs jointly held a 2001 symposium "Aquaculture of Triploid Crassostrea ariakensis in Chesapeake Bay" that produced the following concluding statement: "the intentional introduction of reproductively capable C. *ariakensis* would be imprudent as the ecological consequences are too uncertain to support such an introduction."[3] The University of Maryland Center for Environmental Science presented a parallel apprehension that called for "strict biosecurity and vigilant monitoring to minimize the risks of introduction, and no intentional introduction of C. *ariakensis* until the potential impacts of this on species and ecosystems are completely studied."

These conclusions hail from a number of research efforts currently under way that underscore the difficulty in reaching consensus. As one example, the Virginia Marine Resources Commission has experimented by growing sterile C. *ariakensis* in controlled environments throughout different parts of the Bay with assistance from researchers at the Virginia Institute of Marine Science (VIMS). These "triploid" oysters (as opposed to the fertile

[3] Hallerman, E., M. Leffler, S. Mills, and S. Allen, Jr., 2001. Aquaculture of Triploid *Crassostrea ariakensis* in Chesapeake Bay: A Symposium Report, College of William and Mary, Williamsburg, VA., Oct. 18-19, 2001. Maryland Sea Grant Extension Publication UM-SG-TS-2002-01, Virginia Sea Grant Publication VSG-02-03, 20 pp.

"diploid" oysters) were genetically altered to be reproductively sterile to decrease the probability of a reproductive large-scale introduction of C. ariakensis. Many researchers believe that such hatchery-reared C. *ariakensis* hold the key for rejuvenating the Chesapeake Bay oyster industry.

However, several scientists who attended the symposium stated that if the management decision was made to proceed with large-scale aquaculture of triploid C. *ariakensis*, it would inevitably lead to some introduction of reproductive oysters into the Bay with unknown consequences for population growth and Bay ecology. There is also a risk of triploid reversion to diploidy. Thus, confining the triploids is a primary concern. Several biosecurity measures designed to prevent accidental release of the oysters into the Bay, including laboratory quarantine procedures, physical barriers, and chemical treatment of wastewater to kill any organisms that may escape have already been employed. Despite the promise of hatchery-reared C. *ariakensis*, many serious concerns remain.

There are also fundamental ecosystem differences that exist between states. The lower salinity levels in the Maryland portion of Chesapeake Bay create reduced disease pressures, and have kept alive the hope of restoring the native C. *virginica* species. Researchers are attempting to selectively breed these native oysters to better tolerate MSX and Dermo. In fact, during the above-mentioned symposium, Maryland state agency representatives opposed the introduction of a non-native oyster species in any form. The interspecific competition that could result between triploid C. *ariakensis* oysters in Virginia waters and selectively bred diploid C. *virginica* in Maryland waters is another serious concern.

Finally, although much of the Chesapeake Bay shellfishing industry also agrees that more scientific study is required before a decision to introduce a non-native oyster is made, most aquaculturists and fishermen wish to proceed quickly with the wide-scale introduction of the sterile triploid C. *ariakensis* to protect and enhance their commercial operations. Generally, for the long-term, they also encourage the development of a disease-free diploid stock. However, according to the joint Maryland/Virginia Sea Grant symposium report, Maryland producers are "specifically interested in diploid introduction and might oppose the introduction of a triploid without a concurrent plan for a diploid oyster" for competitive reasons. They believe that a triploid-only introduction in Virginia would "threaten their competitive stance in the marketplace and allow Virginia to get-ahead of Maryland."

Now What?

It is clear that there are many interested players in this debate, and much uncertainty in how to proceed. Policy-makers are faced with the dilemma of incomplete knowledge of the biology and life history of C. *ariakensis*, the lack of consensus among scientists as to the impacts of a non-native species on the Chesapeake Bay ecosystem, and pressure from commercial and economic interests to revive the once-vigorous and lucrative Bay shellfishing industry. There may also be questions as to how oysters will be managed on a regional basis (beyond state jurisdictional boundaries) as an introduced oyster could spread naturally or by human action along the East and Gulf Coasts.

Given the small (and ever-decreasing) population of native oysters in areas where both MSX and Dermo occur, the positive research data that point to the great ecological and economic potential of using C. *ariakensis* to both improve water quality and revitalize the commercial oyster industry, and the belief that illegal introductions into the Bay may have already occurred, it seems likely that some form of non-native oyster introduction will occur in the future unless "conclusive" evidence reveals catastrophic impacts. The only remaining question may be the form of management and control that oversee the operation. A key factor will be the establishment of a dedicated scientific research program.

Near-Term Research Program

On April 2, 2002, representatives of the principal oyster research and resource management interests in Chesapeake Bay met to deliberate priority, near-term research issues related to the possible placement of C*rassostrea ariakensis* in Chesapeake Bay. It is anticipated that the resulting research will address biological and/or ecological questions that should be answered in order to make an informed decision regarding the possible introduction of C. *ariakensis* to the Bay.

The expressed purpose of the meeting was to identify and prioritize research questions and possible approaches related to the ecological and biological functioning of C. *ariakensis* in Chesapeake Bay so that the Virginia and Maryland Sea Grant Programs and the NOAA Chesapeake Bay Office would be in a position to initiate support of research projects that would be most relevant to the issue of introducing this non-native oyster. In addition, output from the meeting was seen as complementing and feeding into the National Academy of Science study of C*rassostrea ariakensis*. The assembled workgroup did not discuss or consider policy or legal matters regarding the introduction of C. *ariakensis*.

Participants in the workgroup included the following:

a) From Virginia –
Virginia Institute of Marine Science (VIMS):
Eugene Burreson
Standish Allen
William DuPaul
Mark Luckenbach
Virginia Marine Resources Commission (VMRC):
James Wesson

b) From Maryland –
University of Maryland:
Roger Newell
Donald Merritt
Kennedy Paynter
Smithsonian Environmental Research Center (SERC):
Greg Ruiz
Maryland Dept. of Natural Resources (MD/DNR):
Chris Judy
Oxford Laboratory
Steven Jordan

c) From Federal Government -
National Sea Grant Office
James McVey

d) From Non-Governmental Organizations (NGOs) -
Chesapeake Bay Foundation:
William Goldsborough

e) Meeting Organizers –
Virginia Sea Grant – William Rickards
Maryland Sea Grant – Jonathan Kramer
NOAA Chesapeake Bay Office – Lowell Bahner
Chesapeake Research Consortium – Kevin Sellner

f) Discussion Recorders –
Paul Ticco and Pauli Hayes – Virginia Sea Grant

Research Priority Identification

The basis of discussion was provided by the October, 2001, symposium concerning C. *ariakensis* held in Williamsburg, VA, that concluded that the ultimate aspect of concern is the release of diploid oysters and possible resulting impacts, both positive and negative. Thus, the present workgroup focused on questions related to such an introduction that might lead to the establishment of a feral population; i.e. issues related to triploid production and aquaculture were not germane to the discussions.

Anyone at least peripherally involved in the question of C. *ariakensis* presence in Chesapeake Bay is aware that this is a "political hot potato" that is likely to be addressed more on state agendas than on scientific foundation, primarily because so little is currently known about C. *ariakensis*. Nevertheless, it is the intent of the research programs that supported convening of this workgroup that scientific research should be available to make significant contributions to the decision-making process. With that in mind, the group spent considerable time deliberating the pros and cons of a variety of research questions related to C. *ariakensis* in Chesapeake Bay. Many of these questions were ultimately seen as pertaining to longer-term research that is beyond the horizons of the workgroup's target and more appropriately within the realm of the National Academy of Science study.

Nevertheless, the group did reach consensus on four aspects of the issue that could be addressed in a reasonably short time frame and would provide the foundation upon which future research priorities and management considerations could be built. The following statements of opportunity describe that foundation.

a) Priority Issue #1: Possible disease/parasite introduction

This issue was viewed by the group as having the highest priority. Screening of C. *ariakensis* to date has encompassed only a search for known oyster pathogens and has not included viruses. There is a need for assessing the pathogen/parasite loadings of the oyster in its native habitat, conducting transmission and pathogenicity challenges, and histologically examining suminoe oysters that are already in Virginia.

Since the group agreed that the disease introduction issue is of primary importance, the meeting organizers decided to support an initial effort to address some of the questions related to pathogen/parasite presence in C. *ariakensis*. Eugene Burreson (VIMS) has agreed to develop a project prospectus involving a bi-state, multi-institutional team to begin working on the issue in 2002.

b) Priority Issue #2: Spawning and reproductive development of diploids

Depending upon what is known about spawning and reproduction of suminoe oysters in their native range, information will be needed as to these functions relative to conditions in Chesapeake Bay. The influences of freshwater runoff, salinity, temperature, food availability, etc., will determine the ability of C. *ariakensis* to reproduce and become established in the bay. In addition, questions concerning the "gamete sink" question should be answered in the near-term. A majority of the questions related to this issue can be conducted under laboratory conditions.

c) Priority Issue #3: Baseline ecological observations

As with Issue #2, extant information about the suminoe oyster in its native habitat should provide a basis upon which the species' ecological niche can be delineated. Such information should then be tested and verified under Chesapeake Bay biological and environmental conditions. Key questions related to this issue concern evaluating possible competition for food with the native oyster, settlement preferences for C. *ariakensis*, whether or not it builds reef-like structures, and if it could become a fouling pest.

d) Priority Issue #4: Post-settlement mortality factors

The fourth highest priority was given to matters related to the survival of post-settlement C. *ariakensis* as these factors will be key determinants of the ability of the oyster to form feral populations. This issue was also seen as leading into questions regarding competition for space and food between the suminoe and native oysters, as well as the effects of long-term exposure to existing diseases upon the suminoe oyster.

These four priorities were seen as being the first-order issues that should be addressed so that management agencies will be able to make better-informed decisions regarding the introduction of C. *ariakensis* into Chesapeake Bay waters. Working on some of these issues in the near future will also provide a foundation upon which the National Academy of Science study can build. Final policy decisions should be made using the best scientific evidence possible while taking into consideration valuable input from all concerned parties.