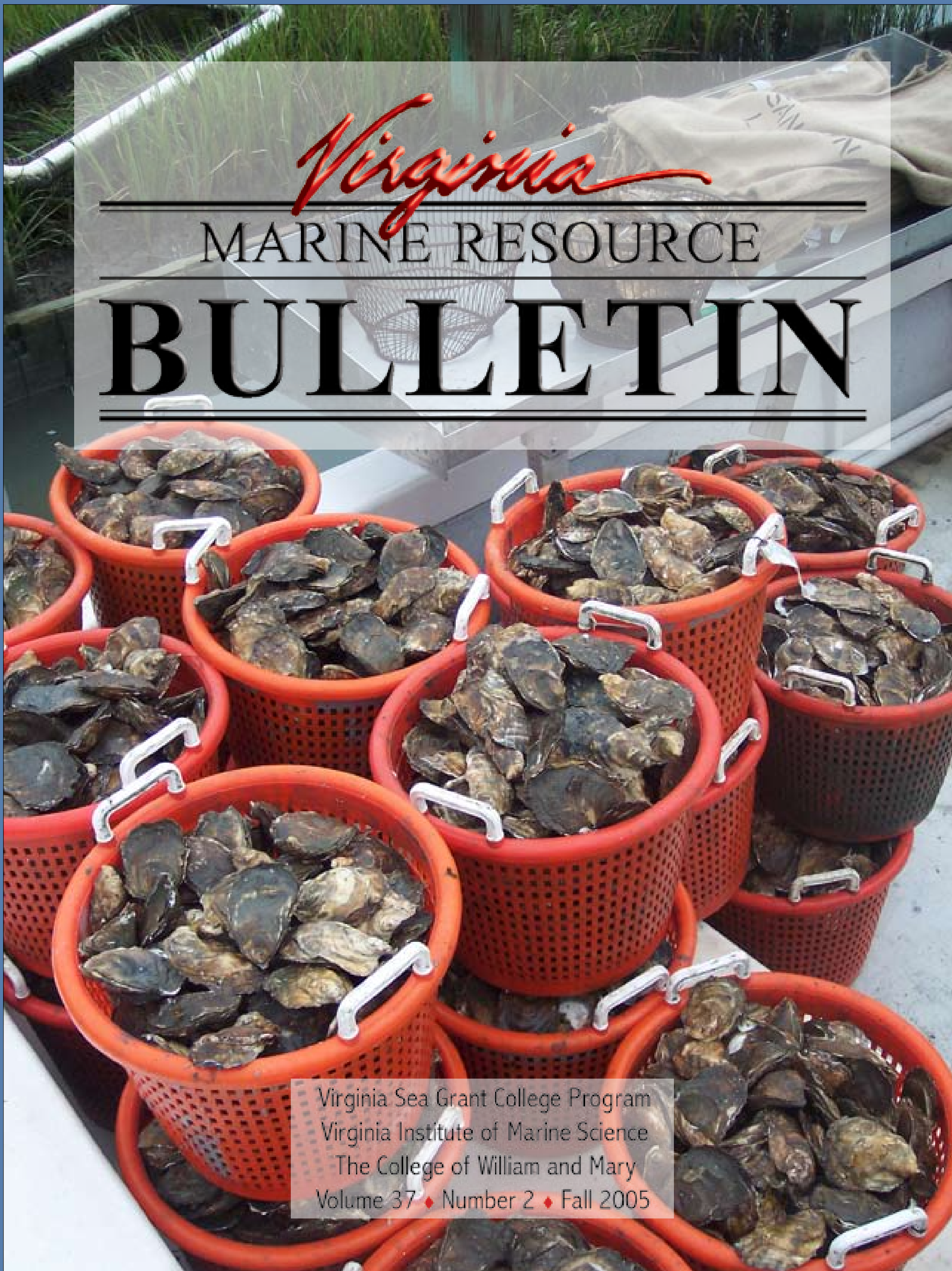

Virginia MARINE RESOURCE BULLETIN

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Virginia Sea Grant is administered by the Virginia Graduate Marine Science Consortium, whose members include the College of William and Mary, Old Dominion University, University of Virginia, and Virginia Tech. Dating back to 1966, Sea Grant is a national partnership of university, government, and industry focusing on marine research, education, and advisory service.

In this issue of the *Bulletin,* we pause to chronicle a long-running study over the efficacy of culturing a non-native oyster in Chesapeake Bay waters. The timing might seem ironic, given the emphasis in the spring edition on Virginia's stepped up efforts to quell the introduction of non-native, invasive species across the state. Recall that Virginia has formed an advisory council to oversee state policy in this matter, and chief among its tasks, offer recommendations which are slated for review by the General Assembly in the coming weeks.

This particular non-native oyster, *Crassostria ariakensis,* represents possibly one of the region's most intensely scrutinized species in recent history. The discourse over its potential use in the nation's largest estuary has embraced public and private interests across the country, and often brought out the "top brass" to force difficult decisions along the way. Federal agencies are currently conducting an environmental impact statement (EIS), intended to broadly span a full spectrum of ecological and cultural concerns.

While talking to people who've been following this debate—citizens with no direct stake in the matter—I identified several recurring themes, which I'd like to share here:

1) All who were questioned believe that the aquaculture of oysters, in general, in Chesapeake Bay is a good practice that will benefit water quality while relieving harvesting pressures on natural oyster reefs;

2) The genesis of the idea to study a non-native oyster for potential use in the bay is rooted in the Virginia legislature, and most believe that politics is driving a push for eventual introduction;

3) Without exception, those who spoke with me believe that the introduction of *C. ariakensis* will occur in the bay, if it has not already taken place;

4) Close observers would like to see the state direct equal resources and energy into the use of a disease-resistant line, or lines, of native oyster. Those in the business believe that such an alternative—in particular, the DEBY oyster—holds great promise for aquaculture and has proven itself a superior product for the half-shell market; and

5) Most believe that the introduction of a non-native species is risky and that, given our history with other introductions to the landscape, we cannot say that benefits outweigh the risks. However, if we're going to proceed with *C. ariakensis* aquaculture, a small-scale approach utilizing tight biosecurity controls is deemed the best way to go.

At present, the undertaking of the EIS has brought things to a virtual standstill, leaving researchers to guess what the next move might be. While frustrating to many, the interruption gives all interested parties time to carefully consider the fundamental question that continues to needle us: What level of risk are we willing to accept? Because after all of the research has been completed and all of the political arm-twisting accomplished, we won't be able to know *everything* about this oyster. Instead, we must make a decision—up or down—about the intelligence of moving cautiously forward.

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COVER PHOTOGRAPH
11-month-old oysters *(triploid C. ariakensis)* from the 2003 marketing trials are headed to the shucking market.

William & Mary
VIMS
Virginia Institute of Marine Science
School of Marine Science

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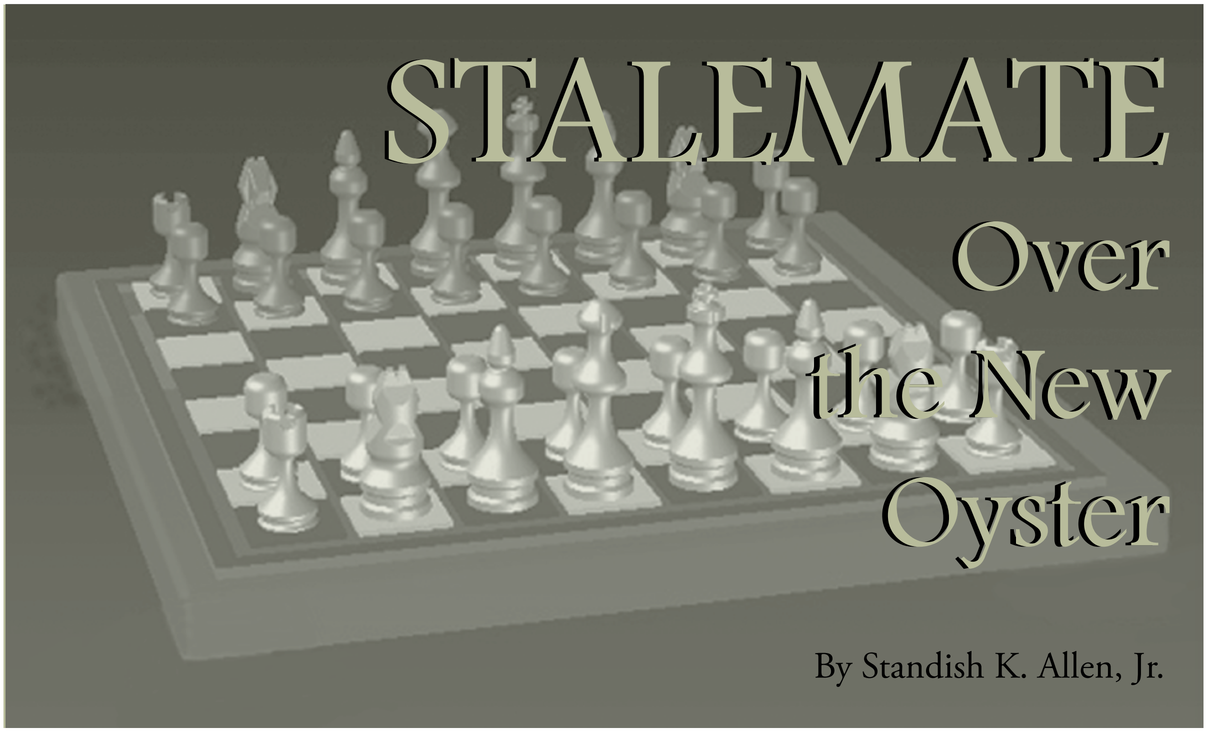


STALEMATE Over the New Oyster

By Standish K. Allen, Jr.

THE EVOLUTION OF COMMERCIAL TRIALS WITH *C. ARIAKENSIS* AND PROGNOSIS FOR THE INDUSTRY

For years, the oyster industry in Virginia has been saying that it was just one hurricane away from ruin. Because so many oysters *(Crassostrea virginica)* shucked in Virginia come from the Gulf, interruptions in supply profoundly affect business here. Unfortunately, Hurricane Katrina was the mother of all interruptions and only served to make an urgent situation more urgent.

By most accounts, Katrina damaged two-thirds of the oyster crop and wiped out or crippled major portions of the infrastructure serving harvesters, not to mention the health risks from polluted waters that had to be pumped out of New Orleans. For the Chesapeake, the statistics today are equally grim and, by now, sadly tiring to listen to: harvests down from millions of bushels to tens of thousands, loss of habitat and heavy sedimentation that impedes recruitment, lack of resolve in limiting harvests, and daunting challenges imposed by newly arrived diseases.

Perhaps a more telling statistic is the lack of major recovery of *C. virginica* populations despite significant proactive measures by federal and state agencies. For example, the Virginia Marine Resources Commission (VMRC) has built nearly 100 reefs in the Virginia portion of the bay and stocked some with adult brood stock. Major, sustained recruitment has been unrealized. A significant, cooperative effort led by the Army Corps of Engineers to build restorative reef systems stocked with disease-resistant oysters (see VMRB, Vol. 35, No.1) has only begun, but has had to contend with shoestring budgets. It's not that these programs have been unsuccessful so much as undercapitalized. That is, the scale of restoration is so immense, small-scale efforts have little chance to turn the tide on damaged ecosystems.

Meanwhile, in the time leading up to Katrina, there has been a storm of controversy brewing over the proposed introduction of the Suminoe oyster, *C. ariakensis.* This article chronicles the events leading up to and including the recently completed Virginia Seafood Council trial of triploid *C. ariakensis* – affectionately called the "million oyster march" (or, MOM). Research on non-native oysters has captured the attention of nearly everyone in the Chesapeake Bay community, and beyond. Developments behind the scenes have been equally captivating. In many cases, there have been tidal shifts in attitudes, politics, and the science surrounding this species. For the industry, it represents a possibility of redemption.

Lead in to the million oyster march

—1990—

Interest in alternative species in Virginia hails back more than a decade. In 1990, the Virginia Institute of Marine Science (VIMS, or the Institute) made the first foray into testing non-natives by proposing to the VMRC —the regulatory body that issues permits for such things—to "examine the resistance of the Japanese or Pacific oyster, *Crassostrea gigas,* to the endemic oyster diseases on the Chesapeake Bay." At the time, annual oyster harvests were about 110,000 bushels–down from the 1.3- to 3.5-million-bushel range realized between 1930-1960, caused principally by the emergence of MSX disease. The Virginia Seafood Council weighed in on the proposal, saying that only the introduction of a new, disease-resistant oyster could salvage the "almost defunct" Virginia oyster industry.

The rationale for the Institute's request was to help rejuvenate the Virginia oyster industry by trying to identify an oyster with "superior natural resistance." The underlying corollary, that "rejuvenation" would entail introduction, was seldomly explicitly mentioned. The proposal actually involved overboard testing of diploid and triploid *C. gigas.* During the permit review process, many outside groups commented on the proposal. There were many objectors, including nearly all the states on the eastern seaboard; other scientists at VIMS; and non-governmental organizations. Chief among the detractors was Maryland, who in unofficial communiqués made it clear that in-water tests of non-natives may just invoke a class action suit. Almost all of the objections centered on the grounds that the research itself may lead to a sustained population of non-native oysters, with uncertain consequences to the ecology of the Bay. This theme—uncertain consequences—is still the most pervasive dissuasion for non-native introduction today. Ultimately, the VMRC denied the request in a 2-6 vote in April 1990.

—1992—

In 1992 the Institute position on non-native testing mellowed with the advent of a new director. VIMS would officially no longer support the introduction of a non-native species—aka *C. gigas*—as an alternative to restoration of natural populations in the absence of a full-scale ecological assessment. However, VIMS would support continued lab research under quarantine conditions and open water testing of triploids under sufficient controls. This position—deferring on diploid introduction but supporting quarantined lab experiments and careful in-water testing with triploids—is essentially the current VIMS position regarding *C. ariakensis* research and development[1], although there are some important differences regarding commercial trials that will be explained later.

The proposal to test disease resistance in *C. gigas* was revised so that overboard challenges would use only triploid individuals (see next page). The new proposal using triploids met with generally the same detractors. However, the use of triploids to prevent inadvertent reproduction during testing carried the day with the VMRC. Another major difference between the original and revised requests was the rationale. Rather than the imputed goal of rejuvenating natural populations using *C. gigas,* the revised proposal maintained that the finding of disease resistance in *C. gigas* could direct future breeding programs or genetic manipulation of *C. virginica.* In the final vote, VMRC commissioners granted permission by a 6-2 margin.

VIMS and the Rutgers' Haskin Shellfish Research Laboratory in New Jersey conducted the first research studies collaboratively using triploid non-natives in the field in 1993. Triploid *C. gigas* were placed in Delaware Bay and the York River. These tests were quite limited because of the need to individually certify (as triploid) each and every oyster destined for the field. The study established that *C. gigas* was highly resistant to MSX disease compared to *C. virginica.*

It's important to note that this use of triploids as an advance warning system for a possible diploid introduction is a first for marine introductions. For example, the International Council for the Exploration of the Seas (ICES) developed a Code of Practice on Introductions and Transfers of Marine Organisms that carefully outlines the steps to be followed during introductions, such as an introduction of *C. gigas* or *C. ariakensis* into the bay. In the guidelines, the "introduction" step (there are many precursors to this one) says that "(d)uring the pilot stage, the progeny, or other suitable life stage, should be placed on a limited scale into open waters to assess ecological interactions with native species, and especially to test risk assessment assumptions."[2] Actually, this "limited testing" is exactly the step that drew the most objections in the 1990 proposal. Because oysters reproduce by broadcasting their gametes into the water, there is effectively no way to prevent them physically (e.g., like a cage) from spreading their progeny. Sterile triploids, on the other hand, effectively act as a genetic "cage" so that "limited testing" does not equate to de facto introduction. It also opens the possibility of much larger scale tests of non-natives than reasonable with diploids alone.

—1995—

Non-native research in Virginia was impelled further in 1995 when the Virginia General Assembly passed "House Resolution No. 450 requesting the Virginia Institute of Marine Science to develop a strategic plan for molluscan shellfish research and begin the process of seeking necessary approvals for in-water testing of non-native oyster species." The chief patron on this bill was W. Tayloe Murphy, now Virginia's Secretary of Natural Resources. If there ever was an implicit mandate for the introduction of a non-native oyster, this was it. We can only assume that the rationale behind the resolution, which included "WHEREAS, it is in the interest of the Commonwealth to determine whether species not native to Virginia waters could play a role in the shellfish industry" was enabling and intended that if good things were discovered about non-native oysters—any non-native oyster—the corollary action was to develop it for the benefit of the industry. In fact, the General Assembly required that the strategic plan address critical points on natural processes (diseases, habitat) affecting shellfish culture; economics; and research in genetics, selective breeding, aquaculture, and non-native species.

Taken as a whole, the charge to VIMS seems clear. Evaluate where we are with our shellfish resources, get a handle on the oyster disease issue, get an aquaculture industry started – even if it means using a non-native species, and tell us what it will cost. VIMS was directed to "complete its work in time to submit its findings, including a report on the progress in seeking approvals for in-water testing of non-native species, to the Governor and the 1996 Session of the General Assembly."

The "Strategic Plan for Molluscan Shellfish Research; including a rational plan for testing application of non-native oyster species" was submitted and comprised two parts. The first part—the strategic plan of shellfish research—defined the most important issues as restoration of native oyster resources (and maintaining other shellfish resources), development of shellfish aquaculture, and determining the significance of shellfish in ecosystem function. The second part—seeking approval for in-water testing of non-native species—was the sticky part. Having already been rebuffed at VMRC hearings for in-water testing of reproductive *C. gigas,* the "rational plan" proposed specific research to start looking at non-native species with superior disease resistance using only triploids. The species chosen: *C. gigas* and *C. ariakensis.* Ultimately, the General Assembly funded only the non-native research part of the "rational plan."

—1996—

The first candidate species out of the starting blocks for the "rational plan" was *C. gigas* because the breeding stocks to make "natural triploids" (see "Polyploid technology and natural triploids") were available from Rutgers. Triploids were deployed in three locations under careful watch and grown for about 18 months.[3] While it was pretty clear that *C. gigas* was resistant to the bay's major diseases, its growth was unremarkable and product perception somewhat repulsive to the East Coast oyster industry.

—1997—

While research with non-natives was underway on the strategic plan, the General Assembly established the Aquaculture Genetics and Breeding Technology Center (ABC) at VIMS in 1997, in recognition of the role that genetic research and selective breeding play in aquaculture development. ABC was expected to play a strong role in economic development as well, promoting a "rejuvenated" oyster industry through aquaculture, for which breeding is highly appropriate. Probably, the General Assembly saw ABC as the mechanism to address the strategic points not funded overtly. It can be argued that with its emphasis on genetic manipulation, breeding, and non-native resources, ABC was the first explicit expression of the intent to use non-native species or their constructs as the basis of aquaculture (economic) development.

ABC began to embark on a systematic accumulation of brood stock – native and non-native, wild and genetically manipulated (i.e., through polyploidy) – as the basis for moving native and non-native aquaculture forward. It is axiomatic that ABC acted and is acting as the enabler of technologies for continued research and commercial experimentation with *C. ariakensis.*

All growers used clam relay cages during the first seafood council trial – providing a veritable fortress against predators and storms. Inside the cages, non-native triploids were further enclosed in PVC bags.

POLYPLOID TECHNOLOGY
AND NATURAL TRIPLOIDS

Triploid oysters were first produced by chemical means, which is another way of saying they were induced to become triploid just after the egg was fertilized. In practiced hands, induced (or "chemical") triploid manufacture produces 85-95% triploidy in the seed, leaving, of course, as much as 15% diploid. This is far too high a percentage of diploids to consider them useful in population control, where the principal concern is keeping the crop sterile.

Fortunately, triploid aquaculture is enabled by the development of tetraploid oysters. Tetraploids have four sets of chromosomes. Tetraploids are fertile and therefore can be crossed with normal diploids to create sterile triploids. Triploids created in this way are referred to as "natural" (or genetic) triploids. Although vastly better than "chemical" triploids, natural triploid production also is not perfect, with the incidence of diploids ranging in the neighborhood of 0.1%.

—1998—

Next in the queue for the "rational plan" was *C. ariakensis.* Unfortunately, in 1998 tetraploids were not yet available, so "natural" triploids could not be produced for field trials (see "Polyploid technology and natural triploids"). Instead, less robust "chemical" triploids were produced and screened individually, assuring that each and every one was triploid at deployment. Triploids were compared with diploid *C. virginica,* admittedly not a very fair comparison. The findings clearly showed a lower prevalence of diseases, lower mortality, and a faster growth rate in *C. ariakensis.* A second, related VIMS experiment started a year later with "chemical" triploids to gauge the long-term stability of triploids over time and to test consumer reaction to the product. Although consumers could distinguish *C. ariakensis* from *C. virginica,* the difference was sufficiently small to demonstrate that the non-native could "slip stream" marketing channels that existed for the native oyster.

Small-scale industry trials

When it became clear that *C. ariakensis* had some key commercial traits—disease resistance and fast growth principal among them—industry members wanted to experience this for themselves in controlled aquaculture trials. The VMRC's Jim Wesson, Department Head for Conservation and Replenishment, led the effort to establish commercial field trials. The Institute provided triploids and technical support.

In 1999, ABC had succeeded in producing a precious few tetraploid *C. ariakensis.* These tetraploids were used to make triploids for commercial trials. There would be no more tetraploids available until 2003. The 2000 industry trials consisted of 600 "natural" triploid *C. ariakensis* deployed at five locations. All sites used clam relay cages, heavy steel cages that rest on the bottom. The oysters themselves were contained in ADPI bags – standard plastic mesh bags that are used all over the world for oyster culture. Oysters were deployed in August and the project was completed when they reached market size.

It's instructive to review the process that was used to vet the first seafood council project and take a census of the attitudes in 2000. It reveals the nature of regulatory authorities, as well as the role(s) that VIMS has played for industry to accommodate their requests. Trials with non-native oysters require a VMRC permit under the statute regulating introduction of non-native marine species in Virginia. VSC makes the request typically in the form of a proposal. The VMRC is obliged, under Chesapeake Bay Program policy, to notify the Living Resources Sub-Committee who then form an ad-hoc committee to review the permit request for a non-native introduction. Since the ad-hoc panel is comprised of representatives from all Chesapeake Bay watersheds and two or more outside members, the proposal gets intense scrutiny. The recommendations of the ad-hoc panel returned to the VMRC but are advisory only. The formation of the ad-hoc committee is supposed to be for first time introductions; however, this particular committee has reviewed every request from the Institute and the VSC to put non-natives in the water since 1996.

In response to the VSC's 2000 request to deploy triploid *C. ariakensis,* the ad-hoc committee recommended against permitting unless specific management and oversight criteria were met.

In addition to the ad-hoc review, VIMS hosted a meeting to review the VSC proposal a couple of weeks before the VMRC hearing, inviting all stakeholders within Virginia and state representatives along the eastern seaboard. New Jersey, Delaware, and Maryland were opposed to the trial. In particular, then Assistant Secretary of Natural Resources for Maryland was especially vocal. Nervous that the proposal was premature and would lead to larger projects, Carolyn Watson went on record to say that "Maryland is opposed to non-native introductions" and asked the VMRC to deny the request.

The Institute's final recommendations to the VMRC incorporated those of the ad-hoc panel. VIMS also agreed to collect the scientific data that the ad-hoc panel had requested, provide a disease analysis at the end of the trial, and provide triploid *C. virginica* controls to compare with triploid *C. ariakensis* (the latter being a recommendation of the Chesapeake Bay Foundation, or CBF). One can begin to see how the VSC project started to engage the Chesapeake Bay community in ways that the academic, research-only trials of VIMS had not. The VMRC later approved the request by unanimous vote.

Although there was a lack of hard data, all participants were able to achieve market size oysters by May of 2001. Most all of the triploid *C. ariakensis* survived, while more than half of the triploid *C. virginica* did not. It was about this time that the industry really sat up and took notice of the potential latent in this non-native species. It was also about the time that industry adopted their new mantra about *C. ariakensis*: "They grow fast, they taste good, and they don't die." VIMS was able to demonstrate that "natural" triploids were in fact more robust genetically than "chemical" triploids that had been used in years past.

Based on the successes from the 2000 VSC trials, another was proposed by the seafood council, this time with 60,000 oysters distributed to 13 different growers. The seed were actually left over from the 2000 spawn. The big variable in this study was that each grower chose his own culturing method. Again, the proposal was scrutinized by the ad-hoc committee and similar recommendations were made and followed. By the end of the trial, most everyone currently in the Virginia oyster industry had acquired some direct or second-hand experience with *C. ariakensis.*

C. ariakensis hits the radar screen

By the end of 2001, the industry was clearly interested in scaling up production of *C. ariakensis.* Although there had been some pressure from watermen for a diploid introduction, the majority of the industry was now committed to proceeding with triploid *C. ariakensis* aquaculture. This is more than a subtle distinction. Triploid aquaculture has been proffered by the Institute and ABC as an intermediate solution between the black-and-white of "do not introduce" and "full-scale introduction with fertile non-natives." Triploid aquaculture would require significant investment by the private sector; it would require upgrades of almost all oyster culture facilities in Virginia; it would require regulations on biosecurity to deal with the growth of the new industry. Yet, the industry was willing to proceed with triploids, realizing that there were unknown and possibly unknowable consequences of a full-scale introduction that would delay that decision for some time.

In October 2001, with the rising tide of interest in triploid aquaculture, ABC organized and hosted a symposium on "Aquaculture of Triploid *Crassostrea ariakensis* in Chesapeake Bay." A broad representation of stakeholders attended, including industry members, scientists, policy, and regulatory groups. The purpose of the symposium was to apprise all stakeholders of the current state of the art in triploid *C. ariakensis* aquaculture and discuss the intention to move forward by scaling up production. It was here that stakeholders heard loudly and clearly that the Virginia seafood industry intended to move ahead, aiming at hundreds of millions of oysters within five years. Perhaps it was here that many realized that this issue transcended Virginia's portion of the Chesapeake Bay and would be appropriate for a National Academy of Sciences (NAS) review. Appropriate or not, such a study would cost $300,000 and it was clear the watermen weren't going to pick up the tab.

Soon after the symposium, position statements on the use of *C. ariakensis* in the Chesapeake Bay were issued by VIMS, the University of Maryland Center for Environmental Science, and CBF. Rats and a sinking ship come to mind. To paraphrase the VIMS statement, this time with a commercial twist: fertile diploids introduction is ill-advised at this time. Sterile triploids have demonstrated their value for economic development but will require due diligence and improvements in biosecurity. Carefully designed commercial trials will provide information on the long-term aquaculture potential and the ecological impacts of *C. ariakensis* and is consonant with the Institute's role in the Commonwealth.

As if in counterpoint, the Virginia General Assembly session in early 2002 passed "House Joint Resolution No. 164," turning up the heat on the *C. ariakensis* issue. The General Assembly resolved that whereas the oyster resources were so bad and triploid *C. ariakensis* aquaculture so promising, they would proclaim their "support for the continuation of efforts to establish commercial aquaculture production of genetically sterile *Crassostrea ariakensis.*" They also proclaimed that if research to assess the ecological risks of introducing *C. ariakensis* fails to prove that the species will be harmful to the public waters of the Commonwealth within 3 years [from 2002], "the General Assembly requests the introduction of the reproductive disease-resistant *Crassostrea ariakensis* into the public waters of the Commonwealth pursuant to guidelines and parameters established by" the Institute and the VMRC.

Credit Ann Swanson of the Chesapeake Bay Commission and Mike Fritz from the Environmental Protection Agency (EPA) for much of the work in parlaying the funds for the NAS study. By March 2002, Swanson announced that funds had been pledged from three federal agencies (NOAA, Fish and Wildlife Service [FWS], and EPA), the states of Maryland and Virginia, the Maryland and Virginia Sea Grant programs, and the Fish and Wildlife Fund.

It's hard to convey the sense of calm that the NAS study brought to the stakeholders – well, most of the stakeholders, save for industry perhaps. The overall feeling among the backers of the NAS study was a sense that the *C. ariakensis* situation was a run-away train. Here, this one small group of Virginia seafood business people had elevated the discussion of introduction of *C. ariakensis* to an international level. On the other hand, there was also a sense of false hope placed on the NAS study because many thought that it would resolve the issue of whether or not introduction was a good idea. Instead, the NAS deliberated three management options: 1) no use of non-natives, 2) open water aquaculture of triploid oysters, and 3) introduction of reproductive, diploid non-natives.

The last, rather precipitous event prior to the successful "million oyster march" of 2003 was the unsuccessful VSC proposal to plant triploids in 2002. Serendipity had a lot to do with this event. By 2002, the VSC was raring to plant increasingly greater numbers of triploid *C. ariakensis* and proposed placing a million oysters among 39 different participants in Virginia (about 25,000 oysters each) for the purpose of assessing economic potential of triploid *C. ariakensis* aquaculture. Three major problems were identified with this proposal and shared among all reviewers: First, because there were no tetraploids available, the proposal had to rely on "chemical," or induced, triploids. (The few tetraploids produced in 1999 were all used for the 2000 spawn and attempts to make more were unsuccessful until the spawning season of 2002.) That meant that there would be in the neighborhood of 50,000-100,000 diploids scattered among the triploids (figuring 90-95% triploidy obtained by the chemical treatments). Second, although ostensibly the study was designed to establish the economics of triploid *C. ariakensis* aquaculture, there was a lack of description for data collection and the specific economic analysis to be used. Third, the number of participants (39) and the prognosis for oversight provoked objections, especially because a number of participants were inexperienced with oyster culture.

The VSC withdrew its request before the VMRC hearings. Although this was undoubtedly a painful experience for the Virginia Seafood Council, in retrospect it probably served an important function in structuring a much more successful 2003 proposal. In fact, the director of VIMS at the time offered the VSC technical assistance in crafting the next draft.

The National Academy of Sciences began its landmark study on *C. ariakensis* in June 2004.

Large-scale tribulations of MOM

The revised, 2003 proposal from VSC included important changes. First, triploids would be "natural" triploids produced from mating tetraploids with diploids, assuring a very low proportion of accidental diploids among the crop. Second, a refined description of the economic analysis to be accomplished on the project would be designed by economist Tom Murray with the Sea Grant Marine Advisory Program (see accompanying article). Third, the number of participants would be whittled down to ten of the more accomplished and experienced industry members. A fourth refinement was the addition of a project manager to assist, oversee, collect economic data, and liaise with scientists and regulators. This position turned out to be key (see page 11).

Still, all were not in agreement. The Institute had few issues with the proposal because it had assisted with its preparation. CBF was "pleased with the changes" that enabled them to offer their full support. The ad-hoc panel was a bit more critical and could not accept the proposal as written, but would support it with modifications. Ultimately the ad-hoc panel's list of concerns were passed on to the VMRC in February 2003 in advance of its public hearings.

One day after the date of the ad-hoc panel report, VMRC Commissioner Pruitt received a letter jointly signed by the EPA, Fish and Wildlife Service, and USDA Forest Service recommending "that further deployment of *C. ariakensis* should not be authorized." Normally, a letter like this would be advisory only. But there was an additional hurdle for the VSC proposal to pass this year – the seafood council had to get an Army Corps of Engineers (ACE) permit to deploy the aquaculture structures that would hold the triploid *C. ariakensis.* As such, the ACE had to open their permitting process to public comment, during which time federal agencies could contribute comments and objections.

For much of the spring, there was no concurrence about whether or not—or under what conditions—to issue the ACE permit to the VSC project. At one point, one or more of the federal agencies threatened "elevation" of the permitting process, which almost assuredly would have postponed things. Elevation is basically equivalent to passing the buck up the chain of command and having a higher-level official deal with the problem. There was no way around getting an ACE permit and, therefore, no way around heeding the federal agencies' objections about the project.

Almost at the last minute, and to avoid elevation, there was an intense series of negotiations and discussions about the risks entailed in the trial. Essentially, the risk boiled down to one primary consideration – the risk that by culturing triploid *C. ariakensis* in large numbers, the oysters would inadvertently establish a self-sustaining (i.e., reproducing) population.

How can this happen using triploids? The real-life fact of the matter is that the tetraploid-diploid cross is extremely effective, but not perfect, meaning that some low frequency of diploids is found in every batch of triploids. How low is the frequency? Up to this point in time, VIMS had only spawned one batch of "natural" triploids, the ones used for the 2000-2001 studies. The Institute knew from all the sampling during that project that four diploids out of 3,643 sampled had been discovered, so it seemed that the effective rate of triploid production was around 99.9%, or one in 1,000. One in a thousand has since become the minimum expectation for every triploid spawn deployed in the field. Of course, one in 1,000 sounds low until you consider that in one million oysters, there will possibly be 1,000 diploids among them.

Probably the single most effective tool in dealing with the federal agencies' insistence on estimating and reducing the risk of triploid *C. ariakensis* trials was a probability model assembled specifically for this purpose by Dr. Mark Luckenbach, using demographic (population) parameters developed by Dr. Roger Mann, both of VIMS. VIMS, along with the project manager, played an enormous role in mitigating and negotiating the risk factors with the federal agencies in order that the Virginia Seafood Council get their required permit.

The model basically addressed the following problem. If you had one diploid among every 1,000 and deploy 100,000 at each site (originally specified for 10 sites), what are the chances that one male and one female diploid will be in close enough proximity to spawn and produce offspring that themselves will live to reproductive size? (Refer to "biosecurity" on page 14.) There are many variables and many unknowns, especially with *C. ariakensis* biology, but the model at least allowed the best available science to estimate the relative risk of various aquaculture methods. The so-called "Luckenbach model" became a driving force in this and subsequent permit negotiations.

In the end, compromises were reached and provisions imposed on the trial to be executed by the participants, the project manager, and the ABC. When the VMRC and the Corps permits were issued, each included 13 provisions for the study as follows:

- ♦ End date of April 1, 2005, although the ACE permit ended June 30, 2004;
- ♦ Semi-annual reports;
- ♦ No transfer of test animals;
- ♦ Mandatory attendance at VMRC meeting prior to deployment;
- ♦ Emergency management and inventory control plans;
- ♦ Mandatory project manager to collect data, ensure consistency, visit all sites bi-weekly, assess inventory, and apprise VMRC of progress;
- ♦ Assume full financial responsibility for retrieving lost oysters, and the ACE permit

required bonding;
♦ Monitor ploidy, gonad development, growth rates, and disease (VIMS);
♦ Certify no more than one diploid in 1,000 triploids in the spawn (VIMS);
♦ Oyster to be a spaced in such a way as to minimize the possibility of reproduction (determined by Luckenbach model);
♦ Quality Assurance / Quality Control plan to be prepared for all required data (VIMS);
♦ Tissue samples from hatchery breeders to be archived for possible forensic work later [in the event of a release] (VIMS); and
♦ Sharing of all data with the state/federal environmental impact statement (EIS) process.

Finally, there was a stipulation, originally raised by the ad-hoc panel, that should recommendations arise from the NAS panel, they would be immediately incorporated into the overall recommendations. Although the NAS Committee on Non-native Oysters in the Chesapeake Bay had only just convened, they did weigh in. In a letter to Commissioner Pruitt of the VMRC, the NAS articulated their concerns about the trial. "If the Commission decides to approve a 2003 field trial, the committee strongly recommends amending the proposal to include measures to reduce the risks described above and require collection of scientific data necessary for assessing the risk of introducing this non-native oyster. For example, more information is needed on the reproductive cycle of *C. ariakensis* in the field, the causes of mortality events, the fidelity and stability of triploid induction, and the growth rates at different locations under various deployment methods." These recommendations clearly invoked the Institute's expertise.

In an irony of ironies, while permit negotiation and discussions about the VSC trial were going on, newly elected Maryland Governor Ehrlich was preparing to announce his intentions to seek the introduction of fertile, diploid *C. ariakensis.* That announcement came in June 2003. This was a 180° shift from the early days of "Maryland is opposed to non-native introductions." Frankly, it helped place the VSC trial—even with a million oysters—in quite a moderate light, taking it from left to center in the spectrum of the non-native oyster controversy.

There was one final element that fell into place exactly in time for execution of the VSC trial. In retrospect, this one coincidental development seems improbably fortunate, because without it, many of the provisions would have been difficult, at best, to fulfill. Virginia's Center for Innovative Technology was able to obtain funding to develop triploid *C. ariakensis* aquaculture in early 2003, at exactly the right time for VIMS to be able to commit to

PROJECT MANAGER

The project manager for the million oyster march was A.J. Erskine, now working with Bevans Oyster Company and Cowart Seafood Corp. in a joint venture, oyster culture project. Installation of a project manager was a key reason for the success of the Virginia Seafood Council trial, and this position has been incorporated in the council's next project as well. Erskine was responsible for insuring that data were collected from all industry participants on a regular basis, facilitating compliance with the spacing and stocking of triploids for biosecurity reasons, record keeping, and emergency management plans. He visited the sites at least every other week. He also participated in the biosecurity negotiations with the Institute and federal agencies and assisted in the VIMS portion of the project. Erskine reported to the VMRC and the ACE—the permit issuing authorities. His position was funded through Virginia Sea Grant's Fishery Resource Grant Program.

all permit provisions concerning the collection of data, due diligence on the triploids, and monitoring, including NAS recommendations. Specifically, this funding now enabled VIMS to carry out two important functions in parallel to the trial:

♦ A quantitative assessment of industry trials of *C. ariakensis,* comparing them to triploid, disease-resistant *C. virginica;* and

♦ Improve biosecurity for the research of non-native oysters in Chesapeake Bay.

Large-scale industry trial

In early June 2003 a batch of triploids was produced at VIMS by crossing tetraploid males with diploid females. The oysters were grown through to setting and, as per the provisions of the permit(s), assayed for incidence of diploids. In order to determine in a statistically valid way whether this batch met the criterion of no more than one diploid among 1,000 triploids, 3,000 oyster spat were tested. In this first batch, ABC determined that there were four diploids among the 3,000. This exceeded the criterion by one diploid, and in so far as these biosecurity protocols had been so ardently negotiated, there was no option but to repeat the spawn and hope for better results the next time. In fact, ABC conducted three more spawns simultaneously. The next triploid spawn examined had two diploids among 3,004 and was duly certified as "biosecure."

Re-spawning delayed deployment until early fall 2003. This had two major repercussions, one good and one not so good. The delay was fortunate because in September of 2003, Hur-

Aquaculture has increased about 10-fold since industry trials with non-natives began. Some growers have scaled up in anticipation of triploid aquaculture by investing in infrastructure like the floating upweller system shown above. Here, A.J. Erskine (former project manager for the VSC trials), cleans upwellers for the joint-venture operation located in the Coan River.

***Top**: Harvest time! One-year-old triploid C. ariakensis from a low salinity site (2003 trials) are being processed at a local shucking plant. Here, the oysters are loaded into a hopper which distributes them to the awaiting shucking team by a conveyor system.*

***Bottom**: Shucked triploid C. ariakensis provided a much needed source of oyster meats for some processors during the VSC trials. Here, pails of shucked meat are at the window awaiting their weigh-ins. The meats are then dumped into larger containers as they begin the first step in the packing process.*

ricane Isabel ripped through Chesapeake Bay. Had the first spawn passed muster, *C. ariakensis* seed may have been in the water at the time. Storm damage, of course, was and remains a principal biosecurity concern for triploid non-native aquaculture. Isabel did, however, cause enough damage to two of the prospective sites that those growers had to withdraw from the trial, leaving eight to receive 100,000 triploid *C. ariakensis* seed each.

The less fortunate repercussion stemming from the delay in deployment was that, at some sites – particularly the lower salinity ones, all *C. ariakensis* did not reach market size by the ACE permit cut-off date of June 30, 2004. Long story short: the VSC had to apply for an extension of the ACE permit in spring 2004, which opened up a new round of biosecurity negotiations with federal agencies. Ultimately, the extension was granted although it entailed even tighter restrictions on grow-out methods. The seafood council was allowed to keep animals in the water until May 2005, if needed.

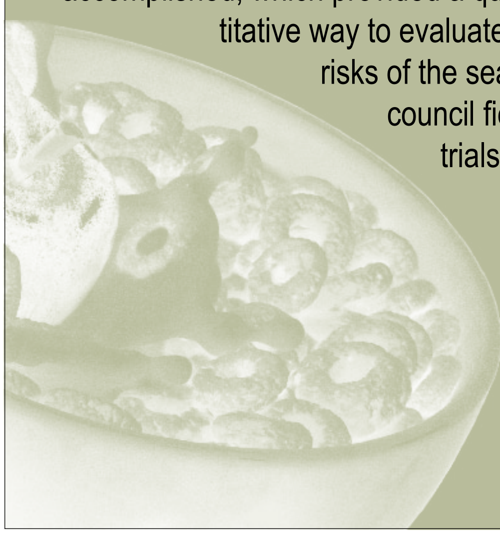
The rest of the story of MOM is one of eight growers, with the able assistance of the VSC project manager, diligently conforming

BIOSECURITY

Imagine a huge bowl of (let's say a million) Cheerios®. Now imagine that one in a thousand is a colored Cheerios®. Half the colored Cheerios® are blue (male) and half, pink (female). Reach into the bowl and randomly grab 200 and put them in an empty baggie. Do that again 500 times. If you happen to grab two colored Cheerios® in that 200, and one is blue and one is pink, then you are on the road to an environmental apocalypse, or so some would say.

You now have a sense of the negotiations between the Virginia Seafood Council and federal agencies regarding triploid aquaculture. In this example the colored Cheerios® represent the diploids scattered among the (uncolored) triploids. And of course it takes two different colored Cheerios® in a bag (cage) to make more Cheerios®, if in fact the baby Cheerios® survive to maturity.

Putting the laws of probability together with the probabilities of survival throughout various life history stages of an oyster (or a Cheerios®) is what the Luckenbach model accomplished, which provided a quantitative way to evaluate the risks of the seafood council field trials.



to the precepts of the trial to grow their triploid *C. ariakensis* seed to market size. Murray and Hudson summarize results of the trial in the accompanying article. During the entire course of the VSC trial, ABC displayed current data on its web page devoted exclusively to the VIMS portion of the work.[4]

Prognosis

In spring 2005, just as the trial was ending, the VSC proposed another trial, also with one million oysters to be deployed among 10 sites, "MOM II." The principal question that VSC was asking: Can we get triploid *C. ariakensis* to market size in one year, thereby entertaining the notion of a one-year crop rotation?

When the proposal was presented to the ad-hoc panel in early 2005, the difference in receptivity was almost overwhelming. In years past, these proposals and the ad-hoc panel seemed almost antagonistic, with non-native aquaculture embroiled in a conflict between economic recovery and ecosystem preservation. This time around, however, the project was welcomed. There was even a comment inviting such projects on a regular basis (i.e., yearly).

What happened? Several things. First, and to the credit of the VSC, the first MOM went off without a hitch. Growers were compliant, the project manager was diligent, valuable data were obtained, and the economic and biological results were encouraging. There were some discouraging data too, such as severe mud-blistering in some of the oysters at some of the sites (due to the polychaete worm, *Polydora*) and lack of shelf-life in *C. ariakensis* that limited marketability in remote markets. But all of it was out in the open and transparent – good and bad.

Second, the NAS report came out in the interim between the beginning and end of MOM (NAS, 2004)[1]. There are many recommendations. Apropos of this discussion on commercial aquaculture of triploid *C. ariakensis,* the NAS had this to say:

"Option 2, aquaculture of triploid, non-native oysters is unlikely to solve the fishery crisis, but it is reversible, at least in its early stages, and offers more opportunity for adapting management to changing circumstances. Over the long term, the risk of establishment of a non-native oyster population increases due to the risk of diploid production from triploid stocks. Adoption of triploid *C. ariakensis* aquaculture may be perceived as progress in reversing the decline of the fishery, possibly reducing the incentive to pursue a rogue introduction. Option 2 has already received considerable scrutiny by the CBP and its member states and federal agencies. Limited field trials have been completed in Virginia and North Carolina and larger trials are in advanced planning stages. The risks of proceeding with triploid aquaculture in a responsible manner, using best management practices, are low relative to some of the risks posed under the other management options. Strict standards and protocols are required to reduce risks and enhance benefits of this course of action."

Clearly, while not endorsing any particular level of triploid *C. ariakensis* aquaculture, the NAS report was receptive to the cautious, remedial activities that the seafood council was up to.

Finally, another factor in the overall change in attitude about triploid field trials is the fact that there are now clearly established mechanisms in place to mitigate the risks of a trial through biosecurity.

The MOM II proposal was also scrutinized by the federal agencies since another permit (or at least an extension of the last one) was needed from the ACE. While ultimately the permit was granted with far less rancor, it has to be said that the provisions for preventing reproduction became a lot more restrictive. Part of the reason is, apparently, that federal agencies are managing for cumulative risk. That is, the last trial had a discreet probability that reproduction occurred, so now let's add that probability onto the permit forthcoming. The trend is clear, and one has to wonder how a cumulative risk management approach will impact the prognosis for commercial scale aquaculture. To be clear, the VSC trials underway today in no way reflect the scale or methods of commercial aquaculture that growers would like to undertake.

To some in the industry, producers should be growing in the range of 200,000 bushels of oysters (~50,000,000 oysters) at minimum, simply to realize the number required to stabilize the industry during the current EIS process. This speaks nothing of where the industry might go if full-scale, triploid *C. ariakensis* aquaculture is allowed. The industry, with the aid of the ABC, is gearing up for that level of production. In a letter to the VIMS director in December 2003, Secretary Murphy requested that the Institute develop a plan for the large-scale deployment of at least 200,000 bushels of sterile non-native *C. ariakensis* on leased bottom. That plan, produced in conjunction with industry members and the VMRC, has been written. It sits.

The 2003 request by Murphy is reminiscent of the 1995 House Resolution No. 450 requesting that the Institute begin seeking necessary approvals for in-water testing of non-native oyster species, to which Murphy was chief patron. If Resolution 450 was the harbinger for MOM, is Murphy's request the portent of commercial aquaculture?

The answer to this question all boils down to "uncertain consequences"; that is, the risk that such activity may lead to a sustained population of non-native oysters. And more specifically, what are the metrics of that risk? Are we going to apply the Luckenbach model that was developed explicitly for MOM-sized trials that are admittedly "uncommercial" by their restrictive provisions? Or, should we apply some meta-risk analysis in which we concede that some reproduction (from the

0.1% diploids) is likely, but monitor population growth (if it grows at all) and eventually try to mitigate the spread? Ultimately, it is a question of "what threshold of uncertainty we are willing to accept" as highlighted by Dr. Luckenbach in an earlier write-up on MOM (VMRB Vol. 35, No. 2). But unlike the introduction of diploid *C. ariakensis,* where the risks *and* benefits are unknown, triploid aquaculture seems clearly has enormous upside potential with arguably less risk. Thus, in a cost-benefit analysis, diploid introduction is not equivalent to triploid aquaculture – even with the possibility that some may reproduce.

At present, the impetus for triploid *C. ariakensis* aquaculture in Virginia is at a stalemate between completion of the EIS (and its uncertain, final voice) and small-scale trials that are strictly regulated by stringent risk analysis. There seems no certain way to proceed and the industry is flummoxed about how to get the agenda "off the dime," when things are looking even more desperate than usual, and more hurricanes are churning off the coast.

END NOTES:

[1]http://www.vims.edu/abc/documents/useof_caria.pdf

[2]http://www.ices.dk/reports/general/2004/ICESCOP2004.pdf

[3]http://www.vims.edu/abc/EndNote1115.pdf

[4]http://www.vims.edu/vsc/

For further reading on the Suminoe oyster, visit Virginia Sea Grant at <http://www.virginia.edu/virginia-sea-grant/library.htm>.

Aquaculture of non-native oysters is common throughout the world, although none of these enterprises has been based specifically on triploid production alone, because the non-native went through full-scale introduction. In France, shown above, production of C. gigas has skyrocketed since its introduction in the 1970s. Currently, France produces over 5 million bushels of oysters based on this species. Most are grown on racks and bags, and the industry consists of a multitude of small, private farmers along the Atlantic coast. Is this possible for the Chesapeake Bay?

Testing the Waters

By Thomas J. Murray and Karen L. Hudson

The Virginia Institute of Marine Science recently teamed up with the Virginia Seafood Council to take a close look at the economics of pilot-scale aquaculture of triploid (sterile) *C. ariakensis.* Between 2003 and 2005, grow-out trials of the non-native oyster were conducted throughout Chesapeake Bay waters in varying salinity regimes (see previous article). Economic analysis and project oversight were funded through the Virginia Fishery Resource Grant Program, a program backed by the Virginia Legislature to stimulate new and efficient ways of doing business within the seafood industry.

The funds were awarded to the Virginia Seafood Council to hire a scientist to serve as project manager to oversee and facilitate the ensuing trials and coordinate the collection of economic data. The manager served as a liaison between the Institute, the seafood council, federal and state agencies, and the numerous parties interested in the research results (see page 11).

Overall, grow-out trials were designed to:

1) Determine if the growing of *C. ariakensis* oysters in Virginia's portion of the Chesapeake Bay is economically feasible for both large and small companies; and

2) Produce an initial market assessment of triploid *C. ariakensis.*

An important, third objective of the project involved the evaluation of different grow-out methods. Several types of gear were employed during the study, which enabled some comparison among methods and attendant growth of non-native oysters in the various environments where deployed. Generally, the oysters were raised in the following systems: off-bottom cages; bags on racks; long-line bags on bottom; Taylor floats; and crab shedding tanks.

A number of marketing approaches were employed, adding yet another dimension to the grow-out study results. For example, some of the larger shucking facilities processed oysters on site and sold them via established retail and food service customers. Other, smaller growers sold primarily "shell stock" oysters to retail, restaurant, and food service institutions or directly to consumers. A few of these firms also sold shell stock oysters to larger shucking houses to determine meat yields.

Running on a parallel track to the economic study, scientists at VIMS conducted a companion inquiry, using Virginia's native oyster, *C. virginica* as a control, to collect biological and ecological data on both species. That growth and mortality information, coupled with economic information gathered from the growers, yields one of the most complete comparisons to date between the two species.

General growth performance

Growth data confirm that *C. ariakensis* outperformed *C. virginica* without exception at every site, in every salinity regime. Disease sampling from all sites revealed light infections for both species, a situation that may be peculiar to the 2003-2005 seasons. However, it is also possible that triploidy, in itself, decreases the incidence of disease. Except for a couple of icing events that killed both species, mortality was relatively low, but somewhat higher in *C. virginica.*

It is likely that high salinity sites and most medium salinity sites can realize nearly 100% harvest within the period of one year. Not known is whether the same success can be realized at lower salinity sites, since growth is somewhat slower under such conditions. A

(Continued on page 20)

Bottom-line results:

♦ Sterile *C. ariakensis* deployed at all eight locations during October 2003 grew very well and generally reached market size by the spring of 2004.

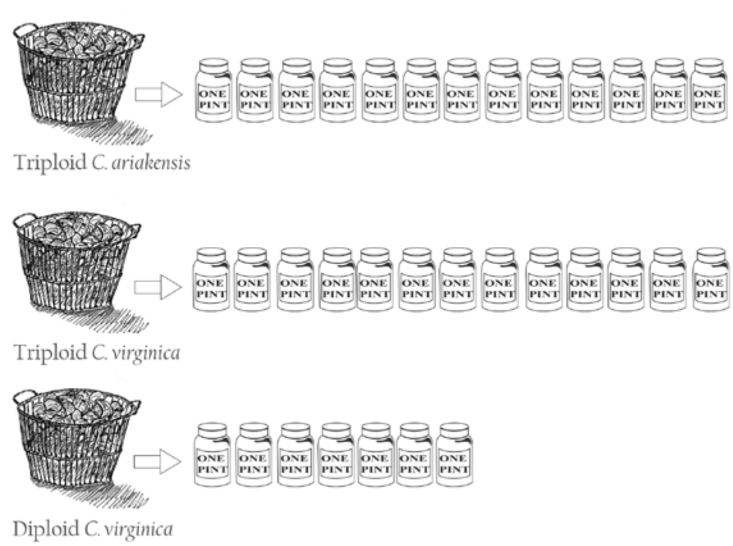
♦ Despite cooler than usual water temperatures (which potentially hurt food availability), *C. ariakensis* grew quickly once acclimated to their sites.

♦ Triploid *C. virginica,* deployed concurrently, did not experience immediate growth. In fact, *C. virginica* grew very little between the time of deployment and mid-spring, 2004.

♦ On average, across all sites the non-native oyster grew 38% faster (actual range, 15-65%) than the native oyster and suffered less mortality (7% relative to 20%, respectively).

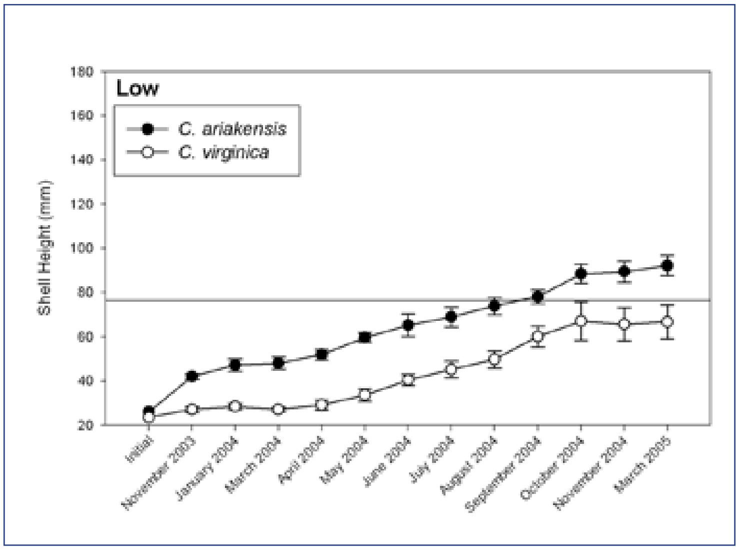
Meat Yields

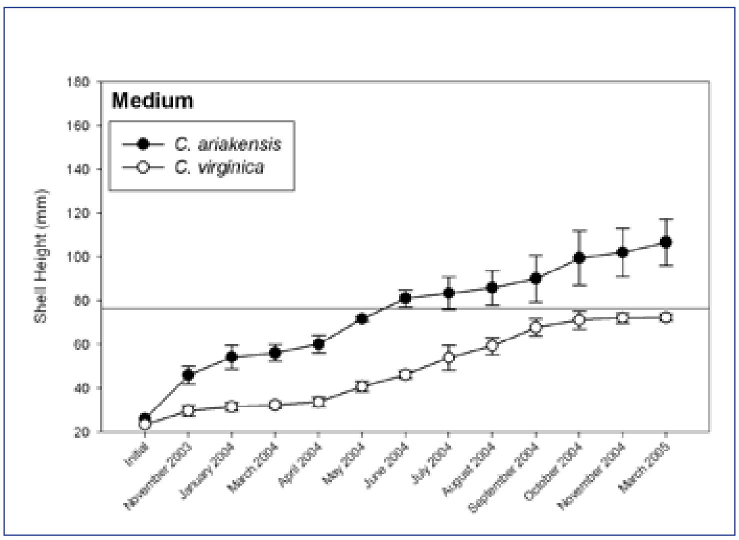
Yields of meat for packing from triploid oysters — regardless of species — are higher than that of diploids, which lose condition in the summer and early fall. Although yields of triploid C. ariakensis and triploid C. virginica are mostly equivalent at similar sizes, triploid C. ariakensis grow much faster in higher salinities, so that yield per year could be double that of C. virginica. The 2005 industry trials are determining whether one-year, market-sized animals can be obtained with triploid C. ariakensis.



Growth in Shell Height:

Million Oyster March Marketing Trials

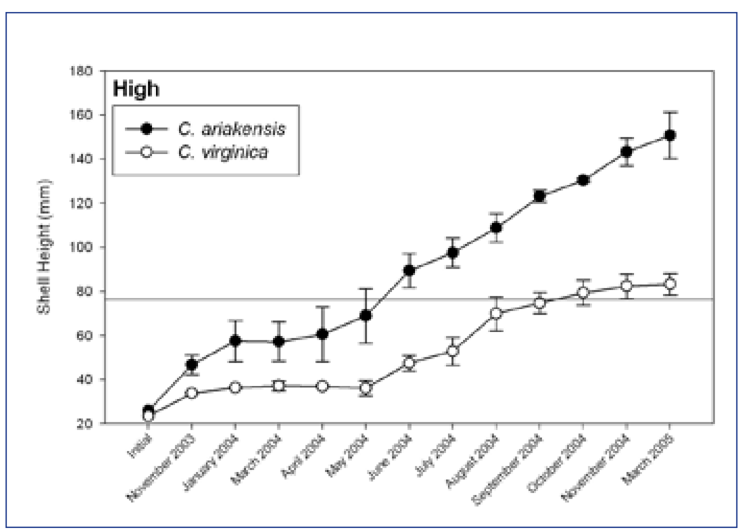




These graphs reveal growth in shell height for both native and non-native oyster species over the course of the 2003 "million oyster march" trials. The data were collected by ABC as part of the comparative, biological data series and were taken from a subset of the commercial animals. This subset was grown separately from the larger set of commercial animals using the same grow-out method, but maintained equal stocking densities for comparison between the two species.

Each graph represents growth in a particular salinity range. Two high salinity site data sets were combined for the high salinity graph, and data sets from three sites were combined for the medium and low salinity graphs.

As you can see, triploid C. ariakensis grew faster than the triploid C. virginica at each salinity range and each time point. Both species of triploid oyster grew faster in high salinity. The horizontal line across each graph is at approximately 76 millimeters, which corresponds to the typical 3-inch market size oyster. Triploid C. ariakensis, on average, reached market size in early summer of 2004 in high and medium salinity waters, and late summer/early fall in low salinity. Triploid C. virginica reached market size beginning in the fall of 2004 in high and medium salinities and, on average, did not achieve market size in low salinity waters.



one-year crop rotation reaps several benefits, of course. Notably, it greatly reduces biosecurity risks. Such a quick turn-around also benefits the grower in terms of improved cash flow and return on investment.

Other results

Some of the *C. ariakensis* were lost due to winter icing at the Saxis, Burgess, Kinsale, Urbanna, Yorktown, and Chincoteague locations. Although *C. virginica* experienced little mortality from those icing events, growers reported that the native oyster appeared more sensitive overall to severe cold temperatures while exposed in floats.

By the spring of 2004, just seven months after field planting, *C. ariakensis* were beginning to reach market size (76mm, or approximately 3 inches). Growers at the high and moderate salinity sites began marketing hundreds to thousands of non-native oysters, primarily to the half-shell market. At that point in time, the native oyster *(C. virginica)* was growing but not nearly at the rate of the *C. ariakensis* and had not yet reached market size. In fact, the native oyster took twice as long—18 months versus 9 months, on average—to reach market size after planting.

Production expenses and revenues

Each participant in the demonstration trials agreed to track their input costs, which included fuel, labor, supplies, and related expenses. That information is especially meaningful when paired with the income generated from sales to both the half-shell and shucking markets.

When examining grow-out costs, consider that some growers used existing materials and supplies (primarily, older cages) for grow-

Individualism was a hallmark of the VSC trials, where each grower chose the method most suited to his location (within biosecurity restrictions). Here, Taylor floats are lined up in the Rappahannock River, each holding bags of triploid oysters for marketing.

At one site on the Eastern Shore, another aquaculture grow-out method was chosen: off-bottom cages. Here, the rows of wire cages are staked off with PVC poles and the bagged oysters are contained inside.

ing oysters. Others chose to purchase new, coated wire cages which ranged from $1,000 to $4,000 in initial investment costs. Associated labor, fuel, and supplies were kept to a minimum across the board, in all locations. The per-unit labor cost appears consistent with typical aquaculture techniques, although added biosecurity measures increased those expenses.

Using an imputed labor cost of $10/hour, the average wage bill for all trials totaled $4,095 over the study period. This represents 37% of the variable costs of grow-out. The average cost of supplies amounted to $5,740 during the period, or 52% of grow-out expenses. Supply costs varied considerably both in amount and type according to the distinct grow-out methods utilized. Treatment of most of these inputs as annual expenses probably understates the annual profit estimated here, since most of these materials can be used for more than one grow-out cycle.

A decision to expense these costs in total was made because of their variability and the fact that, typically, such materials may be expensed under IRS guidelines. Assigning a "useful life" to fabricated gear such as a float or cage would be arbitrary, given their custom-made nature. Therefore, with the exception of the oyster culture raft used at the Saxis location, which was depreciated over an estimated useful life of seven years, other gear and equipment were expensed outright.

At the completion of the demonstration trials in March 2005, growers had marketed 703,878 non-native oysters, reportedly worth nearly $168,000. These oysters were marketed and sold as both shucked and half-shell product. The overall, average sales price per oyster was 24 cents.

Conclusions

The grow-out trials demonstrated that the culturing of triploid *C. ariakensis* is feasible in Virginia waters, even under the relatively rigid grow-out protocols required for biosecurity purposes. Because *C. ariakensis* grows quite fast, the oyster needed tending more frequently to prevent crowding and smothering, which ultimately leads to mortality. Using existing culture techniques, it appears that a relatively small investment of $1,500 to $10,000, when combined with skilled shellfish culture management, can realistically produce 100,000 triploid *C. ariakensis,* with gross returns ranging from $18,600 to $23,000. The range in returns reflects the market price received for half-shell ($.215 ea) versus shucked ($42-44 gal) product.

Preliminary market analysis indicates that the non-native oyster makes an exceptional shucking product. Growers were encouraged, with meat yields as high as 11-14 pints/bushel compared to 7-8 pints/bushel expected throughout the industry for the native *C. virginica.* Operators of shucking houses were favorably impressed and reported that the oyster is easily opened and the meat could be readily removed from the shell stock. These results confirm that *C. ariakensis* offers the potential for an exceptionally profitable shucked product – and one for which processors would pay a premium price.

In contrast, the non-native oyster was not as well accepted in the half-shell market. *C. ariakensis* had a relatively short shelf-life, regardless of salinity conditions during grow-out. Oysters that were kept dry and in ambient temperatures often lasted only one to two days. Those kept in cool storage (45-50˚ F) survived for up to 3-5 days, although those oysters kept in cold storage (32˚ F) succumbed to earlier mortality. Participants observed during this initial trial that grow-out method may have affected shelf life. As an example, those oysters that remained inter-tidally since deployment—even through cold weather months—may have experienced a longer shelf life.

Interesting differences were observed among grow-out methods. Long-line bags on the bottom, used in Urbanna, seemed to expedite the growth of the non-native. This may be due, in part, to the fact that the natural habitat of this oyster includes muddy bottom. Crab shedding tanks, used in Burgess, served as an effective intermediate step in culturing *C. ariakensis* while ensuring biosecurity. Prior to planting, such tanks can be used to increase shell height, possibly staving off predators such as crabs and skates. Floats, on the other hand, encourage oysters to grow very quickly, as they take advantage of surface phytoplankton blooms. The float's location in the water column, about a foot below the surface, helps protect the oysters from freezing temperatures during cold weather months.

Future outlook

While current hatchery potential for triploid oyster production remains fixed, initial and continued success in triploid grow-out may spur additional investment in those hatcheries. The successful demonstrations of both on-bottom culture for a shucked oyster and expansion of an aquacultured half-shell oyster could galvanize efforts within the industry and allow such production to become economically feasible.

Clearly, the prospects for such production are good. During these demonstration trials, sales of *C. ariakensis* contributed $310,000 of total economic impact to the Commonwealth. It is projected that full-scale implementation of *C. ariakensis* grow-out by the 24 existing, small-scale oyster aquaculturists in the state would render a first year harvest of approximately 4 million oysters. Based on recent market prices, the "farm gate" value of those oysters would approximate $1 million during year one and yield a total economic impact of $1.84 million to Virginia.

♦ ♦ ♦

For a copy of the full report, *Pilot-scale Production Economics of C. ariakensis Oysters,* go to www.vims.edu/adv/pubs.

Tom Murray is a marine economist with Virginia Sea Grant. Karen Hudson managed the quantitative assessment of the VSC field trials.

News from the Point

SCALLOP SURVEYS UNDERWAY

Virginia Sea Grant has received a sizeable grant ($600,000+) from NOAA Fisheries to conduct surveys of sea scallop beds in select closed areas of Georges Bank and the mid-Atlantic. The project, to be administered by Dr. William DuPaul, will assess stock levels after various scenarios have played out over the past several years. In one site, the scallop bed has been closed to commercial fishing for more than a year; in another, beds have recently incurred limited fishing effort after a long closure and many scallops have reached advanced age. In the third area, beds sustained considerable fishing effort during 2004 and 2005.

During August, September, and October graduate student Noelle Yochum and marine scientist David Rudders conducted the surveys, which will contribute toward Yochum's thesis project.

The information gleaned from these sampling events will help NOAA Fisheries gauge the success of current regulatory measures intended to ensure the sustainability of the sea scallop fishery in the future. Support for this grant is provided by the research set-aside program, which brings together the commercial seafood industry with NOAA to address fishery challenges.

BRIDGE WEBSITE TO UNDERGO RECONSTRUCTION

Technological improvements this fall will make the Bridge website even more inviting and useful to ocean science teachers. The updated Bridge will be database driven and include a more thorough and productive search engine. Navigation also will be improved. New sections will highlight data lesson plans, teacher top picks, breaking news in ocean science education, and more – all in an attractive, new color scheme.

As always, educators can count on a peer-reviewed collection of the best ocean science materials available online. We hope that you'll visit <http://www.marine-ed.org/bridge> to check out these changes over the coming months.

POLYDORA IN THE SPOTLIGHT

As an extension of a current Oyster Disease Research project investigating the impact of the marine mud worm *Polydora* spp. in cultured native and non-native oysters, a "hardening" experiment has been initiated to address industry concerns on managing the prevalence of these mud worms and the shelf-life of the non-native oyster *C. ariakensis* shell stock. Seed oysters of *C. virginica* and *C ariakensis* were deployed in sub-tidal and inter-tidal locations at three different commercial grow-out sites, each representing high, moderate, or low salinity areas. The oysters will be grown in these tidal conditions at each site through May 2006, with periodic sampling for growth, worm involvement, overall condition, and ultimately, shell stock shelf-life. The effects of inter-tidal exposure during grow-out (hardening) will be evaluated as a method to improve oysters for the half-shell market.

Marine Science Immersion Camp ♦ By Carol Hopper Brill

Nearly 30 Virginia science educators packed their bags for "summer camp" and headed to the Institute's Eastern Shore Lab (ESL) in July. As the field component of a two-week course offered through the Virginia Earth Science Collaborative, the three-day, intensive sessions exposed teachers to the breadth of oceanography as a discipline. Building on preparation by faculty from George Mason and James Madison universities, participants experienced first-hand how geology, chemistry, physics, and biology are integrated in the study of the oceans.

Living the life of field researchers, teachers rose with the early morning tide, collecting data and samples from headwaters to open ocean. They practiced oceanographic sampling techniques with a combination of low- and high-tech sampling devices, characterizing water chemistry, analyzing sediment composition, and identifying biological specimens. Assisted by ESL and Marine Advisory Program staff, teachers worked under the direct supervision of VIMS scientist Dr. Rochelle Seitz and Sea Grant educator Vicki Clark, who put their GMU and JMU colleagues' lecture content into practical application.

Thanks to a "marine science camp" at the VIMS Eastern Shore Lab last July, Virginia science educators can now relate the study of coastal oceanography to their students with the authenticity of first-hand experience. Designer netting to ward off green-head flies was bonus!

Such intense learning experiences create long-lasting impressions. This program was designed to teach oceanography by "immersion" and ultimately help teachers share their research experience with students in the classroom. Confirming that such a design works, one educator said it well: "Now I can teach with more authenticity – the field trips to different habitats, hands-on collection of samples, practice with different equipment, data analysis – I've done it myself."

Well, look at that!

STUDENTS GET THEIR FEET WET

Students from Walsingham Academy took part in a year-long oyster growing project, courtesy of NOAA's Bay Watershed Education and Training program. Throughout the project, they learned about estuaries, water quality and sampling methods, and the flora and fauna associated with oyster reefs. At the end of the year, students and teachers participated in a field experience to a reef to transplant their oysters in the watershed. They are shown here examining the contents of a seine net with education coordinator Bob Carroll, with the Chesapeake Bay National Estuarine Research Reserve in Virginia. A teacher workshop and other resources were provided by Virginia Sea Grant, Oyster Reef Keepers of Virginia, and the Tidewater Oyster Gardeners Association.

Back Cover Photograph:
A floating upweller system represents an efficient use of an existing structure (a dock) to raise C. ariakensis under biologically secure conditions.

TAGGING PROGRAM TARGETS JUVENILE BLUEFINS

For many years, the distribution, behavior, and migration of juvenile bluefin tuna has been largely a mystery. A new, cooperative tagging program intends to change that.

Staff at the Large Pelagics Research Center at the University of New Hampshire, along with collaborators from VIMS and the Massachusetts Division of Marine Fisheries, are tracking the fish as they move up and down the Atlantic coast. Recreational and commercial fishermen have been notified, and urged to return any tagged fish they come across. A $500 reward per tagged tuna has been offered.

For more information about the research project, visit <www.tunalab.unh.edu>. A small percentage of juvenile bluefin tunas may return to Virginia waters during late November.

FAREWELL, READERS

With this issue, I say "farewell" to you and to the Virginia Sea Grant family. I've appreciated hearing from you over the years and saved each and every note.

In the immediate future, I'll focus my time and energy on a short list of non-marine resources associated with our small farm. I expect to leave my desktop publishing program in "sleep" mode – at least for a little while.

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