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Crassostrea ariakensis and the Chesapeake Bay *Exploring Environmental and Policy Issues*

Don Webster, Maryland Sea Grant Extension, Eastern Shore Agent

For more than 40 years, oyster populations in the Chesapeake Bay have been battered by parasitic diseases against which the only defense has been lower salinity waters. Due to the ever-changing nature of salinity patterns, this has led to restoration activities primarily in areas that are at least high enough in salinity to support growth and low enough to suppress disease. At mid and higher salinities, *Haplosporidium nelsoni*, which causes MSX disease, and *Perkinsus marinus*, which causes Dermo, meets with little resistance from *Crassostrea virginica*, the oyster that is native to estuaries from Canada to the Gulf of Mexico. While there are strains of *C. virginica* that can tolerate disease and survive, they are not producing in large sustainable populations.

Major social and economic impacts to shoreside communities have followed the near-elimination of the Bay oyster industry. Another impact has been the health of the ecosystem itself: oyster reefs not only provide habitat for bottom-dwelling organisms and, thus, feeding fish, crabs and other species, they can also exert strong top-down controls on nutrients: feeding prodigiously on algae, oysters use and bind up nitrogen and phosphorus that would otherwise contribute to further degradation of water quality. It is for such reasons that large-scale restoration of oysters to the Bay would have important economic as well as ecological benefits. The problem is that MSX and Dermo are so endemic throughout the Chesapeake that oysters rarely survive beyond a couple of years before succumbing.

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Why is *C. virginica* so unable to defend itself? A century of clear cutting natural reefs for harvests and the subsequent impacts of siltation and runoff are likely key factors. Oysters release eggs and sperm into the water where eggs are fertilized to become free-swimming larvae; after two to three weeks of feeding,those that survive predation begin searching for a surface, usually oyster shells, to adhere themselves to and undergo metamorphosis to become spat. Fewer broodstock oysters over low-lying, if not scattered, reefs generally translates to fewer young oysters — reefs are not being replenished with enough surviving biomass and thus are collapsing or being covered in sediment. In general, baywide conditions that *C. virginica* evolved to grow in may have changed to such an extent that it can no longer thrive under those conditions that now exist.The overwhelming presence of disease, for example, may so compromise the *C. virginica* immune system that it is left vulnerable to other environmental stresses.

A number of research and management efforts have been underway for some time to try and "improve" *C. virginica*'s chances for battling disease. These include the hatchery breeding of strains with an inherent or genetic immunity — while researchers and growers have had some success in using these oysters for aquaculture, it is still uncertain whether they will continue to breed in the wild and eventually produce sustainable populations. Even if this was to occur, it could take decades before there is any significant return of native oysters.This is a key reason why many people in the industry are calling for introduction of a non-native oyster — *Crassostrea ariakensis*, an Asian species — that appears to grow faster than the native and more importantly may be able to tolerate MSX and Dermo.

Since it has been so difficult to overcome the disease organisms that are killing *C. virginica*, an obvious choice is to fully investigate whether *C. ariakensis* can match the attributes of *C. virginica* when it had the ability to survive. Currently, the National Academy of Science has a committee of scientists, economists and policy makers examining the ecological and social implications of introducing *C. ariakensis* in order to make recommendations by late summer. Among its options are (1) to do nothing; (2) to introduce only triploid or sterile *C. ariakensis* which would be used for aquaculture — in other words, controlled plantings under confined conditions; (3) to introduce diploid or reproducing populations.There are a number of environmental and policy questions that must be addressed — here is a summary of those related to the environment.

Environmental Questions Related to *C. ariakensis*

- *Will* Crassostrea ariakensis *survive throughout the Bay?* This is a key question — if it will not, then there is no reason to pursue the introduction. Based on limited field trials of triploid *C. ariakensis* in Virginia in 2000 and 2001 and scientific studies at the Virginia Institute of Marine Science, *C. ariakensis* appears likely to thrive under conditions found in the Chesapeake Bay (for a summary of the VIMS study, see www.mdsg.umd.edu/Aquafarmer): growth seems to reflect salinity with faster growth in higher salinity waters but with survival at all investigated ranges.

- Will triploid or diploid *C. ariakensis* have adverse impacts on other beneficial species? This is another key question that needs to be researched. It would not be worthwhile introducing an oyster that will have a significant adverse impact on other beneficial species in the bay. We must remember that the oyster is only one important component in a healthy ecosystem.

- *Does an introduction of* C. ariakensis *have the potential to affect oysters in other states?* We have seen that non-native species can be moved to places where they were not intended. For example, larvae can drift for long distances and one of the mysteries of the Bay oyster populations is trying to figure out where oysters on a particular bar came from. Therefore, since the decision to introduce a non-native oyster can potentially impact other states, what is that potential and what could the transport mechanism be? (Maryland Sea Grant is funding research that is employing genetic analysis to try and determine oyster recruitment patterns on the Chesapeake; for more information, see Matt Hare and Kennedy Paynter, Title, www.mdsg.umd.edu/Research/R_F-92.html.)

- *If sterile (or triploid) oysters are employed for farming* C. ariakensis, *will they remain sterile, and under what conditions might they change?* Studies have shown that, given enough time, some triploids will revert to non-sterile animals. If this happens, will the gametes of the animals that revert be viable enough to form sustaining populations and will there be enough of them to have the possibility of unwanted reproduction occur?

- *If reproductive (diploid)* C. ariakensis *are brought into the Bay or if triploid* C. ariakensis *become wild, will they colonize and build reefs?* The ecosystem would benefit if *C. ariakensis* forms reef structures through continual setting upon itself. This is largely what current restoration projects with hatchery-bred strains of disease-tolerant *C. virginica* have sought to emulate, though success has been limited.

- *Will* C. ariakensis *outcompete* C. virginica*?* Could diploid *C. ariakensis* survive and reproduce so well that it could completely take over the niche traditionally occupied by *C. virginica*? If it did, would the Bay be better or worse off for it? Furthermore, would we be better off in getting *C. ariakensis* established rather than continuing efforts to culture disease-tolerant strains of the native species?

Policy Questions Related to *C. ariakensis*

In addition to the strictly biological or environmental questions, there are a series of issues that involve public policy. These have important impacts upon human activities and include the following.

- *Can* Crassostrea ariakensis *provide and sustain a commercial fishery?* This question falls into two areas: (1) would this new oyster be able to jump-start a commercial fishery through the aquaculture of triploids; (2) would it provide saleable animals from wild production. Since *C. ariakensis* gives evidence of growing quickly and attaining large sizes, these questions could have an impact upon the decisions of if and how to introduce it. Further, could *C. ariakensis* affect the processing and marketing segments of the industry in the same way that production of large ocean clams affected the quahog industry during the past forty years.

- *If other states are enabled to advance aquaculture techniques for raising this new species, will states like Maryland, where the industry is largely based on harvesting wild populations, be left behind?* This question has been of foremost concern of many watermen and processors in Maryland, as Virginia and North Carolina advocate for the introduction of triploid *C. ariakensis* for commercial aquaculture. Techniques will have to be developed, either through containment equipment or other methods of insuring that all the animals are caught, in order to have a working commercial aquaculture industry. For a discussion of these issues, see "Does the Bay Need a New Oyster?" Chesapeake Quarterly On-Line, www.mdsg. umd.edu/CQ/Fall02/main.html.

- *If only triploid* C. ariakensis *are allowed, will large growers come to dominate the industry?* Triploids have to be produced in hatcheries — an industry based on these animals could lead to the formation of vertically integrated businesses, much like the current poultry industry, that could control oyster production and in effect the growers who would contract to work for them. As with the broiler industry, while the overall impact on the econ-

omy has been large and positive, there has also been a loss of independence by growers who now are directed by the companies that provide their animals, feed, harvesting, and marketing services.

- *Will allowing only the culture of triploid* C. ariakensis *cause a shift in states like Maryland from public harvest to private culture?* The Maryland fishery has always relied upon watermen harvesting public oyster bars. Aquaculture has been negligible in this state, unlike Virginia which based its industry on private growers using bottom grounds leased from the Commonwealth. If only the production of triploids is allowed, would this cause watermen to either become growers or be shut out of the industry? While this outcome would have a small impact today because of the few oystermen left in the industry, it could cause a shift in the management structure from publicly-funded repletion projects to growers risking their own capital in the pursuit of profit.

- *Will allowing the introduction of* C. ariakensis *in any form shift funding away from restoration projects for* C. virginica? This has been a strongly voiced viewpoint that some state and federal agencies have used as a basis for opposing research in the culture of *C. ariakensis* in open waters. The concern is that a great deal of funding has been lined up for restoration of *C. virginica* over the next decade and agencies do not want anything to take away from that singular direction. Unfortunately, if they are wrong, we will not only have spent vast sums of taxpayer-provided dollars in vain but will be a decade behind in trying to investigate new directions that could help provide a solution to the oyster problem.

Research and Action

Sustainable populations of *Crassostrea virginica* will probably not recover to historic levels on their own, certainly not in the near term. We have seen the effects of MSX in the Delaware and coastal bays: after almost a half-century of disease prevalence, oyster populations have not developed a strong enough resistance to the disease to enable natural replenishment. If we take the coastal bays as an example, most of the old oyster bars that existed are now defunct — they are covered with silt and sediment, and unavailable for new oysters to build upon old bars even if there were sufficient animals to spawn and provide the larvae.

Of all the courses that have and can be taken to restore a bivalve population to the ecological niche that was occupied by *Crassostrea virginica*, the most promising at this time seems to be the introduction of a non-native oyster. What is needed is one that can survive in current conditions, provide the basis for a rejuvenated commercial industry and meet the needs for restoration projects.

Finding the answers to these questions will not come quickly, easily, or cheaply. But answers need to be determined upon which management decisions can be based. Targeted research can help to provide many of the answers to key questions that will affect these policy decisions. Since research takes time and resources, the prudent course would be for scientists in several of the states that will be impacted by this new oyster to begin immediately to define the questions that most need answering and refine a course of action that will bring them into concerted and collaborative action to do the necessary work. This must be done, while there is still a remnant of a Bay industry that can be saved and before conditions become too degraded for effective restoration.

To respond to or comment on this article, please go to www.mdsg.umd.edu/Aquafarmer or contact Don Webster at dw16@umail.umd.edu.

C. ariakensis Resources on the Web

Maryland Sea Grant
www.mdsg.umd.edu/oysters/exotics/index.html

Virginia Institute of Marine Science
www.vims.edu.abc/CA.html

Chesapeake Bay Program
www.chesapeakebay.net/nonnativeoyster.htm

National Academy of Science Committee
www.nationalacademies.org

Profitability and Oyster Restoration
Marketing Will Be Critical

Doug Lipton, Maryland Sea Grant Extension Economics Specialist

While restoration of the native oyster in Chesapeake Bay has been posing difficult challenges, restoration of the harvesting and processing industry to historic levels presents its own set of challenges. This is the message I gave to the National Academy of Sciences Committee of Non-Native Oysters in the Chesapeake Bay which met in Fall, 2002,in Fredericksburg,Virginia. The committee is charged with making recommendations regarding the introduction of *Crassostrea ariakensis* as an alternative or complement to restoring native oyster stocks of *Crassostrea virginica*.

Ten years ago, we were exploring the possibility of introducing *Crassostrea gigas*, the Pacific or Japanese oyster to Chesapeake Bay as a way of managing around MSX and Dermo. In 1992, in "Economics of Molluscan Introductions and Transfers" we outlined the economic information that would be needed to determine whether the potential costs of such an introduction would be worth the potential benefits (see D.W. Lipton, E.F. Lavine and I.E. Strand. 1992. Journal of Shellfish Research). We followed that study in 1994 with "A Profile of the Oyster Industry: Northeastern United States," an in-depth analysis of the then status of the east coast oyster industry (D. Lipton and J. Kirkley. 1994. Maryland Sea Grant Extension and Virginia Sea Grant Marine Resource Advisory).In this report we concluded,"More oysters will not revitalize the oyster industry alone. Increased demand and a wider variety of products will be necessary components of a successful industry revitalization."

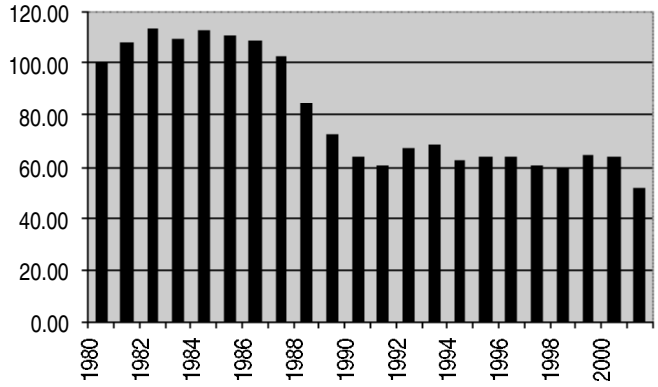


Figure 1. Index of U.S. per capita oyster consumption (1980=100).

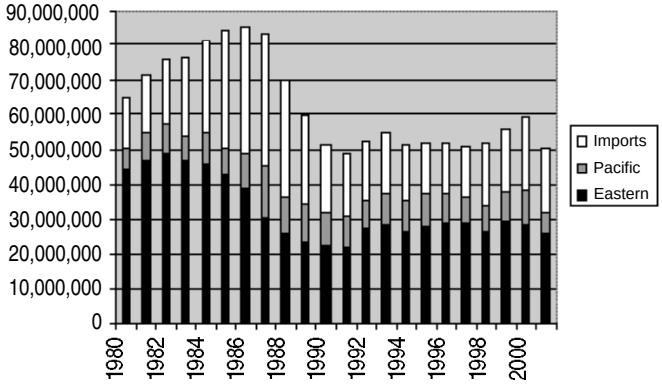


Figure 2. U.S. supply of oysters, 1980-2001.

Historically, the Chesapeake Bay oyster industry was characterized by high volume production but relatively low prices compared with other Northeastern U.S. producing areas; that is because most Chesapeake production was destined for shucking houses as opposed to the higher value half-shell market. The difficulty of restoring a shucking-based industry may be due to the fact that the market for Chesapeake oysters was already declining even before the collapse of production. For example, from 1974 to 1990, the number of processing plants in the Chesapeake region declined from 138 to only 48. Today, only a handful of plants remain in the region for processing Chesapeake-harvested oysters and oysters imported from other regions.

In the 1970s, 15 distinct products were processed from Chesapeake oyster harvests — by 1990 only six product types were being processed. While fresh shucked oysters are the dominant product, in 1970 they made up 76 percent of production; by 1990 fresh shucked oysters accounted for 92 percent.

Figure 1 is an index of U.S. per capita consumption for oysters. Compared with the base year of 1980, oyster consumption of all product forms and sources and species of oysters has fallen significantly. This fall closely follows the decline in U.S. oyster supply (Figure 2). The supply demonstrates that the decline in eastern oyster (*Crassostrea virginica*) pro-

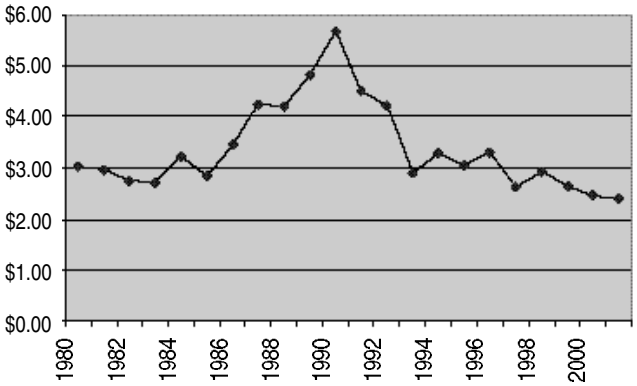


Figure 3. Eastern oyster prices in current (2002) dollars.

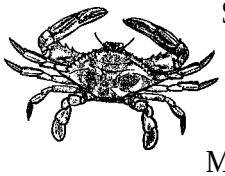
duction,mostly due to the decline in the Chesapeake harvest, was not compensated by significant increases in Pacific oysters or imported oyster products. Figure 3 gives the best indication of what might have occurred in the oyster market: it shows what happened to the price of oysters from 1980 to 2001 with all prices adjusted to 2002 dollars. Initially, as Chesapeake oyster supplies collapsed, the scarcity led to significantly higher prices. The higher price also reflected a loss of the relatively lower value Chesapeake product as compared to the higher-valued Long Island Sound production, which is destined for the half-shell market. While the market tested higher prices from 1987 to 1992, these were not sustainable high prices in the market place. Without any significant increase in production, prices declined to earlier levels, and in 2001 were at their lowest point in two decades.

What would a significant increase in Chesapeake Bay production of any oyster species mean in the current market? Basic economic principals tell us that an increase in production with no corresponding increase in demand will lead to yet lower prices for oysters. This effect would be somewhat offset if the production were to include more higher valued half-shell oysters as opposed to oysters for the shucking market. However, the half-shell market is not of the scale that can absorb quantities of oysters that were traditionally produced in Chesapeake Bay without a significant drop in the prices in that market as well.

With all the focus on how best to restore oysters in Chesapeake Bay, how to structure oyster reefs, what strain or even what species to use, we should also focus on restoring the market for those oysters. How many will we be able to sell, and at what price? Success will not be measured by how many oysters we can produce, but by whether we can build consumer demand that will sustain a profitable industry.

For more information, contact Doug Lipton, dlipton@arec.umd.edu

Blue Crab Research at COMB



Scientists at the Center of Marine Biotechnology, part of the University of Maryland Biotechnology Institute, tagged 25,000 hatchery-reared juvenile crabs for release this past summer into study sites on the Chesapeake Bay. In stock assessment studies conducted with the Smithsonian Environmental Research Center, researchers began following the marked crabs for up to 14 weeks after their release. During the first summer, the released crabs (from 1/2 to 1-1/2 inches carapace width) grew to almost 5 inches.

The blue crab hatchery program began in the summer of 2000 with funding from the State of Maryland and Phillips Seafood Inc. and included assistance from the Maryland Watermen's Association. Further funding has come through the NOAA Chesapeake Bay Office. COMB scientists spawned blue crabs in the hatchery and began rearing thousands in tanks at its Columbus Center aquaculture facility. Yonathan Zohar says, "We are applying the tools of modern biology to better understand the fundamental processes involved in blue crab reproduction, early development, molting, growth and aggression, while developing blue crab hatchery technologies."

Mature blue crabs were place in tanks and exposed to phase-shifted environmental conditions, which have resulted in year-round spawning. Individual females spawned several million free-swimming blue crab larvae. The larvae were fed with microscopic algae and zooplankton and went through nine larval stages before metamorphosing into tiny crabs at four weeks of age. Optimizing the complex feeding regimen of the larvae has resulted in survival rates of up to 70 percent. Crabs are aggressive animals and cannibalistic — experiments to minimize cannibalism included providing shelter structures, large amounts of diversified food and enough space; at the same time, baby crabs were sorted by size, which appears to have helped maintain high survival rates.

Initial experiments indicate that hatchery-reared crabs behave similarly to wild crabs. According to COMB

researchers, crabs raised on a hatchery diet readily begin feeding on natural prey at rates similar to wild crabs. Other experiments focus on ways to promote survival of released crabs. Those reared in hatchery tanks without bottom sediments have lower survival until they gain experience in burying in order to escape predators. Based on current findings, a larger-scale hatchery and nursery is being planned for studies on biology and ecology and the testing of feasibility of stock enhancement in the Chesapeake.

For more information on blue crab research at COMB, contact Steve Berberich at 301-990-4804 or berberic @umbi.umd.edu. For details, see www.umbi.umd/~comb/

Research Update

Hard Clams and QPX: Science Stepping Up

Robert S. Anderson and Matt Hall
University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory

Quahogs, cherrystones, blood clams, chowder clams,little necks, top necks — all are synonyms for one species, the hard clam *Mercenaria mercenaria*. An inhabitant of higher salinity waters, the hard clam has become a major farmed species in east coast waters, especially in Virginia which is among the leading producers. Because of Maryland's lower salinity waters, natural clam production and recent aquaculture efforts in the state are in its coastal bays. Clam farms continue to expand, especially with oyster populations in decline, falling to the diseases Dermo and MSX. However, in a situation eerily similar to oyster disease, some clam operations on the east coast have been getting "hit" by a mysterious infection.

The infection is caused by a parasite so recently discovered that it does not yet have a scientific name. Thus the vague moniker Quahog Parasite Unknown, or QPX for short. QPX is a protist that is ingested by the clam as it filters algae from the water; it attacks the clam's internal organs, forming tiny pinpoints of growing parasite cells surrounded by halos of dead clam tissue. First discovered in wild Canadian clam beds, it has the potential to wipe out entire populations of the shellfish. QPX was later found in clam beds in Massachusetts and New Hampshire — there has been some worry that this could indicate a southward migration.

QPX's mode of infection and exact basis for pathogenicity has yet to be completely worked out, though researchers are currently investigating the details — Robert Anderson at the Chesapeake Biological Laboratory, part of the University of Maryland Center for Environmental Science, is one of the scientists trying to unravel just why QPX infections can be so lethal.Anderson's approach is to study the immunological response of the clam host to the pathogenic parasite that causes QPX disease. Like other bivalves, clams have a number of internal defense mechanisms that effectively destroy other microorganisms including bacteria, yeasts,and protozoans. While typical antibodies are not present in bivalves, microbial invaders can be killed or inhibited by the clam's blood cells and/or serum molecules. The hypothesis being tested is that pathogenic QPX can somehow inactivate or evade the clam's normal immune mechanisms.

One of the most unusual characteristics of QPX is that it normally secretes copious amounts of a mucus-like material. The mucus can be observed surrounding the QPX cells both in infected clams and in the medium around the cells when they are propagated in the lab. Anderson's research group has been investigating the role of this secretion as a significant virulence factor for QPX. Brenda Kraus, a laboratory associate, is working on the ability of the mucus to protect QPX against the clam's serum molecules and blood cells; Christie-Sue Decker, who recently received her master's degree, examined the role of mucus in the inflammatory response.

The blood of the hard clam contains several proteins that will inhibit the growth of QPX in laboratory culture. However, this effect is only seen if the proteins contact QPX that has been washed free of its mucus coat or is in a mucus-free life stage. The interaction is rapid and the effects persist even if the serum proteins are washed off and the QPX cells are returned to serum-free medium. Presumably, these serum proteins could be counted upon to control the multiplication of QPX in infected clams, thereby increasing resistance and lowering pathogenicity. Unfortunately for the clam, the mucoid secretions that coat QPX effectively protect the parasite from the anti-QPX proteins of the clams' blood.

By preincubating washed QPX for various times before exposure to

clam serum proteins, Kraus and Anderson showed a direct relationship between mucus coat development and protection of the parasite from serum defense molecules. Not only does QPX mucus protect it against the clam's blood molecules, but the mucus probably protects it from the blood cells too. Preliminary studies with a confocal laser microscope indicate that mucus-free QPX cells are readily phagocytized (that is, they are internalized and disabled) by clam blood cells; however, this is not the case for mucus-covered QPX cells. The first step in uptake and eventual killing of pathogenic microorganisms by blood cells involves recognition and binding of the pathogen by the blood cell. It is reasonable to think that this process would be diminished if the pathogen is enveloped by mucus, though this is the first experimental evidence to support the idea.

Clams and higher animals often develop inflammatory responses to infections; inflammation can present serious problems and contribute to the pathology of the infection. A common inflammatory response is massive migration of blood cells to the infected tissue. This can cause severe damage to the tissue as a result of the excessive outpouring of toxic substances by the blood cells, in an ineffective attempt to destroy the infecting microbes. In lab studies, Decker showed that the mucoid secretions of QPX contain substances that actively attract clam blood cells. This observation suggests a mechanism for the heavy infiltration by blood cells of the tissues seen in histological sections of sites of QPX infection. One conclusion is that the mucus coat contributes in at least three ways to QPX pathogenicity: by protecting against anti-QPX serum molecules, by protecting against recognition and uptake of QPX by clam blood cells, and by stimulating inflammatory responses in infected clams.

The most effective defense against QPX and other parasitic diseases is selection of disease-resistant clams to rear in hatcheries, whether resistance is produced by natural or human-mediated means. In fact, preliminary evidence from a study conducted at the Virginia Institute of Marine Science indicates that clams from northern states and Virginia fare better when exposed to the parasite than do clams originating from states further south. This observation was a deciding factor in the recent decision by the Virginia Marine Resources Commission to ban import of clam broodstock from states further south. However, no clam populations seem to be totally unsusceptible to QPX, making further research into its infectivity, as well as the immune response of the clam, important to the future of the hard clam industry. By more fully understanding the mechanisms of QPX's pathogenicity, it may be possible to develop reliable techniques to help clam growers counter the effects of QPX.

For more information on Robert Anderson's QPX research, see www.cbl.umces.edu. Matt Hall is a faculty research assistant at the Chesapeake Biological Laboratory.

COMB Recirculating Aquaculture System Patented

The Center of Marine Biotechnology, a research arm of the University of Maryland Biotechnology Institute, has received a patent on the process for a fully-contained, recirculating system for growing marine fish indoors. The patent covers much of the prototype marine aquaculture operation at the Columbus Center in Baltimore (www.umbi.umd/~comb/). With growing criticism of the ecological strain that outdoor ponds and netpen fish farming can lead to, recirculating systems, even with higher production intensities, offer the potential for minimizing such environmental impacts, says COMB director Yonathan Zohar. "Our system is generic, and thus allows culturing of finfish and shellfish species from warm water, cold water, marine or estuarine habitats," he says. The fully computerized system uses artificial seawater, advanced filtration technology, ozone treatment and control over day-light periods, water temperature and salinity.

While recirculating systems have the potential for maintaining disease-free conditions and producing "clean fish that are free of contaminants," such systems also require high up-front costs and, like all aquaculture operations, says Andy Lazur, Maryland Sea Grant Extension Finfish Specialist, profitability is vulnerable to many different impacts, whether they are unexpected price fluctuations of wild fisheries and imports or the availability of high quality, low cost seed. Lazur and Sea Grant Extension Agent Don Webster have organized workshops for growers who use recirculating systems and have covered topics such as disease control, alternative species and biofiltration.

To learn more about recirculating systems from Maryland Sea Grant Extension, contact Andy Lazur at 410-221-8474 or lazur@hpl.umces.edu. For information about the COMB recirculating system, contact Steve Berberich, 301-990-4804 or berberic@umbi. umd.edu.

Fisheries in Europe

Fishes in Estuaries, edited by Michael Elliott and Krystal Hemingway. Blackwell Science (Iowa State Press, a Blackwell Publishing Company), Ames, Iowa. 2002. 636 pp. $144.99. www.iowastatepress. com

Edward D. Houde, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory

Estuaries are water bodies that serve as a link between the land and sea — while they are highly productive, they are often heavily utilized and impacted by human activities. Some of those impacts are reflected in alteration of habitats, deterioration of water quality, heavy use by shipping and boating interests and, of course, significant fishing effort. Estuaries are the spawning areas of many anadromous fishes and serve as nurseries for the young of many coastal-spawning and anadromous species; they are often the site as well of coastal aquaculture and fish farming activities. Hundreds of research papers have been written about fish ecology and fisheries in estuaries in recent decades, most of which focus on particular issues in a specific estuary.

Fishes in Estuaries brings together, collates,and summarizes a massive amount of data and knowledge on European estuaries as it relates to fish (including shellfish) and fisheries. In fact,"European" should have been in the title, for the book purposefully emphasizes estuaries on the European continent, with only occasional reference to other estuaries. The book is the product of efforts by authors from 11 European countries who have collaborated to write the 10 chapters that broadly address issues ranging from estuarine habitats, to fisheries, biodiversity, anthropogenic stresses, science approaches/methods, and management. The initial collaboration that led to the book derived from a European Community program, although the book is not a product of that program. The chapters are not individually contributed papers, but rather are co-authored, collaborative works that address chapter topics defined at the outset. Editor Elliott is also the major contributing author and, I suspect, the driving force behind the book.

The book successfully compiles and catalogs information, presenting it in summarized tabular form in many instances, and occasionally providing case studies that give useful perspectives. While also successful in meeting the stated goal of bringing information on estuarine fish and shellfish together on a wide pan-European basis, it is less successful, in my view, in being "a synthesis of new data." Inclusion of both Geographical and Taxonomic Indices is very helpful for readers interested in finding information on particular estuaries and species. Reference lists at the end of each chapter are comprehensive, but limited mostly to European literature. I discovered several important references to Estuarine Turbidity Maximum (ETM) regions, a present interest, that will be useful in research now being conducted in my lab. ETMs are zones in estuaries where freshwater and saltwater converge and tend to entrap river-borne sediments and plankton, including planktonic stages of fish.

Aquaculture in estuaries and issues related to culture are not emphasized in this book.Though the potential for aquaculture facilities such as net pens to have an impact on estuarine habitat and water quality is mentioned, it is not discussed in any detail. In a chapter on invasive species, aquaculture is noted with respect to potential introduction of "biological pollutants" into estuarine ecosystems and with respect to possible inadvertent introduction of diseases. In the chapter Endangered and Threatened Species, the authors state incorrectly that shads (alosines) "are extensively farmed" in the U.S. Although aquaculturists will not learn anything about culture methods, or even obtain an overview of estuarine aquaculture, the book does provide a broad overview of estuarine habitats and fisheries, and a strong focus on concerns related to human activities and inputs to estuaries. These topics will be of interest to those engaged in estuarine aquaculture or anticipating such ventures.

My conclusion after reading the book is that research on fish in European estuaries is on a parallel path with research being conducted in North America and in estuaries on other continents. Major concerns about habitat destruction and alteration, and on pollutant/contaminant introductions are prominent in a global perspective. The need to better understand trophic interactions and to estimate biological production is universal, as is the emphasis on

causes of variability in abundances and recruitment.

Overall, I found *Fisheries in Estuaries* to be a nice compendium of work on estuarine fishes in Europe that successfully collated and summarized material from many individual estuaries. It does not make a strong or new intellectual contribution to understanding estuarine fish and fisheries, but that was not the authors' objective. The book obviously will be of most interest to European scientists and resource managers, though students from the U.S. who are undertaking thesis research on estuarine fish or fisheries should consult it to learn about progress and knowledge gained outside of North America. I certainly recommend that *Fishes in Estuaries* be acquired by research libraries at institutions emphasizing marine and estuarine science.

For current research efforts by Dr. Edward Houde, see www.cbl.umces.edu. To learn more about research related to the Estuarine Turbidity Maximum and relationships between biology and physics in Chesapeake Bay, see Trophic Interaction in Estuarine Systems, www.chesapeake.org/ties/overview/overview.html

Seafood Nutrition Education

Gayle Mason-Jenkins, Seafood Education Specialist

Seafood can be important for a healthy nutritional diet. To begin with, Omega-3 polyunsaturated oil, a compound that can reduce the risk of stroke and heart attack, is common to most seafood. In addition, fish oils may also act as anti-inflammatory agents and counter such problems as asthma and rheumatoid arthritis. With a few exceptions (for instance, squid, fish roe and prawns), fish are also low in fat and cholesterol, though high in protein — a third of a pound of fish fillet, for instance, can provide as much as 60 percent of daily protein needs. Seafood also is an important natural source of vitamins such as iron and zinc — iron helps in red blood cell formation, while zinc can help heal wounds. Though there have been many public awareness campaigns nationally and regionally about the health benefits of seafood, many consumers are reluctant to prepare fish and shellfish at home because of uncertainties about handling, preparation and storage. It is for such reasons that Maryland Sea Grant Extension has been committed to educating consumers on all aspects of seafood nutrition, from health to handling.

To leverage our educational efforts, Sea Grant Extension and Maryland Cooperative Extension have partnered with other organizations and agencies in numbers of outreach programs, among them, the University of Maryland Eastern Shore's Hotel Restaurant, Human Ecology, Education Units, the health Departments for Somerset and Wicomico Counties, the Maryland Hospitality Education Foundation, the Maryland Department of Education. To date, more than 1000 professionals and individuals have participated in these programs.

To educate consumers about food safety, we have to recognize the difference that seafood can make in a balanced diet. This means targeted education not only for individual consumers but for teachers and trainers. With our partners we have conducted wide ranging programs, including those in food safety, ethnic foods/diverse audiences, food-borne illness and HACCP (Hazard Analysis Critical Control Point). For example, "Your One and Only Body" was designed to teach participants how to recognize the impact that food choices have on the body in the short and long term. A program at the Delaware Cooperative Extension's Annual Family Conference at Delaware State University, a workshop for 200 professionals and individuals, focused on food safety, and selecting and handling sea vegetables and seafood products.

For more information on seafood nutrition education programs, contact Gayle Mason-Jenkins at 410-651-6212 or gmjenkins@mail. umes.edu.

New Coastal Community Specialist

Rachel Smyk-Newton is the Maryland Sea Grant Extension Coastal Community Specialist.Located in the Department of Agricultural and Resource Economics at the University of Maryland College Park, this new position has been made possible with an enhancement grant from NOAA's National Sea Grant College Program. The aim of this enhancement is to build additional capacity in Sea Grant programs to form partnerships with other public and private organizations and agencies concerned with sustainable development.

Ms. Smyk-Newton has come to Maryland Sea Grant from the NOAA Coastal Services Center Coastal Management where she worked with the Maryland Coastal Zone Management Program. Among her activities, she led an effort to develop Maryland's comprehensive shoreline erosion control plan, worked with counties on their regional shoreline erosion control plans and worked on implementing provisions of Maryland's Sea Level Rise Response Strategy. She has also worked as a Wetlands Restoration Program Specialist for the National Marine Fisheries Service Restoration Center in Silver Spring, Maryland. Ms. Smyk-Newton holds a B.A. from Smith College and a Master's degree in Environmental Science and Management from the University of California, Santa Barbara.

For more information on Maryland Sea Grant coastal community efforts, contact Ms. Smyk-Newton at rsmyknewton@arec.umd.edu or 301-405-5809.

New Publications

Chesapeake Quarterly Fall 2002

This third issue of Maryland Sea Grant's new publication focuses on *Crassostrea ariakensis*, the Asian oyster which has given indications it can tolerate the two parasitic diseases, MSX and Dermo, that have been devastating the Bay's native oyster. The feature article "Crisis and Controversy:Does the Bay Need a New Oyster" examines the ecological and social implications of introducing *C. ariakensis* to the Chesapeake. A second articles profiles Sea Grant Shellfish Extension Specialist Don Meritt and the hatchery he runs at the Horn Point Laboratory (part of the University of Maryland Center for Environmental Science, UMCES) — under Meritt, the hatchery has become a key factor in research and oyster restoration in Maryland, particularly in its partnering with the Oyster Recovery Partnership, the Maryland Department of Natural Resources and other agencies and organizations.

Chesapeake Quarterly can be read on-line at www.mdsg.umd.edu/CQ; a free print subscription and past issues are available by contacting Jeannette Connors, connors@mdsg.umd.edu or 301-403-4220, ext. 22.

The Bay Restorer

This newsletter from the Oyster Recovery Partnership reports on its activities in planting oyster spat throughout Maryland's portion of the Chesapeake. In the last several years, the non-profit ORP has stepped up its role in coordinating the planting of disease-free oyster spat (see above) on managed reserves and sanctuaries. ORP's efforts, which are coordinated with the Maryland DNR, federal agencies, Maryland watermen,community organizations and numbers of other partners, are detailed on its website. Upcoming issues of the newsletter are featuring restoration activities in various parts of the Bay.

For more information, contact Executive Director Charles Frentz, Oyster Recovery Partnership, P.O. Box 6775,Annapolis, Maryland 21401, 410-990-4970, and on the web at www.oysterrecovery.org

Pier Review

This new quarterly newsletter from the Center of Marine Biotechnology (COMB), a research center of the University of Maryland Biotechnology Institute, highlights scientific efforts in a number of areas, including aquaculture and fisheries biotechnology and marine natural products. Of special interest is COMB research on the blue crab, *Callinectes sapidus* — more than 40,000 juvenile crabs have been produced for studies on biology and ecology, both for the laboratory and limited field studies.

For more information and a subscription to Pier Review *contact COMB, 701 East Pratt Street, Baltimore, Maryland 21202, 410-234-8800, and on the web at umbi.umd.edu/~comb/*

Japanese Hatchery-based Stock Enhancement: Lessons for the Chesapeake Bay Blue Crab

David H. Secor, Anson H. Hines and Allen R. Place, 2002

As the Chesapeake Bay blue crab fishery continues to face heavy fishing pressure and a faltering stock, many have questioned the potential of raising crabs in hatcheries, study-

ing their reproductive biology, and then releasing them to the wild. While researchers at the Center of Marine Biotechnology have been raising crabs and have begun a program to explore the implications of releasing crabs in Bay locations, questions have been raised about the implications for the commercial fishery and on natural stocks.

To learn how crab aquaculture has fared in Japan, which has 30 years experience, and if that experience holds any lessons for blue crab aquaculture in the Chesapeake, Maryland Sea Grant College sent a team of three researchers, each with a different background, on a two-week study tour of facilities there. *Japanese Hatchery-based Stock Enhancement*, which is the result of that visit, describes efforts in Japan to raise and release juvenile swimming crabs to the open environment, as a means of trying to increase stocks for commercial crabbing. The report also details the diverging views of the research team: one view holds that hatcheries for restocking blue crabs offers considerable promise, especially for particular river systems or subestuaries; on opposing view points out the vastness of the Chesapeake system compared with the relatively smaller Japanese embayments, and argues that stocking will probably prove ineffective.

For copies of the report, contact Jeannette Connors at 301-403-4220, ext. 22 or connors@mdsg.umd.edu. The report is also available on the web at www.mdsg.umd.edu/crabs.

Aquafarmer Reader Survey

This past year we asked you our readers to assess *Maryland Aquafarmer*, to tell us who you are and how we can better serve your interests and needs. We sent a questionnaire to our more than 1000 subscribers (this doesn't include those who access *Aquafarmer On-Line*, an average of some 4000 a month). Our first aim was to find out about your range of interests — the categories weren't mutually exclusive, so that a subscriber might check off several interests. With this said, those who identified aquaculture in general accounted for 41 percent of the returns — 27 percent of the total responses identified an interest in finfish aquaculture, followed by shellfish aquaculture (23%), university research (20%), commercial fishing and government agency (14%), soft crab shedding (13%), restoration (10%), seafood processing (8%); while we separated K-12 and college education, together they accounted for 16 percent. A diverse group of readers!

Most of you (94%) felt that articles were written at the "right" level, neither too technical nor too simple. As far as subjects that you found most interesting, on a scale of 1 (most interested) to five (least interested), there was not a great deal of separation among the following, though I have listed them in descending order: K-12 education, commercial fishing, recreational fishing, seafood processing, soft crab shedding, shellfish and finfish farming. As far as quality in general, 35 percent rated *Aquafarmer* excellent, 55 percent very good, 10 percent good and three respondents gave an average rating.

You requested articles on the way fish farmers deal with a host of problems, more on crab farming and soft crabs, more on university-related projects and articles on the techniques of producing shellfish and finfish.

This summary is based on a response rate of about 25 percent, which is to say that there may be many of you who would like to have us cover other topics in particular ways. I hope to hear from you if that is so — not with a questionnaire but directly by letter, phone, e-mail or the web. *Aquafarmer On-Line* will have a direct link so that you can contact me directly. You will also be able to respond to articles in which you may differ with the author or want to add information that we didn't cover. *Maryland Aquafarmer* aims to report to you on the Mary land Sea Grant Extension Program and to serve the needs of our diverse constituencies. We look forward to hearing from you. Merrill Leffler, editor; leffler@mdsg.umd.edu; 301-403-4220, Ext. 20.

Maryland Sea Grant Research Program

Maryland Sea Grant will support 10 research projects at six research institutions in 2003 and 2004; they cover priority areas for Maryland and the mid-Atlantic in Fisheries and Aquaculture, Disease, Technology, Restoration and Estuarine Processes. These projects were selected based on extensive scientific reviews and reviews by the Maryland Sea Grant Extension Program. Information about research institutions is included at the end of the list.

Winter Mortality of Chesapeake Blue Crabs, *Callinectes sapidus*. Anson Hines (SERC), Victor Kennedy (HPL) and Thomas Miller (CBL)

A Novel Approach to Inducing Sterility in Farmed Fish: Disrupting the Early Establishment of the Gonadotropin System. Yonathan Zohar (COMB)

Growth and Recruitment of Juvenile Chesapeake Bay Blue Crab. Dave Secor and Rodger Harvey (CBL)

Immunological Approaches to Understanding QPX Disease. Robert Anderson (CBL)

Organization of Chitinosomes in *Microbulbifer degradans*: A Strategy for Bioremediation. Ronald Weiner and Steve Hutchinson (UMCP)

Sediment Biogeochemistry and Seagrass Bed Development:A Strategy for Bioremediation. Michael Kemp, Laura Murray and Jeffrey Cornwell (HPL)

Do Oyster Filtration and Wave Attenuation Associated with Oyster Reefs and Breakwaters Improve Sea Grass Habitat? Raleigh Hood, Evamaria Koch, Roger Newell, Elizabeth North (HPL)

Benthic Studies in Chesapeake Bay: (1) Analysis and Synthesis of Faunal Data in Relation to Sediment and Water Column Interactions, and (2) Scope for Future Needs. Robert Marinelli (CBL)

The Role of Small Inlets as Potential Reactor Vessels for Gelatinous Zooplankton in Chesapeake Bay. Denise Breitburg (ANSERC)

Quantifying the Magnitude of Nitrogen and Phosphorus Removal Associated with Restoration of Oysters in the Chesapeake Bay. Roger Newell, Jeff Cornwell and Donald Meritt (HPL)

CBL (Chesapeake Biological Laboratory) & HPL (Horn Point Laboratory) are part of the University of Maryland Center of Environmental Studies

COMB (Center of Marine Biotechnology) is part of the Maryland Biotechnology Institute

UMCP – University of Maryland College Park

ANSERC – the Academy of Natural Science Estuarine Research Center

SERC (Smithsonian Environmental Research Center)

Calendar

Oyster Research and Restoration: Developing Strategies for the Futur e

Annapolis, Maryland • February 17-18, 2003

For more than a decade, NOAA's National Sea Grant College Program has supported wide-ranging efforts to counter the impacts of oyster disease and to address the many setbacks and challenges that the oyster industry has been faced with. Among these efforts are the congressionally-funded Oyster Disease Research Program and the Gulf Industry Oyster Program, which have been developing new tools for disease diagnosis, breeding disease-resistant oyster strains, modeling, rapid detection of human pathogens in shellfish and new processing methods to ensure public health.

In an important meeting this February, the National Sea Grant College joins with Maryland and Virginia Sea Grant in bringing together representatives of the scientific, management, industry and public outreach communities to build on those past accomplishments and to chart strategies and priorities for future directions. The meeting will include plenary sessions and facilitated workgroups. The plenaries will summarize the status of oyster fisheries in the U.S.; share the current status of oyster disease research; and synthesize developments for management oyster restoration. Workgroups will develop recommendations and strategies on the following topics:

- Oyster fisheries management and restoration
- Aquaculture and hatchery issues
- Genetics and oyster populations
- MSX and Dermo — frontiers in disease and diagnostics research
- Public health and processing

The meeting will offer an opportunity for participants to provide substantive input that will lead to the definition of new program priorities.

For registration, hotel reservations and other information on the meeting, which is limited to 150, visit the web: www.mdsg.umd.edu/oysters/meeting or contact one of the following organizers:

Jonathan Kramer
kramer@mdsg.umd.edu
William Rickards
wlr4z@virginia.edu
Jim Mcvey
jimmcvey@noaa.gov

East Coast Commercial Fishermen's & Aquaculture Trade Exposition
Seminar Sessions and Future Waterman's Program

Ocean City, Maryland • February 1-2, 2003

Seminars and junior waterman's program organized
by the Mid-Atlantic Sea Grant College Programs

Jr. Waterman's Program

Saturday, 12:00-4:00

Children move at their own pace through this interactive, hands-on program highlighting fishing, aquaculture and the aquatic environment. Designed to be a trade-show of their own,these Junior Watermen will get up close and personal with the wet and wild,paint a fish, harvest oysters,cast out their best lines, and much, much more. Jackie Takacs and Adam Frederick,Maryland Sea Grant Extension Program,Vickie Clark,Virginia Institute of Marine Science.

Seminars – Saturday

Commercial Fisheries

Targeted Harvesting

11:00 Black Sea Bass:Discard Mortality in Pot Fisheries, Robert Fisher, Virginia Sea Grant

11:30 Effects of Potomac River Fisheries Bycatch Reduction Panels on Pound-net and Haul-seine Catch Composition,Chris Hager, Virginia Institute of Marine Science (VIMS)

Species Health

12:00 Mycobacterium:What Is It Doing to Our Fish? Andrew S. Kane, University of Maryland College Park

12:30 Disease Impacts on Blue Crab Populations, Jeffrey Shield,VIMS

1:00 The Drought and Disease in Native Oysters,Christopher C. Judy, Maryland Department of Natural Resources

Blue Crab Research

Chaired by Doug Lipton, University of Maryland Sea Grant Extension

1:30 Overview of NOAA-Supported Blue Crab Research, Derek Orner, NOAA Chesapeake Bay Office

1:50 Migration of Adult Female Blue Crabs to Spawning Grounds: Mechanism and Routes, Tom Wolcott,North Carolina State University

2:15 The Use of Sanctuaries and Corridors by Chesapeake Blue Crabs, Rom Lipcius,VIMS

2:35 Hatchery Mass Production of Blue Crab Juveniles for Stock Enhancement Research, Yonathan Zohar, University of Maryland Center of Marine Biotechnology

Aquaculture

Chaired by Andy Lazur, University of Maryland Sea Grant Extension

Hard Clam Culture

11:00 Clam Culture Economics and Outlook,Thomas Murray,VIMS

11:30 QPX, an Emerging Disease of Hard Clams:What Do We Know and What Can We Do about It? Lisa Ragone Calvo,Virginia Institute of Marine Science

12:00 The Growth and Development of the East Coast Shellfish Growers Association: How It Benefits Shellfish Farmers, Karen Rivara, President,Aeros Cultured Oyster Company, Inc.

Start-Up Aquaculture

12:30 Aquaculture Production Systems: Extensive vs Intensive, Michael Schwarz,Virginia Seafood Agricultural Research and Extension Center

1:00 Marketing and Economic Considerations,Andy Lazur, University of Maryland Sea Grant

1:30 Direct Marketing Channels for Tilapia, Charles W. Coale, Jr., Virginia Tech

2:00 Example of a Low-Tech Approach to Aquaculture, Daniel Kaufman,Virginia Seafood Agricultural Research and Extension Center

2:20 Aquaculture and Food Safety, Michael Jahncke,Virginia Seafood Agricultural Research and Extension Center

2:10 Aquaculture Information Resources,Andy Lazur, University of Maryland Sea Grant Extension

2:20 Question and Discussion Period, Start-up Aquaculture Panel

Seminars – Sunday

Commercial Fisheries and Seafood

Can We Bring Oysters Back to the Chesapeake?

11:00 Maryland Perspective, Chris Judy, Maryland DNR

11:20 Virginia Perspective, Jim Wesson, Virginia Marine Resources Commission

11:40 Progress with Disease Resistance, Mark Camara, VIMS

12:00 The Asian Oyster: Can the Native Oyster Compete? Mark Luckenbach, VIMS

12:20 The French Experience, F. William Sieling, Chesapeake Bay Seafood Industries Association

State Marketing Programs

12:40 Virginia Update, Shirley A. Estes, Virginia Marine Products Board

1:00 Maryland Update, Noreen Eberly, Maryland Department of Agriculture

Regulations Affect Off-shore Vessels

1:20 Vessel Stability and Watertight Integrity Rules, Robert G. Garrott, U.S. Coast Guard

1:40 Large Whale Take Reduction Plan, Glenn Salvador, National Marine Fisheries Service

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www.mdsg.umd.edu/MDSG/Extension/Aquafarmer/index.html

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