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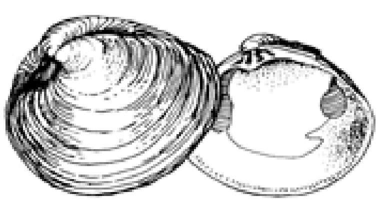

Hard Clam Farming:
Getting Started in Maryland

Don Webster, Eastern Shore Area Agent

The hard clam, *Mercenaria mercenaria,* is a widely cultured species - on the East coast, Florida and Virginia are the largest producers of aquaculturally grown clams while other states have expanded production as demand has increased. The first census of aquaculture carried out by the United States Department of Agriculture in 1998 found the dockside value of hard clams to be $58 million nationally.

Maryland has been a latecomer to *M. mercenaria* aquaculture, also referred to as quahogs, primarily because the higher-salinity areas in which hard clams can grow is limited, though populations occur in areas near the state's southern border, in Lower Tangier and Pocomoke Sounds. However, these populations are sporadic and do not support a substantial fishery. Conditions for the culture of hard clams are limited to the coastal bays, in the waters of Worcester County. Here they are found in natural commercial aggregations and a directed fishery for them has been sustained over time.

Hard clam aquaculture has been able to expand because of the development of hatchery and growout techniques that can make farming profitable. An important factor contributing to profitability is the high market demand for small clams called "cherrystones" or littlenecks": their growout times are short, which helps cash flow. Historically, laws in some states that were designed to protect small clams from harvest have had to be changed to allow farming operations to legally sell them.

Like all farming, clam culture must be approached with caution, knowledge, and a lot of background work. We cannot repeat often enough that aquaculture is a site-specific business; in other words, what works in one location may not work the same way in another. You must first have a plan for development if you are to have any prospect for success.

Aquaculture

There are three distinct phases to most forms of aquaculture, especially shellfish - hatcheries, nurseries and growout.

- Hatcheries obtain and maintain broodstock, conditioning the animals for spawning. Larvae are free swimming, until they metamorphose into their final form. The hatchery seed is usually sold between 1 and 4 millimeters in size.
- Nurseries obtain clam seed and place them in "upwellers" or "downwellers," containment devices that enable clams to feed on phytoplankton in the natural water that is pumped to them. The nursery phase continues from spring through summer until clams have reached 10 to 12 millimeters in size, the size regarded as best for successful planting.

Growers plant seed on bottom grounds, protecting them from predators with netting and bags. Nets or other protective materials must be monitored to prevent the entry of predators, and cleaned to remove fouling organisms that would restrict water flow and, therefore, food (i.e., phytoplankton). Failing to keep netting clean can result in longer than normal growth rates and - the bottom line - can affect financial success.

Getting a Lease

The State of Maryland leases bottom grounds to citizens for oyster and clam culture. Though leaseholds are currently open in Wicomico and Worcester Counties, clam culture is only feasible in Worcester. To obtain a lease, you first need to identify specific bottom areas that have the right soils, good water flow, and adequate protection; you would then mark the grounds with a stake (including your name) and file an application that includes a $300 fee with the Maryland Department of Natural Resources. DNR will arrange to survey the bottom, making sure that it is not currently charted as oyster bar or that it does not meet the criteria for "clam bar." This criteria is defined as not exceeding catch rates of 500 hard clams, 1/2 bushel of soft clams, or 1-1/2 bushels of razor clams per hour. If the proposed area passes, a notice will be published in local newspapers announcing the application. While any citizen has the right to protest the lease, the court is the final adjudicator. If approved, the State grants the lease for a twenty-year period, renewable upon payment of annual lease fees. The current lease rate is $3.50 per acre per year.

Selecting Bottom Grounds

Clams bury themselves in bottom grounds, maintaining their siphons near the surface so that they can draw in water containing phytoplankton. Sandy bottom or sand containing some mud is best: it keeps clams fairly clean and attractive for maximum marketability. Bottom that contains a lot of mud or small clay or silt particles may discolor the shells as well as the meat, rendering them unattractive for the market. While selecting good bottom grounds is critical, location in relation to land is critical as well. For example, is the area subject to runoff which during high rainfall can lower salinity and unduly stress clams? Is the area protected from wind-driven waves, so that it doesn't have the potential for drying up during periods of high winds, a factor that can also stress clams, causing mortality or episodes of disease.

Bottom Culture Techniques

There are several ways to grow hard clams, for example, in soft bags, in hard bags and under netting. Each is designed to protect the animals while allowing them to filter as much water as possible to promote fast growth.

- **Soft bags** were developed in Florida and consist of mesh bags measuring 4 feet on a side (16 sq. ft.) that are sewn around almost all four sides, leaving only a small corner opening into which clams are placed. For market growout, the bags are charged with 2,000 clams in the 10 to 12 mm size range. The bags are then placed together with ropes holding them on each side and laid on the bottom, where they are anchored and marked. Sometimes a small (6-inch high) stick is placed in the middle of the bag, forming a "tent" until the clams have buried in the bottom. The clams are left in the bags, with the grower cleaning and checking the bags periodically until the clams have reached market size. The bags are then picked up and transported to shore for sorting, washing and packaging.

- **Hard bags** are marketed for the growout of both clams and oysters and are popular in several northeast states. They are made of extruded plastic mesh and are usually about three feet long and 1.5 feet wide (4.5 sq. ft.). One end may be thermo-welded closed. If not, both ends will be left open and the bags themselves form an "envelope" into which seed are placed, between 300 and 500 clams of 10 to 12 mm size per bag. The ends are closed with stainless steel hog rings and the bags placed in rows on the bottom. They are cleaned and checked throughout the growout cycle and, at harvest, picked up and returned to shore for sorting, washing, and packaging.

- **Predator exclusion netting** is most frequently used in the mid-Atlantic area. Light plastic netting in sheets measuring 14 feet wide and usually about 50 feet long are used to protect planted clams from predators. The clam beds are raked smooth, then planted with 10 to 12 mm seed, approximately 50 to 125 per square foot. The planting density is dependent upon the food supply, water flow, and resultant growth rate of the clams. The netting is laid over the clams; sand bags, or a reinforcing bar, are laid along the edges to keep the nets anchored over the clams. The grower then "swims" the net, checking to make sure that no crabs or other unwanted animals are underneath the netting. If found, they are destroyed before they can prey upon the seed clams. The netting has to be checked frequently for growth or tears. If nets are torn, they must be immediately replaced. Cleaning can be accomplished using a long pole with a "T" on the end made of aluminum tubing. It is used like a squeegee and pulled across the netting, clearing it of the fouling that will prevent water circulation across the clams. At harvest, the nets are removed, the clams raked and placed in a boat for transport to shore for washing, sorting, and packaging.

Purchasing Seed Clams

Always purchase clam seed from a reputable hatchery or nursery. There are several in the mid-Atlantic that have developed a good reputation for quality seed. With current demand so high, sellers may require a deposit to ensure that growers are sincere and can meet production. Most seed for growout is 10 to 12 mm in size, which is generally recognized as best for survival - smaller seed often results in lower survival.

If growers wish to nursery their own seed, they can purchase 2 to 4 mm clams and raise them in an upweller or downweller until they are of plantable size. Be aware, however, that it will take time to keep these small animals clean; the additional equipment required to protect small clams in a nursery will also incur additional expense.

Growers should also beware of "bargains," especially near the end of the nursery season. Sometimes hatcheries and nurseries end up with their slowest growing seed through the normal process of sorting and grading and retain the "runts." Runts may be genetically slower-growing clams that will perform poorly and result in longer growout times and higher expenses. Another factor to consider is the strain or stock that the clams came from. Clams that are from southern strains seem to have higher mortality during the winter months in the mid-Atlantic, while those from northern strains can be affected by the high summer water temperatures that are found in the area. Those produced from clams neutral to the mid-Atlantic region frequently seem to do better under culture conditions than those from either extreme. Always remember that shellfish imported from other states require a permit from the Maryland DNR. The permit process is to protect the integrity of local stocks. Permit applications should be requested well in advance of the need to import the shellfish seed in order to ensure compliance with the law.

Keeping Equipment Clean

We can't stress enough the critical importance of removing fouling - this will go a long way towards your getting clams to market as quickly as a site will allow. Nets, bags, and other predator exclusion devices need to be kept free of fouling so that the clams can receive the maximum amount of water circulation. More water flow usually equals more food flowing past the clams; more food available to clams means faster growth, healthier animals, and a shorter time to market with a quality product.

Monitoring Clams

The key to monitoring is in deciding what you want to know and how much time you have to learn. At one extreme, you could take samples and measure growth every few days - while you might learn a lot you'd never have much time to do anything else. At the other extreme, you could leave clams until they are ready for harvest - in this case, you wouldn't learn much about improving your operations. Here are some suggestions on what monitoring can do for you.

If you are buying clams from more than one supplier, it might be a good idea to segregate the populations so that their performance can be compared. In planting at different times of the year, or planting seed of different sizes, it could be valuable to keep these plots marked so that they can be monitored and compared against others. You then have to figure out how many clams you want or need to measure to get meaningful data and how to best compare these to make decisions with the data. In order to make comparisons, you do not need to measure every clam on the growout plot. There are good scientific techniques that employ random samples, so that you measure only a portion of the total, and still come out with figures that are statistically significant. To develop a monitoring program, contact a Sea Grant Extension Specialist; we can help also in finding out just how the clams are growing in relation to other variables.

Clam Growers in Maryland

Several residents of Worcester County are currently raising hard clams while one nursery is supplying clam and oyster seed to the area. A cooperative has been formed, assisted by the Worcester County Economic Development Office, with some funding support from the Rural Development Center at University of Maryland Eastern Shore to assist in getting their businesses off the ground. It is envisioned that these offices will provide the basis for research into the best methods for this area as well as knowledge of the growth rates and survival of clam seed in this state.

The Maryland Industrial Partnerships (MIPS) program has funded development of the nursery project, which has previously been reported in the Maryland Aquafarmer (www.mdsg.umd.edu/Extension/Aquafarmer/Summer00.html#2. This unique program teams University faculty with industry partners, funding development and application research to bring new products and techniques to market. The program has been very successful in a wide range of projects over the years, and has been especially beneficial to small businesses with good startup ideas (see www.erc.umd.edu/MIPS).

The trend towards production of hard clams in Maryland looks quite bright at this point, with strong local markets for quality products and a core of people willing to invest their time and resources to bring them into production.

For more information on hard clam aquaculture, see "Clam Aquaculture in Maryland," www.mdsg.umd.edu/Extension/Aquafarmer/Winter01.html#3, or contact Don Webster at (410)-827-8056; webster@mdsg.umd.edu

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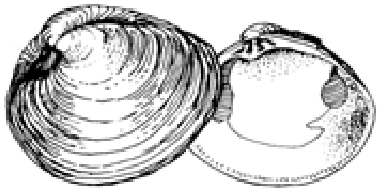

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agpublications.tamu.edu/pubs/efish/433fs.pdf

NOAA Coastal Services Center
www.csc.noaa.gov/lcr/nyharbor/html/gallery/sgmercen.html#life

Chesapeake Bay Program
www.chesapeakebay.net/info/hard_clam.cfm

The Assateague Naturalist
www.assateague.com/nt-bival.html

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Maryland Aquaculture Association

Chip Crum, President

The Maryland Aquaculture Association (MAA) is alive and well. I was recently elected President and Steve Hughes Vice-President. We are both veterans of aquaculture. The mission of the MAA is to give a single voice for those involved in Maryland's aquaculture industry and to serve as a forum and a clearinghouse for aquaculture wisdom and interests. To further this goal, I will travel to meet with aquaculturists across the state to insure the focus of the MAA is exactly where MAA members want it to be.

The logical extension of providing a voice to the state industry is to make our voice heard. In particular, state legislators and citizens need to understand what aquaculture is and how it can benefit Maryland. Further, they need to know what can be done to maximize aquaculture's positive impact. We will have regular postings of MAA events and happenings. Meetings are currently being planned for Frederick County and the Eastern Shore. We are planning lectures by MAA officers on subjects ranging from recirculating systems to fish health to starting your own aquaculture business to water lily culture.

For more information, contact Chip Crum at (301) 878-1882 or Steve Hughes at (410) 465-17664 or sghughes@mail.umes.edu

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Recirculating Systems Roundtable Workshops

Andy Lazur, Finfish Aquaculture Specialist

Maryland Sea Grant Extension is organizing a series of eight workshops over the coming months on operating and managing recirculating systems for aquaculture. The workshops are designed both for those who already own and operate recirculating systems and for those who are interested in exploring their prospects. The first two workshops are listed below.

Recirculating Culture Systems

Thursday, March 14, 7-9 p.m.
Wye Research and Education Center. Speaker: Dr. Fred Wheaton, University of Maryland College

Park.

An introduction to the technology of recirculating culture tanks, including the principles of water re-use, design and components used.

Water Quality Management for Recirculating Systems

Thursday, April 25, 7-9 p.m.
Horn Point Laboratory, University of Maryland Center for Environmental Science, Cambridge, Maryland. Speakers: Andy Lazur and Don Webster, Maryland Sea Grant Extension

Review of important water quality parameters and management practices to optimize water quality. A hands-on monitoring and testing section will be included.

Feedback from these two roundtables will help us direct topics and the sequence of future meetings. Other topics we plan to cover are:

- Solids Capture and Waste Management, Fred Wheaton
- Biofiltration, Fred Wheaton
- System Management and Monitoring, Fred Wheaton, Andy Lazur, Steve Hughes, University of Maryland Eastern Shore
- Feeds and Nutrition, Steve Hughes
- Economics and Risk Evaluation, Karl Roscher, Maryland Department of Agriculture, and Charles Coale, Virginia Tech
- Fish Health Management, Andy Kane, University of Maryland College Park

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For more information on these workshops, contact Andy Lazur at (410) 221-8474, or alazur@hpl.umces.edu

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Dinoflagellates and Estuarine Pond Aquaculture

Dan Terlizzi, Water Quality Specialist

Successful fish farming can be characterized as a constant struggle between entrepreneurial spirit and the various realities of economics, ecology, and biology - Tony Mazzacarro, the owner of Hyrock Farms understands this struggle as well as anyone. Mazaccarro began Hyrock over ten years ago as an estuarine hybrid striped bass farm, the largest pond operation in the mid-Atlantic. The water source was the Manokin River, a tributary to the Chesapeake - the choice of estuarine water was a calculated one: the salt content of the river would eliminate one water quality management concern, namely nitrite. Furthermore, Mazzacarro felt that salt water would produce a better tasting product. Feedback from buyers at the Fulton Market in New York confirmed this and Hyrock sold everything it produced with no significant fish losses.

However, after several years of successful operation, problems began to occur in the form of mahogany tides - these dinoflagellate blooms resulted in several large fish kills in 1996, 1997 and 1999. They presaged the dinoflagellate events on the Pocomoke River in 1997 that came to be associated with *Pfiesteria piscicida* (for more on these events, see "Managing Dinoflagellate Blooms in Estuarine Aquaculture Ponds," Maryland Aquafarmer www.mdsg.umd.edu/Extension/Aquafarmer/Winter00.html). The mortalities at Hyrock Farms provide an important lesson that was largely overlooked in the 1996 fish kill, which was also the first in the Chesapeake region to be associated with Pfiesteria - this lesson is the often quoted precaution that correlation is not causation.

While pond waters did have Pfiesteria present at fairly low levels of several hundred cells/milliliter, another dinoflagellate *Karlodinium micrum* (formerly *Gyrodinium galatheanum*) was present in thousands of cells/ milliliter. Although Burkholder and Glasgow (1997) attributed the mortality to Pfiesteria, there is evidence that *K. micrum* at much higher cell densities was the real culprit

(Terlizzi, et al. 2000). Determining the cause of such kills is important if we are to try and provide effective responses to dinoflagellate blooms in estuarine fish ponds.

Copper Sulfate: A Hazardous Treatment

The first kill at Hyrock associated with *K. micrum* had followed treatment with copper sulfate, which led to speculation that *K. micrum* and possibly other organisms released a toxic compound following the breakup (lysis) of cells that resulted from adding copper. During intensive monitoring efforts at Hyrock in 1996, 1997, and 1998, we focused our attention on *K. micrum*. This collaborative effort with Dr. Pat Glibert of the University of Maryland Center for Environmental Science (UMCES), Horn Point Laboratory in Cambridge, was funded by Maryland Sea Grant and the University of Maryland Agricultural Experiment Station. Our aim was to examine phytoplankton production in Hyrock ponds from a nutrient ecology perspective: we wanted to know if there was any relationship between nutrient quantity or the form of nutrient, for example, ammonia or urea, on the composition of phytoplankton communities and in particular dinoflagellates.

One striking result that appeared in early evaluation of the data was a relationship between urea and the appearance of dinoflagellates (Glibert and Terlizzi 1999). From a management perspective our goals were simple - what organisms were associated with fish stress and mortality and how could we best manage them? Our field observations, although somewhat anecdotal, were convincing - dinoflagellate blooms of any species usually stressed fish. All three of the major kills at Hyrock occurred during blooms of *K. micrum*. While these observations do not absolve Pfiesteria as a factor in fish mortalities at Hyrock or in the Chesapeake, they do raise important questions about its role.

These observations are supported by other findings at Hyrock. For example, Dr. David Oldach of the University of Maryland Medical School, using a DNA probe that detects non-toxin producing strains of *Pfiesteria piscicida,* showed that all of the ponds at Hyrock had tested positive for the organism, reinforcing the view that with Pfiesteria present all the time, fish kills could well have been associated with a dinoflagellate such as *K. micrum* that bloomed occasionally. In addition, none of the fish killed at Hyrock exhibited lesions, one of the reported consequences of Pfiesteria in field and laboratory experiments.

Shortly after the last *K. micrum*-related fish mortality at Hyrock, Jon Deeds at the University of Maryland Center of Marine Biotechnology undertook a study aimed at clarifying the factors leading to the Hyrock kills. He set out to determine whether a toxin was associated with those kills and to evaluate the pathology of this dinoflagellate's action on fish. In lab experiments that mimicked the 1996 bloom management methods of adding copper to Hyrock ponds, he found that a toxic compound was released when copper disrupted cells. His subsequent work has led to the isolation of a toxic fraction that he is currently working to identify (Deeds et al. in press).

A number of known toxin-releasing dinoflagellates species occur naturally in the Chesapeake, though their toxicity in the Bay hasn't been observed as it has in other coastal waters. The laboratory demonstration of a toxin from *K. micrum* and the dinoflagellate's presence during fish kills in the Hyrock ponds may be the strongest evidence that toxin-releasing dinoflagellates are in the Chesapeake.

Dinoflagellate Research

The dinoflagellate problems at Hyrock have given rise to a number of research topics that relate to why particular dinoflagellate and phytoplankton species occur. During field work at Hyrock and during the intense media coverage of the Pfiesteria crisis in 1997 on the Pocomoke River, Mazzacarro pointed out that Hyrock ponds were serving as a "laboratory" for the Bay and provided an opportunity to evaluate how dinoflagellates originate. Since the ponds were fed from the Manokin River and water was added at regular intervals during the summer to compensate for evaporation, one hypothesis was that dinoflagellates were being brought in from the river. To address the possible introduction of harmful dinoflagellates via intake water, Mazzacarro designed an ozone system. Unfortunately, he built the system after the intensive monitoring years of 1996 and 1997 and the question of whether ozonation will completely remove harmful dinoflagellates remains unanswered. However, preliminary work conducted in collaboration with Drs. Pat Glibert and Diane Stoecker, also of the UMCES Horn Point Laboratory, has shown that cyanobacteria could survive the ozonation system.

There is some belief that dinoflagellate blooms may have developed from cysts present in pond sediments. Observations support both intake from the Manokin River and sediment cysts as a source of dinoflagellate blooms at Hyrock. During the toxic event at the ponds in 1999, 5,000 hybrid striped bass fingerlings were lost in a *K. micrum* bloom that originated at the point of intake and appeared to further develop in the pond. It is unclear whether low concentrations of dinoflagellates from the intake water could also lead to harmful blooms through gradual increase in population densities or perhaps through the accumulation of cysts in sediments over time.

To begin evaluating this question, Joe Marinelli, a student in the Hood College Environmental Science Masters program, examined the distribution of dinoflagellate cysts in sediments of Hyrock production ponds. He began by searching the scientific literature for descriptions of dinoflagellate cysts of species that had been observed in the ponds. Unfortunately, a cyst for *K. micrum* has not been described, though a related species and one described at Hyrock, Gyrodinium uncatenum, has been. Marinelli then sampled sediments: using a purification procedure for cysts, he concentrated the samples and followed up with identification and an estimate of the abundance of cysts in ponds. The most abundant cyst observed was tentatively identified as G. uncatenum. Interestingly, there was no relationship between cyst abundance in sediments and ponds exhibiting problems with fish mortality. One possible explanation is that germinating cysts leading to blooms and fish mortality had been depleted in the ponds with fish kills.

In addition to the question of cyst distribution in the ponds, there is the question of what causes cysts to germinate. The life history of Pfiesteria (Burkholder and Glasgow 1997) describes germination stimulated by exposure to by-products of fish metabolism. Earlier work with Pat Glibert had shown a relationship between urea and dinoflagellates in Hyrock ponds, although the mechanisms underlying this relationship are not known. One possibility is that elevated levels of urea might stimulate germination of dinoflagellate cysts. Erin Armbrester, then a senior at Hood College, took sediments from the Hyrock pond with the most recent dinoflagellate bloom (the bloom that had originated from the Manokin River) and treated sediments with nitrate, ammonia and urea. She evaluated the successional pattern of phytoplankton for several weeks and showed dinoflagellates were enhanced in the urea and ammonia treatments. Although Marinelli and Armbrester's work is clearly preliminary, it suggests a role for both cysts and nutritional stimulation on dinoflagellate blooms that developed at Hyrock.

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The problems we experienced at Hyrock Farms with dinoflagellates are not unique. During the early blooms, we learned that hybrid striped bass growers on Pamlico Sound in North Carolina had drilled fresh water wells: they wanted to avoid using the estuarine water that had resulted in harmful algal blooms and mortalities attributed to Pfiesteria. We also learned that *K. micrum* (formerly *G. galatheanum*) had been associated with fish kills in aquaculture facilities in South Carolina and Texas. Most recently, I learned of an inland saline pond aquaculture system in Texas that has been experiencing fish mortalities related to the toxic flagellate *Prymnesium parvum.* It appears that the combination of high nutrients and high fish densities, which are characteristic of intensive pond systems, coupled with saline waters, is a particularly troublesome combination. The catfish industry, with freshwater aquaculture ponds, is based on high densities and concomitant high nutrient levels - management concerns in these systems focus primarily on maintenance of adequate dissolved oxygen and prevention of off-flavors derived from cyanobacteria that flourish in the nutrient-rich environment. While low oxygen concentrations and an abundance of cyanobacteria are problems in estuarine pond aquaculture as well, the primary difference appears to be the higher potential of toxic algae in saline waters.

We have many questions to answer - for instance, will ozonation eliminate the threat of importing harmful blooms and decrease the accumulation of dinoflagellate cysts in the sediments? What are the nutritional and environmental cues for triggering germination of cysts? Does *K. micrum* produce a cyst? Is it unique from the *G. uncatenum* cyst that we believe occurs in Hyrock sediments or did we observe *K. micrum* cysts? Under what conditions and what nutrient concentrations will they germinate? What role, if any, did Pfiesteria play in the mortality events at Hyrock and what are the implications for resource management? An even more fundamental question for aquaculture is this: given the toxic algae that appear to flourish under the high nutrient levels and fish densities typical of estuarine pond systems, is there a future in salt water pond aquaculture? Ultimately this question has an economic component as well as a biological one - while we have learned to manage around toxic dinoflagellate events through regular monitoring and treatment, the biggest hurdles appear to be economic. In the end, the best advice is cautionary, be on guard, stay vigilant.

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Acknowledgements

Thanks to Drs. Pat Glibert, Michael Lomas, Allen Place, Diane Stoecker, Karen Steidinger and Gerardo Vasta for their interest in the dinoflagellate problems at Hyrock. Jon Deeds, a Ph.D candidate at the Center for Marine Biotechnolgy has confirmed our earlier speculation about toxic activity in *K. micrum*.

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Conducting Feed Evaluation Trials: A How-to

Steven G. Hughes, University of Maryland Eastern Shore

Most aquaculturists who have raised fish for any extended period of time have had to make decisions about the feed they are using - is it giving them optimum results, should they switch to another formulation or to another manufacturer. Such decisions can become complicated once other important factors are taken into consideration. The impacts of others can sometimes become confusing if your evaluation is not done correctly. In the following discussion, I summarize some guidelines for doing such an evaluation - if you follow these steps you should feel more confident about your decision making.

Methodology

The key factor in your test is to minimize the number of variables (things that can change the outcome of your test) so that the comparisons you make are the result of the different feeds and not the result of factors unrelated to the feeds. There are a number of important points to keep in mind.

1. Test fish should be of the same strain and of uniform size.
2. Water quality and fish density should be uniform among test groups (tanks or ponds).
3. Test diets should be fed to at least duplicate, and preferably triplicate, lots of fish so the results will be statistically meaningful (this procedure will discount the fact that sometimes very strange things happen to an individual replicate during these tests).
4. Test diets should be manufactured on as close to the same date as possible and stored under the best possible conditions.
5. Proximate analysis (the amounts of protein, fat, ash, and moisture) of all test diets should

be obtained from a commercial laboratory for the most accurate comparison (sometimes the labels on the bags are wrong!).

6. Test diets should be fed on the basis of percentage body weight (overfeeding should be avoided because this practice tends to hide small differences in feed performance) and fish should be weighed at least once every two weeks in order to adjust the amount of feed that they are being fed.
7. An accurate record of the amount of feed that is fed and weight gain, and mortality must be kept with a final count and weight of all test fish (or a very good sample count) at the end of the trial.
8. Any notable disturbance of fish in one or more of the tanks (e.g., disease outbreak in some tanks, tourists frequenting one series of tanks) should be recorded to determine if the disturbance may have affected the final results.
9. Records should be kept of the general health and appearance of all fish and, if costs allow, a sample of fish fed each diet.
10. Tests should be run long enough to adequately test the feeds and must also be given priority over all other hatchery operations if they are to render meaningful results (preferably one person can be assigned to handle the trial to insure some uniformity in feeding procedures, methods of cleaning, etc.).

Trial design and evaluations require at least a basic understanding of statistical procedures (e.g., diets need to be assigned to tanks randomly, fish must be dispersed in a random manner, initial starting weight of various tanks must not be substantially different).

All test fish must be equally subjected to any factor which may affect performance (e.g., if one tank is treated for disease, all tanks must receive the same treatment regardless of fish condition) to rule out the effect of this factor on the final results.

Interpreting the Results

In addition to the guidelines on how to conduct feed comparison trials, there are two issues that should be of concern. The first is that you never directly compare the results from two different feeds that are fed at two completely separate times. There is a tremendous temptation to do this but as noted above, differences in other factors such as weather or water quality may have just as much (if not more) to do with your findings than the feeds.

The second consideration is how do you judge the success or failure of one feed versus another? Though there can be many criteria, for most cases in commercial aquaculture operations the most useful one will be cost/unit weight of fish produced, which should be kept as low as possible. This calculation takes into account the feed conversion ratio (FCR = weight of food fed/weight gained) which gives an indication of how well the fish is actually utilizing the nutrients in the feed and multiplies this factor by the cost of the feed.

Using this method to compare feed X which costs $0.80/kg and has a FCR of 1.2 with feed Y which costs $0.75/kg and has a FCR of 1.5 leads to cost/unit weight produced values (feed cost x FCR) of $0.96 and $1.13, respectively. As can be seen from this example, the less expensive feed Y is not the most economical for an aquaculture operation.

There are many other ways and factors which can be considered in evaluating the final results of your feed trial (feed availability, storage considerations, etc.), so if you would like help in looking further into this process and setting up criteria for your particular operation, contact either your local extension personnel or university staff and they will be happy to assist you.

For more information on feed evaluation trials, contact Steve Hughes at (410) 651-7664 or sghughes@mail.umes.edu.

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Seafood Safety Update
Maryland Crabmeat Quality Assurance Program 2001

Rony Fortin

In Maryland, processing of Chesapeake Bay seafood centers on the blue crab - with the steep decline in oyster harvests over the last decade, fresh picked crabmeat has become the heart of the industry. Crabmeat is a perishable ready-to-eat food that must be processed under high quality and safety standards. As quality goes, so goes the health both of the picked crab industry, which in 2001 consisted of 30 operating plants. The estimated wholesale value of product added up to $20 million.

Since 1992, the Maryland Sea Grant Extension Program has worked with industry operators in conducting sanitation audits and process verification studies in processing plants. The findings help processors to identify procedures that most effectively control spoilage and pathogenic bacteria. In addition to the ongoing audits, a new study was initiated in 2001 to identify sources and controls for *Listeria monocytogenes,* a pathogenic bacterium that federal and state health regulators do not accept at any levels in ready- to-eat seafood. The study was undertaken because a microbiological survey of crab processing plants and crabmeat products characterized a persistent problem with *L. monocytogenes* and related species. The audits included 1,356 Listeria samples alone (other organisms were also isolated).

This study, part of a three year grant funded by USDA and a joint effort of Cornell University (the lead institution), includes Virginia Tech, Louisiana State University and the University of Maryland, will implement and evaluate promising control strategies with cooperating companies in 2002.

To assist seafood processors in improving control of Listeria, Tom Rippen, Seafood Technology Specialist with the Maryland Sea Grant Extension Program, developed an Extension Brief for use by the industry. ("Controlling Listeria in Crab Processing Plants" is available at www.mdsg.umd.edu/Extension/listeria.html). The brief emphasizes sources and control measures rather than technical background. It includes examples of practices that result in the contamination of crab products, and potential prevention methods.

The Crabmeat Quality Assurance Program is a quality management project of the Maryland Department of Agriculture and the University of Maryland Sea Grant Extension program. Crabmeat processors participate voluntarily and undergo several steps of inspections beyond the regular inspection protocol performed by state health regulators. Under

Summary of 2001 Results from 18 Processing Operations

Total Number of Samples Taken: 1,261
Crabmeat Samples Taken: 168
Environmental APC Samples Taken: 299
Environmental Listeria Samples Taken: 794

Crabmeat APC (total plate counts) cfu/g in 168 samples

cfu/g	No. samples	Percentage
<10	6	3.5%
10 - 9,000	146	87.0%
10,000 - 99,000	15	8.9%
>100,000	1	0.6%

Crabmeat Staphylococcus aureus cfu/g in 168 samples

cfu/g	No. samples	Percentage
<10	151	90.0%
10 - 100	5	2.9%
>100	12	7.1%

Crabmeat Listeria Non-Pathogenic cfg/g in 168 samples

No. samples	Percentage	
3	1.7%	Positive
165	98.3%	Negative

Environmental *Staphylococcus aureus* cfu/in2 in 299 samples

cfu/in2	No. samples	Percentage
<10	281	93.9%
10 - 100	8	2.7%
100 - 1,000	4	1.3%
> 1,000	6	2.1%

Environmental Listeria Non-Pathogenic on Equipment, 47 samples

this program, participating crabmeat processors have the privilege of exclusive use of the Maryland fresh cup and pasteurized can. The distinctive label identifies product packed under the quality assurance program.

Compared with previous years, the 2001 program had significant improvements in sanitation controls that met increasingly tighter requirements of regulatory agencies. Overall, the total plate counts (APC) were much lower than previous years; as a result, processors are offering a product of better quality and improved shelf life.

Equipment	No. samples	Percentage
crab barrels	11	23.4%
Retort carts	5	10.6%
Floor drains	9	19.1%
Crab trays	4	8.5%
Scrap hoppers	11	23.4%
Other*		15.0%

* e.g., crab bins, foot rests, chair backs, door knobs, aprons, gloves, picking-tables, claw baskets

47 / 794 = 5.9% Positives

In conclusion, 10 of 18 companies were positive for Listeria

For more information, please contact Tom Rippen at (410) 651-6636 or teripen@mail.umes.edu.

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Recent Publications

Aquaculture of Triploid *Crassatrea ariakensis* in Chesapeake Bay: A Symposium Report

Eric Halleman, Merrill Leffler, Sally Mills and Standish Allen, Jr.

Controlled field plantings of a non-native oyster spat of *Crassostrea ariakensis* that had been rendered infertile in the hatchery have been conducted in Virginia over the last two years. In comparison with the native *Crassostrea virginica*, the non-native Suminoe oyster from China, *C. ariakensis,* has so far shown a startling ability to resist the two parasitic diseases MSX and Dermo that have so ravaged *C. virginica* populations. Futhermore, the oyster appears to grow faster and in preliminary results on taste tests is indistinguishable from *C. virginica.* (See "Field Trial Summary of *C. ariakensis* vs. *C. virginica,"* www.mdsg.umd.edu/Extension/Aquafarmer/Summer01.html. A symposium report on the aquaculture of triploid (infertile) oysters in the Chesapeake, held in Williamsburg, Virginia in October 2001, has been jointly pubished by Maryland and Virginia Sea Grant.

For a copy of this Maryland Sea Grant report (UM-SG-TS-2002-01) contact Jeannette Connors at (301) 405-6376, connors@mdsg.umd.edu, or download from www.mdsg.umd.edu/oysters/exotic/anakensis01/index.html

The Economic Impact on Maryland's Crabmeat Processing of Proposed Regulations: A Possession Restriction on Sponge Crabs and Crabs Smaller than 5-1/4 Inches

Douglas W. Lipton and Shannon Sullivan

An economic analysis of current crab processing practices in the state of Maryland finds that the regulations proposed by the Maryland Department of Natural Resources, restricting possession of sponge crabs and male crabs less than 5-1/4 inches in carapace width, would result in annual lost sales to the Maryland processing industry of $13.5 million.

For a copy of this Maryland Sea Grant publication (UM-SG-SGEP-2002-01), contact Jeannette Connors at (301) 405-6376, connors@mdsg.umd.edu, or download from the web at www.mdsg.umd.edu/crabs/econ_rpt/index.html.

Boating 2000: A Survey of Boater Spending in Maryland

Douglas W. Lipton

In an economic impact analysis based on 220,000 registered and documented boats in Maryland, Lipton found that recreational boaters spend more than $2.3 billion for purchases of new equipment, annual boat-related expenses and trip-related expenses. This spending translates into $970 million of direct impacts by the state's recreational boating and related businesses. It indirectly creates income for workers and business owners in other Maryland industries throughout the economy, creating an induced impact. When indirect and induced effects are accounted for, the impacts from boater spending in 2000 was $1.6 billion dollars, in addition to a total of 28,200 jobs.

For a copy of this Maryland Sea Grant report (UM-SG-SGEP-2001-03), contact Jeannette Connors at (301) 405-6376, connors@mdsg.umd.edu, or download from the web at www.mdsg.umd.edu/Extension/recboat.html.

What's Next for Fish Farmers? Gauging the Future of a Fledgling Industry

Merrill Leffler

This Marine Notes Spotlight article examines the prospects of profitably rearing fish in closed-system recirculating tanks. Though off-the-shelf systems are available, managing those systems economically is a critical factor in success or failure.

This Expansion of the industry is likely to depend on advances in research laboratories that are at work on techniques for spawning a diverse array of species on demand, on the developing nutritional feeds for different life stages and for benign methods for protecting against disease. Marine Notes Spotlight article examines the prospects of profitably rearing fish in closed-system recirculating tanks. Though off-the-shelf systems are available, managing those systems economically is a critical factor in success or failure.

For a copy of Marine Notes, contact Jeannette Connors at (301) 405-6376, connors@mdsg.umd.edu, or download the article from the web at www.mdsg.umd.edu/MarineNotes/NovDec01/index.html.

Controlling Listeria in Crab Processing Plants

Thomas E. Rippen

Listeria monocytogenes, a disease-causing bacteria that has shown up in food processing plants, results from inadvertent contamination that is not carefully controlled. This two-page Extension Brief is especially for processors. It lists the sources of Listeria contamination, ways to prevent contamination by plant personnel, and how to prevent the bacteria from taking up residence.

For a copy of this Maryland Sea Grant publication (UM-SG-SGEP-2001-04), contact Jeannette Connors at (301) 405-6376, connors@mdsg.umd.edu, or download from the web at www.mdsg.umd.edu/Extension/listeria.html.

University of Maryland College Park Magazine: Don Webster's Rough Ride to Academia

Ellen Walker Ternes

The Fall 2001 issue of the UMCP magazine features a story on Don Webster, Maryland Sea Grant Extension Agent. Don is no stranger to readers of Aquafarmer, which he first started, and to the thousands, of watermen, aquaculturists, crab shedders and others in marine trades who he has been working with and assisting for some 28 years. Don came south from Rhode Island after getting his degree in URI's marine technology and commercial fishing program. He joined Sea Grant at its beginning in 1977. Together with first-rate photographs by John Consoli, the article is a fine tribute to a man who has been instrumental in helping to make Maryland Sea Grant Extension the leader that it is in aquaculture outreach in the mid-Atlantic.

Read this article on the UMCP website at: www.inform.umd.edu/cpmag/fall01/don.html

Clam Strain Registry

Tom Gallivan and Stan Allen

In 1998, the Aquaculture Genetics and Breeding Technology Center (ABC) at the Virginia Institute of Marine Science began the initial phase of the Clam Breeding project *Mercenaria mercenaria.* The goal, write Tom Gallivan and Stan Allen, is to produce an annual ABC Hard Clam Brood Stock Catalog full of data on the performance of various lines in industry settings.

For more information and a copy of the registry, published by VIMS and Virginia Sea Grant Marine Resource Advisory (VSG-00-10), contact Standish Allen at (804) 684-7710 or ska@vims.edu. For more on the ABC, visit www.vims.edu/abc.

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News Notes

Bayscaping Program at Chesapeake Biological Laboratory
Jackie Takacs, Regional Marine Agent

BayScaping is an environmental approach to landscape restoration that is designed to benefit wildlife and the restoration of the Chesapeake Bay ecosystem. BayScaped landscapes work with nature to reduce pollution and enhance wildlife habitat. For gardens and yards, bayscaping centers on minimizing fertilizer and pesticide use, wisely managing soil, water and vegetation cover, preventing soil erosion and maintaining proper soil pH.

The Chesapeake Biological Laboratory, part of the University of Maryland Center for Environmental Science, and Maryland Sea Grant - with support from the U.S. Fish and Wildlife Service Chesapeake Bay Field Office - has received a grant from the Chesapeake Bay Trust to begin a new BayScaping program. The program will create a unique education and demonstration site that illustrates the use of BayScaped landscapes in Bay restoration activities. It will include:

- Seven phases of planting over the next five years. Each phase consists of 1 to 3 individual gardens and includes a formal hedge, wildlife habitat and a wildflower meadow.
- Hands-on workshops for the public and teachers.
- Educational materials.
- Self-guided walking tours of BayScaped gardens.

Public workshops (spring and fall 2002) and teacher workshops (summer 2002) are now being planned. For more information, please contact Jackie Takacs, (410) 326-7356; takacs@cbl.umces.edu or Erin Woodrow, CBL (410) 326-7491.

MIPS Proposals Sought

The Maryland Industrial Partnerships is establishes joint university and company projects in which faculty and students conduct research in areas of economic benefit to Maryland companies. MIPS provides matching funds for University project costs. From start-ups to large corporations, Maryland industry can investigate innovative concepts and develop products, processes, and training methods in cost-effect ways. MIPS connects companies with researchers and state-of-the-art facilities from any of the University System of Maryland's 13 campuses.

Proposals for the next round of MIPS funding are due May 1, 2002. Call (301) 405-3891 for more information or to obtain an application packet. Visit the MIPS website at www.erc.umd.edu/MIPS to learn more about the program.

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Upcoming Conferences

National Shellfisheries Association
April 14-18, 2002
Mystic, Connecticut

Special sessions will cover (1) Biology and Conservation of Freshwater Mussels; (2) scallop biology and culture; (3) lobster biology and fisheries; (4) Sea Urchin biology and culture; 5) Blue mussel biology and culture; (6) Offshore fisheries; (7) Bivalve habitat suitability and role of bivalves in the ecosystem/ Environmental impacts of shellfish aquaculture: (8) Diseases of Crustacea: (9) Perkinsus; (10) Harmful algal blooms: (11) Shellfish pathology workshop; (12) East Coast Bivalve Industry Session (e.g. in-water nursery systems, culture of hard clams without predator control screens, and *Crassostrea arienkensis*); (13) Bivalve Disease Status and Trends.

For information on the conference, hotels and other attractions, visit the NSA website at www.shellfish.org/ mystic.htm.

International Conference on Recirculating Aquaculture
July 18-21, 2002
The Hotel Roanoke & Conference Center
Roanoke, Virginia

This fourth biennial international conference and trade show is designed for individuals in industry, government, or academia who are involved with recirculating aquaculture. Past conferences have attracted more than 1,500 participants from the U.S. and 30 foreign countries. Sponsoried by Virginia Tech, the Freshwater Institute, the Aquaculture Engineering Society, the Virginia Sea Grant College and the U.S. Department of Agriculture, the program. will highlight issues on nutrition, waste management, fish health, emerging species, genetics and physiology, aquaculture systems, economics and business management, and the rearing of marine shrimp. There are three tour options, the Virginia Tech Recirculating Aquaculture Center in Blacksburg, the Freshwater Institute in Shepherdstown and the Vic Thomas Striped Bass hatchery in Brookneal. Registration is $295/person if postmarked by June 17, 2002 and $395/person after that date.

To learn more about details and register on line, go to www.conted.vt.edu/aquaculture.htm.

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