MARYLAND AQUAFARMER ONLINE

MARYLAND COOPERATIVE EXTENSION
UNIVERSITY OF MARYLAND
COLLEGE PARK • EASTERN SHORE

http://www.mdsg.umd.edu/Extension/Aquafarmer/index.html

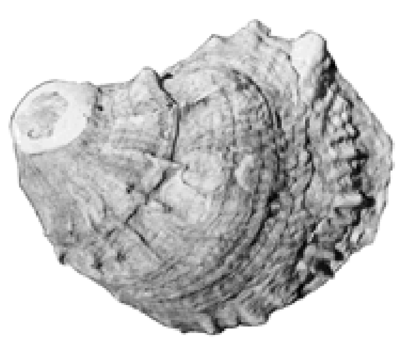
MARYLAND SEA GRANT EXTENSION•4321 HARTWICK ROAD, SUITE 300•UNIVERSITY OF MARYLAND•COLLEGE PARK, MD 20740•(301) 403-4220

Issue 2001-03 **Summer, 2001**

In This Issue:

The Future of Oysters in Chesapeake Bay
Different Paths to Restoration

Don Webster, Eastern Shore Marine Agent
Don Meritt, Shellfish Aquaculture Specialist



After record-setting oyster harvests in the late 19th century, Maryland's oyster fishery began its long decline. By the mid-1930s it had settled into annual landings of two to three million bushels a year from public oyster grounds and remained there for the next half century. In the last decade, however, harvests have plunged to less than a tenth of what they were, averaging under 200,000 bushels a year. This steep downturn had its origins in the 1950s, when the oyster parasite *Haplosporidium nelsoni* spread MSX disease from Delaware Bay southward through the coastal bays and into the lower Chesapeake. MSX and, later, Dermo began ravaging oyster reefs that were already damaged from years of overharvesting, habitat destruction, land erosion and runoff, pollutants and questionable management practices.

MSX caused a fundamental shift in the focus of production: until 1955, Virginia had led Bay-wide harvests with production from private, or leased, grounds. These grounds were planted and harvested by growers who largely relied on the incredible production of oyster seed in the James River. By 1970, MSX had wiped out vast tracts of oysters on these high salinity grounds. Because lower salinities are not as conducive to MSX, many areas in Maryland's upper bay were not as badly affected. In contrast to Virginia, Maryland manages oysters primarily as a public fishery, and has historically discouraged leaseholds for private growers. In 1961, the state initiated a new oyster repletion program to help keep "natural" or public oyster bars in production. This program involved dredging buried shell from non-productive oyster grounds, transporting them into areas that historically had high spat set, then removing oysters after the spawning season for planting on public bars in the upper bay.

With lowered precipitation in the 1980s, high salinity ocean water pushed further up the bay, bringing with it conditions that were more favorable to MSX, which now flourished in areas where it had not previously been a great threat. In addition, the parasite that causes Dermo, Perkinsus marinus, began to appear. MSX and Dermo were thought to be limited to regions where salinities were greater than 15 parts per thousand (ppt). However, by 1980 Dermo had begun to appear in regions with salinities as low as 10 to 12 ppt. Areas that had previously not been threatened by Dermo were now susceptible to these low salinity strains. The management practice of transplanting oysters from areas of high salinity to low salinity in order to purge the parasites was common during this period, including Maryland's repletion program. While this approach seemed to work well with MSX, it proved to be a disaster with Dermo.

Transplanted oysters infected with low salinity-tolerant strains of Dermo probably spread the disease into tributaries that had never before had it. With low precipitation and higher salinities in the 1980s, Dermo began to cause oysters to die in ever-widening areas. It was then that Maryland harvests plummeted - in Virginia, the future was bleaker. Many oystermen left the water, while year after year shucking houses and processing plants began to close down.

Hatcheries and Oyster Restoration

While Maryland and Virginia's resource management efforts focused on maintaining the commercial fishery, by the late 1980s, scientists, environmentalists and other citizens were making a strong case for the importance of oysters and oyster reef habitats as a key factor in the health of the ecosystem. The loss of oysters, they argued, was contributing to the decline of Bay water quality itself. As a primary filter feeder, oysters siphon large quantities of water, removing algae for growth and reproduction. With oyster populations in such low numbers, they were no longer filtering the amount of algae they once did. In 1987, Roger Newell, a scientist at the Horn Point Laboratory, part of the University of Maryland Center for Environmental Science (UMCES), estimated that it would take diminished stocks of oysters more than a year to filter the volume of the Bay, compared with the six days it would have taken at the beginning of the century.

The overabundance of ungrazed algae leads to biological and chemical processes that contribute significantly to the depletion of oxygen and the decline of underwater vegetation. The growing public awareness about the oyster's ecological importance (i.e., in removing algae and therefore nutrients) has been the impetus not only for citizen interest but, surprisingly, active engagement in oyster restoration. That engagement is evident in the popularity of oyster gardening programs such as those sponsored by the Chesapeake Bay Foundation (CBF) and supported by the Oyster Alliance, a partnership of CBF, the Oyster Recovery Partnership, the University of Maryland Sea Grant Program and UMCES. Hatcheries have begun to figure prominently in these and other restoration efforts.

Selective breeding of oysters is being carried out in order to develop broodstock that can withstand the ravages of disease.

The Chesapeake's oyster resources were so great for so long that even during the years of decline in the 1930s, the potential of hatcheries for commercial and restoration aquaculture was largely ignored. However, with the unremitting presence of MSX and Dermo, that view has been changing. Hatcheries make it possible to better control production, for example, to produce oyster seed with undetectable levels of oyster parasites and to attempt breeding oysters that are resistant to disease.

While production size hatcheries are not in operation in the Chesapeake, hatchery activities have been stepped up considerably at the UMCES Horn Point Laboratory - over the next several years, these efforts should begin to provide the kind of data we need to assess the costs and benefits of hatcheries for oyster restoration and aquaculture. Billions of eyed larvae are now produced for setting on bagged or containerized shell in large tanks. They are then moved to boats for placement in nursery areas and, after a month or two of growth, are moved once more to grow-out sites where they are released onto bottom grounds that have been stabilized to accept seed.

As part of the hatchery effort, selective breeding of oysters is being carried out in order to develop broodstock that can withstand the ravages of disease. Selectively-bred stocks such as CROSBreed are being tested in a cooperative effort by researchers at the Virginia Institute of Marine Science (VIMS), the UMCES Horn Point Laboratory, the University of Delaware and Rutgers University. They are also evaluating native stocks that have survived in areas with high disease pressure and comparing them with selectively-bred stocks. These oysters have been placed at sites in Maryland and Virginia and in Delaware Bay. While there are signs of success, it could still take a while to get the proper field tests for demonstrating just how resistant these strains are over the long term.

In addition to the use of hatcheries, state agencies have also begun to explore different restoration strategies. While the Maryland Department of Natural Resources has continued efforts with traditional repletion programs, it is now engaged in programs that include designating oyster sanctuaries which are off-limits to harvest. Such sanctuaries could enhance sustainable production for the fishery by protecting from harvest those adults with inherent (i.e., genetic) resistance to disease, as well as those that exhibit faster growth.

Non-Indigenous Oyster Species

Another approach to oyster restoration has involved the use of non-native or exotic oysters, which scientists originally investigated as candidates for hybrid crosses with *Crassostrea virginica,* the species native to the Chesapeake and the eastern seaboard from Canada to the Gulf of Mexico. They thought that hybrids could combine native taste with disease resistance. Crosses, however, were found not to be feasible and that line of investigation has largely been abandoned.

However, research has expanded to investigate the potential of introducing non-native oysters to the Bay. At first, the Pacific species *Crassostrea gigas* appeared to be a strong candidate - native originally to Japan, it had been imported to the west coast early in the century and has long been the basis of the industry there, which is largely dependent on hatchery production. It is also the basis of commercial production in other countries as well and is the most widely cultured oyster in the world. But *C. gigas* turned out to be a poor choice for conditions in the Bay.

Another species that held promise was the Asian oyster *Crassostrea ariakensis.* Though also introduced into the Pacific Northwest from Japan many years ago, hatchery production was limited there because of the region's high salinities. This doesn't appear to be the case for the Chesapeake - VIMS researcher Stan Allen, using protocols developed by the International Conference on Exploration of the Seas (ICES), began carefully controlled studies of the oyster in quarantine systems. The larvae produced at VIMS were cultured as "triploids," meaning they were rendered sterile through manipulation of the chromosomes, so that they could not reproduce.

Last year, representatives of the Virginia seafood industry petitioned the Marine Resources Commission (VMRC) for permission to conduct trials of triploid *C. ariakensis* in several locations on leased oyster grounds. These trials yielded oysters that are extraordinarily fast growing, reaching market size in about a year, in contrast to the two or four years that *C. virginica* ordinarily takes in Bay waters. Moreover, they yielded a quality product, largely indistinguishable in taste from native oysters and with full, firm meat in an attractive shell. Maryland watermen have remarked favorably on them. Processors in the region, who have imported shell stock for shucking from faraway locations, have been similarly impressed with these oysters.

What does *C. ariakensis* offer the oyster industry in Maryland?

> ***What we can and must begin to do in Maryland is explore the potential for the culture of the Asian oyster, C. ariakensis.***

Based on the trial studies reported by VIMS scientists, *C. ariakensis* thrives in the Bay's warm water and does not appear to suffer from the impacts of either MSX or Dermo, which kill most of our oysters before they reach harvestable size (see sidebar). It also does not seem to be affected by factors that made *C. gigas* unsuitable as a cultured species in the Bay. By employing triploid *C. ariakensis* produced in hatcheries, there is a potential to greatly increase production of a high quality commercial product for the half shell and shucked market; this could offer promise to the faltering seafood industry and provide new economic potential to our rural communities.

C. ariakensis could also help relieve harvest pressure on *C. virginica.* For example, Maryland DNR has already set aside sanctuary areas that prohibit commercial harvest; in expanding such sanctuaries, native oysters with a natural resistance to disease could begin to restore themselves over successive generations because they would be protected.

Just how long would natural restoration take? A decade? Ten decades? We cannot say. But it is a prospect that needs to be investigated.

What we can and must begin to do in Maryland is explore the potential for the culture of *C. ariakensis* - expanded efforts are already underway in Virginia. Specifically, trials of triploids could be deployed in Maryland water's in order to assess growth, mortality, disease resistance and marketability under different conditions. These trials should be carried out in cooperation with watermen and processors and the information shared among all who have an interest in oysters, the commercial fishery and the health of the Bay. If the results prove to be positive, then we must begin to examine the social, economic and policy implications for various restoration and commercial options.

Unlike Virginia, the Maryland oyster fishery historically has been based on harvesting oysters from public grounds, not from privately leased grounds. What then are the potential options of introducing *C. ariakensis?* Furthermore, is there a potential for non-triploid introductions of *C. ariakensis?* If so, how would this species compete with the native oyster? What is its potential for creating reef habitats? What are the costs and benefits of such introductions?

There are many more questions - the answers are not likely to be easy, nor without controversy. Based on the research to date, this non-native oyster may offer us an opportunity to more aggressively reverse the degradation of the Bay and of the fishery itself. We won't know unless we begin to assess those prospects.

top

Field Trial Summary of *C. ariakensis* vs. *C. virginica*

In a study of survival, growth and disease susceptibility of both oysters, VIMS scientists in June 1998 to September 1999 compared triploid (i.e., sterile) *C. ariakensis* with diploid *C. virginica* at replicate sites in three different salinity regimes: low (<15 ppt), medium (15-25 ppt) and high (>25 ppt) in the Chesapeake Bay and Atlantic coast. The medium and high sites were conducive to MSX and Dermo disease. They found the following:

Survivability

- At low salinity sites, mortality of *C. ariakensis* was 14% compared with 81% for *C. virginica.*
- At medium and high salinity sites, mortality of *C. ariakensis* was less than 15% compared with the death of all *C. virginica.*

Growth after One Year in Low, Medium, High Salinity

- *C. ariakensis.* Mean height, 96mm (low), 125mm (medium), 140mm (high).
- *C. virginica.* Mean height, 72mm (low), 85 mm (medium), 75mm (high).

Disease Prevalence during Second Summer

- *C. ariakensis:* 0-28% at three sites, mostly light infections.
- *C. virginica:* 100%, at all sites, heavy infections.

  Adapted from Calvo, G.W., M.W. Luckenback, S.K. Allen, Jr. and E.M. Burreson. 2000. A Comparative Field Study of Crassostrea ariakensis *and* Crassostrea virginica *in Relation to Salinity in Virginia. Special Report in Applied Marine Science and Ocean Engineering No. 360. Virginia Institute of Marine Science.*

top

Oyster Resources on the Web

University of Maryland Center for Environmental Science
Horn Point Laboratory Hatchery
www.hpl.umces.edu/facilities/facilities.htm

Virginia Institute of Marine Science hatcheries
Wachapreague
www.vims.edu/abc/wachapreague.htm
Gloucester Point
www.vims.edu/abc/gbhatch.htm

The Oyster Alliance
www.mdsg.umd.edu/oysters/garden

Chesapeake Bay Foundation Oyster Gardening
www.cbf.org/action/outdoors/oystser_md.htm

top

A Man and his Ideas
Remembering Max Chambers

Don Webster, Eastern Shore Marine Agent

Max Chambers, of Eden, Maryland passed away on May 15 after a long battle with cancer. As I was writing email notices to Max's friends and associates, it occurred to me how many people he had come to know and work with over the years. Now, beyond the pain of the disease he had fought, he left a footprint that was far larger than his stature would suggest.

While we first of all owe Max gratitude for the years he gave in service to this nation before retiring from the U.S. Army, the respect he earned in the Chesapeake region was for his tireless efforts to develop shellfish aquaculture and to bring attention to the condition of the Bay. Max was a prolific writer, sending pointed letters to media outlets, government agencies, scientists and environmentalists, in an attempt to gain wide distribution about the importance of oysters to the Bay and the role of aquaculture. One friend responding to my email wrote that Max had probably already written to the Lord requesting reasons for the current condition of the clouds in Heaven. If true, I trust that the Lord will address him with the same respect that his friends did, while smilingly knowing that there will, of course, be more letters to follow.

I first met Max on the Eastern Shore at the Horn Point Laboratory oyster hatchery over twenty years ago. Horn Point is part of the University of Maryland Center for Environmental Science. He had left a job with one of the largest oyster companies in the country, having become interested in growing oysters instead. He was at the lab to further learn the skills of conditioning, spawning and rearing oysters. Always a quick learner, he went on to build and operate two hatcheries on the lower Eastern Shore with his wife Flo.

The first hatchery was located near Nanticoke and was a masterpiece of simplicity. Hammered together from pieces and parts of other buildings, it was adorned with a sign that read, "This is NOT a government operation. If it was, I'd have twice as nice a facility and only one half the production." He had an enviable success in growing oysters at that site because of the quality of the water, and Max frequently invited scientists to try to find out what it was that provided the excellent growth. This success led him to his interest in phytoplankton and the Bay. Lee Wiegardt, one of the leading oyster producers on the West Coast, visited his operation; he later used photographs he took in lectures to University of Washington graduate students. Lee would finish his talk and say, "Now that you think you have all the knowledge in the world, I'm going to show you something that is simple...and works. You don't need fancy to do the job!"

Max was always amused that watermen who would most loudly proclaim their opposition to private cultivation of oysters would stop at his hatchery "jest t'see what was goin' on." They would often end up staying for hours asking questions and seeing aspects of the oyster life cycle that they had never experienced before. In that, Max was a very good educator. He had a respect for people. His advocacy of oyster aquaculture was founded in a belief that there are better ways to produce seafood rather than letting nature take its course and harvesting what happens to be there. He likened the harvest to trying to feed a modern world while hunting wild game. He made the point that Marylanders had been fighting for centuries over whether we would have a public or private oyster fishery, with the result that we ended up with neither.

In talks, meetings and discussions, he had the ability to phrase questions that struck at the heart of an issue and often made you stop and think about your positions. His ability to reduce arguments to simple terms led to a longstanding respect by those who both agreed and disagreed with his ideas. Max constantly probed for simple answers to complex questions. Even while acknowledging that he was sometimes wrong, we always admired his tenacity and purpose and respected the way he went about it. I do not ever remember seeing Max get mad or become mean-spirited in any arguments - even those in which he cared passionately. There was always the sly smile and a twinkle in the eye that made you know he was getting ready to say something that would find its way like a laser to the intended point.

During the tenure of Governor Schaefer, aquaculture became an issue of economic development for the state. Max helped organize the Maryland Aquaculture Association and served as its first President. He stepped down after two terms. He did so stating his belief that it was time for someone else to take over and voicing the opinion that changing leadership should be necessary in any organization. "If others are not now willing to do their part," he said, "then there's no need for such a group."

The slogan of the industry at that time was "Aquaculture Is Agriculture." Along with his efforts to build a trade association, Max realized that it made good sense to ally with existing groups in order to leverage support. He was a strong supporter of the Farm Bureau, serving on the national advisory board of the American Farm Bureau Federation. His belief in that organization also led to him to become President of the Somerset County Bureau. When he was dealing with other farmers, Max was always happy, because he knew they understood that the problems of aquaculture were inherently problems of free market production. He also saw in their nutrient management problems parallel issues that could potentially be solved by aquaculture as another form of agriculture.

One of our Extension administrators came by my office one afternoon many years ago. He said he was returning from the Maryland Farm Bureau convention in Ocean City and just had to stop and tell me that Max had been there as well. According to him, Max stood to propose a resolution and began by saying, "I'm a farmer too...but my farm is underwater." He went on to explain the problems that aquafarmers faced in Maryland and how he needed Farm Bureau support to help. Max ended up getting all but one of his proposed resolutions passed by the state group.

Max served as the Treasurer of Aquaculture In The Mid Atlantic, an annual conference and trade show supported by the Land Grant and Sea Grant Colleges in the region. He helped build the meeting into one that provided high quality educational programs for growers or potential producers.

In his later years, Max became more fervent in his belief that oysters could provide a means of altering the phytoplankton abundance in the Bay. He wrote letters to many scientists and resource managers. His main thesis was that we are managing our nutrient problem merely from the "supply side," concerned only with preventing nutrients from entering the tributaries, and that we also needed to look at the "demand side" of the problem. We could remove these nutrients from the water, he reasoned, by maximizing the number of filter feeders in the Bay. This would help to reduce the turbidity that prevents sunlight from reaching submerged aquatic vegetation.

Since oysters are effective biofilters, he argued over and over again, we should try to vastly increase their stocks. Removing oysters through harvest will then remove many of the nutrients that caused them to grow, thereby providing nutrient removal as well as commercial production. But, he cautioned, the private sector was better able to carry out this production than public programs, which rely on taxation and do not have profit as their primary motivation. And in order for private industry to become effective, he argued, the layers of stifling laws and regulations, built up over the years by politicians intent on satisfying watermen's demands rather than looking at the expansion of a resource for the future, must be pared away.

Recently, I heard from a Farm Bureau friend who said that Max was in poor shape and was home in hospice care. Then came the note that he had died. It will be hard not to think of him whenever I work with oysters. I will miss his dedication and tenacity as much as his small, bare-footed form working with oysters and trying to teach all who would listen about the marvels of these wonderful animals and what they could do to bring back the health of the Bay. Perhaps some of those he touched will carry on his mission. If men are survived by their deeds and ideas, Max will not be forgotten.

top

Low-Cost Recirculating Systems for Eels

Steven G. Hughes, University of Maryland Eastern Shore

American eels *(Anguilla rostrata)* are an important economic resource for waterman in the Chesapeake Bay region. Most of the eels caught are sold live for either bait or human consumption, but there is increasing concern over methods for holding live eels. Many of the current recirculating tank systems in use do not include adequate filtration and therefore high rates of mortality have been reported due to the fish being stressed and falling victim to secondary bacterial infections. The goal of a recently completed research project at the University of Maryland Eastern Shore's Aquaculture Research and Demonstration Project had two purposes: (1) to improve survival of captive eels that are to be held for a short time and (2) to allow for long-term care of eels being grown for market. The aim was to design recirculating systems in which many of the components could be built by the aquaculturist to conserve costs.

A holding system was designed to hold eels for a minimum period of two weeks while reducing the occurrence of disease and mortality. System evaluation was based on maintenance of optimal water quality, survival and absence of disease. During tests of this system, 90 percent of the eels stocked into the system survived with less than 5 percent exhibiting external symptoms of disease. All water quality parameters were maintained well within levels acceptable for eel culture.

A long-term rearing system was designed to evaluate culture potential and comparison of circular and raceway tanks for eels. Body weight, length increase, specific growth rate (SGR), percent survival, condition factor (K), mean weight gain and adaptability to a striped bass starter diet were used as evaluation criteria for tank design and system performance. Eels (mean initial weights and lengths, 46g and 31 cm respectively) were reared for 16 weeks in the newly designed system. Mean survival was 88.5 percent with all eels weaned onto the formulated feed within eight weeks. Results indicated that eels reared in raceways had slightly greater weight gain and were healthier than eels reared in circular tanks though no other differences were detected.

The holding and rearing system designs effectively functioned as artificial environments for the captive eels. The estimated costs of the holding and rearing systems designed and operated in this study were $2,630 and $6,350.00, respectively, which are less than the cost of many comparable commercial systems.

Cost for construction of any recirculating system depends on the selection of tank design and structural materials. For example, the substitution of other materials (e.g., marine plywood, aquaculture plastic products) for the fiberglass tanks used here to hold fish and house the filters could further decrease the cost.

For more information, contact Steven Hughes at (401) or by e-mail at sghughes@mail.umes.edu.

> *Editor's note. See "American Eel: Biology, Mystery, Management" by Wendy Morrison in* Maryland Marine Notes *at www.mdsg.umd.edu/MarineNotes/index.html. Subscriptions to Marine Notes are available without charge. Contact Jeannette Connors at (301) 405-7500 or email to connors@mdsg.umd.edu.*

For More Information on the American Eel

On eel aquaculture
Rutgers University, Institute of Marine and Coastal Sciences
www.ecoscope.com/eelfarm.htm#eelfarm

On the life cycle and commercial fishery
Chesapeake Bay Program Office
www.chesapeakebay.net/info/american_eel.cfm

NOAA Chesapeake Bay Office
noaa.chesapeakebay.net/spc/eel.htm

top

Research Briefs – Reports from UM Labs

Restoring Atlantic Sturgeon to the Chesapeake Bay

John Trant
Center of Marine Biotechnology
University of Maryland Biotechnology Institute

Atlantic sturgeon was once one of the Chesapeake Bay's largest and longest-lived native fish. Though scientists believe the Chesapeake's native spawning stock were wiped out by overfishing in the early years of the 20th century, reproducing populations of Atlantic sturgeon are present in other coastal areas, most notably the Hudson River system. Even though this species is occasionally seen in the Bay, it is believed to be sub-adult migratory fish that use Bay waters as an opportunistic place to forage between spring and fall.

Beginning in the early 1990s, Maryland DNR began to culture Atlantic sturgeon with the hopes of developing a program that will eventually lead to their restoration in the Bay. In trying to develop a captive breeding population for these efforts, DNR acquired progeny of Hudson River broodstock spawned at the USFWS Lamar Fish Hatchery. In a joint program with USFWS, DNR also collected sturgeon in the Bay through a rewards program, which offers fishermen $100 for wild sturgeon and $25 for hatchery sturgeon; to be eligible, fishermen must make the sturgeon available so that researchers can collect genetic information as well as biological information on length weight and age of captured fish. Sturgeon are also tagged in order to monitor their movements.

In 1996, DNR conducted an experimental release of 3,000 fish to determine the feasibility of future stocking efforts. Hundreds of hatchery fish were recaptured in the bay during the next couple of years until they migrated into coastal waters. This study demonstrated that pre-migratory sturgeon could still grow and survive in the Bay system and that migratory sturgeon still used its waters to forage during much of the year.

DNR has been successful in developing techniques to grow sturgeon in captivity - some of the captive fish may soon reach sexual maturity. When this occurs, reliable techniques are needed to determine sex and reproductive status so that methods can be developed for spawning these fish. The remaining challenges will be to produce adults with viable ova, successfully induce spawning in these adults and to develop a genetically responsible spawning protocol when producing progeny for stocking.

Captive fish have been tagged with a passive inductive transponder (a PIT tag), fin clipped, and measured semi-annually (weight and length). DNA extracted from the fin clips will help determine from which population these fish are derived. DNR will also utilize the genetic data to develop a breeding program that complies with the Atlantic States Marine Fisheries Council (ASMFC) stocking guidelines for genetic diversity in sturgeon restoration programs. The sturgeon are being maintained by Paul Willenborg in ponds during the winter and in tanks at Mirant Mid-Atlantic's Aquaculture Facility at Hallowing Point during the spring and summer months.

Our initial project was to establish a non-invasive method for determining the sex of individual fish. Traditionally, surgery is conducted on five-year old juveniles to visually determine the presence of testes or ovaries. We want to replace this invasive and time-consuming method of segregating males (best for meat production) and females (the source for caviar) with a molecular diagnostic approach. Preliminary results from the white sturgeon aquaculture industry on the Pacific coast suggests that the level of sex steroids (specifically androgens) in juvenile males and females may be quite different. Even though the steroid levels in the juvenile Atlantic sturgeon held at Mirant do seem to roughly correlate with sex, the titers are very low (one tenth of that in juvenile white sturgeon) and the sex-related differences are small. Our hope is that the Atlantic sturgeon would share many of the same attributes as white sturgeon since the Pacific coast aquaculture industry has made significant advancements and, as such, would provide a significant foundation of scientific data and applied procedures. We are currently examining histological samples of immature gonads, hormone titers in the blood, and sex-specific differences in the genomic DNA.

We are also conducting a small project in COMB's Aquatic Research Center in order to evaluate the potential enhancement of growth rates of sturgeon held in environmentally-controlled recirculation tank systems. We're determining appropriate feeding rates and monitoring growth rates and feeding behaviors. At present, feeding rates and the culturing in 25¡C water has resulted in a monthly growth rate of 10 percent for the three-year old sturgeons. While these are impressive rates of growth, we expect better results with the use of a continuous feeding regime in the next phase of this project.

Steven Minnikin, MDNR, contributed to this article; for information about the state's sturgeon restoration programs, see www.dnr.state.md.us/fisheries/recreational/atlanticsturgeon.html.

For more information about Dr. Trant's research, contact him at trant@umbi.umd.edu; for more on his research, see www.umbi.umd.edu/%7Ecomb/faculty/trant/trant.html.

top

Research Briefs – Reports from UM Labs

Molecular Mechanisms Regulating Fish Muscle Development and Growth

Jim Shaojun Du
Center of Marine Biotechnology
University of Maryland Biotechnology Institute

While fish fillets provide high quality protein in the diets of many people, they are also an expensive form of dietary protein. Because fillets consist of skeletal muscle, enhancement of cell proliferation and growth would consequently increase meat production and thus have a great potential for application in commercial aquaculture enterprises. Over the last several decades, scientists have improved fish growth through selective breeding, growth hormone, and gene-based transgenic biotechnology. While such technologies have shown some success in the development of improved broodstock, there is the potential of new molecular technologies that can stimulate the growth of skeletal muscle. To employ such technologies, we need to better clarify the molecular mechanisms that regulate muscle development and growth. This is the focus of research in my laboratory, where we have been studying the cellular and molecular mechanisms that control the embryonic muscle development in fish. Specifically, we use zebrafish and striped bass as model systems to investigate the role of growth factors in the formation of muscle cells during embryogenesis.

The formation of skeletal muscle in vertebrates begins during the early formation of the embryo, or embryogenesis, and extends into adult life. Although the embryonic fiber and adult fiber are formed at different stages, they share the similar molecular and cellular process. All skeletal muscles are formed by fusion of mononucleated myoblasts, the cells which are formed during embroygenesis. Myoblasts proliferate, though some of them withdraw from the cell cycle and commit to differentiation pathways to form muscle fibers. The remaining non-differentiating myoblasts serve as a pool for muscle growth and regeneration. The embryonic muscle serves as a matrix for future muscle development and growth in juvenile and adult stages. Defects in embryonic muscle formation result in a deficit of muscle formation in adult life.

Fish skeletal muscle contains two major types of muscle cells, which can be broadly classified as slow or fast muscle cells on the basis of differences in contraction speeds and metabolic activities. From previous studies, we have found that growth factor Hedgehog protein, secreted by notochord cells, played an important role in the specification of slow muscle cells. (The notochord provides dorsal, i.e., primitive backbone, support.) Overexpression of the Hedgehog protein in zebrafish embryos induced the formation of extra slow muscle cells and, at the same time, blocked the formation of fast muscle cells.

Recently, we identified a family of transcription regulators Glis that orchestrate the differentiation program of muscle cells downstream of Hedgehog. Genetic mutation of Gli2 in fish completely abolished the development of slow muscles.

Understanding the molecular mechanisms that regulate the formation of slow and fast muscles are not only important for basic biological research but it also has great potential for application in commercial aquaculture. Slow muscles, for example, often correlate with continuous swimming, a trait that is not beneficial in crowded tank conditions because of the stress it is likely to induce among all fish. Furthermore, fish that are continuously swimming use energy that could be diverted from growth.

Slow muscle is rich in blood circulation and usually loses its freshness more quickly than fast muscles. The consequence is a decrease in shelf life of fish meat. Based on such observations, molecular and cellular-based interventions that can reduce the proportion of slow muscle by converting them into fast muscle could be of significant benefit to the quantity and quality of fish meat in aquaculture conditions.

It is clear now that muscle development and growth are regulated by many intracellular and extracellular factors including both positive and negative factors. Recent studies have demonstrated that Myostatin(tm) inhibits muscle growth; a member of the TGF-b (Transforming Growth Factor-beta) superfamily, Myostatin(tm) is specifically expressed in developing somites (i.e., body segments) and adult skeletal muscle and has been shown to function as a negative regulator in the control of muscle development and growth in mice and cattle. Knockout mice in which the myostatin gene has been disrupted develops increased skeletal muscle mass two to three times that of wild-type mice.

Recently, a Myostatin homologue has been identified in several fish species. Remarkably, it has been shown that the Myostatin sequences in murine, rat, human, porcine, chicken and turkey are all identical in the mature region of the protein, which suggests that the function of this gene has also been conserved in all vertebrates. While Myostatin is likely to be involved in regulating skeletal muscle mass in fish, the definitive proof of that role is still lacking. Because Myostatin is a negative regulator for muscle development and growth, interfering with its production, receptor binding, or signal transduction will consequently degrade Myostatin activity and lead to increased muscle growth in the animal. Currently, we are investigating if inhibition of the Myostatin function will stimulate proliferation and differentiation of embryonic myoblast cells in fish embryos, and consequently enhance muscle growth in adult fish.

For more information about Dr. Du's research, contact him at dus@umbi.umd.edu for more on his research, see www.umbi.umd.edu/%7Ecomb/faculty/du/du.html

top

Research Briefs – Reports from UM Labs

Sturgeon Ranching in Russia

The decline of sturgeon stocks worldwide has catalyzed diverse programs in aquaculture-based restoration. In Russia, the Sturgeon Ranching Programme in the Caspian Sea was started in the 1950s to compensate for lost spawning grounds, particularly in the Volga River, a primary spawning tributary. "Restoration of Sturgeons: Lessons from the Caspian Sea Sturgeon Ranching Programme," a recent article in *Fish and Fisheries* by David Secor of the UMCES Chesapeake Biological Laboratory and Russian colleagues, surveys the fortunes of the program and discusses a number of issues, among them, fisheries trends, biological and genetic considerations, deterioration of natural stocks, aquaculture and hatchery-based restoration. They conclude that "despite the historical controversy on the use of aquaculture in maintenance and restoration of fish stocks, catalyzing restoration through deliberate releases of hatchery-produced sturgeons merits serious consideration." However, in order to minimize the risks, they identify a number of precautionary approaches that include the following: (1) inventory biological and genetic resources prior to initiation of a recovery program; (2) assess whether suitable habitat still remains through bioenergetic models and small-scale feasibility stockings; (3) maximize genetic diversity of stocked juveniles as much as possible; (4) undergo concomitant programs of habitat restoration and harvest control; (5) monitor the efficiency with which hatchery-produced fish recruit into a spawning population.

A reprint of Secor, D.H., V. Arefjev, A. Nikolaev and A. Sharov, UM-SG-RS-2000-06 (Fish and Fisheries 1:215-230), is available from Maryland Sea Grant. Contact Jeannette Connors at (301) 405-6374 or to connors@mdsg.umd.edu.

top

The Business of Charter Boats

Charles Petrocci

Over this last century, the charter boat fishing industry of Maryland and Virginia has been an important part of regional tourism and a driving force in economic development for many small coastal and Chesapeake Bay communities. From towns like Tilghman Island, Wachapreague and Crisfield, to larger marina sites such as Ocean City, sportfishing boats have been a visual reminder of the region's deep cultural roots in outdoor recreation. Though faced with changing regulations, legal issues and fluctuating resources, charter boating continues to have a positive impact on the economic well being of Maryland and Virginia.

From a business development perspective, the industry in Maryland and across the country has been largely ignored. Millions of dollars are generated each year either through direct sales of charters to consumers or through supportive business costs such as fuel, bait, fishing tackle, boat equipment, dock space, advertising and marketing. For some waterfront communities, the sportfishing industry, with charter boats at its core, are an important attraction for tourists. Marinas hosting charter boats also bring in tourists who are not necessarily sport fisherman but are attracted to weigh-ins and daily dockside activities. Surveys have shown that many visitors to resort areas feel active marinas contribute to part of their overall vacation experience.

Though the charter boat industry directly employs hundreds of people in the Chesapeake Bay and its economic impact ripples through thousands of other service and equipment related jobs, little had been done in the region to address business management needs until a conference held earlier this spring. The University of Maryland and Virginia Sea Grant programs teamed up with Coastal Consultants of Chincoteague to host the Charter Boat Business Management for the Future workshop, which was offered for local boat captains, owners and those interested in the charter boat business.

The more than 50 attendees represented businesses from Virginia Beach to Ocean City, the western shore of Maryland and Virginia, as well as participants from western Pennsylvania. The day-long program (see box below) gave participants an opportunity to learn how to improve business management skills and marketing techniques. A number of guest speakers covered topics such as marketing concepts, current legal issues, customer relations, web page design, hook and release surveys, small business management strategy, economics and developing off-season business.

For more information on the conference and follow-up programs, contact Charles Petrocci at (757-336-6144) or by e-mail to fishhead@intercom.net.

Editor's note. While the Maryland Sea Grant Extension Program has strong outreach activities in diverse aspects of aquaculture and the seafood industry, our agents and specialists work with other interests in the Chesapeake Bay region, from resource management agencies to the recreational boating industry. This report on charter boating is another example of Maryland Sea Grant outreach efforts.

Management Workshop for Charter Boat Businesses

Charter Boat Policy and Promotions
Martin Gary, Biologist, Maryland Department of Natural Resources

Web Page Design
Greg Cain, East Coast Computing

Catch and Release: Impacts and Studies
Jon Lucy, Biologist, Virginia Institute of Marine Science

Charter Industry and Its Impact on Local Tourism

Legal and Safety Issues You Need to Know
Stephen White, Maritime Lawyer, Wright, Constable and Skeen

Charter Boat Business Management
Capt. Mark Sampson, President Ocean City Charter Boat Association

Fishing For Hire: Issues and Contribution to Local Economic Development
Joe Waters, Small Business Development, Salisbury State University

Lisa Challenger, Director Worcester Office of Tourism

Economic Activity of Fishing Tournament
Tom Murray, Marine Business Specialist, Virginia Sea Grant

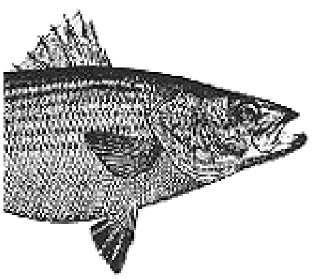
Economics of the Charter Boat Industry
Doug Lipton, Economist, Maryland Sea Grant

top

Aquaculture in the Classroom Update

Adam Frederick, Education Specialist

The "Aquaculture in Action" educators met midyear at the Center of Marine Biotechnology and enjoyed sharing information on how they are using aquaculture and the successes and problems that have been encountered with the systems in 2000-2001. Here are some highlights from the meeting.



Two teachers presented their projects at local conferences related to aquaculture in the classroom: Doug Romano (Cambridge South Dorcester High School) at the Maryland Association of Environmental and Outdoor Educators in February and Ken Baxter (Beall High School) at the Maryland State Department of Education (MDSE) Math and Science Eisenhower Conference in March.

Recent efforts that use clove oil as an anesthetic were discussed. While some educators were still struggling with the dose, they agreed that very little is needed, a few drops per liter, to get the fish "knocked out." Ken Baxter noted that his fish seemed a little groggy even a few days after the clove oil experimentation.

New additions to the Aquaculture in Action web-site were presented, including data input procedure and new forms, the system design and construction from the 2000 workshop, and the new method for finding a project that has been entered by a school on the web. The data input link is still password protected and can only be accessed by participating members. However, by going to the projects link on the main page, users can view project descriptions and data being entered by students on-line. Our next effort will focus on an evaluation tool for the teachers and students involved in our network to help us assess the impacts of aquaculture in science education and other cooperating disciplines (www.mdsg.umd.edu/Education/AinA)

New collaborations with the Maryland Department of Natural Resources fisheries division will streamline the process of permitting and getting fish out to the teachers involved in aquaculture projects. This should be a significant help to teachers who should be able to obtain a wider variety of native species.

The third annual striped bass release day was held on May 25th at Sandy Point State Park for participants raising striped bass. Maryland DNR provided a tagging gun to "tag" out fish so that we can get some tracking and growth data in the future if these fish are hooked or netted. Some 80 fish were released from six different schools. Chesapeake High School in Baltimore, gets kudos for the largest fish weighing in at 590 grams compared to an average of 54 grams when they were delivered in October 2000. Stay tuned for future plans and the next "Aquaculture in Action Workshop" in summer 2002.

For more information, contact Adam Frederick at (410) 234-8850; or write to frederic@mdsg.umd.edu.

top

New Publications

Barley Straw: A Potential Method of Algae Control in Ponds by Bryan Butler, Dan Terlizzi, Drew Ferrier. Watger Quality Workbook Series, UM-SG-MAP-2000-01.

> The use of barley straw for controlling algal growth in ponds is a relatively new development. This fact sheet is a brief introduction to how barley straw has been used to date and provides guidelines on its use for ponds in the mid-Atlantic. For a free copy, contact Jeannette Connors at (301) 405-7500 or by e-mail to connors@mdsg.umd.edu

Maryland's Oysters: Research and Management

> Originally published by Maryland Sea Grant in 1981 and out of print, is a book that continues to serve as a valuable research reference. A critical review and synthesis of literature on the eastern oyster, *Crassostrea virginica, Maryland's Oysters,* along with an annotated listing of selected literature, is now available online in a searchable pdf form. The book is available at www.mdsg.umd.edu/oysters/research/mdoysters.html.

top