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MARYLAND COOPERATIVE EXTENSION
UNIVERSITY OF MARYLAND
COLLEGE PARK • EASTERN SHORE

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

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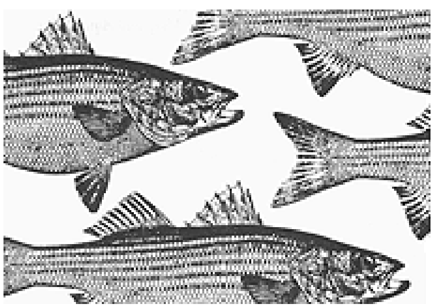


Out of the Pond and into the Tank

Farming Fish Indoors

Don Webster, Eastern Shore Area Agent

Recirculating aquaculture systems refer to a diverse array of closed or semi-enclosed systems, which farmers use for rearing fish and aquatic plants. In Maryland, they are used to some extent in the aquarium trade to grow ornamental or exotic fish; they are in wide use by shedders for producing soft crabs, particularly by those shedders who do not have water front property or where water quality is poor. There are also a number of commercial operators in Maryland, among them, Rick Sheriff on the Eastern Shore, who has raised over the last four years, hybrid striped bass, tilapia, yellow perch, blue gill and other species. While there may be potential for the expansion of recirculating aquaculture businesses in the state, the investment costs are high and profitability still questionable, given fluctuating markets and a host of concerns such as system design and biofiltration, fingerling availability, alternative species, fish health, training and marketing. To get a handle on these concerns, Maryland Sea Grant Extension initiated several meetings with researchers and growers, with the goal of identifying bottlenecks to "growing" and sustaining a profitable industry. These meetings included Karl Roscher, who heads aquaculture programs for the Maryland Department of Agriculture.

Aquaculture research in the University of Maryland System is significant. Engineering, fish disease and nutrition studies are conducted at College Park while reproductive physiology, nutrition and alternative species research is ongoing at the Center of Marine Biotechnology (part of the UM Biotechnology Institute). Broodstock management has been in the forefront at the Maryland Agricultural Experiment Station while recirculating system development has taken place at the University of Maryland Eastern Shore. A variety of aquaculture research studies have been done at the Horn Point Laboratory (part of the UM Center for Environmental Science). To move research out of the lab, the Maryland Sea Grant Extension Program has worked closely for more than two decades with growers throughout the mid-Atlantic to provide the best results that research has to offer. These programs have included workshops and demonstration projects, as well as publications (i.e., Extension briefs, synthesis reports), videos and web-based gateways on aquaculture issues (see www.mdsg.umd.edu/Extension/aqua_fish.html).

Biofiltration

The biological filter is a key component in any system, whether raising finfish or shedding crabs. Biofilters convert dangerous ammonia to nitrite and then to nitrate; if they are not adequate, the system will be unable to produce the desired volume of healthy water. Often, operators do not understand the function or design characteristics of biofilters and end up with poorly operating units.

Biofilter startup and crash recovery has been a topic of concern for many years. Generally, a biofilter's bacterial populations can take a long time to become established - 30 or more days is normal for a new system. Once these biofilters are operating, stressors (e.g., pollutants, or conditions that are unsuitable for the bacterial populations) that can cause them to die or "crash" become a problem since fish are already in the system; the only way to flush the pollutant buildup out of the system is by dumping and refilling with new water. Dumping and refilling are, of course, what recirculating systems are supposed to minimize.

There have been instances where additives to feed have resulted in biofilter crashes. Medicated feeds are especially dangerous in this regard because they include antibiotics in their formulation. These compounds will be circulated through the system, which can result in bacterial populations crashing. Operators also need to be careful about compounds that are sometimes added to feeds for improving shelf life: such compounds may be harmful to biofilters as well. Situations have occurred where biofilters have gone from handling over 600 pounds of feed per day to only 50.

System Design

Although manufacturers offer off-the-shelf recirculating systems, they are still not generic, nor do they carry any guarantee of success. The kind of system a grower chooses will depend not only on the production objectives but the system reliability. A shedding system for soft crab production, for instance, does not require the same level of sophistication as a fish production system, since the crabs are being held for a short time until they molt and are not being fed during this period.

Engineering and design considerations are of major significance in assembling a system so that it will be capable of handling both the initial projected increases in growth and biomass. Fish species differ in their water quality requirements: e.g., tilapia can withstand poorer water quality conditions than striped bass or trout. Temperatures that a system will be operated at are critical, since cold water fish will require different ranges than warm water fish. Temperatures will affect the rate at which bacteria establish on the filter media. At the same time, warmer temperatures are more hospitable to disease organisms.

An important factor in system design is redundancy, or the incorporation of backup units in the event of electrical failure or other such problems. In fish culture, there is a short window in which to get the system back in operation before fish die or are stressed so badly that microbial disease will likely spread rapidly. A fish farmer needs to consider backup systems and weigh the number and type against the cost. At the very least, dissolved oxygen levels will become critical within 15 minutes. Toxin buildup, as well as temperature, must also be considered in designing a system for commercial production.

Fingerlings

A critical input of an aquaculture system is the seed, or fingerlings, with which to begin. Rick Sheriff says his most serious problem is getting adequate supplies of low-cost or reasonably priced fingerlings for species such as yellow perch. Many growers are concerned also about the quality of the fingerlings they receive. There have been cases where local growers, because their operations are small and they were unable to purchase large numbers of seed fish from hatcheries, received fingerlings that were not of the best quality for fast and vigorous growth.

Some transport vehicles are also not well equipped to handle fish for long distance delivery; in addition, some drivers are poorly trained in the techniques for hauling fish properly. Transporting fish under crowded conditions, or carrying water that is poorly tempered or not properly treated for hauling, or using rigs that are not sanitized between loads can result in losses or disease problems within a short time. In one instance, an eel disease was passed to tilapia hauled in a rig that had been used for eels and had not been properly sanitized. Growers have to know the hauler as well as the hatchery in order to get the best quality fish with which to start.

Alternative Species

Intensive recirculating systems require a heavy capital investment and exhibit higher operating costs than extensive systems such as ponds. In order to minimize costs and maximize profit, fish production needs to be evaluated in terms of pounds of fish per gallon or dollars returned per gallon in relation to time. While many operators have been farming tilapia, which are relatively easy to raise and tolerate lower water quality conditions than other species such as striped bass, the market for them has fluctuated, with significant downturns, as more operations have gotten into producing tilapia. Growers need other species that can be exploited for economic gain.

Rick Sherriff, for example, was successfully producing yellow perch, not for mid-Atlantic or East Coast markets, where its value is low, but in the Midwest. With harvests in Lake Erie down from 40 million pounds in the 1980s to 10 million in recent years, Sherriff says there was a wide-open market for his product. The problem now, he says, is that yellow perch fingerling costs have risen and there are no sources for lower-cost fish, as he originally had.

The difficulty with introducing new species, however, is that much of the information needed for success may not be available. It also takes time to develop adequate diets, as well as to work out the culture requirements. Growers taking on these responsibilities may face a long road with marginal returns in developing new species on their own, although the fact of having a "pioneer" or unique species may find the product more marketable than other more traditional species that are being raised by a lot of growers.

Researchers at the Center of Marine Biotechnology, for example, have been working on alternative species for food production, including sea bream, a high value fish in Europe that holds great promise for U.S. growers, says Yonathan Zohar, Director of COMB.

In assessing systems on the basis of returns per gallon, says Andy Lazur, Sea Grant Extension Aquaculture Specialist, growers may find that smaller species that can be raised in large numbers and for other purposes than food fish - e.g., baitfish and ornamentals - may potentially be as profitable as food fish. Other species, like gambusia, or mosquitofish, could provide a ready market in some areas where people need to control these insects in standing water.

Genetics

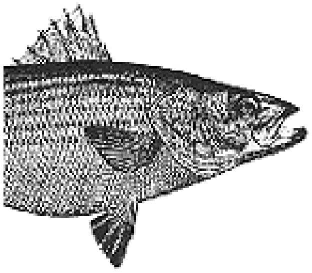
Because many hatcheries that produce seed fish lack expertise in genetics, the quality of fingerlings can suffer, which translates into less than desired growth. Brood fish, for example, are sometimes kept long past the time that they should be discarded, a practice that can increase the potential for inbreeding. Choosing for a single desired trait such as faster growth, then continually crossing only fish that exhibit faster growth, will eventually lead to poor quality fingerlings and can actually result in animals that are slower growing than the originals. Growers need knowledge about the source of their seed fish and their quality.

Fish Health

Biosecurity, the minimizing of bacteria and disease, should be a major concern of all growers. Unfortunately, many growers do not consider this part of the plan for their business. Because of the pervasiveness of disease organisms, it is usually cheaper and easier to prevent problems from occurring rather than treating them when they do. The large surface area in some commercial recirculating systems can make controlling diseases that become established very time consuming and expensive, sometimes even requiring disassembly and sanitation of the entire production unit.

Training

Many system operators begin with a poor understanding of what they need to do to effectively manage a recirculating system. While there are training programs such as those developed by Dr. Mike Timmons at Cornell University and the Freshwater Institute, few operators consider the education that is required before building and operating their businesses. At the very least, they need to have a thorough understanding of water quality measurements and how these factors interact to provide water conditions that are satisfactory to support the health of the aquatic organisms they are raising. In essence, recirculating tanks are life support systems. If critical parameters such as ammonia, nitrite, dissolved oxygen, pH, alkalinity, and temperature are not monitored regularly and maintained within safe conditions, fish will almost certainly suffer - the bottom line is financial loss. Training also means being on top of such issues as markets, prices and the myriad of other factors that affect costs.



In bringing Maryland growers and university researchers together, Sea Grant Extension is formulating plans on how to best assist the aquaculture industry in the state. Our plans will cover the short term, for instance, market assessments, alternative species evaluations and training sessions. But we're in for the long term and will be exploring a range of issues, among them, the economic benefits and costs of different species, new production techniques for fingerlings, and markets and marketing of alternative species.

We want to hear from Maryland growers, those of you who are already operating commercial systems and those who have a strong interest in programs we will be planning over the coming year.

Please contact Andy Lazur at (410) 221-8474 (alazur@hpl.umces.edu) and let us know if you would like to participate in programs designed to help encourage development of the recirculating aquaculture industry.

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Selected Aquaculture Websites

Maryland and Virginia

Aquaculture at the Center of Marine Biotechnology, www.umbi.umd.edu/~comb/programs/aquaculture/aquacul.html

Horn Point Fish Hatchery, University of Maryland Center of Environmental Science, www.hpl.umces.edu

University of Maryland College Park Aquatic Pathobiology, www.aquaticpath.umd.edu

Aquaculture at Virginia Tech, www.research.vt.edu/resmag/resmag2001/aquaculture.html

Maryland Sea Grant, www.mdsg.umd.edu

Online Publications

Fish Culture in Maryland: A Conversation with Reginal Harrell, www.mdsg.umd.edu/Extension/Aquafarmer/Fall99.html#4

Growing Fish Indoors: A Conversation with Yonathan Zohar, www.mdsg.umd.edu/Extension/Aquafarmer/Spring00.html#5

Evaluation of Recirculating Aquaculture Systems, Minnesota Department of Agriculture and University of Minnesota, www.mda.state.mn.us/DOCS/MKTG/Aquacult/Recirc.htm

Southern Regional Aquaculture Center. Publications can be downloaded at www.msstate.edu/dept/srac/fslist.htm#SRAC 450-459 -- RECIRCULATING SYSTEMS

Recirculating Aquaculture Tank Production Systems: An Overview of Critical Considerations, 451

Recirculating Aquaculture Tank Production Systems: Management of Recirculating Systems, No. 452

Recirculating Aquaculture Tank Production Systems: Component Options, No. 453

Recirculating Aquaculture Tank Production Systems: Integrating Fish and Plant Culture, No. 454

Pond Recirculating Production Systems, No. 455

The Economics of Recirculating Tank Systems: A Spreadsheet for Individual Analysis, No. 456

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Aquaculture at UMES

Don Webster, Eastern Shore Marine Agent

The University of Maryland Eastern Shore (UMES) has been involved in research, graduate education, and industry support in aquaculture for more than a decade. Under the guidance of Dr. Steven Hughes, the aquaculture program is currently conducting research on the nutritional and physiological requirements of several species including striped bass, hybrid bass, tilapia, American eels and blue crabs. Additional research is also being conducted on the development of tertiary water treatment methods for recirculation systems. Though many of the research projects are basic in nature, several are also designed to provide information directly to the aquaculturist. The program at UMES is also seeking the opportunity to work cooperatively with Marylands' growers in the development of projects to address the particular needs of this group.

If you would like more information on this program, or if you have ideas for a cooperative project, please contact Dr. Hughes at (410) 651-7664.

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"Home Grown" Shellfish Kits Marketed

Don Webster
Eastern Shore Area Agent

Gordon Shellfish of Snow Hill, Maryland, has developed a new oyster kit that is being successfully marketed in the state. It offers shoreside property owners who have adequate growing areas a way to raise shellfish while learning about how the animals grow.

The "home grown" oyster kit consists of a thousand seed oysters in a floating plastic mesh bag. The bags can be attached to piers or docks and floated at the surface, buoyed up by foam cylinders. The oysters feed on the phytoplankton in the water; with a good food supply, they will grow quite rapidly. Growth rates do vary, however, depending upon the abundance of food available.

One of the most onerous tasks normally found in raising oysters in floating enclosures is the cleaning process. The containers that hold the animals must be maintained so that fouling does not compete with feeding, slowing their growth. The Gordon method floats the plastic mesh envelopes at the surface so that containers only have to be turned every few days in order to keep them clean. Turning them causes the top of the bag with the current fouling to be raised out of the water, where sunlight dessicates and kills the organisms. A simple scrub will then keep the bag clean and allow for maximum oyster growth.

The oysters will need to be thinned out as they grow. Additional containers are available in which to split the seed oysters, allowing them to grow without crowding. Growers can also build their own containers for holding the shellfish as they grow. Many culturists have developed innovative devices for holding their oysters and minimizing the labor involved to maintain them as they grow to maturity. In fact, it's part of the fun in growing them.

Gordon Shellfish is a nursery and growout business that has developed in Chincoteague Bay. The company raises both hard clam seed (Mercenaria mercenaria) and oyster seed (Crassostrea virginica) for sale to growers and farms market shellfish on nearby grounds leased from the State. The company has expanded its capacity each year since it was founded in 1996 and has built a reputation for quality shellfish seed. With the development of its growout kits, Gordon has moved into the market to assist those interested in experimenting with growing their own shellfish. This market has been developing, largely as a result of the efforts throughout the Bay on small-scale gardening of oysters for restoration purposes.

Gordon has advertised widely in Tidewater newspapers, which has resulted in growing sales for this part of their operation. Before getting into shellfish culture, you should be aware of the salinity in the area in which you will be growing oysters: they require certain salinity regimes in order to survive. An indicator of feasibility would be natural oysters growing in the area where you wish plan to rear them.

The Maryland Department of the Environment also reminds property owners that they should be careful when consuming shellfish raised near shore. Many areas are not in approved growing waters and may be contaminated with bacteria that can be harmful to human health. Always check with local health authorities or Natural Resources Police to determine whether the waters you are raising shellfish in are open for harvest and always do an inventory of the area to make sure that no effluent from boats or other sources is affecting the area either.

For more information on shellfish kits, Steve Gordon can be contacted at (410) 957-4100.

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Andy Lazur, New Finfish Specialist

Andy Lazur has joined the Maryland Sea Grant Extension Program as finfish aquaculture specialist; he also has a joint appointment as associate professor at the UMCES Horn Point Laboratory. Lazur came to Sea Grant from the University of Florida Department of Fisheries and Aquatic Science where he was an associate professor for eleven years. His recent research includes the aquaculture of Gulf of Mexico sturgeon and hybrid catfish, characterization and management of effluents from aquaculture ponds in Florida and integration of aquaculture with commercial citrus best management practices.

Lazur has an undergraduate degree in biology from the University of South Carolina, and Masters and Ph.D. degrees in Aquaculture from Auburn University. His current areas of research interest include food and baitfish culture; integration of aquaculture with agriculture for nutrient reduction; effluent and water quality management; production, marketing and economic evaluation of alternative aquaculture species; culture systems technology; and fish restoration.

Lazur has begun work on projects related to alternative species for aquaculture and recirculating systems, both for food production and restoration. Doug Lipton, coordinator of the Maryland Sea Grant Extension Program, says of Lazur, that his expertise in "running aquaculture facilities in Florida and elsewhere makes him ideally suited to help apply this research to aquaculture efforts in the state."

On issues related to finfish aquaculture, contact Andy Lazur at (410) 221-8474 or send email to lazur@hpl.umces.edu.

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U.S. Seafood Consumption on the Rise Again - Will it Last?

Douglas Lipton, Marine Economic Specialist

According to National Marine Fisheries Service statistics, per capita seafood consumption in the United States for 2000 was 15.6 pounds per person, an increase of 0.2 pounds over the 1999 figure; this ties the second highest level on record in 1989. The record per capita consumption of 16.2 pounds occurred in 1987.

The decade of the 1980s was a banner era for the seafood industry in terms of consumer demand. From 1980 to the peak in 1987, per capita consumption rose almost 30 percent, an annual increase of 4.2 percent. If that rate had continued, the 2000 per capita consumption would have been over 25 pounds per person. Instead, the per capita consumption figures bounced around between the high of 15.6 in 1989 and a low of 14.6 as recently as 1997. The average for the 1987-1999 period remained stubbornly at around 15 pounds per capita.

Why did the industry see such growth during the 1980s, then slow down afterwards? Many believe that the initial surge was due to the positive publicity in medical and nutrition journals for fish and shellfish as "heart healthy" foods, particularly because of the presence of Omega-3 fatty acids and their beneficial effects. Thus, the increase of the 1980s probably represented a one time behavioral shift of the seafood-eating public. Once the shift in consumption patterns was made, there were no underlying factors to sustain the impetus for continued growth.

Interestingly, the 1990s corresponded to the period of unprecedented expansion in U.S. and world aquaculture production. World aquaculture increased 154 percent from 1990-1999 and U.S. aquaculture increased by 26 percent. Apparently, these increases in supply did not translate into increases in consumption in the U.S. Instead, aquaculture products displaced consumption from capture fisheries. For instance, U.S. shrimp consumption was a record 3.2 pounds per capita in 2000. Despite a relatively healthy capture shrimp fishery in the United States, a whopping 87 percent of the shrimp we consume is imported, and most of that imported shrimp is from aquaculture.

The overall health of the U.S. economy may have contributed to the favorable per capita consumption figures over the last few years. Most seafood is eaten away-from-home, in restaurants and other food service establishments, and those businesses depend on growth in consumer spending to keep them growing. Thus, the better the overall economy, the more people eat out, and the more likely they are to consume seafood. The sluggish economy of 2001 could signal the end of three straight years of growth in U.S. seafood consumption. Until the industry finds the equivalent of the behavior changing forces of the 1980s - the health effect - per capita consumption will continue to fluctuate within the fairly narrow range of the past two decades. That doesn't mean the industry hasn't grown over that period. The U.S. civilian resident population has increased 21.4 percent since 1980. So the need for more seafood, whether from aquaculture or capture fisheries, will continue to grow even in the face of static per capita consumption.

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Working Cooperatively to Restore Oysters in Maryland

At a recent meeting on Shellfish Restoration in British Columbia, Don Meritt, head of the UMCES oyster hatchery at the Horn Point Lab and Sea Grant Extension Shellfish Specialist, Stephanie Tobash, UMCES, Charlie Frentz, Oyster Recovery Partnership and Bill Goldsborough and Stephanie Reynolds of the Chesapeake Bay Foundation gave a presentation on Restoring Oysters to the Chesapeake Bay: A Coordinated Effort Involving Government, Universities, Community Groups, and Industry.

As the authors write, with Chesapeake Bay oyster harvests at all-time lows, traditional techniques of spreading shell on public grounds to collect spat are no longer reliable for producing consistent numbers of high quality oyster seed. One reason is that diseases such as Dermo are highest in areas where natural spatfall is most abundant.

Using hatcheries and an operating strategy designed to minimize the risk of infection, oyster seed are being produced with little or no Dermo. They have been used to accomplish a wide range of objectives including supplying seed to citizens growing oysters for restoration, re-seeding harvest grounds in areas sensitive to disease, involving commercial oystermen in restoration, and establishing ecological sanctuaries.

In a coordinated effort, the Maryland Oyster Recovery Partnership, the University of Maryland Center for Environmental Science, the Chesapeake Bay Foundation, Maryland Watermen's Association and local community groups have been successful in producing the seed oysters, preparing the bottom, and planting the seed.

For more information, contact Don Meritt at (410) 221-8475; and the Maryland Sea Grant website, www.mdsg.umd.edu/oysters.

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Sea Grant Extension Update

Oyster Institute: Working with Educators

Adam Frederick
Maryland Sea Grant Extension Education Specialist

In June 2001, environmental educators from a variety of organizations and agencies in Maryland gathered for an intensive three-day immersion into the current state of oyster research, restoration potential, and the biology and ecology of Crassostrea virginica, the oyster native to the Chesapeake Bay and coastal waters from Canada to the Gulf of Mexico.

Hosted by the Maryland Sea Grant Extension Program, the University of Maryland Center for Environmental Science (UMCES) Horn Point Laboratory, and the University of Maryland Biotechnology Institute's Center of Marine Biotechnology (COMB), the two-and-a-half-day workshop brought together educators from organizations such as the Chesapeake Bay Foundation, the Living Classroom, the Oyster Recovery Partnership and the Department of Natural Resources.

Dr. Victor Kennedy of Horn Point, Dr. Stan Allen of the Virginia Institute of Marine Science, and Dr. Ken Paynter of UMCES Chesapeake Biological Lab and University of Maryland, College Park, gave presentations on general oyster biology, oyster genetics, and oyster restoration efforts in Maryland and Virginia.. These lectures and discussion were complemented by a day of field and wet lab activities in the Horn Point oyster hatchery, led by Dr. Don Meritt, Jackie Takacs and Adam Frederick of the Maryland Sea Grant Extension Program and Maryland Cooperative Extension. Educators observed filtering or clearing of algae by oysters, worked on oyster anatomy, and learned about commensal organisms and oyster larval behavior via microscopy.

In a demonstration of oyster spawning and fertilization, video microscopy was used to view cell division and the development of embryonic stages. For a video clip of oyster spawning, see www.hpl.umces.edu/facilities/facilities.htm. The oyster spawning demonstration gave educators a better understanding of all the components and resources that underlie hatchery operations, which are a cornerstone of current restoration efforts.

The focus at COMB in Baltimore turned to progress in identifying oyster disease, particularly Dermo (caused by the protozoan parasite Perkinsus marinus). An introductory wet lab on removing hemocytes, the oyster defense-fighting blood cells, for examination and culturing was followed up with a presentation by Dr. Gerardo Vasta on disease mechanisms and diagnostic tools, both past and present. The presentation was integrated with the wet lab experiences so that participants were able to understand the oyster's defense mechanisms and how new tools in biotechnology can be used to assist in rapid and accurate disease diagnosis.

In the lab a demonstration was given of how polymerase chain reaction (PCR) is applied to oyster disease. The PCR technique has been adapted by Dr. Vasta and his team to specifically target a unique segment of DNA produced by Perkinsus marinus.

For more information on The Oyster Institute, the materials that participants were given, and participation in future programs, please contact Adam Frederick at (410) 234-8850.

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National Sea Grant Oyster Disease Research Program

Merrill Leffler, Maryland Sea Grant

Since 1990, the Oyster Disease Research Program (ODRP) has been supporting applied research aimed at combating the impacts of oyster diseases in U.S. Coastal Waters. These diseases include MSX and Dermo, which occur throughout the Atlantic and Gulf Coasts, Juvenile Oyster Disease in hatcheries in the northeast and summer mortalities on the west coast. In the mid-Atlantic, MSX and Dermo, have been especially virulent and have frustrated many efforts to restore natural populations. ODRP is congressionally-mandated and supported by the National Sea Grant College Program. Restoring Oysters to U.S. Coastal Waters: A National Commitment, is a recent report on the progress of ODRP research (see www.mdsg.umd.edu/oysters/disease/index.html). Projects being funded over the next year include the following.

Managing Around Disease: Crassostrea virginica

Cooperative Regional Oyster Selective Breeding (CROSBreed) Project: Comprehensive Strategy for Genetic Rehabilitation and Conservation of Oysters. Standish K. Allen, Jr., Kimberly S. Reece, Eugene M. Burreson, Mark W. Luckenbach and Mark D. Camara, Virginia Institute of Marine Science (VIMS); Patrick M. Gaffney, College of Marine Studies, University of Delaware; Matt Hare; Department of Biology, University of Maryland; Donald W. Meritt, Horn Point Laboratory, University of Maryland Center for Environmental Science (UMCES); Ximing Guo and Gregory A. DeBrosse, Haskin Shellfish Research Laboratory, Rutgers University

This collaborative approach for developing hatchery-reared oyster strains such as CROSBreed that can tolerate both MSX and Dermo disease will disseminate oysters to growers in a variety of current restoration efforts and will evaluate how well they perform. To learn more about CROSBreed, see www.mdsg.umd.edu/oysters/disease/breeding/index.html

Environmental Effects on *Perkinsus Marinus* Infection Rates, Growth and Survival among Dermo Disease-Free Juvenile Oysters Planted at Three Salinity Regimes in an Enzootic Chesapeake Bay Oyster Recovery Area. George R. Abbe, Academy of Natural Science Estuarine Research Center; Steven Jordan and Christopher F. Dungan, Maryland Department of Natural Resources, Cooperative Oxford Laboratory

One means for managing around disease is to plant disease-free hatchery seed in low salinity reaches of Bay rivers. This continuing project is assessing how these oysters perform from seed to adult size; the findings should help commercial growers as well as agencies in planning long-term restoration efforts.

Prevalence and Severity of *Perkinsus marinus* Infection in Created Oyster Reef Sanctuaries: Implications for the Use of Sanctuaries in Regional Restoration Programs. Charles H. Peterson, Institute of Marine Sciences, University of North Carolina at Chapel Hill

Peterson's study will ask how levels of Dermo infection, oyster density and size distribution of oysters differ between sanctuaries and non-sanctuaries; how disease levels, oyster density and size distrbution of oysters vary as a function of the age of sanctuaries; and whether there is evidence of reduced disease with reef height. The goal is to provide a series of recommendations on establishing sanctuaries in the presence of Dermo.

Focus on Perkinsus and Disease Mechanism

In Situ Determination of *Perkinsus marinus* Transmission Dynamics in Low Salinity Habitats: Implications for Disease Avoidance Management Strategies and Oyster Restoration. Eugene Burreson, Kimberly Reece and Lisa Ragone- Calvo, VIMS

In better determining how Perkinsus marinus transmits Dermo disease, VIMS researchers will use molecular diagnostic tools and intensive monitoring to better determine the impacts of a strategy that manages around Dermo by moving infected oyster seed into lower salinity waters, where it is generally less of a threat.

Epizootiology and Pathogenicity of Two Perkinsus Species Parasitizing the Eastern Oyster, *Crassostrea virginica.* Gerardo R. Vasta and Jose A. Fernandez-Robledo, Center of Marine Biotechnology, University of Maryland Biotechnology Institute (UMBI)

Vasta and his team have found that Perkinsus species can differ in their virulence of Dermo disease, though the degrees of differences are unknown. This project will develop the molecular tools to assess the distribution of at least two Perkinsus species on the East Coast and will evaluate their virulence and pathogenicity.

Identification of Candidate Genes for Chemotherapeutic and/or Genetic Intervention in the *Crassostrea virginica/Perkinsus marinus* System using Expression Sequence Tags (EST). Gerardo R. Vasta, Jose A. Fernandez-Robledo and Eric J. Schott, Center of Marine Biotechnology, UMBI

Is it possible to develop drug therapy or genetic techniques that can target *Perkinsus marinus* genes responsible for Dermo and thereby inactivate them? By studying genomic data of *P. marinus* when it is subjected to conditions that increase disease virulence (e.g., high salinity and high iron), Vasta and his colleagues' findings should suggest whether such therapies are worthwhile pursuing.

Intracellular Survival of *Perkinsus marinus:* The Oxidative Stress Pathway as a Target for Therapy. Gerardo R. Vasta and Eric J. Schott, Center of Marine Biotechnology, UMBI

Based on current understanding of the dynamics between *P. marinus* and *C. virginica,* the eastern oyster, Vasta and Shott are studying molecular strategies that could disable the *P. marinus* parasite, either by identifying parasite targets for drug therapy, or by augmenting oyster defense responses.

Antimicrobial Peptides: Overlooked Mechanisms of Disease Resistance? Robert S. Anderson, Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science

This study will focus on the mechanisms of oyster disease resistance at the molecular level. Anderson hypothesizes that antimcrobial peptides play a significant protective role in fighting disease and will examine whether the expression of these peptides is compromised by exposure to such stress as contaminants and low oxygen conditions. Knowledge gained from this study may help identify specific molecules that can provide markers for developing disease resistant oysters by selective breeding or by gene transfer techniques.

Infectivity, Pathogenicity and Epizootiology of the Clam Parasites *Perkinsus* Chesapeake and *Perkinsus andrewsi* in Chesapeake Bay Oysters: Have We Been Misinterpreting *Perkinsus marinus* Epizootiology? Eugene Burreson, VIMS; Christopher F. Dungan, Maryland Department of Natural Resources, Oxford Cooperative Lab; Kimberly S. Reece and Nancy A. Stokes, VIMS

This project will determine how infective and pathogenic two Perkinsus species, *P. chesapeaki* and *P. andrewsi,* are to oysters in order to reevaluate the current understanding of *P. marinus* in spreading Dermo disease. The distribution and abundance of Dermo disease are key considerations in siting oyster reefs, a key management strategy in restoration efforts. Resolving the impacts of different Perkinsus species known to infect molluscs requires rapid, quantitative and specific differentiation, if restoration and commercial aquaculture operations are to be successful.

Process Control Engineering to Improve Oyster Cell Culture Disease Research. Terrence R. Tiersch, Steven G. Hall and Jerome F. LaPeyre, Louisiana State University

Despite years of research, scientists have been unable to establish oyster cell lines, largely because of the inability to maintain cell proliferation in laboratory cultures. Tiersch and colleagues plan to make use of technology that pairs biological and engineering techniques to try and overcome previous impediments. If successful, cell culture lines will offer new research avenues, for example, on controlling oyster pathogens and improving growth rates.

Induction of Potential Pathological States in *Perkinsus marinus* by Exposure to Oyster Tissue Extracts. Modulation of Cell Morphology and Protease/Antigen Production. Stephen Kaattari, Kimberly S. Reece and Eugene Burreson, VIMS

This research project will employ a modification of current in vitro culture methodologies that can provide sensitive tests for oyster stock resistance to *P. marinus* as well as diagnostics to detect infection.

Focus on MSX, Juvenile Oyster Disease (JOD) and Summer Mortality

Elucidating the Life Cycle of *Haplosporidium Nelsoni* (MSX) using an Experimental Approach and Molecular Diagnostics. Eugene Burreson, Lisa M. Ragone Calvo and Nancy A. Stokes, VIMS
Researchers still do not know how MSX disease is transmitted from one oyster to another and whether its life cycle is direct or requires a planktonic intermediate host. In fact, the life cycle of all members of the phylum Haplosporidia remains a mystery. Its elucidation would not only contribute

to scientific understanding of *H. nelsoni* population dynamics and increase the ability to predict its movements, controlled experiments that are currently impossible could significantly advance our understanding of how MSX and oysters interact.

Breeding, Evaluation and Molecular Analysis of Oyster Strains Selected for Resistance to MSX, Dermo and JOD. Ximing Guo, Susan Ford and Gregory A. DeBrosse, Rutgers University; Roxanna Smolowitz, Marine Biological Laboratory, Woods Hole

In this ongoing project, researchers have been breeding and evaluating different oysters strains which have been separately selected for resistance to the three major diseases and for faster growth. By crossing MSX and Dermo-resistant strains with JOD-resistant strains, researchers have been working to develop superior oyster strains. This final year will see completion of field evaluations and molecular analysis of disease resistance.

Evaluation of Inherent and Induced Thermal Tolerance in Protection of Oyster Populations from Summer Mortality Caused by Dermo and MSX Parasitism and Thermal Stress. Fu-Lin E. Chu, VIMS; Ronald S. Tjeerdema, University of California

Heavy Dermo and MSX-associated mortalities often occur during the summer, both on the Atlantic and Gulf Coasts. In this study, Chu and Tjeerdema will evaluate inherent and induced thermal-tolerance in protecting oyster populations from summer mortality caused by Dermo and MSX parasitism and thermal stress.

Molecular and Pathobiology Studies to Identify the Causative Agent of Juvenile Oyster Disease (JOD). Cheryl M. Woodley, Medical University of South Carolina and NOAA/NOS Center for Coastal Environmental Health and Biomolecular Research; Eric R. Lacy, Medical University of South Carolina; Earl J. Lewis, Jr., NOAA/NOS Center at Oxford, Maryland and Charleston, S.C.; Gregg Rivara, Cornell Cooperative Extension of Suffolk County Marine Program

JOD has caused immense losses of oysters from New York to Maine. While growers have been managing around disease, which occurs in hatcheries, significant mortalities continue to occur. Meanwhile, the disease itself remains unkown. This project aims at identifying the causative agent, improving knowledge about the disease process, developing genetic markers of evidence of JOD and JOD resistance, and helping growers plan disease management strategies.

Interactions of *Crassostrea Virginica* Hemocytes with the Putative Etiological Agent of Juvenile Oyster Disease (JOD). Katherine J. Boettcher, University of Maine

A novel species of marine bacteria is currently thought to be the etiological agent related to JOD. A new taxa within the Roseobacter clade of the alpha-proteobacteria, it infects oyster. This study will define the immunological response of *Crassostrea virginica* to the JOD-associted bacterium, for instance, the effects of temperature and salinity, oyster age and size on killing Roseobacter species by oyster hemocytes.

Mortality of the Pacific Oyster, *Crassostrea Gigas:* Identification and Evaluation of Multiple Environmental Stressors and Methods to Reduce Associated Mortalities. Daniel Cheney and Ralph A. Elston, Pacific Shellfish Institute; Carolyn Friedman and Gary Cher, University of California; Christopher Langdon; Oregon State University, Hatfield Marine Science Center; Louis Burnett, University of Charleston; Jonathan Davis, Taylor Resources

This ongoing project to determine the causes of summer mortalities of the Pacific oyster have found a number of potential factors, including oxygen stress, genetic adaptation wherein pedigree lines of oysters show differential growth rates and survival, cumulative stress and blooms of certain noxious algae. Continuing work aims at translating research findings into methods for minimizing mortalities, which have ranged from 10-50 percent during the summer in some growing areas.

Oyster Herpes Virus Threat to U.S. Oyster Producers. Ralph A. Elston, Pacific Shellfish Institute; Bruce Barber, University of Maine; Eugene Burreson and Kimberly S. Reece, VIMS

Oyster herpes virus has been described as occurring in French hatcheries that produce *Crassostrea gigas.* Is it a potential risk to oysters in U.S. coastal waters? In this initial study, the researchers will evaluate *C. gigas* and *C. virginica* seed and larvae from the East, Gulf and Northwest coasts for evidence of infection in order to make a preliminary determination on the health significance and formulate recommendations to manage herpes virus infection in oyster culture.

For information on the Oyster Disease Research Program, contact Dr. Jim McVey, National Sea Grant College Program, (301) 713-2451 x160; e-mail: jim.mcvey@noaa.gov.

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