The Gulf Oyster Industry: Seizing A Better Future

GULF OYSTER INDUSTRY PROGRAM
NATIONAL SEA GRANT COLLEGE PROGRAM

This publication was produced by the Louisiana Sea Grant College Program for the National Sea Grant College Program, September 2003.

Written by Elizabeth Coleman
Design and cover photo by Robert Ray

For more information about the oyster research projects sponsored through Sea Grant's Gulf Oyster Industry Program and Oyster Disease Research Program, contact:
National Sea Grant College Program
NOAA, 1335 East-West Highway
Silver Spring, Maryland 20910

Website:
http://www.nsgo.seagrant.org/research/oysterdisease/index.html

For additional copies of this publication, contact:

Communications Office
Louisiana Sea Grant College Program
Louisiana State University
Baton Rouge, Louisiana 70803

Telephone: (225) 578-6448

GS JOB 54665 AUGUST 2003 ACCT 167-13-5126-3110 MOHAWK 50-10 PLUS SOFT WHITE MATTE 80# COVER-100# TEXT MARKS Q=500

The Gulf Oyster Industry: Seizing A Better Future

Contents

3 Foreword

4 An Industry Under Siege

The traditional oyster industry in the Gulf of Mexico faces challenges that may destroy it. The Gulf Oyster Industry Program, a remarkable partnership among industry, science, and government, provides a practical and effective means for keeping the industry viable.

7 Controlling Disease

The control of oyster pathogens – both those that kill oysters and those that cause human illness – is a priority. Because these pathogens occur naturally in the water, the greatest hope for success in fighting them lies in the laboratory and the hatchery, primarily through genetics research.

10 Protecting Oysters In Place

Research helps oyster farmers to cope with predators, oyster diseases, and other problems by improving husbandry practices on their leases.

13 The Coastal Environment

Shellfish-producing waters are subject to closure because of contamination by viruses and fecal coliform bacteria. Radical changes in salinity caused by freshwater diversion can destroy oyster crops. Some research provides the means to prevent contaminants from reaching oyster-producing waters and to assist oyster farmers in relocating their oyster leases.

15 The Legal Landscape

Frequently changing regulations can confuse oyster farmers about their rights and obligations as leaseholders and cause delays for government agencies planning freshwater diversion projects. An education project provides the objective information needed in decision-making by both the oyster industry and government.

15 Understanding the Market

Consumer attitude and preference studies assist the oyster industry to address consumer concerns about oysters and to plan future educational and advertising programs.

16 A New Vision

The future of the Gulf Coast oyster industry depends on the adoption of new culture methods, marketing strategies, and strains of oysters. The key to such an approach is a strong hatchery research system.

Foreword

When Congress established the National Sea Grant College Program in 1966, it was not building an academic ivory tower, but creating a vigorous participant in the everyday world of the people who lived and worked in coastal areas. The program was to provide a vehicle for developing the nation's coastal and marine resources and perpetuating them for the benefit of generations to come.

The concept has been remarkably successful. Thirty-seven years later, a network of 30 programs, one in every coastal and Great Lakes state, draws on the expertise of thousands of scientists, educators, and outreach specialists in over 200 participating universities and research institutions to address problems in every aspect of the marine and coastal environment: fisheries, aquaculture, seafood processing, wetland management, coastal land loss, marine industry, aquatic recreation, economics, and law. The program's interdisciplinary character and flexibility in teaming with coastal industry and government allow it to respond rapidly to state, regional, and national needs.

The impacts of disease on oysters and the resulting struggles of the oyster farming industry typify the kinds of problems for which Sea Grant is the catalyst in finding practical solutions. Through two major national oyster research programs—the Oyster Disease Research Program and the Gulf Oyster Industry Research Program—Sea Grant has brought together academic researchers and oyster industry leaders to restore the commercial and ecological viability of U.S. oyster harvests, especially *Crassostrea virginica* on the east and gulf coasts and *Crassostrea gigas* on the west coast.

The Gulf Oyster Industry: Seizing A Better Future describes the progress made in the five-year-old Gulf Oyster Industry Program, which targets not only diseases that destroy oyster crops but pathogens carried by oysters that endanger human health. For further information about the National Sea Grant College Program and its oyster disease research programs, contact the National Sea Grant College Program, NOAA, 1335 East-West Highway, Silver Spring, Maryland 20910.

For generations, especially in Louisiana, Gulf Coast oyster fishermen have followed their fathers onto the oyster boats, forming a traditional industry that has consistently produced more than 12 million pounds of oysters a year – half the nation's oyster supply. But each succeeding year seems to bring new challenges that crowd the industry closer to extinction.

AN INDUSTRY

Photo Courtesy of Louisiana Seafood Board

Photo by Robert Ray

Habitat changes, predators, and oyster-killing diseases such as Dermo (*Perkinsus marinus*), caused by a protozoan parasite, are old nemeses that have plagued the industry for years and seem to be steadily getting worse. Coastal urban development, including recreational camps, has contaminated once-isolated shellfish waters with enteric viruses and bacteria that affect humans, causing frequent and widespread closures of oyster beds. Most recently, in Louisiana, coastal restoration projects have brought new problems as the introduction of fresh water and sediment from the Mississippi River has drastically changed the salinity levels of traditional oyster waters and destroyed oyster harvests.

Perhaps the most serious challenge confronting the gulf oyster industry, however, is that posed by *Vibrio vulnificus*, an opportunistic pathogenic bacterium related to the vibrio that causes cholera and commonly found in warm estuarine waters, sediments, and raw shellfish. *V. vulnificus* occurs naturally, even in waters uncontaminated by sewage, so raw oysters from approved shellfish-growing areas can still harbor it.

Although the organism poses no threat to the vast majority of people who eat raw shellfish, a few relatively rare strains produce a severe intestinal infection that can be fatal to people who have depressed immune systems or diseases of the blood, liver, or stomach. The U.S. Food and Drug Administration reports about a dozen deaths annually from *vulnificus*-tainted shellfish, though the number may be higher because not all states report deaths from *V. vulnificus* to the Center for Disease Control in Atlanta.

UNDER SIEGE

Photo by Robert Ray

Photo by Dede Lusk

Cooking kills the vibrio, as well as other bacteria, but fearful consumers nationwide are confused about the risks and many have stopped eating even cooked oysters. Various post-harvest treatments are available for eliminating pathogens so that raw oysters can be safely eaten but each has drawbacks. Heat pasteurization kills bacteria but can change flavor and texture. Low-dose irradiation preserves flavor and lengthens shelf-life but its use with many other foods has been widely opposed. High-pressure processing kills vibrios but causes the meat to detach from the shell. All of these processes kill the harvested oysters and add considerable cost to the product.

In spite of destructive environmental influences, the Gulf Coast still produces plenty of oysters but negative publicity about health risks has reduced prices and consumer demand, especially during the summer season. Nationwide, the consumption of raw oysters has decreased by over 60 percent during the last decade. For gulf oyster producers, this represents economic disaster, as a large part of the national oyster harvest is eaten raw.

The Gulf Oyster Industry Program (GOIP) is administered through NOAA's National Sea Grant College Program and is nationally competitive in its solicitation of research proposals.

Seeking Solutions

In 1997, the struggling Gulf Coast oyster industry made a bold – and unprecedented – decision to seek solutions to its mounting problems through a partnership with the academic research community. A variety of oyster-related research activities already existed within universities across the region, but there had been no coordinated effort or recurring sources of funds for research that could address the problems plaguing the Gulf Coast oyster industry.

Louisiana oyster boat. Photo by Dr. Don Davis.

In 1989 the National Sea Grant College Program had launched the Oyster Disease Research Program (ODRP), but those funds were primarily committed to studies of two oyster parasites that had destroyed East Coast oyster stocks. One of these, colloquially known as MSX, was not a problem in the Gulf of Mexico. The other parasite, Dermo, occurred widely in gulf oysters, but Gulf Coast oyster producers concluded that the variety of issues strangling their industry could not be comprehensively addressed simply by diverting part of the ODRP. Nevertheless, they regarded the ODRP as a model to emulate, a proven success story in the art of the possible.

After petitioning Sea Grant university researchers and administrators for help with a long-term research program, an industry task force took a research prospectus to Washington D.C., where the growers talked to NOAA administrators and appealed to their congressional delegations. Subsequently, to ensure regional benefits, oyster farmers from Florida to Texas formed an organization called the Gulf Oyster Industry Council. In 1998, the U.S. Congress authorized five million dollars for a five-year research program aimed at Gulf Coast oyster industry problems.

Though explicitly aimed at regional problems, the Gulf Oyster Industry Program (GOIP) is administered through NOAA's National Sea Grant College Program and is nationally competitive in its solicitation of research proposals. An industry advisory panel composed of oyster harvesters and processors from each gulf state sets GOIP research goals and ranks preliminary proposals submitted by researchers. After a rigorous scientific review process, a technical review panel of scientists, Sea Grant and National Fisheries Institute administrators, and three oyster industry representatives recommends to the national Sea Grant director the most highly ranked projects for funding. The program has supported scientists in Louisiana, North Carolina, Virginia, Alabama, Florida, Mississippi, Texas, and California in projects ranging from testing a system for treating oyster-polluting wastewater to creating disease-resistant oysters through gene transfer. There are no quick fixes for the complex tangle of problems facing the gulf oyster industry, but significant progress has been made in a number of research priorities identified by the advisory panels.

The Gulf Oyster Industry Program is novel in its management structure and the close working relationship of science, industry, and government. Its comprehensive scope offers the most practical and effective means for the Gulf Coast region to develop, build on, and apply the knowledge needed to keep this important industry from extinction.

"The oyster industry has been an economic engine in gulf coastal communities for generations," says Dr. John Supan, a shellfish biologist with Louisiana Sea Grant and major supporter of the GOIP. "It's important to focus research and outreach efforts on industry priorities through cooperative programs like this."

AN INDUSTRY UNDER SEIGE

CONTROLLING DISEASE

If the Gulf Coast oyster industry is to remain viable, not only must consumers be reassured that gulf oysters are safe to eat but, in order to maintain an adequate harvest, the oysters themselves must be protected from disease. Besides contending with *V. vulnificus* and other pathogens that make people sick, oyster producers are also faced with controlling those that destroy their crops.

One of the worst oyster killers is Dermo (*Perkinsus marinus*), a saltwater parasite that produces a tissue-destroying enzyme causing the oyster to steadily lose weight and finally die. It was first noted as a problem in the Gulf of Mexico in the 1940s; subsequently, it moved up the Atlantic coast to infest Delaware and Chesapeake bays, where it has decimated oyster stocks. In the Gulf of Mexico, Dermo infestations have worsened with the increase of salinity levels in coastal oyster-growing waters and they have been known to destroy up to 50 percent of an oyster crop, especially when the oysters are allowed to stay bedded for longer than two years.

Since the beginning of the gulf research program, the oyster industry advisory panel has selected the control of oyster pathogens—both those that kill oysters and those that cause human illness—as a research topic of highest priority. Because these pathogens occur naturally in the water, however, the greatest hope for success in fighting them lies in the laboratory and the hatchery. Researchers have taken multiple approaches, including genetic manipulation, selective breeding, and the use of various post-harvest treatments to destroy pathogens before the oysters reach consumers. Though some projects have shown encouraging results and are ongoing, others have not warranted further investigation.

Improving the Oyster

Dr. Terry Tiersch, a geneticist with the LSU Agricultural Center's Aquaculture Research Station, has been seeking genetic solutions to disease in aquatic animals for almost ten years, first with catfish and now with oysters. In a GOIP project, along with earlier projects with Sea Grant's Oyster Disease Research Program, Tiersch and Dr. Richard Cooper and Dr. Jerome LaPeyre of the LSU Department of Veterinary Medicine, have been working to develop oysters that are resistant to both Dermo and *V. vulnificus*.

Dr. Jerome LaPeyre works to develop disease-resistant oysters. Photo by Robert Ray.

Dr. Carmen Paniagua-Chavez was successful in growing out thawed oyster larvae. Photo by Elizabeth Coleman.

The work is based on transgenics, the process of transferring genes from one organism to another to impart a particular characteristic. In earlier work with catfish, Cooper and Tiersch had created disease resistance in channel catfish by inserting the gene for a lytic (antimicrobial) peptide, a small protein isolated from the giant silk moth, into the cells of the fish. The product of the lytic peptide gene kills bacteria and some parasites, but is controlled by the catfish's immune system and is produced only in response to a bacterial infection. Tiersch, Cooper, and LaPeyre became interested in applying the same techniques to oysters, especially to control Dermo. The essential first step of culturing the parasite in the laboratory had already been done by LaPeyre.

The use of lytic peptides to impart disease resistance in oysters was an untried idea, and the researchers have had to do much painstaking groundwork.

"We needed several years of preliminary research just to develop the necessary tools for oyster work," says Tiersch. Efficient methods of producing oysters in the laboratory had to be established. Workable techniques for inserting the lytic peptide into the oyster at three major stages of its life—gamete, larva, and adult—had to be developed. These accomplishments took two years but they mark the first time that laboratory gene transfer and expression in the eastern oyster (*Crassostrea virginica*) have been documented.

Because Dermo secretes protease, an enzyme that degrades the lytic peptide, LaPeyre developed and tested protease inhibitors. Oysters treated with the lytic peptide-protease inhibitor combination will, the researchers believe, not only resist Dermo infection but will transfer the disease-resistant gene to their offspring. Some of the lytic peptides kill both *Perkinsus marinus* and *Vibrio vulnificus*. Much work remains, especially the development of an efficient method for inserting the gene into large batches of oysters and the conducting of disease trials, in which treated oysters are exposed to infection and their resistance evaluated.

An achievement that undergirds all the other research in the Aquaculture Genetics Laboratory and makes oyster research possible year-round is a breakthrough in oyster cryopreservation, or freezing, by then-graduate student, Dr. Carmen Paniagua-Chavez. After several years of experimentation, she was successful in freezing and thawing oyster larvae, placing them in a natural environment, and seeing them grow into seedstock oysters. Formerly, research opportunities were limited to only three or four months a year, when oysters could be obtained from coastal beds and reefs.

"Cryopreservation is an essential tool," says Tiersch. "It's easy now to stockpile frozen oyster gametes and larvae with different genetic characteristics, thawing and growing them out as we need them. We're able to work year round without worrying about the availability of wild oyster populations or having to hold live oysters in tanks."

In another approach, LaPeyre worked with Dr. Standish Allen of the Virginia Institute of Marine Science (VIMS) to identify and breed oysters that are naturally resistant to Dermo. After some unusually old and large oysters were found in isolated areas fringing the Gulf of Mexico, LaPeyre speculated that their size and longevity might be explained by a natural ability to kill Dermo. In replicated studies, these oysters' offspring were exposed to Dermo in Louisiana waters.

"The oysters showed superior disease resistance and lower mortality levels than Chesapeake stocks," says Allen. "The results indicate that there is much genetic variation for disease resistance, not only from region to region, but also within a single region as well."

Now, in an effort to develop a reliably disease-resistant stock of gulf oysters, LaPeyre is working with John Supan at the Grand Isle oyster hatchery to conduct an accelerated selective breeding program, in which larvae from the successive generations of the most disease-resistant oysters are grown out and inoculated with Dermo. The researchers hope to obtain hatchery broodstock that is naturally disease-resistant and will transfer the resistance gene to succeeding generations of oysters produced in the hatchery.

An achievement that would make oyster genetic research much easier but has stymied scientists for years is the development of a method for triggering cell division, or mitosis, from a single contaminant-free oyster cell. In a "cell line" or generations of cells directly descended from the same cell, each is a microcosm of the whole organism, containing all the genes that dictate the oyster's characteristics. Such an accomplishment would have incalculable benefits in efforts to understand oyster pathogens and develop oysters with disease resistance. Through GOIP-supported research Dr. Jane Burns of the University of California has made progress toward this goal, as has LaPeyre, but it is a many-stepped process with frustrating dead-ends.

Genetic improvement—adding or enhancing desired traits either through transgenics or the process of selective breeding—may in the long run prove the most effective way to solve the oyster industry's problems with disease. But it's also the slowest. Perhaps more than any other approach, genetic research is a process in which knowledge comes in small increments and requires perseverance.

AN INDUSTRY UNDER SEIGE

Treating the Oyster After Harvest

Researchers have investigated a variety of ways to eliminate human pathogens in oyster shellstock after harvest. Some treatments, such as freezing, heating, and irradiation, are physical processes that can change the character of the oyster itself. Others, such as the use of chemicals and other microorganisms, depend for effectiveness on the fact that the oyster is a filter feeder, capable of pumping through its tissues as much as two and one-half gallons of water per hour. In the filtering process, oysters purify themselves if the water is clean, but depurating (purging) them with treated water can remove pathogens and fecal coliforms faster and more effectively.

But the filtering capacity that makes some treatments effective works against others, and not all agents tested have been successful. For example, Dr. James Oliver of North Carolina State University found that the antimicrobial compound diacetyl eliminated *V. vulnificus*, but when the oysters sensed the presence of the chemical, they immediately stopped the filtering process. When the amount of diacetyl was reduced enough so that the oysters continued to pump, it didn't kill *V. vulnificus* in sufficient quantity.

Rather than using a chemical, Dr. Donna Duckworth of the University of Florida is working with especially developed viruses, or bacteriophages, to kill various strains of *V. vulnificus*. Having used the viruses successfully in infected mice, she is now testing the water conditions under which oysters will take up these viruses and the specific "cocktail" of organisms needed to destroy the bacteria. "This work raises the possibility that bacteriophage could be used both in oysters to make them safer and also as an alternative treatment for people infected with *V. vulnificus*," says Duckworth.

Similarly, at Texas A&M, Dr. Joe Fox has identified strains of probiotic or helpful bacteria to which *V. vulnificus* was sensitive. He successfully eliminated the pathogen by purging infected shellstock oysters with water containing various concentrations of probiotic bacterial mixes.

The use of edible, commercial marinades that can kill vibrios without cooking the oysters has also been explored. Because *V. vulnificus* survives best in water with a slightly alkaline pH, Dr. Marilyn Kilgen and Culinary Institute chefs at Nicholls State University devised a variety of acid-based marinades containing either vinegar or lemon juice and evaluated them for both flavor and their ability to destroy *V. vulnificus*. In the vinegar-based marinades, the levels of *V. vulnificus* were undetectable after 24 hours. Kilgen believes that such a value-added product could benefit not only oyster producers but related industries, as raw oysters treated with these marinades could be offered by restaurants and caterers as appetizers.

Researchers have tried freezing, pressure treatments, and microwave heating, all of which destroyed *V. vulnificus* in raw oysters. When Dr. Dorilz Mestey and colleagues at the University of Florida froze whole and half-shell oysters with carbon dioxide and thawed them after four weeks of storage at -10 °F, *V. vulnificus* bacteria were undetectable. Oysters frozen with liquid nitrogen or blast frozen also showed extremely low numbers of *V. vulnificus* bacteria when thawed. Irradiation,

Photo courtesy of Louisiana Seafood Board

microwave heating, and high pressure treatments conducted by Dr. P. Mallikarjunan of Virginia Polytechnic Institute and colleagues at other institutions were found to control *Vibrio parahaemolyticus*, also harmful to humans, as well as *V. vulnificus*.

Post-harvest treatments may efficiently control hazardous pathogens and lengthen shelf life but there are tradeoffs. Dr. Xu Zhimin of Louisiana State University identified volatile compounds responsible for the major flavors of fresh oysters and studied flavor changes induced by high-pressure pasteurization and hot-cold water treatments in both shucked and shellstock oysters. He found that the treatments caused changes in the oyster's fatty acids that affected aroma, flavor, and texture.

Although widespread public acceptance may be difficult to win, treatment by irradiation does not seem to affect flavor or texture. Convening consumer panels at a Mississippi aquaculture conference and the Boston Seafood Show, Dr. Linda Andrews of Mississippi State University observed that consumers could not tell the difference between irradiated and untreated oysters. According to the panelists, says Andrews, "processed oysters maintained their 'raw' quality and no taste or texture changes were noted."

Removing hooked mussels from oysters. Photo courtesy of Louisiana Seafood Board.

PROTECTING OYSTERS IN PLACE

That the Gulf Coast manages to retain its position as the nation's leading oyster producer is mainly attributable to the accommodations with nature made by oyster farmers as they cope with problems they can't solve. For example, timing is their primary weapon in the fight against Dermo and a major predator, the oyster drill (*Thais haemastoma*). To combat both, oyster farmers often rotate the use of bedding reefs, just as crop farmers rotate the use of fields. Because oyster drills are attracted to bedded oysters, letting a reef lie fallow for one or two years discourages the predators from remaining in the area.

Timing also forms the basis for DermoWatch, a new tool developed through the GOIP by Dr. Sammy Ray, professor emeritus of Texas A & M University, computer scientist Dr. Enrique Kortright, and Dr. Thomas Soniat of Nicholls State University. A predictive computer model, DermoWatch enables oyster growers to calculate exactly how much time they have to harvest their oysters or move them to safer waters before Dermo reaches critical levels and widespread mortality occurs.

Once a month, the researchers carefully monitor a core sampling site in Galveston Bay (four public reefs and three private leases) for the factors that influence the onset and progression of Dermo. At each site, the researchers take samples of oysters at three life stages, measuring their length and testing their tissue for the presence and intensity of Dermo infection. Data buoys provide continuously updated information on temperatures and salinity levels. Each site's data are then plugged into the DermoWatch model, resulting in a prediction of the number of days before the site's oyster population will start dying from Dermo infection. The easy-to-use DermoWatch web site (www.blueblee.com/dermo) allows any oyster producer with the necessary data to calculate the time before oysters must be removed from a lease or be lost to Dermo.

Recently, DermoWatch was expanded from Galveston Bay to Louisiana waters, where oyster sampling and disease analysis are conducted in state public grounds and at a new environmental monitoring station in Bay Tambour near Cocodrie. A new web site, www.dermowatch.org, which incorporates all data sampling sites in Texas and Louisiana, is nearing completion.

"With DermoWatch, *Perkinsus* ceases to be an unseen killer," says Ray. "Growers can follow disease conditions as they relate to mortalities they observe, and the estimate of time to a critical level of the disease allows them to make informed decisions to harvest the oysters, to move them, or to keep the crop in place."

Along with Dermo, predators account for serious reductions in oyster harvests. Greater levels of salinity in coastal oyster-growing waters have exacerbated problems in some areas with oyster predation by the black drum (*Pogonias cromis*), whose powerful teeth can crush up to 30 oysters per day. In other coastal areas, fouling by the hooked mussel (*Ischadium recurvum*) has become a serious nuisance. Both harvests and profits would be higher for the industry were it not for substantial losses to these two pests.

The hooked mussel was recorded in the Gulf of Mexico as long ago as the early eighteenth century. The mussel does not survive to adulthood in highly saline water, but in recent years the increase in fresh water caused by diversion structures has expanded the range of the mussel so that it now infests oyster grounds.

Hooked mussels layer themselves heavily onto oyster shells, rendering the oysters nonharvestable as a commercial product. Manually removing mussels from oysters is a laborious process. Oyster-shucking houses will not accept mussel-fouled oysters because the mussel's shell breaks easily and can contaminate a shucker's oyster pail.

Oyster producers have attempted to solve the problem by relaying (transplanting) their oysters to saltier water, hoping that an abrupt increase in salinity will kill or detach the mussels before the oysters are harvested for market. Sometimes the ploy is successful, but at other times the effort fails. In a GOIP project, Dr. Earl Melancon of Nicholls State University has given oyster producers more predictability in transplanting oysters, thus reducing guesswork and costs.

Melancon developed a mathematical model that predicts the responses of mussels to an abrupt change in salinity in relation to water temperature, air temperature, and exposure to air. He also documented the distribution of hooked mussels in oyster

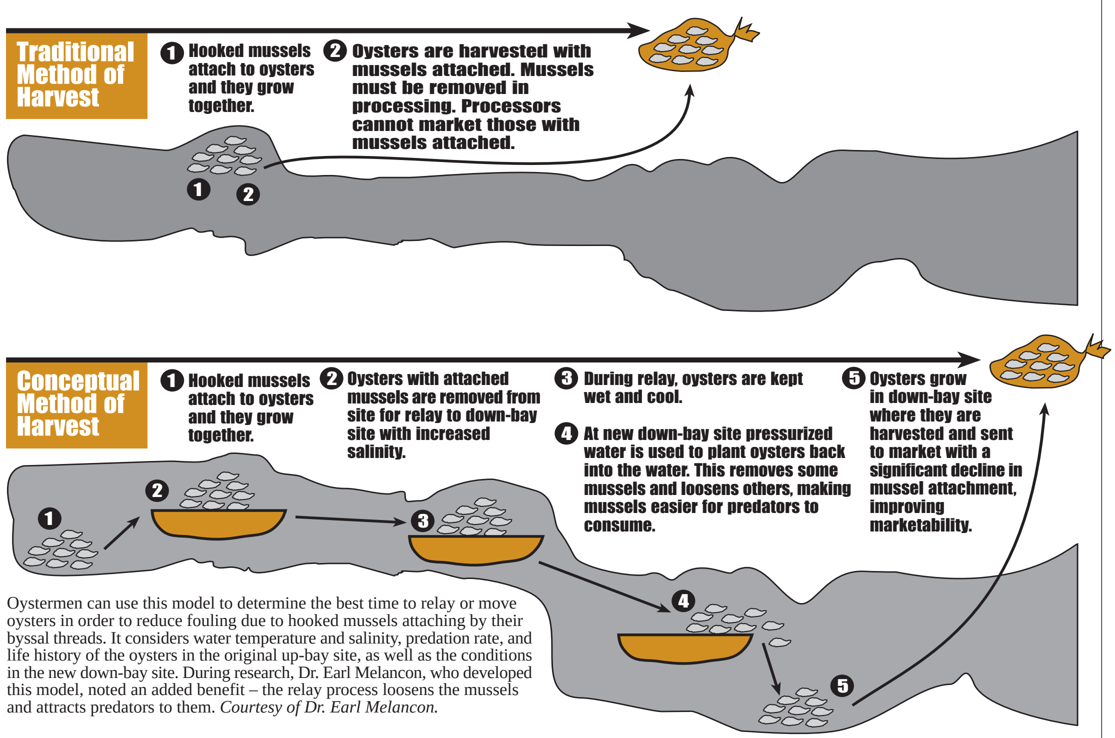
SEIZING A BETTER FUTURE

habitat as influenced by salinity.

"Transplanting is time-consuming and expensive," says Melancon. "A model gives oyster growers a significant degree of assurance that when mussel-fouled oysters are moved under certain estuarine conditions, the mussels will die and fall off."

In the process of making the necessary field and laboratory studies to develop the model, Melancon also developed a new hypothesis that has changed oyster growers' understanding of why relaying works. The main reason that moving oysters to saltwater gets rid of hooked mussels is not so much the stress of the abrupt change but the presence of numerous saltwater predators. Melancon observed that mussels moved to saltwater environments survived only in the crevasses between clustered oysters where predators couldn't reach them easily. He recommended that oyster growers transplant their oysters in moderately to highly saline waters in order to remove mussels quickly, perhaps in as little time as a week if numerous predators are present. Because the black drum, a serious oyster predator, is abundant in high-salinity areas, a quicker reharvest time may be necessary to reduce predation on oysters.

"Mussels are less tolerant of saltwater than oysters, but the driving force in removal is predation," says Melancon.



Oystermen can use this model to determine the best time to relay or move oysters in order to reduce fouling due to hooked mussels attaching by their byssal threads. It considers water temperature and salinity, predation rate, and life history of the oysters in the original up-bay site, as well as the conditions in the new down-bay site. During research, Dr. Earl Melancon, who developed this model, noted an added benefit – the relay process loosens the mussels and attracts predators to them. *Courtesy of Dr. Earl Melancon.*

"If blue crabs, oyster drills, and fish are abundant in the saline areas where oysters are transplanted, they will remove hooked mussels."

Larger seed from oyster hatcheries was studied to deter predators. The ability of hatcheries to mass-produce oyster seed is well established, but Gulf Coast oyster producers depend on the harvest of natural spatfall and do not see the use of hatchery seed as cost-effective in the highly predacious environment in which oysters must grow. To determine if survival of hatchery-produced seed was related to size when planted, Rick Wallace and D.B. Rouse of Auburn University planted varying size groups of seed at two sites with different levels of salinity and monitored them continuously. During the first year, when the researchers planted four size classes, all oysters were lost to predation (primarily by the oyster drill) within eight weeks. The second year, in which the oysters were divided into three size groups, almost all of them, regardless of size, were dead after six weeks.

The researchers concluded that there was no economic advantage for oyster growers to pay more for larger, hatchery-produced seed. "Size may offer some protection from blue crab predation," says Wallace,

Black drum, an oyster predator. Photo by Paula Ouder.

"but not from the oyster drill, which seems to prefer larger seed oysters."

Black drum predation has always been a serous concern for oyster producers, but in recent years gulf-wide legislation has made it worse. At the urging of recreational fishing groups wanting to conserve natural stocks of game fish, state legislatures established bans on gillnetting, which was viewed as the chief culprit in declining stocks of certain fish. The laws prevented the practice of setting gill nets near oyster leases, and drum predation on oysters soared.

In an effort to pursue every possibility for reducing black drum predation by other means, the oyster industry panel funded a GOIP project that proposed a novel approach to deterrence: the use of odors and sounds.

To test the belief that fish show markedly slower rates of feeding when exposed to the scent released by damaged fish skin, Dr. Kenneth Brown and coworkers in the LSU Department of Biological Sciences subjected black drum to the scent of drum carcasses at oyster beds. If this proved to deter, or at least slow, predation, oyster growers could either fix black drum carcasses on their oyster beds or add the chemical components of the scent to the water above. In another project, the researchers used an underwater acoustic system to produce varying frequencies and intensities of sound in order to test the idea that noise might alter black drum feeding behavior. In the same way, "pingers" deter dolphins from tuna trawls.

The results of scent experiments, conducted in outdoor raceways and at several oyster leases in Barataria Bay, varied so widely in replicated studies that differences in feeding rates between experimental and control sites were not statistically significant. The researchers are still analyzing data from sound experiments, but preliminary results indicate that the presence of sound depresses feeding rates no more than 10 to 15 percent.

The disappointing outcome of this project has led many industry leaders to conclude that the only practical solution to the problem of black drum predation lies in the implementation of a directed fishery. But with the current emphasis on gamefish conservation, that is likely to be a hard concept to sell to state legislatures.

SEIZING A BETTER FUTURE

Photo by Ronnie Paille.

THE COASTAL ENVIRONMENT

Cleaning Up the Oyster's Habitat

Though fixing the oyster genetically may take years to become reality, projects to adjust the oyster's environment are perhaps easier to achieve. A major impact on oyster harvesting waters throughout the United States is faulty septic systems in coastal dwellings. In many coastal sites, recreational camps may have no sewerage systems at all. Raw sewage goes directly into streams and bayous, flowing to coastal shellfish-producing waters and contaminating oyster beds. The result is high fecal coliform counts and water that is closed to oyster harvesting.

Dr. Kelly Rusch and Dr. Dean Adrian of Louisiana State University have developed and, with GOIP support, are testing an alternative method for treating domestic sewage from coastal camps. It is called the Marshland Upwelling System, or MUS, and its basic approach is to use the natural soils within a saltwater marsh as a filter to remove viruses and fecal coliform bacteria.

Several versions of wetland waste-treatment systems are now used by industries and municipalities with varying degrees of success and little consensus on best design. Rusch believes that the MUS is the most logical option in coastal areas, especially for camps where usage is intermittent and low cost and minimal maintenance are important.

The MUS uses the natural marsh bed to create an underground on-site treatment system for camp waste. Wastewater is pumped down a well and then forced back to the surface through a sand bed. As the water moves upward, bacteria in the water die or are captured by an anaerobic film on the surfaces of the sand particles, purifying the water. Further filtration is provided by plant roots, which take up the water as it returns to the surface and moves out over the marsh. It's a simple system that works

Rusch has set up experimental systems in both Louisiana and Mississippi, where they have operated for several years with no failures. She has established waste-load limits, determined well efficiency under heavy loads of raw sewage, assessed long-term stability, and prepared a technical manual containing operational guidelines for the MUS. A report on current and alternative on-site sewage treatment options prepared by the EPA's Barataria-Terrebonne National Estuary Program listed the MUS as the top alternative for wastewater treatment.

"This is a low-cost, reliable treatment alternative for coastal wastewater," says Rusch. "The benefit for the oyster industry could be the reopening of closed oyster growing waters."

Understanding Oyster Habitat

About six years ago, to stem the rampant erosion consuming Louisiana's coastal marshes, the state began to build structures to divert nourishing, sediment-rich

SEIZING A BETTER FUTURE

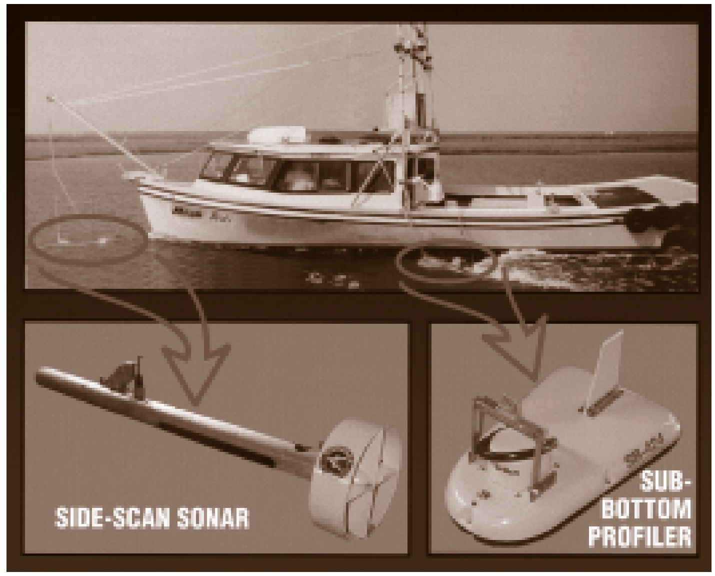
Dr. Kelly Rusch checks an experimental MUS at Fourchon, Louisiana.
Photo by Elizabeth Coleman

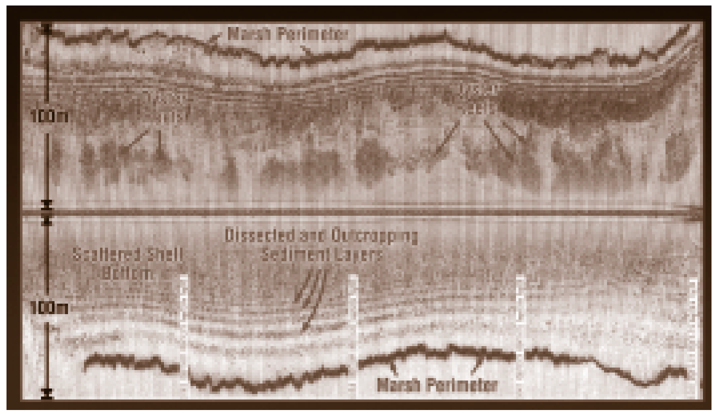
fresh water from the Mississippi River into adjacent lakes, bays, and marshes. Healthy marsh plants flourished, but the effects on oyster grounds, especially in some parts of Breton Sound, were devastating. The extra fresh water upset the range of salinities in which oysters thrived and they died on the reefs or fell victim to fouling by the hooked mussel. Oyster farmers holding leases in the affected areas sued the state, citing enormous production losses directly caused by freshwater diversion.

In response, the Louisiana legislature authorized a relocation program for Barataria Bay oyster leases that might be affected by the next freshwater diversion project, Davis Pond. A key component of the lease relocation program called for evaluating the quality of existing oyster leases, but traditional appraisal methods used by oyster fishermen for generations were inadequate, providing only general classifications of bottom type. In "poling," for example, the surveyor probed the water bottom with a long pole and classified the bottom simply as soft or firm mud, sand, or hard reef with or without oysters, according to the way the pole penetrated the bottom. Maps of shallow-water oyster habitat gave few details of the true distribution, character, and extent of reefs.

To map oyster beds accurately, Dr. Charles Wilson and Dr. Harry Roberts of Louisiana State University combined the use of side-scan sonar, a digital high-resolution subbottom profiler, and a geographical positioning system to provide a detailed and reliable picture of shallow-water bottoms. These combined imaging systems give the researchers a "3-D" picture of bottom conditions, enabling them to map both vertical and horizontal features. They can discriminate between different types of bottoms—for example, shell versus clay—and also distinguish layers of sediment or shell that were deposited during specific time periods.

In a GOIP project, these researchers and oyster industry cooperator Ralph Pausina have been ground-truthing oyster reefs in Barataria Bay, integrating side-scan surveys with dredge sampling in order to compare resulting imagery with the volume of shell recovered and establish quantitative relationships. The system has proved to be an important tool for evaluating and classifying water bottoms as reefs, not only for state oyster managers but eventually for oyster producers who will have a way to monitor changes in their leases. The





With side-scan sonar and a subbottom profiler, data can be collected in two meters of water. Photo courtesy of Dr. Harry Roberts.

researchers are working to find a way to package the side-scan system so that oyster growers can use it to map their reefs.

"Oyster reef topography is constantly changing so it's important to be able to accurately and objectively evaluate the quality of oyster beds and the impacts on them, especially losses in value," says Wilson.

Davis Pond freshwater diversion structure. Photo courtesy of U.S. Army Corps of Engineers.

THE LEGAL LANDSCAPE

When Louisiana oyster producers filed both federal and state lawsuits claiming compensation for production losses caused by freshwater diversion projects, the state of Louisiana responded by quickly changing laws to limit its liability and altering the terms of its oyster-reef leasing program in order to avoid future lawsuits. Anticipating the construction of new diversion projects in the future, the state also adjusted the terms of its oyster lease relocation policy to allow a greater number of oyster growers to participate.

The regulations changed so fast that many oyster growers whose families had used the same leases for generations became confused about what their rights and obligations as leaseholders were and whether they could or should participate in the relocation program. The two sides, government and oyster farmers, became polarized and entrenched in their positions. Nonadversarial information, impossible to obtain from advocates of either side, was desperately needed.

Through several GOIP projects, James Wilkins, Sharonne O'Shea, and Erinn Neyrey of the Sea Grant Legal Program at Louisiana State University conducted an educational program describing the new regulations and their impacts on current and future leasing practices, leaseholder rights, and the legal ramifications for freshwater diversion projects of oyster industry lawsuits. Information was disseminated through publications, public speaking engagements, and news articles. The project has helped oyster farmers understand their options and make informed decisions about relocating their leases. Two publications resulted from the project, "Louisiana's Oyster Lease Relocation Program: A Step Toward Common Ground," by Joe Stevenson, and "An Oyster Fishermen's Guide to Louisiana's Oyster Lease Relocation Program."

UNDERSTANDING THE MARKET

Who eats oysters and why? How often do they eat them? GOIP projects to characterize oyster consumers may help the oyster industry increase sales.

The results of several consumer attitude and preference studies made by Dr. Linda Andrews, Dr. Terrill Hanson and others at Mississippi State University indicate that most oyster consumers are white and Asian males who are 40 to 49 years old. They are also affluent, as those who earned more than $80K per year ate oysters most often. Eighty percent of oyster consumers do so because they love the flavor and on average eat oysters over twice a month. Forty percent of consumers who were aware of the possible health hazards to people with deficient immune systems chose to eat oysters anyway. Larger percentages of oyster consumers live in the Southeast Atlantic and South Central regions of the U.S.

Photo courtesy of Louisiana Seafood Board.

Among regular oyster consumers, the main reasons for not eating oysters more often were given as price (38 percent), product safety (29 percent), and the unavailability of fresh product (20 percent). It is likely, according to Hanson, that people indicating product safety and lack of fresh oysters were concerned about safety. When given the choice of four shellfish and eight finfish products, about 44 percent of oyster consumers rated the oyster as the least safe.

However, 43 percent of *all* oyster consumers and 54 percent of those who were concerned about product safety indicated that they would eat oysters more often if post-harvest depuration were the method used to increase safety. When asked whether they would be willing to pay for a safety treatment program, 61 percent indicated a willingness to pay 34 cents per oyster above the raw oyster price.

Why do people dislike oysters? Not surprisingly, the most common reasons given were aversion to taste, texture, and odor, followed by concerns about product safety.

These surveys provide guidelines for the oyster industry in future advertising and educational programs. Increased sales are most likely to result from programs to persuade existing oyster consumers to increase consumption, rather than from efforts to persuade nonconsumers to start eating oysters. Fertile grounds for increased advertising are the southeast and south central regions of the nation. Clearly, a fresh, safe product is critical, and the oyster industry may be able to increase quality and consumer trust through a depuration program. If the extra costs do not exceed consumer willingness to pay, as indicated in the survey, the treatment charge could be added to the price.

A real boost to expanding the market for oysters will be a GOIP collaboration among the state seafood marketing agencies of Louisiana, Florida, and Mississippi to design a comprehensive consumer education program. Information about the risks involved in eating raw oysters as well as the availability of equally tasty but safer product alternatives will be aimed at both oyster consumers and food service professionals. The development of education materials will be accompanied by efforts to increase the visibility of treated oyster products and consumer access to them.

SEIZING A BETTER FUTURE

A NEW VISION

The Gulf Coast oyster industry has been successful for more than a hundred years, but its future depends on whether it can look past what has always worked to consider new culture methods, new marketing strategies, even new species. The key to such a new approach is a strong hatchery system. Working with geneticists and other researchers, hatchery operators can develop disease-resistant stocks for distribution to producers' leases, culture new species and test innovative grow-out techniques. Louisiana's oyster research coordinator John Supan began a decade ago to help the oyster industry build a viable future through a molluscan shellfish research and education program at the Grand Isle Bivalve Hatchery, the only oyster hatchery in Louisiana.

Supan has worked with oyster growers to produce oyster larvae for seeding on growers' leases, to perfect and test off-bottom grow-out techniques that protect oysters from predators till harvest, and to develop superior oyster

Dr. John Supan at the Grand Isle Bivalve Hatchery. Photo by Robert Ray.

strains such as the triploid, which can be farmed in the Gulf of Mexico.

The triploid oyster offers the oyster industry a remarkable new opportunity. Triploids have three sets of chromosomes instead of the normal two possessed by diploid oysters and are therefore sterile. During the summer spawning season, diploids use up their stored glycogen and yield only lean, poor quality meat. Triploids, however, remain fat because no energy goes into spawning.

"Shucking houses normally lose money in the summer because of low-yield oysters," says Supan. "But triploids have the potential to become a profitable summer crop. If triploids can make money for the shucking houses, the added revenues will more than cover the extra costs involved in producing them."

The major problems with producing triploids are the high rate of egg mortality in the hatchery and less than 100 percent triploidy because of induced chromosome manipulation procedures. But in a GOIP project, Supan is working with Dr. Stan Allen of VIMS, who discovered a way to make a tetraploid oyster—one with four sets of chromosomes. When tetraploids are crossed with diploids, the resulting oysters are all triploids. Supan's goal is to produce triploid oyster seed for use by the gulf oyster industry.

Photo Courtesy of Louisiana Seafood Board.

Supan has also worked with LaPeyre to explore the possibility that triploid oysters might be naturally resistant to pathogens. During the spawning season, they showed a super-ior resistance to *V. vulnificus* compared with that of diploids and it was thought that energy normally directed to reproduction in diploid oysters is used instead for defense in the sterile triploids.

Unfortunately, when the researchers compared the abundance of *V. vulnificus* and intensity of Dermo infection in triploids with those in diploids, they did not find a significant difference. However, they have not closed the door on the idea, because the unexpected results might be explained by unusual environmental conditions during the summers that the GOIP project was conducted. "Both were characterized by exceptionally high water temperatures and levels of salinity," says LaPeyre. "The oysters were under extreme stress and mortality was great."

At present, with support from the GOIP and the Grand Isle Port Commission, Supan is coordinating the establishment of the Grand Isle Aquaculture Park, which will be sited on 91 acres on lower Caminada Bay and modeled after a successful clam farming operation in Cedar Key, Florida. Supan sees the facility as a common tool for oyster industry development and for economic growth within the community of Grand Isle. Supan and other researchers will continue to pursue tetraploidy, improved husbandry, and genetic studies, especially those aimed at developing disease resistance.

In oyster research, where the problems to be solved are numerous and require attack on many fronts, the hatchery offers the best hope, combining practical husbandry with genetic procedures. "When genetic improvements produce superior oyster strains, it doesn't make sense to plant them unprotected on the bottom where crabs, black drum, and oyster drills can eat them," says Supan. "Using advanced, economically feasible grow-out methods for these superior oysters will help genetics research and the oyster industry reach full potential."