MARYLAND
Research, Education, Outreach *Summer 1995*
MARINE NOTES

SPOTLIGHT ON RESEARCH

The New Oyster Wars:
Battling Disease in the Lab and Bay

By Merrill Leffler

In the final decades of the last century, oyster wars in the Chesapeake pitted watermen against the oyster police and each other as they battled over the riches of the Bay's "winter gold." No more.

With those riches gone, oyster wars in the final decade of this century are being fought below water, not by watermen but by poorly defended oysters and marauding protozoans. Known as Dermo (*Perkinsus marinus*) and MSX (*Haplosporidium nelsoni*), these microscopic parasites have been battering oyster populations throughout the Chesapeake. One measure of this onslaught can be seen in commercial harvests — over these last five years, harvests have fallen so low their landed value in Virginia, says Roger Mann of the Virginia Institute of Marine Science (VIMS), "is less than the sale of one median house in Hampton Roads."

So entrenched is Dermo on bottom grounds in the Bay that even in summers with good sets of new oyster larvae, the chances of oysters surviving to harvest size by the second or third year are at best slim, at worst, nonexistent. According to Eugene Burreson, a scientist at VIMS, Dermo commands all of Virginia's oyster bars except the upper James River. With all the emphasis on Dermo, people have tended to forget MSX, says Burreson — that's a mistake. "This year," he says, "we have had the highest MSX infection since 1959."

Probing the immune system of the oyster, researchers witness a raging molecular battle between relentless parasites and the mollusc's faltering defense mechanisms.

Why are oysters so defenseless? Why aren't they able to mount an effective counterattack against Dermo and MSX, as they have against other pathogens? Or conversely, why are these protozoans so successful in eluding defenses the oyster immune system throws at them? And can anything be done to reverse the devastation that these diseases have been wreaking?

Until five years ago, there were few answers that evoked optimism, and no long-range plan for help. That is no

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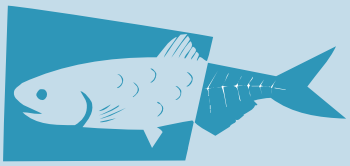
Can America Save Its Fisheries?

Many U. S. fisheries — from coast to coast and in the Great Lakes — are facing historic lows. Will new gear restrictions, limited entry or other management tools be able to turn the tide? Have our fisheries, a public trust resource, become another casualty of the "commons"?

On September 11, 1995, at the National Press Club in Washington, D.C., the national network of Sea Grant programs will sponsor a public issues forum entitled, "Can America Save Its Fisheries?" Panelists will include Michael Sissenwine, chief scientist for the National Marine Fisheries Service; Bart Eaton, president of Trident Seafoods; Suzanne Iudicello, vice president of the Center for Marine Conservation; Billy Frank, chair of the Northwest Indian Fisheries Commission; William Amaru, a Northeast ground fisherman; Wilma Anderson, executive director of the Texas Shrimp Association; John Magnuson, University of Wisconsin; and many others.

For more information, call Ben Sherman at Sea Grant's national media relations office (301) 405-6381.



Oyster Wars, *continued*

longer the case. In the last several years, says Roger Mann, "we have made quantum leaps in some areas of understanding." One reason for these rapid advances has been a Congressionally funded program of research on oyster disease that has made consistent support possible on numbers of fronts, from molecular studies on the interaction between protozoans and the oyster immune system, to development of sophisticated techniques for monitoring the presence of Dermo and attempts at breeding strains of oysters that may eventually be able to resist the attacks of Dermo and MSX.

Once the Chesapeake's most lucrative fishery, the oyster has fallen on hard times. Maryland's 1994-95 harvest of some 162,000 bushels represents a fraction — about 14% — of the harvests of only a decade ago.

The Cellular Front

Scientists have long known that hemocytes, cells in the oyster's circulating fluid, play a major role in fending off invaders. Analogous to the human body's white blood cells, though far less sophisticated, hemocytes are the oyster's first line of defense: in general, when a microbe invades, the hemocyte binds, then surrounds the attacker, and engulfs it in a process called phagocytosis. The cells release bursts of toxic compounds, specifically reactive oxygen intermediates (ROIs) such as hydrogen peroxide, says Robert Anderson of the University of Maryland's Center for Environmental and Estuarine Studies (CEES). When Anderson exposes these hemocytes to Dermo, however, the hemocytes engulf the parasite but he doesn't see the ROIs. The question, of course, is why not? Dermo may survive for a number of reasons, says Anderson. The parasite may prevent oyster hemocytes from triggering the ROIs, it may for some reason be able to withstand them, or it may produce substances that are toxic to hemocyte cells.

New molecular tools have been making it possible for Anderson and other scientists to better examine the chemical weaponry that both oysters and protozoans deploy. For example, using molecular probes and chemiluminescent analysis to detect and quantify ROI production, Anderson no longer depends on counting cells through a microscope. "You could go blind," he says. "These new methodologies give you a chance to count three million cells, not 300."

Many of these studies depend on large amounts of Dermo. Thanks to recent breakthroughs, scientists now have that advantage. The ability to grow Dermo in continuous culture in the lab resulted from a near-simultaneous discovery two years ago by Mohamed Faisal and Jerome F. La Peyre at VIMS, Sharon Shrunk and Stephen Kleinschuster at Rutgers University, and Gerardo R. Vasta and Julie D. Gauthier at the University of Maryland System's Center of Marine Biotechnology (COMB).

> ***We have made quantum leaps in our understanding***

Before having that capability, it was difficult to obtain Dermo in pure form. Moreover, says Anderson, you could not get enough of it. "Now you can make it by the bucketful — it's duck soup." Growing Dermo in petri dishes makes it possible to study its life cycle and how different environmental conditions — for instance, salinity, temperature, heavy metals, chemicals — affect its growth and behavior.

"Culturing the Dermo cell," says Chris Dungen, a research scientist at the Oxford Cooperative Lab, "was a breakthrough whose major benefits we have yet to realize." Two paths of investigation, one in Gerardo Vasta's lab at COMB and another in Mohamed Faisal's lab at VIMS, have been revealing molecular armaments by Dermo that are especially provocative, though the work is in early stages of investigation.

Mohamed Faisal and Jerome La Peyre are tracking enzymes that Dermo releases when it attacks an oyster cell. Called proteases, these enzymes break down oyster tissue and likely contribute to the oyster's demise. The researchers found that Dermo can grow and divide in hemocytes of infected oysters, suggesting, Faisal says, that "factors other than hemocytes may be important in resistance."

While they have observed the presence of Dermo in the Pacific oyster (*Crassostrea gigas*), that oyster appears more resistant than the Eastern oyster (*Crassostrea virginica*). Faisal is focusing on the possible presence of special inhibitors in the Pacific oyster. If he can identify these, he could potentially develop "pro-

tease blockers" that would act something like antibiotics in fighting the parasite.

Still another molecular battle may be taking place over iron.

Iron is critical for growth, both to parasites like Dermo and host organisms like oysters. Because iron is generally much less available than other metabolic needs, competition for iron between the parasite and the host cell is intense, says Gerardo Vasta. Vertebrates have developed strategies against malaria, Vasta points out, by producing iron-binding proteins to reduce the levels of iron available to malarial parasites — "this slows the parasite's growth rate and reduces the pathogenicity of the infection." Recent studies in his lab, he says, "indicate that Dermo has a strong requirement for soluble iron and its growth rates are correlated with iron availability."

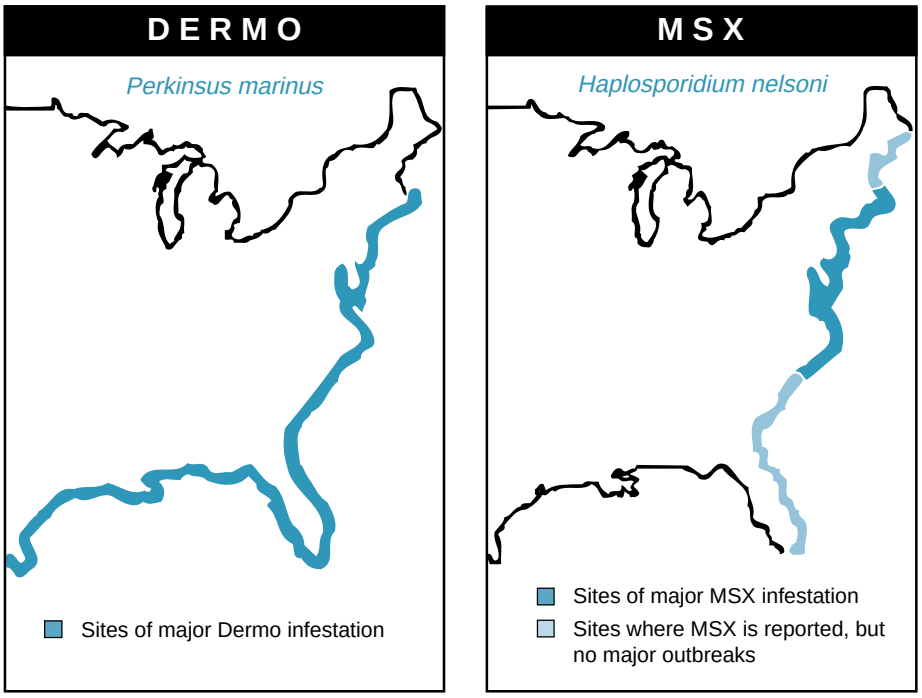
Environmental factors in the Chesapeake may increase the availability of iron. For example, low concentrations of oxygen — or its complete absence (anoxia) — occur in the Chesapeake Bay during summer months and trigger chemical reactions in the sediments that release iron into the water. "This may help explain," says Vasta, "why Dermo is more prevalent during the summer months in oysters that are located in low dissolved oxygen estuaries like the Bay."

Vasta speculates that "excessive iron accumulation in the oyster in summer promotes proliferation of Dermo, which may inhibit the oyster from producing the oxygen compounds it needs to defend itself. By better understanding environmental factors such as iron, it may be possible, he says, "to design strategies for blocking their proliferation."

Both of these investigations, while they hold promise of practical applications, suggest the complexity of uncovering interrelationships between parasitic disease and the oyster immune system. There are other complicating factors. For example, Robert Anderson and Eugene Burreson have shown in lab studies how a pollutant such as tributyltin, a bottom paint for protecting boat hulls, upped the susceptibility of oysters to Dermo. Fu-Lin Chu, also at VIMS, has done comparable studies with polyaromatic hydrocarbons (PAHs), which, once released from the combustion of fossil fuels, gather in Bay sediments.

The interrelated effects of multiple pollutants and the environment remain a complex and tangled web.

While resource managers await the results of such work in the Chesapeake Bay, the Oyster Disease Research Program has already laid the groundwork for addressing problems in other parts of the country, according to Jim McVey, National Sea Grant Program Director for Aquaculture. "The techniques we have developed for studying Dermo and MSX are being employed to study as yet unidentified microbial diseases that have had severe impacts on oysters in other regions, juvenile oyster disease in the northeast, and summer mortality in Pacific oysters in the northwest."



Often inadvertently spread from place to place, oyster diseases have plagued stocks of the popular mollusc through this country and abroad, and have largely ravaged the famed Chesapeake oyster grounds. Maps reprinted courtesy of Susan Ford, Rutgers University.

Breeding for Disease Resistance

"The most important thing we're doing that could make a difference in the relatively near term is a cross breeding program," says Stan Allen of Rutgers University's Haskins Shellfish Laboratory on Delaware Bay. For some years, Hal Haskins and Sue Ford, also at Rutgers, have employed traditional genetic breeding techniques to rear strains of oysters in Delaware Bay that are able to resist the devastating impact of MSX. It is these MSX-resistant stocks, says Allen, which have also gone through one-and-a-half years of Dermo exposure, that will be used in a region-wide planting effort to select for broodstock oysters resistant to MSX and Dermo.

Working with Ken Paynter of the University of Maryland College Park and Don Meritt, Maryland Sea Grant Shellfish Specialist and CEES scientist, and with Eugene Burreson and Mark Luckenback of VIMS, these researchers are deploying the specially bred oysters in floating trays in the Choptank River on the Eastern Shore

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Oyster Wars, *continued*

of Maryland and in Mobjack Bay, Virginia, and comparing their growth and resistance to disease with local oysters. Surviving oysters will then be sent to the shellfish lab for breeding. "We'll at least get a first read-out on survival," says Allen. "If successful, we'll go from there."

While Dermo did not appear in strength in the upper Bay until the late 1980s, it has been an inhabitant of the Gulf of Mexico and other southern waters since about 1950, and was spotted in the Chesapeake as early as 1954. Because southern strains of oysters have been subjected to Dermo constantly for so long, these oysters may have developed natural immunities that Bay stocks, which are terribly susceptible, do not have. "The basic assumption," says Paynter, "is that geographically separated oyster populations behave differently with regard to *Perkinsus*. Some are simply less susceptible."

We now know that parasite abundance is greatest in June, with lower peaks throughout the summer

To test that assumption, Paynter is working with Don Meritt and Pat Gaffney from the University of Delaware to try to identify those populations that are less susceptible to Dermo and disease progression. Using southern oysters from Texas, Louisiana and Florida and strains from the Carolinas and Delaware Bay, they are placing oysters in floating trays at different sites in the Bay, to begin with, in the Wye River, Choptank River and Mobjack Bay. "Our hope," says Paynter, "is to identify populations that are less susceptible to Dermo and disease progression." Pat Gaffney is doing DNA analysis. "If we do find differences," says Paynter, "then we may have a genetic marker to identify resistance."

As one scientist said, it has taken more than a century to deplete the Chesapeake Bay — it will take considerably more than a few years to try to replenish it.

What's Ahead

Until the Oyster Disease Research Program, research support on oyster disease had been spotty, largely because funding support had been spotty. It waxed and waned like MSX, which first showed up in 1957 ravaging oyster beds throughout Virginia, moved up into Maryland, then retreated. Only over the last decade have Dermo and MSX dug in for what seems like the long haul. "These diseases are not going away," says Eugene Burreson.

It is this near-elimination of the oyster fishery that moved Congress to fund the Oyster Disease Research Program. Most scientists and managers agree that in five years it has been a critical factor in spurring rapid progress, not only in expanding our understanding of oyster-parasite interactions and in developing molecular tools to better study such interactions, but also in less heralded advances. "For example," says Steve Jordan, director of the Oxford Cooperative Research Laboratory, a State of Maryland and National Marine Fisheries Service lab, "we now know that Dermo abundance is greatest in the Chesapeake in June, with lower peaks throughout the summer. This is totally new information." Such knowledge could be important for raising and planting seed oysters. "We may be able to develop strategies for better determining where and when we move seed oysters for planting," he says.

While Stan Allen tempers his enthusiasm because practical applications of research may seem slow in coming, the coordinated oyster disease effort, he believes, has been important in many practical and subtle ways. "Everyone is using the Dermo culture now as the way to deal with handling practices," he says. "There is a unity that has been brought about by the funding source — it represents a core of people who have to function together because the funding and the region are small. It will make a difference," Allen says. "We hope it will make a practical difference." ■

On Another Front: Juvenile Oyster Disease

As if MSX and Dermo were not enough, an apparently unrelated die-off of young oysters begin hitting New England in the late 1980s. Known simply as "juvenile oyster disease," this latest threat adds another culprit to the list of oyster killers.

The disease appears to hit hatchery-reared oysters more than those in the wild, according to Steve Jordan, director of the Cooperative Oxford Laboratory. "It's possible that the die-offs are caused by stress," he says, from overcrowding in an aquaculture facility, for example — but he doesn't think that's it.

"Research has now shown that the disease is transmissible," he says. "We also know that higher salinities cause expression of the disease." According to Jordan, "Everything bears the earmark of an opportunistic infection."

"There has been some research that suggests the involvement of *Vibrio* species," says Jordan, "but so far that work is still inconclusive."

Other work, undertaken by researchers like Eugene Small at the University of Maryland College Park, suggests that this juvenile oyster disease may be caused by a protozoan parasite, probably a ciliate of the family *Ciliaphora*. The College Park research team is currently examining oysters to determine the presence of suspect microorganisms.

"We recommend that oyster growers work with survivors from stocks that have already been exposed," says Jordan. These survivors have the best chance of having developed resistance to the disease, he says.

The Frank M. Flower and Sons oyster company on Long Island, hard hit by the disease, is cooperating closely with the University of Maryland, the Oxford Lab and others. The approach of using resistant strains seems to be working for the Flower oyster growers, with production once again returning to high levels. This is promising, since at one point the disease was cutting oyster production in some parts of the region by as much as 50 to 90 percent.

Bay Commission Asks: Are Blue Crab Stocks Stressed?

Legislators of the tri-state Chesapeake Bay Commission heard a cautionary report on the famed Chesapeake blue crab at their most recent meeting, held May 5, in Piney Point, Maryland. University of Maryland researcher Brian Rothschild told the tri-state body of legislators that while the ongoing Baywide crab survey showed a series of rises and falls, the 1994 data indicated a low harvest, relative to the number of people fishing for crabs.

According to Rothschild, in 1994 the blue crab fishing effort was greater than ever, while the catch remained flat. Rothschild pointed out that figures were tentative, since harvest statistics are still being calculated for the Virginia fishery. In Maryland, the 1994 harvest took a strong dive from the very good landings of 1993.

Resource managers often measure catch against effort, with the expectation that more effort should result in higher catches. If, however, stocks are being fished at capacity, additional effort will yield little additional catch. Such appears to be the case for the Chesapeake blue crab in 1994, though researchers and resource managers alike caution against drawing conclusions based on survey results gathered for less than a decade.

Rothschild and others have been undertaking extensive monitoring of the Chesapeake blue crab stocks since 1991, working with funds from the National Oceanic and Atmospheric Administration (NOAA) and others. The Maryland Department of Natural Resources monitors the upper Bay; the University of Maryland Center for Environmental and Estuarine Studies (CEES) monitors the middle Bay; and the Virginia Institute of Marine Science (VIMS) monitors the southern Bay.

Monitoring takes place each winter, when crabs are bedded down in the mud and remain relatively stationary. To sample the bottom, researchers use a metal dredge like the one used in Virginia for winter harvesting of crabs. (See *Marine Notes*, February-March 1994.) Rothschild noted that the survey gives resource managers data that are independent of harvest statistics (which are affected by variables in fishing effort and success rates).

W. Pete Jensen, head of Tidewater Fisheries for the Maryland Department of Natural Resources, reported that Maryland had established a Blue Crab Steering Committee, and that the state was keeping a close eye on the winter crab survey, the crab harvest and other key indicators. Crabbers, he said, are now required to keep a daily log of their catch, which they turn in each month. "Our thinking is this," said Jensen, "we want to react before there is a crisis." Waiting until a commercial species drops below critical levels before acting, he said, ultimately costs everyone much more in social and economic impacts.

Jensen said that he is aware of the ripples created by potential management decisions. "Even discussing additional controls on the crab harvest can cause concern," he said. He described telephone calls from seafood distributors asking whether or not they should be planning to take their businesses elsewhere, if the Chesapeake's blue crab harvest should fall. For now, Jensen said, Maryland is remaining quite cautious about the future. Jack Travelstead, head of the Virginia Marine Resources Commission's Fisheries Management Division, echoed Jensen's concern, and said that his agency had a great deal of confidence in the Baywide winter crab survey now in place.

At the end of the session, Jensen announced to the Commission that Dr. Brian Rothschild, the University of Maryland researcher who has helped with much of the stock assessment work for blue crabs and other species, would be leaving Maryland. Dr. Rothschild, who has accepted a position with the University of Massachusetts, as director of the Center of Marine Science, Environment and Technology, has served as a faculty member and researcher at the CEES Chesapeake Biological Laboratory since 1980.

Crabs are big business in the Bay — annual harvests of some 100 million pounds bring about $186 million to Maryland and Virginia. As effort increases, resource managers worry about fishing pressure, especially on female crabs, which are now increasingly making it to market alongside male crabs, or "Jimmies."

Bay Trust on the Web

The Chesapeake Bay Trust now has a web address for those interested in grant opportunities, deadlines and other information, including application forms. Located in Annapolis, Maryland, the Bay Trust is funded by the purchase of Bay license plates, a special state income tax check-off and private donations. The Trust, celebrating its tenth anniversary this summer, has raised some $12 million since its inception, funding more than 1,500 Bay-related projects.

The Bay Trust's new internet address is: http://www2.ari.net/home/cbt. For more information, call Thom Burden (410) 974-2941 or use e-mail: cbt@ari.net.

Alliance Announces Watershed Watch

The Alliance for the Chesapeake Bay has launched "Watershed Watch," a new information service aimed at giving communities the resources to initiate their own efforts to help protect and restore the Chesapeake watershed. Watershed Watch includes an 800 telephone number, upstream field trips, assistance in learning about tributary strategies, contact lists of key people and agencies, homeowner education materials, speaker lists and other information. To learn more about Watershed Watch call the Alliance at (410) 377-6270.

World Aquaculture Society

Libraries and others interested in obtaining the latest aquaculture information from the World Aquaculture Society can contact the WAS home office for a list of special prices and offers for such publications as: the *Journal of the World Aquaculture Society;* the quarterly magazine, *World Aquaculture*; and the book series, *Advances in World Aquaculture*. Call Juliette L. Massey (504) 388-3493.

Protecting Maryland's Coast

Maryland's coastal bays will become part of the National Estuary Program, clearing the way for a comprehensive plan to protect and manage these important natural resources. Maryland Secretary of the Environment, Jane Nishida, and Secretary of the Department of Natural Resources, John Griffin, joined other federal, state and local officials to announce EPA's approval of Chincoteague, Sinepuxent and Assawoman Bays into the national program.

According to MDE, Maryland's coastal bays provide approximately 25% of the state's total seafood landings, and tourist spending there accounts for more than $2 billion annually. For more information, call Quentin Banks (410) 631-3003.

Striped Bass Research Study

Incorporating information available up through April 1994, the *Striped Bass Research Study Report for 1993* details monitoring studies, gives a status report on the fishery and summarizes management activities. The report covers all four major anadromous stocks of striped bass along the Atlantic coast, specifically those spawning in the Roanoke River (North Carolina), the Chesapeake Bay (Maryland and Virginia), the Delaware River and the Hudson River (New York).

The report gives a nod to research on acid rain, habitat degradation and other problems, but cites overfishing as the primary cause of the decline of striped bass. For more information, contact the U.S. Fish and Wildlife Service (FWS) at (410) 573-4500. The report was prepared by the FWS, the National Marine Fisheries Service (NOAA), the National Biological Service and the Atlantic States Marine Fisheries Commission.

Fishing for a Future on TV

Fishing for a Future, the 30-minute video written and directed by Michael W. Fincham and produced by the Maryland Sea Grant College in cooperation with the National Oceanic and Atmospheric Administration, will air on Maryland Public Television (Channel 22) on August 23 at 7:30 PM. According to MPTV, *Fishing* will immediately precede *Maryland State of Mind*, the series hosted by Scott Simon that highlights research and education underway throughout the University of Maryland System. *Fishing for a Future*, which documents a new catch-and-release ethic, won a CINE Golden Eagle Award this spring, the third such award garnered by Fincham for his work in film and video.

Catch-and-release can help save our fish populations — if done properly. That's the message of two videos available from NOAA and Maryland Sea Grant, Fishing for a Future *and* Keeping Score. *For a price list for these and other Sea Grant videos call (301) 405-6376.*

Conferences, Etc.

Environmental Finance Conference

The Second Annual Mid-Atlantic Conference on Environmental Finance will be held on the College Park campus on September 13-14. Like last year's conference, panels and presentations will focus on the challenge of funding environmental projects in an era of tight money and demanding environmental problems, such as the control of nonpoint-source pollution. Unlike last year, this year's conference will be available to attendees at the University of New Mexico, and the University of Tennessee, as part of a satellite uplink designed and directed by the University of Maryland School of Public Affairs.

The Conference is sponsored by the University of Maryland's Environmental Finance Center (EFC), part of an expanding network of universities focusing on the issue of environmental finance, an effort supported by the U.S. Environmental Protection Agency (EPA). The EPA's Office of Resource Management is cooperating with five EPA regional offices around the country to mount this educational and assistance program. For more information, call Elizabeth Hickey, EFC Coordinator (410) 405-6383. The Maryland EFC is hosted by the Coastal and Environmental Policy Program at the Maryland Sea Grant College.

Head for the Mountains

As the leaves begin to fall, the Mid-Atlantic Highlands Coordinating Council will hold a conference at the Canaan Valley Resort and Conference Center in Davis, West Virginia, October 24-26. The Council, newly formed this past May, is dedicated to the sustainability of the Mid-Atlantic Highlands, an area that includes the Appalachian Mountains and parts of Pennsylvania, Maryland, West Virginia and Virginia.

The conference will explore the history of the Mid-Atlantic Highlands and its current ecological and economic condition, examine case studies and offer field trips to nearby resource and restoration projects. For more information, call Ron Preston, U.S. EPA, (304) 234-0245.

Submerged Lands Conference

The 14th annual Submerged Lands Management Conference will take place in Annapolis, Maryland September 24-28, 1995. Covering a wide range of topics, the conference will include sessions on the Chesapeake Bay and Critical Area Program, the Great Lakes, the Gulf of Mexico, Long Island Sound and other areas.

Specific topics will include casino gambling on public waters, harbor issues — including a focus on Baltimore Harbor's "renaissance" — the management of declining fish and shellfish stocks, aquaculture, submarine archeology, submerged lands management and other issues. For more information, write the Maryland Board of Public Works, P.O. Box 1510, Annapolis, MD 21404-1510.

Gartlan Addresses Land Managers

Virginia State Senator Joseph Gartlan, who has a long history of involvement in Bay watershed land issues, will address the conference of Northern Virginia Land Managers in Prince William County on August 2. The conference is open to the public for a $10 fee and will cover a range of land use issues, including commercial waste disposal, wastewater treatment, wetlands planning, urban forestry and other topics. For registration information, call the Virginia Cooperative Extension Service in Prince William County (703) 792-6285.

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Maryland Marine Notes
Maryland Sea Grant College
0112 Skinner Hall
University of Maryland
College Park, Maryland 20742
phone (301) 405-6376
fax (301) 314-9581
e-mail: mdsg@mbimail.umd.edu
web: http://www.mdsg.umd.edu

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End Notes

Noteworthy

■ **Life of the Lakes** Michigan Sea Grant's *The Life of the Lakes: The Great Lakes Fishery*, a package of educational materials about the world's greatest freshwater fishery, recently received two national awards. The 55-minute broadcast-quality video component was named Best Environmental Film of 1994 in the 32nd annual Michigan Outdoor Writers Association's National Outdoor Travel Film Festival. The Teddy Award is named for former U.S. President Theodore "Teddy" Roosevelt, long associated with American conservation.

In addition, Agricultural Communicators in Education (ACE) has awarded the entire *Life of the Lakes* package a silver certificate in the educational materials category of its national critique and awards competition. ACE is the professional association of communicators who work in universities for agriculture and natural resources departments and colleges.

Produced by Michigan Sea Grant in cooperation with Outreach Communications at Michigan State University (MSU), the video program has been broadcast by more than 30 Public Broadcasting System affiliates nationwide. The video is the centerpiece of a package of educational materials produced in collaboration with the MSU Department of Fisheries and Wildlife. The package includes a brochure with background information on the Great Lakes fishery; a curriculum guide to Great Lakes fishery educational materials; and a set of six posters, one for each of the lakes and one for the Great Lakes Basin.

The complete package costs $40. (Individual components can also be purchased. Canadian orders add 15% for postage and handling. Orders under $100 must be prepaid.) Order from Michigan Sea Grant Extension, 334 Natural Resources Building, MSU, East Lansing, MI 48824-1222, phone (517) 353-9723.

■ **Sea Grant Director Wins Pew Award** Judith McDowell, Sea Grant Director at the Woods Hole Oceanographic Institution, has been awarded a 1995 Pew Conservation Scholars Award. Pew Scholars receive $150,000 over a three-year period to support their work in environmental science, with a focus on biological diversity. McDowell, who received her Ph.D. from the University of New Hampshire in 1974, plans to use her award to examine the interactive effects of natural and anthropogenic stressors, such as toxic chemical contaminants, on coastal shellfish populations. She hopes to gain new insights into the adaptive mechanisms by which coastal shellfish cope with multiple stressors in their environment and to use those insights to develop management strategies for contaminated shellfish stocks.

Publications, Etc.

■ **A Look at Lightning** Lightning strikes abound during the summer and increase as one heads down the Atlantic coast to Florida. Florida Sea Grant has produced both a 24-page booklet ($2) and a video ($15) detailing the threat of lightning to sailboats and steps one should take to minimize the risk of damage caused by lightning strikes. Write Florida Sea Grant, University of Florida, P. O. Box 110409, Gainesville, FL 32611. (Make checks payable to the University of Florida.)

■ **Global Biotechnology** A new publication details the expansion of marine biotechnology in several industrialized nations. *The Global Challenge of Marine Biotechnology*, 372 pp., by Ray Zilinskas, Rita Colwell, Doug Lipton and Russell Hill, is available from Maryland Sea Grant for $24.95. To order call (301) 405-6376.

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