MARYLAND

Research, Education, Outreach *Volume 17, Number 4*

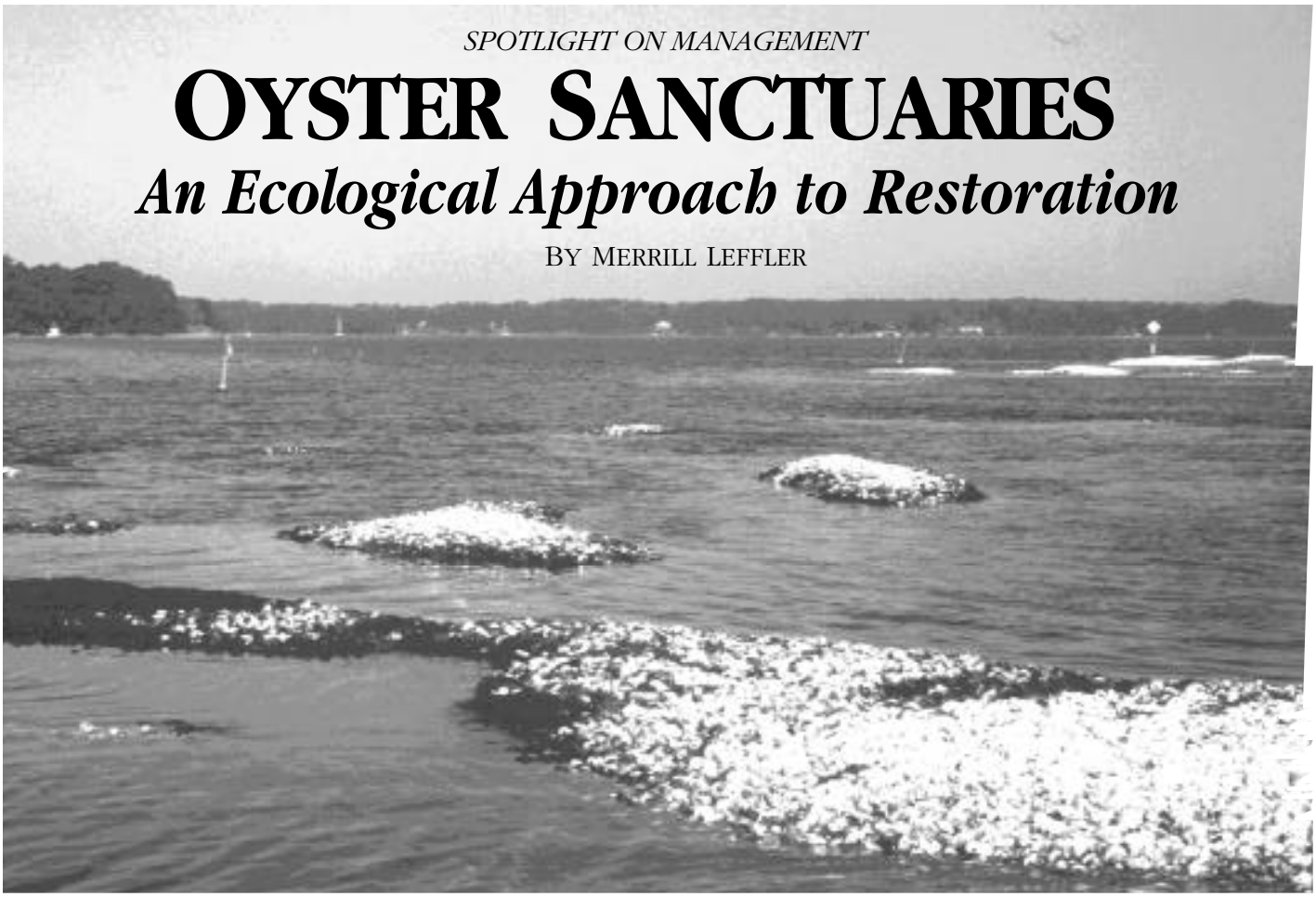
MARINE NOTES

SPOTLIGHT ON MANAGEMENT

OYSTER SANCTUARIES

An Ecological Approach to Restoration

BY MERRILL LEFFLER



A scientific consensus calls for a new concept of oyster management, one that recognizes the vital ecological function of oyster reefs for the health of the Bay.

Once the Chesapeake Bay teemed with oysters — oysters so large and plentiful that early visitors returned to the Old World astonished by what they had seen. In the words of Francis Louis Michel, after a visit to the Bay in 1701, "The abundance of oysters is incredible. There are whole banks of them so that the ships must avoid them. They surpass those in England by far in size, indeed they are four times as large."

By the end of the nineteenth century, those "banks" of oysters had fallen to the iron teeth of oyster dredges, many pulled by large schooners come down from New England to harvest the Chesapeake's "white gold." Scientists and others who had witnessed the destruction of the Bay's oyster reefs began to warn that without more careful management, oyster populations and the fishery they support were headed for ruin.

As early as 1891, John Hopkins biologist William K. Brooks blamed what he saw as the coming failure of Maryland's oyster fishery on "improvidence and mismanagement and blind confidence." Brooks, one of the "few greatest of American zoologists" according to an article in *Science* magazine in 1908, ex-

Sanctuaries, continued

pressed anger and dismay, arguing that soon there would be no oysters left "to replenish the beds."

The failure of the Bay's oyster fishery has taken longer than Brooks, and those scientists who followed, expected — a tribute perhaps to the oyster's resilience and fecundity. Nevertheless, failure it has been. Harvests — one measure of the state of the oyster — are today less than 20 percent of what they were twenty years ago and only a few percent of what they were at the beginning of the century.

It is against this backdrop that scientists in Maryland and Virginia have released a scientific consensus, under the auspices of the Chesapeake Research Consortium (CRC), setting out specific actions that could guide long-term restoration of oyster populations to the Bay.

The consensus calls for a new concept of oyster management, one that recognizes the vital ecological function of oysters and oyster reefs for the health of the Bay. By constructing substantial reef habitats and properly managing them, the scientists contend, there is a better chance to develop a sustainable oyster fishery, one that does not depend on public subsidies to keep it going.

At the heart of the consensus, which grew out of a recent meeting in Wachapreague, Virginia, is the recommendation to reestablish oyster reefs that are high above the bottom — living structures that are natural to the Bay ecosystem but have been nearly eliminated. These reefs must be protected in sanctuaries, the scientists say, off-limits to harvesting.

Because adult oysters release eggs and sperm directly into the water, depending on chance contact for fertilization, the proximity of adults is crucial to the success of new larvae. The billions of eggs and sperm released from large oyster reefs are likely to lead to much higher percentages of fertilized young than eggs and sperm released on small reefs or from oysters that are scattered along the bottom, as is the case in many areas of the Bay.

"I think this is a breakout opportunity for getting oyster management on a science-based track."

Restored reefs, high above the bottom and exempt from harvesting, would be continual sources of larvae says Eugene Burreson, chair of the CRC scientific consensus group and Director of Research and Advisory Services at the Virginia Institute of Marine Science (VIMS). The free-swimming larvae would likely ripple out into non-sanctuary habitats where they would set on shell and, once grown, could then be harvested. In this way, adds Victor Kennedy, a biologist at the University of Maryland Center for Environmental Science (UMCES), it is conceivable that enough protected reefs could eventually invigorate the commercial fishery by becoming a sustainable provider of seed oysters.

Science & Oyster Management

Historically, oyster policy and management in Maryland and Virginia has focused on one goal, the support of the commercial oyster fishery. Even Brooks based his arguments for conservation in economic terms. In claiming that "our method of managing the oyster industry has been a failure," he wrote that "it has yielded on the average some ten million bushels of oysters annually from grounds which are capable of yielding five hundred million bushels each year."

The argument for restoration no longer rests on the commercial fishery alone.

In the last ten years, we have begun to appreciate the significant role oysters play in filtering algae from the water — in so doing, they remove nutrients and help improve water quality. A paper by UMCES scientist Roger Newell in 1987 made the dramatic point that oyster populations at the beginning of the century could have filtered the entire Chesapeake in several days, while the populations remaining at the end of the 20th century would take more than a year. Only more recently, however, have we begun to appreciate the *extent* to which healthy oyster reefs are critical habitat — not only for oysters but for the myriad of other organisms that healthy populations of crabs and fish depend on.

It is for such reasons that the scientists who met in Wachapreague argue that "restoration must not be to manage oysters just to support a fishery, but they must be restored and managed for their ecological value, in such a way that a sustainable fishery can exist."

In a recent study of the history of oyster management, Johns Hopkins researcher Christine Keiner concluded, "The involvement of Brooks and other researchers in the Maryland oyster culture debate illustrates the weak role of scientific authority in influencing public policy making." Active engagement in trying to influence policy, she writes, "was thwarted by grassroots resource-use groups, primarily Chesapeake oystermen."

Are today's scientists anymore likely to be successful than they have been over the last hundred years?

Some are skeptical. One says privately that state management equates the public fishery as belonging to watermen — but notes that the rest of us are the public as well.

Don Boesch, UMCES President, is actively optimistic. "I think this is a breakout opportunity for getting oyster management on a science-based track," he says. "While I may be an

eternal optimist, there are key differences between former times and now."

To begin with, says Boesch, there is the depressed state of oyster populations in the Bay — they are at all-time lows and at the mercy of parasitic diseases, MSX and Dermo in particular. While oysters have had improved survival in these last few years, that survival appears to be the result of "wet" seasons, heavy spring and summer precipitation which has kept water salinity low and disease pressure low as well. This year's drought conditions and high salinities, many scientists predict, are likely to favor disease, bringing more dead and dying oysters.

But a second key phenomenon, Boesch points out, could have surprising political influence on the way that both Maryland and Virginia manage oysters. That phenomenon is the expanding number of oyster gardeners, more than a thousand citizens as well as school age children, who have been participating in programs to grow oysters in floating racks for restoration efforts. Organized by VIMS in Virginia and the Chesapeake Bay Foundation in cooperation with Maryland Sea Grant Extension and UMCES in Maryland, oyster gardening is not merely teaching citizens to grow oysters but is educating them about the importance of oysters and oyster reefs as critical habitat.

There is a third reason for the potential influence of this scientific consensus. The impetus for the consensus itself came from a meeting that Bay scientists had with the secretaries of Natural Resources in Maryland and Virginia. "Typically, management agencies in Maryland and Virginia go about their efforts separately," says Eugene Burreson. He felt that scientists should be able to come up with Bay-wide goals and strategies, "and that we could reach a consensus on what should be done based on scientific data and principles." If we could do that, Burreson says, "then we could go to the managers with our consensus." Virginia Natural Resources head John Paul Woodley, Jr., and former Maryland DNR head John Griffin agreed.

The success of oyster reefs ecologically and for the fishery will depend on locating large reefs in protected sanctuaries.

Reefs Are Essential Habitat

That left to their own devices, oysters will form large reefs should come as no surprise. It is well-known from Colonial writing that oyster "rocks" were often hazards to navigation, though early on harvesting began reducing the height of reefs. Some have argued that, initially, harvesting helped to increase natural production by spreading oysters more widely; if so, advantage slowly turned to disadvantage as land runoff increased — the consequence of clearing forests for agriculture — and over the years began to smother many of the decimated reefs.

In the last twenty years, parasitic disease, MSX and Dermo especially, have wreaked havoc on Bay oysters, killing many before they reach harvestable size (see www.mdsg.umd.edu/oysters/ for more on the history of oyster disease). But the success of disease may, to some extent, be a consequence of resource management practices. For example, state programs for moving oysters from seed grounds onto other public grounds each year have inadvertently spread infected oysters throughout the Chesapeake. Furthermore, harvesting itself removes oysters that have survived disease pressure — therefore removing as well their inherent resistance and the resistance they might pass on to their progeny.

In a scathing conclusion to *The Precarious State of the Chesapeake Public Oyster Resource*, William Hargis and Dexter Haven, both of whom are Emeritus Professors of Marine Science at VIMS, write, "the principal causes of the long-term decline in Chesapeake Bay oyster populations on the public grounds are neither disease nor pollution but persistent overharvesting and its consequent impact on broodstock size and composition, negative genetic impact, and associated habitat destruction."

From the perspective of traditional management of the public oyster grounds in the Chesapeake, the call by scientists for permanent reef sanctuaries on public grounds that have historically received natural spat set (the settlement of free-swimming larval oysters) is probably the most radical. These reefs must rise "substantially" from the seafloor, the scientists say, to at least one-half the water depth. While shell may be planted around these reefs to enhance the setting of new oysters, perhaps for future harvest, the reefs themselves must be off-limits to commercial harvest, they say.

The success of oyster reefs ecologically and for the fishery will depend on locating large reefs in protected sanctuaries. They will provide enhanced habitats and, in the long term, more oysters. There is scientific and field evidence to support their claims.

In an extensive review of research on the role of oyster reefs as habitat, Loren Coen of the South Carolina Department of Natural Resources, Mark Luckenback of VIMS and Denise Breitburg of the Academy of Natural Sciences Estuarine Research Center conclude that the construction of reefs that provide "adequate vertical relief" and "the establishment of broodstock sanctuaries protected from harvesting pressure are important for restoring oyster populations."

James Wesson, Chief of the Conservation and Replenishment Division

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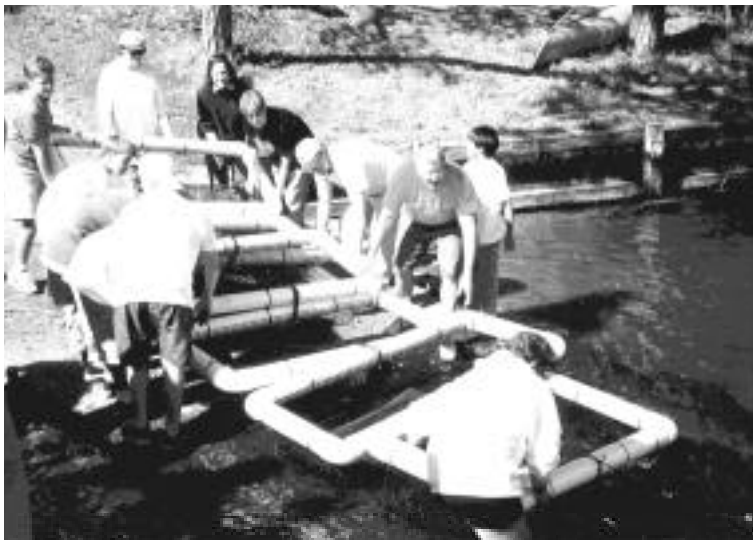
Oyster Gardening in Chesapeake Bay

BY MERRILL LEFFLER

Oyster gardening has been taking hold in the Chesapeake Bay. Along the shores of the Bay's rivers and tidal flats in Maryland and Virginia, citizens of all ages are raising oysters, not to eat, but for the restoration of oyster reefs and habitat. Spearheaded in Virginia by the Virginia Institute of Marine Science and in Maryland by the Chesapeake Bay Foundation and the University of Maryland, the oyster gardening program has been growing rapidly, says CBF's Bill Goldsborough.



Chesapeake Bay Foundation

"We have more than 300 gardener families so far in Maryland and about 40 classes with some 1,200 students."

In 1997, the Foundation joined with the Maryland Sea Grant Extension Program (MSGEP), the University of Maryland Center for Environmental Science (UMCES) and the Oyster Recovery Partnership to form The Oyster Alliance, which has embarked on an extensive program of educating citizen-gardeners. "We have more than 300 gardener families so far in Maryland and about 40 classes with some 1,200 students," Goldsborough says. "We haven't stopped growing."

The Alliance offers training forums for gardeners that range from the construction of "Taylor floats" for growing oysters to techniques for ensuring the most efficient growth, says Don Webster, Sea Grant Extension Agent. The forums are also a way for gardeners to keep in touch with new methods for rearing oysters and research advances that might have applicability to their efforts.

In a program this winter, for example, Dr. Standish Allen of the Virginia Institute of Marine Science briefed participants on a breeding program to cultivate oysters that are better able to resist both MSX and Dermo, the two diseases that have devastated Bay oyster populations for more than a decade. These CROSBreed (Cooperative Regional Oyster Selective Breeding) oysters are currently being monitored by scientists in the mid-Atlantic region for disease resistance in various locations — the researchers hope that spat from the specially-bred oysters will eventually be available for oyster gardeners.

Don Meritt, Sea Grant Extension Shellfish Specialist at the UMCES Horn Point Laboratory, has been producing seed oysters in hatchery tanks for the gardening program. And the Oyster Recovery Partnership has recruited volunteers to do the labor-intensive work involved in moving millions of oyster spat. "A non-profit organization, the Partnership has a single mission," says Executive Director Mary Jo Garreis, "of helping to restore Maryland's oyster resources for ecological and economic revitalization."

This summer, the Oyster Alliance began a new program to train Master Gardeners. "We're providing them increased education," says Webster, "so they can serve as the point of contact for gardeners and provide on-site assistance in their locales." The two-day workshop included presentations on such topics as basic oyster biology and reef communities, hatchery operations, monitoring equipment and disease. "The Master Oyster Gardener will become the local link in a chain of producers working to rehabilitate oyster reefs," Webster says. "They will also help with data collection for the website Maryland Sea Grant is developing," he says, "which will become our information hub and will be one part of a comprehensive web site on the oyster."

The Oyster Alliance has combined the strengths of different groups who have a common goal, says Webster. "Our efforts are only a beginning. They will help enhance our oyster reefs and in the long run," he adds, "help advance an effective commercial shellfish aquaculture industry."

For more information on the oyster gardening program, contact the Chesapeake Bay Foundation, (410) 268-8816 (www.savethebay.cbf.org). For a printed copy of Oyster Gardening for Restoration & Education, *contact the Maryland Sea Grant College by calling (301) 405-6376 or check the web for an adapted version of the fact sheet as well as related information on oysters (www.mdsg.umd.edu/oysters/).*

Sanctuaries, continued

of the Virginia Marine Resources Commission (VMRC), has overseen the building of 15 reefs since 1993. "The monitoring results have clearly demonstrated the value of the reef structure in ways that should have been obvious in the beginning," he writes in a report to the Virginia General Assembly. Reef structures protect young oysters from predators; oysters also grow faster and spawn more effectively when off the bottom. In comparing spat set for low-lying oyster bottom and for a constructed reef, Wesson found striking differences: 11 spat per meter on the bottom compared with 100 spat per meter on the reef.

The Great Wicomico is a "trap" estuary, Wesson points out, "where many oyster larvae are retained in the river." In 1996, VMRC deployed 2,000 bushels of oysters from Tangier Sound on the newly-constructed reef. In 1997, they found that spat set in the Great Wicomico increased remarkably, up to five miles from the reef. "We surmise," he writes, "that aggregation of these oysters on the reef resulted in much improved fertilization rates."

In Maryland, Kennedy Paynter, a researcher at the UMCES Chesapeake Biological Laboratory and UM College Park, has been working with the state DNR and Army Corps of Engineers in comparing constructed reef habitats with "flat habitats," the more-scattered remains of natural reefs. With 15 sites in the Choptank, Patuxent and Chester rivers, Paynter has not found differences in spat set between the two. However, the Maryland and Virginia reefs are not comparable, Paynter says: the Virginia oyster reefs are large vertical structures in which some of the peaks are exposed at low tide; the Maryland reefs are smaller mounds of oysters. "What we need to do," he says, "is construct reef structures that are more vertical, say 50 percent of water depth, so that in 20 feet of water, for example, the reefs will be 10 feet high."

Even small reefs appear more productive than low-lying shell, however. "What is staggeringly different between the flat habitats and our constructed reefs," says Paynter with evident excitement, "is the vibrant nature of the reefs." Extensive underwater videotaping of both habitats in Maryland waters give dramatic evidence. "The video shows an immense diversity of animals using the small reef habitats, from barnacles and anemones to grass shrimp to perch and crabs. Unlike oysters on the remnants of natural reefs which lie flat on the bottom," Paynter points out, "oysters on the constructed reefs are growing vertically. They look like 8 or 10-inch flower pots sprouting up into the water." Paynter's observations complement studies that Coen, Luckenback and Breitburg summarize in their review article: "oyster reef communities along the Atlantic and Gulf coasts are highly diverse," they write, "and include numerous species rare or absent in adjacent soft-bottom habitats."

Building reefs will be no small undertaking and will take a sizeable commitment by government agencies and the private sector. An idea of the costs can be gleaned from estimates by the Virginia Department of Environmental Quality and VMRC to construct sanctuary reefs as part of the newly-formed Virginia Oyster Heritage Program. The cost for constructing eight one-acre sanctuary reefs in the Rappahannock River — each 8- to 10-feet high and surrounded by 25 acres of 10-inch deep oyster shell — is estimated at $380,000 per site.

The bi-state Chesapeake Bay Aquatic Reef Plan and the Oyster Fishery Management Plan of 1994 called for restoring 5,000 acres of three-dimensional oyster reef habitat by the year 2000. While Maryland and Virginia have gotten started, it is only a beginning — with more than 400,000 acres of public ground in the Chesapeake, there are numbers of questions that need answers. For instance, what are realizable oyster restoration goals over the next decade? What is the potential effect on habitat and fisheries? How many sanctuaries and reefs will it take? What size should they be? How far apart? Because harvests have been so low, there is hardly enough shell to meet the restoration needs — what alternative materials are available?

And yet, while these difficult questions remain, decades of research have accumulated a wealth of information, on potential reef materials, on predation and disease, on growth and reproduction. As Don Boesch and Eugene Burreson say, the time for a strong link between science and management has never been better.

For Further Reading

Chesapeake Bay Oyster Restoration: Consensus of a Meeting of Scientific Experts. 1999. Chesapeake Research Consortium. Produced by Virginia Institute of Marine Science, Gloucester Point, Virginia. Check www.vims.edu/vimsnews, or contact Publications, VIMS, PO Box 1346, Gloucester Point, VA 23062, (804) 684-6565.

Brooks, W.K. 1905. The Oyster: A Popular Summary of a Scientific Study. Johns Hopkins Univ. Press, 1996 [1891, 1905].

Coen, Loren D., Mark Luckenbach and Denise L. Breitburg. 1999. The role of oyster reefs as essential fish habitat: A review of current knowledge and some new perspectives. In Lee R. Benaka, ed. Fish Habitat: Essential Fish Habitat and Rehabilitation. American Fisheries Society, Bethesda, MD.

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*Kennedy, Kennedy S. 1989. The Chesapeake Bay oyster fishery: Traditional management practices in Marine Invertebrate Fisheries: Their Assessment and Management, ed. J.F. Caddy. Wiley, 455-477. (UM-SG-RS-89-03.)

*Kennedy, Victor S. and Linda L. Breisch. 1983. Sixteen Decades of Political Management of the oyster fishery in Maryland's Chesapeake Bay. Journal of Environmental Management 16:153-171. (UM-SG-RS-83-03.)

Luckenback, Mark, Roger Mann and James Esson, editors. In press. Oyster Reef Habitat Restoration: A Synopsis and Synthesis of Approaches. Virginia Institute of Marine Science. Gloucester Point, VA.

**Available from Maryland Sea Grant*

Students Complete Summer Fellowship Program

The eleventh year of Maryland Sea Grant's summer undergraduate research program ended in August, when students presented results of their summer's work at a seminar held at the University of Maryland Center for Environmental Science (UMCES) Chesapeake Biological Laboratory (CBL). Each of the fourteen students were paired with a scientist-advisor, and conducted an independent research project at either CBL, the UMCES Horn Point Laboratory or the Academy of Natural Sciences Environmental Research Center (ANSERC).

The Maryland Sea Grant fellowships are supported by a grant from the National Science Foundation through its Research Experience for Undergraduates (REU) Program. Students, their home colleges, research topics and advisors were:

• **Audrey Barnett** (Millersville University, Pennsylvania). The effect of humic substances on heterotrophic dinoflagellate population growth. Advisor: Dr. Diane Stoecker.

• **Heidi Enslin** (College of St. Elizabeth, New Jersey). Using plants to determine availability of heavy metals in the Anacostia River. Advisor: Dr. Fritz Riedel.

• **Michael Evans** (St. Mary's College, Maryland). Phlyogenetic microbial community analysis by fluorescent in situ hybridization with 16S ribosomal RNA probes. Advisor: Dr. Paul del Giorgio.

• **Elliott Hazen** (Duke University, North Carolina). Ontogenetic, spatial and temporal variability in the diet of the Atlantic croaker, *Micropogonias undulatus*. Advisor: Dr. Ed Houde.

• **Dan Huber** (Duke University, North Carolina). Analysis of environmental conditions facilitating algal blooms of *Aureococcus anophagefferens*. Advisor: Dr. Pat Glibert.

• **Jessica Keister** (Baldwin-Wallace College, Ohio). The effects of nutrient availability on bacterial growth efficiency in aquatic salt marsh ecosystems. Advisor: Dr. Roger Newell.

• **Mike Lameier** (University of South Carolina). Grazing preferences of calanoid copepod *Acartia tonsa* on nauplii and phytoplankton. Advisor: Dr. Mike Roman.

• **Randy Lee** (California State University). Impact of waves on periphyton load on *Zostera marina* leaves in the Chesapeake and Chincoteague Bays. Advisor: Dr. Eva-Maria Koch.

• **Chris Root** (Dartmouth College, New Hampshire). Role of epiphyte loading in reduction of growth rate in *Zostera marina*. Advisor: Dr. Walter Boynton.

• **Aisha Rawlinson** (University of Maryland Eastern Shore). The influence of small-scale turbulence on feeding behavior of ctenophores. Advisor: Dr. Tom Miller.

• **Rhonda Rumsey** (College of Oneonta, New York). Historical trends in the deposition of mercury in the deep sediments of Baltimore Harbor and the Chesapeake Bay. Advisor: Dr. Rob Mason

• **Brandy Smith** (Savannah State University, Georgia). Dynamics of N_2 and CH_4 in Choptank River marsh creeks. Advisor: Dr. Jeff Cornwell.

• **Anna Parker** (Duke University, North Carolina). Effects of suspended sediments on *Acartia tonsa* (Copepoda) egg production. Advisor: Dr. Marie Bundy.

• **Audrey Wise** (Millersville University, Pennsylvania). The effects of zooplankton abundance on the growth rate of *Mnemiopsis leidyi* and *Gobiosoma ginsburgi*. Advisor: Dr. Denise Breitburg.

REU students were selected from 125 applicants nationwide. Maryland Sea Grant will offer the Research Experiences for Undergraduates fellowship program again in 2000. It is open to students who will have completed at least two years of undergraduate work by summer 2000, will be enrolled as undergraduates the following fall, and are U.S. citizens or permanent residents. To receive application materials in January 2000, call (301) 405-6376. For general information on the REU program, check the web at www.mdsg.umd.edu/Education/REU.html.

The Bay's Future

We can imagine the Chesapeake of the past, when John Smith first sailed between the Virginia capes into what he called its "large and pleasant navigable rivers." But as an ongoing restoration effort struggles to balance environmental concerns with the increasing pressure of population growth, can we visualize the future of the Chesapeake?

There are two projects underway to focus on the Chesapeake Bay in the 21st Century. The first is "Chesapeake 2000," an effort to gather input from those who live in the region (through a process called "Listening to the People"), in order to shape the next major Bay agreement, to be signed by the governors of the Bay states and their state and federal partners in June 2000. To learn more about Chesapeake 2000 and "Listen-

ing to the People" visit the web at: www.chesapeakebay.net/C2K/listen.htm

The second effort is "Chesapeake Futures," a project undertaken by the Bay Program's Scientific and Advisory Committee (STAC). In an effort to sharpen our vision of the future, teams of scientists and experts will develop three scenarios leading to and beyond the year 2030. Using data and trend analysis, as well as their collective experience, the scientists will outline likely outcomes if we continue on our present course (Scenario 1), if we work to enforce existing laws and programs (Scenario 2), and if we take more aggressive action to restore the Bay (Scenario 3).

Results from the Chesapeake Futures effort will be communicated directly to Bay Program partners, in advance of the Chesapeake 2000 agreement. To learn more about Chesapeake Futures visit the web at: www.chesapeake.org/futures/

Publications

Science and Uncertainty

A new book titled *Communicating Uncertainty: Media Coverage of New and Controversial Science*, explores the interactions that swirl around scientific uncertainty and its coverage by the mass media. It looks at these issues from three different perspectives — those of communication scholars who have studied uncertainty in a number of ways; those of science journalists who have covered these issues; and those of scientists who have been actively involved in researching uncertain science and talking to reporters about it. In particular, it examines how well the mass media convey to the public the complexities, ambiguities, and controversies that are part of scientific uncertainty.

Published by Lawrence Erlbaum Associates, Inc., the book is edited by Sharon M. Friedman, Sharon Dunwoody and Carol L. Rogers. For information about possible discounts or to order, contact the publisher by phone, (201) 236-9500 or 1 (800) 9-BOOKS-9; fax (201) 235-0072; or e-mail, orders@erlbaum.com.

End Notes

Web Sites of Interest

■ ***HazNet Web Site.*** The HazNet website gathers information and resources from Sea Grant programs, the National Oceanographic and Atmospheric Administration and other public and private sector sources, helping people meet the challenges presented by natural hazards such as riverine flooding, storm surge, coastal erosion, seismic events and hurricanes.

HazNet is a two-year project funded through a National Sea Grant College Program grant, and organized by the network of Sea Grant programs nationwide. The site can be found at www.haznet.org.

■ ***Explore the Ocean Depths.*** Students and teachers, parents and children can surf the virtual seas to depths of 2,000 feet to study diverse and fascinating marine life, with the launching of two new web sites on the Sustainable Seas Expeditions that explore ocean resources at America's 12 national marine sanctuaries.

The Sustainable Seas Expeditions web site, www.sustainableseas.noaa.gov, and National Marine Sanctuaries web site, www.sanctuaries.nos.noaa.gov, conducted by the National Geographic Society and the National Oceanic and Atmospheric Administration's National Marine Sanctuaries program, together provide pages of rich and varied content about the exploration and conservation of the ocean.

Throughout the next year, trained aquanauts will pilot DeepWorker 2000, a one-person submersible capable of going to depths of 2,000 feet to photodocument the natural history of each sanctuary's plants and animals. What they discover and record in daily mission logs will help the sanctuaries build the first permanent marine monitoring network in the marine sanctuaries and educate the public on the many wonders within these protected areas.

Along with daily mission logs, the web sites offer a calendar of scheduled web chats and student summits, facts about research and scientists, a look at the innovative technology they use, detailed maps and a photo gallery of the habitats unique to each site. Education pages will feature results from some of the major educational initiatives of the expeditions and offer opportunities for students and educators to share in their discoveries.

Noteworthy

■ ***Exotic Species CD.*** Minnesota Sea Grant has produced a compact disk version of its award-winning Sea Grant Nonindigenous Species (sgnis) Web site, www.ansc.purdue.edu/sgnis/. For those who don't have internet access, this CD is the best source for comprehensive scientific information on zebra mussels, eurasian ruffe, round gobies, sea lamprey and spiny waterfleas. To order a CD, which costs $14, contact Minnesota Sea Grant, 2305 East 5th Street, Duluth, Minnesota 55812-1445, phone (218) 726-6191.

■ ***Gardens for the Bay.*** The state of Maryland is marking the coming millennium with a year-long Celebration 2000 in the arts, education, environment, history, human services and philanthropy. A signature environmental project for the celebration, called MaryLandscapes, advocates helping to preserve the Chesapeake Bay through environmentally sensitive gardening.

Through a grants program, community groups, nonprofit organizations, municipalities and others received money to plant Bay-friendly gardens in public locations around the state. For a list of the gardens and their locations and to find out more about them, check the web at www.maryland2000.org/projects/marylandscapes/marylandscapes.htm or call 1-877-MD2-0001.

Calendar

November 12-13 — Coastal Bays

Ocean City, Maryland. Delmarva Coastal Bays Conference III will reassess the health of, and threats to, the most important fisheries and aquatic resources within the distinctive shallow-water estuarine system that stretches from lower Delaware to Cape Charles, Virginia. Initial scientific presentations will provide context for subsequent sessions on current Best (Resource) Management Practices, minimizing user conflicts, and outlining strategies for enhancing and sustaining those resources on which the economics and quality of life in Delmarva largely depend. For registration and other information, contact conference organizer Assateague Coastal Trust by phone, (410) 629-1538, fax (410) 629-1059 or e-mail, act@beachin.net.

November 16-19 — Marine Ornamentals

Kona, Hawaii. The Marine Ornamentals '99 Conference will bring together those interested in the collecting, culture and conservation of marine ornamental species including fishes, corals and live rock, as well as those who are concerned about the regulatory regime in which these species are traded, transported and marketed. The conference will provide an opportunity for participation by researchers, businessmen and hobbyists alike.

For details about the conference or registration information, see the web at www.soest.hawaii.edu/SEAGRANT/marine_ornamentals99/index.html or contact the conference manager by phone, (425) 485-6682, fax:, (425) 483-6319, or e-mail, worldaqua@aol.com.

Maryland Marine Notes
Volume 17, Number 4
July-August 1999

Maryland Marine Notes is published six times a year by the Maryland Sea Grant College for and about the marine research, education and outreach community around the state.

This newsletter is produced and funded by the Maryland Sea Grant College Program, which receives support from the National Oceanic and Atmospheric Administration. Managing Editor, Sandy Rodgers; Contributing Editors, Jack Greer and Merrill Leffler. Send items for the newsletter to:

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