MARYLAND

Research, Education, Outreach *November-December 1996*

MARINE NOTES

SPOTLIGHT ON RESEARCH

The Trouble with Toxics in the Bay

BY JACK GREER

Does the Chesapeake Bay have a toxics problem?

Are the chemicals that run off the land or the particles that descend from the sky measurably affecting the Bay's food web? Are the effects of heavy contaminant loading in harbors and industrial areas confined to these regions, or do physical and biological processes carry them farther into the Bay? Is oyster disease a signal that toxic chemicals are compromising the oyster immune system? These are the kinds of questions that citizens and scientists throughout the Bay watershed are asking. The answers, however, are far from simple.

According to ongoing research, there are indicators suggesting contaminants could have important, if sometimes subtle, effects on the Bay's ecology. While these indicators are often ambiguous, a team of researchers, with the support of the Chesapeake Bay Environmental Effects Committee (CBEEC), have begun to map the relationship between sources of contaminants and their biological effects.

Skip Brown

Public opinion surveys show that public perception is out of whack. Most people still believe that industry — big industry — is the problem. But most contaminants do not come out of a pipe.

A Smoking Gun

At least as long ago as 1962, when Rachel Carson in her book *Silent Spring* fingered DDT among other compounds as a random chemical killer, environmentalists and resource managers alike have often searched for a "smoking gun" — a chemical contaminant guilty of causing a significant ecological problem. In the case of the Chesapeake Bay, there have been clear cases of what writer William Styron has called "a murder most foul."

Styron was referring, in a newspaper article, to the "killing" of the James River by the pesticide Kepone, spilled into the river by Allied Chemical Company and its contractor until authorities closed the Hopewell, Virginia plant in 1975. Because of the spill, authorities worried about contaminated shellfish and other seafood, and scientists were indeed able to track the entry of that poison into the food web. In other cases as well — oil spills, high chemical contaminant loads in the sediments of commercial harbors — the causes and effects of toxic pollution in the Bay are relatively clear.

Please turn page

Toxics, continued

But beyond these specific cases, what is the overall impact on the Bay of a steady rain of contaminants on the ecosystem? In order to address this question, the Sea Grant College Programs of Maryland and Virginia, with the support of the National Oceanic and Atmospheric Administration's Chesapeake Bay Office, and the cooperation of the U.S. Environmental Protection Agency and the Chesapeake Bay Program, brought together scientists from across the Bay region to meet at the Belmont Center near Baltimore to distill from recent research what we know — and what we don't — about contaminants in the Chesapeake.

A Contentious Debate

The issue of toxic contaminants in the Chesapeake Bay is not new. A six-year study of the Bay, supported by the Environmental Protection Agency, culminated in a series of reports in the early 1980s that documented the presence of metals and other contaminants in the Bay and called for a more thorough understanding of how these contaminants move through the Bay and its food web.

But, how to begin this discovery process is a problem in itself. There are numerous "camps" of scientific thought that argue for differing approaches. Some researchers call for a greater focus on bioassays that can track chemical contaminants in the tissues of living organisms. Other researchers call for a more ecosystem-oriented approach that studies how contaminants move from one level of the food web to another. Still others argue for close investigation of responses at the cellular level, for example, to see how contaminants might affect an organism's ability to fend off disease.

Scientists and resource managers meeting at the Belmont Center represented some of these approaches — though by no means all. "Our goal," says Chris D'Elia, director of the Maryland Sea Grant Program, who helped convene the meeting, "was to have researchers in the CBEEC Program assess the status of our knowledge about contaminants in the Bay and to identify information and research needs."

Over the past thirty years, we have seen an evolution from end-of-pipe sources to more diffuse sources. Maybe we need to use the same approach with toxics that we've used with nutrients.

The scientists' answers to the fundamental questions about contaminants are summarized in a new report, *Chemical Contaminants in the Chesapeake Bay*, highlighted in a sidebar accompanying this article.

Repeatedly, the scientists at this meeting emphasized that while we know a fair amount about inputs of toxic materials into the Bay, we are still just learning how to measure the effects of those contaminants on Bay organisms, and on the Bay ecosystem itself.

Not Just the End of a Pipe

Contaminants enter the Chesapeake Bay from a number of sources, according to Joel Baker and other scientists at the Belmont meeting. Says Baker, "Public opinion surveys by the Chesapeake Bay Foundation and the Chesapeake Bay Program show that public perception is out of whack. Most people still believe that industry — big industry — is the problem. But most contaminants do not come out of a pipe." Even in the case of urban runoff, he says, where pollutants may come out of a pipe, the pipe is owned not by industry but by the city.

"Over the past thirty years," continues Baker, "we have seen an evolution from end-of-pipe sources to more diffuse sources. Maybe we need to use the same approach with toxics that we've used with nutrients." Nutrients also often come from diffuse sources, such as runoff from farms in rural areas or stormwater in developed areas. Baker points out that getting people to understand the real sources of contaminants will take a good deal of public education. He also notes that dealing with diffuse sources requires different management strategies.

Generally, he says, the upper Bay is more dominated by the input of rivers, so it receives more of its relative contaminant load from riverine sources. The lower Bay, where the rivers have less direct influence, sees a greater impact from diffuse sources, including from the atmosphere.

The Chesapeake Bay Program's *Chesapeake Bay Basinwide Toxics Reduction Strategy Reevaluation Report* lists much of what we know about sources of contaminants found in the Bay. For example, the report holds that metal loading to the Bay is highest in the Potomac River, followed by the Susquehanna, the west Chesapeake, the James, the mainstem Bay, the Patuxent, Eastern Shore, York and Rappahannock basins.

In general, the scientists at the Belmont Center felt confident, from extensive monitoring data, that environmental legislation — such as the Clean Water Act and the Clean Air Act — has led to vastly reduced inputs of chemical contaminants into the Bay from business and industry and other "point" sources. Because of these point-source reductions, and because of a growing population in the Bay's 64,000-square-mile watershed, diffuse or "nonpoint" sources of

contaminants are becoming more important all over the Bay, and these sources remain more difficult to track and more difficult to control.

What are these diffuse sources? For one thing, whenever we burn something, we potentially put contaminants in the air. Even before the colonists arrived in the sixteenth and seventeenth centuries, Native Americans set fire to the forests to hold down the undergrowth and to improve their hunting grounds. Now we seldom burn off our forests, but we do burn ancient forests constantly — in the form of heating fuel, coal, diesel and gasoline. This constant conflagration, whether from expansive suburbs burning heating oil all winter or from the endless parade of cars and trucks up and down the region's many highways, sends a cloud of hydrocarbons and other compounds into the air. Wind, rain and other precipitation bring it down again — into the watershed of the Bay and its tributaries.

As University of Maryland professor Alan Taylor has said, 90% of the watershed is land, not water, and once contaminants fall on the land, following their path to the Bay "becomes difficult." Clearly contaminants from both burned and unburned (as from oil spills) fuels find their way into the Bay, as PAHs (polycyclic aromatic hydrocarbons) and other compounds that are listed on the Bay Program's Toxics of Concern list.

In addition to fossil fuel products, the incineration of garbage, which may contain toxic products such as batteries, can lead to the emission of mercury and other contaminants. Though not as widespread as the fossil fuel problem, such diffuse sources are one of many delivery mechanisms to the Bay. Another poorly understood mechanism throughout the watershed is seepage into groundwater from septic tanks, which may contain traces of solvents and wastes poured down the drains of countless households. From both suburbs and cities, stormwater runoff also delivers an onslaught of motor oil, cleaning fluids, and assorted contaminants from driveways, roadways and parking lots. And from agricultural areas and even forests, the Bay receives pulses of herbicides and pesticides, such as the gypsy moth treatment Dimilin.

What Happens to Contaminants in the Bay?

The toxics story becomes more complex once contaminants enter the Bay. Researchers such as scientist Larry Sanford have been tracking their movement. Sanford, of the Center for Environmental and Estuarine Studies' (CEES) Horn Point Laboratory, has worked with his colleagues to calculate how contaminants move along the surface of the sediment, how they interact with other particles and how they are finally buried.

According to Sanford, tidal action in the mid-Bay erodes a thin layer of sediment — about 0.1 to 1 mm thick. This thin layer migrates with tidal currents, lengthening the time it takes for contaminants to become buried.

The key question, and one still under investigation by researchers, is whether contaminants — in or on the sediments, for example — find their way into the food web, and begin to move through Bay's living organisms.

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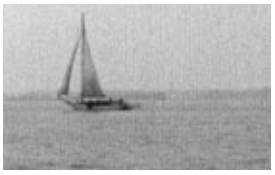
Why Are Toxics So Difficult?



At least since the large EPA study of the Chesapeake Bay in the early 1980s described toxic chemicals as a threat to the Bay's health, scientists have struggled to understand the impact of various contaminants on the Chesapeake. The issue remains a difficult one.

Analytical Tools and Methods

- Researchers have been limited by their ability to detect contaminants in tiny amounts and mixed in with other compounds. Recent improvements in technology have allowed researchers to analyze samples with greater accuracy, and to identify smaller and smaller amounts of contaminants.

- Previously, researchers were not able to track early biological effects of contaminants, and so could not witness what is generally the first response of an organism to a toxic threat. With new genetic and molecular tools this is now possible.

Experimental Designs

- Researchers must design complex experiments that will allow them to isolate the effects of contaminants. This can be extremely difficult because the levels of contaminants range from trace amounts to major spills and because the ecosystem is so complex.

- Scientists must be able to account for differing forms or "species" of metals and other contaminants — these forms may change, depending on a number of physical, chemical and biological factors.

Making Connections

- Scientists must design ways of applying results obtained in the laboratory, where they can control conditions, to the open environment, where conditions are much more chaotic.

- Researchers face a difficult challenge in relating the behavior of contaminants in the environment to the effects they observe; linking environmental effects with human health issues can prove especially difficult.

Toxics, continued

Significant evidence has emerged to date that this does indeed occur.

In the Baltimore Harbor, for example, researcher Jim Sanders and his colleagues at the Benedict Estuarine Research Center (BERC) found that a small fish (the mummichog) took up more contaminants at low tide than at high tide. They concluded that this occurred because fish feeding in the shallows would come into direct contact with contaminated sediments more often at low tide, when very little water covered the tidal flats.

Beyond these direct contacts with contaminants, scientists are tracking more puzzling possibilities. In the Patuxent River, for example — an area clearly less polluted than Baltimore or Norfolk harbors or the Anacostia River — phytoplankton in the river can concentrate contaminants. Sanders and his colleagues have determined that once concentrated, the contaminants can be tracked to the Bay floor, as the phytoplankton sink to the bottom. There, the contaminants have the potential to enter the food web that thrives on the riverbed.

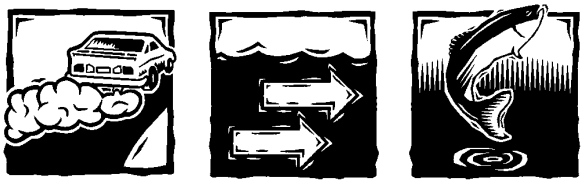
Most importantly, Sanders has determined that contaminants may also cause an unwanted shift in the populations of phytoplankton. Arsenic, for example, appears to cause one type of algae to die down while another type takes off. This means that algae blooms can differ widely, especially in their effect on such organisms as copepods and other zooplankton that graze on them.

"Our findings suggest that the biomass [the overall amount of phytoplankton] doesn't really change," Sanders says, "but the composition of that biomass does."

For animals that feed on phytoplankton, this change may be crucial. Dan Terlizzi, a Sea Grant Extension Specialist trained in the study of phytoplankton, compares it to a cow eating normal grass versus grass blades the size of a tree trunk. Clearly, he says, in the latter case the cow would go hungry. This is the case with zooplankton that graze on algae. Oysters also feed on algae, and there has been much speculation that they too are finding fewer desirable and nutritious species to eat.

Since phytoplankton form the very base of the Bay's food chain, any change there affects not only the zooplankton that graze on them, but the small fish that graze on the zooplankton, and the larger fish that eat them. According to CEES researcher Ed Houde, zooplankton (like copepods) make up a major source of food for juvenile species of fish, such as striped bass. Other fish, menhaden, for example, feed directly on phytoplankton, and in turn become a major food source for larger fish, like blue fish. By unintentionally causing shifts at the base of the food pyramid, we may have caused shifts at the top — shifts we still do not fully understand.

Report Highlights



The following points are among the significant conclusions of a new Maryland Sea Grant report, *Contaminants in the Chesapeake Bay,"* resulting from a December 1995 meeting of researchers:

- Monitoring has shown that contaminants emanating from diffuse sources (e.g., car exhaust and other air deposition, stormwater runoff, household and boating solvents and other chemicals) are becoming relatively more important than industrial sources, which have been dramatically reduced since the passage of Clean Water and Clean Air legislation.

- In addition to identified "hot spots" (Regions of Concern) evidence exists that low-levels of contaminants in the Chesapeake Bay have an impact on organisms at several major levels of the food web.

- Specifically, research shows that oysters exposed to chemical contaminants in the Bay are more vulnerable to diseases such as Dermo. This may be especially significant, given current efforts to restore oyster reefs and oyster populations in the Chesapeake.

- Exposure to trace metals and other contaminants can affect phytoplankton populations under research conditions, for example, causing shifts in species composition. Since phytoplankton form an important base of the Bay's food web, changes here could have significant impacts throughout the Bay.

- Studies have indicated that certain chemicals appear to affect both individual species (such as copepods, which can be damaged by Dimilin, a treatment for gypsy moth infestations) and species diversity (as through contact with compounds used as preservatives in wooden bulkheads).

- Because of the evidence of biological impacts — even at relatively low levels of contamination, and because diffuse sources may be more difficult to control than point sources — it is imperative that we further investigate the effects of contaminants at environmentally realistic levels, on key facets of the Bay's food web.

Is the Gun Smoking?

For many years, Robert Anderson of the CEES Chesapeake Biological Lab has been looking as closely as anyone for a direct connection between chemical contaminants in the Chesapeake Bay and the poor health of species such as the oyster and the striped bass.

He has been experimenting with low doses of tributyltin and other compounds, to determine whether or not such doses interfere with the immune system. According to his research, the effects are clear. He can document that the immune response slows and becomes less effective once an oyster has been dosed with TBT.

But when asked whether he thinks chemical contaminants are responsible for the decline of oysters in the Chesapeake Bay, Anderson refuses to make that leap. To nail down that connection in a truly scientific manner, researchers will have to continue to study the effects of contaminants in the open environment under a range of natural conditions, such as changes in salinity, oxygen and temperature, which alone can affect an oyster's resistance to disease. (See for example, "Building Better Predictors of Stress," Marine Notes, September-October 1996.)

For now, the researchers who attended the Belmont Center meeting conclude that we have made great strides in understanding where contaminants come from and how they move — physically and chemically — throughout the Bay. Where we have only begun to make progress, they say, is in understanding the biological effects those contaminants can have — not only on large organisms like fish, but also on the microscopic plants and animals that make up the foundation of the Bay's food web.

For a copy of Chemical Contamination in the Chesapeake Bay: A Synthesis of Research to Date and Future Research Directions, *the report compiled from the workshop on toxics held at the Belmont Center, contact the Maryland Sea Grant College by phone, (301) 405-6376; fax (301) 314-9581; or e-mail, connors@umbi.umd.edu.* ■

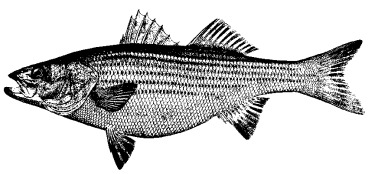
Takacs to Fill New Sea Grant Extension Position

The Maryland Sea Grant Extension Program has hired Jackie Takacs as its newest marine agent. Formerly an oyster hatchery assistant at the Center for Environmental and Estuarine Studies (CEES) Horn Point Environmental Lab (HPEL), Takacs will be now be stationed at the CEES Chesapeake Biological Laboratory (CBL) in Solomons Island, Maryland. In her new position, she will undertake outreach programs in aquaculture and other marine-related issues.

According to Doug Lipton, Coordinator of the Sea Grant Extension Program, "Jackie's experience with both shellfish and finfish aquaculture will be a tremendous help as we work on oyster restoration and other projects in Southern Maryland." Lipton says that Takacs will be able, for example, to help the state as it attempts to get the most out of the oyster hatchery at Piney Point.

Ken Tenore, marine scientist and head of CBL, is excited about the new position. "CBL has its roots in Southern Maryland," he says, "and this gives us a chance to work with other parts of the University to mount a new outreach effort in this part of the state."

Takacs began her new job on November 4 and can be reached at CBL (410) 326-7356. Takacs replaces Rich Bohn, who left Sea Grant Extension to become the executive director of the National Aquaculture Association. The Sea Grant Extension Program is a joint effort of the Maryland Sea Grant College and the Cooperative Extension Service, in cooperation with the Center for Environmental and Estuarine Studies, the University of Maryland Eastern Shore, the Columbus Center, and other partners.



Lab Director Retires

Kent Fuller, director of the Center for Environmental and Estuarine Studies (CEES) Appalachian Environmental Laboratory (AEL) in Frostburg, will step down as laboratory director and will retire from the faculty in early 1997 after 30 years with CEES and its predecessor, the Natural Resources Institute.

Donald Boesch, president of CEES, announced the retirement and observed that under Fuller's leadership, AEL grew from "a small office" into "Western Maryland's leading environmental research and education facility." Boesch went on praise Fuller's "powers of negotiation," which, coupled with a "clear vision," enabled him to steer AEL to its present status.

Professor Fuller is a native Western Marylander. He was born and raised in Cumberland and held a bachelor's and a master's degree (with distinction) from Frostburg State University. In 1966 he was appointed to the conservation education faculty at the Western Maryland Laboratory of the Natural Resources Institute in LaVale, Maryland.

The mission of the Institute was broadened over the years to include an array of environmental studies, eventually leading to the formation of CEES in 1973. Fuller played a key role in moving the laboratory to its present location on the campus of Frostburg State University in 1976, and he helped to form the consortium of Garrett Community College, Frostburg State and CEES that led to an award-winning undergraduate program in Fisheries and Wildlife Management.

MEES Students Receive Knauss Fellowships

Sara Gottlieb and Jill Stevenson, both graduate students in the Marine-Estuarine-Environmental Sciences (MEES) program at the University of Maryland, College Park, are this year's Maryland recipients of Knauss Marine Policy Fellowships. The Fellowship Program, begun in 1979 and coordinated by the National Oceanic and Atmospheric Administration's (NOAA) National Sea Grant Office, provides graduate students across the nation with an opportunity to spend a year working with policy and science experts in Washington, DC. Fellows are competitively selected from a list of graduate students recommended by the directors of the 30 Sea Grant programs in individual states.

Pictured above left is Sara Gottlieb, at work in the lab, and above right is Jill Stevenson, when she was an REU fellow at HPEL in 1991.

For her Fellowship year, Sara Gottlieb will work full-time in the office of Representative Steven LaTourette of Ohio, co-chair of the Great Lakes Task Force. She will also help out in the Northeast-Midwest Institute in the office of Senator John Glenn. Gottlieb worked for two years as a Maryland Sea Grant Trainee, first with UMCEES Chesapeake Biological Laboratory (CBL) researcher Douglas Capone and then with Benedict Estuarine Research Center (BERC) researcher Cynthia Gilmour. Joseph Mihursky, of CBL, is her major advisor. Currently, she is working with Mark Sagoff in the Institute for Philosophy and Public Policy in the UMCP School of Public Affairs. She plans to complete her Ph.D. after her she finishes her Fellowship. Gottlieb received her undergraduate degree, with an environmental science major, in 1994 from the College of William and Mary.

Jill Stevenson will work in NOAA's National Marine Fisheries Service, in the Office of Sustainable Fisheries, Division of Highly Migratory Species, with several researchers, including Richard Surdie. Stevenson currently works as a graduate assistant with CBL scientist David Secor doing research on the Atlantic sturgeon. She plans to complete her M.S. in Fisheries Science in the MEES program by Spring 1997. Stevenson received her bachelors degree in 1992 from Columbia University, where she majored in geochemistry.

Stevenson and Gottlieb first came to the University of Maryland when they received summer fellowships in Maryland Sea Grant's Research Experiences for Undergraduates (REU) program, funded by the National Science Foundation, and awarded to outstanding students studying marine and environmental science. Stevenson spent her 1991 undergraduate fellowship at Horn Point Environmental Laboratory (HPEL), working with scientist Jeff Cornwell on sediments and biogeochemistry. Gottlieb spent hers in 1993 at CBL, working with Joel Baker to conduct research on the effect of herbicides in the Patuxent River.

The process for selecting Knauss Fellows begins with the submission of applications by candidates recommended for their excellence by Sea Grant Directors across the nation. The National Sea Grant office then conducts a rigorous review process and awards fellowships to the top candidates. This year the Fellowship program received fifty-five applicants from twenty Sea Grant programs and presented twenty-five awards. Maryland was one of six programs with two Fellowship awards.

Over the years, Knauss Fellows have worked in the legislative and executive branches of the federal government in locations such as the office of U.S. Senators and Representatives, on Congressional subcommittees and at agencies such as the National Science Foundation and NOAA. Fellowships run from February 1 to January 31 and pay a stipend of $30,000.

The application deadline for next year's Knauss Fellowship Program is September 1, 1997. For more information, or an application brochure, contact: Susan Leet, Maryland Sea Grant College, 0112 Skinner Hall, University of Maryland, College Park, Maryland 20742, phone (301) 405-6375, e-mail: leet@umbi.umd.edu. Brochure information can also be found on the web: http://www.mdsg.umd.edu/ NSGO/ Knauss.html.

Maryland Marine Notes
Volume 14, Number 6
November-December 1996

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. Editor, Jack Greer; Art Director, Sandy Rodgers. Send items for the newsletter to:

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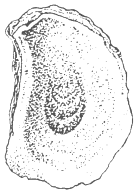
web: http://www.mdsg.umd.edu/MDSG/

End Notes

Sea Grant RFP on the Web

■ *The Maryland Sea Grant College* will be issuing its biennial Request for Proposals (RFP) for the 1998-1999 funding cycle at the end of February 1997. To request a copy of the RFP booklet, call Ellen Lundgren at (301) 405-6371. The RFP will also be posted on the web at: http://www.mdsg.umd.edu/MDSG/Research/RFP.html.

RFP for Oyster Disease Research



■ *The National Sea Grant College Program Office* has issued a request for proposals for the Oyster Disease Research Program (ODRP) for 1997 and 1998. Funding for FY 97 is $1.465 million and for FY 98, $1.5 million. Proposals will be accepted for one and two years duration.

The official aim of the program is "to provide, through a coordinated research program, the technological basis for overcoming diseases which currently limit oyster production in the United States." While the ODRP emphasis is on diseases associated with the eastern oyster, proposals addressing disease problems of other oyster species will be considered.

While you can contact Sea Grant programs for a copy of the RFP, it is also available on the world wide web, which gives brief summaries of studies over the last two years. To request a printed copy of the RFP, call (301) 405-6371.

Proposals should be submitted to respective Sea Grant programs. While all documents must be in the National Sea Grant Office by March 15, 1997, each Sea Grant Program sets its own due date. In Maryland, proposals are due to Research Director Gail Mackiernan by February 25, 1997. The ODRP web address is: http://www.mdsg.umd.edu/NSGO/research/oysterdisease/.

Video Award

■ A series of video news releases created as a result of the Sea Grant National Fisheries Forum "Can American Save Its Fisheries?" have tied for second place in the 1996 International Gold Screen Competition of the National Association of Government Communicators (NAGC). The releases were produced by Michael W. Fincham, of Maryland Sea Grant, Ben Sherman, National Media Coordinator, and Jay Humphries of Florida Sea Grant. Awards were presented at the national meeting of in Austin, Texas. The Forum took place in September 1995 at the National Press Club in Washington, DC.

Grant Opportunities

■ *The Environmental Protection Agency (EPA) and the National Science Foundation (NSF).* EPA and NSF currently have $6 million available for research grants. Proposals are sought for three research areas: Water and Watersheds, Technology for a Sustainable Environment, and Decision-making and Valuation for Environmental Policy. Application deadline is January 31, 1997. Information on the grants is on the web at: http://es.inel.gov/ncerqa/grants/interagency.html and by e-mail from Robert Menzer (menzer.robert@ epamail.epa.gov) or Melinda McClanahan (mcclanahan.melinda@epa.gov).

Calvert Environmental Trust for Youth

■ *The Board of Supervisors of Calvert Soil Conservation District* and the citizens of Calvert County have joined forces to increase youth involvement in community organization and environmental activities. For more information contact The Calvert Environmental Trust for Youth, (410) 535-1552.

Seminars

■ *MDNR Assessment Service Seminar Series* is held in the Tawes Building conference room in Annapolis at noon. For more information, call Ann Smith at (410) 974-3782.

January 17 — David Secor, University of Maryland, Effects of hypoxia and temperature on growth, survival and respiration of juvenile Atlantic sturgeon

February 21 — Carol Richardson-Heft, Maryland Department of Natural Resources, Homing behavior and home range of largemouth bass (*Micropterus salmoides*) in the upper Chesapeake Bay

March 20 — Frank Coale, University of Maryland, Why nutrients from animal manure can end up in the Bay: It's all Isaac Newton's fault"

April 17, 1997 — Pauline Vaas, Duke University, Development of resource-specific environmental quality indices for Chesapeake Bay incorporation of citizen's perspectives

May 15, 1997 — Sara Gottlieb, University of Maryland, ecological restoration and the concept of place: A Calvert County case study

■ *Smithsonian Environmental Research Center* (SERC), Edgewater, Maryland. For more information, call (301) 261-4190.

January 9 — Olav Oftedal, National Zoological Park, the importance of nutrition in the conservation of reptiles

January 16 — Eric Wommack, UM Center of Marine Biotechnology, The ecological role of marine bacteriophages: the little engine that could

January 23 — Elgin Perry, Statistics Consultant, techniques for measuring and assessing trends in dissolved oxygen

January 30 — Gus Shaver, Ecosystems Center, Marine Biological Laboratory, Temperature and primary productivity in arctic tundra

Publications

The Water-Wise Gardener

This handbook includes sections on planning, implementation, data evaluation and reporting, as well as examples of surveys, impact sheets, and marketing materials that have been successfully used in public education. To order copies, send check for $15.00 payable to Treasurer, VA Tech, The Water-Wise Gardener, Office of Consumer Horticulture, 407 Saunders Hall, Blacksburg, VA 24061.

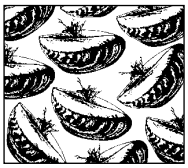
Oceans and Coasts

In 1996, the United Nations Commission on Sustainable Development reviewed the progress achieved since the 1992 Conference on Environmental and Development. To contribute to this important review, a special issue of *Ocean and Coastal Management Journal* has been published on the Earth Summit Implementation and the progress achieve on oceans and coasts during this time period. Editors of this special issue are Biliana Cicin-Sain and Robert W. Knecht. Copies of the issue are available from Elsevier Science for $25.00 U.S. plus $3.00 US for shipping and handling. Order from: Catherine C. Johnston, *Ocean and Coastal Management*, Center for the Study of Marine Policy, University of Delaware, Newark, Delaware 19716, phone (302) 831-8086, fax (302) 831-3668.

Opportunities in Ocean Science

Expanding Opportunities in Ocean Sciences is a proceedings of A Conference to Strengthen the Links between HBMSCU Undergraduates and Oceanic Graduate Studies held September 11-12, 1995 at Hampton University, Hampton, Virginia. Sponsored by NOAA's National Marine Fisheries Service, the conference aimed at forming a partnership among government science agencies and academia to develop strategies and an action plan to increase minority student enrollment in and successful completion of degree programs in the aquatic sciences and employment in oceanic marine sciences. To request a copy of the proceedings, contact Ambrose Jearld, Jr. at the NOAA National Marine Fisheries Science Center in Woods Hole, Massachusetts, by e-mail (Ambrose.Jearld@NOAA. gov), fax (508) 495-2258, or phone (508) 495-2318.

Calendar



January 28-31 — Zebra Mussel Conference, New Orleans, Louisiana. The Zebra Mussel and Aquatic Nuisance Species Conference, the seventh international conference, will be held at the Radisson Hotel. For registration information contact Elizabeth Muckle-Jeffs, 567 Roy Street, Pembroke, ON K8A 6R6 Canada. Phone: (800) 868-8776. Fax (613) 732-3386.

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