MARYLAND

Research, Education, Outreach *January-February 1996*

MARINE NOTES

Traversing the Chesapeake from the Northern Bay to the Virginia capes, researchers seek clues to the Bay's productivity.

SPOTLIGHT ON RESEARCH

At the Heart of Plenitude:

The Bay's Complex Circulatory System

BY MERRILL LEFFLER AND JACK GREER

While there is good reason to be concerned about the healthy recovery of the Chesapeake and its diminished resources, this shallow bay still ranks high among the nation's most productive estuaries. What accounts for this plenitude? What makes it such a rich source of fish, shellfish and other organisms? At least one team of scientists believes that the answer lies in the complex physical forces that link the Bay's chemistry and its biology — a watery circulatory system that nourishes a massive productivity.

Those physical forces are many — the estuary's sharp layering between outflowing fresh river water and incoming ocean water (the pycnocline) or between cold and warm water (the thermocline), its currents, its waves, its seiches (wind-driven water sloshing back and forth across the Bay), its many types of fronts. Like arteries, these physical forces deliver nutrients and other compounds, and move and attract living organisms — from microscopic plankton to large fish.

Determining just how this circulatory system interacts with organisms is a central challenge of TIES (for Trophic Interactions in Estuarine Systems), a unique and ambitious research effort by scientists at the University of Maryland System's Center for Environmental and Estuarine Studies (CEES).

They have set a daunting task for themselves — Walter Boynton and William Boicourt admit that they were thrilled and a little scared when they received word from the National Science Foundation that their six-year research project had been funded. With this award they have an opportunity to pull together an unparalleled understanding of one of the world's most productive water bodies, to literally map the way it functions.

(Continued on page 2)

Heart of Plenitude, *continued*

Taking the Pulse of the Bay

The Chesapeake operates in pulses, says Boynton, pulses of water that may shuttle organisms or even trap them: hurtling springtime river flows, ocean tides, and jets of scooting bottom water that result from sharp changes in topography. "Pulses play a role in setting up the physics of the estuary," says Boynton. "We would not have the same physics if river flow were constant."

Pulses help set up physical structures, such as fronts — areas where, as with weather fronts, temperature and density differences create dynamic transition zones. The CEES researchers want to find out if secondary production — of zooplankton and fish — forms around these fronts in the way that primary production (in the form of algal blooms) appears to.

One kind of front forms sharp boundaries that result when different water masses meet, lighter layers often lying atop denser layers. Fronts come in different sizes and can last for varying lengths of time. Some may come and go in a few hours — the result of wind, for example — some may last for a few days, others for two or three weeks. The best known example of a long-term front is the so-called "maximum turbidity zone" — a recurring physical structure where freshwater flowing down a river hits brackish estuarine water, the river's single flow mixing with the estuary's more complex tidal flow.

"A decade ago we didn't know enough about nutrient cycles or primary production to reasonably attempt this."

The maximum turbidity zone serves as the scene for intense chemical and physical activity in a tributary or estuary, with some river-borne particles settling out and others becoming entrained in the frontal zone. In the Chesapeake Bay, the most notable maximum turbidity zone occurs north of the Bay Bridge where the largest influx of freshwater in the Bay flows from the Susquehanna River, entraining sediments, algae and other particles. "It is such zones — both in the rivers and mainstem Bay — that we're interested in," says Boicourt.

The researchers hypothesize that seasonal pulses of nutrients from land, air and ocean accumulate in frontal zones and set in motion the processes that produce algal blooms. Are these major zones for secondary production as well — for zooplankton, fish and other organisms that feed on the Bay's plant life? "That's what we're guessing," says Boynton. Their belief is, according to Boynton, that such pulsing systems have an inherently high capability for secondary production. Zooplankton and larvae may be attracted to the algal growth, or they may themselves be caught up in these physical structures.

The timing and strength of these pulses shift from year to year because of climatic events — in particular

In the coming year physical oceanographer Larry Sanford (on right) will join the TIES effort to link the Bay's physics with its biological abundance. Sanford is pictured here with graduate student Weiqi Lin, as they study Bay wave patterns in a current Sea Grant-funded study.

variations in the amount of rain and snowfall — that fuel the flow of freshwater into the Bay. In the spring of 1995, for example, pulses of freshwater came early and were relatively small. Measurements this past spring should give researchers a good baseline for comparisons over the next five years, when there will almost certainly be higher flows, Boynton says, with larger pulses of freshwater at varying times. The researchers wonder, for example, how major forage fish (like anchovies) and their predators will school and behave as the system moves from low-pulse, low-flow years to years with a heavy spring flow.

Answers to such questions could tell us a lot about how the circulatory system of the Chesapeake helps explain the productivity of

Each spring, river waters cascading into the Chesapeake encounter salty tidal waters coming up Bay from the ocean. The density differences between fresh and salty water — influenced as well by winds, tides, gravity, and bottom topography — result in fronts that scientists believe are highly fertile zones for the production of fish.

what H. L. Mencken called the Bay's "protein factory."

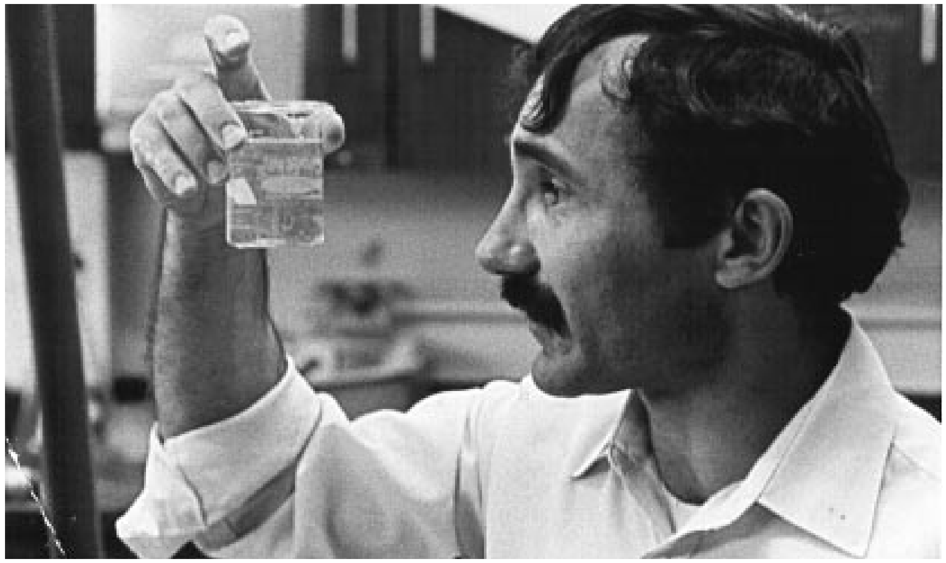
According to Walter Boynton, such an ambitious analysis of the Bay's secondary production would have been impossible before now. "A decade ago we didn't know enough about nutrient cycles or primary [algal] production to reasonably attempt this," he says. Nor did the researchers have the technology to take thousands of rapid measurements up and down the Bay system, from the Virginia capes to the Chesapeake and Delaware Canal.

Now, says Boynton, they have both the science and the machine — in the form of the remarkable Scanfish (see sidebar on "High Tech Fish").

Building on the Past

As a scientist, what excites Boynton is always the next set of questions. Though we don't have the whole story about nutrients, he says, the programs we've worked on have taught us a lot. For example, extensive monitoring by the Maryland Department of Natural Resources and scientific projects such as PROTEUS (for Processes of Recycling, Organic Transformations and Exchanges between Uplands and the Sea) have supplied researchers with a wealth of data. PROTEUS in particular (part of the National Science Foundation's Land Margin Ecosystem Research program) expanded on knowledge resulting from the multistate dissolved oxygen project supported by the National Oceanic and Atmospheric Administration (NOAA) and the Maryland and Virginia Sea Grant programs. According to Boynton and other scientists, these and related research programs have now positioned us to ask the all-important next set of questions, why is secondary production so efficient in the Chesapeake?

PROTEUS helped researchers establish what Boynton calls the "first-order dynamics" of how nutrient inputs, varying as they do from year-to-year because of climatic effects, drive nutrient cycling and primary production. It showed, says Boynton, that annual changes in such processes as primary production and nutrient recycling are directly related to changes in inputs of nutrients from the watershed.



CEES Researcher Ed Houde tracks the distribution of fish throughout the Chesapeake. Intensive sampling over the next five years should begin to reveal if zooplankton and fish are drawn to special productivity zones.

Those shifts in nutrient levels and the timing of their delivery result in turn from annual differences in river flow and other physical factors such as the strength of the pycnocline. The pycnocline forms an invisible boundary — between buoyant, downflowing river water and dense, inflowing saltwater. The strength and extent of the pycnocline, just one of the Bay's fronts, have important effects on ecological processes — such as the delivery of oxygen — throughout the estuary.

While research on dissolved oxygen gathered five years of data at several lateral locations across the Bay between the Choptank and Patuxent rivers, the new TIES project calls for extensive shipboard measurements over the entire length of the Bay for several years. Coordinating with weekly Baywide airborne surveys of algal abundance and distribution by CEES researcher Larry Harding, scientists will gather enough data to further confirm that ecological processes such as the extensive patchiness of algal blooms are driven by pulses of nutrient inputs and the timing of physical forces.

"It may be that 90 percent of the secondary production is occurring in 10 percent of the Bay's area."

To date, research suggests that some physical structures recur in predictable regions — for example, gravity currents in what physicist William Boicourt refers to as the "hydraulic control point," the region in the Bay between the Rappahannock and Potomac rivers where a steep change in bottom topography accelerates water flow. (The Bay deepens from the Potomac north to Kent Island.) Others, like the turbidity maximum zone north of the Bay Bridge, will shift depending on the strength and timing of spring flow from the dominant Susquehanna River.

But there are many other physical structures that form as the result of pulses — they may often occur in more limited regions and for shorter lengths of time. Fronts, for example, can form during tidal exchanges, or when a mass of moving water at one temperature meets another mass at a different temperature or salinity. While differences in density segregate these water masses, gravity — along with tides and winds and freshwater flow — drives them through the estuary, often mixing them as water moves in and around the Bay's many twists and turns, over its tidal flats, its narrow creek mouths, its deep river channels.

The more researchers learn about how these different areas behave, the better they may be able to suggest to managers which parts of the Bay are significant in fostering production of fish and shellfish. "It may be," says Boynton, "that 90 percent of secondary production is occurring in 10 percent of the Bay's area. We don't know this, of course. But it's a central question —a hypothesis we're working with."

If this hypothesis proves to be true, its implications could lead not only to improved management of fisheries but to a more effective targetting of Bay clean-up efforts. ■

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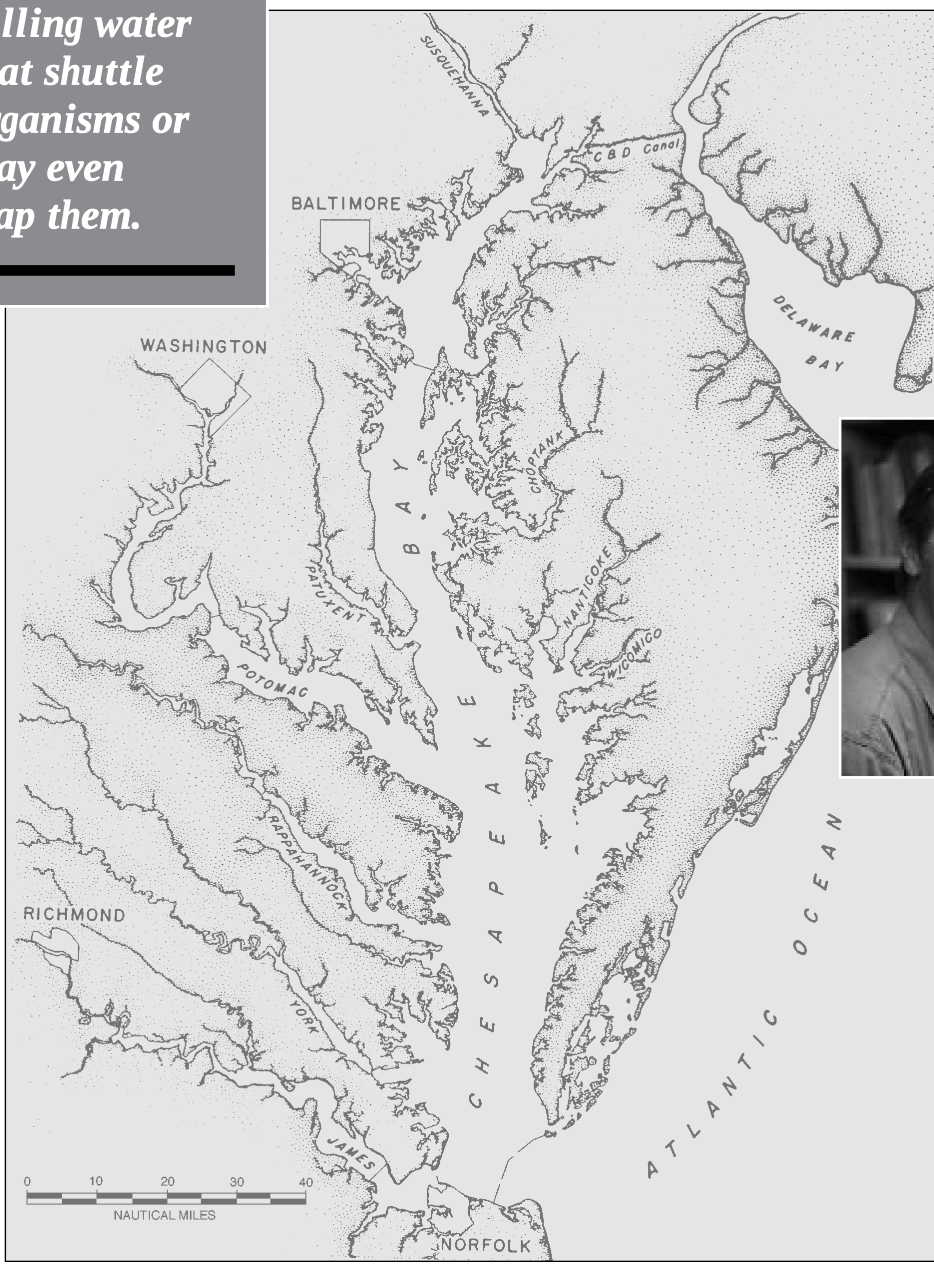

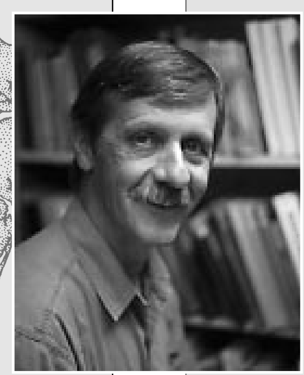

Over the next five years, the team of CEES scientists led by Walter Boynton (pictured above) will concentrate their research efforts in the Bay on key physical features such as maximum turbidity zones and other frontal regions.

A High Tech

It is one thing to speculate on interactions between physics and biology in the Chesapeake, quite another to map their complex relationships.

When researchers intensively studied dissolved oxygen processes in the mid-Bay during the 1980s, they would take a suite of vertical measurements every two meters at 6 locations across a transect between the Choptank and Patuxent rivers. In a day, they might take 36 measurements, among them temperature, salinity, dissolved oxygen and nutrient levels.

These provided them with a series of data points — dots on a graph — from which they drew their mental maps of the Bay's ecology. Now they can, in little more than an hour, take 36,000 salinity measurements, 30,000 dissolved oxygen measurements, 30,000 zooplankton samples.

The difference is the advent of new technology, most notably a flying underwater wing called the Scanfish. With this new instrumentation the researchers can see what they could not see before. "The structure of the Bay is much more complex," says researcher Michael Roman. "It surprises you and makes you come up with new theories. It's like seeing satellite photographs for the first time."

Mechanical fish have been used in the open ocean for some years, says William Boicourt. The most common are the Batfish out of Halifax, Nova Scotia and the Sea Soar out of California — fat jet airplanes with small wings fitted with instruments and towed alongside the research vessel.

For the Bay, the researchers needed something more fit for shallow swimming. In the Scanfish, says Boicourt, "we have something like a stealth bomber, a flying wing."

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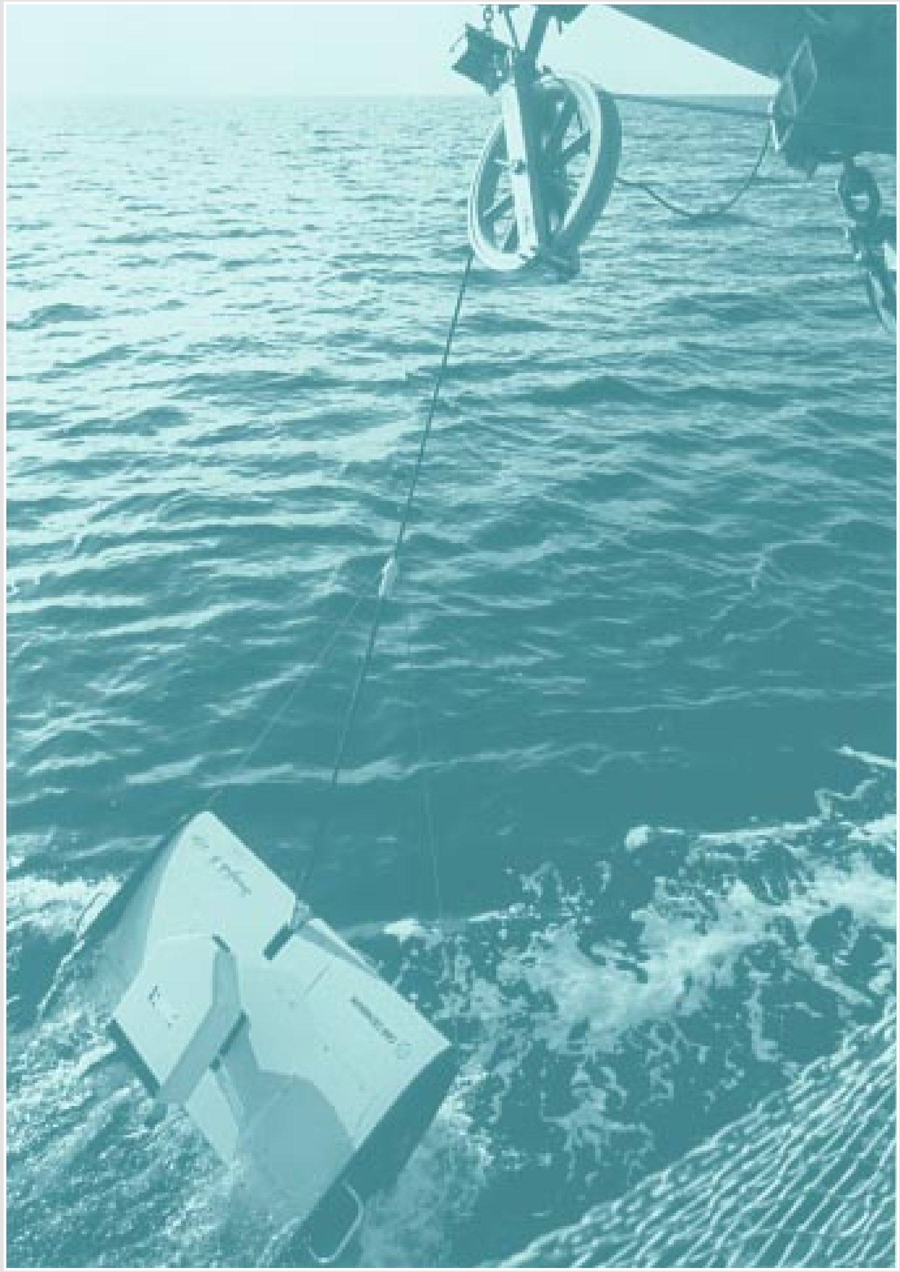
As the Scanfish is towed, it rises and falls alongside the research vessel, gathering data on temperature, salinity, oxygen and zooplankton. Though optical counters for counting zooplankton have been available for a while, says Michael Roman, in the last several years their sensitivity has increased remarkably. “We see a ticker tape of zooplankton going through, sizes from tiny *Acartia tonsa* to fish larvae, pockets of critters even at low oxygen that we missed before,” he says. “I get more data now in one cruise than I have in 25 years.”

Using the Scanfish, the research team covers the Bay twice over ten days, from its mouth to the Chesapeake and Delaware Canal, sampling 26 to 28 transects. On the first cruise, the crew uses the Scanfish and fish acoustics, mapping as they go, capturing as many variables as possible, as fast as possible. “Three days,” says Boicourt. “And we don’t stop.”

Then the ship returns to the CEES’ Bay labs at Horn Point and Solomons to change crews. The boat travels again to the Bay mouth, hitting every other criss-cross — now with 12 in the scientific party, as many as the research vessel *Henlopen* will hold. On this second leg, researchers take process measurements, calibrating production, catching fish to positively identify species. Fisheries scientist Ed Houde trawls for fish — he wants to know species and size distributions, what the fish eat, and if there are correlations between the physical features and the way these fish and their prey are organized.

“We want to be able to examine growth rates,” Houde says, “to see if fronts promote growth or if they simply aggregate fish and predators together or if there is even a net benefit at all.”



Scanfish — a new underwater flying vehicle — is enabling scientists to sweep the entire Chesapeake Bay rapidly, taking thousands of measurements that will help CEES researchers identify whether the Bay has regions of major biological production.

“In the dissolved oxygen project, we learned a good deal,” says Michael Roman, “but we were connecting the dots between measurements with our best calculations.” The inferences that researchers could draw about small-scale fronts and other circulation features were limited. Now instruments on the Scanfish are filling in the dots with real measurements — and helping CEES scientists to see more than they ever could before. ■

End Notes

Noteworthy

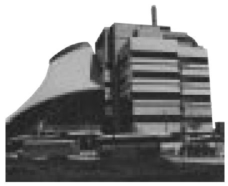
In Memoriam: Ellen Fraites Wagner

The Chesapeake Bay community lost a dedicated advocate when Ellen Fraites Wagner passed away on Thanksgiving after a long struggle with an incurable lung disease. Ellen Fraites was widely known as the point person on Bay issues for Governor Harry Hughes and played a key role in state government during a time when the Critical Area Act and other important Bay legislation and programs took shape.

After Governor Hughes left office, Ellen Fraites Wagner attended the Kennedy School at Harvard University in environmental policy. She then returned to the University of Maryland, where she helped to guide the University's Coastal and Environmental Policy Program (CEPP), which she had helped start while in the Hughes administration. While at CEPP she wrote an ambitious analysis of environmentalism, published in the *Environmental Leadership Report: Environmental Activism in Maryland*, which is available from the Maryland Sea Grant College.

Ellen's spirit and dedication to the Chesapeake Bay and to the environmental movement in Maryland will be sadly missed.

Ellen Fraites Wagner, pictured here (at center) during a planning meeting for the Environmental Management of Enclosed Coastal Seas (EMECS), died on Thanksgiving Day.



Columbus Center Takes Off

In fulfillment of its mission to bring science to people, the Columbus Center, located in Baltimore's Inner Harbor, launched an ambitious education program this fall. In slightly over eight weeks its science and technology education effort — called SciTEC — brought together some 902 students and teachers representing 27 schools or education programs.

Students and teachers met with working scientists, participated in wet labs and took advantage of high tech computers. Taking part in a computerized "scavenger hunt," students searched the World Wide Web for marine-related information. Interest was intense, according to Treopia Washington, Director of Education and Outreach. "The only way we can end each session," she said, "is by turning off all computers from the teacher's master switch!"

For more information about the Columbus Center's marine education efforts, call Maryland Sea Grant education specialist Adam Frederick, (410) 576-5743.

Conferences, Etc.

Blue Crab Symposium

A syposium entitled, "Blue Crab Fisheries of North America: Research, Conservation and Management," will take place on April 14-19, in Baltimore, Maryland. The symposium, held in conjunction with the National Shellfisheries Association, will offer reports on the status of the blue crab fishery in individual states, as well as presentations by experts in the areas of blue crab habitat and management.

There will be a $30 registration fee. For information, contact Aaron Rosenfield, Oxford Field Station of the Beaufort Laboratory, NOAA, 904 S. Morris Street, Oxford, MD 21654-9724, phone (410) 226-5193, fax (410) 226-5925.

Outlook for Environmental Prediction and Stewardship: 1996 and Beyond

On January 23, in Washington, DC, Dr. D. James Baker, Undersecretary of Commerce for Oceans and Atmospheres and Administrator of NOAA will speak. Reception at 6:30 P.M., speaker at 7 P.M. To RSVP or for information, contact Donna Weiting, (202) 482-5196.

Biotechnology in the Sustainable Environment

Planned for April 14-17, conference topics will focus on the changing landscape for biotechnology and bioremediation. A particular emphasis will be placed on future prospects for environmental biotechnology relative to changing strategies for bioremediation and an increasing role in pollution prevention.

The meeting will be held at The University of Tennessee Conference Center in Knoxville, Tennessee. If you would like to receive more information, please call (423) 974-0280 or by e-mail at UTConferences@Gateway.CE.UTK.edu.

The Sixth International Symposium on Society and Resource Management: Social Behavior, Natural Resources, and the Environment

This symposium will take place on May 18-23 at Pennsylvania State University, University Park, Pennsylvania. Registrations will be accepted by mail or fax through May 3. Walk-in registrations will be accepted only as space allows. For registration information, contact Sixth ISSRM Symposium, Short Courses and Conferences, Pennsylvania State University, 306 Agricultural Administration Building, University Park, PA 16802-2601, phone (814) 865-8301, fax (814) 865-7050.

Watershed '96

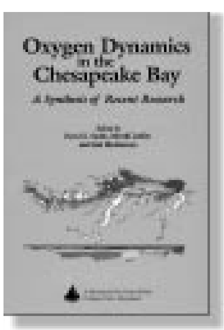
Watershed '96 is being sponsored by NOAA and thirteen other federal agencies and the Water Environment Federation. The conference is scheduled for June 8-12 at the Baltimore Convention Center. Watershed '96 will bring together 1000 managers, scientists and individuals interested in watershed management. For information call (301) 713-3113, ext. 169.

The 10th Workshop of the International Association of Phytoplankton Taxonomy and Ecology

This symposium, in Granada, Spain, will take place on June 21-30. Contact: Miguel Alvarez Cobelas, Centro de Ciencias Medioambientales (CSIC), Serrano 115 dpdo, E-28006 Madrid Spain (Fax: 34-1-5640800) Pedro Sanches Castillo, Dept. Biologia Vegetal, Fac. Ciencias, Univ. Granada, Avda. Fuentenueva s/n E-1800 Granada, Spain. Fax: 34-58-243254.

Publications, Etc.

Oxygen Book in Second Printing



Oxygen Dynamics in the Chesapeake Bay, a synthesis of research findings on processes regulating the depletion of dissolved oxygen in the Bay, is now in a second printing. Its four chapters — on the role of circulation, nutrients and plankton, microbial action and benthic-pelagic interactions — "provide a comprehensive, well-integrated picture of what is known about the circulation and biogeochemical processes controlling dissolved oxygen dynamics," wrote Christopher S. Martens in *Geochimica et Cosmochimica Acta.* "The book should prove useful," he wrote, "to researchers, teachers and managers interested in an integrated approach to understanding the variety of processes at work in estuarine environments."

Published by Maryland Sea Grant College, *Oxygen Dynamics in the Chesapeake Bay*, edited by David E. Smith, Merrill Leffler and Gail Mackiernan, was the result of a six-year research program coordinated by the Maryland and Virginia Sea Grant programs, with support from the National Oceanic and Atmospheric Administration. The book is published in cloth and is available for $24.95.

Also available from Maryland Sea Grant is *Dissolved Oxygen in the Chesapeake Bay: A Scientific Consensus* (UM-SG-TS-92-03), an 18-page report that summarizes a workshop on a number of issues related to depletion of dissolved oxygen, its principal causes, whether its extent and duration has increased historically, the consequences of oxygen depletion for biota and the effect of the Chesapeake Bay Program's 40 percent nutrient reduction goals for improving Bay health. This publication is free of charge. Contact Maryland Sea Grant, (301) 405-6376.

Environmental Finance Course

For the past eight years, the Office of Executive Programs, University of Maryland, College Park, has trained federal, state and local officials in a wide area of topics, including public sector finance. Now that program, which is located in the School of Public Affairs and directed by Susanne Slater, has added an environmental finance course to their curriculum and made it a requirement for those seeking a masters degree.

The environmental finance course will be offered in the spring semester and will be available by satellite to participants around the country in day-long sessions spread over six-weeks. Dr. Allen Schick, of the School of Public Affairs, will serve as a primary lecturer. The Environmental Finance Center (EFC) housed in Maryland Sea Grant, along with other EFCs around the country, will also provide content and lectures for the course. For information call (301) 405-6343.

Exploring the Carolina Coast

The Dismal Swamp. The Underground Railroad. Fisheries conflicts on the Outer Banks. North Carolina's coast serves as a rich historical and ecological canvas for *Coastwatch*, the bimonthly magazine produced by the North Carolina Sea Grant College Program. As Jonathan Yardley noted recently in the Washington Post, residents of the Washington, D.C. metropolitan area, avoiding the crowds of the Mid-Atlantic beaches, increasingly find their way to the Outer Banks and the quiet beauty of the Carolina coast.

With its popularity, the Outer Banks also confronts a range of problems, from conflicts between recreational and commercial fishing interests to pollution from a burgeoning swine industry. *Coastwatch* uses a feature-style format to discuss such issues as limited entry for commercial fisheries, efforts to protect dolphins, aquaculture of hybrid striped bass and mapping the shifting Carolina coast.

The magazine also explores local history, including the so-called Underground Railroad, where Carolina harbors became points of departure for slaves sailing for freedom under cover of darkness, and a look at the historical lighthouses that signaled the danger of the capricious Carolina capes.

To subscribe to *Coastwatch* ($15/year), or to learn more about the Carolina coast, write North Carolina Sea Grant, Box 8605, N. C. State University, Raleigh, NC 27695-8605.

Knauss Fellowship Awarded to MEES Student

Tim Battista, a graduate student in the University of Maryland Marine-Estuarine-Environmental Sciences (MEES) program, is the recipient of this year's Knauss Marine Policy Fellowship.

Beginning in February 1996, Tim will work full time for one year with his sponsor, Dr. Mark Monaco, in the Division of Strategic Environmental Assessment within the National Ocean Service, NOAA, based in Silver Spring. His first project will entail the development of GIS-based "Next Generation" oil spill contingency planning for the Gulf of Mexico and the Southeast Atlantic. Within this context, he hopes to develop methods for integrating the private and public sectors, and to "discover more effective and efficient means of incorporating science into policy-making decisions."

Tim is currently working as a research assistant with researcher Lawrence Harding at Maryland Sea Grant and at the CEES Horn Point Laboratory in GIS-related studies. After the fellowship and completion of his M.S. in the MEES program, Tim plans to continue on to law school to enhance the legal and policy dimensions of his background.

The Knauss Marine Policy Fellowship Program, begun in 1979 and coordinated by NOAA's 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. Over the years, fellows have worked in the legislative and executive branches of the federal government in locations such as the offices of U.S. Senators and Representatives, on Congressional subcommittees, and at agencies such as the National Science Foundation and the National Oceanic and Atmospheric Administration. Fellowships run from February 1 to January 31 and pay a sttipend of $30,000.

The application deadline for next year's fellowship program is September 1, 1996. 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.

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