MARYLAND

*Research, Education, Outreach* *September-October 1996*

MARINE NOTES

*SPOTLIGHT ON RESEARCH*

# Building Better Predictors of Environmental Stress

BY MERRILL LEFFLER

Along the banks of St. Leonard's Creek on the Patuxent River, scientists at the Benedict Estuarine Research Center have begun a long-term study that should greatly improve our ability to manage complex coastal systems like the Chesapeake Bay.

Today's resource managers rely heavily on the use of computer models, such as the Chesapeake Bay Program's Water Quality model, to test various control strategies, for example, the effects of reducing nutrient inputs on dissolved oxygen in bottom water. Over the last decade, continuing research and monitoring in coastal systems — as well as improved computer power — have greatly increased the sophistication of these models. They now mimic, to a degree, basic food web and other ecological relationships, and can be used to predict ecological responses to various management actions.

Nevertheless, existing models are still limited in their predictive accuracy, says Benedict researcher Denise Breitburg, because modelers are unable to include key ecological relationships. That is because the basic research to clarify these often complex relationships has not yet been done — it requires a large coordinated effort of scientists with diverse expertise, it is time-consuming, and it is, therefore, costly.

The major issue is that organisms do not respond to a single factor at a time, but to a suite of stresses acting together. And simultaneously, they are being influenced by the activities of other species, which in turn are being affected by multiple environmental factors.

In the Patuxent River and the Chesapeake Bay, those key factors include the interactive effects of high nutrient loading, toxic contaminants and dissolved oxygen levels which can vary from total absence to super-saturation. How do such complex interactions reverberate though the ecosystem? How does the system respond, from clouds of algae to schools of large fish? And most importantly, how can we achieve a basic understanding of these responses so that we can better predict environmental change and improve management of our coastal ecosystems?

## A Question of Complexity

Scientific research has clarified a good number of cause-and-effect relationships when it comes to individual environmental stresses such as high nutrient loading and low dissolved oxygen. We also know how heavy nutrient loading and changing temperature affect phytoplankton production, or how phytoplankton may respond to contaminants under a range of oxygen conditions.

But the open environment is considerably more complex: organisms from phytoplankton to sediment-dwelling

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Sandy Rodgers

*How do high nutient loads interact with trace metals and varying concentrations of dissolved oxygen to affect the Chesapeake Bay and other coastal systems? Denise Breitburg explains to Sea Grant's Gail Mackiernan how experiments in an array of twenty controlled ecosystems (called mesocosms) will provide the first findings to answer this question.*

# Stress, continued

worms to oysters to anchovies and striped bass are all responding to multiple stresses that continually occur in unknown combinations.

Until now, controlled experiments designed to measure the effects of such interactive stresses, under different conditions, have been limited — and predictive models are the poorer.

"Clearly," says Donald Scavia of the National Oceanic and Atmospheric Administration's Coastal Ocean Program, which is funding the project, "the interactions are what we know least about. If you base management decisions on isolated cause-and-effect relationships, you're missing the important interactions."

It is those interactions, says Denise Breitburg, that scientists at the Benedict lab, along with other researchers, are after. And in a big way.

A wide-ranging multi-disciplinary team has begun intensive experiments on the ecological effects of multiple stresses that will run over five years, experiments that make use of mesocosms and large field enclosures set in the Patuxent River.

Researchers will model experimental results and then begin linking those results to a network of other models designed to predict the effects of management actions on the Patuxent River.

***"These experiments will not only help us compare the effects of single and multiple stressors, they will enable us to test the importance of complexity itself."***

"If all goes well," says Jim Sanders, director of the Benedict lab, "then for the Patuxent and other coastal systems, we'll have a mechanism for being able to better predict what might happen within a system. "And," Sanders adds, "we'll also be able to pragmatically step back from those predictions and ask if a management response is worth the cost."

The goal is ambitious and chancy. "But research is all about gambling," says Donald Scavia, "and there has been no such program to deal with interactions on this scale." After all, he says, "this project is looking at multiple impacts on a full spectrum from mesocosms to field enclosures to field studies to modeling for watershed dynamics to looking at the economic impacts of multiple stressors."

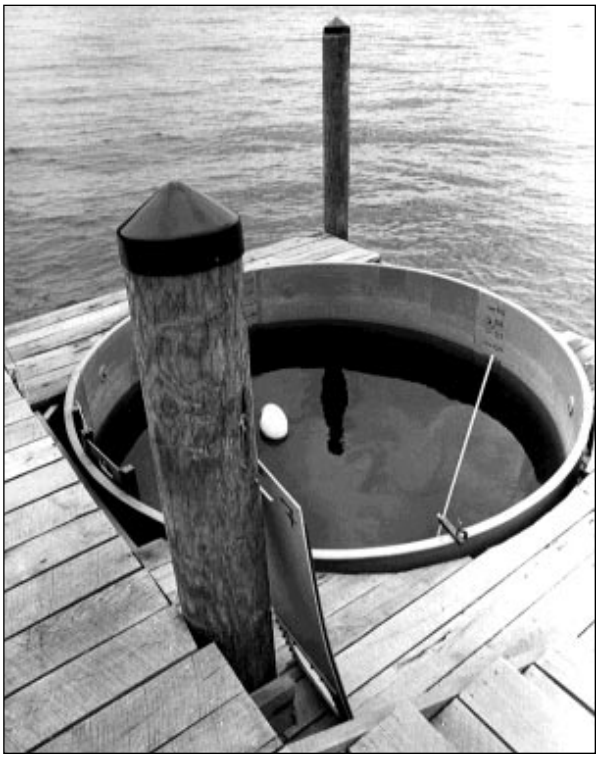
It is a challenging undertaking, which begins with adept experimental design.

### Designing Experiments

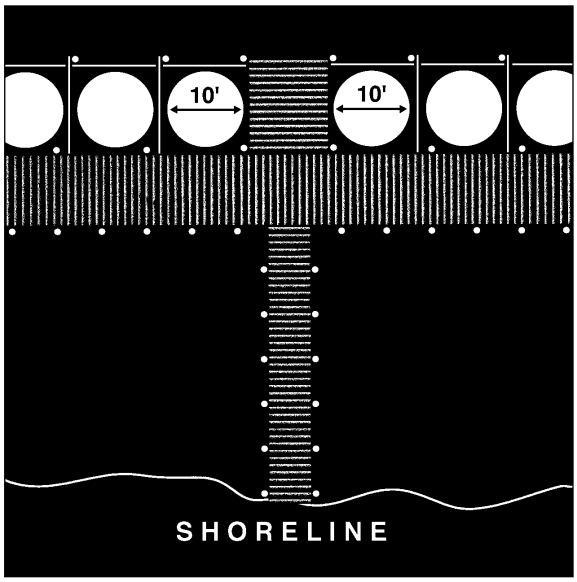
"The centerpiece of our study," says Denise Breitburg, "is a series of mesocosm and large-enclosure field experiments." Mesocosms have been designed to run controlled studies of single and multiple stressors at different levels of ecological diversity, from very simple to more complex environments. The larger field enclosures will actually be located in the Patuxent River, so that researchers can examine the impacts of multiple stressors on environments of greater complexity than the mesocosms.

"These experiments" says Breitburg, "will not only help us compare the effects of single and multiple stressors, they will enable us to test the importance of complexity itself."

For Breitburg, there are at least several issues that involve ecosystem complexity. The first involves the effects of multiple stressors such as high levels of toxic chemicals and nutrients, and low dissolved oxygen: their interactions



Sandy Rodgers




*Large field enclosures in the Patuxent River like the one shown at left, one of two set up this summer at the Benedict Estuarine Research Center, will enable scientists to simulate the river's complex biodiversity. By 1997, ten to twelve of these field enclosures will hold experiments which will assess the cumulative impacts of nutrient and trace metal loading (see diagram above, adapted from the original schematic by Jeff Smallwood).*

# From Ecology to Economics

If the goals of the Benedict project were only to improve scientific understanding of systems like the Patuxent River, they might be ambitious enough. And certainly, those are some of the major goals. "Five years from now," says Denise Breitburg, "we should have a much better understanding of how the cumulative impacts of nutrients, trace metals and low dissolved oxygen levels affect the [Patuxent] ecosystem." And we should also have a better understanding, she says, "of how much useful information you can get from simple versus complex experiments."

But NOAA's Coastal Ocean Program, which is supporting this project, is after much more, says Donald Scavia — in the long run, quantitative tools that resource managers can use to assess the potential effects of different management actions. More than that, he says, policy makers need to be able to assess the economic impacts of those actions — and this study, says Scavia, aims to do that as well.

From experiments on the response of phytoplankton to multiple stressors in one cubic meter mesocosms to predicting economic impacts of management actions for the Patuxent River — such is the breadth of the Benedict project. It is that ambitious uniqueness that excites Doug Lipton, a resource economist at the University of Maryland College Park and coordinator of the Sea Grant Extension Program.

One of those economic impacts is the effect of changing water quality conditions on the abundance of recreational fish and what those changes could mean for sports fishing.

Lipton is part of the research team that includes experts in field measurements and monitoring, ecological modeling, watershed studies, fisheries ecology and economics. These wide-ranging experts come from the Smithsonian Environmental Research Center, the State University of New York-Buffalo, the University of Virginia, the University of Connecticut, the Maryland Department of the Environment, and SENES (Specialists in Energy, Nuclear and Environmental Sciences) in Oak Ridge, Tennessee.

Skip Brown

If the project is successful, says Lipton, "for the first time we'll be able to say that reduction of nutrients has some predictable implications in economic terms." In this case, Lipton's aim will be to relate how different nutrient and toxic loads — under current, improved and worsened conditions — impact the availability of recreational fish. He will then be able to estimate the economic consequences of the changes in sport fishing that will result under those different conditions.

It is a long route to get from phytoplankton to striped bass. Can it be done? Scavia is not sure whether it will be possible to quantify and deal with cumulative stress over such scales. "But given the needs of better managing our coastal systems," he says, "we have to try some new scientific and economic approaches."

"At the very least," says Scavia, "we are seeding the future for what we will have to be able to do."

could prove more devastating than one might predict when looking at those same stresses individually.

A second issue involves the effect different levels of ecological complexity may have in modifying multiple stresses, for example, does a more complex, or diverse, ecosystem differ in its capacity to handle multiple stresses?

A third issue has to do with how much useful information the different mesocosm environments can give, compared, for example, with the large field enclosures.

The starting place for these questions are 20 one-cubic meter mesocosms — they have been designed to run replicate experiments that span five levels of complexity, from environments containing single-celled phytoplankton to environments with fish and bottom dwelling organisms.

- **First level:** Phytoplankton
- **Second level:** Phytoplankton + copepods
- **Third level:** Phytoplankton + copepods + fish
- **Fourth level:** Phytoplankton + copepods + fish + sediments
- **Fifth level:** Phytoplankton + copepods + fish + sediments + benthos

To sort through the effects of cumulative stress, researchers need to distinguish how each of these environments responds to single stresses, for example, to different nutrient concentrations, then to different trace metal concentrations. The metal concentrations are based on the findings of Benedict scientist Gerhardt Riedel who has taken intensive measurements seasonally throughout the Patuxent River.

Researchers have already begun blending mixtures of nutrients and trace metals in the mesocosm experiments.

Each year, experiments will be run several times over five-week periods

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## Stress, continued

— the reason, says Breitburg, is to account for variations that occur naturally and seasonally.

What is the relation of mesocosms to the Patuxent environment? How well will the findings — and the computer models that are developed to make ecological predictions from those findings — reflect what managers can expect in the Patuxent?

One way the Benedict researchers propose to answer such questions is with experiments in larger tanks, tanks more diverse in ecological complexity and therefore more representative of the Patuxent River.

To do this, says Breitburg, they conducted trial runs this summer with two 10-cubic-meter tanks that they placed near shore in the Patuxent. These tanks, which filter water from the river, make it possible to increase species diversity: sandy areas, oyster reefs, a wider variety of fish, benthic invertebrates, clams and oysters.

By next summer, ten more tanks will be operational. Together with the mesocosm studies, says Jim Sanders, the experimental project is "immense." It involves a "careful dance of many institutions and senior investigators with different expertise who are trying to get information on time scales that are interpretable."

As a scientist with expertise in the effects of trace contaminants on phytoplankton, he has had to "step back," he says. "I had to open up my biases and think of what a fish ecologist wanted out of this study, what a modeler wanted out of it. My personal interest became more subservient to the whole."

The experiments, as he says, are only the first stage — other researchers waiting for the numbers so that they can then link the results in St. Leonard's Creek with the entire Patuxent River. Their findings will shed new light not only on the workings of Chesapeake creeks and rivers but on coastal systems throughout the world. ■

# Planting Oysters in the

Jackie Takacs had spent the whole day standing in the Choptank River, and now the tide was cresting at about a foot and a half above normal.

The waves moving across the surface of the river were hitting her at neck level, and she literally had to dive down to find the remaining bags of oyster shell she had been helping to move all day long. Sea nettles, which had drifted in with the tide, were waiting for her when she surfaced, draping their stinging tentacles over her hair, her face, her arms.

Anyone else might have considered this a rather dismal situation. But for Takacs it was a great day.

For more than a month, Takacs, an oyster hatchery assistant, had worked with Sea Grant Extension specialist Don Meritt and others at the Center for Environmental and Estuarine Studies (CEES) Horn Point Oyster Hatchery to set oyster larvae — despite the fact that low salinities had made this effort extremely difficult. According to Don Meritt, salinities in their section of the Choptank River reached only 7 parts per thousand (ppt) by mid-summer, and barely reached 7.5 to 8 ppt as summer drew to a close. "About 8 to 10 ppt seems to be the magic number for setting oysters," says Meritt.

Last year, mid-summer salinities reached 9 to 10 ppt up river, at the newly reclaimed oyster bar where the oyster spat are taken to mature. In a "normal" year (and Meritt cautions that there is no such thing as a normal year, since climatic patterns swing from wet to dry years) the salinity may hover at 12 to 14 ppt in their region of the Choptank. Last year, which was at least a bit more "normal," hatchery operators began setting oysters at the beginning of the summer. This year, they had to wait.

Although production setting of oysters did not start until the beginning of August this year, by the time a month had passed the Horn Point Hatchery had set 5 million oysters — twice the amount they set last year. This is a remarkable achievement, especially in a low-salinity year.

"We are really proud of what we were able to do this year," Meritt says, and he gives a great deal of credit to Takacs.

Their success was due to a number of factors, but according to Takacs, the most important ingredient was "tender loving care."

### Far More Than Oysters

Although spawning and setting oysters have occupied both Takacs and Meritt for much of the year, they have also helped to educate a wide range of people about oysters and their importance in the Chesapeake Bay. "We spent 20 days working with teachers and students this past year," says Takacs, who estimates that well over 500 people passed through the hatchery, from kindergarten students to the University of Maryland System Board of Regents.

In September, Takacs called Doug Romano, a teacher at Dorchester High School, to ask for high school student help with moving oysters from grounds off Horn Point to well up the Choptank River — the project is part of a larger effort to rebuild oyster bars in the Chesapeake Bay. So far the bar looks promising, according to Kennedy Paynter, University of Maryland College Park researcher who is working with Meritt on the project. Last year's spat on the

# Chesapeake

BY JACK GREER

***The year of '96 will go down as a cool, wet one, and a bad time for anyone trying to set oysters in the Chesapeake region. Oyster hatchery operators up and down the Chesapeake Bay, especially in Maryland where the water is fresher, found it extremely difficult — if not impossible — to set oysters in the low salinity water. Don Meritt (shown above in the field and in the hatchery), of the University of Maryland's CEES Horn Point Lab and a Sea Grant shellfish specialist, was one person who succeeded. He and Jackie Takacs, after overcoming numerous stumbling blocks, finally set even more oysters than they did last year. In 1995, from June through August, they set some 2.5 million oyster spat. In 1996, and not starting until the beginning of August, Meritt and Takacs set more than 5 million oysters before the summer ended.***

upriver oyster bar are showing a sixty percent survival rate.

One group in particular, the Living Classrooms Foundation, has worked closely with the Horn Point Hatchery, bringing students both from "at-risk" groups and from "gifted and talented" classes. All of them work hard learning about oysters and ecology in an intense hands-on program.

"A mother called me after the oyster planting this year," Takacs says, "because her son had left his shoes." The parent said that her son had arrived home exhausted but excited after a long day of moving oyster shells.

Working together and building team spirit is one of the goals of the Living Classrooms Foundation. To help foster this sense of teamwork, Takacs divided the students into teams this past summer and had them examine a four-year-old oyster reef off the beach at Horn Point. The students studied oysters and their habitat and the organisms growing on and around them. "I asked the students to think about what might be eating the oysters," she says, "and what might be eating what is eating the oysters."

The students studied the spat being raised in the hatchery's large tanks, called upwellers. "I asked them whether we could just plant them [the tiny spat] in the Bay," she says. After looking at the four-year oyster bar, the students could see that without being set on other shell (cultch), the spat would simply sink in the mud or become easy food for predators.

As well as teaching students about the biology of oysters, she has put their energies to good use, moving shell bags, counting spat and calculating survival rates. She has recruited graduate students at Horn Point to help bag shell — something they can do throughout the year.

Says Meritt of Takacs's contribution to this year's successful oyster hatchery production: "She did it. She basically did it." ■

# High School Aquaculture

BY J. ADAM FREDERICK

Students at South Carroll High School in Carroll County, Maryland, have been designing innovative aquaculture systems in a unique research course that challenges them to solve practical problems while working as part of a team.

The aquaculture projects provide a means for integrating such subjects as engineering, math, computer-aided drafting and composition with concepts of water quality and biology.

Under the direction of award-winning teacher Bob Foor-Hogue, the students have built seven recirculating aquaculture systems, ranging in size from 150 to 550 gallons. In addition to designing the systems, the South Carroll students produce multimedia programs and write grants to support the funding for these projects — they have been successful for each school year.

The Hall of Exploration at the Columbus Center in Baltimore will incorporate an aquaculture exhibit that is being designed by the South Carroll students as part of an exhibit highlighting aquaculture research at the University of Maryland Biotechnology Institute's Center of Marine Biotechnology — it will also illustrate how aquaculture provides an exciting way to study many aspects of science.

Visitors to the Hall will be able to see a work in progress as students and teachers collaborate in constructing and stocking the systems with such fish as yellow perch, trout and shad.

*Editor's Note: The Columbus Center's National Center for Marine Biotechnology Research and Education will open a public Hall of Exploration in spring/summer of 1997. Maryland Sea Grant Extension Education Specialist J. Adam Frederick is based at the Columbus Center, developing and implementing education programs.*

# Mathias Medal Awarded to Outstanding Scientist

Clifford W. Randall, environmental and civil engineer at Virginia Tech, has received the 1996 Mathias Medal in recognition of his outstanding contributions to the restoration of the Chesapeake Bay. The medal is awarded jointly by the Sea Grant programs of Maryland and Virginia, and the Chesapeake Research Consortium (CRC). EPA Administrator Carol Browner presented Randall with the Mathias Medal at the annual Chesapeake Executive Council meeting, held this year in Harrisburg, Pennsylvania. Browner praised Randall for his research and education efforts, singling out his contributions in the area of biological nutrient reduction technology for waste treatment plants.

Randall is current chair of the Chesapeake Bay Program's Scientific and Technical Advisory Committee, and is widely known for his leadership in applying high quality science to answer practical needs.

The Mathias Medal was established to recognize researchers both for excellence in marine science and for fundamental contributions to our overall understanding of the Chesapeake. It is named for Charles "Mac" Mathias, former U.S. Senator from Maryland who is often called the "father" of the Chesapeake Bay restoration effort.

## Deborah A. Bronk Receives ASLO's 1996 Lindeman Award

The 1996 Raymond L. Lindeman Award has been presented annually since 1987 to recognize an outstanding paper by a young limnologist or oceanographer. This year's award was presented to Deborah A. Bronk for a her paper on nitrogen processes, coauthored with P.M. Glibert and B.B. Ward and published in *Science* magazine.

In her dissertation research at the University of Maryland System's CEES Horn Point Environmental Laboratory Bronk focused on the relationship between phytoplankton growth and nutrient dynamics in the ocean. In a series of papers (Bronk and Glibert, 1993, 1993a,1994) culminating in the 1994 *Science* article, she was able to measure the release of dissolved organic nitrogen from phytoplankton and was able to estimate the contribution of this flux mechanism to mass balance experiments.

ASLO, the American Society for Limnology and Oceanography, presents the annual award. The citation for the award-winning paper is: Bronk D.A., P.M. Glibert and B.B. Ward, 1994, Nitrogen uptake, dissolved organic nitrogen release, and new production. *Science* 265: 1843-1846.

## Southern Maryland Heritage Partnership Releases Area Plan

The Southern Maryland Heritage Partnership recently released a plan detailing the steps it will take to balance the preservation, conservation and development of natural and cultural resources in Calvert, Charles and St. Mary's counties. Located on the Chesapeake Bay and the Potomac and Patuxent rivers, these counties are three of the fastest-growing in the state.

To obtain a free copy of *The Southern Maryland Heritage Area Plan — Where Time and Tide Meet*, call (410) 535-4583 in Calvert County; (301) 645-0551 in Charles County; (301) 475-4626 in St Mary's County; or call the Chesapeake Bay Program Office, 1-800-YOUR-BAY.

The partnership expects to use state and federal assistance programs to begin implementation of the plan.


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## Maryland Sea Grant to Issue RFP

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, according to Assistant Director for Research, Gail B. Mackiernan. Mackiernan notes that the RFP will be distributed later this year because of scheduling changes at NOAA's National Sea Grant Office. In response to a recent National Research Council review of the Sea Grant Program, the National Sea Grant Office is reducing the time between requests for proposals and the awarding of grant funds. NOAA will also eliminate duplicative review procedures, and will be moving all Sea Grant programs around the country to a similar schedule to encourage cooperative projects and to simplify the grant management process.

Those with address corrections, or who feel that they may not already be on the RFP mailing list, should call Ellen Lundgren at 301-405-6371. The RFP will also be posted on the Sea Grant Web Site (http://www.mdsg.umd.edu).

## Exotic Species Web Site Online

A new web site offers science-based information on zebra mussels and other nonindigenous species thanks to the Great Lakes Sea Grant Network. The site contains a comprehensive collection of research publications and education materials produced by Sea Grant programs across the country.

This site is useful for industrial and municipal water users, shoreland property owners, boaters, resource management agencies, students, teachers, outreach professionals and researchers.

Although currently focused on zebra mussels, the site also contains Sea Grant information on four other invaders, the Eurasian ruffe, the round goby, the sea lamprey and the spiny waterflea.

The address is: http://www.ansc.purdue.edu/sgnis/. A CD-ROM version will soon be available for those users without Internet access.

## Seminars

### *Chesapeake Biological Lab*

*These seminars will be held at the Chesapeake Biological Laboratory's Coastal Chemistry Laboratory at 11:00 am.*

November 15 — Dr. Michael Newman (University of Georgia), Questioning Current Paradigms in Ecotoxicology

November 22 — Dr. Kyle Hoagland (University of Nebraska), Pesticide Effects on Aquatic Communities: Higher Order Interactions

December 6 — Dr. Fred Pinkney (USFWS), Ecological Assessment of PCB and DDT in the Potomac River

### *Maryland Department of Natural Resources*

*The Assessment Service Seminar Series is held in the Tawes Building conference room in Annapolis at 12:00 noon.*

November 14 — Mitch Keiler (Maryland Department of the Environment), The Hydrogeomorphic Method for Wetlands Classification and its Application to Coastal Plain Stream Systems

December 12 — Margaret Palmer (University of Maryland), Community and Ecosystem Ecology of Benthic Invertebrates in Warmwater Streams

January 17 — David Secor (University of Maryland), Effects of Hypoxia and Temperature on Growth, Survival, and Respiration of Juvenile Atlantic Sturgeon

## "A Celebration Of Biological Science"

On November 18-19 Dr. Rita R. Colwell, President, University of Maryland Biotechnology Institute; Dr. David J. Ramsay, President, University of Maryland at Baltimore; and Dr. Robert C. Gallo, Director, Institute of Human Virology will host a gala inauguration of the Institute of Human Virology.

At this historic gathering a number of luminaries of 20th-century biological research will celebrate pioneering advances and contributions toward our understanding of life as we approach the next millennium.

Distinguished speakers and presenters will include E. O. Wilson, David Baltimore, Freeman Dyson, and other well-known experts, such as: Hilary Koprowski, George Klein, Erling Norrby, Tasuku Honjo, Judah Folkman, Maurice R. Hilleman, J. Craig Venter, Theodor O. Diener, Hans Wigzell, Alexander Rich and Manfred Eigen.

The inauguration will take place at the Medical School Teaching Facility, University of Maryland at Baltimore School of Medicine, 685 West Baltimore Street. For information, call (410) 706-8614 or e-mail: schorr@umbi.umd.edu.

The inauguration is organized by Dr. Hilary Koprowski and Dr. Stanley Prusiner in commemoration of the opening of The Institute of Human Virology in Baltimore.

# Conferences

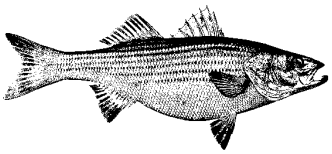
### *Conference on Shellfish Restoration*

November 20-23. Hilton Head, South Carolina. The 1996 conference will focus on restoration of molluscan shellfish and their habitat. For more information, contact: Elaine Knight, South Carolina Sea Grant Consortium, 287 Meeting Street, Charleston, SC 29401, (803) 727-6404, Fax (803) 727-2080, e-mail: knightel@musc.edu.

### *Third Marine and Estuarine Shallow Water Science and Management Conference*

December 1-5, 1996. Holiday Inn on the Boardwalk, Atlantic City, New Jersey. The 1996 conference will include session topics related to specific habitat in the shallow water zone identified by the conference Steering Committee to be of critical importance along in coastal regions. For more information contact: Edward Ambrogio (215) 597-3697.

### *Spatial Data and Remote Sensing in Invertebrate Fisheries Habitat, Research and Management*



April 19-20, 1997. This workshop will be held at the Holiday Inn in Fort Walton Beach, Florida. Suggested topics include: detection of plankton blooms; invertebrate habitats (including reefs) and migrations; physical and chemical habitat dynamics; stock location, abundance and identification; vessel tracking in commercial fisheries. For further information, contact Gary Smith, Cooperative Oxford Laboratory, 904 S. Morris Street, Oxford, MD 21654.



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