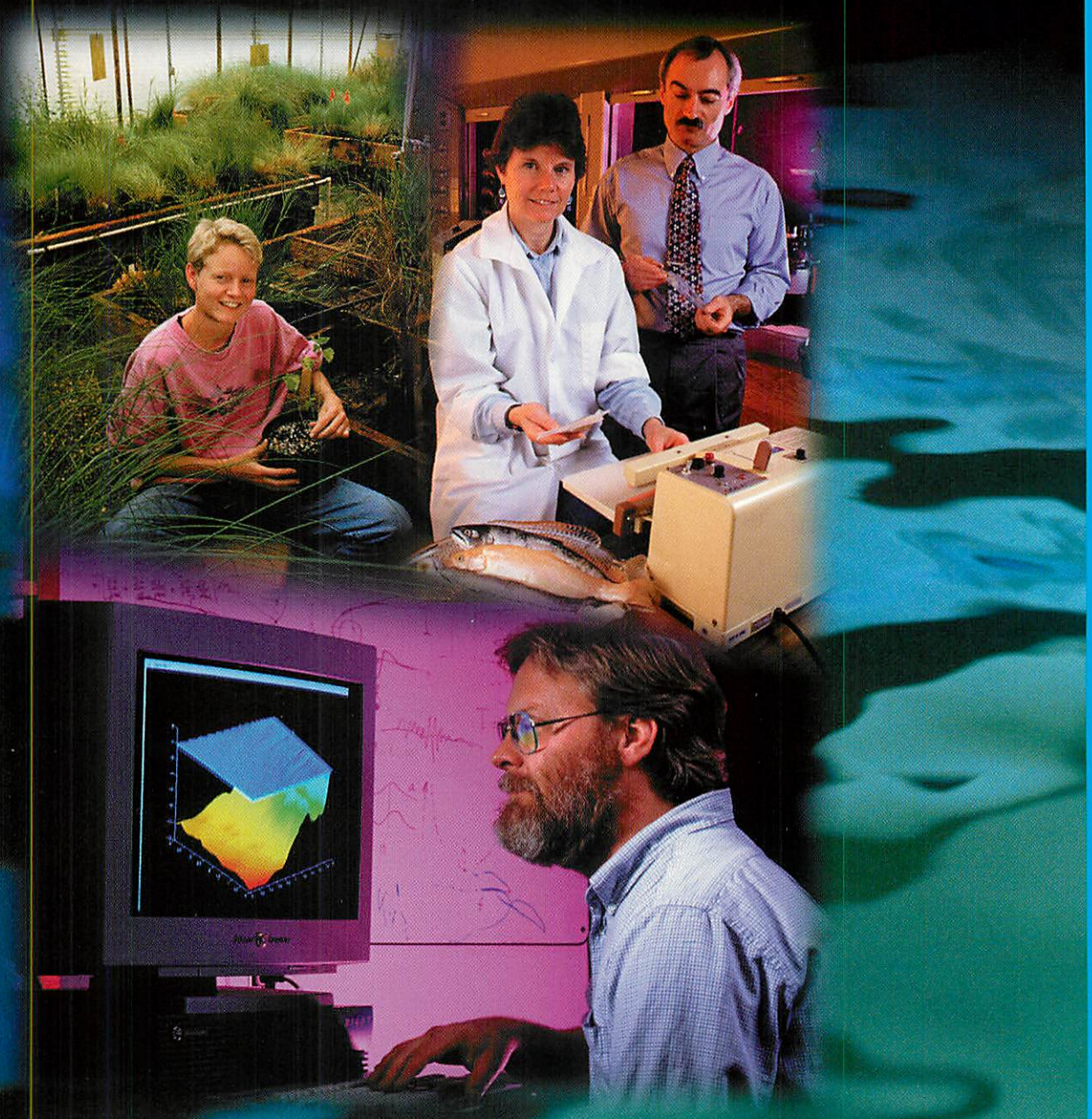
UNIVERSITY OF DELAWARE SEA GRANT

REPORTER

Volume 14, No. 1 — *Special Issue 1995*



On Course for Progress

Annual Report ◆ University of Delaware Sea Grant College Program

UNIVERSITY OF DELAWARE SEA GRANT
REPORTER

UNIVERSITY OF DELAWARE SEA GRANT REPORTER is published twice a year by the University of Delaware Sea Grant College Program to inform the public of marine research, issues, and events that affect Delaware.

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The University of Delaware Sea Grant College Program is a member of a national network of universities committed to research, education, and technology transfer designed to meet the changing needs of our ocean, coastal, and Great Lakes regions. The program is financially supported by the National Oceanic & Atmospheric Administration, U.S. Dept. of Commerce; the State of Delaware; and the university. Dr. Carolyn A. Thoroughgood, *Director.* Mr. Richard W. Tarpley, *Executive Director.*

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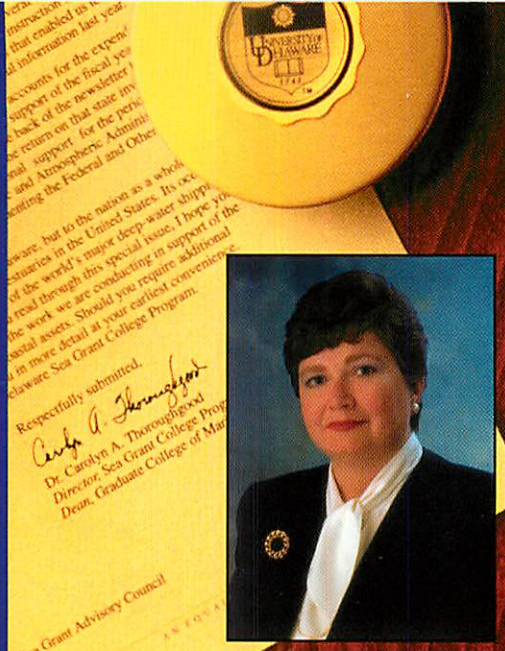


When the U.S. Congress founded the National Sea Grant College Program in 1966, it sought the academic power of the nation's universities to accelerate the research, education, and public service efforts aimed at creating tangible benefits for the coastal environment and humankind.

Since our first project in 1968, the University of Delaware Sea Grant College Program has produced important results for Delaware, ranging from the development in our early years of surgical sutures and other medical products from the chitin in blue crab shells, to the recent establishment in Lewes of Composite High Pressure Technologies, Inc., which grew from a Sea Grant project on wave energy to a high-technology company that has created the DELPUMP for use in mining, manufacturing, water purification, and other operations.

During the past year, as part of our biennial proposal process, Delaware Sea Grant underwent rigorous review by a federal panel of coastal experts. The result was a project award of more than $2 million over the next two years, which is supporting 15 new research projects in marine biotechnology, coastal engineering, environmental studies, seafood science and technology, and marine policy; the hands-on training of graduate students; and public service efforts by the Marine Advisory Service and Marine Communications staff targeted to provide thousands of Delawareans with timely, useful information on subjects ranging from aquaculture to ecotourism.

Recently, Delaware Sea Grant received notification of an additional $300,000 award from the National Sea Grant College Program over the next three years. We successfully competed against 28 other Sea Grant programs in the nation to garner this funding for new, interdisciplinary initiatives in coastal ecosystems health that will key on the development and practical application of satellite technology to pressing resource management issues in the Delaware River and Bay, and Delaware's Inland Bays.

This report highlights selected accomplishments made by our scientists, students, and outreach staff during the past year. As we set our course at a time in our history as dynamic as the sea itself, we will continue to address coastal challenges and opportunities that will bring real benefits to Delaware, its environment, citizens, and economy.

Dr. Carolyn A. Thoroughgood
Director, Sea Grant College Program
Dean, Graduate College of Marine Studies

Shoring Up the Coast

Knowing more about how waves behave can help us predict — and cope with — shifting shorelines.

The focal point of Delaware's beach replenishment efforts is the high-tourism corridor from Rehoboth Beach to Fenwick Island. In 1994, the state spent $2.8 million on major renourishment projects here, which are conducted by the Shoreline and Waterway Management Section of the Department of Natural Resources and Environmental Control. Delaware's beaches attract more than 2 million visitors each year. In a recent Sea Grant survey of 562 beach visitors, 79% said they would be willing to contribute to an annual beach protection fund.

Life is a beach," the T-shirt proclaims, acknowledging the pleasure and relaxation most of us associate with the shore. For coastal managers, however, the slogan is a statement of their livelihood, as they play a tug of war with wind, wave, and tide to keep wide, sandy beaches in place.

According to Robert Henry, who oversees the Shoreline and Waterway Management Section of the Delaware Department of Natural Resources and Environmental Control, Delaware spends an average of $1 million per year on beach nourishment, in which sand offshore is pumped back onto eroded beaches. Last year, Henry says, the budget was unusually high — $2.8 million—due to several long-planned replenishment operations at Dewey Beach, Bethany Beach, South Bethany Beach, and Fenwick Island.

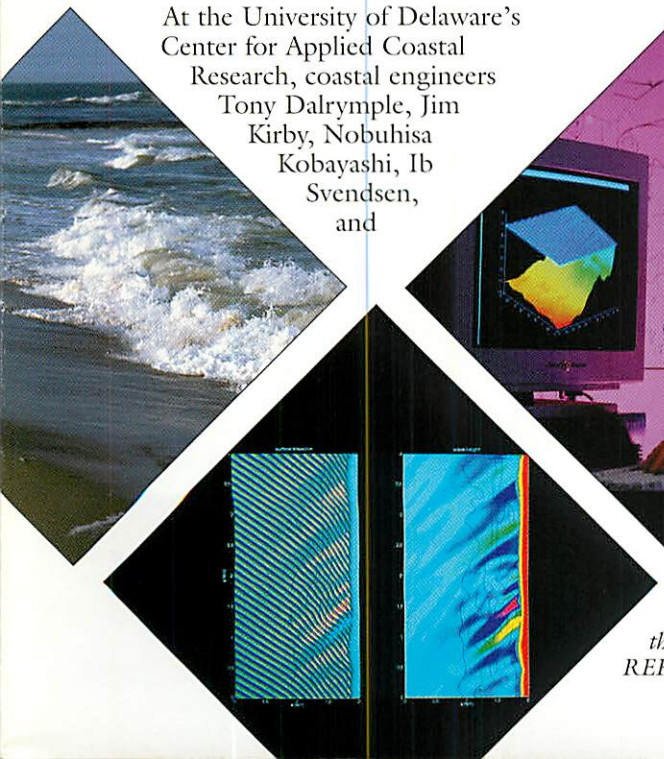
As the cost to maintain our beaches climbs into the future, in response to major storms as well as sea-level rise of now about a foot per century, beach managers increasingly will need long-term models of the shoreline to assist them in determining whether to replenish the beach, build structures like offshore breakwaters to protect it, plan a strategic retreat, or simply let nature take its course.

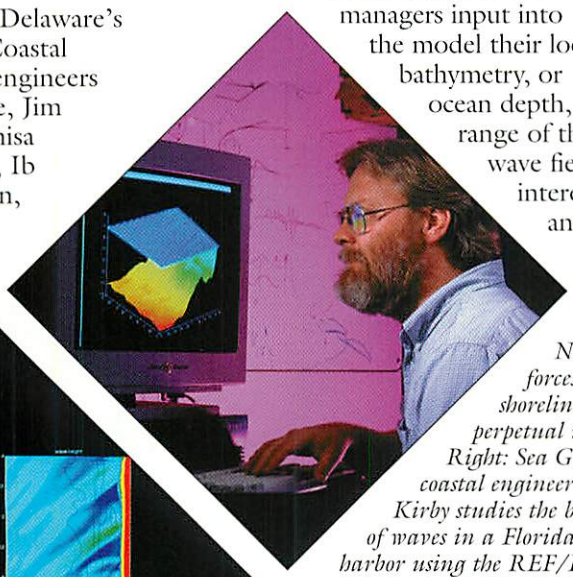
At the University of Delaware's Center for Applied Coastal Research, coastal engineers Tony Dalrymple, Jim Kirby, Nobuhisa Kobayashi, Ib Svendsen, and their students are working to develop computer models that can eventually help us predict the behavior of the shoreline under a variety of situations and time scales.

But determining how the coastline will behave under any scenario requires an understanding of the many forces that impact the beach, including breaking waves, wind, tidal currents, and sea-level rise, which all must be analyzed, quantified, and verified in order to build accurate models.

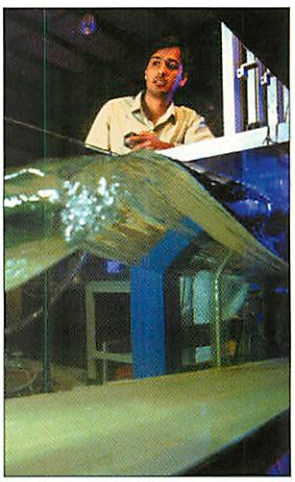
Currently, the coastal engineering group is making steady progress in the development of computer models that numerically represent wave behavior in both the open sea and near shore. Using devices such as the directional wave basin, a 66-foot-long, 66-foot-wide, and 3.3-foot-deep apparatus equipped with 34 wave-generating paddles, the team can simulate the coastal sea and apply the principles of physics and mathematics to convert wave action into useful coastal planning and design tools.

For example, the group's popular Refraction/Diffraction (REF/DIF) model can show how waves behave near harbors, inlets, and islands. Coastal engineers and managers input into the model their local bathymetry, or ocean depth, the range of the wave field of interest, and several other parameters, and the computer produces a color profile of local wave conditions. The model can be used to determine, for example, what changes in wave height might occur if a new channel were dredged near the harbor, helping firms to test structures or strategies before they are implemented. This helpful tool is being used by coastal engineering firms and government agencies in the United States and abroad.





Left: Natural forces keep shorelines in perpetual motion. Right: Sea Grant coastal engineer Jim Kirby studies the behavior of waves in a Florida harbor using the REF/DIF computer model. Shown below is a one-dimensional view, looking down on the sea, of the wave profile revealed by the REF/DIF model.



Graduate student Arun Chawla simulates the interaction of waves and currents near the shoreline in a wave tank at the Ocean Engineering Lab in the University of Delaware Center for Applied Coastal Research.

While the complex nature of coastal processes requires patient scientific unraveling, the ultimate goal of Delaware Sea Grant coastal engineers is to keep building their knowledge of coastal processes, force by force, to develop a predictive model that can show how the shoreline will evolve over time—critical information for coastal managers facing tough, costly decisions about future erosion control and for citizens who live and play near the water's edge.

Growing the Plants of Promise

Genetically engineered plants may help transform wasteland into farmland in the future.

Salt—the residual product of long-term irrigation and overfertilization—is taking its toll on the world's arable land. In the United States alone, nearly 13 million acres of irrigated land have been damaged by salinization, thwarting the growth of corn, wheat, and other important crops.

For example, many premiere agricultural areas, such as California's San Joaquin Valley, have severe salt problems. And even in some coastal states, including Delaware, where annual rainfall is high, at about 40 inches, salt problems have developed in agricultural land due to sea-level rise and salt-water intrusion. Coastal fields that have been farmed for more than a century are now subject to flooding with estuarine water during storms and will no longer support traditional crops.

However, some plants thrive in saline conditions, and we need look no further than the salt marshes along the Delaware coast to find them.

Salt-meadow hay, smooth cord grass, and other marsh plants, called *halophytes,* have the unique ability to tolerate salt. Botanists Jack Gallagher and Denise Seliskar of the Halophyte Biotechnology Center at the University of Delaware Graduate College of Marine Studies are working to understand this complex trait in their quest to develop plants capable of restoring salty land to its former productivity.

The Sea Grant researchers are addressing the development of salt-tolerant crops from two directions. The first is to turn salt-marsh plants into food and forage crops. Through a decade of research using tissue-culture techniques to genetically select halophyte varieties that have high nutritional value and taste (see photos), the scientists have developed halophyte hay, grain, and vegetable crops, which are now being tested in China, Egypt, Israel, Pakistan, Thailand, and the United States in Delaware.

The scientists also are using genetic engineering to improve halophytes for crop use. Specifically, they are incorporating a gene for cold tolerance into

In the Halophyte Biotechnology Center at the University of Delaware Graduate College of Marine Studies in Lewes, botanist Denise Seliskar examines one of dozens of beakers containing salt-marsh plant cells. The shaker table keeps the cells suspended in growth medium. Each cell mixture will be transferred to a test tube where it will form a callus, a mass of undifferentiated plant tissue from which many new plants can be grown. Such tissue-culture techniques help "speed up" nature to produce many plants with many different genetic characteristics, accelerating scientists' work to select plants with desirable traits such as high seedling vigor. Many of the salt-marsh plants surrounding graduate student Antonia Witje in the halophyte greenhouse (above) have been regenerated using this technique.

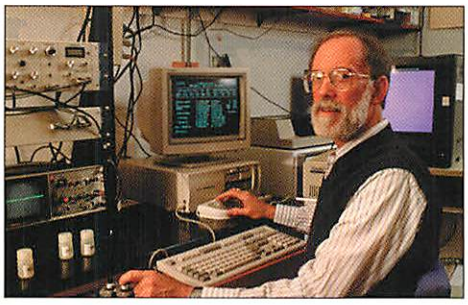
one species so that it can be grown in cold climates as grain. The DNA from another organism is transferred to the halophyte by firing small DNA-coated particles into the cells with a device similar in concept to a BB gun or by using a nonvirulent strain of a plant disease-causing bacteria as a carrier.

Approaching the development of salt-tolerant crops from another direction, the researchers are working to understand the complex mechanisms of salt tolerance in halophytes so that this unique ability can be infused into traditional crops like corn and wheat, enabling us to realize an elusive dream for agriculture in saline areas worldwide.

Currently, the Sea Grant research team is comparing two common marsh species—salt-meadow hay, a relative of maize and other crops, and seashore mallow, a relative of cotton and okra.

Salt-meadow hay has salt glands that help it excrete sodium as it takes in seawater, while seashore mallow, a species without salt glands, appears to contain a sodium exclusion mechanism in its roots. By studying these plants at various levels of organization—from cells, to roots and shoots, to whole plants—the scientists will lay the groundwork for isolating salt-tolerance genes, a critical goal if we are to regain growing areas lost to salt.

Breaking the Chain of Rust



Immerse a sample of stainless steel in any untreated fresh or seawater and within hours, it may be covered with bacteria that can set off a chemical chain of events ending in metallurgical disaster: rust.

Stephen Dexter (above), a corrosion engineer at the University of Delaware Graduate College of Marine Studies, is one of only a few scientists in the world who are examining bacteria's influence on corrosion for the benefit of industries and agencies ranging from steel manufacturers to the U.S. Navy.

His current project is to determine if bacteria cause the rapid corrosion that occurs at stainless steel welds. For example, when a new stainless steel tank or piping system is filled with fresh water to test for leaks before being placed into service, discrete biodeposits form along the steel welds if the water is not removed within a few days. Stainless steels ordinarily are considered to be resistant to corrosion in low-salinity waters, but under the bacterial deposits at the welded sites will be small pits, or pinholes, that open into vast cavities where the tank or pipe has been ravaged by rust.

In finding out whether bacteria initiate the corrosion attack or if these microbes simply attach and grow after rusting has begun, Dexter will gain needed data in advancing our knowledge of one of the most troubling forms of corrosion and how we can control it. Currently, corrosion costs the United States an estimated $150 billion per year.

▲ *Metals in water may become home to bacteria like these, which can speed up rusting.*

Stopping the Zebra Mussel in Its Tracks

The zebra mussel, *Dreissena polymorpha* (right), a tiny black-and-white striped shellfish native to Eurasia, was discovered in North American waters in July 1988, in Lake St. Clair, near Detroit, Michigan. It is believed to have "hitched a ride" to the United States in the ballast water of Eurasian tankers bound for the Great Lakes.

Like the Mediterranean fruit fly, the sea lamprey, and many other exotic, or non-native, species before it, the zebra mussel soon proved it could cause considerable damage—by using its glue-producing foot to attach itself to nearly anything in fresh water, from intake pipes at power companies to boat engines, leading to costly control efforts, and by reproducing abundantly and feeding extensively on the food supply needed by native fish, the impact of which is not yet fully understood.

The zebra mussel now inhabits 20 U.S. states and two Canadian provinces, and although it has not yet reached Delaware and many of the Mid-Atlantic states, a major outreach program supported by the National Sea Grant College Program is under way here to increase public awareness of the threat.

Throughout the National Sea Grant College network, research also is under way to learn more about the zebra mussel's biology and physiology, and its control. At Delaware Sea Grant, marine biochemist J. Herbert Waite (shown at left with graduate student Nicole Eddington) is working to determine the chemical and genetic composition of the adhesive the zebra mussel generates to attach itself to objects under water. This research on "mussel glue" may lead to development of a chemical control aimed specifically at the zebra mussel, as well as provide the chemical recipe needed to create a synthetic adhesive with valuable applications in medicine and dentistry, such as repairing torn corneas and attaching crowns and dentures.

Tracking Trace Metals

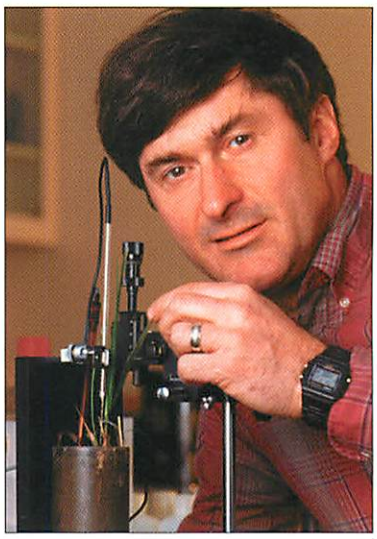
How do trace metals enter the Delaware Estuary and what do they do once they get there?

Marine scientist Sheila Moore has just finished processing the last trace metal sample of the day in the high-tech "clean lab" at the University of Delaware's Lammot du Pont Laboratory and delivers the analysis to Sea Grant project leader Tom Church. The lead concentration in this sample of water from upper Delaware Bay is 0.5 parts per billion. While the amount may seem infinitesimal, in the realm of trace metals, tiny amounts can have a significant impact on aquatic life.

Trace metals are important because they can be both essential for all life and harmful when introduced by humans to the natural aquatic environment in unnatural amounts. For the past decade, chemist Tom Church and his research team have been working to determine where the trace metals in the Delaware Estuary come from, what happens to them once they enter the estuary, and what risks or problems these metals may pose for estuarine life as well as local citizens.

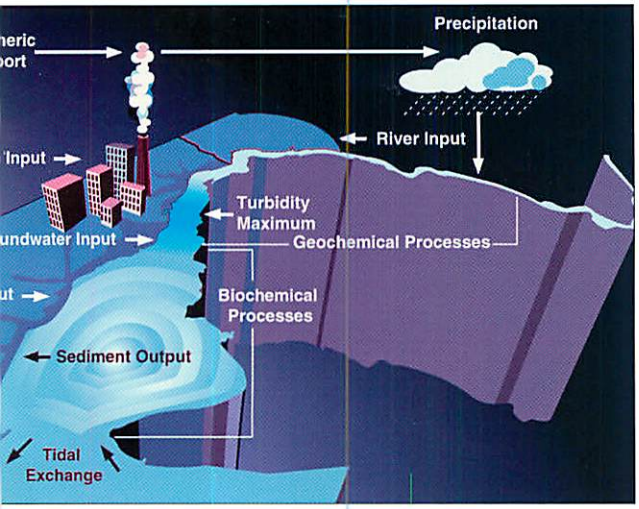
"Generally speaking, if the amount of sunlight is adequate, then the quantity of some major or minor nutrient will always limit how much algal growth, or primary productivity, occurs in natural waters," Church says. "However, when people are present and using such waters to dispose of trace metals that have been concentrated during ore refinement or the manufacture of metal products, for example, it's just as likely that a toxic metal is limiting plant growth. It doesn't take much metal disposal in coastal waters and estuaries to have an adverse effect on marine life," he explains, "because toxicity can occur at very low levels—say, one millionth of a gram of metal per liter of water. That's roughly equivalent to a grain of sand in an Olympic-sized swimming pool."

Church and his associate Joe Scudlark have revealed that compared to other estuaries on the East Coast, the Delaware Estuary has among the highest concentrations of trace metals. They have determined that the chief inputs in the estuary are from three major sources: the Delaware River, which carries trace metals from past and present industrial activities in the vast watershed and from other sources; precipitation; and salt marshes, which continually undergo active sulfur and metal cycling.



Developing a tool to help scientists easily determine the chemical form, or species, of iron and other trace elements in sediments is a major goal of chemist George Luther's Sea Grant research. He is perfecting a unique microelectrode that can be inserted into the sediments of a salt marsh, harbor, or bay to quickly measure a number of highly reactive metals and chemicals at the same time. The environmental monitoring tool has attracted the attention of scientists in the United States and abroad.

Dressed like surgeons in the garb required for work in the trace metals lab, or "clean lab," chemist Tom Church and marine scientist Sheila Moore observe the atomic absorption spectrophotometer as it analyzes the concentration of lead found in a sample of Delaware Bay seawater. Church and his staff have developed lab procedures that may be described as "ultra-clean" because they help eliminate extraneous sources of trace metals that may contaminate environmental samples.



Trace metals are small quantities of elements like iron or lead that enter our waterways through a number of sources and processes. This diagram depicts the major inputs and outputs of trace metals in the Delaware Estuary and the processes that influence their behavior.

Yet once trace metals enter the Delaware Estuary, where do they go? Through data gathered on a series of research cruises over the past two decades, the Sea Grant researchers have developed a behavioral portrait of seven key metals: cadmium, cobalt, copper, iron, manganese, nickel, lead, and zinc.

Once they enter the estuary, the highly reactive dissolved iron, manganese, and cobalt tend to be quickly converted to particles and settle out into sediments, while cadmium, copper, nickel, lead, and zinc—deemed more "conservative" in behavior than the others—are taken up and used by algae and other marine life and eventually are exported to coastal waters.

"The Delaware Estuary appears to be well buffered for many toxic trace metals thanks to organic complexing agents believed to be of salt-marsh origin," Church says. "Thus, the alteration of wetlands should be considered with caution. In addition to disturbing these complexing agents, the dredging or filling of salt marshes may remobilize their vast stores of sequestered trace metals, which could be harmful to marine life."

In new Sea Grant research, Church and Scudlark are initiating a detailed investigation in the Delaware Estuary of mercury, a trace metal that poses a human health risk through the consumption of contaminated fish. Mercury has unique sources and biogeochemical behavior and requires highly specialized sampling and analysis techniques. This study will provide some of the first information on the sources and ecological fate of mercury in Delaware Bay and coastal waters.

The Age of Ecotourism

Can nature tourism thrive without harming the environment?

While the word "ecotour" may formerly have conjured up images of the Galapagos Islands, Great Barrier Reef, Antarctica, and other exotic destinations, today in the United States, more and more travelers are staying closer to home to get away from it all and get back to nature.

Sea Grant Marine Advisory Service specialist Jim Falk (right) discusses marketing techniques with John Hall, operator of Rehoboth Bay Shuttle Charters. Hall offers a Classroom by the Sea Program to educate people of all ages about marine life.

Home to one of the world's major staging areas for migratory shorebirds, vast marshes, two national wildlife refuges, 11 state parks, and 260 miles of ocean and bay coastline, Delaware offers a range of ecotourism activities ranging from bird-watching to canoeing. But can this new industry boost the economy without harming the natural amenities that sustain it?

"The defining qualities of ecotourism are sustainability, conservation, respect for natural and cultural resources, learning, appreciation, and responsibility," says Sea Grant Marine Advisory Service specialist Jim Falk. "Ecotourism seeks to enhance the economic development of less developed areas not just by pumping tour dollars into the economy, but by helping local residents generate their own income as incentive to preserve natural resources. In essence, ecotourism seeks to build a bridge between environmental stewardship and economic development."

Nearly 200 people participated in Delaware's first ecotourism conference, cosponsored by Sea Grant, on November 16, 1994.

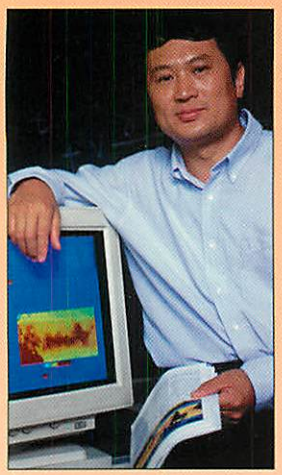
This past November in Dewey Beach, Falk organized the first ecotourism conference in Delaware in conjunction with the Division of Parks and Recreation in the Department of Natural Resources and Environmental Control, the Sussex County Convention and Tourism Commission, and the Rehoboth Beach-Dewey Beach Chamber of Commerce. The event brought together nearly 200 people, from business owners to environmental groups, to begin a dialogue on ecotourism's possibilities and pitfalls.

Falk says that among the positive results of the conference have been the development of several committees that are now working to develop an inventory of existing ecotourism-related programs and attractions in Delaware; an evaluation of the potential for a formal ecotourism organization in the state; and planning for a follow-up conference.

According to Megan Epler Wood, executive director of the Ecotourism Society, Delaware is in the forefront in the U.S. ecotourism movement. The economic boost provided by ecotourism was estimated at $238 billion worldwide in 1994.

A Young Career of Distinction

Sea Grant scientist Xiao-Hai Yan (below), associate professor of applied ocean science at the University of Delaware Graduate College of Marine Studies, was one of only 30 faculty nationwide to be selected for the prestigious 1994 Presidential Faculty Fellow Award. Through this award, the president of the United States recognizes early in their academic careers the scholarship and leadership of some of the nation's most outstanding science and engineering faculty.



Yan has used satellite remote sensing technology to provide significant new insights into ocean dynamics. For example, he was the first to show how satellite data of the ocean's surface could be used to study phenomena beneath it, such as the depth of the ocean's mixed layer, the upper layer of water that is uniform in temperature and composition due to mixing by surface winds. Mixed-layer depth is of importance to many scientists, including marine biologists studying the growth of algae.

In 1992, Yan and his colleagues conducted a remote sensing study of the western Pacific warm pool, a large body of unusually warm water believed to be the spawning ground of the climate disturbance El Niño, that was the first to confirm from space a definitive link between ocean surface temperature and a global climate trend. It attracted the attention of the national and international scientific community as well as the media.

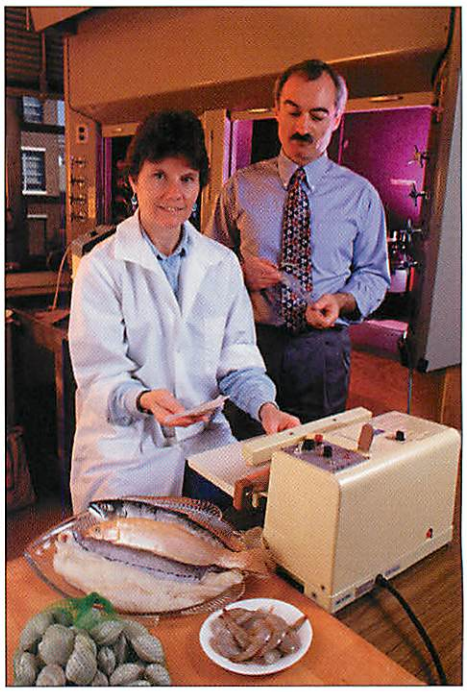
Currently, in Sea Grant research, Yan is working with colleague Vic Klemas to develop satellite feature recognition and tracking techniques that can be used to monitor the health of Delaware Bay and other coastal waters.

Enhancing Seafood Safety

Food scientists are putting the pressure on bacteria.

While many Americans love seafood—in 1993, we consumed an average of 15 pounds per capita, seafood safety and handling concerns have been on the minds of many consumers lately due to several media reports.

The U.S. Food and Drug Administration's Office of Seafood assures consumers that the seafood supply is safe and wholesome. The most common seafood-borne illnesses are caused by a combination of bacteria normally present in the environment and food-handling errors.



▲ *Seafood specialist Doris Hicks and food scientist Dallas Hoover prepare fish and shellfish samples for high-pressure pasteurization.*

To address these problems, Dallas Hoover, a food scientist in the University of Delaware's College of Agricultural Sciences, and Doris Hicks, seafood specialist for the Sea Grant Marine Advisory Service, have been exploring the use of high pressure to pasteurize seafood. Their goal is to increase the safety of seafood while maintaining its fresh flavor and texture.

Hoover has been conducting pressure research on foods at Delaware since 1984, yet industry interest in this food processing method has been limited until recently, when activities in Europe and Japan led to new commercial efforts.

In 1991, the Meidi-Ya Food Factory Company of Japan launched production of high-pressure preserved fruit jams that were reported by sensory panels to have superior color, texture, and flavor compared to heat-processed controls.

In their laboratory research, Hoover and Hicks have been experimenting with high-pressure pasteurization of crab meat and oysters. In recent taste tests, trained judges found no significant difference between ready-to-eat untreated crab meat and crab meat pressure treated at 3,400 atmospheres (the equivalent of about 50,000 pounds per square inch) for 20 minutes at 25° C.

This same high-pressure treatment also enhanced the shelf life of shucked oyster meat and inactivated a dangerous pathogen that may occur in oysters: *Vibrio parahaemolyticus.*

The scientists are now exploring the use of high-pressure treatment for other seafood processing applications, ranging from inactivating parasites in finfish to destroying pathogens in smoked seafood and improving the texture of squid to enhance preparation and consumer acceptability.

An outreach publication to share the Sea Grant research results with industries and government agencies is now in development. Several companies already have contacted Hoover regarding possible collaborative studies, including Kraft General Foods, R.W. Frookie, Inc., and the Delmarva Poultry Industry.

▲ *Blue crabs are Delaware's most valuable shellfish catch. According to the Shellfish Section of the Delaware Department of Natural Resources and Environmental Control, in 1994, commercial crabbers in the state caught 123,351 bushels of blue crabs, which is just over 5.9 million pounds. The catch was valued at nearly $4.2 million.*

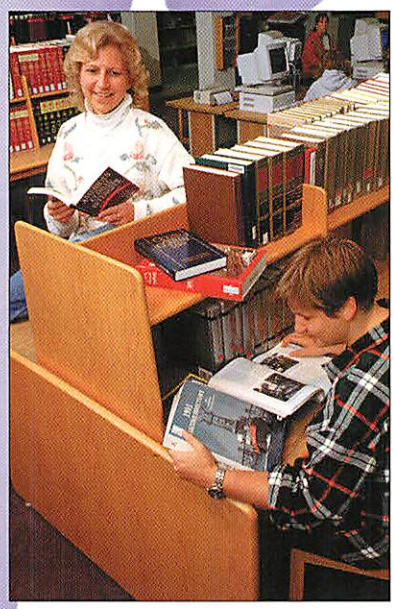
Students Win National Sea Grant Fellowships

Charlotte de Fontaubert and Rebecca Metzner, both Ph.D. candidates in marine policy at the University of Delaware Graduate College of Marine Studies, have been selected for the 1995 National Sea Grant Federal Fellows Program. Endorsed by the U.S. Congress, this competitive program matches highly qualified graduate students with host agencies in the legislative and executive branches of the federal government, providing them with a unique, year-long educational experience.

De Fontaubert is working for the Senate Foreign Relations Committee, where her first assignments have included assisting with preparations for ratification of the United Nations Convention on the Law of the Sea and joining the U.S. delegation to the United Nations Conference on Straddling and Highly Migratory Fish Stocks. A native of France, she has master's degrees in law from Université Paris Assas, in management and international business law from Université Paris Dauphine, and in sea-use law, economics, and policy from the London School of Economics and Political Science. Her interests are in coastal management as a means to achieve sustainable development and in international assistance and exchange programs.

Metzner is working for the Senate Committee on Commerce, Science and Transportation, where her first projects have included assisting with preparations for reauthorization of the Magnuson Fishery Conservation and Management Act and the Coast Guard Act. The Wilmington native has a bachelor's degree in biology from Princeton University and a master's degree in economics from the University of Delaware. Her interests are in fisheries policy and management, including the use of individual transferable quotas (ITQs) as an alternative to traditional management tools.

Each of the nation's 29 Sea Grant programs may nominate up to four students to this national program. Of the 57 nominated for this year's class, 25 were selected. Delaware Sea Grant is one of seven programs to be represented by more than one fellow.



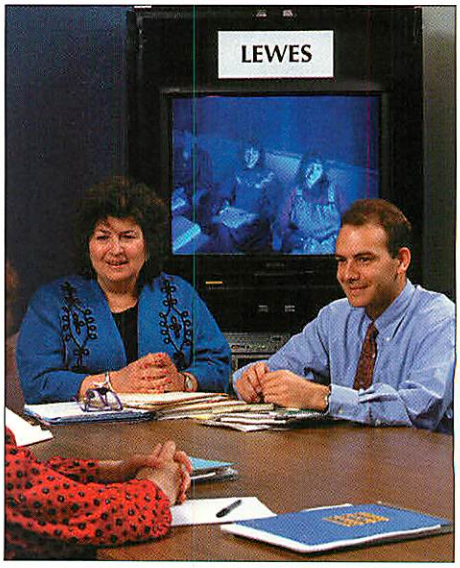
▲ *As 1995 National Sea Grant Federal Fellows, Charlotte de Fontaubert (seated) and Rebecca Metzner, Ph.D. candidates in marine policy at the University of Delaware Graduate College of Marine Studies, will gain a bird's-eye view of the political process on Capitol Hill.*

A Whole New Way of Looking at the Ocean

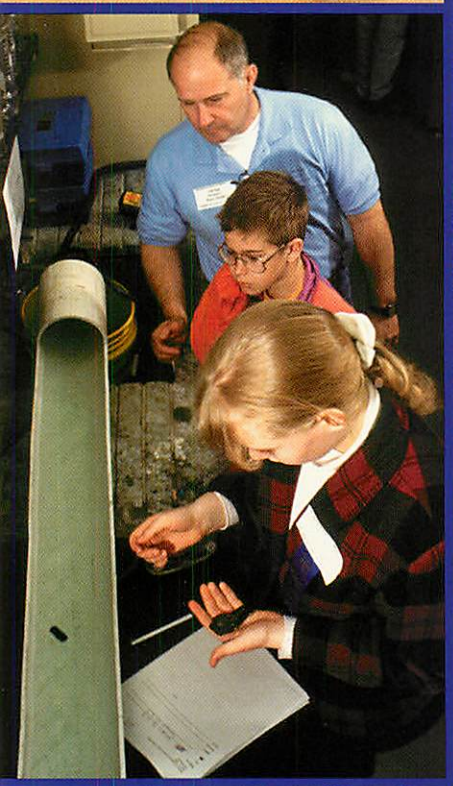
The old saying that "the whole is greater than the sum of its parts" has special meaning for Biliana Cicin-Sain and Robert Knecht, co-directors of the University of Delaware's Center for the Study of Marine Policy. Their Sea Grant research has focused on bringing a more holistic approach to how we manage the ocean than the resource-by-resource method that typifies ocean governance today.

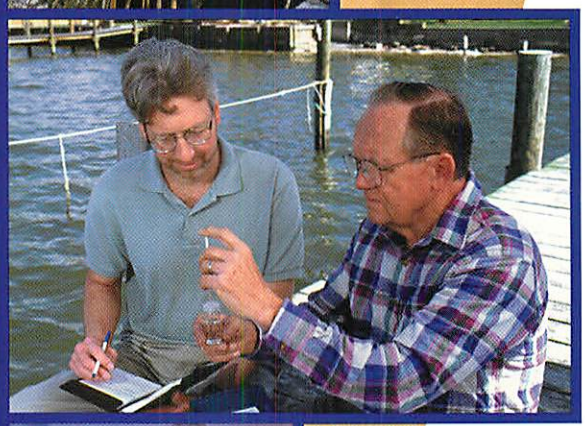
"Although the United States has many laws dealing with the ocean, they are largely single-purpose in nature—only addressing single resources or issues such as fisheries or oil, with little consideration of the effects of one use on other uses," says Cicin-Sain. "In general, the present system does not offer an integrated strategy, or vision, for the protection, enhancement, and use of our ocean resources."

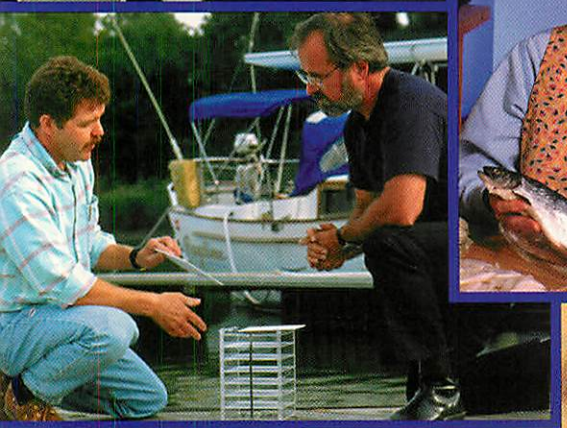
To advance a more integrated management approach, Cicin-Sain and Knecht have formed the "Ocean Governance Study Group," a panel of 37 national and international policy experts who are engaging interest in the strategy from federal, regional, and state coastal managers. The Delaware Sea Grant policy team has also developed a framework for integrated coastal management that recently was presented to the Marine Board of the National Research Council. Currently, the team is working on a book on integrated ocean management for the United Nations that will be distributed to coastal managers around the world.

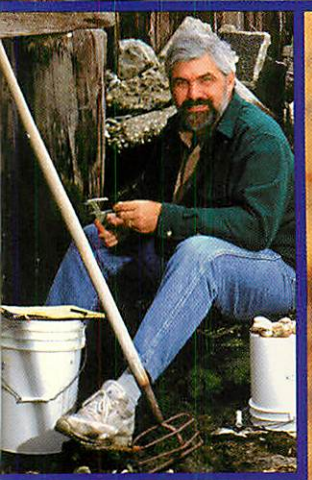


In the Interactive Television (ITV) classroom, Biliana Cicin-Sain, co-director of the Center for the Study of Marine Policy, leads her students in Newark — and 90 miles away at the Lewes campus — in a discussion of coastal management theory. ▶









Putting Scien

Outreach staff provide technic

The University of Delaware Sea Grant Marine Advisory Service (MAS) and Marine Communications staffs put Sea Grant to work for the public, by applying scientific expertise to coastal problems and opportunities in cost-effective, innovative ways; educating students of all ages about the environment; and providing citizens with timely, objective information.

From their base at the University of Delaware Graduate College of Marine Studies in Lewes, the six-member Sea Grant Marine Advisory Service (MAS) travels the state to foster the wise use, conservation, and development of Delaware's coastal resources by providing objective, research-based information to a broad range of residents, from schoolteachers to fish farmers.

Marine biologist Kent Price directs the staff's activities and conducts a variety of research initiatives in support of the program. During the past five years, he coordinated the Scientific and Technical Advisory Committee of the Inland Bays Estuary Program, which examined such complex

Meet the Sea Grant Marine Advisory Service! Clockwise from top: Kent Price, MAS director, examines seaweed in the Inland Bays in research to determine the importance of these plants as a food source for fish. ◆ Joe Farrell (left) marine resource management specialist, watches as Rehoboth Beach resident Larry Wonderlin tests the dissolved oxygen level in a seawater sample taken from Rehoboth Bay. ◆ Doris Hicks, seafood specialist, conducts both applied research projects and public outreach programs to promote the safe use and handling of seafood. ◆ John Ewart, aquaculture specialist, measures the growth of hard clams he recently planted in a local stock enhancement project. ◆ Jim Falk (left), marine recreation and tourism specialist, shows boater Joe DeCormis, at the Summit North Marina, a monitoring device to detect zebra mussel larvae in local waters. ◆ Bill Hall, marine education specialist, oversees an experiment to determine water-flow rate, as a judge for the 1995 Delaware Science Olympiad.

Communication—The Vital Link Between S

The Marine Communications Office plays a critical role in extending Sea Grant research results and providing timely educational and information services to audiences in need. Coordinators Tracey Bryant and Pamela Donnelly, with marine outreach specialist Beth Chajes, and art director David Barczak, develop a variety of award-winning publications, the SeaTalk radio series, and videos on topics from marine careers to water-quality monitoring.

◆ *Zebra Mussel Decal Puts Boaters on Alert.* The zebra mussel is a tiny freshwater shellfish that causes a host of costly problems (see page 4). In conjunction with the Department of Natural Resources and Environmental Control, Delaware Sea Grant recently produced a free decal for boaters and anglers that

ce to Work for the Public

al assistance, marine education, and timely information.

problems as pollution, erosion, and habitat loss in Rehoboth, Indian River, and Little Assawoman bays—Delaware's Inland Bays. This past autumn, Price was elected Chairman of the Board of the new Delaware Center for the Inland Bays, which was established by the General Assembly to oversee and facilitate the implementation of a long-term approach for the wise use and enhancement of the Inland Bays watershed.

▲ *Eighty watermen hit the pool in their survival suits in this sea safety and survival training program sponsored by Sea Grant and AT&T last year.*

As MAS marine resource management specialist, Joe Farrell addresses a variety of initiatives related to coastal water quality and sustainable development, fishing vessel safety, and conflict resolution. The Inland Bays Citizen Monitoring Program, which he manages, is now in its fourth year of operation. Through this program, 40 volunteers of all ages and backgrounds are taking and testing water samples on a regular basis at locations along the Inland Bays. The data are being used by resource managers to build a water-quality data base for the watershed and by the state Office of Shellfish and Recreational Waters to determine areas safe for shellfish harvesting. The citizen monitors recently began a new project with the town of South Bethany to assess the water quality of local lagoons.

As MAS seafood specialist, Doris Hicks works to improve seafood safety through research on high-pressure pasteurization (see page 7), training programs on safe handling practices for industry, and safety and nutrition seminars for educators and consumers. One of her major initiatives is to help commercial fishermen, fish farmers, and seafood wholesalers and retailers implement the U.S. Food and Drug Administration's mandatory seafood inspection program, which is based on the Hazard Analysis Critical Control Point (HACCP) system, with its preventive controls to ensure the safety of U.S. seafood.

To aid fish farmers, MAS aquaculture specialist John Ewart provides technical advice, operates the Delaware Aquaculture Resource Center—which served more than 1,000 people last year—and conducts field projects in finfish and shellfish culture. Currently, he is assessing the technical feasibility of hard-clam stock enhancement as a management tool for Delaware's Inland Bays. Populations of the hard clam *(Mercenaria mercenaria)* have been static or in decline in the bays due to pollution, fishing, and other factors. Small-scale field plantings of seed clams have proven successful. During the next year, Ewart will conduct a larger, pilot-scale planting of 50,000 clams in Rehoboth Bay.

Many business and economic development issues in Delaware have ties to the coastal tourism and recreation industries, as Jim Falk, MAS marine recreation and tourism specialist, well knows. In addition to spearheading efforts to bring state attention to ecotourism planning during the past year (see page 6), Falk provided local marina operators and resource managers with the local satellite link to the 21st National Technical Conference on Docks and Marinas and developed several seminars on marketing and advertising for seasonal businesses in conjunction with the university's Small Business Development Center and the Sussex County Convention and Tourism Commission.

Every year, MAS marine education specialist Bill Hall teaches 500 Delaware educators about marine and aquatic sciences, and every year those teachers pass on their knowledge to our leaders of tomorrow—some 75,000 middle school students (grades 4–8). Hall also develops curriculum tools that range from hands-on activities in water education to popular bulletins on marine life that are used extensively by schoolteachers in Delaware and throughout the region, by the Smithsonian Institution and other agencies, and by the general public. He also recently helped design the Frameworks document that will serve as the basis for the state's K–12 environmental science curriculum.

Sea Grant Goes on Line

You can take a "quick tour" of University of Delaware Sea Grant research and outreach, find out how to participate in coastal stewardship activities, view our latest publications catalog—and place your order electronically with us—by visiting us at this address on your next trip on the Information Superhighway:

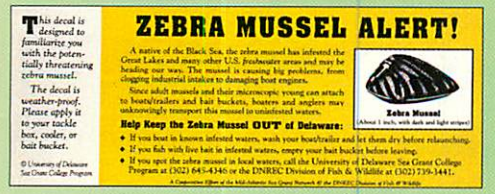
World Wide Web

http://www.udel.edu/cms/seagrant.html

See you soon!

ea Grant and You

lists preventive steps to keep the zebra mussel out of Delaware waters. To order your copy, please call Marine Communications at (302) 831-8083.



This decal is designed to familiarize you with the potentially threatening zebra mussel.

The decal is weather-proof. Please apply it to your tackle box, cooler, or bait bucket.

© University of Delaware Sea Grant College Program

ZEBRA MUSSEL ALERT!

A native of the Black Sea, the zebra mussel has infested the Great Lakes and many other U.S. freshwater areas and may be heading our way. The mussel is causing big problems, from clogging industrial intakes to damaging boat engines.

Since adult mussels and their microscopic young can attach to boats/trailers and bait buckets, boaters and anglers may unknowingly transport this mussel to uninfested waters.

Help Keep the Zebra Mussel OUT of Delaware:

- If you boat in known infested waters, wash your boat/trailer and let them dry before relaunching.
- If you fish with live bait in infested waters, empty your bait bucket before leaving.
- If you spot the zebra mussel in local waters, call the University of Delaware Sea Grant College Program at (302) 645-4346 or the DNREC Division of Fish & Wildlife at (302) 739-3441.

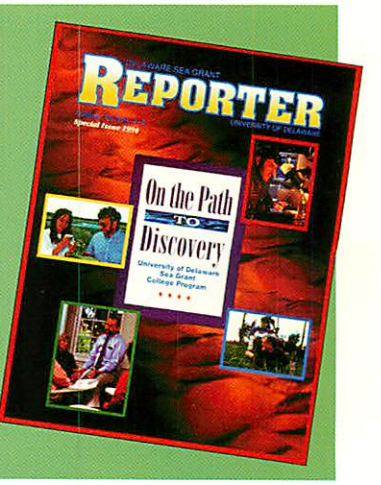
Zebra Mussel (Actual 1 inch, with dark and light stripes)

A Cooperative Effort of the Mid-Atlantic Sea Grant Network & the DNREC Division of Fish & Wildlife

◆ *Stay Tuned to SeaTalk!* Now in its twentieth year, our *SeaTalk* radio public service announcement series provides quick tips on topics ranging from seafood nutrition to boating safety. The series is broadcast on 40 stations in the Mid-Atlantic region, with an estimated audience of 11 million.

◆ *New Publications Catalog Now Available.* We recently printed our new catalog of publications and audiovisuals. To order a free copy, call Marine Communications at (302) 831-8083, or if you have access to the Internet, check out our electronic catalog at the address in the sidebar above. Catalog orders for free publications may be placed electronically at *MarineCom@mvs.udel.edu.*

◆ *Newsletter Wins International Award.* The *University of Delaware Sea Grant Reporter* received an award of merit in the 1995 international competition of the 19,000-member Society for Technical Communication. The free newsletter reaches more than 5,500 readers.



University of Delaware Sea Grant College Program

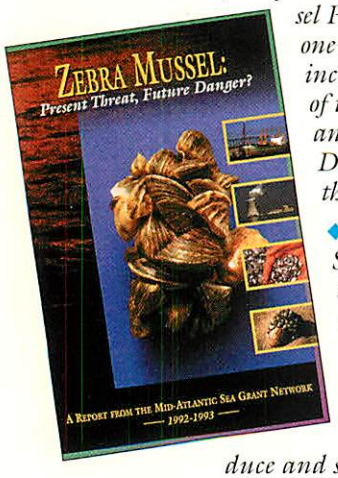
Financial Report

July 1, 1994 – June 30, 1995

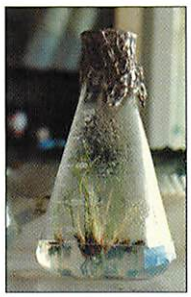
Program Area	State Funds	Federal & Other Matching
Marine Biotechnology	25,253	157,795
Coastal Processes/Engineering	36,506	163,073
Environmental Studies	32,704	177,967
Fisheries	8,905	89,872
Seafood Science/Technology	12,779	32,505
Policy Studies	22,824	109,827
Marine Outreach	202,267	548,708
Graduate Education	0	406,894
Program Management	35,262	119,920
Totals	**$376,500**	**$1,806,561**
Grand Total		**$2,183,061**

In addition to this funding, University of Delaware Sea Grant investigators continue to be recognized for important coastal ocean research from other programs within the National Oceanic and Atmospheric Administration, U.S. Department of Commerce. Funds for these "pass-through" projects are managed by Delaware Sea Grant and are an important mechanism for development of comprehensive and integrated research efforts:

- *Dr. J. Herbert Waite received $199,930 from the Zebra Mussel Program for a three-year project to develop a molecular strategy that will specifically prevent fouling by the zebra mussel* (Dreissena polymorpha) *and not harm non-target organisms.*
- *Ms. Tracey Bryant and Mr. James Falk received $25,000 from the Zebra Mussel Program for a one-year project to increase awareness of the zebra mussel and its threat to Delaware and the region.*



- *Dr. Denise Seliskar received $200,000 from the Estuarine Habitat Program for a two-year project to produce and select varieties of wetland plants best suited for marsh restoration.*
- *Drs. Jack Gallagher and Denise Seliskar received $225,000 from the Estuarine Habitat Program for a three-year project to select transgenic plants that will grow in saline conditions for development of industrial and food products.*



- *Dr. Vic Klemas received $25,039 from the Coastal Ocean Program to conduct a one-year study of coastal land use and pollution along the Baltic Sea coast using remote sensing and GIS modeling.*

- *Dr. Jean Pierre Plé received $57,000 from the U.S. State Department for a one-year project to examine policy considerations for conservation of the Atlantic bluefin tuna.*

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Come to Coast Day!
Sunday, October 1, 1995

University of Delaware
Sea Grant College Program
University of Delaware
Newark, DE 19716-3530