

UNIVERSITY OF DELAWARE SEA GRANT REPORTER

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Using Space-Age Technologies to Monitor the Coast's Health



From their orbit hundreds of miles above us, satellites continuously record information about the Earth with cameras, radar, and special scanners.

Thanks to these “eyes” in space — and Delaware Sea Grant research aimed at bringing into sharper focus what they see along the coast — resource managers soon may gain new tools for assessing the health of ecosystems as complex as the Delaware Bay.

“Coastal managers need to be able to easily observe resources like the Delaware Bay and track key health indicators, from the pollutants in the water, to the productivity of wetlands that serve as nursery areas for the bay’s fish,” says Professor Robert Knecht, co-director of the University of Delaware’s Center for the Study of Marine Policy.

Robert Cohen



As part of their coastal health research, Professors Vic Klemas and Biliana Cicin-Sain compare satellite images of the Delaware Bay.

“From their vantage point in space, satellites can provide resource managers with real-time data on entire bays, marshes, and watersheds,” he notes. “But the time and costs associated with acquiring and interpreting satellite images have limited the use of this technology by coastal managers.”

During the past three years, Knecht and UD marine scientist Vic Klemas have coordinated a special research initiative, funded by a \$1 million grant from the National Sea Grant College Program, to overcome some of these

obstacles and provide resource managers with innovative technologies for monitoring the coast.

Called the “Coastal Ecosystem Health Project,” the monumental effort has brought together UD experts in fields from oceanography to agriculture and an advisory committee of resource managers from throughout Delaware.

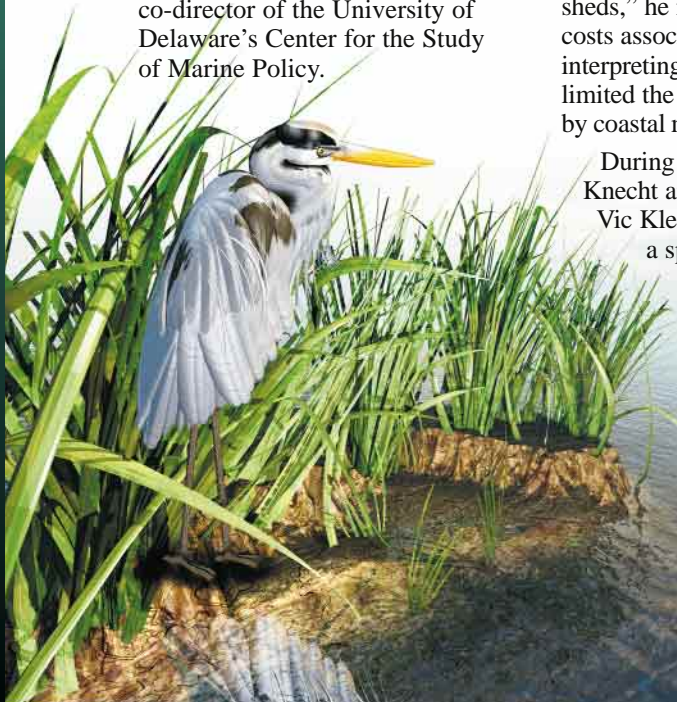
Their goal has been to harness the “vision” of satellites and other imaging technologies to help a coastal environment threatened by challenges as diverse as wetlands loss and the fish-killing microbe *Pfiesteria*.

(Continued on page 2)



Diane Perry

On a field trip to the Delaware shore, Professor Robert Knecht (second from right) and marine policy students discuss coastal management issues.



(Coastal Health, continued from page 1)

Detecting Changes in Wetlands

Delaware Sea Grant's Coastal Ecosystem Health Project has been organized into three components. The goal of the first research group, led by Professor Vic Klemas, has been to integrate land-cover data gathered by satellites into a Geographic Information System (GIS) for monitoring wetlands health.

A GIS is a computer system that allows the user to create a composite map of an area from multiple layers of data. A GIS of the Delaware coast might include a satellite image overlaid with zoning maps, highway maps, and others of interest to the user.

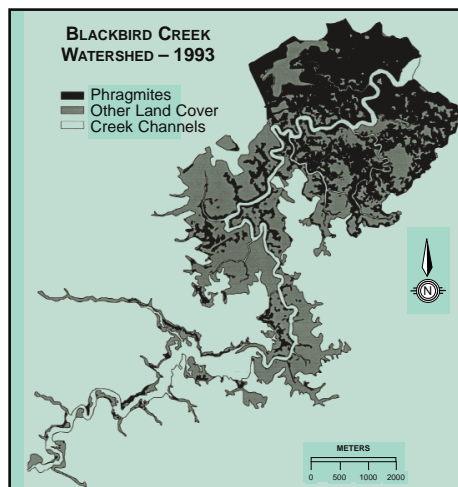
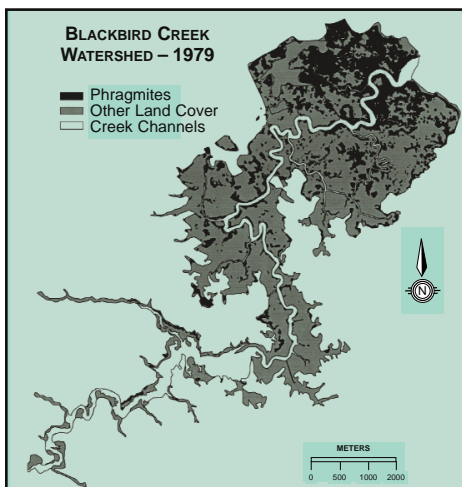
Robert Cohen



Invasive marsh plants such as common reed (Phragmites australis) can be monitored by satellite, aiding control efforts.

“By incorporating satellite and aircraft images into a wetlands GIS, we can show resource managers changes in land use affecting wetlands, from encroachment by urban development, to invasion by nuisance plants such as *Phragmites*,” says Klemas.

Klemas's team used Landsat Thematic Mapper satellite images and aerial photographs to map the *Phragmites* in the wetlands of the Blackbird Creek and St. Jones River watersheds in 1979 and 1993. Both sites are part of the National Estuarine Research Reserve system, a network of protected areas for research and education.



These figures, derived from satellite images and aerial photos by researchers in Delaware Sea Grant's Coastal Ecosystem Health Project, show the dramatic advance of the invasive plant Phragmites into the wetlands of the Blackbird Creek watershed. Phragmites is shown in black. The figure at left shows the watershed in 1979; at right is the watershed in 1993.

A satellite detects visible and infrared light reflected from features on land, from farmland to construction areas. The amount of light reflected varies by feature or, in the case of a marsh, by plant type. Each marsh plant species has a unique “spectral signature,” and Klemas and his team have learned to read many of them.

Since satellite images are accurate to a resolution of 1 to 2 acres, Klemas's team relied on photos taken by aircraft to gain an even sharper focus of the wetlands in the two watersheds. In an aerial photo, *Phragmites* is easy to spot because it is greener and taller than other marsh plants.

The team's analysis showed an increase in *Phragmites* from 1979 to 1993 at both sites despite intermittent control efforts. At Blackbird Creek, the plant expanded its range from 26% to 45% of the watershed, or from 917 acres to 1,569 acres. In the St. Jones River watershed, the plant increased its coverage from 4.4% to 7.4%, or from 150 acres to 254 acres.

The team concluded that *Phragmites* could invade the entire Blackbird Creek study site, while the plant's expansion in the St. Jones River watershed appears to be limited to upland edges due to higher salinities at that site.

“Together, satellites and GIS can provide coastal managers a faster and more comprehensive tool for assessing wetlands than traditional field techniques,” Klemas says. “The data can be compared easily from year to year to help managers detect changes in wetlands health.”

The cost of satellite data is decreasing dramatically, Klemas adds. “Currently, one satellite image, which is the equivalent of a 100-mile-by-100-mile area, costs \$4,000. With the launching of Landsat 7 this June, it will be only \$400,” he notes.

Spotting Algae in Delaware Bay

Satellites can be used to track an important water-quality indicator: concentrations of microscopic plants in surface waters. Satellites detect the light reflected by plant chlorophyll.

As shown in these figures of Delaware Bay, high chlorophyll concentrations generally are associated with shallow regions. The abrupt shift in concentrations beyond the bay's mouth denotes the boundary between the outflowing Delaware Coastal Current and the less productive waters of the continental shelf. The decrease in chlorophyll concentration in the lower bay on October 4 appears to be due to strong, persistent winds.

Focusing in on the Delaware Bay

While Klemas's team used satellites to track wetlands changes related to coastal health, oceanographer Xiao-Hai Yan and his team have focused on developing a remote sensing system to help resource managers more easily track changes in the Delaware Bay.

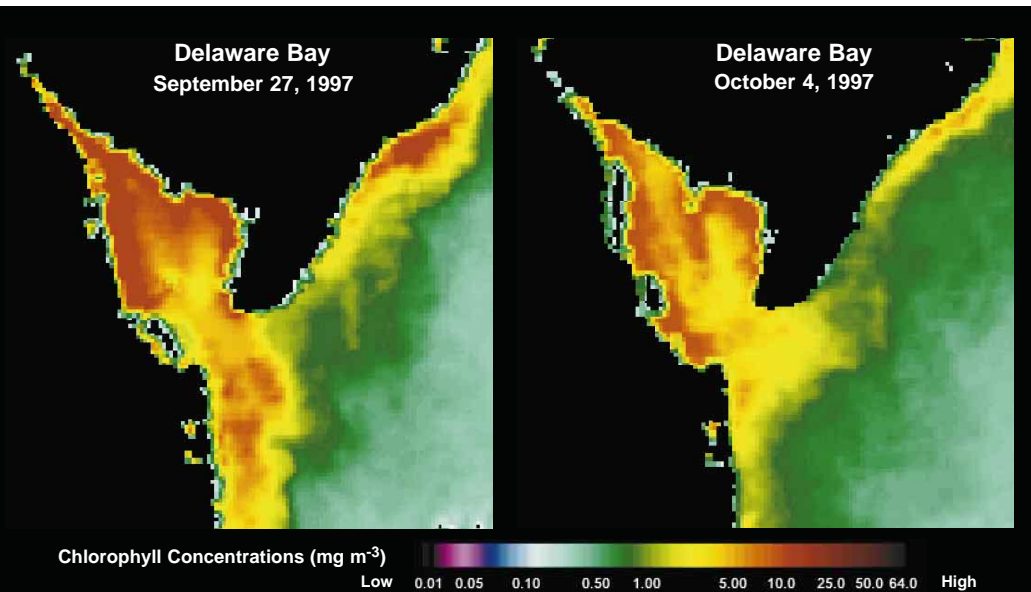


Professor Xiao-Hai Yan (left) discusses a new technique for interpreting satellite data with graduate students participating in Sea Grant's Coastal Ecosystem Health Project.

As its name implies, “remote sensing” refers to monitoring a subject at a distance. Remote sensors may range from microwave radar on satellites, to the listening devices used in underwater acoustics research.

Using data derived from satellite images, space shuttle photographs, and acoustics profilers, Yan and his group have developed a monitoring system for the Delaware Bay that includes a number of parameters that may be used to assess the bay's health, from water temperature and salinity, to suspended sediments.

A major challenge faced by Yan's team was to figure out how to help satellites “see” better in order to distinguish between sediments and algae in bay surface waters.



The concentrations of sediments and of chlorophyll from algae are important indicators of aquatic health. Sediments prevent sunlight from penetrating to algae, which need light to grow. The microscopic plants represent the first critical link in the bay's food chain.

Satellites can easily discern chlorophyll concentrations in the open ocean, where the water is clear of sediments. But in the Delaware Bay, sediments from land runoff cloud surface waters, making it difficult for satellites to sort out what is sediment and what is algae.

To overcome this limitation, Yan and his team developed a new satellite data processing method using a neural network. Modeled after the brain's interconnected system of neurons, neural networks have been used for tasks ranging from translating foreign languages to interpreting medical data. The mathematical processing method can sort out patterns and "learn" from trial and error.

"Once we 'primed' it with a training set of data from actual water-quality measurements taken in Delaware Bay, our neural network method was able to model suspended sediments versus chlorophyll to a much higher degree of accuracy than conventional analyses," Yan says.

"We hope this technique will save resource managers time and effort in gathering and assessing water-quality data on the bay," he notes.

Formerly, such data could be gathered only through water-sampling operations conducted from research vessels in the bay.

Looking at the Coast through the Eyes of Resource Managers

The third vital component of Sea Grant's Coastal Ecosystem Health Project has been to establish open lines of communication between UD scientists and resource managers at agencies throughout the state and region.

Led by Professor Biliiana Cicin-Sain, co-director of the UD Center for the Study of Marine Policy, the outreach team established a Managers Advisory Committee for the project (see sidebar below). This group of coastal managers provided input to scientists regarding

managers' goals and monitoring needs. During the past three years, scientists and managers have shared information through regular meetings and through the *Coastal Courier* newsletter created by Sea Grant expressly for the project.

In cooperation with resource managers, Cicin-Sain's team also developed case studies on the state's coastal management programs, reviewing their missions and accomplishments. This information is being shared with managers to aid them in standardizing monitoring techniques and in advancing the state's watershed approach to coastal management.

As the UD scientific team wraps up a technical report on the technologies developed for the Coastal Ecosystem Health Project, research coordinator Robert Knecht reflects on their progress.

"Only by breaking down the walls between academic disciplines and between academicians and managers can progress result," he says. "We've brought together a diverse group of people, solved a number of challenges, and succeeded in demonstrating how space-age tools can be used to monitor the coast. It's our hope that the project will serve as a model for other states working to advance state-of-the-art technologies for the benefit of the environment." — Tracey Bryant

Editor's Note: A technical report on Sea Grant's Coastal Ecosystem Health Project is in production. For more information, please contact the UD Marine Communications Office at (302) 831-8083.

Building Better Bridges between Coastal Managers and Scientists

Establishing strong partnerships between resource managers in the field and UD coastal scientists has been critical to the success of Delaware Sea Grant's Coastal Ecosystem Health Project.

Under the leadership of Professor Biliiana Cicin-Sain, co-director of the UD Center for the Study of Marine Policy, a Managers Advisory Committee was formed to provide input to the project to ensure the usefulness of the monitoring techniques developed. Coastal managers from the Delaware

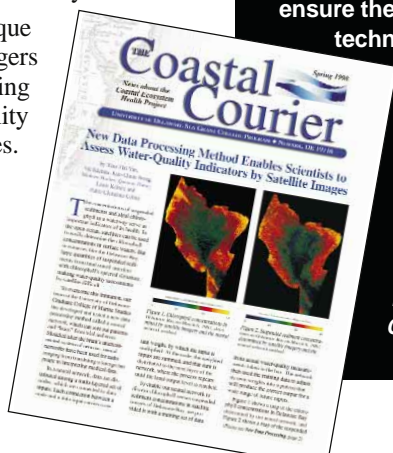
Department of Natural Resources and Environmental Control (DNREC), the Center for the Inland Bays, Partnership for the Delaware Estuary, and county governments all participated.

"Working together we've built the bridges that help strengthen science and management," she says. "The ultimate beneficiary should be the coast we all treasure."

Delaware Sea Grant developed the *Coastal Courier* newsletter to help share Coastal Ecosystem Health Project results with resource managers.



DNREC hosted this workshop in January, co-sponsored by Delaware Sea Grant, to define key indicators of Delaware's environmental health.





Sea Notes

Highlighting People, Publications, and Events of Interest to Our Readers

Delaware Sea Grant Receives \$2.8 Million for Marine Research and Education

The University of Delaware Sea Grant College Program has been awarded \$2.8 million to conduct 23 marine research and education projects critical to Delaware and the Mid-Atlantic region over the next year. The grant includes \$1.25 million from the National Oceanic and Atmospheric Administration in the U.S. Department of Commerce, and \$1.55 million from the State of Delaware, the University, and other sources.

The projects target six major areas: coastal ocean studies, environmental technology, coastal engineering, marine biotechnology, fisheries, and education.

In coastal ocean studies, scientists will assess dissolved oxygen conditions in the Delaware River and Bay to determine if present water-quality guidelines need revising; examine the impacts of dredge spoil on the bay's bottom-dwelling organisms; and use infrared

technology to map coastal groundwater seeps and assess their importance in carrying nutrients and contaminants to the bay.

In Delaware's Inland Bays, researchers will determine the importance of tidal motions on bay nutrient and oxygen levels.

Other coastal ocean studies include refining

a unique sensor that can rapidly analyze the chemistry of seawater and sediments, and developing the widely regarded nuisance plant *Phragmites* into a first-rate "sludge buster" for use in wastewater treatment facilities.

In environmental technology research, a team of marine scientists and engineers

will explore the feasibility of using lighthouses in Delaware Bay as remotely controlled field stations for gathering acoustic, weather, tide, and current data for long-term ecosystem assessments.

Coastal engineering research will focus on developing predictive models for shoreline change and improving erosion mitigation strategies. A team of coastal engineers will examine the hydrodynamics of rip currents, turbulent eddies in the surf zone, and other phenomena. Scientists also will conduct an economic analysis of "beach nourishment," or preserving the beach with sand, versus "retreating" from the beach and allowing nature to take its course in specific coastal areas.

Marine biotechnology researchers will study how organic pollutants impact the Delaware Bay's microbial community. Scientists also will couple molecular genetics and geochemistry to examine the bacteria that thrive in the extreme temperature and chemical conditions found at deep-sea hydrothermal vents. These bacteria possess enzymes that may be valuable in a host of high-temperature industrial applications such as food processing.

In fisheries research, scientists will determine the optimal nursery conditions for two of the region's most commercially valuable flatfish — summer flounder and southern flounder. A related study will focus on the effects of low oxygen conditions on feeding, growth, and survival of

young weakfish, summer flounder, winter flounder, and striped bass. The goal of both projects is to help resource managers define essential fish habitat.

Economists will develop simulation models for commercial and recreational fisheries that can predict the effects of commonly used management techniques. Other scientists will continue research on how Delaware Bay circulation processes impact the bay's blue crab population.



Fisheries scientist Tim Targett and graduate student Ursula Howson collect flounder for fish habitat research.

Robert Cohen



Coastal engineer Robert Dalrymple conducts an experiment on rip currents in the UD Ocean Engineering Lab.

Students Awarded

Two University of Delaware graduate students in marine studies — Alison Sipe and Dosoo Jan — are diving into ocean policy-making efforts in the nation's capital. They have been selected as National Sea Grant Fellows.

Sponsored by the National Sea Grant College Program, in the National Oceanic and Atmospheric Administration (NOAA), the fellowship matches outstanding graduate students with host agencies in federal government, providing the scholars with a paid, year-long experience working on marine issues.

On February 1, Sipe began working at the National Science Foundation in the Division of Ocean Sciences. She wants to gain an insider's view of the grant process that drives basic research in marine science.

A master's degree candidate in marine biology-biochemistry, Sipe has assisted her adviser, Dr. Craig Cary, on a Sea Grant marine biotechnology project aimed at finding an antifoulant to repel the shipworm. This wood borer, which is actually a clam, feasts its way through millions of dollars in ships, pilings, and other coastal structures each year. In 1997, Sipe received the National Shellfisheries Association's Student Poster Award for her description of the research.



Alison Sipe

Scientists In the News

The horseshoe crab will continue to be a focal point of research, as scientists work to develop a cost-effective artificial bait that chemically mimics the animal. The project's goal is to relieve fishing pressure on the declining horseshoe crab, which is used as bait in several fisheries.

At Delaware State University, aquaculture experts will define the optimal methods for growing crawfish and bait fish in the Mid-Atlantic region.

Delaware Sea Grant will continue its strong commitment to hands-on education of graduate students in marine studies, by providing them with the opportunity to work side-by-side with their professors on Sea Grant research projects.

A significant public education mission will be conducted by the Sea Grant Marine Advisory Service (MAS) based at the Lewes campus and by the Marine Communications Office in Newark. Efforts are under way in areas ranging from aquaculture to teacher training in marine science. The staff develop publications, workshops, and Web sites, and coordinate the University's award-winning Coast Day festival.



Fish Scientist Reels in Listeners

Did you catch UD fisheries scientist Tim Targett (photo, near left) on the air waves recently?

He was interviewed by the American Association for the Advancement of Science (AAAS) for their "Why Is It?" radio series. Broadcast on more than 160 radio stations nationwide, the series also is frequently heard on the Mutual Broadcasting System's "America in the Morning" news program.

Targett tackled a listener's questions about the flatness of flounder. To hear Targett's response, which was broadcast on January 19, cast your line for the AAAS Web site at www.scienceupdate.com, or link to it from "Scientists in the News" under News & Events at our Web site — www.ocean.udel.edu/seagrant.

Coastal Engineer "Jaws" about Waves

Coastal engineer Robert Dalrymple (photo, far left) has been riding a wave of publicity since providing the science behind a story in *National Geographic*.

The article "Maui Surf," in the magazine's November 1998 issue, highlights the monster waves called "Jaws" that are formed a dozen times a year off Maui's north shore.

At *National Geographic's* Web site, surfers can learn more about how "Jaws" is formed, by linking to Dalrymple's page at the UD Center for Applied Coastal Research — www.coastal.udel.edu/ngs.

Dalrymple's analysis of "Jaws" also was featured on CNN's Web site at cnn.com/TECH/science/9810/30/surfing.yoto.



Sea Grant Fellowships

Sipe also has undertaken a number of public education efforts, ranging from tutoring high-school students in math and chemistry, to designing hands-on science activities for UD's Coast Day festival. She is a native of Wilmington, Delaware.

Dosoo Jang has been assigned to the International Programs Office in NOAA's National Ocean Service, where he is helping to implement bilateral activities between the United States and China and Japan in coastal environmental science and technology.

A doctoral candidate in marine policy, Jang has special interests in integrated coastal management, which encourages the incorporation of science into the policy-making process and views the marine environment as a whole rather than as a set of unrelated resources.

Last year, he worked as an integrated coastal management consultant at the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (UNESCO). He received NOAA's Ocean and Coastal Management Award for excellence in graduate study in 1997.

A native of South Korea, Jang makes his home in Ellicott City, Maryland, with his wife and two daughters.



Dosoo Jang

Robert Cohen



James M. Falk,
MAS Director

Falk Named Director of Marine Advisory Service

James M. Falk is the new director of the University of Delaware Sea Grant Marine Advisory Service (MAS). Based at the Hugh R. Sharp Campus in Lewes, MAS specialists travel the state to conduct outreach projects in marine education, seafood technology, aquaculture, resource management, and recreation and tourism.

"Jim brings a great deal of experience and enthusiasm to this position, which is critical to the welfare of our Sea Grant program," said Dr. Carolyn A. Thoroughgood, Sea Grant director. "Under his leadership, we look forward to continuing to serve Delawareans with timely, useful information about coastal concerns important to all of us, from *Pfiesteria* to shoreline protection."

A resident of Rehoboth Beach, Falk has a master's degree in recreation and resource development from Texas A&M University. He joined Delaware Sea Grant as a marine recreation and tourism specialist in 1978 and later served for six years in the dual role of MAS leader and specialist. Since 1992, he has focused his outreach efforts on priority projects in zebra mussel awareness, ecotourism, beach safety, and water-use planning for the state's Inland Bays.

Falk is vice-chairman of the Scientific and Technical Advisory Committee of the Center for the Inland Bays and a board member of the Sussex County Convention and Tourism Commission. Throughout his career, he has been recognized by various organizations for his public service efforts in areas ranging from boater education to beach safety. In 1997, he and colleagues received the Governor's Tourism Award for helping to develop state initiatives in ecotourism.

Falk replaces former MAS director Kent S. Price, who will retire from the University later this year after 33 years on the faculty of the College of Marine Studies. Price, a marine biologist, served as MAS director for the past six years.

8,000 Brave Rain to Attend Coast Day

The weather for Coast Day 1998, on October 4, was drizzly and gray. But it didn't put a damper on the public's enthusiasm for learning more about the ocean.

An estimated 8,000 visitors turned out for Sea Grant's award-winning festival at the Hugh R. Sharp Campus in Lewes. The annual event's goal is to increase public awareness and understanding of the ocean through fun, interesting activities.

Highlights included a special Year of the Ocean exhibit in Cannon Lab that introduced visitors to the deep sea, coral reefs, and beaches. Visitors could inspect the homes of deep-sea tubeworms, view colorful reef fish in an aquarium, and see the formation of sandbars along the beach in a continuously operating wave tank.

In nearby Smith Lab, students from Talley Middle School transformed a greenhouse into an undersea adventure, complete with steaming hydrothermal vents.

Dozens of other indoor activities were available, from lectures on El Niño and other topics, to the Great Crab Race, Internet tours of the *Titanic*, and seafood cooking demonstrations by local chefs.

Outside, the artist Wyland kicked off the Delaware leg of his national Ocean Challenge to boost sea awareness and



▲ The artist Wyland — famous for painting life-size marine murals on buildings across the United States — kicked off the Delaware leg of his national Ocean Mural Challenge at Coast Day. Students of all ages joined together to paint a mural on a 24-foot-long canvas.

stewardship. Famous for his “Whaling Walls” — life-size marine murals he’s painted on buildings throughout the nation — Wyland inspired students of all ages to join together in painting an ocean mural on a 24-foot-long canvas.

Coast Day had a lot to offer seafood lovers, from seafood pizza and fried clams, to the ninth annual crab cake cook-off and first-ever Seafood Chowder Challenge.

The chowder challenge was a friendly competition between the First State Chef’s Association and the Delmarva Chefs and Cooks Association. Coast Day visitors were served a 2-ounce portion of each chowder and asked to vote for their favorite.

When the votes were tallied, “Clam Chowder — Hot and Spicy Delmarva Style,” by the Delmarva Chefs and Cooks Association, came out on top.

Created by chef Bob Davis, of Phillips by the Sea Restaurant in Ocean City, Maryland, the creamy New England-style chowder combines clams, potatoes, bacon, and lots of seasoning.

The chowder challenge will return next Coast Day, on Sunday, October 3, 1999. In the meantime, gather family and friends and stir up some “Clam Chowder — Hot and Spicy Delmarva Style.” The winning recipe, listed below on the left, serves 21!

▼ For the Coast Day Essay Contest, Delaware fifth-graders were asked to imagine they were marine scientists on a deep-sea expedition. Top essayist Lauren Cook wrote about her imaginary trip to the Great Barrier Reef off Australia. She cautioned readers about the danger of upsetting the ecological balance of the reef by gathering sea life as souvenirs. Next to Cook, far left, in the photo below are Rebecca Collins (second place), Whitney McMillon (third place), Danielle David (honorable mention) — all from Frankford Elementary School — and Anne Claire McBride (honorable mention), from Bayard Intermediate School.

Clam Chowder—Hot and Spicy Delmarva Style

6 oz bacon, diced	1 teaspoon rosemary
1 oz jalapeño peppers, diced	2 teaspoons thyme
1 cup onion, diced	1/2 teaspoon garlic powder
1 cup celery, diced	4 teaspoons Tabasco sauce
1 oz flour	4 oz pimientos, diced
3 cups clam broth	6 oz potatoes, cooked and diced
3 cups water	4 cups canned clams, drained
1 tablespoon clam base (Minors)	2 cups heavy cream
1/2 teaspoon white pepper	

Sauté bacon 3/4 cooked. Add celery, onion, and jalapeño peppers and sauté until just soft. Add flour, reduce heat, and cook about 10 minutes. Add clam juice, water, and clam base; stir well. Bring to a boil, reduce heat to low again, and add all spices, potatoes, pimientos, and clams. Simmer for 20 minutes.

Remove from heat and stir in the heavy cream. For larger batches of chowder, additional cooking time will be needed. Serves 21. Preparation time, 1 hour.

This Recipe Will Float Your Boat!



1998 Coast Day Essay Contest Winners

In keeping with this year's Coast Day theme, "Year of the Ocean," five talented Delaware fifth-graders were asked to write an essay about the following topic: "Imagine you are a marine scientist who is about to embark on a deep-sea expedition. Where are you going? What will you search for, and why is it important? What will your discovery do for the future?"

Please join us in congratulating these fine writers at an awards ceremony at 2:45 p.m. at the Raintonland.



The Deep Sea

Perhaps no area of the ocean is more shrouded in mystery than the deep sea. Years ago, it was believed that the ocean's greatest depths were devoid of life. But recent discoveries have revealed that the deep sea is home to many fascinating creatures.

Here live huge clams, 8-foot-tall tubeworms that resemble giant lipsticks, and bizarre-looking fish equipped with big mouths and stretchy stomachs to make the most of what little food floats down from above, such as whale carcasses.

Where is the deep sea? The ocean bottom is divided into three major areas: the continental shelf, continental slope, and deep ocean basin.

The continental shelf extends from the shore for an average of 30 miles, with hills, ridges, and canyons similar to the Grand Canyon.

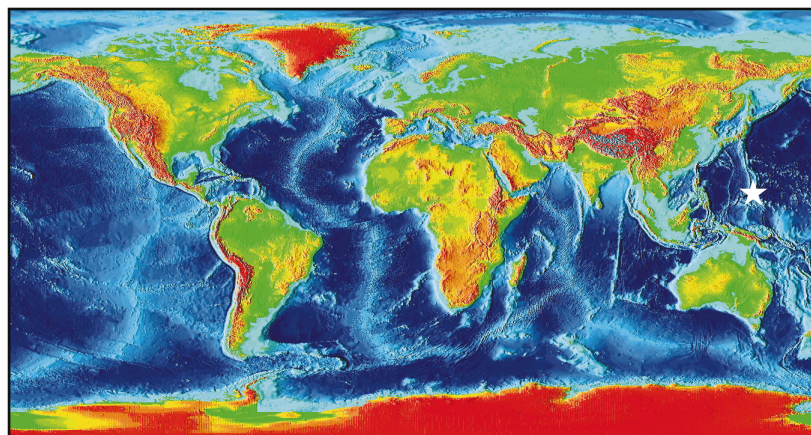
At a depth of about 660 feet, the continental slope begins. It descends about 12,000 feet.

Then the ocean floor deepens sharply and its features resemble those on land, only on a much larger scale, with great plains and mountains higher than Mt. Everest.

In fact, the Earth's longest mountain range is under the sea. Over 30,000 miles long, this mountain range, called the Mid-Ocean Ridge, snakes its way around the globe.

In some areas along the ridge, the gigantic plates that form the Earth's crust are moving apart, creating cracks in the seafloor where super-hot water spews out. Called *hydrothermal vents*, these underwater geysers release clouds of minerals that resemble smoke coming out of a chimney. That's why scientists call hydrothermal vents "black smokers."

Extraordinary animals live near these vents, able to withstand the tremendous pressure created by the weight of the vast sea above them. In the Pacific Ocean, huge clams and tubeworms are the most distinctive inhabitants, while eyeless shrimp are found deep in the Atlantic Ocean.



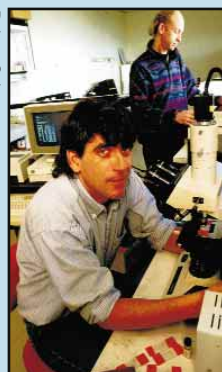
NOAA, National Geophysical Data Center

How Deep Is the Ocean? The deepest point on Earth (starred above) is at the bottom of the Mariana Trench, a depression in the Pacific Ocean east of the Mariana Islands. In this trench, about 200 miles southwest of Guam, lies the deepest point on Earth. Called the "Challenger Deep," it plunges to a depth of nearly 7 miles!

Deep-Sea Worm Is Earth's Hottest Creature

University of Delaware marine scientist Craig Cary (left) recently discovered that an inhabitant of the deep sea is the most heat-tolerant creature on Earth. The Pompeii worm (*Alvinella pompejana*) can survive temperatures up to 176°F — nearly hot enough to boil water.

Formerly, the Sahara desert ant was believed to be the most heat-hardy creature, foraging briefly in the desert sun at temperatures up to 131°F.



Robert Cohen

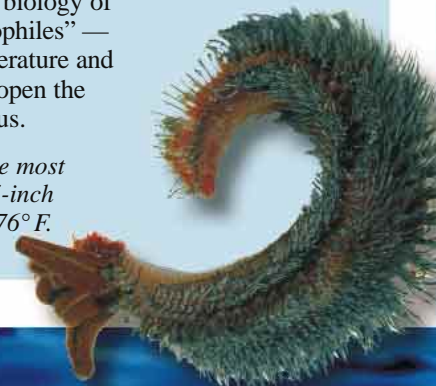
Dr. Craig Cary

Cary's research was conducted onboard the submersible *Alvin* at hydrothermal vent sites in the Pacific Ocean west of Costa Rica. Using a long probe called "The Mosquito," he found that the worm's rear end sits in super-hot water, while its head, which sticks out of the worm's tube home, rests in water that is much cooler, about 72°F.

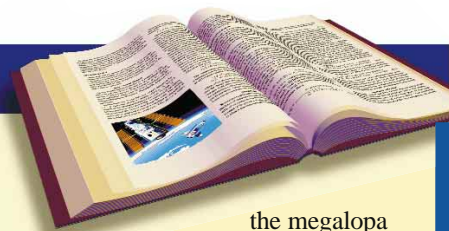
Covering the Pompeii worm's back is a fleece of bacteria that can also "take the heat." These bacteria may harbor enzymes useful in such high-temperature industrial applications as processing food and drugs, making paper, and dislodging oil inside wells.

By learning more about the unique biology of the Pompeii worm and other "extremophiles" — organisms that thrive in extreme temperature and pressure conditions — scientists may open the door to new products useful to all of us.

The Pompeii worm is believed to be the most heat-tolerant creature on Earth. This 5-inch worm can live at temperatures up to 176°F.



NEW PUBLICATIONS



Please mail your request, and if necessary, your check payable to "University of Delaware," to *University of Delaware, Marine Communications Office, Newark, DE 19716-3530*. A nominal fee is assessed to defray printing and postage costs for certain publications.

For additional publications by Delaware Sea Grant and the entire Sea Grant network, please visit the National Sea Grant Depository's Web site at www.nsgd.gso.uri.edu.

In the Public Interest

Seafood Safety: What Consumers Need to Know. Written by seafood specialists at the Delaware and Alaska Sea Grant programs, this brochure informs consumers of the proper handling and storage techniques required to keep seafood safe to eat. *Free.*

Pfiesteria piscicida: Facts about a Fish Killer. The microscopic organism *Pfiesteria* is believed to have caused major fish kills in estuaries from North Carolina to Delaware. Learn more about the complex organism in this fact sheet. *Free.*

Publications Catalog. Delaware Sea Grant has developed publications on a wide variety of topics, from horseshoe crabs to coastal landscaping. This revised catalog also describes videos and slide/tape programs available for sale or rental. *Free.*

Journal Reprints

On the Relative Importance of the Remote and Local Wind Effects to the Subtidal Variability in a Coastal Plain Estuary (DEL-SG-14-98) by K.-C. Wong and J. Moses. Reprinted from *Journal of Geophysical Research* 103(C9): 18,393 – 18,404. The spatial structure associated with wind-induced circulation is important to the long-term transport and distribution of waterborne material. This study demonstrates that the subtidal sea-level fluctuations in the Delaware Estuary are more strongly forced by remote rather than local wind effects. However, local wind effects may be more important in producing subtidal currents at any point along the estuary's cross-section. *Cost: \$1.*

Recent Developments in the Use of Voltammetric Solid-State Microelectrodes to Understand Diagenetic Processes (DEL-SG-15-98) by G. Luther III, M. Taillefert, A. Bono, P. Brendel, B. Sundby, C. Reimers, D. Nuzzio, and D. Lovalvo. Reprinted from *Mineralogical Magazine* 62A: 921–922. The scientists deployed the microelectrode on a Remotely Operated Vehicle to measure dissolved oxygen, manganese, iron, and sulfide at a 10-meter-deep site in Raritan Bay, New Jersey. *Cost: \$1.*

Early Life History of Hemigrapsus sanguineus, A Non-Indigenous Crab in the Middle Atlantic Bight (DEL-SG-16-98) by C. E. Epifanio, A. I. Dittel, S. Park, S. Schwalm, and A. Fouts. Reprinted from *Marine Ecology Progress Series* 170: 231–238. Recently introduced to the U.S. northeast coast, the Japanese shore crab (*Hemigrapsus sanguineus*) has established populations extending throughout the Middle Atlantic Bight. This study shows that the crab's spawning season in the southern part of the bight continues for at least four months, which is much longer than the spawning seasons of native crabs. While zoeal larvae tolerate a wide range of temperature and salinity combinations,

the megalopa stage appears to have more stringent requirements, which may restrict them to the rocky shores of the coastal ocean and adjacent high-salinity regions of the estuary. *Cost: \$1.*

Technical Reports

Disasters and Coastal States: A Policy Analysis of Presidential Declarations of Disaster 1953–97 (DEL-SG-17-98) by R. Sylves. The author investigates the 44-year history of U.S. presidential disaster declarations for 30 coastal zone states and 9 commonwealth/trust territories. Based on data compiled by FEMA, NOAA, and other federal agencies, he tracks the record of natural and man-made disasters involving gubernatorial requests for presidential disaster declarations. GIS displays of coastal disaster experience are provided to promote multi-hazard disaster mitigation; to compare coastal zone disaster experience with inland disaster experience; and to statistically analyze the variables that seem most important in explaining declaration approvals and turndowns. *Cost: \$5.*



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