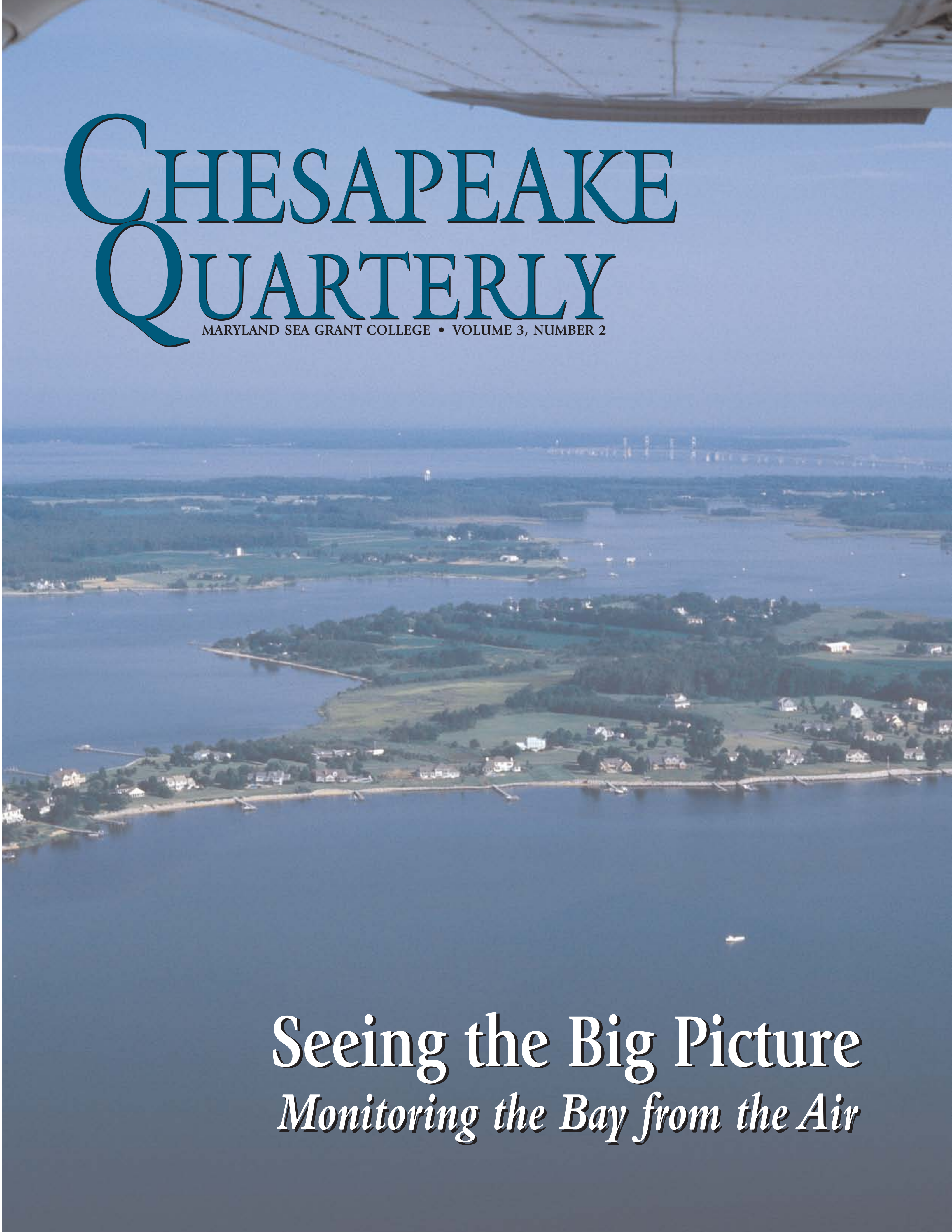

Chesapeake Quarterly

MARYLAND SEA GRANT COLLEGE • VOLUME 3, NUMBER 2

Seeing the Big Picture

Monitoring the Bay from the Air

contents

CHESAPEAKE QUARTERLY

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Cover photo: *A summer day from 500 feet, looking north across Kent Island toward the Bay Bridge.* PHOTO BY JACK GREER. ***Above:*** *The Bay's mosaic of land and water, seen from the DeHavilland Beaver that for years carried remote sensing instruments up and down the estuary, gathering data.* PHOTO BY LARRY HARDING.

The engine of the Piper Arrow whines up to 2000 rpm. The pilot throws a switch and throttles up again, the plane shuddering on the runway with the force of the single propeller, its brakes locked tight.

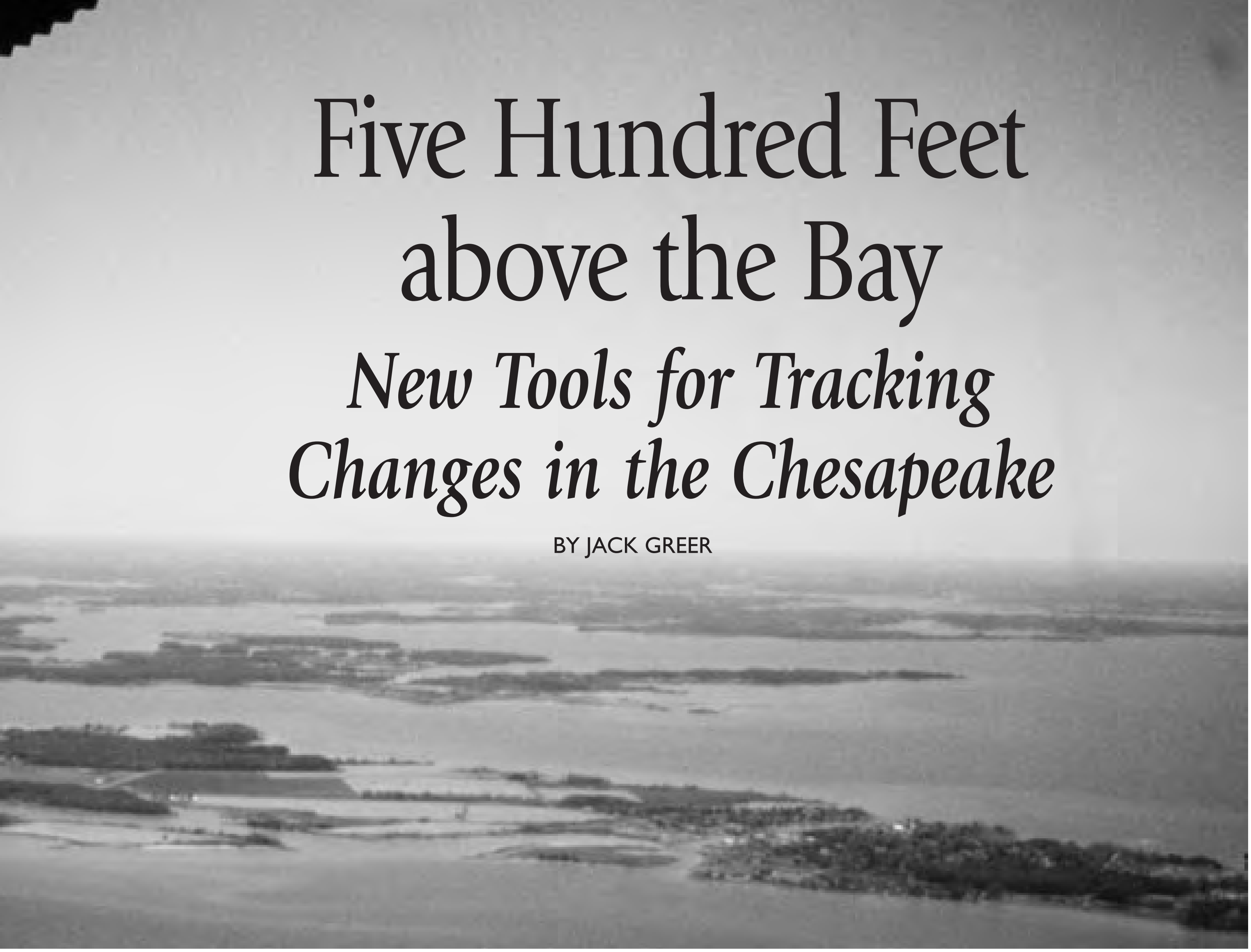
"You have to check out both magnetos," the pilot says, "in case one of them stops working while you're in the air. That's what fires the spark plugs."

This seems a very good idea.

With redundant systems checked out, the pilot releases the brakes, and the Piper's spinning prop pulls us along the runway. Always, when a plane takes off, there is a sense of escape, of slipping off a shackle you didn't know was there, and in a small plane the effect is even greater, the sense of risk keener.

Pushing the throttle farther forward, the pilot coaxes the plane into a breakneck pace, as it races directly for a small gap in a line of trees. Long before we get there, the wheels have left earth, the small airfield has begun to drop away, and we are over Beards Creek and climbing fast. The pilot appears relaxed, confident, having done this many times before.

The pilot at the controls of this small private plane is Larry Harding, a researcher at the University of Maryland Center for Environmental Science who has spent two decades and most of his career studying the Chesapeake Bay from the air. He keeps his private plane at Lee Airport, located on the shores of Beards Creek way up the South River and one river south of Annapolis, Maryland. From here a plane quickly reaches the Bay near Thomas Point lighthouse, and then in a matter of minutes is winging over the Eastern Shore.



Five Hundred Feet above the Bay

New Tools for Tracking Changes in the Chesapeake

BY JACK GREER

From his seat high in the air Harding can see the low-lying patchwork of creeks and inlets that define the Bay's drowned landscape. He can also see the way the color of the water changes, shifting shades of blue and green and brown. At times clear lines appear like sharp borders between tidal currents heading in and out of the Bay and its rivers. In this mix of currents and color Harding can see, especially in late spring and summer, dense blooms of algae, fed by nutrients from the land but also driven by the caprice of currents and by the principal power behind photosynthesis, the sun.

To understand the rich mix of the Bay's algae — its primary producers — one must be able to track shifting populations up and down the estuary as they respond to changes in nutrient levels, weather conditions and river flow.

"People often talk about nutrients causing algal blooms," Harding says, "but that's not the only factor."

The tiny plants that lie at the base of the Bay's food web — what scientists like Harding call primary producers — depend on a particular recipe of nutrients, water chemistry and sunlight. Take away sunlight — during stormy, cloudy periods, for example — and photosynthesis falls off.

To understand the rich mix of the Bay's algae — its primary producers — one must be able to track shifting populations up and down the estuary as they respond to changes in nutrient levels, weather conditions and river flow. And because the Bay is some two hundred miles long, with countless eddies and swirls, following those shifting populations over a period of days, weeks, months and years presents a daunting challenge.

To track when and where the Bay's large patches of algae will appear, Harding and his research team need more than a view from the air — they need another set of eyes as well, a sophisticated array of instruments and analytical tools researchers had barely envisioned when he first started in science more than thirty years ago.

Upwellings

Harding's first glimpse of the ocean's primary producers took place off the coast of California, where he grew up. As a graduate student at Stanford University and then at the University of California at Santa Barbara, he studied the physiology of phytoplankton, floating microscopic plants

Remote Sensing Then . . .

Today researchers have remarkable tools to produce a data-rich bird's eye view of the Chesapeake at multiple scales of resolution, but it has not always been that way. The idea of looking back at the Earth from the air is as old as photography itself. Since the 1840s, people have been trying to take pictures from above. In the years preceding the invention of the airplane, intrepid individuals used hot air balloons, kites and even pigeons to take aerial photographs. Once pilots were able to take to the skies in airplanes, aerial photography for military reconnaissance and topographical mapping quickly became routine. But it was the advent of space flight and the ability to put satellites in orbit that gave birth to the modern field of remote sensing and has allowed scientists to make quantitative measurements of the Earth's surface, its atmosphere and oceans.

Satellites quickly evolved to carry instruments that could monitor global weather, ozone depletion in the atmosphere, earthquakes and other geological activity, and ocean conditions. Nimbus 7, launched in 1978, carried the Coastal Zone Color Scanner (CZCS) that was the first instrument to scan the world's oceans to map chlorophyll concentrations in water. The project continued through 1986, when the Nimbus 7 satellite was deactivated, beginning a 10-year gap in the collection of satellite ocean color data. In 1996, the ADEOS-1 satellite was launched carrying the Ocean Color and Temperature Sensor (OCTS). This instrument enjoyed only a one-year career before malfunctioning.

The launch of the SeaWiFS sensor on the Sea Star satellite on August 1, 1997 marked a major turning point for ocean remote sensing. SeaWiFS, a joint project between NASA and Orbital Sciences Corporation (OSC), has provided seven years of high quality data on chlorophyll abundance and primary productivity with the goal of examining oceanic factors that affect global change. Its coverage of the eastern seaboard, including a complete picture of the Chesapeake Bay every two days, has proven invaluable for scientists like UMCES researcher Larry Harding.

The Sea Star satellite and SeaWiFS sensor are tentatively scheduled to be deactivated in December 2004, but ocean remote sensing will not experience any break in service. Two new satellites are already in place, carrying instruments that also collect high quality ocean color data. Terra (launched in 1999) and Aqua (launched in 2002) as part of the Earth Observing System (EOS) carry the MODIS sensor, a state-of-the-art instrument that samples 36 spectral bands as compared to the 8 sampled by SeaWiFS. Together, Aqua and Terra provide daily morning and afternoon coverage of chlorophyll abundance in Chesapeake Bay.

Though many satellites are circling the earth, only a handful of them observe and monitor the marine environment. When NASA took a tally in 2000, of 8,681 satellites orbiting the earth only 2,465 were operational and the remaining 6,216 were classified as space junk. Fortunately, there are still orbital paths to spare and environmental satellites like SeaWiFS and others will continue to form the backbone of NASA's Mission to Planet Earth.

— Erica Goldman

DEUTSCHES MUSEUM, MUNICH

COURTESY OF THE LEE WELLS COLLECTION

G.R. LAWRENCE

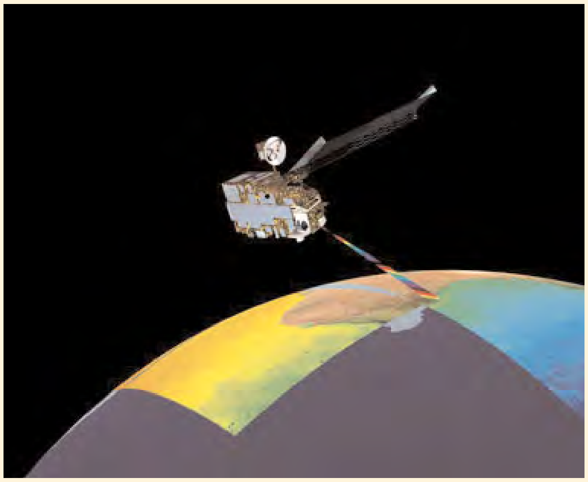
***The desire to capture views of Earth** from above inspired many innovative approaches. The miniature, remotely triggered "pigeon camera," patented by German pharmacist Julius Neubronner, photographed a castle in Kronberg, Germany in 1908. An array of 17 kites, launched by photographer G.R. Lawrence, captured this panorama of San Francisco after the great earthquake of 1906. Balloons were used for both early reconnaissance missions and for science — this balloon, Explorer II, rose 72,395 feet in 1935 to study conditions in the upper atmosphere, setting a world altitude record which remained unbroken for the next 20 years.*

that provide both food and oxygen to the world's oceans. Research cruises aboard the *New Horizon*, a research vessel out of the Scripps Institution of Oceanography, took him from San Diego to Point Conception (just north of Santa Barbara), an excellent area to study the upwelling of ocean currents — and interestingly an area about the same size as the Chesapeake Bay.

"Along the west coast, the driving forces of climate were El Niño and La Niña," Harding says, referring to the large-scale warming and cooling cycles of the tropical Pacific Ocean. We know now that such changes in ocean temperatures and currents can drive large-scale climatic changes, bringing storms or drought to the continent. What interested Harding though, was the ocean's biological response, and especially the mix of plankton, both plant (phytoplankton) and animal (zooplankton) — the primary producers and the critters that graze on them.

Research cruises along upwelling sites, where rich ocean water rises from the depths, revealed a smorgasbord of plankton, and sampling showed dense patches of algal blooms, resulting from nutrients, currents and other factors. "But a ship can only sample at 10 to 15 knots," Harding says — a slow speed for

. . . and Now



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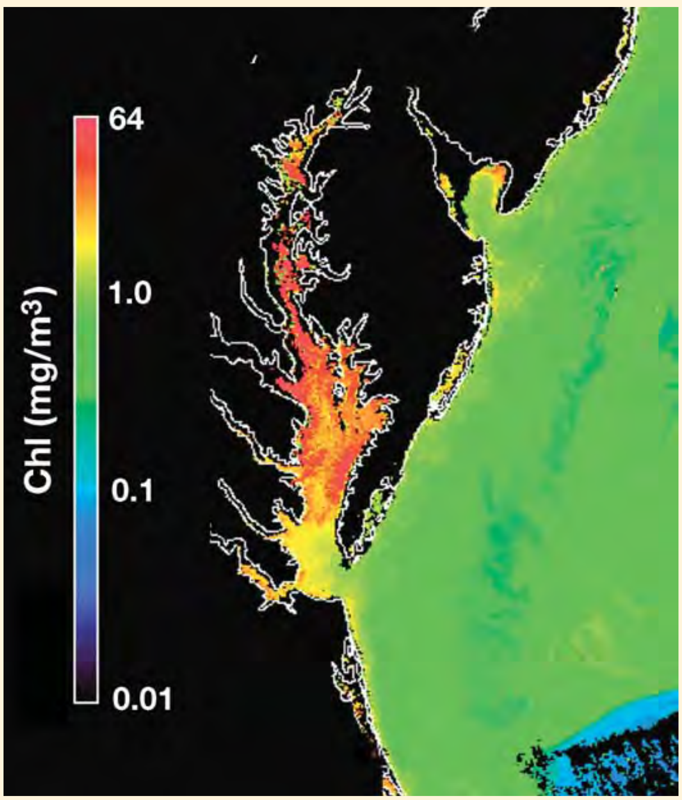


LARRY HARDING

Today, scientists receive measurements *of the biological productivity of the land and oceans, fire occurrence, snow and ice cover, surface temperature, clouds, and water vapor twice daily with sensors such as the Moderate-Resolution Imaging Spectroradiometer (MODIS) carried on the Terra satellite, shown above. The SeaWiFS sensor on the Sea Star satellite also continues to produce a time series of chlorophyll abundance in the oceans and estuaries, producing a complete picture once every two days.*

covering a couple hundred miles of coastal ocean.

As the 1980s began, Harding left the west coast and headed east, first to the Johns Hopkins University and later to the University of Maryland. He brought with him an intense interest in algal blooms and upwelling, and what he found was another area rich in productivity, driven not by large-scale changes in ocean temperature but by large-scale variations of rainfall in a 64,000-square-mile watershed.

"I began working with Tom Fisher [an ecologist at the University of Maryland Center for Environmental Science (UMCES)]," says Harding. "We studied phytoplankton, light and nutrients in the Chesapeake Bay, and to some degree in the Delaware Bay and the Hudson River, for comparison." The researchers were looking along salinity gradients for zones of productivity. Just as upwelling caused rich productive areas along the Pacific coast, Harding reasoned, salinity gradients could be driving areas of dense algal production in a coastal system like the Chesapeake.

Harding and Fisher wrote up their findings in the mid-1980s and began to add to the literature of algal production in coastal systems. The timing could not have been better, since the multi-state effort to restore the Chesapeake Bay had begun to pinpoint overabundant algae — a result of excess nutrients in the watershed — as a fundamental threat to the health of the Bay's ecosystem.

Though the prevailing wisdom was that excess nutrients were harming the Chesapeake, the actual documentation of that process remained weak. "We knew we were under-sampling," says Harding. Where were these algal blooms occurring? When? What was the precise correlation between rainfall, river flow and algal production? Were the Bay's physical features, its deep trenches and shallow shoals, creating eddies and upwelling zones ripe to support algal blooms?

A ship, says Harding, could drop its sampling gear into one area and totally miss an algal bloom in another area — or it could miss it in time, by being in the right place on the wrong day.

The Chesapeake Bay Institute at Johns Hopkins had long-term data going back to 1949, gleaned from shipboard samples in transects that followed the Bay's mainstem. Other researchers had samples as well, some of which helped to provide data at the edges, in the Bay's important shallow areas. "Before the 1980s scientists just patched all this work together," Harding says, "to get a picture of how the Bay works." It wasn't until 1984, he says, when the Chesapeake Bay Program's monitoring effort began, that an integrated approach started to track the Bay's response to all the nutrients and other contaminants poured into it by a growing population and a sprawling, rapidly urbanizing watershed.

In addition to the painstaking research taking place on the ground what was needed was a synoptic view, a bird's eye view of the whole Bay, from north to south, from western shore to eastern shore, over time — from season to season, from year to year. Harding and his colleagues took to the air.

A Bird's Eye View

From many miles above the earth satellites like the NIMBUS 7, launched in 1978, had begun to provide just such a glimpse. In 1987 and 1988 Harding began to work with Wayne Esaias and Chuck McLain from the National Aeronautics and Space Administration (NASA), using data from a coastal zone scanner known as CZCS. "This was very exciting," Harding says, "but even though it was called 'coastal zone' it was really an ocean scanning system." The results were "broad brush," Harding says, providing composites that were pieced together from accumulated scenes. To study a coastal system like the Chesapeake Bay, the resolution needed to be much greater — the bird had to fly lower, its eyes more sharply focused.

In 1988 Harding applied for a summer faculty fellowship to work with NASA and began test flights with airborne sensors. Onboard a small aircraft — a single-engine DeHavilland Beaver — Harding and his colleagues mounted a unit known as ODAS, the Ocean Data Acquisition System. Like scanners mounted on NIMBUS and other satellites, the ODAS system measures light reflected from surface waters. Light comes in colors, and it is that color spectrum that these sensors measure and assemble.

What can we tell from the color of reflected light? We can, if the instruments and computer programs are good enough, pick out specific pigments. We can pick out sediments and organic materials and the color of the water itself.

For more than fifty years we've known that chlorophyll, the basic pigment of photosynthetic plants, absorbs light at the blue end of the spectrum.

Inside the

From 500 feet in the air, scientist Larry Harding can measure the total amount of chlorophyll in the Bay and how it varies in space and time. From chlorophyll abundance, he has developed a model to calculate primary productivity, or how much carbon the Bay's floating plants fix by photosynthesis in a specific area in one day. But it takes some wet shipboard sleuthing to identify the cast of characters that are driving the Bay's complex food web. A postdoctoral scientist in Harding's group, Jason Adolf is trying to figure out which groups of phytoplankton are in the Bay and to link this information back to data collected by aircraft and satellite surveys in order to tease apart the environmental factors that are driving their distribution.

JACK GREER

Jason Adolf

"The goal of this work was to open up the 'green box' of chlorophyll in the Bay and to decipher what groups of phytoplankton are both present and active at a given location or point in time," says Adolf, taking care to credit ecologist Hans Paerl at the University of North Carolina in Chapel Hill for coining the phrase.

All photosynthetic algae and certain bacteria (cyanobacteria) contain chlorophyll *a* (one subtype), but the techniques used to quantify it from an aircraft or satellite cannot resolve the differences among groups of photosynthesizers. The major groups that contain chlorophyll *a* also have other distinctive photopigments (such as fucoxanthin, peridinin, zeaxanthin, and others), so the unique chemical structures of these pigments can be used to identify what types are in a sample.

From 1995 to 2000, Adolf worked with Harding's group to collect and analyze water samples taken seasonally across regional scales that match Harding's aircraft surveys. Using a method called high performance liquid chromatography (HPLC), which separates compounds and quantifies them based on their chemical structure and light absorption properties, he identified which groups of phytoplankton were present at different times of the year.

Adolf found that 93 percent of all the chlorophyll *a* in the Bay's "green box" came from four major groups: diatoms, dinoflagellates, cryptophytes, and cyanobacteria. But he found that the relative abundances of these groups in different seasons changed dramatically from year to year. "We didn't expect to see such a variable pattern," he says.

Adolf's findings did support the current paradigm of a spring to summer transition in species composition that is driven by early high freshwater flow in the winter and low flow in the summer. Diatoms tend to be very abundant in spring and less abundant in summer. Adolf found that they make up roughly an average of 70 percent of the biomass in spring but only 28 percent in summer.

Although only single-celled, diatoms have distinctive cell walls made of silica and a characteristic structure called a frustule, which consists of two valves that fit within each other. They vary widely in size, ranging from two microns to several millimeters, and in shape, from spheres to cylinders to pancake-like discs.

Most diatoms are not capable of active movement. Conventional thinking holds that in the Chesapeake Bay diatoms dominate in the spring because the water is turbulent enough to keep them in suspension, explains Adolf. When tributary inflow to the Bay subsides in the summer, diatoms sink to the Bay floor forming a thick carpet of organic matter that contributes to the low oxygen conditions typical of late spring and summer. During high flow years, diatoms are more abundant and persist longer into the summer.

Diatoms

MARINE BIOLOGICAL LAB, WOODS HOLE

Cyclotella litoralis

Diatoms are generally good food sources for filter-feeding zooplankton, bottom-dwelling invertebrates and larval fish. *Cyclotella* is one genus that is exceptionally plentiful in Chesapeake Bay. Some species in this genus have long, thin spines that are thought to help with flotation.

Dinoflagellates comprise an average of 20 percent of the total phytoplankton biomass of the Bay at their highest seasonal abundance, which according to Adolf's analysis occurs in the summer, dropping to as little as 4 percent in the fall. Single-celled organisms, dinoflagellates are often photosynthetic — but not always. Their name is derived from the two whip-like flagella that allow them to move actively through the water column. Unlike the silica-laden diatoms, dinoflagellates have a cell wall made

Bay's "Green Box"

of cellulose, which, in some species, is divided into a distinctive armor known as theca. These plates form unique geometries that can be used for classification.

Dinoflagellates are important sources of food for higher trophic levels in the Bay, but they are also somewhat infamous for releasing harmful toxins and for changing the color of the water when they proliferate and reach high densities. The dinoflagellates *Prorocentrum minimum* and *Karlodinium micrum* are the chief culprits in the Chesapeake behind a phenomenon known as mahogany tide. When these species bloom, the high biomass may severely limit the amount of oxygen available to other organisms, sometimes resulting in local fish kills — *K. micrum* is known to have caused several fish kills in aquaculture facilities in the Bay. Although no cases of shellfish poisoning resulting from toxins produced by these dinoflagellates have been reported in Maryland waters, according to the Department of Natural Resources, scientists and managers suspect that they do have the potential to be toxic to shellfish. *Prorocentrum micans* is a cousin of *P. minimum.*

Dinoflagellates

MARINE BIOLOGICAL LAB, WOODS HOLE

Prorocentrum micans

Cryptophytes comprise an average of 35 percent of the plankton biomass in the fall, according to Adolf's analysis, but are not as well known as other groups of algae in the Bay. Like dinoflagellates, they are single-celled, have flagella, and are capable of movement. They have a distinctive carotenoid pigment called alloxanthin, in addition to chlorophyll, making them easy to distinguish from the other groups. Cryptophytes are also notable for an additional compartment in their nucleus that contains nucleic acid. This structure is thought to be a relic of the nucleus of a formerly free-living red algal cell that had been taken up through a process called "endosymbiosis." The genus *Cryptomonas* dominates the cryptophyte assemblage in the Bay.

Cryptophytes

MARINE BIOLOGICAL LAB, WOODS HOLE

Cryptomonas spp.

The final major group of photosynthesizers in the Bay are the cyanobacteria. Cyanobacteria are not algae, but true bacteria that also contain chlorophyll and perform photosynthesis. In the summer, Adolf found that cyanobacteria account for an impressive average 26 percent of the chlorophyll biomass in the Bay. Cyanobacteria are quite small and usually unicellular, though they may grow in colonies large enough to see, particularly in fresh water, arranged in long, filamentous formations. They contain an accessory pigment called phycocyanin, which gives the group its name and, combined with a unique carotenoid called zeaxanthin, allows for ready identification.

Although in some ecosystems cyanobacteria are a valuable food source, in the Bay they tend to be harbingers of poor water quality. Recent cyanobacteria blooms in Colonial Beach, Virginia, for example, have caused repeated beach closures. There are many cyanobacteria that are either toxic or inedible, and they tend to thrive under nutrient-enriched, eutrophic conditions. Some cyanobacteria can actually metabolize nitrogen from the atmosphere (N_2), converting it to ammonium. In some bodies of water, nitrogen fixation caused problems with nutrient overenrichment.

Cyanobacteria

MARINE BIOLOGICAL LAB, WOODS HOLE

Synechococcus spp.

Ultimately, Adolf hopes that information about species composition at the base of the food chain will help to untangle the web of culinary preferences that drive the consumers in the Chesapeake Bay ecosystem. "We know from other research in the field that a varied diet of different species of phytoplankton tends to promote more successful growth and reproduction by grazers higher up the food chain," says Adolf. "And we know that there will be differences in the food web when the Bay is filled with one type of phytoplankton versus another," he says.

Making the link between photosynthetic algae and species dynamics at higher trophic levels still remains a challenge. "People would love to be able to use floral composition data to address questions about fisheries abundance," says Adolf. But the "green box" of the Bay still has plenty of secrets yet to share.

— *Erica Goldman*

For more about phytoplankton diversity in the Bay, visit DNR's site on Chesapeake Bay Life: www.dnr.state.md.us/bay/cblife/algae/index.html

A Few Bad Actors

While algal blooms are a natural part of the Bay's productivity, too many algae can rob botom waters of oxygen. Beyond this, there are a few species of noxious and potentially toxic algae that can cloud rivers and spoil beaches. The state of Maryland operates a 24-hour hotline at 888.584.3110 that citizens can call to report algal blooms, as well as sick or dying fish. The Maryland Department of Natural Resources (DNR) also urges the public, including physicians, to call this number in the event of human illness believed to be associated with algal blooms or fish kills.

This summer has already seen surface scums and shoreline accumulations of blue-green algae, dominated by toxin-producing *Microcystis* — most evident at Colonial Beach, Virginia, and on the western shore of the Potomac River downstream of the Route 301 Bridge. Other areas affected by blue-green algal blooms during June 2004 include the Sassafras River, Bush River, Seneca Creek and lower Gunpowder River — all tributaries in the upper Chesapeake Bay — as well as the Potomac River at Sandy Point and Mattawoman Creek.

For continual updates on problem blooms in Bay waters, visit DNR's Eyes on the Bay site: mddnr.chesapeakebay.net/eyesonthebay/index.cfm

For more on harmful algal blooms worldwide, visit the Woods Hole Oceanographic Institution: www.whoi.edu/redtide/

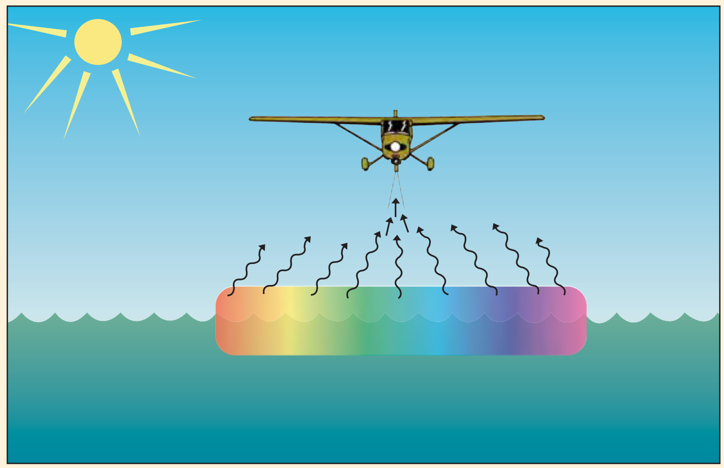
In Plane Sight

Small airplanes provide just the right scale of resolution for capturing the big picture of phytoplankton abundance and change through time in the Chesapeake Bay.

While shipboard sampling is critical to ground-truth measurements taken from the sky, providing information about species composition and primary production, these surveys are too patchy and infrequent to synthesize information over the whole estuary. Measurements from satellites like SeaWiFS occur regularly, providing a complete picture of the Bay every two days, but the information is too coarse to resolve the spatial scale of plankton distributions in a coastal system like the Bay.

For Larry Harding, the airplane has become both his scientific and personal *modus operandi*. He has applied aircraft-mounted remote sensing technology on spatial scales over which an aircraft flies, parceling the Bay into a set of 7000 pixels that can be reconstructed to visualize the estuary at a resolution of one square kilometer — a scale fine enough to see subtle changes in plankton abundance but broad enough to capture the full extent of a bloom.

LARRY HARDING



SANDY RODGERS

Reacting to the sun's radiant energy, *aircraft-borne sensors quantify chlorophyll by reading the changing intensity and color signature of light as it reflects out of the waters below. The single-engine DeHavilland Beaver shown above gathered data up and down the Bay for six years using the Ocean Data Acquisition System (ODAS), which was among the first generation of such equipment.*

The Ocean Data Acquisition System (ODAS) was the first generation of aircraft remote sensors that Harding used in Chesapeake Bay and he successfully collected data with it from 1989-1995. ODAS was comprised of 3 radiometers, instruments that quantify the intensity of electromagnetic radiation in three different wavelengths in the blue to green range of the visible light spectrum. Chlorophyll absorbs light in the blue part of the color spectrum, but not in the green. When there is more chlorophyll in the water, more blue light is absorbed, so less is reflected. This is why the phytoplankton-rich Bay appears greenish while the deep ocean, where primary production is scarce, is blue to the eye. By calculating a ratio of blue to green light reflected, scientists can calculate how much chlorophyll is in the water.

With a sensor that points straight up out of the top of the airplane, ODAS, and the generation of tools to follow, also collect data on the total amount of sunlight on a given day (irradiance) and have an instrument to measure the temperature of the water (SST-Sea Surface Temperature).

Harding began using a new set of aircraft remote sensing instruments in 1995. The major innovation of these devices has been an increase in the number of wavelengths of light sampled. The new scanner, the SeaWiFS Aircraft Simulator, paralleled the SeaWiFS satellite scanner, measuring the same 8 wavelengths so that the data could be compared. One of the advantages of data collected at low aircraft altitudes is that there is much less interference from the atmosphere. The newest model of this simulator (SAS III) now measures 13 wavelengths of light, including and adding to those sampled by the SeaWiFS satellite scanner. Sampling additional wavelengths improves Harding's ability to resolve chlorophyll abundance in highly turbid conditions or at the extremely high concentrations that accompany seasonal blooms of diatoms and dinoflagellates.

Harding's group currently makes up to two-dozen aircraft overflights of the whole Bay in a given year and he has made a series of monthly flights over the Choptank and Patuxent rivers over the past four years, through a separate program called the Coastal Intensive Site Network (CISNet). Combined with regular water samples that span the length and width of the whole Bay and ocean color images from several satellite sensors, Harding has amassed a long-term data set of the physical and biological parameters that make the Bay tick. As shifts occur in the Bay's plankton composition over space and time, Harding's sensors are almost certain to see them.

— Erica Goldman

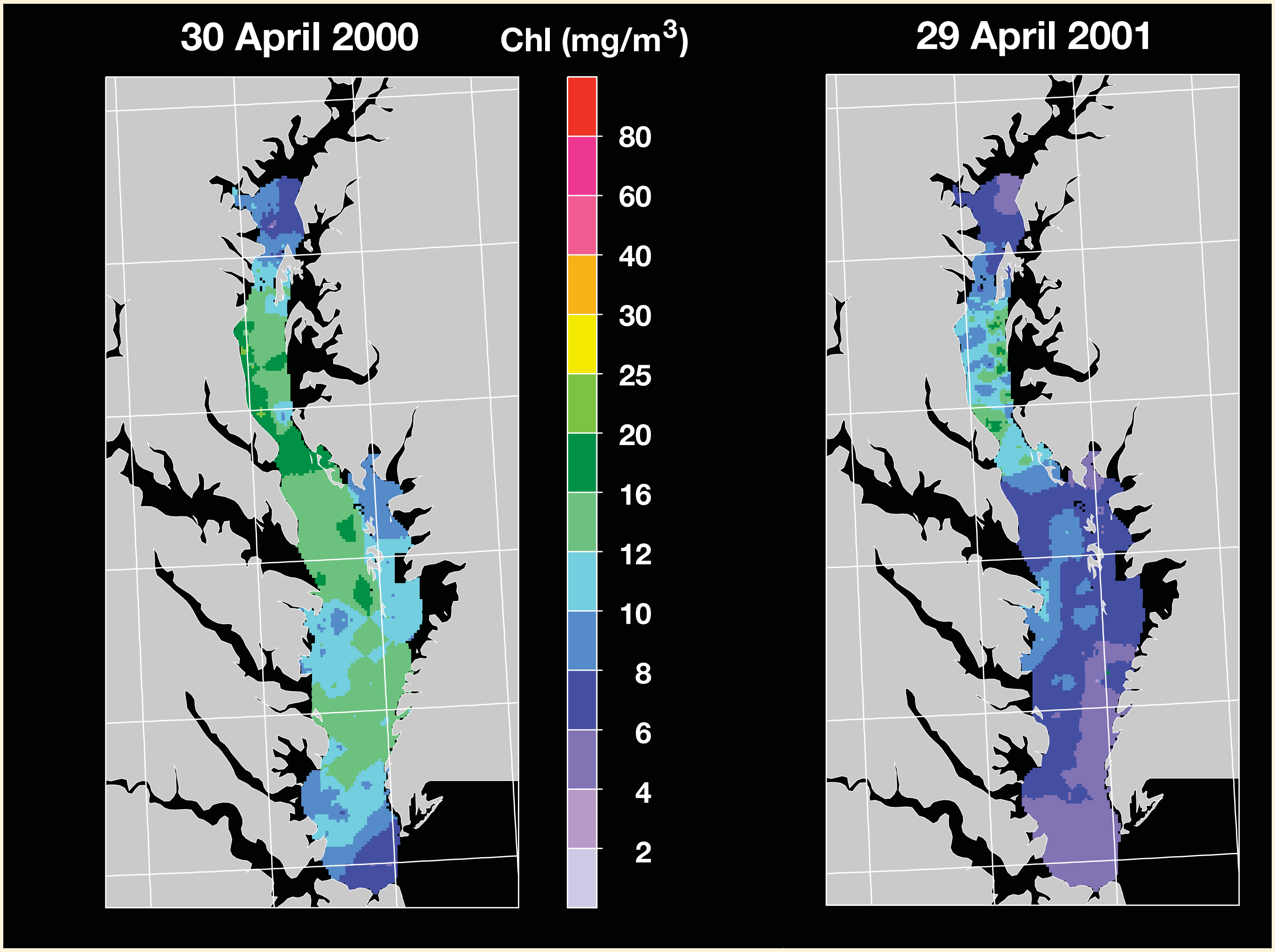
Where there is less chlorophyll — as in the open ocean — the blue shines through. Where there is more chlorophyll, less blue light reflects back. Think of chlorophyll as a sponge that sucks up the color blue, says Harding.

Interestingly, the color green — the color we most often associate with plants — can stay fairly constant in these readings, he says, like the hinge on a door, as the color blue swings up and down, according to the density of chlorophyll.

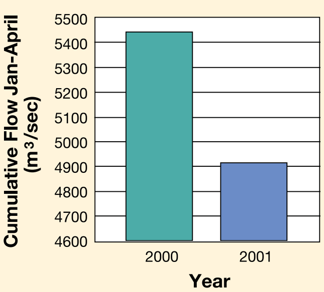
Like a painter, the researcher who uses color as a tool must know his palette. In the Chesapeake Bay, for example, the color of the water changes as one flies from north to south. Its character changes because of sediment and organic matter, what Harding calls "conservative factors" — factors that vary from place to place and must be set aside before analyzing other signals. These basic factors are tied to salinity, and by the time one reaches the lower Bay the character of the water has changed and become essentially like that of the coastal ocean.

While the low-altitude airplane flights worked well, observing the Bay from a steady 500 feet above sea level, a shallow estuary like the Chesapeake Bay remains a tough place for remote sensing. There are areas of local turbidity, Harding says,

A Tale of Two Years



LARRY HARDING



Color-coded for ease of visualization, *these charts of the Chesapeake show two very different days at the end of April. In 2000, a year with high river flow from January through April, relatively dense algal concentrations (shown in green) are detected by aircraft-borne sensors. The next year, with lower flows from January to April, those same sensors see much clearer water, represented here in blue and purple. Like a biological bellwether, the southern Bay in particular responds quickly to shifts in nutrient loads. In low-flow years the Bay begins to resemble its past, when fewer nutrients left waters clearer and when light penetrated down to rooted underwater plants.*

and shallow places where the sensor can "see the bottom." This can really "screw things up," Harding says, and the farther up-Bay one flies, the harder it gets. Getting good readings north of Baltimore and the Patapsco River remains difficult, he says, but fortunately that doesn't matter too much, because the real action in terms of measuring changes in algal production lies farther south, in Virginia's portion of the Bay.

Harding and his team flew the ODAS instruments until 1995, and then they switched to a new package called SeaWiFS (Sea-viewing Wide Field-of-view Sensor). The team used a specially developed SeaWiFS Aircraft Simulator (SAS) carried aboard their airplane, preparing to match their data with that from a satellite high above the earth. After some delay, a SeaWiFS scanner was ultimately launched on a satellite in 1997, an exciting moment for Harding and his team. From a NASA monitor at the Goddard Space Flight Center in Greenbelt, Maryland, they watched as an L1011, a large cargo plane, took off from Vandenberg Air Force base with a Pegasus rocket strapped to its belly. Dropped from the mother ship, the Pegasus fired and carried the satellite into an orbit more than 700 kilometers above the earth. "We were just hoping it wouldn't blow up," Harding says. By the fall of 1997, the new satellite was sending down data that the research team could match with the data they had gathered from their aircraft-borne sensors.

The problem with satellite data for researchers like Harding is picking out a signal from all the noise the sensors pick up, like listening for your favorite tune in a sea of static.

"About 95 percent of the signal [picked up by the satellite] comes from the atmosphere," says Harding, so the readings are "contaminated" from the beginning. This confounding "path radiance" must be removed before researchers can begin to tease out the part of the signal that pertains to light reflected from surface waters.

The SeaWiFS satellite provides data from some 80 to 130 passes per year, providing images on a scale of 1.2 kilometers, a broad brush that gives scientists a lot of data they can use to track changes in the global ocean. But for more detailed analysis, researchers still need a closer look, and since 1995 Harding's group has flown their SeaWiFS aircraft simulator, following a zig-zag path down the Bay to get maximum coverage. (See "In Plane View.")

Out of this stream of data Harding and his colleagues have tracked the appearance and disappearance of algal blooms that come and go in the Bay like time-lapse photographs. He has now assembled one of the longest such datasets in the world, providing accurate real-time pictures of the algal blooms that have become such a major concern for the Chesapeake. What have these photographs revealed? Can they, like X-rays or CAT-scans, help us diagnose what has happened to the Bay, and what is likely to happen?

The Day After Tomorrow?

While the productivity of the Chesapeake Bay may not be directly related to large-scale ocean events like El Niño, it is tied to the region's and the hemisphere's climatic patterns. Those patterns generally unfold over long periods of time, and for the most part they do not happen in an unbroken sequence. A trend toward increased rainfall may be punctuated by years of drought. Gradually increasing temperatures may be interrupted by exceptionally cold winters. Taking samples over the period of a couple of years simply will not begin to suggest trends or long-term changes in climatic patterns or the ecosystem responses that such shifts can cause.

Comparing fifteen years of data from aircraft, satellite and shipboard measurements, Harding cannot yet see a real trend in the Bay's primary production. The Bay, it seems, has leveled off at a fairly high rate of algal growth. "In the early 1950s you would see densities of phytoplankton [measured by chlorophyll] at levels of 1 to 2 milligrams per cubic meter in the southernmost reaches of the Bay," Harding says. "Now they are at 5 to 6 milligrams — something like a 500 percent increase."

The goal, he says, is to get back to 1 to 2 milligrams again.

While Harding's view from the air has not yet shown a significant response to the region's continuing management efforts, he feels confident that once the response is there he will see it.

"Any response to management efforts will show up in the lower Bay," he says. "I'm more confident of that than of anything."

In the lower Bay — from the Rappahannock River to the Virginia capes — where nitrogen is generally less abundant, it gets used up fast by algae, Harding says. This means that this area is very sensitive to increases and decreases in nitrogen, and as those levels change, the signal will be readily apparent in chlorophyll measurements taken in the southern Bay. (See "A Tale of Two Years.")

Harding feels especially confident of this because nature, in all its variability, has provided those who study the Chesapeake with some very dramatic "experiments." Some years provide striking contrasts, and Harding points to years that shifted from low flows to high flows, including 1995/1996, 1999/2000, and 2002/2003. In each of these years the Bay watershed went from low flow to high flow conditions. These natural experiments allowed researchers to watch the Bay's response, and the difference was undeniable. The low-flow years, Harding says, show what a long-term response to lower nutrient loads would look like, with densities of algal growth dropping, the water clearing, and underwater grasses improving. In high flow years the algae return.

As it is now, algal production is closely linked to flow — as measured by gauges at the Susquehanna River's Conowingo Dam. The higher the flow, the more algal production. This effect has no doubt been amplified by agriculture and development in the watershed, where rainfall races unchecked across farm fields, parking lots and down storm drains. Not only has development added more nutrients to the watershed, but we have sped up the nutrient delivery system through countless culverts, ditches and drain pipes. Gone are many of the forests and vegetated buffers that once slowed the flow.

At the same time, large regional climatic patterns may be presenting another challenge to our nutrient reduction efforts. Those who track large-scale climate change are predicting warmer and wetter weather for the Mid-Atlantic region. Such predictions are tricky, since climatic patterns respond to a number of factors, including global ocean events such as El Niño and La Niña and, in the Atlantic, the North Atlantic Oscillation.

David Miller, a doctoral student at the UMCES Horn Point Laboratory and part of Harding's research team, examines the connections between weather data from the last 15 to 20 years and compares them to what monitoring and remote sensing tells us is happening in the Bay. His goal is to better understand and predict how the ecosystem responds to changes in weather, and especially rainfall.

Miller uses weather data to characterize each day as a particular type — a Nor'easter pattern, for example, or one dominated by the Bermuda High. Looking at as many as ten dominant patterns, he compares weather to changes in flow in the Susquehanna River, and then to downstream changes in the Bay. "Larger scale phenomena like El Niño don't have much of a signature in the Bay — though we always look for it," says Miller. Mostly, he says, their approach is regional, looking for shifts and trends in weather patterns at a synoptic scale, from the Rocky Mountains to Bermuda, from Nova Scotia to Florida.

Their ultimate goal is to link climatic patterns to responses of the Bay's phytoplankton. By documenting these links, the researchers are building a climatology of the Bay — not a study of climate alone, but a long-term description of how the Bay's primary producers respond to differing conditions, including river flow and nutrient loads. This climatology can then be placed in the larger context of changes seen on the scale of continents and oceans.

Ocean currents in the North Atlantic, generally the purview of a few oceanographers and climate experts, have recently captured the public imagination. Script writers for the film *The Day After Tomorrow* posited a dramatic shift in the Atlantic's oceanic "conveyor belt" — currents that carry warm water north in the Gulf Stream, across the Atlantic, and then back down past Europe, where the current then sinks beneath the surface before warming again in the tropics. In the film, a rapid cooling of that current by icy Arctic water, released as global warming melts huge ice fields, presages a new ice age. While this is science fiction, some evidence exists to suggest that climatic changes can occur relatively quickly — if a global "tipping point" is reached. More likely in our lifetimes, however, will be gradual changes that could have uncertain effects on ecosystems like the Chesapeake Bay.

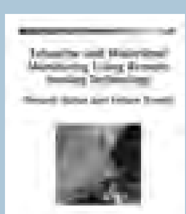
Climate models suggest, for example, that by 2030 the climate of Washington, D.C. could be more like that of Norfolk, Virginia, and by 2090 it could be more like that of Charleston, South Carolina or Atlanta, Georgia. According to these models, winters would become warmer. If weather in the Chesapeake watershed does become wetter and warmer, more rainfall — especially without better stormwater and wastewater management in place — could mean more algal production and more areas of low oxygen.

These changes will be hard to spot in the short term, and difficult to track with scattered monitoring efforts. The kind of long-term, synoptic view provided by satellite and aircraft remote sensing offers the best hope of tracking the Bay's biological response to alterations in nutrient loads, climate and other factors.

The first signs of a recovering Bay will likely occur south of the Rappahannock, and will be best detected by a system that never sleeps and that won't miss the action by being in the wrong place at the wrong time.

Without that kind of reading of the Bay's pulse, we may not know precisely when the day after tomorrow will arrive.

Report Examines Remote Sensing in the Bay



A new report on remote sensing in estuaries will be available in September from Maryland Sea Grant and the Chesapeake Bay Program's Scientific and Technical Advisory Committee (STAC). The result of a workshop held in Annapolis, Maryland, the report is entitled, *Estuarine and Watershed Monitoring Using Remote Sensing Technology: Present Status and Future Trends.* The 48-page summary examines the varying technologies that have made modern remote sensing possible, and recommends ways to better integrate and make use of data from these new methods.

The report notes that much has happened since a 1977 conference sponsored by NASA, EPA and the University of Maryland and entitled "Applications of Remote Sensing to the Chesapeake Bay Region." At that conference Senator Charles "Mac" Mathias warned the participants that the Chesapeake Bay was in danger of becoming a "dead sea" if we did not better understand and protect it. Now, more than 25 years later, we do know much more about how the Bay works and what factors most threaten its health.

Researchers and managers participating in the Annapolis workshop explored recent and ongoing efforts in remote sensing and how they fit into the current effort to monitor and model conditions in the Chesapeake. They concluded that for remote sensing data to be useful in the Bay region researchers and managers alike must work to integrate highly resolved data from buoys, towed instruments, aircraft and satellites with data from more traditional sources.

Also important, the report notes, is better use of satellite images such as NASA's Landsat earth-imaging system for monitoring the Bay's watershed, as well as better ways of using new technologies to examine and predict changes in wetlands.

The report notes that aircraft and satellite-borne sensors can monitor areas of the Bay that are otherwise under-studied, and points out that given current conditions — such as overabundant algae, increased turbidity and the depletion of oxygen — remote sensed data can help provide diagnostic tools critical for defining what will constitute a "restored" Bay.

The report will be available as a pdf on the Maryland Sea Grant web site at www.mdsg. umd.edu.

Remote Sensing Web Links

Early History

www.nasm.si.edu/galleries/lae/script/be_frame.htm

Aircraft Remote Sensing

Chesapeake Bay Remote Sensing Program
www.cbrsp.org

Satellite Remote Sensing

SeaWiFS
seawifs.gsfc.nasa.gov/SEAWIFS/

Earth Observing System (EOS)
eospso.gsfc.nasa.gov

MODIS
modis.gsfc.nasa.gov

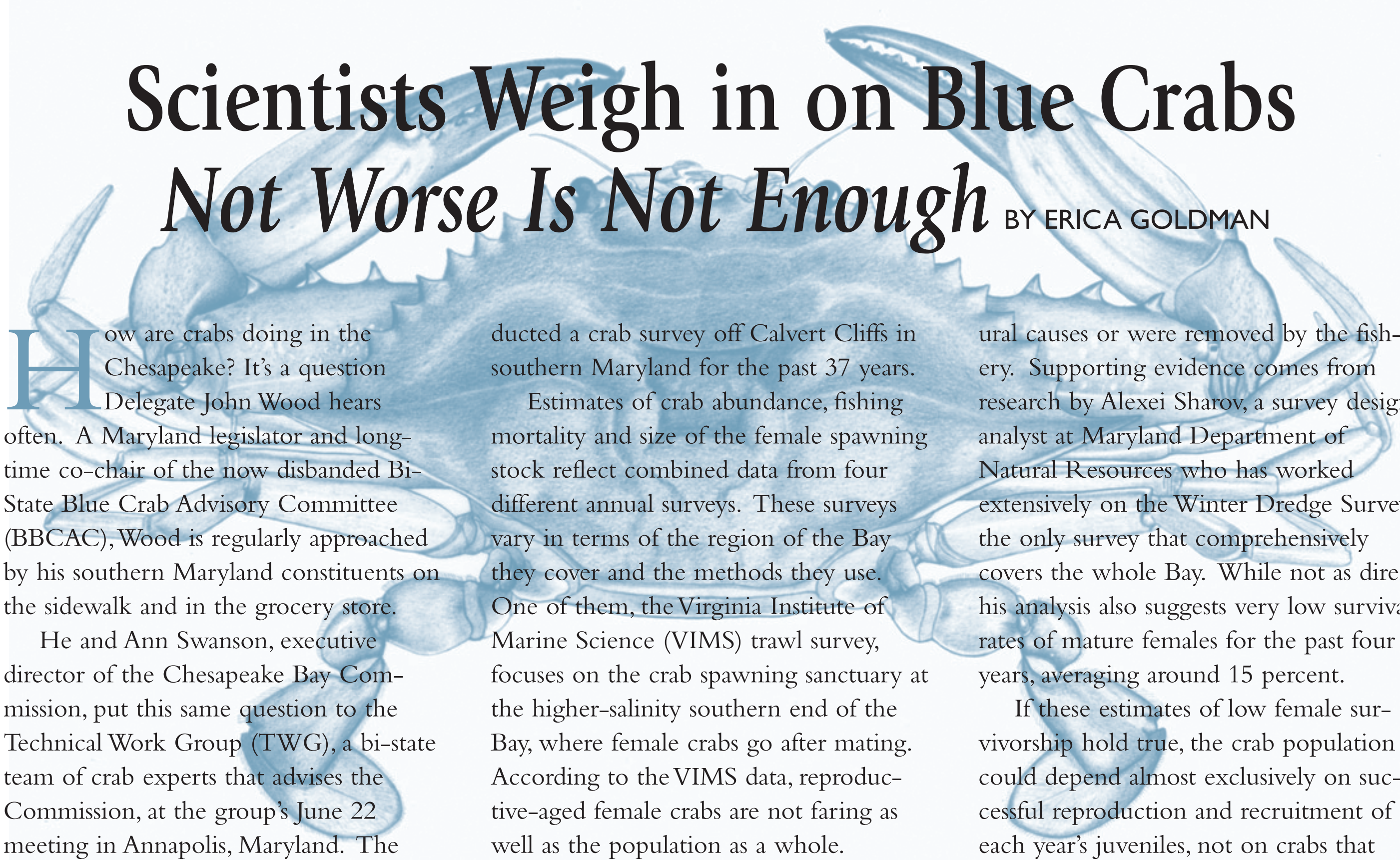
Aqua
aqua.nasa.gov

Terra
terra.nasa.gov

Scientists Weigh in on Blue Crabs

Not Worse Is Not Enough

BY ERICA GOLDMAN



How are crabs doing in the Chesapeake? It's a question Delegate John Wood hears often. A Maryland legislator and long-time co-chair of the now disbanded Bi-State Blue Crab Advisory Committee (BBCAC), Wood is regularly approached by his southern Maryland constituents on the sidewalk and in the grocery store.

He and Ann Swanson, executive director of the Chesapeake Bay Commission, put this same question to the Technical Work Group (TWG), a bi-state team of crab experts that advises the Commission, at the group's June 22 meeting in Annapolis, Maryland. The answer from crab biologists and resource managers, whether from Maryland or Virginia, was essentially the same: "Not worse."

They chose this answer carefully. The truth is, they said, that while a years-long slide in population has leveled off and perhaps even turned the corner slightly, the population is still well below the long-term average, and some troubling signs remain.

According to the annual Chesapeake Bay Blue Crab Advisory Report, prepared by the Chesapeake Bay Stock Assessment Committee (CBSAC) and released on June 2, blue crab abundance has improved compared to the near historically low levels of the previous four years. At the same time, watermen reported strong harvests as the season began. But while the "not worse" diagnosis may be a sign that recent declines in the crab population are slowing, it is at best a reason for "cautious optimism," says Swanson.

"It will take at least three to four years of heading in the right direction before we can really say anything," says George Abbe of the Academy of Natural Sciences Estuarine Research Center in St. Leonard, Maryland, who has conducted a crab survey off Calvert Cliffs in southern Maryland for the past 37 years.

Estimates of crab abundance, fishing mortality and size of the female spawning stock reflect combined data from four different annual surveys. These surveys vary in terms of the region of the Bay they cover and the methods they use. One of them, the Virginia Institute of Marine Science (VIMS) trawl survey, focuses on the crab spawning sanctuary at the higher-salinity southern end of the Bay, where female crabs go after mating. According to the VIMS data, reproductive-aged female crabs are not faring as well as the population as a whole.

Fewer Females?

Of the four crab surveys used, the VIMS trawl survey is the only one that counts females in the southern Bay sanctuary, where they have escaped being caught in a given season and successfully returned to their spawning ground, explains VIMS fishery biologist Rom Lipcius. While data from the other surveys show slight increases in the spawning stock, the VIMS survey reflects no obvious improvement — in fact, a preliminary analysis shows that the female spawning stock may have continued to decline for the tenth consecutive year. "We are certainly not on a doubling path," Lipcius says, referring to a goal stated in BBCAC's 2001 Action Plan to increase the blue crab spawning stock two-fold.

The precarious plight of female crabs was also the sobering subject of a presentation by VIMS fisheries population biologist John Hoenig at the TWG meeting. Hoenig's data suggested that only 2 percent of female crabs that made it to the spawning ground in 2002 survived until the next season. The remaining 98 percent of mature females either died of natural causes or were removed by the fishery. Supporting evidence comes from research by Alexei Sharov, a survey design analyst at Maryland Department of Natural Resources who has worked extensively on the Winter Dredge Survey, the only survey that comprehensively covers the whole Bay. While not as dire, his analysis also suggests very low survival rates of mature females for the past four years, averaging around 15 percent.

If these estimates of low female survivorship hold true, the crab population could depend almost exclusively on successful reproduction and recruitment of each year's juveniles, not on crabs that live and spawn for multiple seasons, he explained.

A population that replaces itself each year through reproduction may not pose a problem in itself, says fisheries economist Doug Lipton, director of the Maryland Sea Grant Extension Program. Shrimp are an "annual crop" like this, he explains. This reproductive high-wire act does, however, make the crab population more vulnerable if recruitment of juveniles fails due to disease, unusual weather or some other factor, because there will simply be fewer mature crabs around to maintain the stock's reproductive capacity.

Meanwhile, other efforts are underway to enhance recruitment of juvenile crabs to the population to ward off the specter of a future recruitment failure. Estuarine ecologist Anson Hines, from the Smithsonian Environmental Research Center (SERC) in Edgewater, Maryland presented preliminary results from collaborative work with physiologist Yonathan Zohar and others at the UM Center of Marine Biotechnology (COMB) in Baltimore. The research team is experimenting with enhancing crab populations on a local basis by releasing hatchery-raised juveniles in different tributaries.

CRAB © AL KETTLER

Since the project began in 2002, COMB scientists have reared a total of 81,000 juvenile crabs to a size of 20 millimeters — about as big as a grown man's thumbnail. So far, 45,000 crabs have already been released and another 30,000 will be released over the course of this summer. While it's too soon to evaluate whether these efforts will help bolster the population, Hines reports that some crabs tagged upon release have been found successfully migrating southward from the upper Bay in the fall through the deep channel — along with the wild crabs.

Counting Crabs

In order to gauge how the crab population is faring year-to-year and to set safe guidelines for future harvests, scientists and managers need to know more than just how many crabs are in the Bay. They need to have a handle on the rate at which crabs are removed from the population by fishing, as well as how fast they are dying by natural causes.

Think of it like a credit card account, says fisheries ecologist Thomas Miller, from the UMCES Chesapeake Biological Laboratory in Solomons, Maryland. "Crab abundance is your balance, fishing mortality is the interest rate charged on that money. When the population is overfished, it will not have the reproductive capacity to replace itself. This is the equivalent of too little money to meet your monthly expenses," he says. "If we fish the population at too high a rate, no matter what the abundance now, we will eventually go broke."

Accurately estimating fishing mortality on the crab population in the Bay is no easy feat. Over the past few years, scientists have come to a consensus that the method that they have used to measure fishing mortality has several important drawbacks, and this year CBSAC has formally adopted a new approach.

Previously, crab mortality was calculated using a "length-based" approach, similar to the method used for tracking fish populations. Basically, the length-based method assumes that if the average size of the population goes down — meaning that a greater percentage of surviving crabs are small — then more legal-sized large crabs are being removed from the population either by natural causes or by fishing, explains Miller.

But relying on size for crabs can be misleading. Unlike fish, which increase in size continuously as they get older, Miller says, crabs grow discontinuously and undergo a series of molts, reaching sexual maturity at 12-18 months. While we understand the crab's life history pretty well, the relationship between growth and age remains less certain — so knowing a crab's length may not tell us its age. This means you can't tell if you're looking at a product of this year's spawn, or last year's or the year before that.

The new method, called "direct enumeration," does not rely on crab size at all. Instead, mortality is calculated based on a direct count of the number of crabs buried in the sediment over the winter — measured by the Winter Dredge Survey — and from a measure of the number of crabs harvested during the previous season. Because this method does not rely on certain assumptions about whether the crab population is currently in a stable state of equilibrium, as does the length-based method, researchers believe it to be a more precise way to measure fishing mortality for species like crabs that grow by leaps and spurts.

According to Miller and others, the direct enumeration method is more sensitive to changes in fishing pressure, and it provides a more accurate way to estimate fishing mortality. Relying on this method will likely produce higher mortality rate estimates than indicated by the length-based approach, says Miller. And factoring in higher mortality rates when setting population targets for the future will lead to a more precautionary approach, one that the scientific community endorses.

Science and Policy

Overall, the mix of good news and bad news for blue crabs presented at the June TWG meeting sparked lively debate. But scientists were unified in urging continued financial support for high quality research and data collection, effective monitoring, and a continued cautious approach to management. It is hard to tell at this point, they said, whether recent increases in the crab population have resulted from new fishing regulations that went into effect in 2001, or whether changes are due mainly to high year-to-year population variability in the Bay. In either case, the group agreed that "holding the line" on crab regulations would be the decision most consistent with the best scientific evidence available.

Another challenge facing this group of scientists — who have contributed their expertise to evaluating and advising on the Bay's precariously poised blue crab population over the past few years — is that shifting regional priorities have pulled legislative attention away from the problem. Although the scientists in the TWG do still report to the Chesapeake Bay Commission and the legislators involved, the formal body (BBCAC), which included a representative group of stakeholders, dissolved last year from lack of financial input from the states. "What is really missing is a feeling of a bi-state investment at a coordinated level," says Swanson.

"It is clear from the meeting that there remains a strong commitment from the scientific community to remain engaged and to advise on the best science available for crab management," says Miller. But the loss of BBCAC has left its mark. "It is sad. I see a need for a formalized way for states to collaborate. The formal structure was really important," Miller says. In the meantime, the TWG scientists remain determined to place good data in the hands of decision-makers. They have agreed to meet again in the fall, and plan to produce another science-based status report on the health of the crab population and on sustainable management of the fishery.

For more on blue crabs, see last year's TWG report, Blue Crab 2003: Status of the Chesapeake Population and its Fisheries, *at www.chesbay. state.va.us/crabpubs.htm.*

Extension Faculty Excel

Two of Maryland Sea Grant's Extension's specialists have been honored recently with prestigious career awards for their outstanding work in the community. Seafood technology specialist Thomas Rippen was one of the recipients of this year's Excellence in Extension award from the University System of Maryland and education specialist J. Adam Frederick has been awarded the National Marine Educators Association's (NMEA) James Centorino Award, given for distinguished performance in marine education by professionals who are not classroom teachers.

Both of these awards reflect Rippen and Frederick's cumulative efforts to date. Rippen's major contribution to Maryland's citizens has been to worry about the safety of our seafood so, once at the grocery store, we don't have to. His specialties are thermal processing of crabmeat, developing packaging and prepackaging methods to give the industry a 12-month shelf life for their product, and seafood safety education. He has helped to produce materials for a standardized training course that is administered through the Hazard Analysis and Critical Control Point (HACCP) alliance, a federal food safety program that seafood processors have been required to implement since December 18, 1997. The program requires seafood processors, which includes companies that pack, process or hold seafood for shipment, to thoroughly evaluate each step of their operation as it affects product safety. The key to its effectiveness, says Rippen, has been to help train instructors within the industry to identify where problems can crop up and to institute a set of monitoring practices at certain stages in the processing.

Frederick's efforts in developing resources for informal marine education in the state of Maryland draw from both his nine years working for Maryland Sea Grant and his preceding nine years as a classroom teacher in Frederick County, where he developed a keen sense for the kinds of materials that are useful to classroom teachers. As an informal educator now, Frederick does not write or teach formal curricula. He designs programs and enhancements that can be used with curricula and helps teachers decide how they are going to teach them.

Frederick and his colleagues' contributions include the *Aquaculture in Action* program, a collaboration with Carroll County Public Schools to create network of "aquaculture educators" in Maryland; a series of interactive marine education modules that allow students in different countries to share and discuss data through web-based video conferencing; and the SciTech Education Program, conducted with the University of Maryland Biotechnology Institute in Baltimore to provide hands-on laboratory experiences for students in grades 3-12 that cover topics in microbiology, molecular biology, developmental biology, aquatic ecology, and natural products. Some of these programs have had far-reaching influences. Frederick is currently working with a group of non-traditional schools involved with the Maryland Department of Juvenile Justice where their aquaculture program has been so successful that they want to offer their students a vocational certificate or diploma so they can illustrate their job skills. "It is these kinds of impacts that are especially meaningful to me," says Frederick.

EDWIN REMSBERG

HAROLD ANDERSON

Extension in action: *Tom Rippen (above), with a seafood worker; J. Adam Frederick (below right) talks with a student in the NSF Research Experiences for Undergraduates fellowship program coordinated each summer by Maryland Sea Grant.*

Both Rippen and Frederick are quick to credit others and acknowledge collaborators for their recent honors. Rippen recognizes Extension leader Doug Lipton (Excellence in Extension Award recipient in 1994) for efforts in putting together a nomination packet on his behalf. "This award is largely about having a good program leader. Doug is terrific," he says. Frederick says that the best part about the award is receiving the nomination from the mid-Atlantic region. "Winning is almost secondary. It means a lot when the people within your own region nominate you," he says.

But win they both did. Rippen was recognized at an awards ceremony held on April 21 in Ellicott City, Maryland. Frederick received his award at the annual meeting of the NMEA at Eckerd College in St. Petersburg, Florida on July 22.

New Course for Tenore

After more than 20 years of service as director of the UMCES Chesapeake Biological Laboratory, Ken Tenore will step down as of September 1, 2004. Tenore, an expert in benthic ecology and coastal oceanography, will continue in his role as a professor at the lab and as a driving force behind a center he started — the Alliance for Coastal Technologies (ACT), a public-private partnership focused on developing and applying sensor technology for coastal research and monitoring.

According to UMCES president Don Boesch, "The transformation of CBL on Tenore's watch, both in terms of physical facilities and intellectual capacity, has been truly phenomenal." CBL is now recognized around the world for the excellence of its science, notes Boesch, and Tenore leaves a "solid legacy" on which to continue to build this reputation.

In addition to science and science administration, during his years at CBL Tenore has pursued an interest in the ethics of science, an area he has helped to emphasize with students — for example, through seminars conducted with Maryland Sea Grant's Research Experiences for Undergraduates (REU) program.

Coastal Community Changes

Maryland Sea Grant bids farewell to coastal community extension specialist Rachel Smyk-Newton, who will be leaving at the end of July. In her nearly two years' time with Sea Grant, Smyk-Newton has launched Maryland's contribution to the NOAA-wide Coastal Community Initiative, aimed at implementing outreach programs to better understand the interconnectivity between the economy and the coastal environment. She has represented Maryland Sea Grant on the Coastal and Watershed Resources Advisory Committee, which serves as an advisory team to the Maryland Coastal Zone Management Program, on the Consortium for Atlantic Regional Assessment Advisory Council, and on the Chesapeake Bay National Estuarine Research Reserve (Maryland) Coastal Training Program Advisory group. She has also completed Regional Shore Erosion Assessments for Dorchester and St. Mary's counties. Maryland Sea Grant Extension will be looking to hire a new coastal community extension specialist. If interested, please contact Extension Leader Doug Lipton (dlipton@arec. umd.edu) for details.

National Sea Grant's Cyber-Debut

Earlier this month, the NOAA National Sea Grant Office (NSGO) unveiled its new website, linking the suite of Sea Grant Colleges across the United States to each other and to the nexus of activity at the Federal level.

The new site features an easily navigable array of information on Sea Grant's priority areas and initiatives, the Sea Grant College Network, funding opportunities, fellowships and more. The Request For Proposals (RFP) portal provides up-to-date information on the status and deadlines for National Strategic Initiatives (NSI) such as the Oyster Disease Research Program, the Aquatic Invasive Species Research and Outreach Program, and the Ballast Water Technology Demonstration Program.

The new site illustratively highlights National Sea Grant's ten themes and three national priority areas related to the health and sustainability of coasts and coastal economies. Behind each theme area link, the site presents the "Issue" and the role of Sea Grant in addressing it in a concise and informative manner. See for yourself at www.nsgo.seagrant.org/index.html

Maryland Sea Grant Releases Planning Survey

The Maryland Sea Grant (MDSG) program will mail out a survey in the next few weeks seeking input towards the development of a new strategic plan to guide the program over the next five years, from 2005-2010.

Government agencies, legislators and citizens are committed to taking actions that will return the Bay to a healthier status, one that supports a diverse well-functioning ecosystem, a variety of uses and multiple communities. This restoration will require strong research and outreach efforts to provide a foundation for deciding what a restored Bay will look like.

According to director Jonathan Kramer, the survey will help MDSG plan what its role should be in that restoration and help to identify critical questions it can realistically address through the research it funds. The insights provided by the survey will also help the program define priorities that will best position it to make strong contributions over the next five years.

Those who return the survey, says Kramer, will serve an invaluable role in helping the program "foster sustainable use, conservation and restoration of coastal and marine resources in Maryland, the Mid-Atlantic and the nation." If you'd like to participate in the survey, call 301.403.4220, x 10, or visit the web at www.mdsg.umd.edu.

Aquaculture in Maryland

Aquaculture Symposium, August 10-11, 2004, Radisson Hotel, Annapolis, Maryland. This symposium is aimed at bringing together faculty interested in the development of aquaculture for research, industry and restoration. Open to any faculty member at any public or private institution in Maryland and surrounding states, the meeting may be of special interest to those in the fields of biology, engineering, economics and business, and the social sciences.

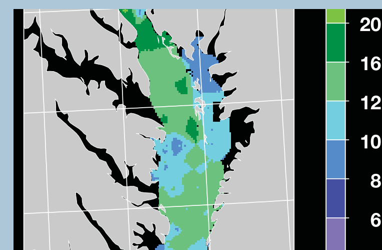
On the agenda are invited speakers, who will address the current situation of the industry and ongoing aquaculture programs within the University System of Maryland (USM); representatives of member institutions who will provide overviews of their research and production facilities; and time for interactive discussions among faculty, industry and political leaders.

SANDY RODGERS

The Maryland Agricultural Experiment Station, the University of Maryland Sea Grant College and the Maryland Department of Agriculture are sponsoring the symposium. On August 12, as a follow-up to the meeting, USM institutions operating aquaculture facilities will host a day of open-house tours. Attendees will be encouraged to visit one or more of these sites for a firsthand look at the work being done and to discuss ideas with the faculty operating them.

The registration fee for the symposium is $50, and includes conference materials and continental breakfast and lunch for both days. For more information or to register, contact Martha Milligan at the Wye Research and Education Center, by phone, 410.827.8056, ext. 134, or e-mail, mmilliga@umd.edu.

Why Color?



We printed this special issue of *Chesapeake Quarterly* in full color because the subject of the main article focuses on remote sensing of the Bay from satellites and airplanes. This research relies on generating color maps to interpret the complex data collected, maps that cannot be converted into accurate, readable black-and-white versions. Since you would lose part of the story without the maps, we decided to add color to this issue. We hope it adds to your understanding of the research.

Chesapeake Quarterly is also available on the web at www.mdsg.umd.edu/CQ

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