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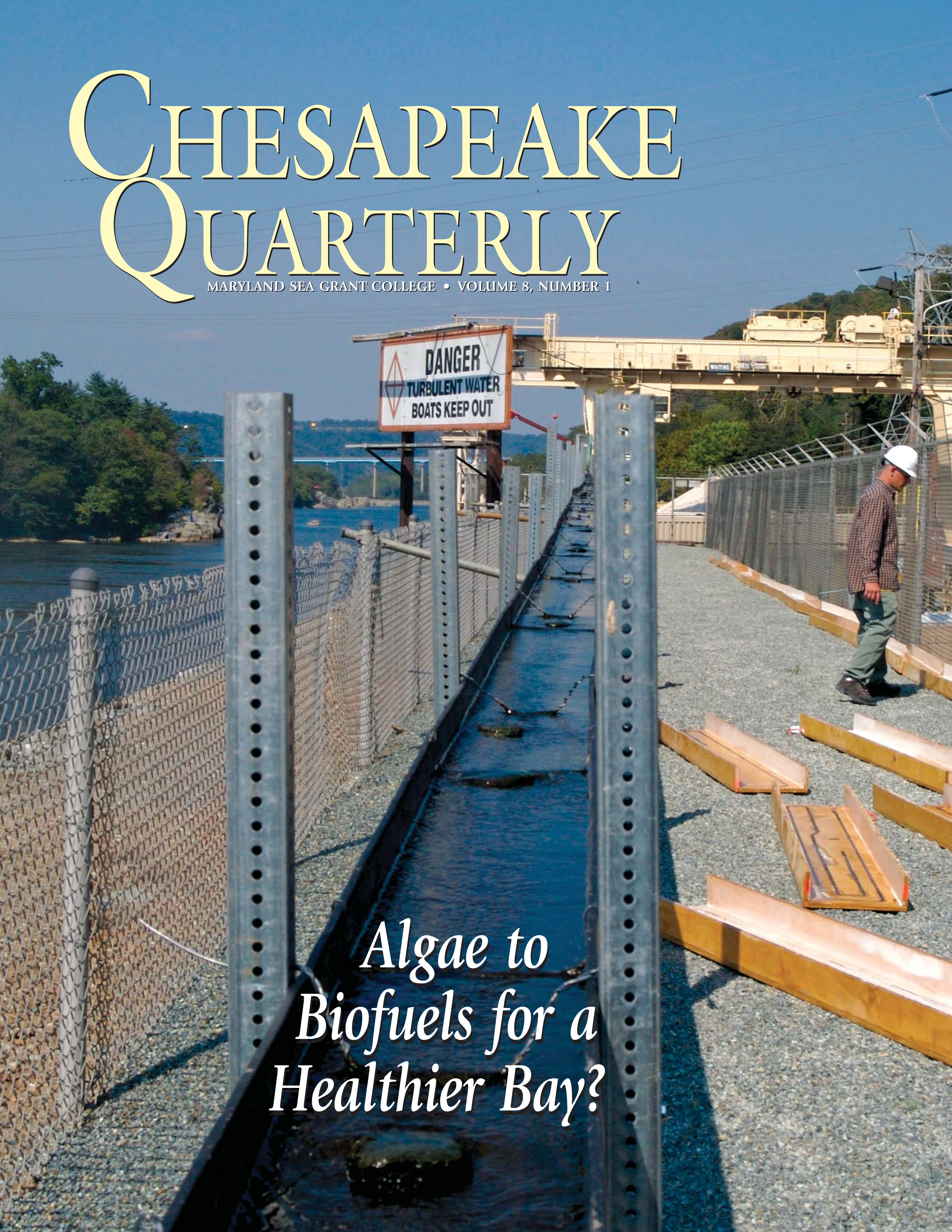

Algae to Biofuels for a Healthier Bay?

contents

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Chesapeake Quarterly explores scientific, environmental, and cultural issues relevant to the Chesapeake Bay and its watershed.

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Cover photo: *Like a conveyor belt for nutrient removal, this Algal Turf Scrubber uses mats of algae to take up nitrogen and phosphorus. Could devices like this help clean Susquehanna River water before it reaches the Chesapeake Bay?* PHOTOGRAPH BY ERICA GOLDMAN. ***Opposite page:*** *Natural nutrient processors, marshes offer a perfect example of how plants in the right place remove excess nitrogen and phosphorus — but we need more help than marshes can now provide.* PHOTOGRAPH BY SANDY RODGERS.

Nature to the Rescue?

Change is in the air. Literally. Greenhouse gases now peak at record levels. Global temperatures are on the rise. Extreme weather seems commonplace.

But a sense of public accountability for global environmental woes also builds stronger every day. Newspapers report on airlines initiating new voluntary carbon offset programs, where ecologically conscious travelers can help to counterbalance the negative effects of air travel by donating money for planting trees. A major European grocery chain recently began to "carbon label" some of their products to inform customer decision-making. Consumers can now discover the amount of carbon released through production, transport, and consumption of the food they eat.

Are we nearing a tipping point for behavior change? Rising energy costs and dwindling oil supplies now drive interest in the growth of alternative energy resources. But in the state of Maryland, at least, gas stations do not provide any real alternatives to traditional fossil fuels and most cars cannot yet accommodate them. In a climate of mounting pressures on the environment, coupled with a building sense of personal responsibility, what will ultimately force the cascading effects of real change?

The key, according to many scientists and policy makers, lies in thinking and acting across traditional boundaries. Innovation will likely spring from new technologies. It may come from entrepreneurship. It also may come from unexpected pairings, the creation of new economic incentives to push changes in current practices — creative agents of change in a nation hovering at the brink of economic freefall.

In this issue of *Chesapeake Quarterly*, we explore innovative pairings of economics and invention, pairings where, if done right, both monetary profit and environmental restoration could go hand-in-hand. It's a story about seizing a moment in time, about how enterprising scientists are capitalizing on a national movement in one area to build momentum, capacity, and financing for much-needed progress in another.

Here in the Chesapeake Bay, we examine a case in which the hot new world of biofuels as a source of alternative energy will link directly to cleaning up nutrient pollution — using an approach some 30 years in the making. It's an attempt to harness the power of living ecosystems to restore ecological balance to a damaged Bay.

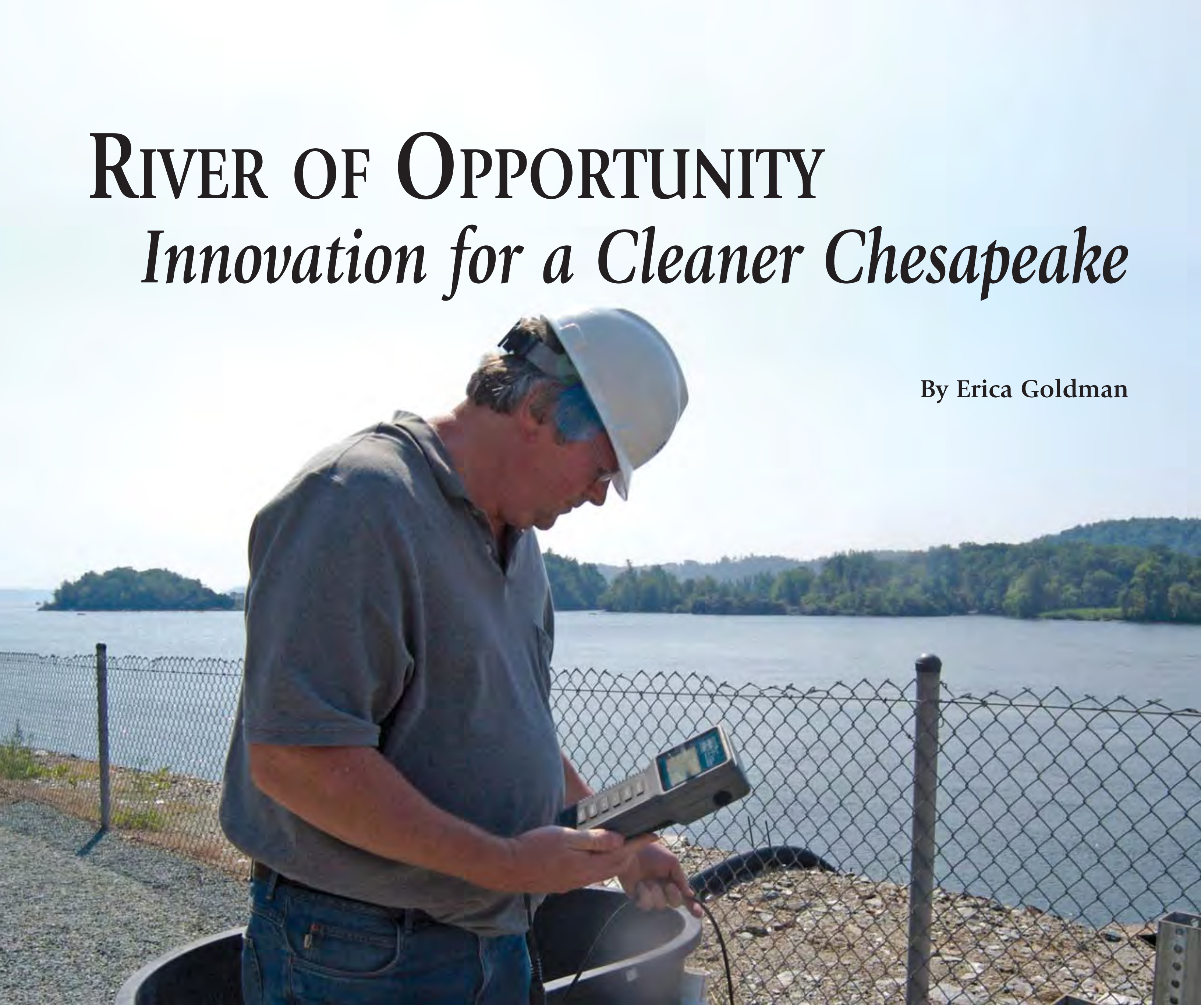
In an elementary school science class, I remember "inventing" a backpack that scuba divers could wear. The device would have small trees living inside a sealed plastic sac. As the diver exhaled carbon dioxide through a tube leading to the sac, the tiny trees would transform carbon dioxide into oxygen and return freshly scrubbed air to the diver for his/her next breath. Given the challenge of swimming with the required number of trees, this scheme would never have worked. But the intent was on target — it makes a lot of sense to look to nature for help in solving a human problem.

By looking closely at how nature works, some scientists believe that it will be possible to find that place where economics and invention intersect. A way to get it both ways — to bolster the economy and to restore the environment. In these troubled times, this kind of win-win sounds pretty good.

— *Erica Goldman*

River of Opportunity
Innovation for a Cleaner Chesapeake

By Erica Goldman



On faraway hillsides in New York and Pennsylvania, water begins a downhill journey toward the longest river in the eastern United States. By the time that flow reaches the Conowingo Dam in Maryland, where the Susquehanna River's 18-million-acre watershed drains into the Chesapeake Bay, more than 40,000 cubic feet per second rush in at a single point of entry. At this neck of the funnel, at least half of the Bay's total load of nitrogen and phosphorus makes its entrance. It has come from farmland and urban pavement, septic tanks and the outfalls of sewage treatment plants. Once in the Bay, these nutrients feed the prolific growth of microscopic algae that has become the hallmark of a degraded Chesapeake.

Walter Adey sees this pollution chokepoint at the Susquehanna River in a unique light. For him, the neck of the funnel represents a golden opportunity to set things right for the Chesapeake. This veteran ecologist from the Smithsonian Institution has a bold idea, one more than 30 years in the making. His concept could rid Susquehanna River water of excess phosphorus and nitrogen before it enters the Bay and inject oxygen into bottom waters at the same time. He's calculated that his approach would cost a lot less than current estimates for cleaning up nutrients in the watershed. And he thinks that the time to try it has finally arrived.

On a bank high above the Susquehanna River perches the Muddy Run Pumped Storage Plant. Just up the road, horse-drawn buggies amble through the rolling

Along the banks *of the Susquehanna, environmental engineer Patrick Kangas monitors rising levels on his oxygen meter. The water he measures, drawn from the river, has journeyed down a long raceway and passed over hundreds of thousands of filaments of algae. Now oxygen-rich and lean on nutrients, it returns to the river though a black rubber hose.* PHOTOGRAPH BY ERICA GOLDMAN.

green hills of dairy farms in Pennsylvania Amish country.

In sharp contrast with the surrounding landscape, the plant's scaffold towers string power lines across the water. An aluminum raceway — eighteen inches wide-by-300-feet long — sits propped off the ground by aluminum stilts. Reversing turbines rise in the distance. Each night these structures transport water up from the river to a reservoir. Susquehanna River water, rich in nutrients and low in dissolved oxygen, courses down the raceway, pulsing over a plastic mesh surface carpeted by long hair-like strands of algae.

Standing near the bottom of the raceway, Patrick Kangas pulls an oxygen probe from the water. Its black wand dangles from a wire on a handheld console. He jots the value in his notebook, adjusting his hard hat and repositioning his glasses so he can see the page clearly. He takes another measurement with a pH meter, waits for the probe to equilibrate, and writes down the number. Then he walks along the edge of the raceway and climbs a short flight of metal scaffold stairs to the water input area. Since this section is elevated, gravity carries the water downhill. He plunges the probes into the water again, first oxygen, then pH, and scribbles down a second set of numbers.

Since he took over for his graduate student earlier that morning, Kangas has been taking measurements every three hours. These measurements are part of a 24-hour series of oxygen and pH readings of water flowing over the algae-covered raceway.

This long contraption is called an Algal Turf Scrubber, the key to Walter Adey's visionary idea to capture nutrients from the river. Kangas, a professor of environmental engineering at the University of Maryland College Park, is working to implement a pilot project to test that vision. The goal of their project is ambitious: Harness the power of fast-growing, photosynthesizing algae to take up nutrients like nitrogen and phosphorus from polluted water. In turn, let the algae pump the water full of oxygen. Then vacuum up the algae and feed it to a reactor for making a biofuel — in this case, butanol. Clean the Bay, tap into an emerging market for alternative energy, and create a revenue stream to drive the clean-up effort — all in one fell swoop. Kangas is eager to test the promise of Adey's dream.

Harnessing Light from the Sun

Adey's idea for the Algal Turf Scrubber came from his studies of coral reef ecosystems back in the 1970s. Since 1964, Adey has served as a curator and research scientist for the Smithsonian Institution. Though speaking today from his book-filled office at the end of a long corridor off the National Museum of Natural History's archived fossil collection, he's spent nearly 20 years at sea in the Caribbean. There he studied algae in coral reefs and devised ways to continue his studies by bringing reefs into the lab — in microcosms and mesocosms, experimental enclosures that approximate natural conditions. He founded the Smithsonian Institution's Marine Systems Laboratory at the museum in D.C., a lab that specialized in developing such experimental ecosystems. From 1975 to 1999, he served as its director.

In his early studies of Caribbean coral reefs, Adey and his team of student researchers discovered that most of the reef's primary productivity occurred in lush algal turfs growing on dead coral. It seemed that these algal turfs were highly adapted for capturing energy from the sun. Adey's team discovered that by replicating the natural wave surge and current that algal turfs experience on coral reefs, they could reproduce the high levels of light capture and growth seen in the wild. The key as it turned out was the surge of the waves. That rhythmic force mixes the water and helps to expose the plants fully to pulses of sunlight.

Adey went on to develop a method for growing algal turf on mesh screens and using them to help control water quality in coral reef aquaria. He created a 130-gallon experimental coral reef microcosm at the Marine Systems Laboratory, using an Algal Turf Scrubber as the only way to control its water chemistry. After eight years as a closed experimental ecosystem, the reef demonstrated coral calcification rates equal to the best four percent of wild reefs. Boasting an estimated 800 species, it ranked per unit area as the most diverse reef ever measured.

The secret behind the success of the Algal Turf Scrubber is biomimicry, explains Adey, replicating conditions like wave surge that optimize growth rates and productivity for algae in the natural environment. The mesh on the scrubbers attracts the settlement of diverse species of algae present in the surrounding water.

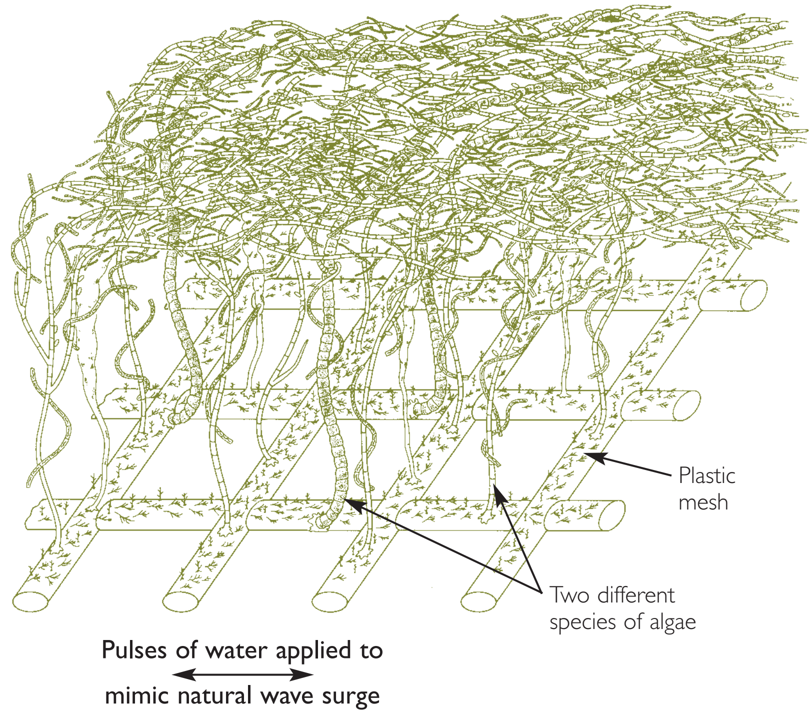
Like all plants, algae use nutrients like nitrogen and phosphorus to grow. They also remove or sequester carbon from the atmosphere and release oxygen as a byproduct of photosynthesis. Algae grow fast and are 5 to 10 times more efficient at photosynthesis than their more complex plant cousins. To keep photosynthetic rates high, the algae must be harvested every 6 to 12 days, which maintains their peak growth rate. These frequent harvests also mean that plenty of algae become available as raw material for producing a biofuel.

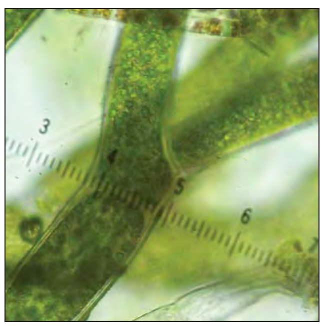
Scaling up on the Susquehanna

With oxygen and pH measurements completed, Kangas makes his way back down to the bottom of the scrubber raceway. There the water collects in a big plastic bucket before being flushed down a black rubber hose back into the Susquehanna River. He glances at his notebook.

At the top of the apparatus, where untreated river water enters the system directly, the oxygen concentration measured 5.8 milligrams per liter. This is low, the equivalent of 64 percent saturated.

At the bottom of the raceway, after traveling across hundreds of thousands of algal filaments, the oxygen concentration of the water has roughly doubled, measuring 11 milligrams per liter or 134 percent saturated. The water is so saturated that oxygen is actually being lost to the atmosphere, Kangas explains. At night, with no solar energy available to enter the system, rates of photosynthesis drop. But by eight in the morning, the algae get to work again.





Mimicking flow dynamics *over coral reefs, nutrient-rich water from the Susquehanna River pulses down the aluminum raceway of an Algal Turf Scrubber (top and middle left). The raceway is lined with a highly textured plastic mesh that encourages algae to grow (diagram, top right).* Spirogyra *(bottom left), an unbranched, weedy species of algae, currently dominates the mesh. Researchers hope to encourage the growth of* Cladophora *(bottom right), another common local species, whose highly branched geometry is better suited for producing biofuels. Practical dreamer Walter Adey (opposite page) invented the Algal Turf Scrubber technology more than 30 years ago and he's working to implement it on a large scale in the Chesapeake Bay.* DIAGRAM COURTESY OF WALTER ADEY; PHOTOGRAPHS OF ALGAE BY DAIL LAUGHINGHOUSE; PHOTOGRAPHS OF WALTER ADEY AND OF ALGAL TURF SCRUBBER BY ERICA GOLDMAN.

Kangas cannot measure nitrogen and phosphorus uptake in real time, as he can with oxygen and pH. But the results he's recently received — from water samples sent for analysis at the U.S. Department of Agriculture's laboratory in Beltsville, Maryland — show dramatic reductions. Nitrogen concentrations drop by a third from where water enters at the top of the algae raceway to where it exits at the bottom, dumping back into the Susquehanna. "It's amazing," Kangas says.

Kangas showed the nutrient reduction numbers he was getting from the Algal Turf Scrubber pilot study to his department chair, Frank Coale, an expert in agricultural nutrient management. Coale said that these scrubbers appear to be 50 times more powerful than cover crops, planted in winter months to take up excess nutrients from the soil.

What if this pilot project could be scaled up?

Adey has big dreams of doing just that. He envisions 3000 acres of scrubbers — an area more than four times the area of New York City's Central Park. That's only a tiny fraction of the Susquehanna watershed, but he estimates that a system that size could remove the entire Susquehanna portion of excess phosphorus delivered to the Chesapeake Bay (three million pounds per year). With this, he calculates, would come an oxygen injection to the river of approximately 200 million pounds per year. Adey speculates that this might be sufficient to remove algal blooms from the upper Bay and to make a sizeable dent in the extent of hypoxia in the main stem.

Exelon Power, which owns and operates the Muddy Run Storage Plant and the Conowingo Dam, has offered their support for the first step in the scale-up — an expansion that would take the size of the scrubber system up to 12 acres. Mary Helen Marsh, the general manager of Exelon Power's two hydro stations, helped Kangas and Adey to secure the site at Muddy Run for their trials and supports the expansion of the pilot onto land adjacent to the Muddy Run Reservoir.

Marsh says that she was excited by the opportunity to help with research that will protect the environment down the road. From a company perspective, she explains, it also complements Exelon's initiative to mitigate its carbon footprint by the year 2020. Since algae sequester carbon dioxide from the atmosphere, this project fits right in.

The technology for scaling up looks promising. HydroMentia, a company based in Florida that specializes in water pollution control, now holds the industrial license for the scrubber technology. They've designed a modular system of 12-acre units that can be put together to achieve the kind of acreage that the Susquehanna would ultimately need. Algal Turf Scrubber systems as large as three acres are currently used to treat the agriculturally contaminated waters of Taylor Creek, a tributary of the highly eutrophic Lake Okeechobee in Florida, the second largest freshwater lake in the United States. At that scale, the plant removes nutrients from 15 million gallons of water per day.

But the pilot project at the Susquehanna River has a long way to go before it could fulfill Adey's dream of reducing nutrient pollution. Two important hurdles block the path to such a scale-up in this region: Money and land.

Scaling up would not come cheap. According to Adey, to move up in size to the first 12-acre scrubber module would cost roughly $5.5 million. To make it all the way to a 3000-acre system would require on the order of $1 billion. This is real money.

Space poses another problem. "The problem with this technology is that you need land," says Kangas. "It takes a lot of land. That throws everything off because land is so expensive."

But the Algal Turf Scrubber systems could be installed in small strips on different pieces of farmland — the 3000 acres would not have to come in a giant, uninterrupted swatch — which means that little bits of land here and there could go a long way. And over the whole watershed, 3000 acres accounts for only a small fraction of the five million acres of farmland. Kangas and Adey have been working with the agricultural community to add the scrubber technology to the suite of incentives that already exist to encourage farmers

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Barley to Biofuel

Can a commodity crop turn a profit while helping to clean the Bay?

Victor Szalvay

Across the train tracks, at the far end of town, more than 200 people cluster in a dusty parking lot, near a blue and white tent specially set up for the occasion. Their business suits seem out of place in economically depressed Hopewell, Virginia but the dazzling sunlight of the cool, clear fall morning projects promise and opportunity.

The crowd has gathered to witness the groundbreaking of a new biofuel plant, just off the Appomattox River, a tributary of the James River and the Chesapeake Bay. This plant will use barley to produce ethanol, and it's the first of its kind in the United States.

Barley is a winter crop that's planted in rotation with corn and soybean, during a time when fields would otherwise lie fallow. It requires much less nitrogen fertilizer than corn, commonly used in ethanol production, and it helps to anchor the soil in the winter, guarding against nutrient-laden runoff to vulnerable waterways. When worked into the crop rotation scheme, planting barley would make it impossible for farmers to plant corn in successive years, further limiting the impact of that more heavily fertilized crop in the Chesapeake landscape.

Currently, there's not much of a market for barley in the Mid-Atlantic states. And without promise of profit, there's little incentive for farmers to begin planting it. Can the planned biofuel plant entice farmers to turn the Chesapeake into a hotspot for barley production? If so, will barley grown as a commodity for profit still yield a net benefit for water quality in the Bay?

If We Build It…

Osage Bio Energy, the Virginia-based company building the new biofuel production facilities in Hopewell, is gambling on the "Field of Dreams effect." If they build the market, the barley will come. The new plant will have the capacity to produce 65 million gallons per year of ethanol, making it second in scale worldwide only to a plant in Salamanca, Spain. To operate, the plant will need 30 million bushels of barley a year, according to company spokesperson John Warren. Right now, production across all of the Mid-Atlantic states falls short by roughly an order of magnitude, he says.

To encourage farmers in the region to begin stepping up barley production to meet the demand of the plant in time for its planned opening in 2010, Osage Bio Energy and its partners have launched a "Barley Bin Builder Yield Contest." Farmers in Delaware, Maryland, Virginia, Tennessee, Kentucky, North Carolina, and South Carolina are eligible to enter, with promises of cash prizes and a grand-prize truck for the highest barley yields per acre.

Farmers may still need additional convincing, says Frank Coale, the chair of the Department of Environmental Science and Technology at the University of Maryland and an expert in nutrient management and crop production. "A good farmer is a good businessman," he says. A fallow field in the winter doesn't cost him anything. The decision to plant a winter grain, by contrast, requires an investment of money and labor. In addition, planting a winter crop will limit the farmer's flexibility to plant corn that following summer, explains Coale. There needs to be a market advantage for planting barley to make it worthwhile for the farmer.

If Osage Bio Energy's predictions pan out, the growing market for ethanol will provide the necessary incentive to boost barley production on the farm. Part of the company's strategy is to sell diverse products derived from barley. Along with fuel-grade ethanol, the new plant will produce 151,700 tons of barley protein meal per year, a high-quality animal feed, and 44,600 fuel pellets made from barley fiber that can be used as renewable fuel. Additionally, the new plant will equip itself to take advantage of "second-generation" technology as it becomes available. So-called cellulosic ethanol production can use woody material and crop residue, such as barley straw, as biomass for ethanol production. Though the technology has not yet been fully developed, the Chesapeake region is poised to become a leader in this area.

Barley is considered a "generation 1.5" biofuel, explains Ann Swanson, Executive Director of the Chesapeake Bay Commission, who helped to lead the initiative to make the Bay region a leader in cellulosic biofuel production. It serves as an important stepping-stone toward cellulosic ethanol, seen as an ultimate goal for this region because woody materials, perennial grasses, and corn stover can provide clear benefits for nutrient reduction and improved water quality.

Cellulosic biofuel production requires a pretreatment process to make it possible to extract the sugar for fermentation. This stage of production faces technological obstacles, currently preventing cellulosic ethanol from being cost-competitive with grain ethanol.

Similar hurdles have already been tackled successfully in extracting sugar from barley, explains Kevin Hicks, a crop conversion scientist for the U.S. Department of Agriculture in Wyndmoor, Pennsylvania. Barley has an abrasive hull which must be removed before conversion. It also contains compounds called beta-glucans, Hicks explains, which form a stiff gel when the grain is ground into a mash. Hicks' team had begun working on these problems in 2002, well before there even was a major biofuel industry. In collaboration with biotech company Genencorp, they've developed ways that use enzymes to reduce the stickiness of the beta-glucans, while increasing the ethanol yield. "No one has ever done this before," he says. "We are the first."

With these technological obstacles resolved, the mechanism of turning barley into biofuel should run smoothly. And if the market for barley expands as Osage Bio Energy hopes, the Chesapeake region could become a hotbed of production. What would such an expansion of barley acreage mean for the Bay?

Barley and the Bay

When barley is planted as a cover crop solely for the environmental benefits of removing excess nitrogen from the soil, it remains unfertilized and often unharvested. But if farmers begin planting fallow fields with barley to produce a harvestable crop, they'll also start fertilizing that crop to maximize yield. Will a fertilized barley crop undo the potential water quality benefits associated with getting a winter crop out in the fields?

The consensus seems to be that adding fertilized barley acreage to the region will still prove a net water quality benefit, even though no one can yet estimate by how much. "Any time you have a growing crop out there in the winter that is receiving relatively little nutrient input, it's going to be positive," says University of Maryland's Coale. "The bottom line," agrees Chesapeake Bay Commission's Swanson, "is

Erica Goldman

On a cool, crisp morning, *Osage Bio Energy broke ground for a new barley-based ethanol plant in Hopewell, Virginia (above). Barley (shown in the field and close up on opposite page) grows year round and helps remove excess nitrogen from the soil. It's also a prime choice as a feedstock for biofuel in the Chesapeake region. PHOTOGRAPH OF BARLEY STALK (OPPOSITE PAGE, TOP) BY THOMAS VOEKLER.*

that this will mean that at all points during the year, there will be plants taking up nitrogen in the soil versus no plants, where the only option for that nitrogen is to become mobile and run off those fields as rainwater."

Think about the big picture, says Osage Bio Energy's Warren. The region currently grows barley as an unfertilized cover crop on roughly 10 percent of its farms. If only those 10 percent of farms switched to growing barley as a fertilized commodity crop, then yes, the total nutrient input to the system would go up. But the demand of the new biofuel plant will necessitate a tenfold expansion of total barley acreage — to some 300 million acres, he says. This would almost certainly result in a large net reduction of mobile nitrogen overall.

While experts feel that the predicted increase in barley acreage in the region would prove a net positive for the Bay, there are no hard numbers to support this. The Bay Program's model is not equipped to run these scenarios and there are no field data available, says Coale. "What would be absolutely beautiful," he says, "would be if the ethanol company teamed up with grain growers organizations and Bay folks to generate this research."

Ultimately, if Osage Bio Energy can lean on scientific data to say that growing barley to produce a biofuel will also help clean up the Bay, it will do wonders to promote their "green" image and to capture the interest of the environmental community. Meanwhile, the company is continuing to reach out to farmers in the region, hoping to sell the idea that planting barley is worth the risk — that turning barley to biofuel will reward the investment of labor and money manyfold.

— E.G.

to clean up polluted waters in the Chesapeake watershed.

"We already pay farmers to plant cover crops and riparian buffers," says Kangas. "Can we pay farmers to have an Algal Turf Scrubber system — as a tax incentive?"

In addition to cover crops, what if there were Algal Turf Scrubbers on every farm? On every creek? This is a vision for the Chesapeake that Adey and Kangas share.

Building an Economy

Harvest is still a few days away, but already algae grow thick on the mesh screen of the turf scrubber. The algae are mainly a weedy species called *Spirogyra*, explains Kangas. He and Adey had hoped to see more of another species called *Cladophora*, which is more highly branched and better suited for biofuel production. But in this real-world application, the mesh of the scrubber seeds with whatever species is most abundant and competes most effectively for space.

At the peak of summer, the team harvests the scrubber every five days. The weather is cooler now so the growth rate of the algae has slowed, spacing out harvests by several more days. Harvesting the algae is simple, explains Kangas. Turn off the water flowing into the system. Vacuum up the algae with a Shop-Vac, making sure to leave enough behind on the mesh to jumpstart further algal growth.

A Maryland-based company, Living Technologies, founded by Adey's former graduate student Tim Goertemiller, has built its business constructing and selling Algal Turf Scrubber systems. Now they're expanding the enterprise to become a "lawn service" for algae harvesting, beginning with the project on the Susquehanna River and another pilot project on the Eastern Shore. They don't have many algae customers yet, but they're hoping for business to grow.

"The notion of job creation is real. We're trying to build an economy, not just an academic experiment," says Kangas. Adey and Kangas hope that producing a biofuel will be the key driver that sets this new economy into motion.

The scrubber technology has begun to gain traction on its own merits in the water quality world, says Adey. But, he says it's been difficult to build financial support for large-scale projects. For example, HydroMentia designed a 1440-acre system for the Suwannee River of northern Florida, a plant that would be able to treat three billion gallons of water per day. But lack of sufficient funding has slowed the project.

In the Chesapeake Bay, it's going to be a "long, slow slog, because nobody really wants to pay," Adey says. "We have shown that we can reduce nutrients more cheaply and more completely than what is being done, but the money is locked up in the system."

One of Adey's former students completed a survey of restoration funding over a three-year period. The dollar amount added up to more than one billion dollars, but according to the survey, all of it had already been spoken for.

What could drive more financing for nutrient management in the Chesapeake Bay?

Adey thinks that the key lies in tapping into the nation's growing demand for bioenergy. At the sunset of his career, he is seizing on what he sees as a critical window of opportunity to put his 30-year-old invention to work at a large scale.

Adey is betting that the biofuel component of the project will draw considerable investment and interest, as well as demand for the final product. He plans to construct a pilot biofuel plant to accompany the proposed 12-acre scale-up of the scrubber system. With the algae harvested, the biofuel plant would produce an estimated 40,000 gallons per year as a combination of butanol and biodiesel. As a bonus would come 9000 pounds of hydrogen, which could be used to power operations at the plant. By Adey's calculations, an acre of algae produces more than 10 times the energy produced from an acre of corn.

The whole country is now poised at

the tip of a bioenergy revolution, with a new federal administration that plans to make alternative energy a top priority. "But there is no market yet for ethanol- [or butanol-] based fuels in the state of Maryland," says Kangas. There are a few service stations that provide biodiesel, but that's it. Unlike in the Midwest, Maryland has no ethanol plants and only a handful of biodiesel plants that run on poultry carcasses and waste vegetable oil. "We are really at the beginning," Kangas says.

Erica Goldman

***Researcher Patrick Kangas** and Tim Goertemiller of Living Technologies, a Maryland-based company, discuss plans for a second pilot Algal Turf Scrubber at the Muddy Run Plant on the Susquehanna River.*

The choice of a plant for butanol, rather than ethanol, is unusual, since even beyond Maryland butanol doesn't yet have a market. But Adey's looking toward markets of the future. Butanol can be used as a direct, 100 percent replacement for gasoline, whereas ethanol is more volatile and needs to be mixed in with gasoline at 10 percent. Because it is less volatile, butanol can also be transported more easily.

Adey's collaborators at Western Michigan University and the University of Arkansas have identified a bacterial fermentation process to make butanol and hydrogen from algae, with the additional capability to remove oils to produce biodiesel. They are working now on fine-tuning a bacterial fermentation protocol called the Ramey Process. The algae vacuumed off the Algal Turf Scrubber system first will be processed to extract algae sugars and then fed directly to the biofuel reactor.

Cost and Benefit

According to Adey's master plan, biofuel production would ultimately help fund nutrient management in the Chesapeake. But setting the various pieces in motion will require a significant startup investment. The construction of a biofuel plant at the proposed 12-acre Algal Turf Scrubber site would cost roughly $1.3 million. The prospect for securing funding for the plant looks good. Adey has recently joined with a large group of scientists at the Virginia Institute of Marine Science and the College of William and Mary, as well as a consortium of engineering companies, to move the project forward. The William and Mary Research Institute has presented proposals to the Norwegian oil company Statoil, the U.S. Department of Energy, and Exelon to expand the pilot to a larger scale. But making a biofuel from algae is expensive. The cost of chemical conversion runs about $2.00 per gallon, and that doesn't include the cost of producing the algae. Though at this point the technology works well, and many companies are claiming that they can do it, the economics don't necessarily follow suit, says Adey. "We're not there yet. We can't make a biofuel from algae used to take nutrients out of the Bay and make a profit doing it," he says. "Not yet." Not unless we also get paid to remove the nutrients, he says.

But the country may be fast approaching a tipping point, says Adey, a tipping point that would make them willing to try bold new ideas. "People have to be afraid enough to try innovation. This is what has happened with energy," he says.

The key, says Adey, will be to link the cost of nutrient management directly to the production of biofuels. He offers the following scenario. Current estimates suggest that it costs $200 per kilogram to clean up phosphorus and $10 per kilogram for nitrogen. Suppose you invest half of this amount toward developing the 3000-acre Algal Turf Scrubber system and, at the same time, establish a nutrient trading program. Since the scrubber technology can remediate phosphorus for $25 per kilogram — roughly one-tenth the usual cost — and remove five times the amount nitrogen as phosphorus at the same time for no additional cost, this investment would completely cover the costs associated with biofuel production.

A nutrient trading system would also provide a strong financial incentive for farmers to maintain scrubber systems on their land. "In a trading system, one polluter buys credits from another," explains Dan Nees, the director of the Chesapeake Clean Water Fund, which focuses on establishing a market for improved water quality in the Bay. Nutrient trading functions much like the emerging carbon trading market, where emission credits can be bought and sold within a total allowable cap. Under such a system, if a farmer implements Best Management Practices on his land, such as cover crops or Algal Turf Scrubber systems, he can earn a profit by selling those credits to a farmer that chooses not to reduce his nutrient load, Nees explains.

A water quality market for nutrient trading in the Bay is still in the early

From Algae to Alternative Energy

In January 2009, Continental Airlines completed the first flight of an algae-powered jet. Using a biodiesel blend of two types of alternative oils — algae and jatropha, a weedy plant that produces oil-rich seeds — the 90-minute test flight went off without a hitch.

As the airline industry has come under increasing scrutiny for its contribution to total greenhouse gas emissions — a whopping three percent worldwide, according to the Intergovernmental Panel on Climate Change — startup companies and basic research efforts have ramped up to meet the growing demand for cleaner, greener jet fuels. Many are placing their hopes in fast-growing algae, whose high lipid content can provide the necessary oils for biodiesel blends that can meet the specs of the aviation industry.

More than a dozen companies have sprung up in recent years to harness algae's power for alternative fuel production. In late 2008, Bill Gates and the Rockefeller family made investments totaling more than $100 million in Sapphire Energy, a company in San Diego working toward a commercial-scale facility to produce oil from algae. Another California-based company, Solazyme, recently made headlines for developing a novel fermentation process to produce fuel from algae, without the need to capture energy from the sun.

But despite soaring investments of intellectual and financial capital, the pathway from algae to jet fuel and other biodiesels remains complicated by technological hurdles. The primary obstacle: Coaxing algae to convert sunlight to lipid-rich biomass in such a way that the conversion process becomes cost-effective.

This is not a new problem. During the last major energy crisis, in the 1970s, the federal government made a significant investment in biofuels derived from algae. From 1978 to 1996, the U.S. Department of Energy's Office of Fuels Development funded a program to develop algae-derived renewable transportation fuels. The main focus of this Aquatic Species Program was the production of biodiesel from high lipid-content algae grown in ponds, using waste carbon dioxide from coal-fired power plants.

Although tremendous advances were made in the science of manipulating the metabolism of algae and the engineering of microalgae production systems, cost concerns ultimately shut down the Aquatic Species Program. Analyses concluded that there was little hope for making the algae-to-fuel conversion process cost-efficient and that the constraints were biological, not engineering-related. To be cost-efficient would require near-theoretical levels of conversion efficiency from sunlight to algal biomass — plus the ability to induce algae to maintain a high lipid content, which is not its natural state. Even with such assumptions in place, projected costs for biodiesel remained two times higher than current petroleum diesel fuel costs.

Although the recent surge of interest in biofuels from algae has brought new technologies and new approaches, the same problems remain. Researchers and entrepreneurs are trying new methods for growing algae. Instead of using open ponds where it is challenging to maintain algae at optimum growth rates, they are using photobioreactors, closed triangular chambers made from sheets of polyethylene plastic, which bubble supplemental carbon dioxide through the system. Other researchers are experimenting with biochemical techniques to "trick" the algae into producing more lipid bodies to increase their potential yield for biodiesel.

Ultimately, "the bottom line rests on scale-up costs," according to microbiologist Jennie Hunter-Cevera, president of the University of Maryland Biotechnology Institute. The question remains, she writes in a recent report on next-generation biofuels (see "Building Capacity for Biofuels in the Bay"), "Can a commercial-scale algae facility produce biodiesel at a cost competitive with petroleum or other biofuel sources?"

Some scientists remain skeptical. The crux of the problem, explains the University of Maryland's Patrick Kangas, is that few species of algae intrinsically contain a high fatty acid content. The only way to get high lipid content in algal cells is to force conditions that cause the cells to make a lot of fatty acid, he explains. One method is to drive the growth rate up by providing a lot of nutrients and then starving them, which sends a metabolic signal to the cell to store fatty acids. People have done this successfully in the lab, but it hasn't worked on a big scale, he says. "I just don't think it is going to work. It is very expensive and it doesn't happen that way out in nature."

Regardless of whether biodiesel from algae can become a cost- and energy-efficient enterprise, investment in algal biofuels still holds great promise. Algae can be used for applications like the Algal Turf Scrubber at sewage treatment plants or in other polluted waters (see "River of Opportunity"). The algae byproduct of nutrient remediation can be used to produce either biodiesel or other fuels such as ethanol and butanol, which do not require the lipid-rich material for the conversion process. Since algae can grow 20 times faster than most land-based crops and can make use of nutrient-rich wastewater to fuel its growth, it may have a key role to play in the greening of America's energy future.

The success of new startup ventures to produce jet fuel from algae may be years in the making, but algae's promise for alternative energy has already taken flight.

— *E.G.*

Mark Eichberger, courtesy of Continental Airlines

***Pioneering the first algae-powered** air travel, Continental Airlines successfully completed a test flight (shown taking off in early 2009) using a biodiesel blend of oils derived from algae and the jatropha plant. Though algae biodiesel is not yet commercially competitive, the high cost of fossil fuels and determined entrepreneurship have rekindled interest in it, reviving a major area of research once the focus of the U.S. Department of Energy's Aquatic Species Program, as outlined in this 1998 report (right).*

stages, but if it's going to happen anywhere, it will be in the Chesapeake, according to Nees. "I think we are in the area with greatest opportunity to make it happen," he says. Groups such as Forest Trends, the World Resources Institute, and the Chesapeake Bay Foundation are actively exploring mechanisms to create such a market. "We have big opportunity in front of us," Nees says, "but we have a lot of work to do."

In Adey's vision, the biofuel piece of the equation could help jumpstart the revenue stream necessary to set a nutrient trading program into motion. Once the demand for biofuels really takes off in the marketplace — and Adey is confident that it will — producing a biofuel will become more profitable. Then incentives will grow for farmers to use the scrubber technology to supply algae for biofuel production, as well as to earn nutrient reduction credits for their efforts.

"We have a real shot," Kangas agrees. "We think this can clean up the Bay and produce biofuels at the same time."

Finished with his oxygen and pH measurements for the next several hours, Kangas heads off to speak with Tim Goertemiller and his crew, who are on site for the day working to construct a second pilot Algal Turf Scrubber raceway. He makes his way around pieces of wooden track laid out for assembly, navigating a narrow space between the existing raceway and a chain link fence. The air is pungent with the sharp smell of sealant, applied to the seams of the raceway to make it watertight.

The second raceway, which will soon be raised on aluminum stilts next to its neighbor, offers an opportunity to further refine the scrubber design for the Susquehanna River before advancing to the 12-acre pilot. Unlike the first design, the base of this new raceway has a series of heating coils, which help keep the test system from freezing during the cold winter months. Ultimately, the multiacre systems will lie flat on the ground where they will be less likely to freeze. Kangas is also working with Adey's graduate student, Dail Laughinghouse, to seed the mesh of the new raceway with *Cladophora*, the more branched species that he had hoped would dominate in the other scrubber.

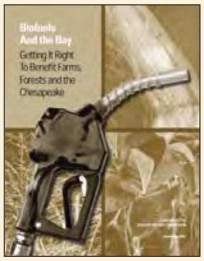
The project is gaining steam. Adey just received word that the Norwegian petroleum giant Statoil plans to provide funding to the biofuel component of the project through the William and Mary Research Institute. With further help from the Department of Energy and Exelon, the team of scientists and engineers from the Virginia Institute of Marine Science and William and Mary will help hone the process for converting algae to butanol and biodiesel and help support an estuarine and offshore scrubber system that the team is developing in the lower Bay. The scientific team will also study the size and placement of the scrubbers to maximize their impact on the Bay's health. Thirty years after Adey completed the initial design for the Algal Turf Scrubber technology, he is starting to see the fruits of his efforts.

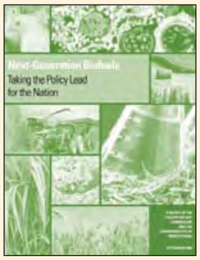
"Walter sees this as his legacy," says Kangas. "As he gets older, he wants to do something that will really make a difference." Even five years ago, no one was really thinking about biofuels. In 2004, project leaders anticipated that the algae harvested from Algal Turf Scrubber system at Taylor Creek would be considered waste and hauled away, increasing the cost of the project by more than 30 percent. But today the emerging biofuel market is what will help make the nutrient management merits of scrubber system financially feasible, Kangas says.

"[Adey] is a bold thinker. He came up with this idea that we could do away with the dead zone in the Bay by having all of these Algal Turf Scrubbers," says Kangas. Effects on that scale might still be a long ways off. But "you can see it," he says. "It is happening right here."

— *goldman@mdsg.umd.edu*

Building Capacity for Biofuels in the Bay





The Chesapeake region is aiming to position itself as a leader in the biofuel arena. At its annual meeting in November 2008, the Bay Program's Executive Council passed a directive on biofuel development in the watershed, requiring that states coordinate biofuel policies, construct infrastructure to support biofuels production, provide incentives to farmers to begin growing biofuel crops, and promote biofuel use. The Executive Council represents all of the top leadership in the Bay states — the governors of Maryland, Pennsylvania, and Virginia; the administrator of the U.S. Environmental Protection Agency; the mayor of the District of Columbia; and the chair of the Chesapeake Bay Commission, a legislative body serving Maryland, Pennsylvania, and Virginia.

The directive issued by the Executive Council emerges from recommendations in two biofuel reports produced by the Chesapeake Bay Commission in 2007 and 2008. The reports assert that the Chesapeake region is poised to become a leader in the biofuel arena but that biofuel production must be coupled with sound nutrient management practices. Since the watershed is not yet vested in corn-based ethanol, an alternative fuel considered damaging to the environment, the reports cite a unique opportunity to grow biofuel production alongside nutrient management efforts and to cultivate the development of "next-generation" biofuel feedstocks. These include perennial grasses and woody crops that help absorb nitrogen and reduce sediment loads in local waterways.

"There has been extraordinary response to both reports," says Ann Swanson, executive director of the Chesapeake Bay Commission. The key, she says, is to make sure that the region moves forward with nutrient management in mind.

"If we seize the energy opportunities without linking them with environmental safeguards, we are heading for trouble," she says. "However, if we couple the two, we are heading for an opportunity that we haven't been tossed in hundreds of years."

— *E.G.*

For More Information

Algal Turf Scrubber
http://www.algalturfscrubber.com/

Walter Adey
http://www.walteradey.com/

Patrick Kangas
http://www.nrmt.umd.edu/kangas.htm

Osage Bio Energy
http://www.osagebioenergy.com/

U.S. Department of Energy's Aquatic Species Program Report
www.nrel.gov/docs/legosti/fy98/24190.pdf

Building a Capacity for Biofuels in the Bay: Chesapeake Bay Commission Biofuels Reports
http://www.chesbay.state.va.us/biofuels.html

Sleuthing a Cover Crop Conundrum

By Erica Goldman

Driving to work on a cool fall morning, Dan Terlizzi pulls to the side of the road, stopping by the edge of a farm field near his house to collect material for the day's experiment. The rural farm field has exactly what he needs — winter wheat — and it's just 45 minutes from his ultra-modern lab at the University of Maryland Biotechnology Institute Center for Marine Biotechnology (COMB) on Baltimore's Inner Harbor.

Terlizzi, a plant physiologist and Maryland Sea Grant Extension Specialist in water quality, is trying to determine how well the plant material he collected on this late fall morning is actively breaking down nitrate. Nitrate is the form of nitrogen that becomes mobile in soil and ultimately enters the water, promoting excessive algal growth. Winter wheat, grown in the Chesapeake watershed, is known for its ability to remove residual nitrate from the soil. But over the past few years, Terlizzi has learned that cover crops may not be removing nitrate as efficiently as previously thought.

Last spring, Terlizzi sampled various cover crops growing in farm fields all over Maryland, looking at soil types that differed from place to place. Using a simple biochemical test, he found that cover crops such as rye and winter wheat were barely breaking down any nitrate at all. Especially in soil high in clay content, he found almost no activity of the enzyme (nitrate reductase) that takes the punch out of nitrogen by converting its highly mobile form nitrate to nitrite. Nitrite is then converted to ammonia, which can be used directly by the plant.

What was stopping these cover crops from breaking down nitrate?

With great care, *Sea Grant Extension specialist Dan Terlizzi (above left) adjusts the temperature of a water bath. Here he will incubate samples from a nearby farm field to determine how well a cover crop is breaking down nitrate. After an hour-long interval, lab technician Marcia Guedes (above right) adds the last chemical in the protocol. The magenta color in the vial (left) indicates that an enzyme (nitrate reductase) is active in these samples of winter wheat. This means the cover crop is doing its job.*
PHOTOGRAPHS BY ERICA GOLDMAN.

Leaning across the lab bench, Terlizzi checks the temperature of the water bath, a rectangular metal tub insulated in a cocoon of Styrofoam. He puts on his glasses, looking professorial with his silver hair and beard, then peers at a long thermometer submerged in a few inches of water. On the bench opposite him, lab technician Marcia Guedes picks up the narrow leaves of winter wheat that Terlizzi filched from the field and cuts them into 1-cm strips. They fall into a plastic dish resting on a scale. She transfers the leaf cuttings into glass vials and adds several chemicals, carefully placing each one in a test tube rack submerged in the water bath.

The samples will incubate for an hour. If nitrate is actively being reduced, the liquid in the vials will turn a deep magenta color when a final chemical is added after the incubation period.

In the spring samples, Terlizzi believes that excess ammonia in the soil was to blame for blocking the activity of the vital enzyme called nitrogen reductase. He's found that if ammonia is available to the plant, even in small amounts, it will obstruct the breakdown of nitrate — a phenomenon known as "ammonia inhibition." Metabolically, ammonia is a "freebie source of nitrogen for amino acids necessary to the plant," explains Terlizzi.

Ammonia can reach farm fields either from ammonia-based fertilizers or from the atmosphere through precipitation. That plants can metabolize ammonia is not necessarily a bad thing, explains Terlizzi. "It's great if plants absorb ammonia, but if this causes them to stop using nitrate there are a couple of concerns," he says. Ammonia is less mobile in soil than nitrate, he explains, but the very rains that deliver the ammonia and shut down the breakdown of nitrate, cause the nitrate to move through groundwater or surface water — toward the Bay. Also, over time ammonia applied as fertilizer in the soil will convert to nitrate through a bacteria-led process known as nitrification.

In the fall, nitrate levels in the soil should be high. When annual crops like corn and soybeans die at the end of summer, nitrate from fertilizer application remains in large quantities. Are cover crops doing a better job at removing nitrate from the soil at this time of year?

After the vials with plant matter have incubated for an hour at 30°C (86°F), Guedes removes them from the water bath. To each one, she adds a chemical to stop the reaction from progressing any further. Then she adds another chemical that will bind to the product of the reaction, nitrite, making it turn color.

An instant after Guedes adds the final chemical, all of the vials, except the controls, turn bright magenta — a sign that the nitrate reductase enzyme is extremely active.

Guedes then uses a colorimeter to quantify the "purpleness" in each vial. Measuring how much light has been absorbed acts as a proxy for the amount of nitrate reduced. They find that the absorbance readings are off the charts. So much so that the colorimeter reads "out of range" for several of the samples. In these cases, Guedes dilutes the sample with distilled water and takes the reading again.

Terlizzi is surprised, but pleased, by this definitive result. In the four sets of experiments Terlizzi and Guedes conducted last spring, they never saw this bright purple color, indicating that nitrate reduction had been occurring at very low levels, if at all. But in the fall, these cover crops clearly seem to be breaking down nitrate. This is good news for the Bay. These plants seem to be doing their job during the critical time for making sure excess nutrients don't find their way into the waterways.

But the result also raises questions. Terlizzi's not sure why certain crops seem to be so sensitive to ammonia in the spring, but not the fall. As a next step, he plans to take the chemical test out of the lab into the field — a quick farm crop assay of enzyme activity. His ultimate goal as both a researcher and Sea Grant Extension specialist is to translate these results into recommendations that farmers can use — such as what types of cover crops to plant at what time of year in what types of soil. He has some solid clues now as to what makes the nitrate metabolism process tick. But he says he's got a lot more work to do.

Roots of a Career

Courtesy of Dan Terlizzi

Cultivating a lifelong connection *with the land, Dan Terlizzi and his wife Cecilia found a fulfilling empty nest project in growing wine grapes near their Maryland home.*

Dan Terlizzi's interest in farms has roots that are both personal and professional. Though primarily focused on algae and marine water quality issues as a Sea Grant Extension specialist, his interest in plant physiology and behavior of more traditional crops goes way back. His wife Cecilia grew up on a farm and he started dating her when he was 15. "Our dates involved pitching hay and helping on the farm. They needed her help, so if I wanted to spend time with her, I had to help too."

Terlizzi and his wife ended up building a house on the family farm northwest of Baltimore and "put a big stake in the ground by doing so." They moved in 1981 and still live there today. Now that their two sons are grown, they've started cultivating wine grapes. The idea has percolated since a sabbatical in Italy several years ago, and the Terlizzis now plan to sell their grape harvest to the local wine industry.

As an undergraduate at St. Mary's College, Terlizzi studied biology with a marine spin, an interest that he'd cultivated since his early childhood in Bermuda as a "military brat." Though he found himself gravitating toward the study of phytoplankton ecology, he realized that everything about the discipline was grounded in basic physiology. So he chose a traditional plant physiology program at the University of Maryland, one that broadened his focus to understand how physiological processes compared between algae and traditional crop plants like corn and soybeans. His "aha" academic moment came during a course in plant mineral nutrition. It was the "perfect course at the perfect time," he says, making him think deeply about nitrogen and phosphorus in the Bay, an area of focus that has defined his career ever since.

After finishing his Ph.D., Terlizzi did soybean herbicide work for the U. S. Department of Agriculture and then worked in the private sector for about 10 years. When the opportunity came up to return to the University of Maryland through Sea Grant Extension, he was delighted to come back into the university system. He started off doing marine extension agent work out of a county office. Although he enjoyed interacting with clientele and teaching, he missed research and began incorporating an applied research program in his fieldwork.

The opportunity to return more fully to research arose in 1997, after Terlizzi had been involved as a water quality advisor during the controversy over *Pfiesteria*. He was invited to move his base of operations to the University of Maryland Biotechnology Institute's Center of Marine Biotechnology (COMB), where he would have his own lab space, with access to all of the center's technical resources. Now Terlizzi says that maintaining a lab presence at a basic science institute like COMB, while keeping his applied focus as Sea Grant Extension faculty requires a lot of "hat switching." But it's a balancing act that keeps things interesting.

— E.G.

Knauss Fellows for 2009

The Knauss Marine Policy Fellows for 2009 all come out of graduate programs at the University of Maryland. Safra Altman, Marvourneen Dolor, and Becky Holyoke will put their expertise to work for the next year in the Office of Oceanographic Research, the Department of Commerce, and the Office of Marine Sanctuaries.

Safra Altman will spend her fellowship year in the office of Policy, Planning, and Evaluation in NOAA's Office of Oceanographic and Atmospheric Research. She will work with the Joint Subcommittee on Science and Technology and OAR's Senior Research Council.

Currently a doctoral candidate in the interdepartmental Behavior Ecology Evolution Systematics (BEES) program, Altman has focused on the effect of biodiversity on invasion and invasion success in San Francisco Bay. She used marine fouling communities — the algae and animals that live and grow on submerged rocks, docks, and boat hulls — as model communities. Much of this work was done in collaboration with the Smithsonian Environmental Research Center. She expects to complete her Ph.D. in 2009.

She has also been involved recently in projects describing biodiversity in twilight reef environments, or coral reefs that are 50-150 meters below the sea surface. Altman received a Master's in Oceanography from the University of Connecticut and a Bachelor's in Biology from Brown University.

Marvourneen Dolor will serve as an environmental research specialist in the St. Lawrence Seaway Development Corporation (SLSDC) in the Department of Transportation. She will be the first Knauss fellow to work at the SLSDC. She will fill the role of "resident scientific expert" in the Corporation. Her tasks will involve advising leadership on environmental issues, in particular ballast water policies.

Dolor received her Ph.D. in Environmental Chemistry in January 2009. Her dissertation work was aimed at determining what chemical processes control deposition of the trace element rhenium in marine sediments. This information may enable scientists to use rhenium in sediments as an indicator of historical deterioration in coastal marine environments due to human impacts. Dolor received her undergraduate degree in Marine and Environmental Sciences from the United States Coast Guard Academy.

Rebecca Holyoke will work as a policy analyst with the Office of National Marine Sanctuaries under the supervision of Margo E. Jackson, Senior Policy Advisor (and the current Acting Deputy Director of National Marine Sanctuaries).

She will assist Jackson, as well as Policy Development Specialist Jim Sullivan, with reviews of relevant environmental legislation and regulations, requests regarding program budget development, and responses to legislative and/or public inquiries.

Holyoke received her Ph.D. in Marine Estuarine Environmental Sciences in 2008. Her dissertation focused on the influence of eastern oyster (*Crassostrea virginica*) biodeposits (feces and pseudofeces) on nutrient exchange at the sediment-water interface in shallow tidal creeks of Chesapeake Bay. After finishing her degree, she served as a postdoctoral researcher with Dr. George W. Luther, III in the College of Marine and Earth Studies at University of Delaware, assisting with moored observatories, *Alvin* dives, and manuscript preparation. Holyoke received her Bachelor's in Biology from Brescia University.

Safra Altman

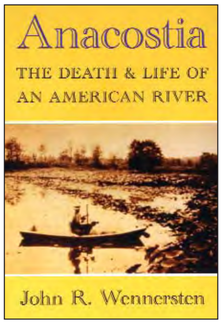
Marvourneen Dolor

Becky Holyoke

The Knauss Fellowship, established in 1979, is coordinated by the National Sea Grant Office of the National Oceanic and Atmospheric Administration (NOAA). Named for John A. Knauss, a former NOAA administrator, the program provides graduate students across the country with an opportunity to spend a one-year paid fellowship working with policy and science experts in Washington, D.C.

Fellowships run from February 1 to January 31 and pay a stipend of $33,000 plus $7000 for health insurance, moving, and travel. Applicants must apply through the Sea Grant program in their state. For more information, visit the web at: Maryland Sea Grant, www.mdsg.umd.edu/Policy/knauss.html or the National Sea Grant program, www.seagrant.noaa.gov/knauss/knauss.html.

Anacostia River, Stories at Sea



Anacostia: The Death & Life of an American River, *John R. Wennersten, Chesapeake Book Company, 2008.* If the Anacostia is the nation's forgotten river, then John Wennersten is helping us to remember it.

Wennersten is the right man for the job. Author of books like *The Oyster Wars* and *The Chesapeake Bay: An Environmental Biography*, he has a knack for evoking the richness of Bay history.

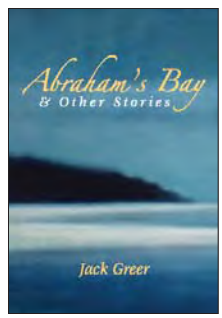
The picture he paints for us of the Anacostia is not always pretty.

Out of a plantation culture that gave us leaders like George Washington, mansions like Mount Vernon, and a national capital at the confluence of the Potomac and the Anacostia, came other legacies. Slavery. Social and racial divides. Rampant land speculation and bankruptcy.

The Anacostia rises from this difficult and bloody past with a fascinating story to tell. There are grand dreams by Washington D.C.'s designer, Pierre L'Enfant, to make the city a great international port, using the Anacostia's deep channels. There are bold financial ventures and shady dealings, personal fortunes made and lost.

This story of the Anacostia is often one of degradation, of the ruined environmental health of the river and of the disenfranchised communities that have lived on its shores.

But Wennersten ends his book with currents of hope and an "Anacostia prayer." He sees that the grand dreams have not died after all, and he concludes that urban watersheds — even highly degraded ones — can be restored, if we only have the will.



Abraham's Bay & Other Stories, *Jack Greer, Dryad Press, 2009.* Jack Greer's stories are peopled by characters who are ocean sailors linked by their love of the sea. All of them, for different reasons, have left the U.S. mainland for the open waters of the Atlantic and the islands of the Caribbean where they face inner fears and outside threats from storms, strangers, and their own failures of judgment. In the title story, a cardiologist sailing among the islands by himself is stranded one night and confronted by a menacing islander; in "Souvenir's Last Passage," an aging woman faces a hostile boarding in the dead of night. Greer's stories are strikingly realistic, their lean narrative style graceful and exact, anchored in a sailor's competence that is always attentive to the sea and its beauty, but also alert to its dangers.

Director of Communications and Public Affairs at Maryland Sea Grant, Greer has worked on and written about Bay issues for nearly three decades. During all these years, on his own time, he has also written fiction and poetry, twice winning awards from the Maryland State Arts Council for his fiction.

Greer will read from *Abraham's Bay & Other Stories* on Sunday, March 29 at the bookstore *Politics & Prose* on Connecticut Avenue in Washington, D.C.

Read BayBlog, see the Photo Gallery, and send your comments at *Chesapeake Quarterly Online* at www.mdsg.umd.edu/CQ

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