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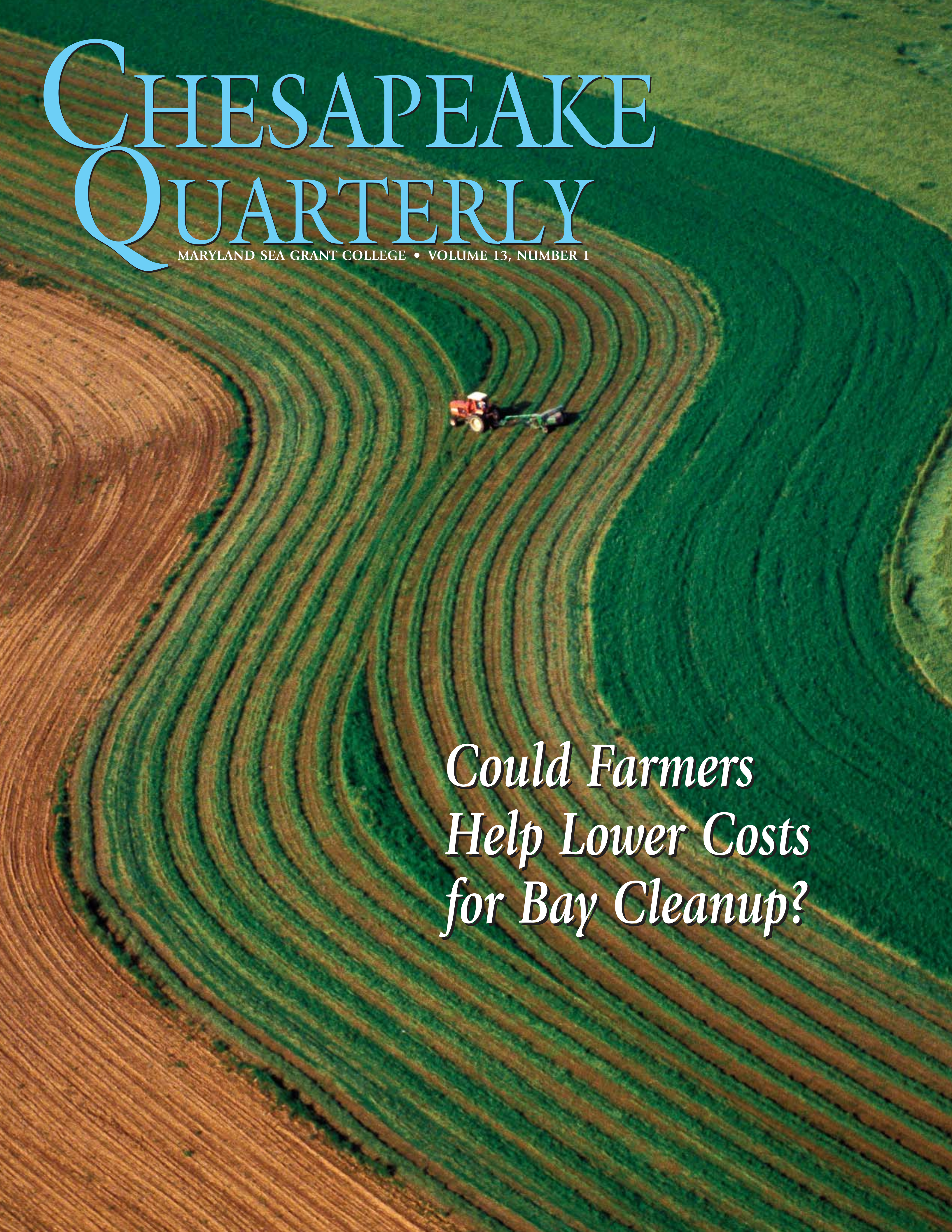

Could Farmers Help Lower Costs for Bay Cleanup?

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***Cover photo:** Contour plantings like those on this farm in Frederick County, Maryland, help reduce runoff.* ***Page 3:** Mike Brubaker (top) stands amid cover crops that he grew on his farm in Mount Joy, Pennsylvania, as part of a deal with a local wastewater treatment plant to reduce nutrients flowing to the Chesapeake Bay. A market for such "nutrient trades" has yet to develop but may one day help municipalities reduce their costs of complying with federal and state rules on nutrient discharges. This wastewater treatment plant (bottom) serves Howard County, Maryland.* PHOTOGRAPHS: COVER, DAVID HARP; P. 3, TOP, JEFFREY BRAINARD, AND INSET, CLARK CONSTRUCTION AND THE LITTLE PATUXENT WATER RECLAMATION PLANT.

TRADING AWAY TOWARD A CLEANER BAY

Jeffrey Brainard

Deals between cities and farmers may benefit both and lower the costs of cleaning up the Chesapeake Bay. So why are there so few trades?

Mike Brubaker will be the first to tell you that succeeding in dairy farming today takes a lot more than milking cows. The Brubaker family has run a farm near Lancaster, Pennsylvania, since 1929 and has seen plenty of changes as the operation grew from fewer than a dozen cows to 900 today.

The Brubakers have made it a point of family pride to reduce the farm's impact on the surrounding environment using methods that also return income to the farm's bottom line. They installed solar panels on top of their cowsheds and a digester that turns methane from cow manure into electricity, which they sell to the local power grid.

So the Brubakers considered it only natural to venture into another innovative idea for helping both their wallets and the land. In 2007, they became one of the first farm operations in the entire Chesapeake Bay watershed to enter into a deal for what is called water quality trading. This kind of trading depends on cooperation between farmers and cities, using tools drawn from economics and markets to lower the overall cost of cleaning up and preserving the Bay's water quality.

The Brubakers' trade went like this: They signed a contract with the Mount Joy Borough Authority, which operates a wastewater treatment plant that serves their town. The Brubakers agreed to plant cover crops and follow other practices on their farm to reduce its nitrogen runoff by more than 8,000 pounds a year. In return, the authority agreed to pay them about $36,000 annually. The swap was an economical way to help the authority reduce the plant's nitrogen output, which eventually flows into the Susquehanna River and the Chesapeake Bay. Pennsylvania and other states are requiring sewage treatment plants to reduce their nutrient discharges as part of a Baywide effort.

The Brubakers and the authority renewed this water quality trade, and it continues today. "It seemed to make a whole lot of sense because we're in the same watershed that they're in," says Mike Brubaker, standing on his farm in the middle of a field of rye planted as cover crop. "We're trying to add practices that provide a sustainable environment and an economic win together."

How to meet environmental restoration goals at reasonable cost is an ongoing challenge for policy makers in the Chesapeake Bay region, and water quality trading may offer a tool to lower costs, analysts say. State and local officials have grown concerned about the expense since the Environmental Protection Agency (EPA) in 2010 established its plan to reduce the excess nitrogen, phosphorus, and sediments that are flowing into and endangering the Bay. High levels of nutrients fuel processes that decrease oxygen in the water and kill aquatic life, creating the Chesapeake's chronic and well-known dead zones. In the cleanup plan, the EPA set limits (called TMDLs, or Total Maximum Daily Loads) for nutrients and sediments that flow off the land in Maryland and five other states into the Bay.

The limits reflect the EPA's analysis of how much nutrient runoff would allow the estuary to function as a healthy aquatic ecosystem. The limits also reflect how states divided responsibility for reducing nutrients among the sources that discharge them, including wastewater treatment plants, stormwater drainage systems, and farms.

Now, water quality trading is gaining attention from the EPA and the states as a key tool to help lower those nutrient-reduction costs. The costs could run into the billions of dollars, especially for cities facing upgrades to treatment plants and stormwater drainage pipes to reduce nutrient runoff. Trading looks attractive because farmers can adopt certain farm-management practices that appear to reduce nutrients more cheaply than cities would pay to trim their nutrient discharges by the same amount.

In a nutrient trade, for example, a farmer can plant cover crops, like barley and wheat, in the fall. These crops take up excess nitrogen from fertilizer before it reaches the Bay. The grower can use these and other methods not only to reach the government's TMDL target level for farms in his area — he can also reduce his own farm's nutrient runoff further still. The farmer can then create "credits" representing the additional amount of nitrogen he reduced, and he can sell the credits to a wastewater treatment plant that needs to make cuts in its nutrient discharges to hit its TMDL limit. The farmer profits, and the plant's ratepayers save money. This is a little like when a farmer generates electricity from a windmill or a methane-fueled generator: he can use what he needs and sell the excess to the power grid.

Beginning in 2005, Pennsylvania, Maryland, Virginia, and West Virginia enacted rules to allow nutrient credit

trades. But, it turned out, rules alone haven't been enough to prompt trades involving farmers. Not only was the Brubakers' one of the first such trades in any of those states — to date it is one of the only ones.

"Water quality trading is often seen as a magic bullet, it's going to solve all our problems," says Lisa Wainger, an economist at the Chesapeake Biological Laboratory of the University of Maryland Center for Environmental Science. But in the Chesapeake watershed and other regions where trading has been tried, she says, "it's never really generated the success that people hoped it would."

She and other economists who have studied these outcomes suggest that markets for trading water quality credits have been slow to develop here because the state rules that govern trading were designed conservatively to protect water quality rather than ease trading. Some rules, for example, were crafted to account for the risk that farm-based practices would not reduce nutrients by as much as expected. But such a rule may also preclude the substantial cost savings that trading was meant to provide. Economists say that the states may need to consider other market-based tools besides nutrient trading in order to juggle these competing priorities successfully.

***Brubaker Farms has won recognition and awards** for its environmentally friendly farm practices, including a digester that converts manure from the farm's dairy operation (above) to electricity. So a nutrient trade with a wastewater treatment plant seemed like a natural fit, Mike Brubaker says. Today, Maryland treatment plants use equipment to lower nutrient discharges (right); one day, Maryland plants may offset increased discharges by buying nutrient reduction credits from farmers.* PHOTOGRAPHS: TOP, JEFFREY BRAINARD; RIGHT, CLARK CONSTRUCTION AND THE LITTLE PATUXENT WATER RECLAMATION PLANT.

From the Air to the Water

A lot of the questions posed by water quality trading come straight out of Economics 101. What does it cost to produce something? What will people pay for it? And how well do those match up?

The idea of trading credits for reducing water pollution was borrowed from a similar approach used successfully to control air pollution. In the 1990s, the EPA allowed the operators of coal-burning power plants to trade credits to control the airborne compound sulfur dioxide. Some plants reduced their discharges by more than they were required to and sold credits to other plants that faced bigger bills to make such reductions. This kind of sale is called "cap and trade." Mandatory caps on power-plant emissions have been credited as a major reason for the reduction of acid rain and the acidification of Northeast lakes, and trading has been credited for reducing the cost.

Some studies have estimated that a trading approach could generate big cost savings in the effort to clean up the Chesapeake Bay. The beneficiaries might include the 475 municipal sewage treatment plants in the Bay's watershed. Their discharge permits require them to meet the federal targets for nutrients and sediment. To make the required reductions, the plants are facing a combined cost of $385 million annually, according to a 2012 analysis by scholars at RTI International, a nonprofit research organization in North Carolina. Plant operators, however, could cut their costs by nearly 40 percent by buying an equivalent amount of nutrient reduction credits from farmers.

The savings could be even greater for municipalities if you add in the additional cost to upgrade their stormwater systems, a big expense that hikes their total cost to $1.47 billion annually. Trading could reduce this overall bill by 80 percent, or more than a billion dollars, RTI International's analysis found.

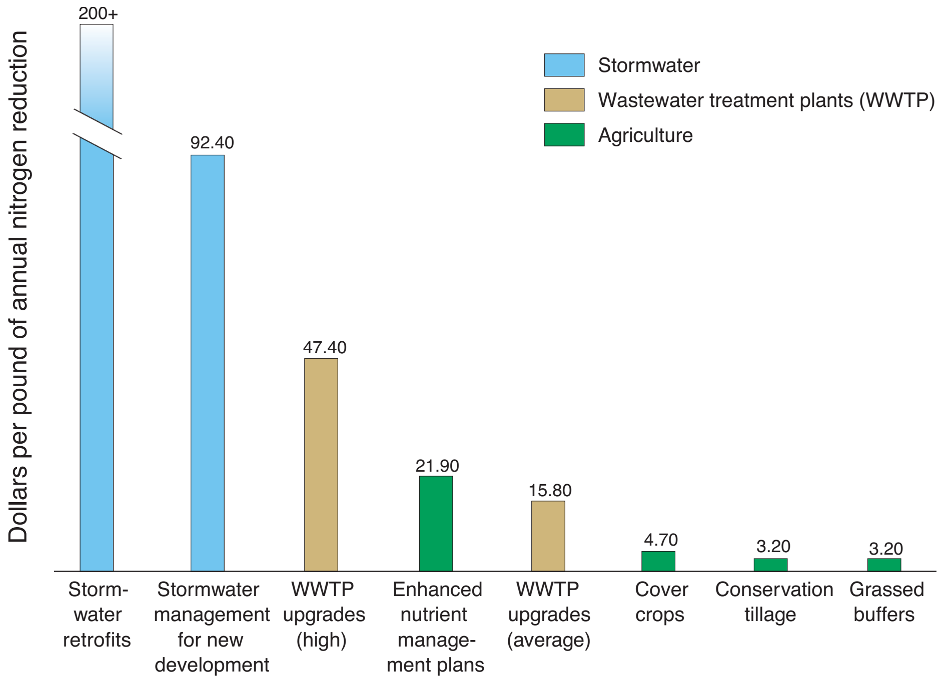
The analysis is a best-case scenario — for example, it assumes that many farmers who could generate and sell credits by installing nutrient-reducing practices would actually do so. But trading requires both a supply and a demand — and there is little demand yet for nitrogen reduction credits produced by farms.

The Demand Side

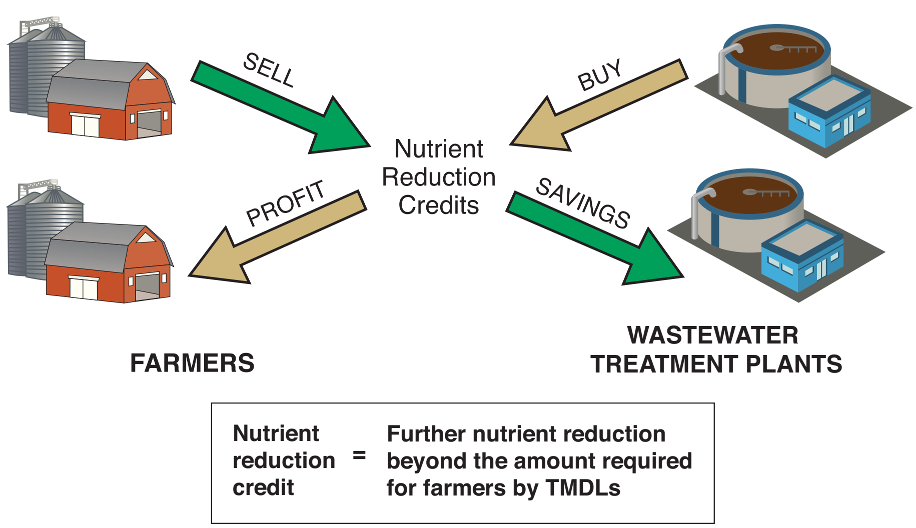
Lack of demand is partly a result of state rules about trading.

In 2004, Maryland required the 66 largest publicly owned sewage treatment

Reducing Nitrogen: Agriculture's Cost Advantage



How a Water Quality (Nutrient) Trade Works



Using management practices like cover crops *(top), farmers can reduce a pound of nitrogen at a lower expense than it costs municipalities to upgrade nutrient-removal equipment at wastewater (sewage) treatment plants or to modify pipes to control urban stormwater runoff. In a "nutrient trade" (bottom), an urban source of nitrogen or phosphorus buys "credits" from a farmer who reduces his nutrient discharges, and the credits count toward the buyer's required reduction. Nutrient trading has yet to develop in the Chesapeake Bay, and the amount of savings in practice remains to be seen.*
GRAPHICS: TOP, EXCERPTED FROM A FIGURE FROM THE WORLD RESOURCES INSTITUTE; BOTTOM, MARYLAND SEA GRANT FIGURE (DRAWINGS: FARM, KIM KRAEER AND LUCY VAN ESSEN-FISHMAN, IAN; TREATMENT PLANTS, TRACEY SAXBY, IAN)

plants to achieve a low level of nutrient discharges using new treatment technology. That has remained the state's policy since the TMDL limits on nutrients in the Bay were announced. Under the rules, these plants cannot buy nutrient reduction credits until they have installed this technology.

However, Maryland's rules do allow treatment plants that have completed these upgrades to purchase nutrient credits to deal with expected future population growth. The state is projected to add 478,000 households by 2035, which threatens to pump more nutrients into the Bay. After sewage plants in Maryland install the nutrient-removal technology, they will have some capacity to accommodate more residents and more wastewater. Eventually the plants' nutrient discharges will bump up against the TMDL caps for discharges. But most Maryland plants won't hit those limits for another decade or longer. By then, operators may find nutrient trading a cheaper alternative to additional technology upgrades.

Developers may also start shopping for nutrient reduction credits from farmers. In 2013, the state finalized a new set of rules, called Accounting for Growth, to prevent newly built houses and businesses from adding nutrients above the TMDL limits. Developers will have to make compensating decreases or "offsets" in these discharges, and it may be economical for developers to pay farmers for nutrient reduction credits.

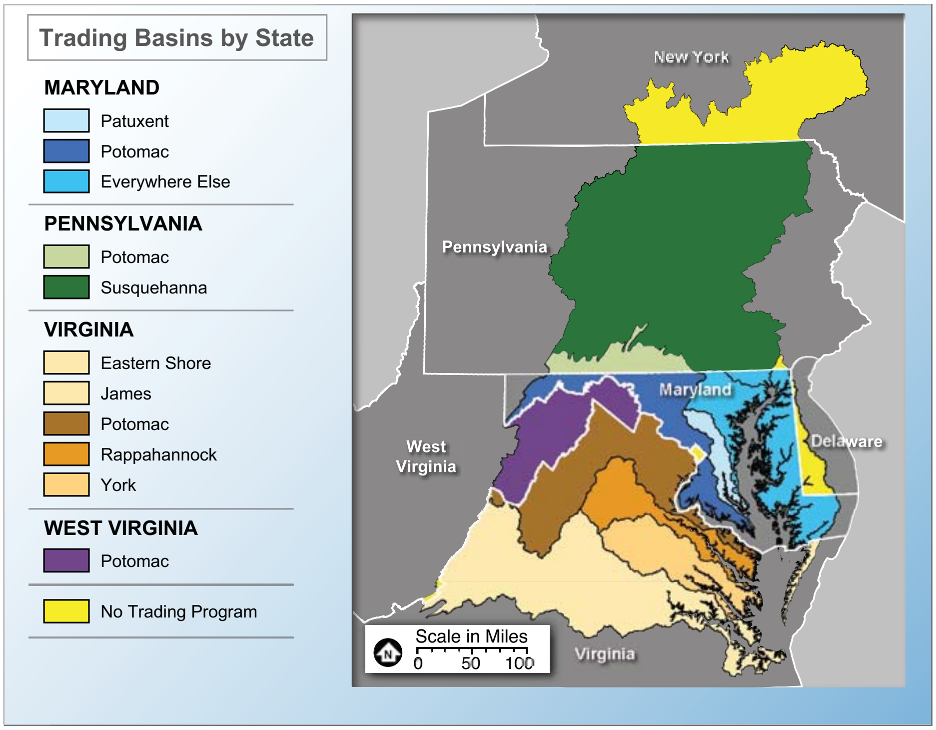
Demand for nutrient trades may also come from municipal stormwater systems in Maryland. The TMDL cleanup plan will require the largest urban systems to reduce current nutrient discharges and to compensate for population growth after those reductions are achieved. But the Maryland Department of the Environment has not yet issued regulations that would allow this trading to begin.

The Supply Side

Just as some state rules limit demand for nutrient credits, they also limit supply. Economics 101 teaches that if you restrict the supply of something, its cost rises. And if the cost of nutrient reduction credits rise, the savings from nutrient trading could be less than expected.

One such rule lowers the supply of nutrient credits in Maryland, Pennsylvania, Virginia, and West Virginia by restricting trades to designated areas. Maryland, for example, allows trades within the Potomac basin, within the Patuxent basin, or within the rest of the

Geographic Boundaries for Nutrient Trading
Chesapeake Bay Watershed



States that allow nutrient trading *require the buyer and seller to be located within the same area. The rules are meant to maximize the benefits of trading within each basin, but this restricts the supply of credits and increases their price compared to a scenario in which trading is allowed across basin and state boundaries.* MAP: PINCHOT INSTITUTE FOR CONSERVATION, WASHINGTON, D.C.

state, but it disqualifies trading across any of these zones.

Requiring both buyer and seller to swap credits only within the same zone ensures that each river basin reaps some benefit from any trade. Otherwise, nutrient levels could rise in one basin if a wastewater treatment plant there bought nutrient reduction credits from a farmer in a different basin. Some observers have criticized nutrient trading because of its potential to create localized "hot spots" of nutrient pollution in the water near urban sources like sewage treatment plants and stormwater pipes (see box on pollution hot spots, p. 8).

Despite the environmental benefits of geographic limits on trading, economic analyses indicate that allowing trading across basins would generate significantly larger savings compared with restricting trading to within basins. It's Economics 101 again: the bigger the supply of a product, the lower the cost. If the states in the Chesapeake Bay watershed allowed water quality trading across boundaries of basins and states, this would create the largest such trading zone in the United States. But the states would first have to agree to a common set of rules for determining what is a nutrient reduction credit, and this has yet to happen.

Another kind of rule that tends to lower the supply of nutrient credits is a requirement for conserving farmland. Maryland, Pennsylvania, and West Virginia prohibit retiring "substantial" portions of farms to generate credits for trade. Putting agricultural land into conservation programs, such as planting trees on less productive land, offers some of the most cost-effective, efficient ways of reducing a pound of nitrogen from reaching the Bay. However, the trading rules restrict taking large amounts of land out of production to generate credits because this results in a smaller local farm economy.

Hedging against Uncertainty

Yet another rule that restricts the supply of nutrient credits is one that requires buyers to purchase more credits than they need, as a safety factor to protect the Bay's water quality.

Virginia adopted this kind of rule because it's very difficult to measure accurately the amount of nutrient reduction accomplished by particular farm management practices. The best-case scenarios predict that practices like planting cover crops will reduce nutrients by a particular amount, day in and day out. But they don't: agricultural researchers have found that the actual reductions are highly variable. A lot depends on factors like rainfall. (In a rainy year, more nutrients are washed into the Bay no matter what practices are in place.) Unlike at a wastewater treatment plant, there's no pipe coming off a farm field containing a gauge to record nutrient levels.

But nutrient trading depends on certainty — a buyer needs to purchase a specific amount of nutrient reduction. So to deal with the variable results of farm practices, Virginia requires buyers to purchase the equivalent of two pounds of nutrient reduction by farmers for every one pound of nutrients that buyers actually need to meet their nutrient targets. In March, the EPA issued a memorandum asking the other states with trading programs to adopt that approach in most cases when farmers sell nutrient reduction credits. (In very limited cases where reductions can be measured directly, the EPA memorandum allows for a less conservative "trading ratio" of one to one.)

The price of reducing uncertainty is that this method raises costs. An analysis by Lisa Wainger and her colleagues found that a two-to-one ratio would raise the cleanup cost for the Potomac watershed by three to four times compared to a lowest-cost scenario that used a ratio of one to one.

Wainger says we can increase trading activity by relaxing rules like these. She adds, though, that policy makers will have to find the right balance between reducing costs and protecting the Bay's water quality. Ignoring uncertainty in the results of farm practices could translate into slower progress toward meeting the Chesapeake's TMDL nutrient targets.

More scientific research could help policy makers work toward this balance, she says. Existing estimates of nutrient reductions come from formulas developed by expert panels that review available research; the formulas equate particular agricultural practices with specific amounts of nutrient reduction. But many practices have not been studied under a range of field conditions, so further research could help to make these formulas more accurate and reliable.

Meeting the Baseline

Another kind of rule that may further limit the supply of nutrient credits is called a "baseline." This rule is meant to ensure that farmers meet their own targets for reducing nutrient runoff to the Bay before they can sell nutrient reduction credits. All farms within a single region in Maryland must meet a single baseline level that is consistent with the TMDL target for that area. To reach the baseline, many farmers will have to reduce their existing nutrient runoff levels.

However, once farmers achieve their own target, they may have relatively few nutrient reduction credits to sell to municipal buyers. That's one conclusion of research by Marc Ribaudo, an economist who has studied possible effects of state rules on nutrient credit trading in the Chesapeake Bay. He's a 30-year veteran of the Economic Research Service of the U.S. Department of Agriculture. His office in downtown Washington is far from the Bay's shores, but a souvenir sits atop his office bookshelf — a felt hat that looks like a crab. (Ribaudo says it stays on the shelf, not his head.)

Think of a baseline as the farmer's price of admission to the trading market floor. A baseline creates an incentive for farms to meet and exceed the TMDL targets for agriculture.

An incentive may be needed because the Clean Water Act — the law on which the TMDL targets are based — exempts crop farms. This means that the EPA can't require crop farmers to meet the TMDLs, as it can sewage treatment plants. Congress exempted crop farmers from the law because it's difficult to measure the amount of nutrients flowing off farms to determine compliance. However, farms are the single largest source of nitrogen and phosphorus delivered to the Chesapeake Bay.

A profit incentive might encourage farmers to put in place farm-management practices, like cover crops, that reduce the amount of nitrogen and phosphorus flowing into neighboring streams and the Bay. Other such practices include planting streamside buffers of grass or trees and using no-till planting and less fertilizer. In the Chesapeake Bay, some farmers have been doing these steps voluntarily for years, with help from government subsidies. In 2013, Maryland spent about $20 million to reimburse farmers up to $100 per acre for planting a total of more than 400,000 acres of cover crops. But even with these kinds of supports, voluntary efforts by farmers across the entire Bay watershed have not been enough to meet the voluntary reduction targets set by states before the TMDL nutrient limits were established.

Ribaudo and his colleagues wanted to know how a baseline requirement would affect farmers' willingness to create and sell nutrient reduction credits voluntarily. The researchers compared potential demand for, and supply of, nutrient credits across the entire Chesapeake Bay watershed. Ribaudo estimated demand based on the needs of large wastewater treatment plants. To estimate supply, the researchers analyzed the nutrient-management practices already in place on farmland and the potential payoffs from additional practices. They examined a scenario in which farmers received government subsidies to cover all costs of meeting the baseline.

What Ribaudo found ran counter to some common expectations about nutrient trading. Even with government subsidies, a strict baseline requirement — one that allowed farmers to emit relatively few nutrients to the Bay watershed — didn't seem to prime the pump for nutrient trading or incentivize participation by farmers. To the contrary: a stricter baseline requirement resulted in fewer nutrient credits sold by farmers to sewage treatment plants compared to a scenario with no baseline requirement at all.

The Effects of a "Baseline" in Nutrient Trading

	Reductions by farmers in nitrogen runoff (millions of pounds)		
Baseline*	Sold as credits**	Used to meet farmers' baseline	Total reduction in runoff
15 pounds per acre (more strict)	4.5	19.8	24.4
35 pounds per acre (less strict)	8.8	33.1	41.9
65 pounds per acre (not strict)	12.1	38.5	50.7

** Maximum pounds of nitrogen allowed to be discharged per acre annually.*
*** One credit equals one pound of reduced nitrogen discharge.*
Note: Figures assume a taxpayer-funded subsidy of 100 percent to help farmers meet the baseline. Some figures are rounded.

Before farmers can trade nutrient credits, *state rules require them to carry out management practices to reduce their own nutrient runoff levels to a target, "baseline" level. Research indicates that a low ("strict") baseline level results in fewer credits for sale, and in less overall reduction of nutrients discharged into the Bay, than a higher ("not strict") baseline level. In several parts of Maryland, the baseline for farmers would be close to the "strict" level shown here.* TABLE SOURCE: MARC RIBAUDO, ECONOMIC RESEARCH SERVICE, U.S. DEPARTMENT OF AGRICULTURE

Will Trading Create Pollution "Hot Spots"?

Courtesy Chesapeake Bay Program

A wastewater treatment plant needs to limit its discharges of nitrogen and phosphorus to meet the Environmental Protection Agency's limits on nutrient runoff in the Chesapeake Bay. The idea behind nutrient trading is that the plant can save money by paying a farmer to reduce his nutrient runoff by the required amount. But the farm might be located some distance away from the treatment plant. As a result, this nutrient trade could create a "hot spot" of excess nutrients near the treatment plant that might harm water quality and aquatic life there. That's why some people oppose nutrient trading in the Chesapeake region.

But whether — and where — "hot spots" would be created remains to be seen. The Chesapeake Bay Program office, which represents the EPA and its state partners, did an analysis in 2012 concluding that a substantial amount of nitrogen trading could occur across the entire Bay watershed without risking water quality in local areas. The reason has to do with how the EPA set up the nutrient target levels for the estuary, the so-called TMDLs or Total Maximum Daily Loads. The EPA divided the Chesapeake's watershed into 92 segments and figured out the amount of nutrients in each segment that would ensure that water quality was acceptable throughout the tidal portions of the Bay watershed.

But the EPA set these limits conservatively. In most of the 92 segments, the limits are lower than they need to be to achieve satisfactory water quality in those segments (as measured by dissolved oxygen, for example.) This is especially the case in the upper portion of the Bay's tributaries like the Potomac River. The EPA set each segment's limit to protect water quality not only in that segment but also in the main channel of the Bay — an area roughly from the Patuxent River's mouth to the Potomac's. That stretch is home to the Bay's persistent, low-oxygen dead zones, which are created there by the interplay of excess nutrients and physical conditions, like high salinity. The TMDLs mandate particularly low nutrient limits in those segments to achieve acceptable water quality, and the limits in all 92 segments were designed conservatively to accomplish that goal.

All of this opens the door to water quality trading. The buffer built into the TMDLs for local segments means that a sewage treatment plant could buy nutrient reduction credits to avoid having to reduce its own nutrient discharges — but the purchase might not impair water quality in that segment.

In a memorandum issued this year, the EPA suggested ways for state authorities to evaluate and regulate nutrient trades to ensure that local water quality is protected. For example, the risk of creating a hot spot would be lower if the seller of a nutrient reduction credit, such as a farmer, were located upstream of the buyer, the EPA said. (The reduction in nutrients by this farmer would tend to reduce the load of nutrients near the plant — an effect that would not occur if the farmer were located downstream of the plant.)

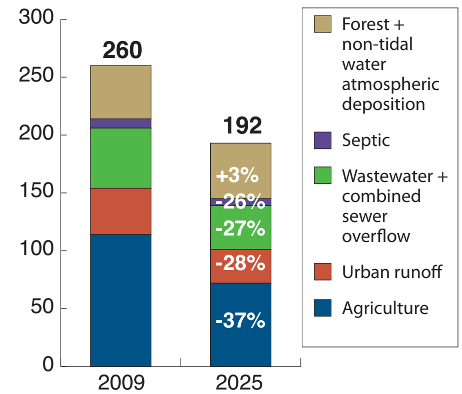
If nutrient trading in the Bay "caught on fire" and many trades occurred, the Chesapeake Bay Program would need to examine the effects of individual trades on local water quality, says Rich Batiuk, the program's associate director for science, analysis, and implementation.

"Models are not perfect, but they are part of our accountability system, and we could confirm for ourselves and those involved in the trades that there was not, in fact, an impairment on that local water quality," Batiuk says. "We think we've got the tools in place to understand the relative influence of those trades" on local nutrient amounts.

— *J.B.*

Targets for Bay Nitrogen, by Source

(Millions of pounds)



***Under the cleanup plan** for the Chesapeake Bay, sources that emit nitrogen into the Bay are required to cut levels by 2025. Farmers will be required to make larger cuts than other sectors. State rules for nutrient trading require farmers to meet targets for reducing nitrogen before they can sell nutrient credits to urban sources — which may limit the volume of nutrient trading, economists say.* GRAPHIC: EXCERPTED FROM A FIGURE FROM THE CHESAPEAKE BAY PROGRAM

What is more, under a strict baseline requirement, farmers accomplished less total reduction in nutrients — the reductions required to meet the farmers' baseline and the reductions farmers sold as credits — compared with a scenario with a less strict baseline (see table, p. 7).

In other words, Ribaudo says, you can invite farmers to help out urban neighbors by selling them nutrient reduction credits. Or you can ask farmers to reduce their own nutrient runoff levels. But it's unlikely that farmers will do a lot of both under a strict baseline. Even with a profit incentive, some farmers won't meet the baseline at all. Others will, but these farmers will produce relatively few credits at a price attractive to buyers.

Ribaudo's pace quickens as he elaborates. "If you're telling point sources that they can reduce their costs through trading, and then you develop a trading program that is very stringent for the nonpoint sources [farmers], then the point sources aren't going to benefit by it," he says. Instead, operators of sewage plants will have little choice but to upgrade treatment technology to limit nutrient discharges, "and the [Bay's] water quality will improve, but it's going to be more expensive than it would be otherwise."

The analysis by RTI International — the one that predicted big cost savings from water quality trading — acknowledged that a baseline could reduce those savings. But RTI didn't estimate by how much.

Alternative Approaches

Do the states with trading programs need to relax the existing baselines? In several areas of Maryland, like the Patuxent River watershed, these levels are stricter than the lowest baseline level examined in Ribaudo's analysis.

Ribaudo explains that he didn't identify an ideal baseline, one that would best advance the dual goals of cutting costs for urban sources and reducing overall nutrients in the Bay. That would be difficult to calculate for a variety of reasons, he says.

However, Ribaudo says his findings suggest that by enacting a relatively less stringent baseline requirement, states could make nutrient trading more attractive to both farmers and urban sources. Like Wainger, he acknowledges that relaxing trading rules means that environmental rules may not be met — the farmers may not meet their own targets under the TMDLs for reducing nutrients in the Bay. To help farmers achieve their targets, he says, states could offer them additional financial incentives and support to complement trading programs.

For example, pilot projects in Ohio and Canada have used governmental and non-governmental agencies as middlemen to arrange transactions between buyers and sellers and to promote the most cost-effective reductions in nutrients. In the Greater Miami River watershed in Ohio, farmers submitted bids to supply nutrient reduction credits. A regional water authority selected the bids that offered the largest nutrient reduction at the lowest price (a process called a reverse auction.) The authority financed payments to farmers in part from fees it collected from wastewater treatment plants that had excess nutrient discharges.

In such a program, the middleman can rank bids by which ones offer the best evidence that the farm practices described would reduce nutrients consistently and reliably. This kind of approach can reduce the need for high trading ratios and stringent baselines that can hinder trading by increasing costs, says Wainger.

Another tool for helping farmers meet the TMDL limits would financially compensate growers whose yield of crops declined because they reduced their fertilizer applications in order to reduce their nutrient runoff levels. A pilot study in the Chesapeake Bay led by the American Farmland Trust found the cost of that approach might be lower than the cost of Maryland's cover crop subsidies.

***Economist Lisa Wainger** and her colleagues studied the effect of rules that require buyers to purchase two nutrient reduction credits from farmers for every one credit they actually need. This is to provide a safety margin because farm-based efforts to reduce nutrients produce variable results. But in practice, these rules also could substantially increase the cost of the credits — and so lower the cost savings achieved through nutrient trading.* PHOTOGRAPH: SARAH HOUDE

With more incentives like those, Ribaudo says, "You can probably get a whole lot more bang for your conservation budget than we're currently getting."

Analyses of supply versus demand may not matter much if farmers don't want to participate in nutrient trading for reasons other than dollars and cents. Some farmers have voiced irritation that they are already being asked to make larger reductions in nutrients to meet the TMDL targets than urban sources are.

Farmers may also object to nutrient trading because the rules require that a monitor annually visit the farms selling nutrient credits to make sure the required nutrient reduction practices were followed. Many farmers might see such inspections as unwelcome and intrusive. The potential hassle might not be worth the money. Under Virginia's trading program, revenue would amount to only $5,000 annually on a typical, 600-acre crop farm, according to an analysis led by Kurt Stephenson, an agricultural economist at Virginia Tech. That was a fraction of the farm's annual revenue of more than $1 million.

A Farmer's Bottom Line

On the Brubakers' farm in Pennsylvania on a recent day in early spring, the short green cover crops of rye would soon make way for seeds of corn. The rye had played a part in stopping nutrients from the previous year's corn fertilizer from entering Charles Creek, which runs across the farm. About two miles south, the creek's flow enters the Susquehanna River, the Chesapeake's largest tributary.

But unless demand and prices increase for nutrient reduction credits, the bottom-line benefit to other farmers might resemble the Brubakers' experience. Although the nutrient trade has saved some money for the borough authority and its ratepayers, the trade is a losing proposition on paper for his family, Mike Brubaker says.

It cost the farm about $45 an acre to plant the cover crops that provide the nutrient reduction that is the basis for the trade. That includes the costs of seed and equipment to plant it using no-till methods. That's higher than the $36 per acre that the farm earned from the trade.

"It's a number that's good enough for us to continue," Brubaker says. He explains that the cover crops provide an added benefit to his farm that isn't reflected in those revenue numbers — they reduce soil erosion, helping to maintain the soil's productivity. Still, the lack of easily demonstrable profit from nutrient trading may be one reason there have been so few trades in Pennsylvania so far.

"It's been a couple of years" since Pennsylvania began allowing nutrient trading, Brubaker says, "and there's not a lot of excitement about it. You don't see the amount of players to make a healthy marketplace."

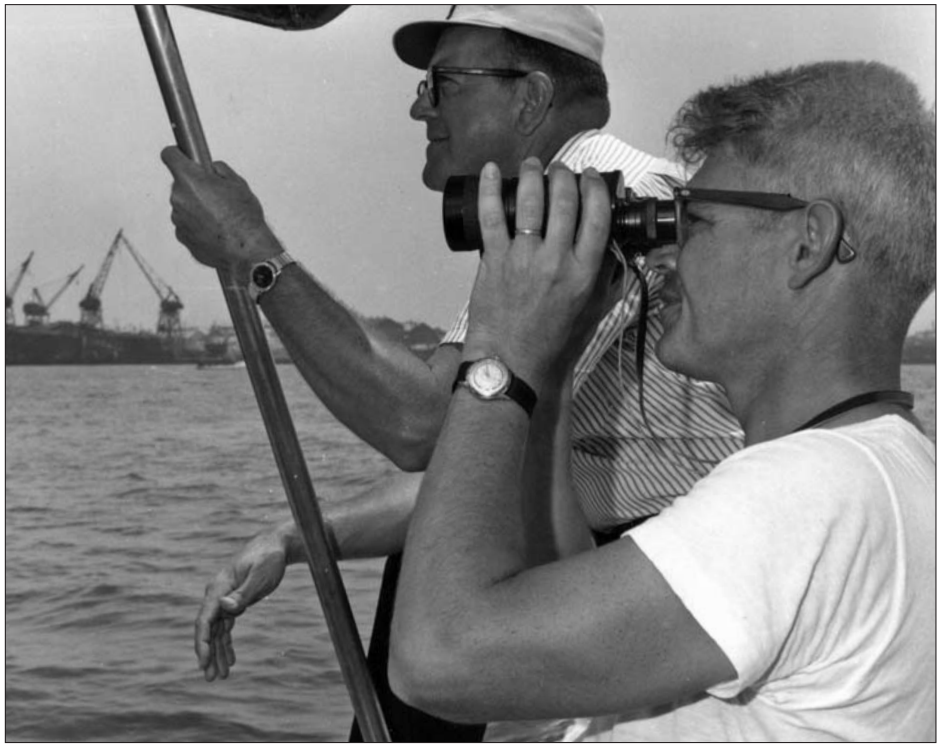
— *brainard@mdsg.umd.edu*

THE MAN WHO SAID TOO MUCH

Bill Hargis and the Rise of a Marine Lab

Michael W. Fincham

This is the fourth article in a series about the pioneers of Chesapeake Bay science.



He came home to Virginia from the war in the Pacific and made himself an expert on the parasites of fishes. The G.I. bill got him through college by 1950 and his brains got him through graduate school, first in Richmond and then in Florida. That's when he began describing new species of trematodes, small and flat and wormlike creatures that like to infect mollusks.

After the dramas of wartime, William J. Hargis, Jr. decided to focus his life on quiet, detailed, some would say esoteric, research: collecting fish, isolating parasites, preparing slides, and staring endlessly into microscopes so he could patiently, patiently give each parasite its proper name.

All his work got him a name and his name got him a job, a good job that brought him back home again in 1955 when the Virginia Fisheries Laboratory in Gloucester Point decided to hire a parasitologist. Four years later, his work and his charisma got him a better job: director of this small Bayside laboratory that would soon become the Virginia Institute of Marine Science (VIMS). By 1959, Bill Hargis was launched on his life's work: building a broad-based marine research lab in his home state.

It would not prove a quiet career. He would, time and again, launch himself into noisy public debates about pollution threats to the Chesapeake Bay, especially threats from oil and chemical industries. He had a duty, he believed, a responsibility as lab director to speak up for what science had to say about pollution. "He had tremendous pressure to tone down results and say everything was okay," said one of his faculty members, "and he stuck to the science." It was a duty he never dodged. "Science came first," said another, "and let the chips fall where they may."

When all the chips fell, however, he found himself unpopular with some politicians who believed in payback. A state police detective would be sent to VIMS — he looked like the old TV detective Columbo in a trench coat, said one researcher — and he would spend nine months investigating Hargis and his lab, asking questions, taking notes, and patiently, patiently looking for mistakes.

When a lab director is doing two things at once — building fast and speaking out — it is, perhaps, easy to make mistakes. And Hargis was doing both. "I was ambitious," he said years later. "I wanted to make this place the Woods Hole of the Mid-Atlantic. That was the name of the game."

He wanted to build fast because there were other players in the game — and they had a head start on Hargis. In Maryland, Don Pritchard had been running the Chesapeake Bay Institute (CBI) at Johns Hopkins University since 1949.

And Gene Cronin had been leading the long-established Chesapeake Bay Laboratory (CBL) since 1955. It was a growth era for marine labs, and Hargis was playing catch-up in the race for money and recognition. "We competed," he said. "The question was: 'Who was going to be Mr. Chesapeake Bay?' "

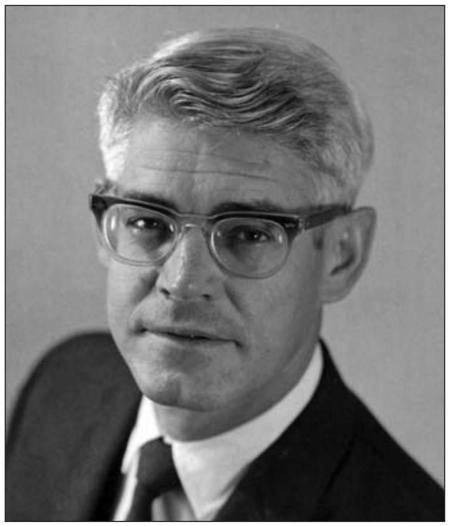
Hargis wasn't just following in the footsteps of Pritchard and Cronin in Maryland; he was trying to surpass their labs. "Bill wanted to build a bigger, better, more impressive organization," said Jerry Schubel, "so his strategies were different." An associate director at Pritchard's lab, Schubel became an expert on lab building, heading up a major lab at New York's Stony Brook University and later leading two of the largest aquariums in the country. What was so different about the Hargis strategy? According to Schubel, Hargis was an entrepreneur.

No longer the patient parasitologist, he turned his directorship into his greatest experiment: a 22-year test of a fast-moving, risk-taking model for building a modern marine lab. To grow his lab quickly, for example, Hargis did all the hiring himself. "There were no such things as search committees," said Don Boesch, a graduate student and faculty member under Hargis and now president of the University of Maryland Center for Environmental Science. A new scientist would just show up at the lab one day, much to the surprise of other lab scientists, none of whom were consulted about new hires. According to Boesch, "Bill was not happy with faculty input."

And an unhappy Hargis could be a forceful presence. Under a shock of hair that went gray early, he had a broad, expressive face, a strong jawline, a deep voice, and a readiness to use the whole package to get what he wanted. He could cajole on occasion, intimidate when he wanted to, and negotiate when he had to.

He didn't do much negotiating with the faculty he hired. They could spend 25 percent of their time doing what they wanted. "The rest of your time is mine," Hargis told them before putting them to work on projects he thought were important to Virginia. "The state's paying your salary," he said, "and that's the way it's going to work."

His was a hiring strategy tied to a funding strategy. He brought on researchers from diverse disciplines, expanding the lab's focus beyond the problems of the state's commercial fisheries. And just as quickly he expanded his search for funding by making himself and his lab well known in Washington, D.C., policy circles. He recognized early on that federal agencies, many of them newly organized, would become major sources for research funding.



***Bill Hargis was a native son,** with a mother from Tangier Island out in the middle of the Chesapeake Bay and a father from the hill country down in the southwest corner of the state. He went to World War II with the Army Air Corps and came home to lead the Virginia Institute of Marine Science where he organized a major hydraulic modeling study of the James River (opposite page).* PHOTOGRAPHS: COURTESY OF THE VIRGINIA INSTITUTE OF MARINE SCIENCE

"He wanted to be a national player," said Boesch, and he succeeded. He became chairman of both the National Advisory Council on Oceans and Atmosphere (NACOA) and the Coastal States Organization (CSO), two big-picture groups that were developing federal policies for managing the country's ocean and coastal resources. In those posts, Hargis lobbied for efforts like a Coastal Zone Management Program, a network of Sea Grant colleges, and a string of estuarine sanctuaries.

With all his travels, Hargis was working a multipronged strategy to benefit VIMS. He tried to shift the federal focus away from traditional "blue-water oceanography," the province of well-established labs and schools. He hoped to win more support for what he called "green-water oceanography," the province of coastal labs like VIMS that focused on the problems and economic potential of estuaries and inshore waters. By the mid-1970s, his lab was landing contracts and grants from a dozen federal agencies. His greatest funding coup was a huge grant from the Bureau of Land Management (BLM) that would pay VIMS to run chemical and oceanographic surveys along the Mid-Atlantic coast.

VIMS was landing big-time funding, but in the Hargis dream, a big-time marine lab also had to have something else: a large, ocean-going research vessel. The famous labs, Woods Hole up in Cape Cod and Scripps out in California, had big boats. According to Boesch, "It is part of the manhood of oceanographic institutions."

With his big-boat obsession, however, the Hargis reach would finally exceed his funding grasp and even endanger his career. To get his ocean-going vessel on the cheap, Hargis made a deal with the U.S. Navy to take over a surplus minesweeper, the *U.S.S. Thrush.* And he made a deal with the state, saying he would not spend much on converting it into a research vessel.

To finish up the conversion cheaply, Hargis had to make yet another deal: a risky barter arrangement with a red-bearded ship's carpenter named Jim Taylor. In exchange for the carpenter's extra unpaid work on the minesweeper, Hargis agreed to let Taylor take home a salvaged boat engine so that he could strip it for spare parts for his own boat. It was a small deal for a piece of surplus junk, said Mo Lynch, a long-time program manager at VIMS. But the deal would nearly prove the undoing of a lab director.

With conversion completed, Hargis

renamed his vessel the *R/V Virginian Sea* and ordered it out on the Atlantic, overriding the worries of scientists concerned about its sea-going safety. "I was told, 'No ifs, ands, or buts!'" said Don Boesch, one of those scientists. "I was going to take this vessel out." Hargis wouldn't brook dissent, and he couldn't afford delay. He needed to start collecting BLM payments for running their coastal surveys.

In his rush to build fast, Hargis was running into a classic problem facing many entrepreneurs: cash flow. To make money he would have to spend money he didn't have yet. Most of those hard-won federal funds could only be collected after all the work was completed, all the reports were filed, and all the budgets closed out. As so many new contracts and grants came flooding in, his financial office soon sank underwater, struggling with slow invoicing, frequent extensions, and reimbursements that were often delayed and sometimes denied. VIMS began finishing many budget years with expenditures outrunning collections.

His solution: take out temporary loans from the state's general funds to cover each year's shortfall. When the state loans came due and federal payments were still uncollected, he would make loan payments by overspending his state accounts. To cover this new deficit, he would turn around and apply for a temporary loan. Then he would repeat the cycle the next year. And the next. According to the state's Joint Legislative and Audit Review Commission (JLARC), he managed to take 11 such loans in one 12-year stretch, a practice that left the lab with a large and growing long-term debt.

While state auditors were noting the Hargis habit of deficit spending, some economic planners and Tidewater politicians were tracking the Hargis history of publicly criticizing popular projects and powerful industries.

As a new director, he challenged a long-standing request by business leaders for a deepwater channel that could bring more ocean ships up the James River to Richmond. In 1962, he spoke at public meetings and wrote critical analyses, arguing that a deeper channel in the James might endanger oyster beds by funneling more high salinity waters over the beds and unleashing more oyster parasites and predators. His questions made him popular with oystermen and won him funding for a hydraulic modeling study, a multi-year project that delayed the channel project into oblivion.

Analyzing sediments, finfish, and oysters *in 1975, VIMS chemist Bob Huggett found evidence that Allied Chemical Corporation had been dumping a pesticide called Kepone into the James River for 10 years. A toxic insecticide that does not degrade easily, Kepone proved carcinogenic and capable of causing neurological and cognitive dysfunctions in humans. The VIMS findings led to a closure of James River fishing waters in 1975, a U.S ban on Kepone use in 1978, and a global ban in 2009.* PHOTOGRAPH: COURTESY OF THE VIRGINIA INSTITUTE OF MARINE SCIENCE

In 1975, however, Hargis upset the entire seafood industry, annoyed a giant chemical company, and embarrassed a state environmental agency — all this during the Kepone debacle, the most notorious episode of toxic pollution in the history of the Chesapeake Bay. The crisis began in Hopewell where the state health department had to shut down Life Sciences Products, a small company producing a pesticide called Kepone in a town called "The Chemical Capital of the South." Kepone killed rats and ants, but it also left workers with tremors, chest pains, enlarged livers, sterility, and neurological disorders. Hargis quickly sent out VIMS researchers led by Bob Huggett, an environmental chemist, and they began finding Kepone in sediments and oysters and finfish in numerous locations along the James River and the lower Bay.

When Hargis announced Huggett's findings, concerns about the safety of Virginia seafood began rising, only to skyrocket when the federal Food and Drug Administration said that Kepone was a carcinogen. By December 1975, Governor Miles Godwin, Jr. was finally forced to halt oystering, commercial fishing, and sportfishing for a 100-mile stretch of river reaching south from Richmond down to the mouth of the Chesapeake Bay.

"We had some very scared people," said Huggett. And some very angry people: as the fears and the fishing closures cut the sales of all Virginia seafood, thousands of watermen went out of business or moved to other rivers. Some of them launched bomb threats and death threats against VIMS researchers, says Huggett. "I slept with a shotgun by the bed."

Hargis made sure somebody would pay a price. He announced that VIMS research had also linked the pollution to Allied Chemical Corporation, the giant firm that first began producing Kepone in 1966 before jobbing the work out to Life Science Products. The link came from Huggett and the oyster samples that he had been taking since 1969 at 10 locations around the Bay. When he checked his early samples, Huggett found Kepone. "It proved," he said, "that Allied was also dumping Kepone into the river."

It also proved that Virginia's State Water Control Board was not doing its job. Investigations revealed that the board had taken no action as Kepone wastes ran through Hopewell's water treatment plant for nearly a decade, causing periodic breakdowns in the plant and steadily contaminating sediments, oysters, and finfish. For oystering, the ban would last 10 months. For most finfish species, it would last 13 years.

Life Science Products, the Allied offspring, went out of business, but Allied Chemical, the original producer, had to settle lawsuits from victims and, in addition, pay a $13.2-million fine. The bulk of the payment, $8.2 million, went to founding the Virginia Environmental Endowment, a grant-making organization still at work addressing environmental issues in the state.

While the Kepone crisis was still hot, Hargis also spoke out against a popular oil industry project. In 1976, the Hampton Roads Energy Company proposed building an oil refinery in Portsmouth near the mouth of the Elizabeth River, a good spot for oil-tanker deliveries. The Elizabeth, however, flows into the mouth of the James River, and the James flows into the mouth of the Bay, ensuring that an oil spill here could have devastating impacts on nearly every key commercial fish species in the lower Bay. Ocean-spawned fish congregate in that area while adjusting to salinity changes, pregnant female blue crabs bury themselves in the nearby mud every winter, and the lower James River holds the oyster seed beds that are so essential to the oyster industry. "If you had to pick a bad spot [for an oil refinery], that was it," said Bob Huggett.

When Hargis came out against the project, he was not alone. The refinery location drew criticism from the seafood industry and from three federal agencies. The opposition from Hargis and his VIMS scientists, however, left Governor Godwin with no support from the state's leading marine lab. "He was not a popular guy with the governor," says Huggett. "That's how he fell out of grace."

His fall was sudden. Shortly after opposing the oil refinery, Bill Hargis found himself facing criminal charges, sitting in the old red-bricked Gloucester courthouse accused of grand larceny. His alleged crime: stealing state property.

A big-time marine lab needed a research fleet, *and Bill Hargis tried cobbling one together with surplus boats from other organizations. His proudest catch was a 144-foot Navy minesweeper (above) that he converted at great cost into a research vessel he called the* R/V Virginian Sea. *His plan: stop paying to rent ocean-going ships and start charging rents for running coastal surveys. The ship never proved an effective research platform, never brought in much money, and nearly cost Hargis his career.* PHOTOGRAPH: COURTESY OF THE VIRGINIA INSTITUTE OF MARINE SCIENCE

It was his dream ship, the minesweeper called the *R/V Virginian Sea*, that was now threatening to sink his career. The detective sent by the state police had poked around VIMS long enough to discover the swap deal that Hargis had made with Jim Taylor, the ship's carpenter. On that evidence the Gloucester County Attorney charged the director of the state's largest marine lab with stealing a state-owned engine.

His trial in September 1976 was, for Hargis, a fall from grace that hurt for a long time. "I knew I wasn't very popular," he said, decades later, "but I didn't think I was unpopular enough to have the state police come down here after me." To prepare for his trial, Hargis took leave from the job he had held for 18 years. "That was," he said, "a lonely time."

He wasn't alone long. Local friends raised money for his legal fund, and Herbert Kelly, a prominent member of the Board of Trustees for the College of William and Mary, stepped forward to defend him. When Kelly questioned the ship's carpenter, Jim Taylor sat on the witness stand, stroking his red beard, and told the jury "the theft" was simply a barter deal he and Hargis had worked out. Hargis sat at the defense table watching the jury and worrying. "You look up there," he said, "and you realize those 12 people can decide whether you live or die professionally."

In the end, however, only one person decided his legal fate. "Where is the crime?" said Judge James B. Wilkinson of Richmond. After listening to the prosecution case, he dismissed the charge, dismissed the jury, and verbally indicted the state police. "It's rather shocking to me," he announced in open court, "that the Virginia State Police have wasted nine months on something like this."

Hargis, according to the news reports, was embraced by his wife and two sobbing daughters, but he showed no emotion and made no comment on the politics behind the investigation and trial. The reporters covering the trial, however, sensed political payback when they saw it, and cited his outspoken stands about Kepone pollution and the oil refinery project in Portsmouth.

The governor was still unhappy with Hargis. After the trial, Miles Godwin, Jr. turned over the state police report, all 243 pages, to the independent Board of Administration that oversaw VIMS and suggested they might want to take action about their lab director. When the board put the report aside and welcomed the lab director back to work, the governor called Hargis in to his office and told him it might be time to make a change.

The big change came in 1979. The independent board was dissolved, and VIMS and Hargis were put under the administration of the College of William and Mary. Two years later Hargis resigned as director. "I got the message from the president that it might be a good idea if I went back to the bench," said Hargis. The message Hargis took away was that the lab would not do well getting state support if he remained director. It was time for the deal maker to become a researcher again. He wasn't going to hold back his lab, he said. "It was my baby."

Why did Bill Hargis lose his position? Political payback or financial problems? Opinions vary, even among his supporters. Many saw politics at play in his trial and his resignation. VIMS researcher Bob Diaz said the trial "was completely trumped up, a move to get rid of him." And Bob Huggett said, "It was payback." According to Mo Lynch, however, Hargis still had support from many legislators, if not from the governor. "It was the financial thing," said Lynch. "It was the red ink that cost him his job."

Did his entrepreneurial model work? In 1959, he took charge of a fishery lab with six scientists and 26 support staff. And by 1981, he was leading a broad-based institute with 71 scientists, more than 400 support staff, and grants and contracts coming in from 24 separate agencies. His little fisheries laboratory had morphed into a large research institute with an active advisory service and with programs in marine culture, pollution studies, wetlands science, and biological, chemical, geological, and physical oceanography.

It would take two decades, but another Virginia governor would finally honor Hargis for leading VIMS through its greatest growth era. In April 2004, Governor Mark Warner signed the bill naming the VIMS library as the William J. Hargis, Jr. Library.

Would his model for leading a lab work today? Perhaps not. "Leadership is not just command," said Boesch, "it is bringing people along." Lab directors are no longer in position to order researchers around, in part because individual scientists bring in much of the funding that supports their salaries and their laboratories. And the authoritarian style so loved by Hargis would no longer work well for recruiting the most creative scientists, the potential rainmakers a laboratory needs to flourish. In the contemporary model, researchers rather than lab directors are the entrepreneurs.

But the Hargis model had its payoffs. In commander mode, he would order his faculty to head out on the Bay and bring back basic data on blue crabs, finfish, wetlands, and seagrasses. And long-term data sets that began on his watch are now seen as essential for tracking the health of the Chesapeake.

In April 2004, Bill Hargis joined Governor Mark Warner *(above) to sign a bill naming the VIMS library as the William J. Hargis, Jr. Library in honor of his work in leading VIMS through its greatest growth era. A number of laurels came to Hargis late in life. In 1997 he received the Mathias Medal from the Virginia and Maryland Sea Grant programs for applying science to public policy. And in 2003 he accepted the Thomas Jefferson Medal and the Virginia Lifetime Achievement Award, both for contributions to science.* PHOTOGRAPH: COURTESY OF THE VIRGINIA INSTITUTE OF MARINE SCIENCE

In the eyes of many who worked with him, Hargis remains a hero, perhaps a flawed one, remembered for his willingness to speak out for science and take the political heat. But in recent decades science leaders have developed a different model for shaping public policy on environmental issues. According to Boesch and Schubel, many science leaders now favor a consensus approach: gather experts and get them to work out the best policy recommendations possible on the basis of present, perhaps incomplete, knowledge. It's a safer model, perhaps, offering cover for individual scientists, and it probably provides advice that is more accurate, more nuanced, and more influential. It's easier to ignore the lone scientist. It's harder to dismiss a whole cadre of experts. Or bring them to court on trumped-up charges.

But here also the Hargis model worked, up to a point. There's been no deepwater ship channel dredged up to Richmond, no repeat of the toxic Kepone catastrophe, no oil spill disaster on the crab-spawning grounds of the lower Bay.

Bill Hargis never learned to keep his mouth shut — after stepping down as director he wrote and spoke out for years about mismanagement of the oyster fishery — but he did learn some lessons. In his last year as director, he finally began cutting the lab's long-running deficit. He sold several vessels and reduced the fleet operations staff from 55 workers to six, one of them part-time.

And he asked the Navy to take back the big boat that he had — at great expense and at great risk — converted into an ocean-going research vessel. The Navy retrieved its minesweeper, and in 1982 it converted his dream ship, the *R/V Virginian Sea*, into scrap metal.

— *fincham@mdsg.umd.edu*

Knauss Fellows from Maryland for 2014

Maryland Sea Grant is sponsoring three dedicated graduate and post-graduate students who recently began Knauss Marine Policy Fellowships for 2014 in the Washington, D.C., area. The program, coordinated by the National Sea Grant Office, places fellows in legislative or executive branch offices in the federal government that work on ocean, coastal, and Great Lakes policy issues.

The three fellows, all of whom studied at the University System of Maryland, will spend one year using their research knowledge and graduate experiences to help the National Oceanic and Atmospheric Administration (NOAA) to develop marine and coastal resources policies and programs.

Tammy Newcomer Johnson is spending her fellowship year in the National Sea Grant Office at NOAA, where she serves as a national resource specialist.

As a doctoral student in the Marine Estuarine Environmental Sciences program at the University of Maryland, College Park, Johnson explores the impacts of urbanization on the ecology and water quality of the Chesapeake Bay. Her research focuses on the capacity for stream restoration and stormwater management projects to reduce excess nitrogen flowing from urban areas to the estuary.

Before beginning graduate school, she worked on a number of research projects through a program called the Baltimore Ecosystem Study. These included efforts to map the occurrence of flash floods in the city. She also served as a fellow at the National Science Foundation and collaborated with students and teachers at the K-12 level to design hands-on environmental science lessons revolving around water, biodiversity, and carbon.

Seth Sykora-Bodie is working at NOAA's Office of Protected Resources, a division charged with conserving the nation's threatened species, including sea turtles, Atlantic sturgeon, and several species of whales.

As the special assistant to the director and deputy director, he helps to coordinate ocean policy between the office and NOAA's National Marine Fisheries Service. As part of a new initiative in collaboration with the Office of Science and Technology, he also works to incorporate planning for climate change into efforts to conserve and manage aquatic species.

Sykora-Bodie is a dual master's degree student in environmental policy and conservation biology at the University of Maryland, College Park. His research originally focused on exploring the best ways for small island nations to prepare for climate impacts, including rising sea levels.

Recently, he turned his attention to conserving marine protected areas — habitats where regulations curtail commercial fishing to give struggling fish populations the chance to recover. He has studied how changing atmospheric and oceanic conditions could harm or help marine species living in these areas.

Emily Tewes is digging into climate change as she works with the Assistant Administrator Climate Goal Board at NOAA.

This group, made up of assistant administrators from different line offices of NOAA, advises the agency's top leaders about issues related to climate change as they develop national policies. The board addresses issues like extreme weather events, how climate affects water resources, building more resilient coasts, and ensuring the sustainability of marine ecosystems.

In 2013, she earned her master's degree from the Marine Estuarine Environmental Sciences program at the University of Maryland, Eastern Shore. There, she studied how offshore wind development might affect organisms living along the ocean's bottom on Maryland's Atlantic coast. She also participated in research studies exploring a wide range of topics, including plant chemical ecology, ornithology, and fisheries science.

The Knauss Fellowship, begun in 1979, is designed to present outstanding graduate students with an opportunity to spend a year working with policy and science experts in the federal government. Fellowships run from February 1 to January 31 and pay a yearly stipend plus an allowance for health insurance, moving, and travel. Applicants must apply through the Sea Grant program in their state. For more information, visit:

- Maryland Sea Grant Program, Knauss Fellowships www.mdsg.umd.edu/education/knauss/
- National Sea Grant Program, Knauss Fellowships www.seagrant.noaa.gov/knauss

— *Daniel Strain*

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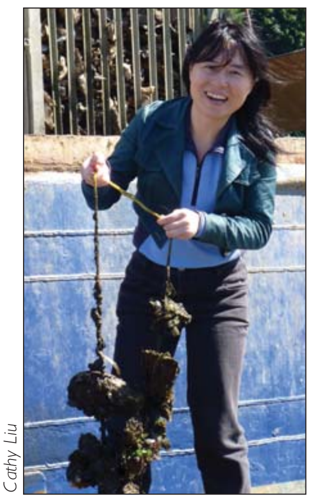
Maryland Sea Grant Extension Welcomes New Seafood Specialist

Food scientist Chengchu (Cathy) Liu has been appointed as the new seafood technology specialist for the Maryland Sea Grant College Program. Liu will provide leadership in outreach service and education for the Maryland seafood industry and consumers. She will help seafood processors to comply with food safety standards and regulations and support the growth of a viable seafood industry in Maryland and the region. Liu succeeds Tom Rippen, who retired in 2013.



Cathy Liu

"We are excited that Dr. Liu has joined our extension program," says Fredrika Moser, director of Maryland Sea Grant. "She brings to this position a strong research background in aquaculture and a passion to connect university expertise with Maryland's seafood industry."

Maryland has long prided itself on its seafood, but the state's seafood industry faces challenges that include increased competition from imported products and declining fisheries. Liu will spearhead a long-running effort by Maryland Sea Grant Extension and its partners to help sustain these economically and historically important local businesses.

Liu was born and raised in China and received a master's degree in food science from the Southwest Agricultural University in Chongqing, China, in 1992. She earned her Ph.D. in food science from Ehime University in Japan in 2000. Liu served as director of the Laboratory of Marine Bioresources Utilization at the Shanghai Ocean University in China from 2004 to 2013. In spring 2013, she came to the United States to work as a visiting professor at the U.S. Food and Drug Administration Gulf Coast Seafood Lab and later at Oregon State University.

Over her long career, Liu has made pioneering advances in limiting the transmission of dangerous *Vibrio* pathogens through shellfish products, a topic relevant to the Chesapeake's seafood industry. These bacteria live in marine environments in the Bay and across the globe and are a leading cause of food-borne illnesses in the United States.

Working with Pacific oysters, a close cousin of bivalves living along the Atlantic coast, Liu co-developed a flash freezing procedure followed by frozen storage that cools oysters to around -140° F and stores them at -4° for five months. The process kills more than 99.97 percent of particular *Vibrio* pathogens growing in the oysters, she says, enough to meet safety requirements set by the FDA. She hopes to apply her research and other food science and technology to ensure the safety of Maryland seafood.

In her new position, Liu will also lead seafood safety training workshops around the Mid-Atlantic to assist seafood processors in implementing the FDA Food Safety Modernization Act and related federal and state regulations. Liu is a certified trainer for Seafood Sanitation Control Procedures and Hazard Analysis and Critical Control Points, or HACCP, which has become a centerpiece of the FDA's seafood safety regulations. The agency expects at least one employee from each processing plant to be trained in HACCP procedures.

Liu says she's excited to apply her research to support coastal communities in Maryland. "Seafood science is an actively applied science," she says. Scientists can do more than just publish academic studies, says Liu. "It's better if your research can achieve economic, environmental, and social benefits."

— *Daniel Strain*