CHESAPEAKE QUARTERLY

MARYLAND SEA GRANT COLLEGE • VOLUME 3, NUMBER 1

Oceanographers on the Bay

A Bay in Motion


SANDY RODGERS

Estuaries are perhaps the most complex of coastal systems. The mixing of streams of fresh and saltwater driven by the flow of rivers and tides is then confounded by wind, the passage of storms, and a submarine topography of deep channels, sills and the abundant shallows that are so critical to life in the Chesapeake Bay. Superimposed onto this Bay in motion are the longer cycles of drought and flood that in the past few years have had such a profound impact. Our heavily populated watershed — a human dominated ecosystem — faces growing urban and suburban development and an evolving agricultural landscape that continues to contribute nutrients and sediments. These stressors have meant an increase in the extent and duration of oxygen depletion (anoxia) in Bay waters during 2003 — as we go to press, the outlook for the coming summer appears to be similar if not worse. To understand what this means, it is important to understand how this Bay works, or in other words, to understand the context — both physically and biologically — within which human impacts and ecological responses play out.

In this issue of *Chesapeake Quarterly*, Michael Fincham tells the story of two scientists whose careers are linked by an academic lineage and a deep commitment to understanding the physical structure of this estuary. Beginning his work in the Bay in the 1940s, Donald Pritchard defined the very fundamentals of how estuarine circulation works — an accomplishment of great importance both here in Chesapeake Bay and to all estuaries worldwide. His student, William Boicourt, has advanced from this foundation to develop a much more detailed picture of the subtle mechanisms and control points that regulate flow and impact biological function. Over the course of two scientific generations, these researchers have helped us to understand how the Bay functions on time scales from days, to seasons to years. Equally as important, both have been willing and active participants in the process to inform policymakers, managers and the public at large — engagement in the best sense of the word.

Jonathan Kramer
Director
Maryland Sea Grant

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Cover photo: *Bill Boicourt, in front of the* R.V. Cape Henlopen, *before a research cruise.* **Opposite page:** *Boicourt and research assistant Tom Wazniak lower a ScanFish into the water where it will undulate through the Bay, measuring temperature, salinity, dissolved oxygen, chlorophyll and plankton.* *PHOTOGRAPHS BY MICHAEL W. FINCHAM.*

Betting on Big Science

BY MICHAEL W. FINCHAM

It will be nearly midnight when they finally throw the ScanFish off the boat.

Standing on the stern of a research vessel as it pulls slowly out to sea, Bill Boicourt can see a string of lights receding behind him. They mark the bridges that stretch like bright ropes laid across the southern gateway into the Chesapeake Bay. The oceanographer is back out on the ocean again, at least for a little while.

> ***There is a weather under the Bay, it seems, and it features some of the same events we watch on the evening newscast, including storms, cyclones, high-pressure systems, low-pressure systems and fronts of all kinds.***

Tall, athletic and highly verbal, Boicourt has some salt in his hair and thirty years of research trips on his resume. He's out on the back deck, the working end of the *R.V. Cape Henlopen*, getting ready to launch his favorite research tool — a sleek yellow wing, chopped bluntly at the outer tips and called, logically enough, a ScanFish. It's a high-tech metal and fiberglass fish, crammed with sensing gear, but this fish can't swim on its own. Boicourt's plan is to drop the ScanFish out here in the ocean, then tow it back into the estuary and haul it northwards for nearly 200 miles, all the way up through the heart of the Chesapeake.

But for now the *Henlopen* is in a holding pattern, waiting for an incoming ship to clear through one of two deep-water channels, the main runways that big ships use on their approach into the Chesapeake. Operated by the University of Delaware, the *Henlopen* is 120 feet long, a good size for a coastal research vessel, but a small fish in these waters.

Up on the darkened bridge Captain Jimmy Warrington is using radar and binoculars to track everything that's moving out on this coastal crossroads. Off to the south, he can see a huge warship riding at anchor, its black mass blotting out the shoreline beyond. Out to the east where the blackness stretches towards Europe, all he can see of the incoming ship is a dim running light. It could be a tanker, bulk carrier or container ship, but at this distance, its light is barely visible and barely moving. Since it's early April, Warrington also has to watch out for North Atlantic right whales, big fish that sometimes cruise these waters.

Out here along the Continental Shelf is where Boicourt did his thesis work as a graduate student, but he's spent much of his career working the inside waters of the Chesapeake Bay. He's a physical oceanographer, a species of oceanographer that focuses on water masses and their motions.

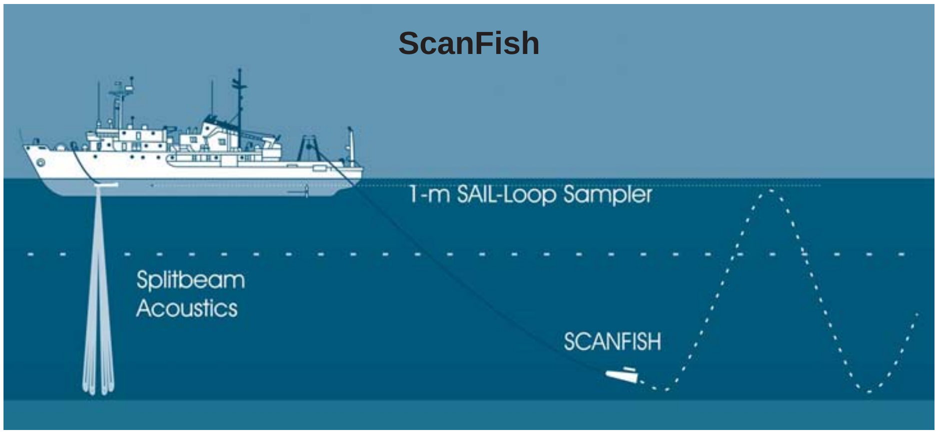
It's a branch of science that's closer to physics than to marine biology or ecology, but its closest cousin is meteorology. "We are sort of the meteorologists of the ocean," says Boicourt, now a professor at the Horn Point Laboratory of the University of the Maryland Center for Environmental Science (UMCES). "We are trained a lot of times in the same institutions by the same professors as meteorologists. We're both dealing with fluids on large scales, what we call geophysical scales."

Meteorologists deal with the fluids of air, oceanographers with the fluids of water. "There are differences: water is heavier than air," he says, "but the basic math and the ways we go about looking at things are remarkably similar."

There is a weather under the ocean and the Bay, it seems, and it features some of the same events we watch on the evening newscast, including storms, cyclones, high-pressure systems, low pressure systems, and fronts of all kinds, some of them stationary, some mobile, some quite ephemeral. In the Bay there are also two slow-moving jet streams: river water heading south and seawater moving north. Just like weather fronts in the sky, these masses of water create structures and forces in the Bay. They're not as easy to see as clouds or rain or wind, but they affect nearly every life form found in the estuary.

As the incoming ship clears through, Boicourt and the deck crew go to work. A crew member operates the port-side A-frame, hoisting the ScanFish off the deck. Grabbing the lift rope, Boicourt strains backward to keep the device from swinging too fast out over the side. At 300 pounds, the ScanFish is an easy lift for the A-frame, but if it swings out too fast, it can pendulum back, smashing an oceanographer.

The ScanFish plunks lightly on the water, then floats quietly — too quietly. "We need to speed it up a little bit," Boicourt calls out. "It's caught at the surface." The ship's technician keeps working the winch controls, paying out cable. As the boat picks up speed, the ScanFish burbles along, then starts a slow dive into dark water.



BILL BOICOURT

One of a new generation *of data-gathering tools, ScanFish enables scientists to collect large amounts of information in a fraction of the time. Before this new technology a typical Bay transect would take one hour and provide about 30 measurements. The ScanFish, in an undulating transect, can provide measurements of multiple factors every two feet, up to 90,000 an hour.*

The ScanFish will be dragged through the Bay for the next 30 hours, zigzagging up and down, its sensors hauling in an ocean of data, over 90,000 data points an hour on salinity, dissolved oxygen, chlorophyll and plankton. It's just one of the sophisticated — and expensive — instruments that Boicourt and his research team have introduced into estuarine oceanography.

In 1989 they created the Chesapeake Bay Observing System (CBOS), a network of two to seven buoys that can constantly measure and instantly communicate data about a suite of water and weather conditions. For those who study the physics of water masses, the sensors in the ScanFish and in the moored buoys in the Observing System have created a quantum leap in high-resolution data gathering.

But it's an expensive leap. A ScanFish, fully outfitted, costs about $200,000. A research vessel to tow it goes for $7,000 a day. A single CBOS buoy, with all its sensors and electronics, can carry a price tag of $100,000. In terms of dollars per data point, these devices are a bargain, and they add up to small change compared to the costs of deep-ocean technology. But in the tidal waters of estuarine research, this is big dollar science.

Will there be a payoff from these huge streams of data that oceanographers are now hauling in? This is the bet riding on that high-cost technology that Boicourt just offloaded into the midnight waters of the Continental Shelf.

Up on the ship's bridge, the crew has already changed shifts. The captain has been relieved by Mike Popovich, the young first mate who gets "the dog watch" from 11:30 until 5:30 a.m. when the galley opens for breakfast. Down in the science lab, Boicourt checks the computers monitoring the ScanFish, then clambers back to his bunk down on the third level. When he wakes up for his own 4 a.m. watch, the oceanographer will be back in the Chesapeake Bay.

* * *

The first professional oceanographer to work the Chesapeake arrived here over 50 years ago, shortly after World War II, and within a decade made the decisive discovery that changed the history of science on the Bay.

First trained as a meteorological cadet, Don Pritchard had been one of a select group of Army soldiers sent to the Scripps Oceanographic Institution to learn new techniques for forecasting sea conditions for amphibious landings. Shortly after D-Day, he landed on Omaha Beach to head the sea swell forecasting team for the Normandy invasion.

For six months he and his partner, Robert Reid, worked up daily forecasts for weather, wave conditions and tides, enabling the Allies to keep offloading troops, tanks and artillery across the beaches. Unloading on the beaches worked, enabling the Allies to head inland in force while the Germans kept thousands of troops tied up waiting to defend the port cities of Northern France. Don Pritchard found himself at the hinge of history. He was 22 years old.

After the war he returned to Scripps, recruited by Harald Sverdrup, the famous Norwegian oceanographer who was creating the first full-scale graduate program in oceanography in America. Sverdrup's students, some called them “apostles,” would find a hot job market when they finished, and they would form the core of the first great generation of American oceanographers. Even before he completed his Ph.D., Don Pritchard was hired by Johns Hopkins University to head up a newly created Chesapeake Bay Institute. He was now 27 years old.

His hiring was the result of an unusual agreement among two marine labs and the United States Navy. When Reginald Truitt, head of Maryland's Chesapeake Biological Lab, wanted to recruit a scientist to study the Bay's hydrology, he went to the Office of Naval Research, and he brought with him Nelson Marshall, the head of the Virginia Institute of Fisheries. They found the Navy eager to maintain America's new edge in ocean science and willing to put up funds for a new Chesapeake Bay Institute.

The funds came with two conditions: The two state-run labs would have to help fund the new facility, but the new Institute would operate independently of them. Truitt and Marshall agreed to ante up $30,000 each, a sizeable sum from each lab's budget, and the Navy matched them with another $30,000. That was a lot of money in 1949. With $90,000 Pritchard would have enough to set up a lab, buy some boats, hire scientists and technicians, and launch the most ambitious research yet attempted on the Bay.

Truitt and Marshall, in turn, had their own conditions. The new Institute would focus mainly on the physics of the Bay, with some chemistry and geology thrown in. It would not compete with the Maryland and Virginia labs in biology and fisheries science. After all, both directors ran their labs largely with funds directed at research on the Bay's highly profitable and heavily harvested commercial fisheries for oysters, blue crabs and striped bass. As Pritchard later explained the deal, “The original conception was: you needed someone working on the *whole* Bay, not just on the two halves, someone who would look at *how* the Bay functions, not necessarily the living resources in it.”

Pritchard compiled a long-term record that suggested anoxia and hypoxia were occasional but recurring events, especially during late spring and summer.

By putting that much money on the table, Truitt and Marshall were rolling the dice, making an early big-time bet on oceanography. And on a young war veteran who was now expected to produce major discoveries, plus a payoff for all those biologists studying oysters and blue crabs.

* * *

Bill Boicourt begins his day on the *R. V. Henlopen* with a bet of his own, a small bet about oxygen levels in the Bay.

By the time he scrambles out of his bunk for his 4:00 a.m. watch, the *Henlopen* has re-entered the Bay, taken a right turn and headed north, towing the ScanFish through the dredged-out deeps of the York Spit channel, then through the natural deeps of the Virginian Sea Trench.

Entering the science lab, he sits down in front of three computer screens, sips on his coffee and checks on the data streaming up from the ScanFish. “We ought to make a bet, a best guess about what the oxygen depletion is just below the Bay Bridge,” he says to Xinsheng Zhang, the scientist who is going off watch. “Let's see who's right.”

The Bay Bridge, near Annapolis, is still more than 100 miles north, and nearly 20 hours away, but Boicourt, awake and wired with coffee, is pushing for predictions. “I want your best guess, Xinsheng.” Down here along the Virginia Sea Trench, waters at depth are fairly well oxygenated with dissolved oxygen running around 5 milligrams per liter. That's a touch low for this time of year, Boicourt notes, but still healthy for fish life. Waters falling below 4 milligrams, on the other hand, are labeled hypoxic (for low oxygen). Below 2 milligrams, they are labeled anoxic (for no oxygen) and unable to support life, except for anaerobic bacteria.

Don Pritchard observed levels of anoxia back in 1949, the first year he took samples on the Bay. Over the next 20 years he compiled a long-term record that suggested anoxia and hypoxia were occasional but recurring events, especially during late spring and summer. When spring rains and runoff bring high inputs of sewage, fertilizer and animal waste, all these nutrients overfertilize the Bay's waters, producing blooms of algae and phytoplankton. When those plankton die, they sink to the sediments where they cause another kind of bloom: a population explosion among bottom-dwelling bacteria. As they feed on and decompose dead plankton, these bacteria suck oxygen out of the water.

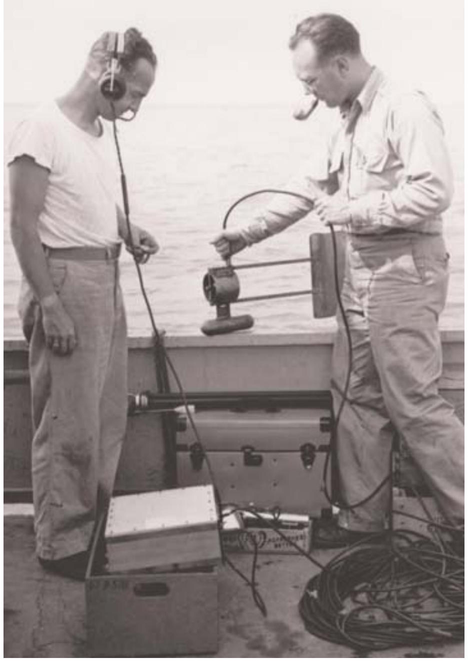
Pritchard's oceanographers also worked out the physics that helped create these events. They identified a boundary called the pycnocline that can block the normal mixing of bottom waters with oxygen-rich surface waters. When a strong pycnocline develops, the result is extreme stratification with little or no mixing. Anoxic waters remain capped in a “dead zone” along the bottom. Fish kills and crab kills usually follow.

Boicourt and Zhang aren't the only contemporary scientists watching dissolved oxygen. Anoxic episodes are now public events, stirring up debates among scientists and launching news releases from environmentalists. State agencies in Maryland and Virginia track oxygen closely, considering it one of the key indicators of general ecosystem health. The Environmental Protection Agency's (EPA) Chesapeake Bay Program has set a Bay-wide average of 5 milligrams per liter as the goal for the restoration effort.

A numerical modeler working on plankton populations, Zhang finally settles on a guess of 4.0 for oxygen at the Bay Bridge before heading off for his bunk. Boicourt's bet is more precise and less optimistic: He picks 3.43. He's predicting the waters at the Bay Bridge — even this early in April — will already be hypoxic.

* * *

The pipe smoking Don Pritchard *got his introduction to oceanography working out sea swell forecasts for the Normandy Invasion of World War II. The first oceanographer to study the physics of the Chesapeake Bay, he discoverd the two-layer flow pattern that underles water circulation throughout the Bay.*



DON PRITCHARD

The key discoveries came early for Don Pritchard. In 1950 and 1951, the young oceanographer and his new staff motored down to the southern Bay in their research vessel, a converted yacht called the *Joanbar*, and mounted a series of now-famous research expeditions along the James River in Virginia. They brought with them a collection of new tools, some adapted from deep-water oceanography, some created *de novo* back in their workshop.

At station after station, they took current, temperature and salinity measurements at multiple depths. The surface water, they found, was river water moving seaward. And down below the fresh water they found seawater sliding in the opposite direction. Colder, saltier, denser, the seawater was flowing up river.

After the measurements came the mathematics. From all his data points, so painstakingly acquired, Pritchard worked out the basic equations of motion that described the circulation of the James River, then scaled his equations to explain the estuarine circulation for the entire Chesapeake Bay. He quickly published a seminal monograph on "Estuarine Hydrography" that revolutionized thinking about the Chesapeake and estuaries around the world.

It was a fundamental paradigm, a turning point for Bay science, according to M. Gordon "Reds" Wolman of Johns Hopkins University. "In terms of understanding how the Bay works," he said, "Don Pritchard's physical model was absolutely essential." It changed thinking about the Bay more than any other single piece of research, according to Gene Cronin, the man who followed Reginald Truitt as a long-time director of the Chesapeake Biological Laboratory.

What Pritchard had described accurately for the first time was the basic two-layer flow that dominates water movement throughout the tidal Chesapeake and its tributaries. It's a steady-state model, the idealized underlying pattern for a system that never stays stable long. Complicating the interplay between fresh water and salty water are forces like winds, tides, river discharges, the topography of the Bay and the rotation of the earth.

Figuring out the physics of all these forces would keep Pritchard busy for decades and leave plenty of work for the oceanographers who followed him. Out of that early model they would derive an assemblage of estuarine features ranging from turbidity maxima to plume fronts, upwelling fronts, lee waves, eddies, vertical mixing, stratification and anoxic zones.

Betting on Pritchard had paid off, not just for the state labs that put up the money, but for all those fishery biologists studying the Bay. They could start to work now on figuring out how that two-layer flow was responsible for moving around and mixing nutrients and plankton and early-stage larvae for blue crabs and oysters and finfish.

As first in the field, the young oceanographer had nailed the essential physical feature of nearly all estuaries.

And set the paradigm that would keep oceanographers busy in the Chesapeake for the rest of the century.

* * *

As the *Henlopen* motors north through the night, Boicourt stands his watch sitting on a stool and eyeballing three separate computer screens that track the ScanFish's progress up the Bay. Out in the black water behind the stern, the flying wing alternately climbs towards the surface, then noses over into a steep dive. Water is forced through tubes that can instantly measure temperature, salinity, oxygen and fluorescence, an indicator for algae and their oxygen-creating chlorophyll. The student is getting to play with instruments his mentor never had.

Boicourt first heard of Don Pritchard when he was a senior at Amherst weighing his options. The physics major got a call from the oceanographer asking him if he was coming to Johns Hopkins University for graduate school. "I had no idea who he was," says Boicourt, but he knew Hopkins had great lacrosse teams and he knew he didn't want to be a laboratory physicist. "I had this image of a physicist in a white lab coat and glasses and a pocket protector," he says. "And I didn't want to be in a lab." No place for a lacrosse player, better the back deck of a research vessel out on the Continental Shelf at midnight. Oceanography sounded like something that would keep him out of the office. With Pritchard on the phone, he chose a career. "Okay," said Boicourt. "I'll come."

Trained in Pritchard's model of estuarine dynamics, he soon began exploiting new field techniques and collecting data that challenged some of its key concepts. Lucky enough to start graduate work during an era of steady funding from the Navy, Boicourt worked with a scientific and technical team that was designing and testing new devices for measuring ocean flow, including current meters that could be moored in place to collect long-term data. While still a graduate student, Boicourt headed up the first Hopkins expedition to try anchoring current meters out on the Continental Shelf. That experiment deployed meters 20 miles out from the mouth of the Bay. Later missions — after a lot of trial and error and advice — would put buoys 100 miles out.

It was Boicourt's long-term data from these off-shore and in-bay current meters that threatened to disrupt Pritchard's classic model of estuarine circulation. Instead of a slow-moving, two-layer flow, Boicourt reported tremendous variability in water flows — the result of wind power on water movement. In the country's largest estuary, there's plenty of space for the wind to crank up, building waves and shoving water up or down the Bay. Wind motions and tidal surges can nearly bury any signal of an underlying pattern. "Here I come with long-term current measurements," says Boicourt, "And sure enough I can't see the steady two-layer flow very easily because of all this wild wind motion."

The wind effect was clear to anyone who saw Hurricane Isabel push Bay waters far up the streets of Annapolis and Baltimore last year. It was clear to Pritchard also. From his surf forecasting work on the beaches of the Normandy Invasion, he knew that wind could move water quickly, but the mentor never had the tools or the long-term measurements that his students later had.

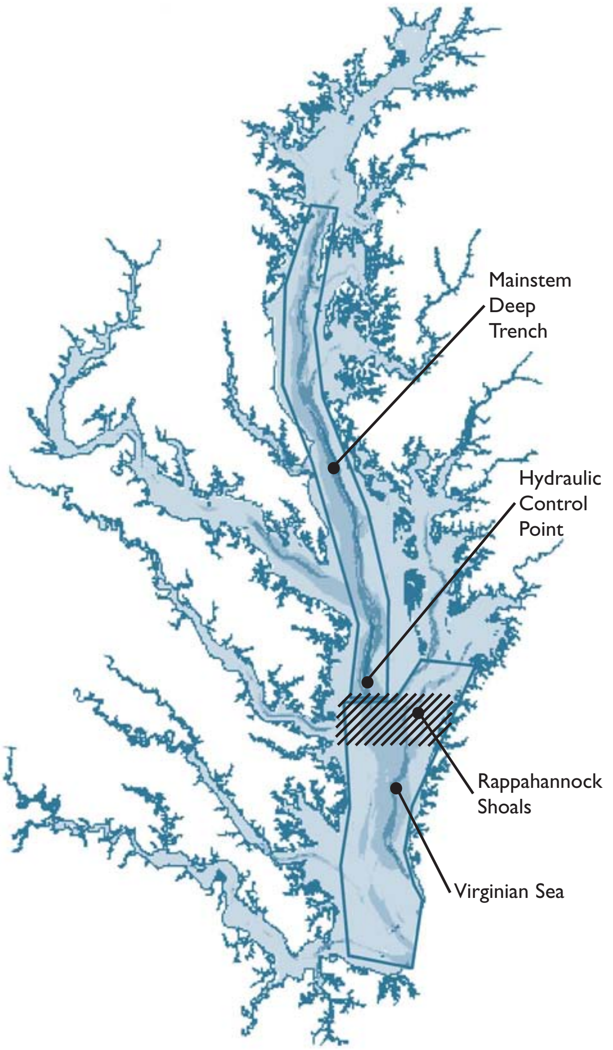
Out of Boicourt's pioneering work,

The Geography Below the Bay

The Chesapeake is known as a shallow estuary *(average depth 18 feet), but there are valleys and ridges and plateaus running along its bottom. The bathymetry of the Bay plays a big role, not only in ship navigation, but in circulation patterns that affect food chains, fish migrations and levels of dissolved oxygen.*

The Deep Trench (90 to 160 feet) stretches from the Bay Bridge south through the mainstem. It follows the paleochannel for the Susquehanna River that ran through here during the last Ice Age. The Trench ends in an abrupt rise at the Rappahannock Shoals (38 to 44 feet), creating a Hydraulic Control Point where south-flowing surface water has to squeeze past salty, north-flowing bottom water.

Below the Shoals, the bottom drops again, but not as deeply, into the Virginian Sea, a wide swath of water that includes a trench nearly 70 feet deep and a hole nearly 150 feet deep.



MAP SOURCE: EPA REGION III.

both offshore and in the Bay, came a whole line of research on the way wind can alter the estuarine circulation pattern. It's a classic example of how science often progresses: from mentor to student, from simple to complex. A paradigm is established, then challenged. New data from new tools gradually expand and complicate and occasionally replace the old model.

At the Chesapeake Bay Institute one group of oceanographers was constantly challenging Pritchard, sometimes to his annoyance, pointing to their new data on winds and currents and the forcing functions of distant water. "It is just natural of young people to say: 'Oh, this is wrong, I want to throw over the paradigm,' " says Boicourt.

For the "Young Turks," as Boicourt calls them, it was a case, perhaps, of paradigm envy. Pritchard had been first in the field — he had "the open slate," as Boicourt puts it — and no amount of new data could overturn or erase his basic discovery. "Has there been as fundamental a change in our understanding of estuaries since Pritchard's two-layer flow?" asks Boicourt before answering his own question: "No. That is a fundamental process. And we still have trouble working out all the physics about it."

The end result was paradigm enrichment. A second generation of oceanographers began building models to account for wind forces and other sources of variability in Pritchard's basic two-layer flow. "It is not totally fair to describe what we do as a mop-up operation," says Boicourt. "But in some sense it has been — scientifically."

Pritchard, late in his life, often admitted that his discoveries came from being first in the Bay, but he also said he would like to start over with the tools that were available now. The mentor, it seems, was capable of instrument envy.

And with good reason: devices like the ScanFish and the Chesapeake Bay Observing System would lead to discoveries barely dreamt of in his paradigm.

One of those discoveries lies just north of the Rappahannock River where

The Hydraulics of a Hot Spot

Why is the Bay so productive? A new hypothesis about the physics of underwater systems may help answer this question.

The Hydraulic Control Point is a kind of sluice gate in the middle of the Bay that regulates the flow of incoming ocean water. Its discovery came as a surprise, especially for Bill Boicourt, and illustrates the interplay between two kinds of oceanographers: ocean (or Bay) observers and mathematical modelers.

As a physical oceanographer, Boicourt is primarily an observationalist, specializing in testing and developing data-gathering equipment and working out techniques for deploying them out on the water. He knew there were structural features like Hydraulic Control Points in the fjords of Norway where glacial moraines form high sills, separating seawater from fresh water. He also knew nobody had ever found one in the middle of a partially mixed estuary like the Chesapeake.

This new discovery began with the work of Shenn-Yu Chao, a numerical oceanographer who tests and develops mathematical models, working with the kind of data that Boicourt and other field workers have collected over the years. While developing a general model of hydraulic controls in estuaries, Chao looked at old data left over from Tropical Storm Agnes, a major flood event that hit the Bay in 1972. In the old data he saw a rapid decline in saltwater coming up the Bay during and after the runoff flooding. He suggested a Hydraulic Control was active in the Chesapeake.

The location, according to his analysis, should be right at the juncture where the Deep Trench meets the Rappahannock Shoals. The Trench is the old paleochannel that runs straight down the mainstem, stopping abruptly at the Shoals, a wide band of built-up bottom south of the Potomac River. This coupling of a ridge with a drop-off creates a sill similar to those in the fjords of Norway.

Chao works down the hall from Boicourt at the Horn Point Laboratory of the University of Maryland Center for Environmental Science, but that didn't make it any easier for a boat-deck researcher like Boicourt to believe a numerical modeler. "This is embarrassing. I sure didn't see it," he admits. But the ScanFish did, sucking up data points by the billions on a series of tows that crisscrossed the Shoals and Trench in 1999 and 2000. "Lucky we had the ScanFish," he says, "because you need the resolution there to pick this up." If he had made a bet about these findings, Boicourt would have lost — and lost big. "It turns out," he says, "the Hydraulic Control is much more important than even he (Chao) thought."

Here's roughly how the Hydraulic Control works. Incoming ocean water, dense and cold and salty, surges slowly north along the bottom of the Bay while outgoing river water, light and warm and fresh, slides south along the surface. Separating them is a boundary called the pycnocline. Ocean and river water both move with a net average speed of around six miles a day. Twice daily their progress speeds up and slows down with the tidal cycle.

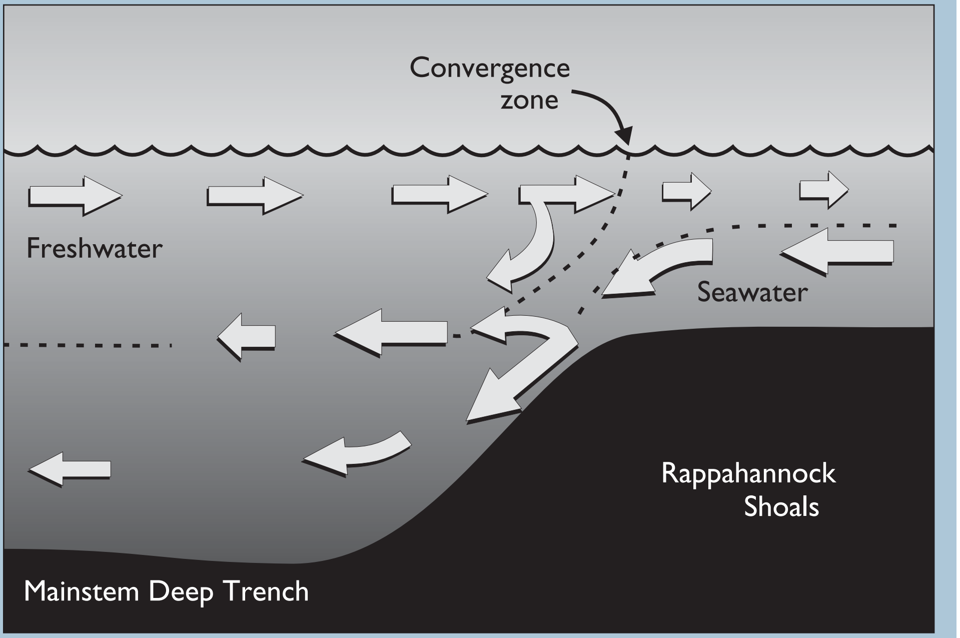
That's the steady-state model of estuarine circulation, according to the physicists, but steady states never last for long on the Bay. At the Shoals, these two streams suddenly have to squeeze through a narrow slot or sluice gate. Under unsteady states — say heavy winds or river runoffs — all kinds of collisions occur. And the physics gets complicated.

Consider scenarios like spring runoff, wind storms or tropical storms: Strong flows of outgoing river water rush down the mainstem, overwhelming ocean water at the Shoals and pushing down on the pycnocline. The result is like turning a valve: ocean water is slowed to a trickle, robbing the upper Bay of saltwater and zooplankton, fish larvae and oxygen.

The valve can be turned on, often fairly suddenly. Wind patterns will blow surface water away from the sill, lifting the pycnocline, releasing all that backed-up bottom water, unleashing unseen waterfalls well below the surface of the Bay. Ocean water will come flooding over the sill and down into the Deep Trench. A batch of high salinity water will ferry plankton and fish larvae and oxygen into the upper Bay. "You'll sometimes get two weeks of strong pulsing flow," says Boicourt. "And then it'll shut down again."

Along the Hydraulic Control, physics amplifies biology. Water masses are driving against each other, creating density fronts and downwellings that collect nutrients and plankton and fish larvae. These convergence zones can become biological "hot spots."

Hot spots like this are now the cornerstone for a new hypothesis about the persistent productivity of the Chesapeake Bay. The research question: Why such an abundance? "You get more fish than you would predict, given the amount of plant production," explains Mike Roman, a zooplankton ecologist and Director of the Horn Point Laboratory. The proposed explanation: Because the physics of the system creates so many front-like features that collect algae and plankton and fish larvae, setting up "chow lines" for foraging fish at key sites around the Bay.



BILL BOICOURT

***The Hydraulic Control Point** in one of its phases. The Rappahannock Shoals create a narrow sluice gate where two streams of water try to squeeze past each other. In this example, south-flowing surface water rubs up against salty, north-flowing ocean water, creating density fronts that collect nutrients, algae, plankton and fish larvae. These convergence zones can turn into biological "hot spots" where food, prey and predator are all crowded together in small, productive ecosystems. The collision of salt and fresh can also split off a stream of surface water (as shown above), driving it down to mid-level and causing a reverse flow that carries warm, well-oxygenated water back up the Bay.*

These chow lines, says Roman, are sometimes visible. A foam line marks the boundary where water masses collide. Fish come schooling in to feed on plankton. Birds come wheeling over to dive on the fish. Fishermen in boats arrive soon after.

Scientists have also been accumulating along these hot spots. Oceanographers and biologists and plankton ecologists teamed up for numerous sampling runs as part of a long-term study called TIES, their acronym for Trophic Interactions in Estuarine Systems. With funding from the National Science Foundation, scientists at the Horn Point Laboratory worked together with colleagues from the Chesapeake Biological Laboratory, the University of Delaware, Old Dominion University and NOAA's Great Lakes Environmental Research Laboratory. On two dozen cruises, they crisscrossed these chow lines in a sampling frenzy, deploying a number of new tools like the ScanFish as well as old tools like plankton nets and fish trawls.

All this fieldwork dredged up abundant data about all levels of the food web — and provocative evidence for the productivity hypothesis. "In one trip with the ScanFish, I collected more data than I had in 20 years," says Roman, and when he looked at it a clear pattern leaped out. "We analyzed six years of data," he says, "and some areas light up every single time. There are regular [hot] spots of higher zooplankton — and the fish have evolved to swim and find them out."

Now that science has evolved to find these hot spots, the productivity of the Bay is turning out to be quite "patchy." Twenty percent of the Bay's waters, Roman estimates, may hold 36 percent of the zooplankton.

Where are these hot patches? North of the Chesapeake Bay Bridge — way north in a dry year — is the Estuarine Turbidity Maximum, a mixing zone where the front of the salt wedge meets freshwater river flow from the Susquehanna. Wherever a major river empties into the mainstem, rich river plumes are formed. Below Smith Point, south of the Potomac, is the on-again, off-again Hydraulic Control Point. Down near the mouth of the Bay, is the Cyclonic Eddy, just inside the southern end of the Eastern Shore peninsula.

You can't find these patches on boating charts of the Bay, not yet. They are not as striking or evocative as the Bay's famous bridges and lighthouses and coves and creeks. But they are starting to show up on most research maps, famous now as the key places where the Bay's unique physics drives its bountiful biology.

a great hump of sand sprawls across the bottom of Virginia's Bay, blocking deep-water passage northwards.

* * *

Shortly after 5:00 a.m., with the *Henlopen* at the upper edge of the Virginian Sea Trench, First Mate Popovich turns sharply northwest, steering into a dredged-out shipping channel that slices straight as a drainage ditch through an uprising shallows known as the Rappahannock Shoals.

By now there's a pale light leaking onto the bridge. Meteorologists call it Nautical Twilight, the whisper of light that precedes pre-dawn light. Down in the science lab, Boicourt can glimpse it through a porthole, in between checking the data stream coming up from the ScanFish. To an oceanographer these Rappahannock Shoals are more than a speed bump on the shipping route to Baltimore. They can affect the physics of water masses, much like the Rocky Mountains can affect the physics of air masses heading east across the continent.

It's well past dawn when the *Henlopen* approaches the northern edge of the Rappahannock Shoals, but Boicourt is still inside. Standing in front of two flat panels mounted high on the cabin wall, he checks the ship's course and speed across the bottom, then points down at a spread-out nautical chart. "We're coming up to a big drop off," he says, walking over to the winch control to play out more cable. He's going to send the ScanFish down into one of the deepest natural troughs in the Bay.

Here where the Shoals end, the Deep Trench begins. Stretching north towards Annapolis, it's the paleochannel for the old Susquehanna River that ran through here during the last Ice Age. From average depths of 40 to 45 feet over the Shoals, the Bay suddenly plunges into a Trench with depths of 100 to 160 feet. At this junction of Shoals and Trench, oceanographers have discovered a turbulent and unexpected feature of the Bay's bathymetry. It's called the Hydraulic Control Point. Created by the physics of wind and water and friction, it plays a major role in the biology of the upper Bay.

At the Shoals, two streams of Bay water — each heading in an opposite direction — have to squeeze through one narrow slot. As ocean water, cold and salty, surges north along the bottom, it has to push gradually over a wide, uprising ridge. River water flowing south, on the other hand, is running through the long Deep Trench. It faces a steeper rise and sharper funneling.

Collisions can occur — caused by winds or rain or runoff or a dozen other scenarios. Stronger flows of south-running river water can pile up at the northern edge of the Shoals, creating a tight squeeze for incoming ocean water. River water can occasionally push down on the pycnocline to the point where ocean water is literally cut off at the pass. The physics of these collisions control the hydraulics of the upper Bay.

Think of a sluice gate, says Boicourt, or an internal valve that can slow down the flow of deep ocean water into the upper Bay for weeks on end. Ocean water, of course, comes in bearing gifts like plankton, fish larvae and crab larvae and an abundance of oxygen. When the valve is shut, all this rich, salty water backs up behind the shoals, starving the upper Bay.

The same forces that shut the valve — the physics of wind and water and topography — can suddenly turn the spigot back on again. Wind can change this structure fairly suddenly, holding back the surface water, releasing the pycnocline upwards — and opening the valve at the Hydraulic Control Point.

The result is a chain reaction — starting with an unseen waterfall unleashed below the surface of the Bay. "This blast of high salinity water will go over these falls, these internal falls, into the deep part of the Bay," explains Boicourt. "That change, that transition, has a profound influence on the exchange of salt and fish and phytoplankton and nutrients." A burst of high salinity water will slide northwards at a speed of 10 miles a day, carrying plankton and fish larvae and

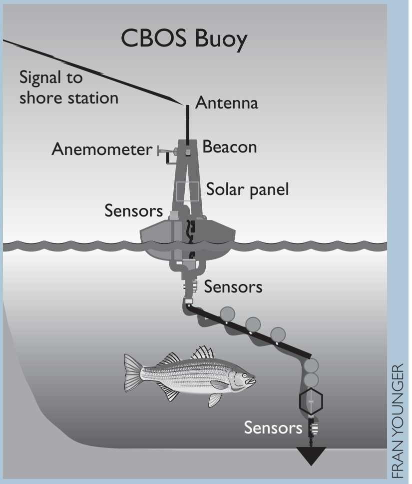
Predicting Underwater Weather

There's a weather under the Bay, complete with high-pressure systems, low-pressure systems, several kinds of fronts and two kinds of slow-moving jet streams. Think of physical oceanographers as meteorologists of this underwater world. As they figure out the physics that controls the system, they should be able to predict the underwater weather more accurately — and take a lot of guesswork out of the forecasting game that so many people have to play.

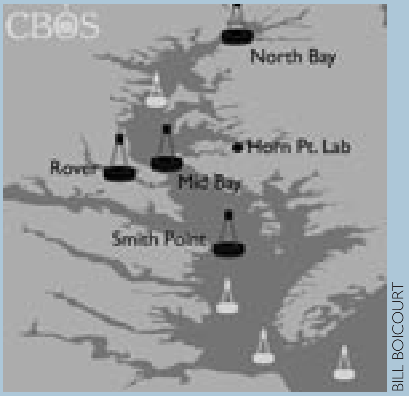
Those were the selling points when Chesapeake Bay Observing System (CBOS) began — better physics and better forecasting. Over the last 15 years, Bill Boicourt has kept the system running despite hurricanes, lightning strikes, icy winters, vandalism and up-and-down funding cycles. Funding so far has come from more than three dozen sources. That's a lot of grant writing, but it has allowed Boicourt to keep buying new buoys, rebuilding old ones and restocking them with the latest in advanced sensing gear. In years of good funding he's had seven buoys taking data simultaneously.

Physics and forecasting, according to Boicourt, are still the selling points for CBOS-like systems expanded to cover the entire Bay and the Mid-Atlantic coastal waters. CBOS may soon morph into a newer, larger network of buoys and land-relay towers, capable of relaying even more real-time data about the weather above and below the Bay. The results could boost Chesapeake Bay science and help protect the Maryland economy.

If the future arrives according to Boicourt's forecast, CBOS could evolve into a cooperative regional system with more stable funding and more partners from academe, state and federal government, and private corporations. Players could include the Virginia Institute of Marine Science (VIMS), Old Dominion University, the Environmental Protection Agency, NOAA's National Ocean Service, the U.S. Navy, the U.S. Coast Guard, the Alliance for Coastal Technologies, and state agencies in Maryland and Virginia. The result would be a cooperative system, perhaps with a new name, that would provide real-time weather and water data from the head of the Bay all the way out onto the Continental Shelf.



FRAN YOUNGER



BILL BOICOURT

Like a band of robots, *CBOS buoys stand watch over the Bay. Some stay on station year after year, like the one off the Choptank River. Others come and go, moved to monitor a particular area, or pulled for fear of ice. Shown on the map are a string of buoys, some on station and some still proposed, waiting for the region's next investment in remote sensing.*

There are even larger plans afloat. Congress is now considering a proposal for funding and expanding systems like CBOS and linking them together into a larger coastal network. That could mean more money and more acronyms. CBOS might be renamed and linked into something called IOOS (Integrated Ocean Observing System) or C-GOOS (Coastal Global Ocean Observing Systems), both of which would be part of an overall system called GOOS. Those plans drew a major endorsement last week in the Preliminary Report of the U.S. Commission on Ocean Policy.

The science prize is long-term data that oceanographers can use for figuring out the physics of the Bay and other coastal systems in greater detail. Better forecasts are also in those details, especially details about water temperatures, winds on the Bay, waves and currents that result from those winds.

The practical prizes are real-time products forecasting what the system is doing today and tomorrow. That's important for big commercial shippers who need to know water levels up in Baltimore Harbor and small recreational boaters who want to know wave conditions out on the mainstem. Real-time models of current flows would help with search-and-rescue missions and with emergency responses to natural disasters like storm surges and human accidents like oil spills and chemical leaks. CBOS can even help with Homeland Security with high-frequency radar that helps track large and small ships as they move about the Bay.

oxygen. Water masses colliding here at the Control Point can also create oddities like internal underwater waves and a three-level flow pattern caused by surface water diving beneath incoming ocean waters.

All this action at the Hydraulic Control Point tends to collect algae and plankton and larvae near the surface, turning this turbulent zone into one of the Bay's biological "hot spots." Wherever water masses bump into each other, convergence zones are formed, gathering food and creating "chow lines" for fish, according to Mike Roman, a plankton ecologist and the director of the UMCES Horn Point Laboratory.

There are other recurring hot spots at the head of the Bay, down at the mouth and at numerous sites along the mainstem. At the north end is the Estuarine Turbidity Maximum (ETM), a mixing zone where the leading edge of the salt front meets fresh water flowing down from the Susquehanna. A moveable feast, the ETM shifts its position depending on river flow, sliding up Bay in dry years and down Bay in wet years. At the south end of the Chesapeake, there appears to be a Cyclonic Eddy, according to predictions by Raleigh Hood, a modeler at Horn Point. As water flows around the bottom corner of the Eastern Shore peninsula, it seems to create a slowly swirling eddy. And finally, where large rivers meet the Bay, rich plume fronts are created. All these features are natural traps for algae and plankton making them natural targets for fish.

Hot spots are at the center of a new hypothesis about a couple of perennial puzzles: Why do estuaries, in general, hold more fish per acre than oceans? And why does the Chesapeake still hold more fish than other estuaries. Perhaps because the physics of the system creates so many front-like features that collect algae and plankton and fish larvae, setting banquet tables around the Bay for foraging fish.

Now that the physicists of the Bay are able to find these fronts, biologists are expanding some of their old paradigms for explaining the rich productivity of the Bay.

Not a bad payoff for the high-dollar bet that, 50 years after Pritchard's first work, there is still a lot to learn about the physics of the estuary.

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None of the learning comes easy, not even with high-tech gear, not when you're working on the water.

Shortly before sunset, near the end of Boicourt's afternoon watch, the ScanFish suddenly goes wildly off track, swinging crookedly at the end of its cable like a horse that's thrown its jockey.

Scientist and crew winch the ScanFish up onto the back deck of the *Henlopen*, and the guessing game begins. Boicourt and Bryan Kidd, the technology guru for the boat, spend 40 minutes down on their knees on the darkening deck, probing the innards of the left-side panel with screw drivers and needle-nose pliers before they find the problem. One tiny, 10-cent screw had slipped out of place and disappeared into the Deep Trench.

The ScanFish is back in the water shortly after dark. By 11:00 p.m. it is taking deep trough samples as it passes under the Bay Bridge, and it's clear that Boicourt has won his bet on dissolved oxygen. The waters below the Bay Bridge are already hypoxic in early April — just as he'd guessed. That's bad news for the Bay. "It's going to be a big year, I think, for anoxia," says Boicourt.

The last job for this cruise of the *Henlopen* is to pull up a big, expensive, and badly damaged buoy that spent the winter locked in the ice out on the Choptank River.

For three years, it had been taking measurements on weather and water conditions and relaying real-time data back to the Horn Point Laboratory. Then in January, the buoy went dead.

As the *Henlopen* glides up to the floating yellow tower on a gray morning in April, Boicourt can see why: The superstructure is banged up, the radio antenna is busted, and the solar panels are shattered. That's just the damage above the water line. This is what the ancient physics of ice can do to the latest technology for science.

The big buoy is one part of the Chesapeake Bay Observing System, a network of data-gathering buoys and land-relay stations that Boicourt first pioneered back in 1989. He began CBOS, as it's called, with two buoys, but in years when the funding was there Boicourt has had seven buoys out on the Bay simultaneously.

Every winter Boicourt has to face some tricky gambles with CBOS. Will the Bay ice up around his buoys? If so, which ones should he take out. "In the northern Bay, up near the Susquehanna River, the salinities are low, so it always freezes up there," says Boicourt. "We always take that out." But he gambles a lot with the mid-Bay buoy and usually wins. The Choptank River was supposed to be a safe bet.

For the buoy pickup, the entire *Henlopen* crew minus the cook turns out in hard hats and life vests. Hoisting a two-ton tower on board a crowded deck is awkward, even dangerous work, with an engineer running the crane and everybody else pushing with poles or pulling with ropes, trying to keep the fat-bottomed buoy from smashing the boat or the crew.

As they slowly swing the buoy on deck, Boicourt can see the rest of the bad news. The ice field cut ugly brown gashes in the yellow foam protecting the hull. It knocked the tower on its side, breaking all the weather sensors, pulling the data cable out and opening a hole in the side. After the ice damage, waves kept slapping through the hole, slowly flooding the electronics package buried in the hull. "We lost at least $30 to $40 thousand dollars worth of gear here," he says, pointing to the water now draining out of the hull.

It's one of the costs of doing science at sea, according to Boicourt. Oceanographers have been losing meters and buoys to the Bay ever since Don Pritchard started work in 1949. Systems like CBOS and ScanFish represent elegant technical advances in data gathering, but they still fall victim to 10-cent screws that disappear into the Deep Trench, lightning strikes that knock out telemetry towers and winter weather that ices over the Chesapeake.

Along with the mishaps have come the payoffs: better forecasts for shipping on the Bay and deeper insights in to the physics of the system. But these kinds of systems — and these kinds of payoffs — are only built through years of trials and errors and ice damage. “We’ve had these disasters before,” says Boicourt, ”and we will again in the future.”


MICHAEL W. FINCHAM

A weather buoy comes aboard *after a bad winter in the Chesapeake Bay. Ice fields cut and battered the hull and caused flooding that destroyed the electronics package carried inside.*

The future may hold more trials for Boicourt, not only in the Bay, but back out on the Continental Shelf where he began his research career. Since the physics of the Bay’s circulation is driven, in part, by the physics of ocean circulation, he hopes to plant one of his CBOS buoys outside the mouth of the Bay so he can track the condition of incoming ocean water.

That incoming Shelf water may, in turn, be driven by forces let loose hundreds of miles away. Consider the Gulf Stream, one of Boicourt’s favorite examples. As it curves east of Canada, it can spin off an eddy of cold water 100 miles wide that starts cruising south through the deep water next to the Continental Shelf. “On the way down, it’s banging against the Continental Shelf,” says Boicourt, “injecting high-salt water and organisms into the Shelf waters, conditioning the whole water that the Chesapeake Bay talks to.”

As those Shelf waters then surge in at the southern end of the Bay, they carry remnants of that eddy — temperature, salinity and density conditions that will drive the physics of the Bay system all the way to Baltimore and beyond. Half the water in the Bay is ocean water. Salty water off Annapolis is shaped, in part, by seawater off Nova Scotia.

If that eddy from up north sounds a lot like the butterfly effect from Chaos Theory, remember that it was a meteorologist, Edward Lorenz, who first stumbled upon Chaos Theory. A single butterfly flapping its wings produces a tiny change in the atmosphere. Months later, on the other side of an ocean, a hurricane that wasn’t going to happen hits land. Or one that was going to happen never forms.

Meteorologists try to overcome the anarchy of nature by bringing more weather stations on line and building more sophisticated mathematical models. Oceanographers, their first cousins, are trying the same tack. “We are all sitting there saying, why don’t our models work?” says Boicourt. “Well, we have to include that long-range influence, and that is one of the reasons that we have to have large, nested observing systems.”

That means more than an expanded CBOS. Wending its way through Congress is a proposal for a network linking a number of existing coastal observing systems along the Atlantic seaboard. Chesapeake Bay modelers would be working with data from the Gulf of Maine, from Cape Cod, Long Island Sound, the Jersey coast and some of the coastal states to the south. These systems would be nested, in turn, in an even more ambitious, and expensive, Global Ocean Observing System.

Boicourt thinks the investment will pay off. Billions of data points, faster computers, more agile mathematical models — what do they add up to? What would CBOS do with data on distant waters. “With advanced techniques and advanced computer power,” says Boicourt, “we can now write numerical models that are very accurate and very resolved.”

The up side of Chaos Theory is better (but not perfect) predictability and a better understanding of the Big Picture. Meteorologists can give pretty good 24-hour forecasts for the Bay weather, and they can connect them to forces like the North Atlantic Oscillation, El Niño in the Pacific or Global Warming around the planet.

Oceanographers think they can do the same thing for the underwater weather of the Chesapeake Bay. The eddy from up north would still come this way, but they would know when it’s coming and what kind of water it’s carrying. They could also work out forecasts about what happens when remnants of the eddy try to cross the Rappahannock Shoals and start cruising up the Deep Trench towards Baltimore. Numerical oceanographers, of course, would have to put all that data together in their mathematical models.

Walking around the work deck of the *Henlopen*, Boicourt, the boat-deck scientist, is already putting his banged-up buoy back together in his head. “We’ll have to replace the hull. We’ll sandblast all the metal parts, replace the electronics.” he says.” We’ll need new solar panels.” The tower, at least, is still usable. And the oceanographer is still optimistic. “We’ll get it back in shape.”

If the country is ready to place another bet on big science, Bill Boicourt will be ready to take his buoys back out on the ocean.

Brush Receives Mathias Medal

Grace Brush, a scientist well known for her work on the pre-Colonial ecology of the Chesapeake Bay, has won the prestigious Mathias Medal in recognition of scientific excellence. William R. Brody, President of the Johns Hopkins University, presented the award to Brush on May 6, 2004 at a well-attended ceremony in Washington, D.C.

Named for former Maryland Senator Charles "Mac" Mathias — who is widely credited with launching a federal-state partnership to restore the Bay — the Mathias Medal recognizes scientists whose work has had a significant impact on policies affecting the Chesapeake. Awarded by the Sea Grant programs of Maryland and Virginia and the Chesapeake Research Consortium, the Medal has been given only four times since its creation in 1990.

A professor in the Whiting School of Engineering, Department of Geography and Environmental Engineering at the Johns Hopkins University, Brush is the first paleoecologist to win the award. She is also the first woman.

Brush pioneered studies that use the presence of plant pollen, microscopic organisms and other substances in Bay sediments to track changes in the estuary and in the watershed that surrounds it. Her studies have provided the basis for much of our understanding of how and when the forests surrounding the Bay were first cleared, and how resultant shifts in sediment loads and water chemistry changed the Bay and its ecosystem. "When policymakers attempt to compare the Bay of the past with the Bay of the future," says Maryland Sea Grant director, Jonathan G. Kramer, "they turn to the work of Grace Brush." Kramer calls her work "pivotal," because it has detailed the story of the Bay's response to human settlement, beginning with the clearing of the region's forests and continuing right up to the impacts of sewage treatment plants.


WILL KIRK, JHU

"Grace Brush has been extremely helpful in identifying the impacts of land use changes on the Bay," says Ann Swanson, Executive Director of the Chesapeake Bay Commission. "Her work is very concrete. It's added to the quiver of facts you need to hit the target [of nutrient reduction]."

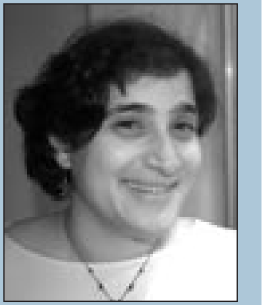
"There are many scientists working on the Bay, but only a few who really influence you," says Swanson. "Grace Brush is one of those few."

Ted Poehler, Vice Provost for Research at the Johns Hopkins University, calls Brush a "cornerstone" of her department. "Grace has a long and impressive history at Hopkins," he says. "She helped others and helped to bring stability to that program and to [the study of] the Chesapeake Bay." Poehler points out that Grace has set an important example for women in science. "Back in 1956, when she got her doctorate, the number of women in engineering fields was quite small. The women who did enter the sciences were more likely to enter biology or chemistry." Researchers like Brush were really "pioneers," he says. "It was pretty lonely." Adds Poehler, "We need more role models like Grace."

Maryland Sea Grant Welcomes New Science Writer

A new science writer has arrived at Maryland Sea Grant, Erica Goldman. With a Ph.D. in biomechanics from the University of Washington, and experiences both in journalism and marine policy, Goldman is well suited to tackle the often complex topics that emerge from marine issues in the Chesapeake region. Raised right in Manhattan, she has developed a keen appreciation for the outdoors and the marine environment and now finds that the big city can be a little "claustrophobic."

Goldman has worked as a writer at Washington Sea Grant and at *Science*, the journal of the American Association for the Advancement of Science (AAAS), where she focused on reporting news and synthesizing scientific articles for the web. She also served as a Knauss Fellow on Capitol Hill, where she had an opportunity to observe firsthand the role of science in shaping marine policy on a national level.


MICHAEL W. FINCHAM

Her interests in research and in writing came together in 1999, when science writer David Gordon spoke to her science journalism class. Though her graduate work was highly specialized, says Goldman, she found that she missed "the breadth of science."

In her fellowship on Capitol Hill she took on the role of explaining the marine sciences to a larger audience, where science, policy and public interests meet. "Sea Grant," she says, "is placed right at that intersection."

Leffler Takes His Leave

MICHAEL W. FINCHAM

After twenty-three remarkable years of writing about and reflecting on science and the Chesapeake Bay, Merrill Leffler retired from his post as writer and editor for the Maryland Sea Grant College on April 1, 2004.

Born in Brooklyn, New York, and raised in North Carolina, where his family had moved during his preteen years, Leffler graduated from the North Carolina State University with a degree in physics. One of his first jobs was with the National Aeronautics and Space Administration (NASA), where he became a vehicle manager, in charge of launching rockets for atmospheric and meteorological research.

Leffler early on found himself drawn to words and literature, however, and as columnist Henry Allen wrote in a *Washington Post* feature, Leffler turned away from his aeronautical career to pursue the language and literature that he loved. Leffler went on to graduate school in English literature at the University of Maryland and then at England's Oxford University. He taught literature at the University of Maryland, the U.S. Naval Academy, and at literary workshops here and abroad.

In addition to his own writing and teaching, Leffler has long encouraged and promoted the efforts of others. Through his own company, Dryad Press, he has published the work of numerous poets and writers, with a special emphasis on Holocaust literature. One collection of Israeli poems on war and peace, entitled *After the First Rain*, carries a preface by former Prime Minister Shimon Peres, who spoke fondly of the work at the book's inaugural reading in Washington, D.C.

For those interested in the Chesapeake Bay, Leffler is best known for his in-depth articles on marine science and affairs. For many years he has followed scientific studies of the Bay ecosystem and its fisheries, including the oyster industry — from the resurgence of parasitic disease in the mid-1980s to heated debates over the introduction of non-native oyster species, such as *Crassostrea gigas* and, currently, *Crassostrea ariakensis*.

Leffler's work is informed by deep understanding, the result not only of numerous interviews with researchers throughout the region and beyond, but also of painstaking reading of scientific journal articles, reports and research notes. At Maryland Sea Grant Leffler found a place where he could join his interest in science and his passion for writing. "When I saw the advertisement in the *Post* [in 1981]," Leffler said, "I said, 'This is the job I want.'"

Many would agree that it was a happy confluence. With issues facing the Chesapeake growing increasingly complex, and with many clamoring for over-simplified solutions, Leffler's careful and balanced analysis of issues such as oyster aquaculture, fisheries management and contaminants in the Chesapeake helped to provide measured and sophisticated background and up-to-date information for a broad, interested audience. He also helped to explain the Bay's intricate physical and biological dynamics, the forces that drive its rich food webs and fabled productivity.

Leffler may be retiring from the nine-to-five life, but he'll be just as busy. This summer he will present lectures on culture, literature and sense of place in Great Britain, and then will return to the things he loves most — his family, including two young granddaughters, and his literary work. A farewell gathering held at the end of March in College Park served as testimony to the community's fondness and regard for him. "When I came to Sea Grant I found people who care about the same things I do," he said. He also found a community of scholars and others who came to appreciate his unflagging curiosity, intelligence and warmth.

Snakeheads Go Beyond the Pond

When the first of the northern snakeheads, the Asian exotic fish that can breathe air and survive for short periods on land, was plucked from a Crofton, Maryland pond in the summer of 2002, it catapulted onto David Letterman's Top Ten list and grabbed the nation's collective consciousness. Now the infamous fish is back in the Chesapeake region and it could be settling in to stay.

Troubles began again on April 26, when an angler snared a 19-inch, female snakehead from a pond in Wheaton, Maryland. Over the next week, the Maryland Department of Natural Resources (DNR) drained the pond but did not find other fish.

Any sigh of relief was short-lived, however, and the following weeks have brought further cause for concern. On May 7, a fisherman landed an immature female snakehead from Little Hunting Creek, a tributary of the Potomac River in Virginia. Later in the week, another angler pulled up another female on the nearby Maryland side of the Potomac, in Charles County. And a few days after that, a participant in a bass fishing competition snagged a third snakehead, of a similar size, from a site along the Potomac about 10 miles downstream from Little Hunting Creek. Maryland DNR has posted emergency snakehead fish warning signs along the Potomac. The agency is encouraging fisherman who catch them to kill them and to expeditiously report findings to the authorities.

U.S. GEOLOGICAL SURVEY

Unlike ponds, which can be drained, the Potomac River is a system of interconnected waterways that stretches for 280 miles. "From a management standpoint, finding the fish in an open body of water certainly elevates the level of concern," says Andy Lazur, an aquaculture extension specialist from Maryland Sea Grant Program, who served on the Maryland Snakehead Scientific Advisory Panel in 2002. "And if the fish does become established, managers will have to manage around the fish. And there are limited tools available," he says.

But finding a few snakeheads in the Potomac does not mean that a reproducing population has established. "Three fish, a population does not make," cautions Paul Shafland, director of the Non-Native Fish Research Laboratories of the Florida Fish and Wildlife Conservation Commission in Boca Raton, Florida. "Three fish out of the same and adjacent systems does certainly raise your eyebrows, but it is important to confirm the existence of a population before jumping to any conclusions," he says.

Some believe that the evidence is already fairly compelling, however. "Snakeheads are probably already pretty widespread in the system," says fisheries biologist and snakehead specialist Walter Courtenay from U.S. Geological Survey's Florida Integrated Science Center in Gainesville. The larger fish caught in Wheaton is of a different size and age class than the three caught in the Potomac, and these bodies of water can all be linked together geographically which suggests that there might be a reproducing population, he says.

But even if the snakehead is here to stay, the effect of a new predator in the food web will take years to understand and, in the end, may not have a catastrophic ecological impact. "Freshwater fish communities are far more plastic and resilient than we would expect," says Shafland. "An introduction of a freshwater exotic is more akin to ecovandalism than ecoterrorism," he says. In addition, other predators in the system, such as largemouthed bass may actually consume snakeheads. According to Lazur, "There is no way to predict how these fish will respond as both predator and prey in the system. It remains to be seen."

Whether or not snakeheads live up to their "Frankenfish" profile in the media, they have become poster children for communicating the risks of introducing exotic species to the environment. "If there is one take-home message from the snakehead introduction," says Shafland, "it is that it is the public's responsibility not to release exotic species into the wild. It is illegal and it is inhumane for the animal. We need to take this seriously," he says.

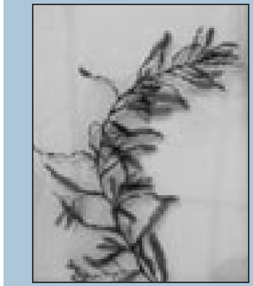
— Erica Goldman

Northern Snakehead Weblinks

Snakehead profile – http://www.invasivespecies.gov/profiles/snakehead.shtml

Washington Post Webcast with Andy Lazur – http://www.washingtonpost.com/wp-dyn/articles/A36762-2004May18.html

Bad Year For Bay Grasses



Submerged Aquatic Vegetation (SAV) in the Chesapeake Bay dropped by 30 percent from 2002 to 2003, according to a report synthesizing the annual aerial SAV survey data collected by the Virginia Institute of Marine Science. Released on May 18 by the Chesapeake Bay Program, the report calls this the largest single-year decline in SAV since 1984.

The marked decline of Bay grasses in 2003 is linked to near-record rainfalls during last spring and summer that washed colossal amounts of nutrients and sediment from the land into the Bay, according to the report. Increased water turbidity, when combined with cloudy, sunlight-poor days, hampered the grasses' growth.

Bay grasses are critical players in the Chesapeake Bay ecosystem. They oxygenate estuarine waters and provide food, shelter and nursery areas for juvenile striped bass and crabs. They also act to reduce pollution by absorbing nutrients and trapping sediments.

Since the 1960s Bay grasses have seen a steady decline due to poor water quality and enhanced growth of epiphytes — which foul underwater plants. Scientists and regional partnerships have been working hard to reverse the trend through directed restoration efforts. In the past 15 years, there has been some regrowth of SAV in the Bay, but at least in brackish areas, recovery has been limited to one species commonly known as widgeon grass, explains ecologist Michael Kemp of Horn Point Laboratory.

"Thirty years ago, in this same region, there were six or seven species that were pretty abundant. As a community, it was much more robust. Now the system is much more vulnerable to variation in climate — like what occurred in 2003," he says.

Kemp is not surprised that a single year with extremely high levels of precipitation caused such a striking decline in SAV. "It's a reminder that the plants disappeared originally because of poor water quality. And this underlying problem has not improved," he says.

— Erica Goldman

SAV Weblinks

Chesapeake Bay Program – http://www.chesapeakebay.net/baygras.htm

Virginia Institute of Marine Science – http://www.vims.edu/bio/sav/

Maryland Department of Natural Resources – http://www.dnr.state.md.us/bay/sav/index.html

NOAA Chesapeake Bay – http://noaa.chesapeakebay.net/sav.htm

US Fish & Wildlife Service Chesapeake Bay Office – http://www.fws.gov/r5cbfo/CBSAV.HTM

New Rip Current Web Site

RIP CURRENTS

Summer is off to a somber start in southeast this year. In May alone, three drowning-related deaths in Florida have been blamed on rip currents, fast-flowing cells of water that move offshore. To raise beachgoer awareness, the National Oceanic and Atmospheric Administration (NOAA), in partnership with the United States Lifesaving Association and the National Sea Grant College, kicked off a nationwide campaign on May 24 to communicate critical safety information.

A key component of the campaign is a new website from NOAA's National Weather Service, "Break the Grip of the Rip" [http://www.ripcurrents.noaa.gov/index.shtml], that provides real time safety information on surf height and rip current risk for eight sites on the Atlantic Ocean, ranging south from New Jersey to Florida, three sites on the Gulf Coast, and three sites on the Pacific Ocean. The site also aims to inform swimmers about rip currents, how to recognize them, and how to survive them safely if encountered. It emphasizes the importance of going with the flow and not fighting the current. "Think of it like a treadmill that cannot be turned off, which you need to step to the side of," the site advises. The website is complemented by a nationally-standardized sign for beach communities and a brochure that will be available in both English and Spanish.

Ocean Policy Commission Releases Preliminary Report

That the oceans are in serious trouble is the clear message of a recently released preliminary report of the U.S. Commission on Ocean Policy. Made public on April 20, the report calls for action to be taken now to reverse serious declines in water quality and a host of problems, including loss of habitat and living marine resources, plaguing U.S. coastal and ocean waters. It recommends enhancing and radically changing approaches to cooperation and coordination at the federal, state and local levels and stresses the need for ecosystem-based management.

Other major recommendations propose restructuring U.S. ocean governance, including establishing a National Ocean Council within the Executive Office of the President, strengthening the National Oceanic and Atmospheric Administration and increasing spending on marine research and education. Overall, the report estimates costs for reversing declines and restoring the nation's coasts and oceans at about $4 billion annually, and suggests these funds could come from existing offshore oil and gas leasing activities that occur within U.S. coastal and shelf waters.

The report has some good news for the Chesapeake Bay as it endorses many of the goals set forth in *Chesapeake 2000*, the blueprint for Bay management. Regional oversight and management of coastal watersheds are valuable, according to the report, and coordinated efforts such as those currently working in the Chesapeake are important models for how U.S. coasts should be managed. The Sea Grant College program is cited several times in the report as an important and successful mechanism for bridging the gap between ocean research and education, and additional support for this program is urged.

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

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