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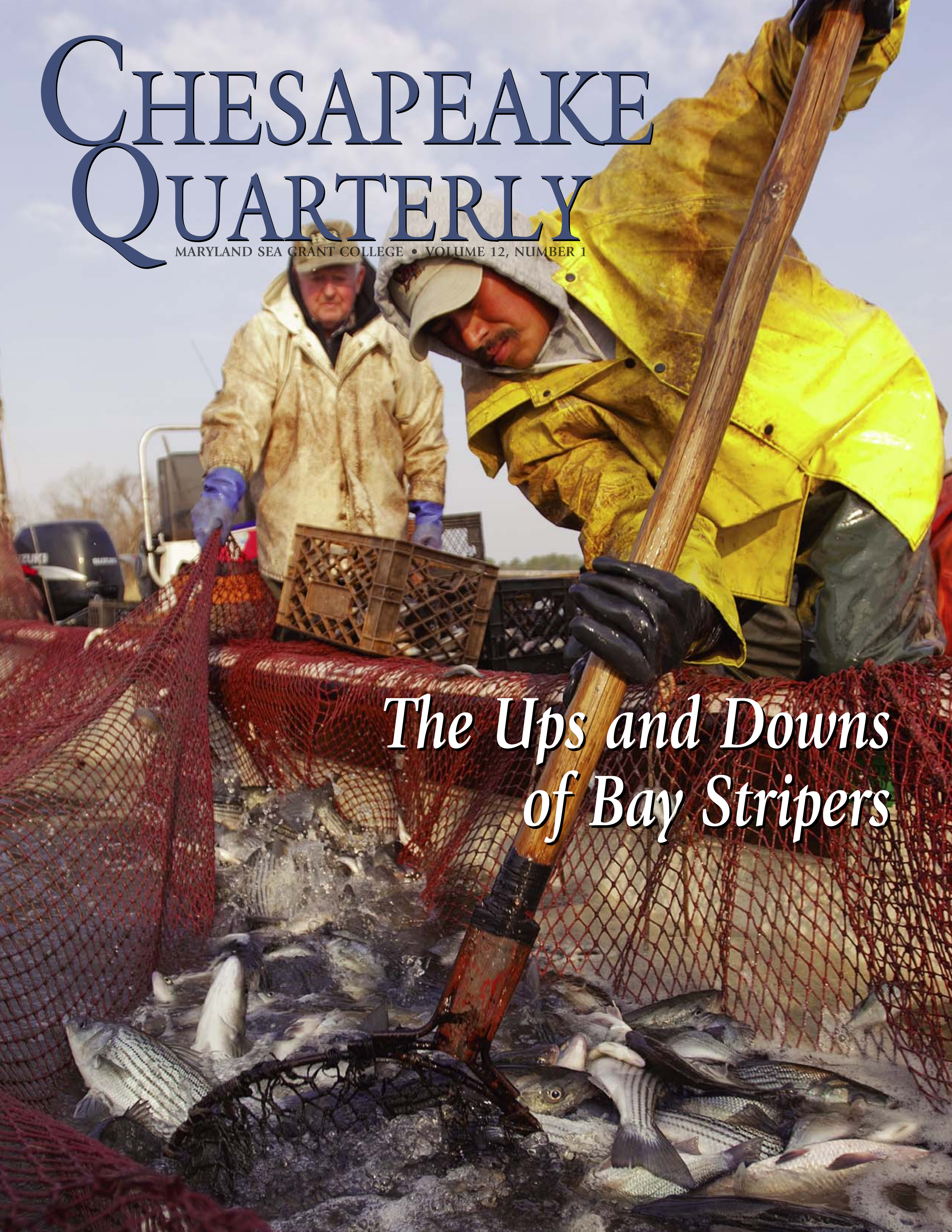

The Ups and Downs of Bay Stripers

contents

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

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Cover photo: *Billy Callaway (at the tiller, standing behind one of his workers) is the third generation of his family to fish for striped bass out of pound nets in the Chesapeake and its tributaries.* ***Page 3:*** *Like the stump of a fallen tree, this cross-section of a striped bass otolith, which has been meticulously cut and polished, gives us a window into the fish's life. Count the rings on this mineral structure and you can see the striper's age. Looking even closer, scientists can spot clues to where this fish had swum and when.* PHOTOGRAPH: COVER, DAVID HARP; OTOLITH ON P. 3, DAVID SECOR

LENDING AN EAR

White perch and striped bass tell us about their travels

Daniel Strain

David Secor keeps a collection of ear bones. The inner-ear appendages, called otoliths, are tucked away on a shelf in his laboratory in Solomons, Maryland. He has samples from bluefin tuna, white perch, and a dozen other fish species. There's even one from the largest striped bass ever caught in the state. But right now, he's holding an otolith taken from a golden tilefish. It's white and about the size and shape of a small seashell.

"Aren't they beautiful" says Secor, a fisheries ecologist at the Chesapeake Biological Laboratory of the University of Maryland Center for Environmental Science (UMCES). "See how sculpted they are?"

And, yes, this otolith — which, like a seashell, is actually a mineral deposit, not a true bone — is notched all around with small bumps and rivulets. For Secor, however, the real beauty here lies in the information this otolith carries.

Like a tree, each otolith contains internal rings circling around its core. Count them, and you can see how old this tilefish was when it died. More important, chemical clues hidden within Secor's otoliths can also help scientists like him trace the paths the fish took as they migrated.

On the Chesapeake Bay, the migrations of white perch and striped bass are likely as old as the estuary itself. Each year, they swim tens of miles, and sometimes hundreds of miles, from the rivers where they were born to salt water and back again.

But recent studies, and Secor's own otoliths, show that these migration patterns may be more complicated than previously thought. The prevailing view had been that entire stocks of these fish always migrate together — if some go, all go. But Secor and colleagues have found that a subset of white perch living in the Bay never migrate. Instead, they spend their entire lives in their freshwater rivers. What's more, the long-term survival of many fish populations could depend on such unexpected behaviors, Secor says. His work adds to a growing body of research that suggests that, when it comes to understanding and conserving fish, diversity counts.

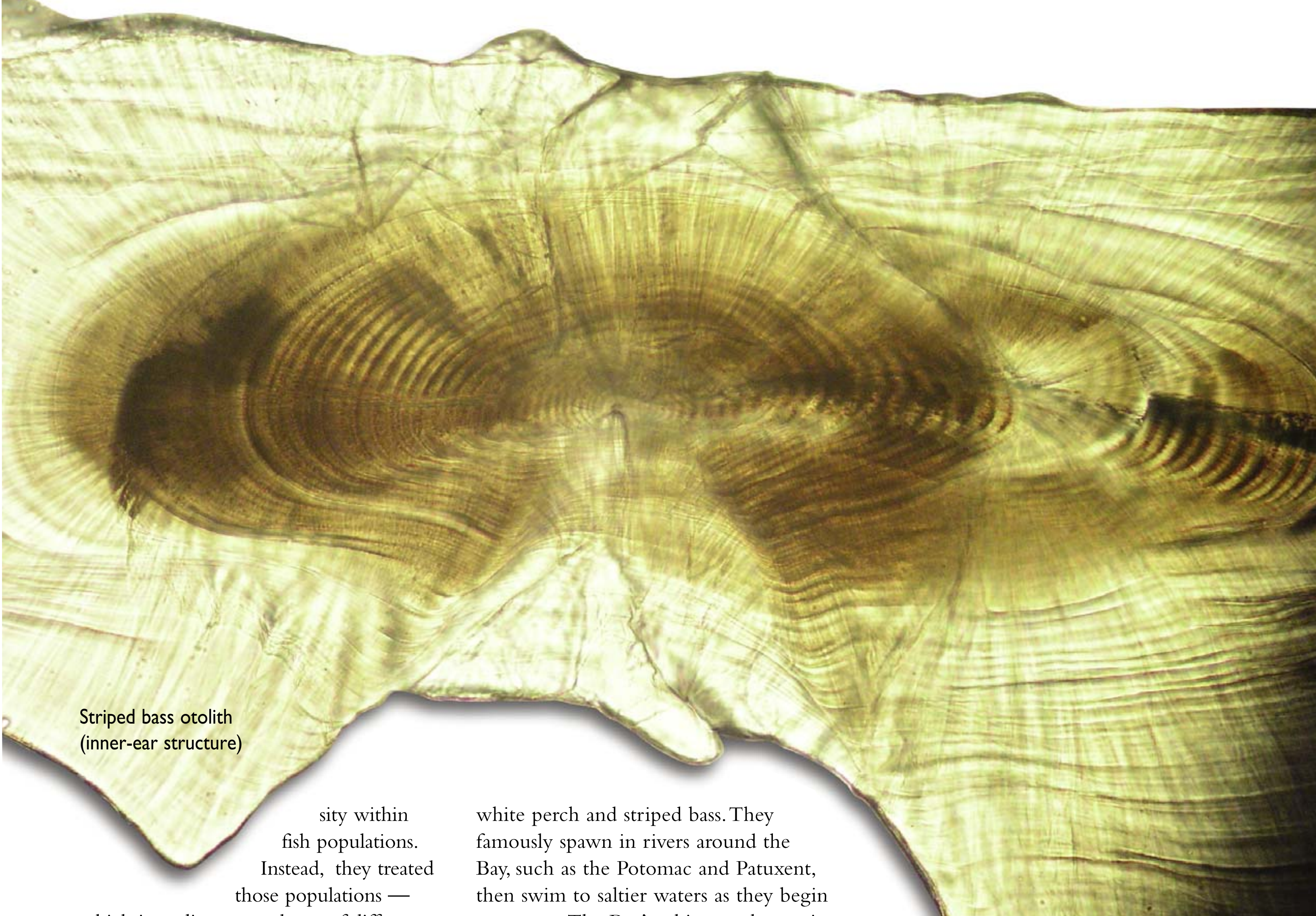
"We get insights into how fish differ that are very much more sensitive and very much more sophisticated than fisheries science had 120 years ago," says Tom Miller, director of the Chesapeake Biological Laboratory. "But I do think it remains to be seen about what role they have in fisheries management."

Birds Do It, Fish Do It

Migration heretics — animals whose travels don't match conventional wisdom — are far from a new concept in biology. The sight of geese flying south en masse may signal the start of autumn for many. But scientists have long known that birds don't always migrate like they should. Small subsets of birds from many traveling populations, in fact, don't migrate at all, instead staying behind in the territories where they were born.

The phenomenon is called "partial migration" — because only part of the population migrates in any one year. It's been recorded in a number of bird species, including red-tailed hawks and European robins. But, until recently, no one had looked for it in marine fish.

That's because, for many decades, fisheries scientists largely glossed over diver-



Striped bass otolith (inner-ear structure)

sity within fish populations. Instead, they treated those populations — which in reality are made up of different types of individuals with unique behaviors — as a single, unified lump. In fisheries-speak, such a homogeneous group is called a stock. And stocks, for the purpose of scientists, migrate as one and spawn as one. No partial migration allowed.

Such a concept made it possible for scientists to do the sorts of calculations that allowed them to set quotas and fisheries seasons, Secor explains. But it stuck. "The stock became the population," he says. "And that view was fairly rigid for many decades."

But some, like Secor, weren't content with that. Before moving to Maryland in 1991, Secor had spent a year studying red sea bream, rabbitfish, and other aquaculture fish in Japan. "It wasn't as interesting to me looking at a tank with a fish in it as it was trying to look out here," he says, indicating his office window with a view of the Bay. "What's intrigued me is what's hidden."

Like the lives of fish, he says. Take white perch and striped bass. They famously spawn in rivers around the Bay, such as the Potomac and Patuxent, then swim to saltier waters as they begin to mature. The Bay's white perch remain in the estuary, but striped bass venture farther, eventually leaving to roam the Atlantic coast as far north as Canada. Each species of fish returns each year around springtime to spawn. But those migrations take place underwater and over many miles.

Secor and a generation of scientists like him, however, began using new research methods, including new ways of looking at otoliths, to open up that underwater world.

Still, figuring out what to do with that new understanding is complicated. "We're getting a wealth of information now," says Steve Cadrin, who studies new ways of assessing the health of stocks at the University of Massachusetts Dartmouth. "But we need to sort out this wealth of information. What of these new complexities are really important to us and which of them do we need to consider to do a better job with our fishery management?"

White Perch
Morone americana

Duane Raver

White perch are one of the most abundant fish in the Chesapeake Bay, and they spend their entire lives there. These perch are closely related to striped bass.

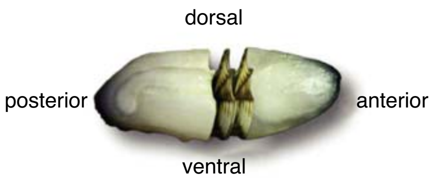
Distribution: White perch are found from Nova Scotia to South Carolina but are most abundant from the Hudson River to the Chesapeake Bay.

Key distinguishing markings: They are silvery in color and frequently have irregular, dusky longitudinal lines along their body.

Size: Adults can grow up to 19 inches, but are more commonly found at about seven to ten inches.

SOURCE: MARYLAND DEPARTMENT OF NATURAL RESOURCES

How to slice an otolith



You could call him the otolith collector: *David Secor admires a striped bass otolith. The inner-ear structures — which help fish sense their motion and orientation, much like our own inner ears help us to balance — come in all shapes and sizes. Some are about as long as a guitar pick, while others, like those from bluefin tuna (bottom left), are much smaller. To analyze otoliths, you first have to slice horizontally to obtain a thin section (top left).* PHOTOGRAPHS: ABOVE, DANIEL STRAIN; LEFT TOP, VIRGINIA INSTITUTE OF MARINE SCIENCE; AND LEFT BOTTOM, DAVID SECOR

Punk-Rock Fish

To begin to answer those questions, Secor turned to white perch (*Morone americana*). These silver and spiny-finned fish are an angler's dream in the Chesapeake. They're abundant and never hard to find. Secor calls them the white lab rats of the Chesapeake. "I love white perch," he says with enthusiasm.

So just over ten years ago, Secor and his graduate students at the time, Richard Kraus and Lisa Kerr, began collecting and examining otoliths from perch caught on the Patuxent River. Because of the way they're made, otoliths absorb some of the chemical signatures that are unique to particular ecosystems, such as freshwater or saltwater habitats. And those cues can give scientists hints to where a fish has been and when.

One of the newest windows to those secrets comes from oxygen atoms. Every water body carries two major types of this basic element, Secor explains, a lighter version and a heavier version. Salt water, however, tends to bear a lot more heavy oxygen atoms than fresh water does. So think of them like a ship's logbook. If Secor sees a lot of heavy oxygen atoms in a particular otolith, for instance, he can be pretty sure his fish had spent time in salty water.

Using this log, Secor found that perch had more in common with birds than their scales would suggest. Most Patuxent perch did make the circuitous trip from the upper Patuxent River toward the Chesapeake and back again on a yearly basis — just what you would read in a Bay nature guide. But others, about three percent, stayed where they were. Secor calls these exclusively freshwater fish, which looked like any other white perch, "residents." What's more, that strategy seemed to get locked in for the fish's life. Once a perch became a resident or a migrant, it usually stayed a resident or a migrant.

Drawing from that study, Secor expanded his research to other major rivers on the Chesapeake, from the mouth of the Susquehanna south to Virginia's James River. And in each, his team found similar groups of residents mixed in with migrating fish. How many residents the researchers found depended on the river in question and what the weather was like that year. Residents, for instance, were common in the upper Bay but rarer in Virginia. Migrants were most abundant during drier years.

Secor had discovered his case of marine partial migration.

Scientists had previously known that certain species of salmonlike fish, such as brook trout around Québec, showed similar behavior. But Secor's perch study was one of the first to discover an example of partial migration in a non-salmon fish. He and his colleagues, whose research was funded in part by Maryland Sea Grant, published their results in a number of journals, most recently in 2012 in *Estuaries and Coasts*.

And Secor, at least, wasn't inclined to pass his findings off as an accident. "You could say 'Well, that's just an anomaly,' " he says. But "it may be that these minority behaviors are prevalent in other marine fishes and… have some function in the ecosystem and the population."

In other words, weird behaviors do matter. To understand why, you need to first understand what the triggers for partial migration are.

And that, Secor says, may come down to the classic dilemma posed by the British punk band The Clash: should I stay or should I go? If you get all the food you need living in a river, for instance, there's no reason to leave. But if a river's crowded and food is scarce, you'd want to migrate, even if that exposes you to predators. And, in fact, he and his colleagues found that perch born later in the year — or those most likely to face crowding and food scarcity — usually become migrants. Fish born earlier, however, tend to be residents.

Secor suspects that the fish aren't genetically programmed to be one or the other — they're merely reacting to the conditions they're facing. In fact, there's no evidence to suggest that residents only reproduce with residents or migrants with migrants. Instead, when it comes time to spawn, they mix.

But Secor says that the perch population as a whole may need different kinds of individuals, some that stay and others that go. Think of them as the tortoise and the hare from the nursery tale. The migrants are the hares. They grow fast and reproduce a lot, thanks to the usually abundant supplies of food in the Bay's mainstem. So if you want your population to expand as quickly as possible, they're your guys.

But migrants aren't dependable. A simple disturbance, such as a year of bad weather, could wind up eliminating much of the Bay's prime food sources and, by extension, a whole season's worth of migrants. Residents, however, live in a more stable environment, which allows them to continue to chug along during both good years and bad. They're your tortoises, and the offspring they produce sustain the population over time. Each strategy, in other words, has something to add to the overall population's chances of winning the race for survival.

Secor dubbed this success through a diverse set of behaviors a "portfolio effect." In stock markets — the Wall Street kind — you never want to put all your money into one company. Likewise, in the case of fish, a population shouldn't depend on only one strategy (also called a life history) for succeeding in a threatening world. "When you have diverse life histories…what you end up with is resilience," says Graham Sherwood, a research scientist at the Gulf of Maine Research Institute in Portland, Maine.

Sherwood studies similar behaviors in Atlantic cod, and he wagers that partial migration may be much more common in fish than many expect.

"The more you look at this, the more ubiquitous it is," Sherwood says. "Pretty much every [animal] species does this to some degree or another."

White Perch: Migrants Vs. Residents

Location	% Migrants	% Residents
Upper Bay	31	69
Potomac River	35	65
Choptank River	55	45
Nanticoke River	81	19
York River	68	32
James River	82	18

To bring in the Bay's bounty, *like these striped bass sold at Captain White's Seafood City in Washington, D.C. (top), Chesapeake watermen follow fish as they migrate upstream and downstream each year. But sometimes that gets tricky. Most white perch caught in the lower Chesapeake from 2005 to 2006 tended to migrate as expected, according to estimates by David Secor and his colleagues (table). But, more often than not, perch from the upper Bay never left the freshwater rivers where they were born.* TABLE SOURCE: KERR AND SECOR, 2012; PHOTOGRAPH, DANIEL STRAIN

Conserving Diverse Fish

That includes striped bass in the Bay, a favorite among watermen, says Secor, who's been examining migration diversity in these fish, too. For stripers, who have recovered from a steep decline in the 1970s brought on by overfishing, partial migration isn't simple. Preliminary results from Secor's otolith analyses suggest that juvenile stripers don't have just two migration strategies — staying or going. They have many. Some young bass, for instance, begin migrating downriver as expected, then weeks later, for reasons that aren't clear, make a U-turn and come back.

Because each of those migration strategies may be important to the long-term success of striped bass, Secor argues that it's important to conserve that diversity — protecting fish across an array of Bay habitats.

These new research findings surrounding the diversity of fish stocks could one day influence how fisheries managers set their policies. But diversity shouldn't be considered in fishery regulations simply for diversity's sake, says Steve Cadrin of the University of Massachusetts. First, researchers will need to fill in the emerging picture of multi-faceted fish populations with additional details. Some behaviors, for instance, may be more critical than others for sustaining a flagging population. And figuring out which are which could become one of the bigger challenges facing fisheries scientists over the next few decades. "We don't want [management] to be so complex it's impractical," he says. "But we don't want it so simple that it's not effective."

Some scientists are working to figure out new ways of quantifying the importance of fish diversity. Cadrin, for instance, collaborated with Secor and Kerr to use mathematical analyses to investigate which of the Patuxent's perch, residents or migrants, might be most important for the populations. As expected, their results show that while migrants boost the fishery's sheer numbers, residents can keep the population from collapsing during bad years. Those results were published in 2010 in the journal *Ecological Applications*.

Regardless, Secor says, there's no turning back now. With modern analyses, fisheries science has entered a new era — one in which you can't ignore the diversity within fish stocks. "Really the statement that I believed when I was growing up, that the life of sea animals is hidden, is really no longer true," he says.

Which is a big revelation from a few little otoliths.

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Taking the Long View

The Fall & Rise & Fall of Stripers & a Lot of Less-famous Fish

Michael W. Fincham

Don't call him Ishmael. You'd never find Bob Wood in a Herman Melville novel. There's no damp, drizzly November of the soul that would send him out to sea in search of a Moby Dick or even a menhaden. Wood did his boat time during graduate school: day-long cruises on the Chesapeake Bay, dragging fish trawls, hauling up small fish, counting them, tossing them back, recording data. Then doing it again. And again. And again.

He didn't like it then, he doesn't miss it now. There was the seasickness, but mostly it was a day lost to his dissertation work. And that dissertation work was where he did most of his trawling. He hauled out older fish surveys done by other people on other boats and even culled through records of long-ago fish catches by watermen who once upon a time went chasing after stripers and blues, yellow perch and white perch and menhaden.

Wood was also chasing something. He launched another kind of fishing expedition, one that carried him through archives of climate data where he began hauling up records on high-pressure systems and low-pressure systems, rain events and snow storms, high-flow years and low-flow years. He even began dredging up decades-old data on regional climate patterns with names like the Ohio Valley High, the Azores-Bermuda High, the North Atlantic Oscillation.

He was chasing a connection: a big, Moby Dick-like connection. Could there be a link

Striped bass, for thousands of years, *have been coming back to the great spawning rivers of the Chesapeake Bay. And scientists, for decades, have been trying to figure out why striped bass reproduce so well during certain eras and so poorly during other eras. Bob Wood (right) has come up with a new theory that may answer these old questions.* PHOTOGRAPHS: STRIPED BASS ON OPPOSITE PAGE, DAVID HARP; THIS PAGE, MICHAEL W. FINCHAM

between those large-scale climate forces and those sudden, unexplained boom years when big numbers of new stripers and other Bay-spawning fish come surging down the Bay's major rivers? What about other boom years that brought large hordes of ocean-spawning fish like menhaden sweeping off the continental shelf and into the estuary?

Bob Wood never had an itch to go to sea, but his long obsession with climate links eventually led him to a mysterious force lurking out there in the middle of the Atlantic Ocean. It's now called the AMO, short for the Atlantic Multidecadal Oscillation. It's a cycle lasting 65 to 75 years during which sea-surface temperatures warm up for several decades before cooling down for several decades. Wood didn't discover the AMO — but he did discover the connection between the AMO out there in the Atlantic Ocean and fish species back in the Chesapeake Bay.

And it took a while. By the time he discovered the AMO connection, he was no longer a graduate student, but the director of the Oxford Cooperative Laboratory, working for the National Oceanic and Atmospheric Administration (NOAA). He calls his latest breakthrough a teleconnection. "It means far-apart connections," he says. "If you see things in one place, it seems to affect things in another place." A famous teleconnection would be the El Niño/La Niña cycle in the Pacific. El Niño is a warming of Pacific waters that, among other effects, can bring rains to California and drought to the Midwest. La Niña is a cooling period with opposite effects. The AMO is something like that. It is a distant warming and cooling of waters in the middle of the Atlantic, and according to Bob Wood, it is the force that largely controls the rising and falling of striped bass and menhaden populations in the mainstem of the Chesapeake Bay.

And it's a force over which we have no control.

When the AMO gives us good years for new stripers, it generally gives us poor years for new menhaden. And menhaden, of course, are the fish that stripers love to feed on. So the warming of the AMO will give you a lot of stripers, but not a lot of food. And vice versa. Good times for menhaden will often be poor times for stripers. A lot of food, but not a lot of stripers.

That's a twist worthy of the old gods out of Greek myths. Every gift they ever gave us mortals carried a dark side. As mere mortals trying to manage the natural world, we instinctively try to maximize all the fish that matter most to us. We want a Bay full of stripers *and* a Bay full of menhaden. But that may not be an option.

Data from the Deeps — and the Shallows

Bob Wood didn't always get seasick on boats, but when he did, he toughed it out.

Like most graduate students in fisheries science, he had to take his turn working the trawl surveys that the Virginia Institute of Marine Science has been running every year since 1955. Unlike most students, he didn't love being out on boats.

Summer trips were usually the worst for Wood, a tall slender student with dark hair, a dark beard, and a delicate stomach. When the trawl boat would make a haul down near the mouth of the Bay, the deckhands would dump the catch on the big, sloshing culling table, and Wood would go to work sorting fish — with ocean swells rolling under the boat, with diesel fumes hanging over the deck, with jellyfish tentacles slapping at his face. Picking through the flopping fish, he'd try to figure out which were larval anchovies or alewives, yellow perch or white perch, which were white mullet, satinfish shiner, bigeye scad, or bighead sea robin.

When it got bad, he'd go over to the side of the boat and throw up. Then he'd lie down on the deck, summer or winter, and wait until the next trawl was done. When the net came up, he'd scramble up and take his place at the table again. He always went back to the table. When it got worse, when he got dehydrated and went greenish in the face, the captain put him ashore. He left him on a dock down near Norfolk and called the lab to come pick him up. This only happened once, but it made Wood a legend around the lab.

Back in his office, however, grinding away on his dissertation, Wood learned to love the rich load of fish data the trawl survey hauled home. The survey hit all the salinity levels of the estuary, covering the lower Bay, motoring up to the freshwater reaches of its large rivers, and recording all the fish species it caught: who's coming on strong, who's not, who's looking healthy, who's looking sick. Begun in 1955, the VIMS survey is now the oldest ongoing trawl survey in the country. It hits 1,224 stations a year and over the decades that adds up to more than 240 species, 41,000 net hauls, and 20 million fish samples.

Up and Down
Striped Bass
Morone saxatilis

Duane Raver

Striped bass inhabit coastal waters and are commonly found in bays but may enter rivers in the spring to spawn. Some populations are landlocked. The U.S. East Coast migratory population is composed of three major stocks: Hudson, Chesapeake, and Roanoke.

Distribution: On the Atlantic coast, these fish range from the St. Lawrence River, Canada, to the St. Johns River, Florida, although they are most prevalent from Maine to North Carolina.

Key distinguishing markings: The striped bass is a silvery fish that gets its name from the seven or eight dark, continuous stripes along the side of its body.

Size: Striped bass can grow as long as 60 inches.

SOURCE: MARYLAND DEPARTMENT OF NATURAL RESOURCES

Wood also had fish data from the shallows of the Bay. Both Maryland and Virginia had long-running net seine surveys designed to trap young stripers swimming near the shore. Maryland began its survey back in 1954, Virginia in 1967. Both states focus on striped bass, the Bay's most popular gamefish and, for decades, one of its most profitable commercial catches. But in each state the surveys collect data on dozens of other species as well.

Data from the deeps and data from the shallows, piling up decade after decade. The key questions, the *raisons d'être* for all the surveys were these: who's having a good year for offspring, who's having a poor year, and what does that tell us about how many fish are coming next year?

The Seesaw Signal

How many striped bass could be coming next year has befuddled scientists for decades. Their sudden and unpredictable boom years can turn out twice as many offspring as the year before, sometimes three times as many, sometimes 10 times as many. More than 30 years ago, biologists Don Heinle and Joe Mihursky came up with a clue: cold, wet winters bode well for a striped bass boom year.

Bob Wood came at the issue from a different angle. Before he was a fisheries scientist, he was a climatologist who spent a lot of time looking at huge, noisy data sets jammed with multiple variables. If certain weather patterns brought on boom years for stripers, perhaps those same patterns were also bringing boom years for other species at the same time. "I thought the patterns in nature are not one fish at a time," says Wood. "If there is an environmental signal, it is probably not going to pick out a single fish."

To probe all his data, Wood tried a statistical technique called Principal Component Analysis. Designed to dig out patterns buried in the data, this analytic tool uncovered an unexpected connection: whenever fish that spawned in the Bay did well, fish that spawned in coastal waters did poorly. And vice versa: whenever coastal spawners did well, Bay spawners did poorly.

Wood discovered another surprise in the data: these patterns lasted for several decades. Boom years for stripers, for example, seemed to come in bunches, and so did bust years. And the pattern affected a lot of fish: The Bay spawners include species like alewives, blueback herrings, white perch, yellow perch, shad, and, of course, stripers. The coastal spawners who come in from the continental shelf include spot, croaker, hardhead, weakfish, drum, and, of course, menhaden.

"I did not expect to see what I saw," says Wood, who quickly gave his discovery a name: the CBASS recruitment pattern, short for Chesapeake Bay Anadromous, Shelf-spawning Species. That's a mouthful, perhaps helpful to scientists. It's a Chesapeake seesaw: when one fish group goes up, the other goes down.

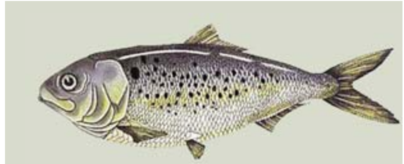
Was the seesaw signal real? His finding was so unexpected Wood went back to the table again, searching through other data sets, looking for more evidence of the seesaw pattern. Baltimore Gas and Electric Company, for example, had records of how many fish were sucked into their intake pipes at the Calvert Cliffs Nuclear Plant. For that data Woods had to pull mildewed paper reports out of old file cabinets in a musty basement and then copy the data by hand, a job he managed to find fascinating. "I actually got to see the pattern emerge, watch it grow and develop," he says. And wherever he looked, in every data set he surveyed, the same seesaw appeared: when Bay spawners go up, coastal spawners go down — and vice versa.

His big surprise set him off on another search: what could be causing these alternating ups and downs? His first instinct was to look for some kind of climate force just as Don Heinle, Joe Mihursky, and others had done decades before. They tied boom years for stripers to cold, wet winters and late springs. The melting of ice and snow, they suggested, helped scour more detritus off the land, feeding the zooplankton that in turn feed tiny, newly spawned stripers. Timing is crucial: if that surge of water and food comes late and lasts deeper into spring, then plenty of food will be in the rivers just when stripers are spawning. Survival chances for their offspring can skyrocket.

For Wood, weather patterns were only a starting point. His inner climatologist told him there might be larger climate forces that create cold, wet winters and late springs. The key, he suspected, could be regional patterns in atmospheric pressure, always measured as pressure at sea level. "You can interpret everything from sea-level pressure," says Wood. Pressure fronts create huge air masses and move them around. They tell the wind which way to blow, they send us low-pressure zones that bring gray skies and big storms, they give us high-pressure zones that bless us with calm sunny weather. They could also be bringing us boom and bust years for fish species.

Wood had to go trawling again, this time in a sea of climate data. He hauled up records of regional sea-level pressures

Down and Up
Menhaden
Brevoortia tyrannus



Maine Department of Marine Resources

Atlantic menhaden are one of the most abundant fish species in estuarine and western coastal Atlantic waters. Native Americans in pre-colonial America called the fish "munnawhatteaug," which means, "fertilizer," and menhaden are probably the fish that the indigenous tribes urged the Pilgrims to plant along with their corn.

Distribution: Nova Scotia, Canada, to Central Florida.

Key distinguishing markings: Menhaden are silvery in color with a distinct black shoulder spot behind their gill opening. They also have a variable number of smaller spots on their sides. Their caudal (tail) fin is deeply forked.

Size: The maximum size of Atlantic menhaden is approximately 15 inches.

SOURCE: MARYLAND DEPARTMENT OF NATURAL RESOURCES

during every spawning day for 32 separate springtime Bay spawning seasons. It was another climatology approach never tried before in fish-stock studies. And it paid off. Wood was able to identify two regional pressure patterns, the Ohio Valley High and the Azores-Bermuda High, that seemed to control boom years and bust years for stripers and other Bay spawners.

If the Ohio Valley High dominates the mid-Atlantic during March, then the seesaw lifts Bay spawners. Cold and wet winters last longer, loading the rivers with more food for new fish. But if the Azores-Bermuda High shifts westward and dominates the Mid-Atlantic during March, then the seesaw lifts up coastal spawners. A warm, dry spring arrives early, setting up wind patterns that help carry more menhaden and coastal fish across the continental shelf and into the Bay.

This Chesapeake seesaw pattern was his first discovery, and it paid off in other ways: a Ph.D. in 2000, a post-doctoral appointment at the Chesapeake Biological Laboratory, then fairly quickly a job with the NOAA Chesapeake Bay Office. Shortly thereafter he was appointed director of NOAA's Cooperative Oxford Laboratory. It was an amazing rise, said another scientist. Wood was a graduate student sorting fish on trawl surveys, and four years later he was in charge of a federal marine research laboratory.

Amid his fast rise, however, big questions still lingered about his research. The Ohio Valley High and the Azores-Bermuda High seemed to be driving those fish populations — but what was driving those regional climate patterns? The big fish was still out there.

The Roller Coaster

In the year 2000, Bob Wood got his doctorate and the Atlantic Multidecadal Oscillation (or AMO) got its name. This ocean cycle brings several decades of warming waters followed by several decades of cooling waters in the Atlantic basin. A dozen years after it was named, the AMO remains loosely described and its effects widely debated.

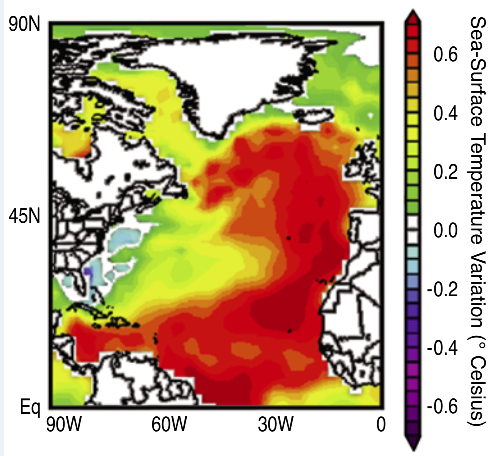
The temperature swings can be small, but the cycle seems to have far-reaching effects. An earlier warm phase of the AMO has been tied to the Dust Bowl of the 1930s and the droughts of the 1950s. Since the early 1990s, the AMO has been in a warm, positive phase — and we've seen twice as many big hurricanes, including Isabel, Ivan, Katrina, and Sandy. We've also seen some boom years for new stripers.

When Bob Wood began reading about the AMO, his inner climatologist came alive again. "When I saw that it had cycles, I said 'Wow!' Then I looked at the statistical correlations," he says, "and it was amazing." The recent ups and downs of the AMO seemed to correlate with the ups and downs of fish populations in the Chesapeake.

Proving an AMO connection, however, took some more digging. Wood's fish data went back 60 years, but the data on the AMO ocean temperatures goes back 150 years, with some tree ring studies tracing the AMO some 400 years into

The Highs and Lows behind Boom and Bust Years for Chesapeake Bay Fish

Fish populations are driven, in part, by regional-scale weather patterns, and those patterns are driven, in turn, by larger-scale climate forces with daunting names like the Atlantic Multidecadal Oscillation, the North Atlantic Oscillation, the Azores-Bermuda High, and the Ohio Valley High.



The reddish zones above indicate the areas where sea-surface temperatures fluctuate during the AMO cycle. This map shows a warm phase.

SOURCE: NOAA EARTH SYSTEM RESEARCH LABORATORY

The Atlantic Multidecadal Oscillation (AMO) is the natural cycle of long-term changes in sea-surface temperatures in the North Atlantic basin. Decades of warmer waters in the basin alternate with decades of cooler waters. Each warm phase can spread over thousands of miles (see red area in map at right), and it can last 20 to 30 years. And each cool phase can last that long and spread that far, creating a cycle lasting 65 to 75 years. The temperature difference can be quite small, less than 1 degree Celsius between a high point and a low point in the cycle, but that small difference can have huge effects on climate forces. The AMO interacts with regional air-pressure patterns to affect seasonal weather patterns, creating good years and poor years for fish reproduction.

The North Atlantic Oscillation (NAO) describes changes in the atmosphere above the Atlantic Ocean, changes that may cause or result from changes in sea-surface temperatures. The atmosphere near Iceland features a permanent low-pressure region that interacts with a permanent high-pressure region near the Azores Islands, creating a pressure gradient that affects other regional weather patterns. When the difference between these regions is great (when the Icelandic Low is really low and the Azores High is really high), the results include stronger westerly winds, colder and drier weather over the northwestern Atlantic, but warmer and wetter weather in northern Europe, parts of Scandinavia, and the eastern United States.

The Azores-Bermuda High, as its name suggests, is a high-pressure system that migrates back-and-forth between the Azores Islands in the eastern Atlantic and Bermuda to the west. From January to June it migrates westward and usually dominates coastal weather in the Mid-Atlantic during summer months. When it arrives early, the result can be warmer, drier, calmer weather and wind patterns that help newly spawned fish move from coastal waters into the Bay.

The Ohio Valley High is a persistent high-pressure system over the eastern United States. In certain years, it can prolong winter conditions in the Mid-Atlantic, resulting in more rain and snow and runoff, thereby improving chances that the offspring of Bay-spawning fish will find more food in the rivers.

the past. To extend his fish data, Wood went to fishing reports in old newspapers and anecdotes in histories of defunct sportsmen's clubs. His breakthrough, however, was close at hand. On the library shelves at his own Oxford laboratory, he turned up an old book, published in 1964, that listed all the U.S. fish harvests all the way back to the 1880s.

That gave an opening for Wood to figure out how many new fish were entering the estuary in decades past. Before long he had striper and menhaden data stretching back 120 years. In his new data he found his old seesaw pattern: when stripers were up, menhaden were down.

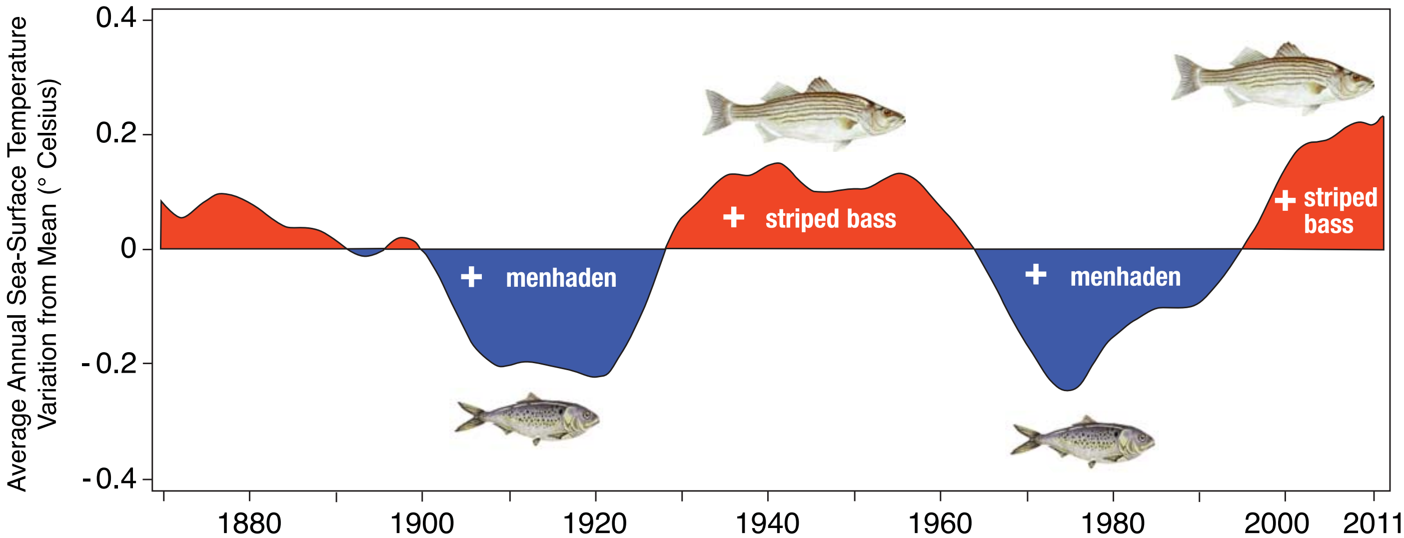
And in the AMO records, he had his teleconnection. Striper numbers were rising during warm decades of the AMO and sagging during cool decades. And menhaden were doing the opposite. It was the AMO that seemed to be driving the Ohio Valley High, the Azores-Bermuda High, and the fish populations of the Chesapeake Bay. "For 30 to 35 years, things will start getting better and then go down again," says Wood. "And then we'll start the roller coaster ride all over again. You go up the hill and down the hill, up the hill and down the hill" (see graph, opposite page).

What Wood finally produced was a big-picture theory, a picture that can be pretty "fuzzy," he admits, but one that carries a good deal of explanatory power. During a warm phase, air masses off the ocean collide with cold fronts off the land, and the clash creates winter coastal storms. Nor'easters, sometimes called "white hurricanes," pull moisture off the ocean, creating late-winter rain and snow across the Chesapeake watershed. The end result during springtime snowmelt and runoff is higher river flow, more fish food in the rivers during spawning, and an expanded nursery zone for tiny new stripers. Voilà, a boom year for stripers.

A boom year is not the only benefit: the AMO can bring boom decades. Since the AMO's current warm phase heated up in the early 1990s, striper counts in young-of-the-year surveys have jumped strongly in five years — with fewer bust years in between. They shot up in 1993, a year that brought a heavy mid-March snow storm in the Mid-Atlantic region. They shot up after the blizzard of 1996, after the President's Weekend storm of 2003, and once more after the late January blizzards of 2011. We'll see what the "Snowquester" storm of March 2013 yields.

Wood's theory can't tell you whether next year will bring a lot of stripers. "The AMO is a general tendency," says Wood. It can tell you the probability that a warm decade will bring more big storms and those storms will bring more boom years for stripers.

The Effect of the AMO on Striped Bass and Menhaden Reproduction



Stripers and menhaden ride the roller coaster: *the Atlantic Multidecadal Oscillation (AMO) is an ongoing series of long-duration rises and drops in sea-surface temperatures in the North Atlantic as measured against a mean sea surface temperature (designated above as zero on the vertical axis). Several decades of warmer waters (red zones above) will be followed by several decades of cooler waters (blue zones above). Instrument-based evidence for the AMO goes back 150 years, but studies of paleoclimates find the AMO signal reaching back 400 years. Research by Bob Wood (illustrated in this graph) suggests that the warm phase also brings more frequent jumps in striped bass reproduction, while the cool phase brings better years for menhaden reproduction.* *SOURCE: MARYLAND SEA GRANT FIGURE USING AN AMO GRAPH PLOTTED WITH DATA ON SEA-SURFACE TEMPERATURES DEVELOPED BY ALEXEY KAPLAN ET AL. (ADJUSTED TO REMOVE WARMING ASSOCIATED WITH HUMAN ACTIVITIES)*

And it can tell you why good years for stripers can lead to poor years for menhaden. All those storms and wind patterns that supply food for stripers can scatter the offshore larvae of menhaden and other coastal spawners, making it more difficult for them to move off the ocean and into the estuary.

When the AMO shifts into a cool phase, menhaden do much better. Cooler temperatures create frequent high-pressure fronts, leading to fewer storms, calmer weather, and easier passage for fish moving out of shelf waters and into the estuary. The menhaden picture is still fuzzy, in part because it's difficult to monitor the offshore migrations of all those shelf-spawning fish. "I'm not sure we've nailed down how most of these critters make it into the Bay," says Wood. That will take a lot of old-fashioned, on-the-water sampling cruises out in the rolling waters of the coastal ocean. Wood has no plans to be aboard.

The Downhill Ride

If Bob Wood is on the right track, then fisheries managers in Maryland and Virginia will have to rethink their options. The current warm phase of the AMO gave us a good run of boom years, but that run may be winding down. According to several reports, the warming seems to be waning, turning downhill towards a relatively cooler phase. The Chesapeake may soon see fewer boom years for stripers.

And a lot of fisheries scientists, at least, think Wood is on the right track. The AMO, nearly unknown a decade ago, is drawing a lot of attention in recent years, according to Ed Houde, a prominent fisheries biologist at the Chesapeake Biological Laboratory. "It's a powerful factor that influences fish production, particularly the reproductive dynamics of fish," says Houde. "And Bob's work is probably the best of it here in the Chesapeake region."

Wood is no Cassandra crying doom, he is a scientist trying to forecast the future and he hopes managers will listen. To preserve striper populations, fisheries managers will not have as many boom years to boost fish stocks. But they will have options.

One of them, if you buy Wood's theory, would be reducing fishing pressure on stripers fairly early. That option does more than avoid collapse. Boom years can still pop up during the cool era — albeit less frequently — and keeping a good number of stripers in the spawning rivers can magnify those year classes. And there may be more menhaden around for stripers to feed on.

"We want to get back to this ideal good time with lots of striped bass and lots of menhaden," says Wood. "When you were a kid, your father caught all those fish. And when you grow up, you expect even more of that. The answer is: it may not be obtainable."

Trying to get the both of best worlds at the same time, a Bay full of stripers and a Bay full of menhaden, sounds a lot like old-fashioned hubris. You remember hubris: in the old Greek dramas that was always the fatal flaw. That's what got the gods laughing.

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Discovering the Chesapeake: Profiles in Science

THE OYSTER DREAMS OF W.K. BROOKS

Could science save a seafood industry?

Michael W. Fincham

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

In May 1879 a young biologist boarded a steamboat in Baltimore and headed for the Eastern Shore town of Crisfield, Maryland. He hoped to spend the summer figuring out how oysters in the Chesapeake Bay managed to make baby oysters. There were French and German theories about oysters that he wanted to test. And there was also a hope that science could help save a Maryland oyster industry that was facing its first major crisis.

William Keith Brooks was only 30 years old, a short and stout man who often needed a haircut and probably arrived in Crisfield still sporting the bushy brown beard he grew back in graduate school at Harvard. His employer, the Johns Hopkins University, was only three years old, a privately funded school designed to focus on research and graduate studies. For the biologist and his new university, this summer research foray would be a chance to make names for themselves. It would also be the first effort to apply academic science to managing the fisheries of the Chesapeake Bay.

Within two days of his arrival in Crisfield, Brooks would use a simple watch glass and his ever-present microscope to make a discovery that would bring him both fame and notoriety in Maryland. His findings — and his advocacy for those findings — would raise hopes that oyster harvests could be increased a hundredfold in the Chesapeake Bay. There was a snag, of course, a large snag: under the 1884 Brooks plan oyster fishermen would have to give up more space in the Bay for oyster farmers. His plan, after kicking off 130 years of debate, is now getting its first large-scale test in Maryland waters.

***As a student, William K. Brooks** studied at Harvard with Louis Agassiz, the Swiss scientist who became one of the founding fathers of the modern scientific tradition. As a biologist on the faculty of the Johns Hopkins University, Brooks became the first great oyster scientist in America and an early (and unsuccessful) advocate for oyster farming in Maryland waters.*

CREDIT: COURTESY OF THE JOHNS HOPKINS UNIVERSITY

The crisis that brought Brooks to Crisfield in 1879 was the recent drop in oyster harvests in the Chesapeake Bay. In the decades after the Civil War, those harvests exploded as watermen discovered huge oyster reefs in Tangier and Pocomoke sounds, and the transcontinental railroads opened new markets in the west. Tongers and dredgers were soon battling each other to mine those new oyster reefs, and both groups were battling the Maryland Oyster Police. During this ongoing scramble, Maryland harvests rose from three million bushels a year in 1861 to 14 million bushels in 1874.

Then came the big slump, the first of many: by 1879, the annual harvest dropped from 14 million to 10 million bushels. Ten million bushels would be a bonanza today when annual harvests usually hover around one percent of that, at 100,000 bushels, but oyster entrepreneurs of the 1870s thought the seafood industry had gone over a cliff.

Could science save this seafood industry? The head of the Maryland Fish Commission hoped so, and he invited Brooks to bring his graduate students from Johns Hopkins down to Crisfield and set up a summer research camp in the heart of oyster country. The year before, Brooks had organized his first summer camp, calling it the Chesapeake Zoological Laboratory and basing it down at the mouth of the Bay. To entice Brooks to Crisfield, the Maryland fish commissioner outfitted his team with a steam yacht equipped for dredging oysters and provided three barges that his team could use for both lodging and lab facilities.

One science question Brooks hoped to answer was: how do oysters reproduce? According to several French and German researchers, oyster eggs were fertilized within the shell of female oysters, and the embryos stayed safe inside long enough to develop tiny shells. Brooks had begun testing that theory during the previous summer camp down at Fort Wool, Virginia. He spent much of his time that session prying open oyster shells without ever finding a single baby oyster lingering in the shell of a single female oyster.

At Crisfield he tried a new approach. On May 21,1879 he opened a dozen oysters and identified three females filled with eggs and one male ready with ripe sperm. Scraping out the eggs and sperm into a watch glass, he tried mixing them together. And then he set up his microscope. Within two hours, he could see that sperm was fertilizing the eggs floating in the watch glass. "Nearly all my eggs," he wrote, "had been started on their long path toward the adult form."

His finding was revolutionary. Oyster babies were not born inside the shell of females as described by French and German biologists. With the American species, females released their eggs out into the water where, if they were lucky, they met up with sperm released by male oysters. The tiny oyster offspring that emerged out of these meetups then had to survive on their own in the water: there would be no safe harbor inside a mother's shell. "The young of our oyster," wrote Brooks, "swim at large in the open ocean."

The scientific importance of his findings was recognized immediately. A German journal quickly published his science paper. A French scientific society gave him a medal. And in this country, journalists decided the Chesapeake oyster showed truly American traits. Our oyster was "more adventurous" than the European species, wrote one observer. It was more "independent," wrote another. "It refuses to be tied to its mother's apron strings," said a third.

His discovery, it now seems, was an example of a classic paradigm shift in scientific theory. A paradigm is generally defined as a set of unexamined assumptions underlying an accepted theory, assumptions that affect the way scientists see — or fail to see — evidence right in front of their eyes. Boxed in by a preexisting theory about European oysters, Brooks kept looking for evidence in the wrong place. Only when he began thinking outside the box — or in this case outside the shell — did Brooks make his breakthrough.

Paradigm shifts can be painful.

"Learn to draw," *Brooks told his students. In the era before microscopic photographs, Brooks drew what he saw under the microscope or what he dissected on his lab table. He created stunning and detailed illustrations of numerous species. The drawing above shows the internal anatomy of an oyster, including the hinge, the hinge ligament, the muscle, the pericardium, the gills, and the lips.* CREDIT: DRAWING FROM THE OYSTER, BY W.K. BROOKS, © THE JOHNS HOPKINS UNIVERSITY, USED WITH PERMISSION

Brooks still had difficulty in believing what he was seeing. Before publishing his findings, Brooks spent much of his time in Crisfield trying to disprove his own discovery. After opening more than 1,000 oysters without finding a single baby inside a mother oyster, Brooks finally announced, "I have accumulated enough evidence to show beyond the possibility of doubt that eggs are fertilized outside the body of the parent."

In Maryland his discovery raised hopes for huge oyster harvests in the future. Each female oyster, according to his estimates, could release millions of eggs, and Brooks could usually fertilize 98 percent of the female eggs in his watch glasses and tumblers. Science would still have to solve a number of technical problems before oyster culture could take off, but Brooks believed, rightly so, that they were solvable. "These investigations," said Maryland's fish commissioners, "have placed it within our power to multiply the oyster to an indefinite amount."

Because of his fame the General Assembly asked Brooks to lead the Oyster Commission of the State of Maryland, an effort to investigate an industry suspected of overfishing the state's oyster reefs. His university gave him paid leave, and Brooks went to work trying to apply his biological findings to reorganizing a rambunctious oyster fishery.

The result was his in-depth commission report on the problems and potential of the oyster industry in Maryland. According to Brooks, most of the problems stemmed from overfishing of the natural bars, and most of the potential lay in the expansion of oyster farming. To protect the existing oyster bars, Brooks recommended a series of steps: halting harvests during the breeding season, setting size limits, returning small oysters to the reefs, and dumping shucked shell back in the Bay to create a base where new oysters could settle. If applied, these would have represented first steps towards scientific management of the Bay's wild fishery.

But Brooks had a bigger dream. He wanted to apply the new understanding of oyster biology in ways that would unleash the hidden bounty of the Bay. The state should lease out tracts of the Bay bottom, he said, allowing large private oyster farms in the deeper waters and smaller plots along the shoreline. The payoff, he promised, would be huge: while the sales from oyster fishing brought in $2 million a year in 1880 dollars, the harvest from farming could bring in hundreds of millions, and the tax revenues, he estimated, could pay most of the cost of state government.

It was a bold plan, but it was immediately bedeviled by bad timing. Brooks published his final report of the oyster commission in 1884 — but the next year brought a harvest of 15 million bushels, the highest total in history. The state had called upon Brooks, hoping his science could save the oyster fishery, but the problem seemed to have solved itself without his science and without his farms. So said his critics, and they were numerous and politically powerful.

Brooks, however, kept pushing hard for his plan. His friends described Brooks as quiet and thoughtful — "the shyest man in Baltimore," said one — yet he quickly launched himself into the middle of a heated policy debate. He may, in fact, have been the first Maryland scientist to step beyond the traditional role of academic researcher when he became an advocate for oyster farming and for science-based management of the traditional fishery. To reach non-technical audiences, he wrote articles for *Popular Science Monthly*, and in 1891 he published *The Oyster*, a popular summary that laid out in layman's language the biology of the oyster and the potential of farming.

Despite his advocacy, Brooks would see little progress toward oyster farming in his lifetime, even as his prophecies of long-term declines for the wild fishery began coming true. Within five years of his report, the harvest was down to a third of its historic high, but the General Assembly made no move to encourage farming. Anti-leasing forces would manage to cripple every pro-farming initiative attempted, both through political power and poaching, not just during Brooks's era but during the next 130 years.

Why didn't oyster farming catch on in Maryland? In her 2009 book, *The Oyster Question*, historian Christine Keiner suggests that Brooks misread the culture of Tidewater communities and underestimated their political power. His advocacy for private leasing set up an inevitable clash with long-standing beliefs of watermen, and it was a clash he was bound to lose. Watermen held that the oyster grounds were a commons open to all, an idea reaching back to the Magna Carta. Oyster farming, according to Brooks's various critics, was "a monstrous proposition," a conspiracy between "the scientific fraternity" and corporate cartels, a conspiracy that would privatize the public commons and reduce watermen to wage slaves.

In pushing their beliefs, Maryland watermen had political power that reached far beyond their population numbers. Each county in the state had one senator in the General Assembly, and in Maryland that meant the many Tidewater counties, though sparsely populated, could easily outvote the urban areas and the nontidal counties.

His ideas outlived his enemies, especially his belief that science should be applied to managing the oyster fishery.

There's a sad irony in Brooks's career. His discovery in the summer of 1879 raised hopes that science could help save the oyster industry, but the leasing debate may have derailed the first efforts to apply science to the task of managing the traditional oyster fishery. As harvests continued to slide, the state legislature began adopting some of his recommendations — but slowly and only over the objections of watermen who remained politically powerful and distrustful of scientists. By the time the legislators acted, the horse was already out of the barn. According to the *Baltimore Sun*, the great reefs were being strip-mined by 8,000 tongboats and 2,000 dredge boats. During Brooks's lifetime, much of the Bay's original oyster stocks were removed.

The loss of the great reefs did more than devastate the economy of the Tidewater region: it also altered the ecology of the Chesapeake ecosystem. Oysters, we now know, played a major role in the ecology of the Bay, filtering out much of the algae and plankton that now cause annual dead zones of low or no oxygen. Compounding the catastrophe were two disease epidemics that arrived in the 1960s, further depleting the already depleted reefs. One hundred years after Brooks published his book, oyster stocks were down to less than one percent of their historic numbers.

For the rest of his life Brooks would remain an advocate of oyster farming, but he focused most of his academic research on basic morphological studies of other marine species, including tunicates, brachiopods, arthropods, and coelenterates. In his last years, his writings turned to philosophical and metaphysical topics that many of his own students found obscure. In 1908, at the age of 60, he died after a nine-month struggle with congenital heart problems that had burdened him all his life.

His ideas, however, outlived his enemies. Perhaps most important was his belief that science should be applied to managing the oyster fishery. Cull limits were introduced, seasons were established, shell return was encouraged. Enforcement became more aggressive. Science-based management is now the stated goal for the state agencies that regulate all the Bay's fisheries.

Another idea that survived was his belief in waterside marine labs. His Chesapeake Zoological Laboratory, created as an annual summer camp, was the first laboratory to focus some of its energies on the Bay. That makes it the forerunner for the half-dozen marine research labs that now perch along the shores and rivers of the Bay. And along the Choptank River, the Horn Point Laboratory operates a hatchery that usually spawns half a billion disease-free oysters a year, applying in large scale the basic biology that Brooks first worked out with his watch glass and microscope.

Brooks's dreams about oyster farming would also survive. In 2010, the governor of Maryland — on the advice of yet another oyster advisory commission — announced major plans to encourage oyster farming in the waters of Maryland's Chesapeake Bay. New legislation removed long-standing legal blocks to private leasing of Bay bottom and established new oyster sanctuaries carved out of the traditional harvest grounds of the wild fishery. And more than a century after Brooks died, the state of Maryland began to organize new workshops to train watermen on how to finally become oyster farmers.

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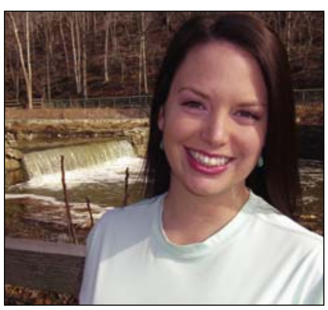
Knauss Fellows in Maryland for 2013

Maryland will support four Knauss Marine Policy Fellows in 2013 to work for federal agencies on issues involving marine and coastal resources. The fellows, all of whom studied at the University of Maryland, will focus on topics such as the Deepwater Horizon oil spill, fisheries, and international affairs.

Jennifer Bosch is spending her fellowship year in the Office of Laboratories and Cooperative Institutes at the National Oceanic and Atmospheric Administration (NOAA). She plans to collaborate with researchers and decision makers to help them create policies and other tools to solve environmental management issues.

As a doctoral student in marine ecology and environmental science at the University of Maryland, she has studied the biogeochemistry and ecological impacts of the Chesapeake Bay's low-oxygen regions or "dead zones." She is analyzing shifts in benthic invertebrate community structure and consequences for nutrient cycling processes.

As an undergraduate and later a marine scientist at Rutgers University, she developed and ran a satellite data system about sea-surface temperatures that remains widely used by scientists and commercial and recreational fishers.



Nicole Bransome is the inaugural Knauss fellow for the Department of the Interior's Ocean, Coasts, and Great Lakes Coordination team. As a policy and communications specialist, she will coordinate Interior's work on oceans across the department's bureaus and with federal partners.

Bransome is pursuing a master's degree in the Marine Estuarine Environmental Sciences program at Maryland. For her thesis, she is modeling restoration of diadromous river herring in Maine and the resultant potential recovery of their groundfish predators, like Atlantic cod.

Originally from Maryland, Bransome found a passion for marine science while volunteering with National Park Service biologists on studies of tidepools in San Diego. She also spent a year working for AmeriCorps in the Maryland Park Service.

Carrie Soltanoff is serving in the National Marine Fisheries Service Office of International Affairs at NOAA. Her portfolio will include shark and Atlantic tuna conservation, bycatch reduction, and regulation of foreign fishing vessels. She will produce

briefing materials and policy papers for meetings and negotiations on international issues.

Originally from upstate New York, Soltanoff completed a master of science degree in the Sustainable Development and Conservation Biology program at Maryland.

She served as a Peace Corps volunteer for two years in Ecuador, where she conducted work for her thesis about shifting environmental baselines among fishermen — the idea that each generation of fishermen has a distinct view of the current state of fish populations — and the implications for management of a marine reserve.

Metthea Yepsen is working in NOAA's Restoration Center in the Office of Habitat Conservation as a policy and science coordinator on the office's Deepwater Horizon oil spill restoration efforts. She will assist in ensuring that science and adaptive management are integrated into restoration initiatives.

Yepsen received an M.S. degree in environmental science and technology from Maryland with a focus on wetland ecology and restoration. For her thesis research, she worked on a U.S. Department of Agriculture project to evaluate the effectiveness of federal wetland conservation practices and restoration in agricultural areas. To measure ecosystem services provided by wetlands, she compared plant communities in natural, restored, and farmland sites in several Mid-Atlantic states, including Maryland.

Yepsen completed a bachelor's degree in the humanities, studying diplomatic history. Her career path changed when she joined AmeriCorps in Hawaii, where she peformed conservation work. Those experiences sparked an interest in a career in environmental 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 Washington, D.C. 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

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Marcellino Retires as Administrative Director

Bonny Marcellino, assistant director for administration at Maryland Sea Grant, has retired after 15 years of service.

Marcellino's tenure was marked by several initiatives to modernize the administrative systems that enable Maryland Sea Grant to support research, education, and outreach about coastal resources. Under her leadership, the program was an early adopter of new tools in electronic systems and grants and data management.

For example, Marcellino worked closely with our IT and research staff to develop software for online proposal development, submission, review, and approval that was heralded for its innovation in the Sea Grant network. In addition, Marcellino's success in electronic management was nationally recognized and led Maryland Sea Grant to be one of a handful of programs selected by NOAA to test a beta version of a new evaluation tool, which evolved into the agency's National Information Management System (NIMS) and later the Planning, Implementation, and Evaluation Resources (PIER) system.

"She was innovative and a terrific administrator, one of the finest I've worked with across many different jobs," said Fredrika C. Moser, director of Maryland Sea Grant. "We will miss her expertise and professionalism and the critical role she played in grants management for our program."

Allen Is New Assistant Director for Research

Maryland Sea Grant has named Michael Allen as its new assistant director for research. Allen, who served since 2012 as the college's research and education coordinator, will bring years of experience as a research administrator and freshwater ecologist to the position.

Allen will oversee the management of Maryland Sea Grant's diverse research portfolio, which includes studies to better understand the dynamics of the Chesapeake Bay and its watersheds and the sustainable use of Maryland's natural resources.

He will also manage the college's graduate research fellowships and its summer research program for undergraduates, Research Experiences for Undergraduates (REU). Each year the REU program places promising undergraduate students from across the country in research labs on the Chesapeake Bay to work with scientist mentors to design and conduct their own research projects.

Allen hopes to expand Maryland Sea Grant's outreach to undergraduate and graduate students, particularly to people who traditionally have been underrepresented in the marine science community, such as women and members of minority groups.

Before joining Maryland Sea Grant, Allen worked in two positions at the U.S. National Oceanographic and Atmospheric Administration (NOAA). As a Sea Grant Knauss Marine Policy Fellow, he served as an analyst for the agency's Office of Laboratories and Cooperative Institutes. Later he worked as a contractor in the agency's Office of Planning, Policy, and Evaluation. He developed national research policies and programs for the agency and coordinated a 150-person workshop in Florida to explore the science behind the devastating Deepwater Horizon oil spill.

Allen received his Ph.D. in ecology, evolution, and conservation biology from the University of Illinois Urbana-Champaign in 2009.