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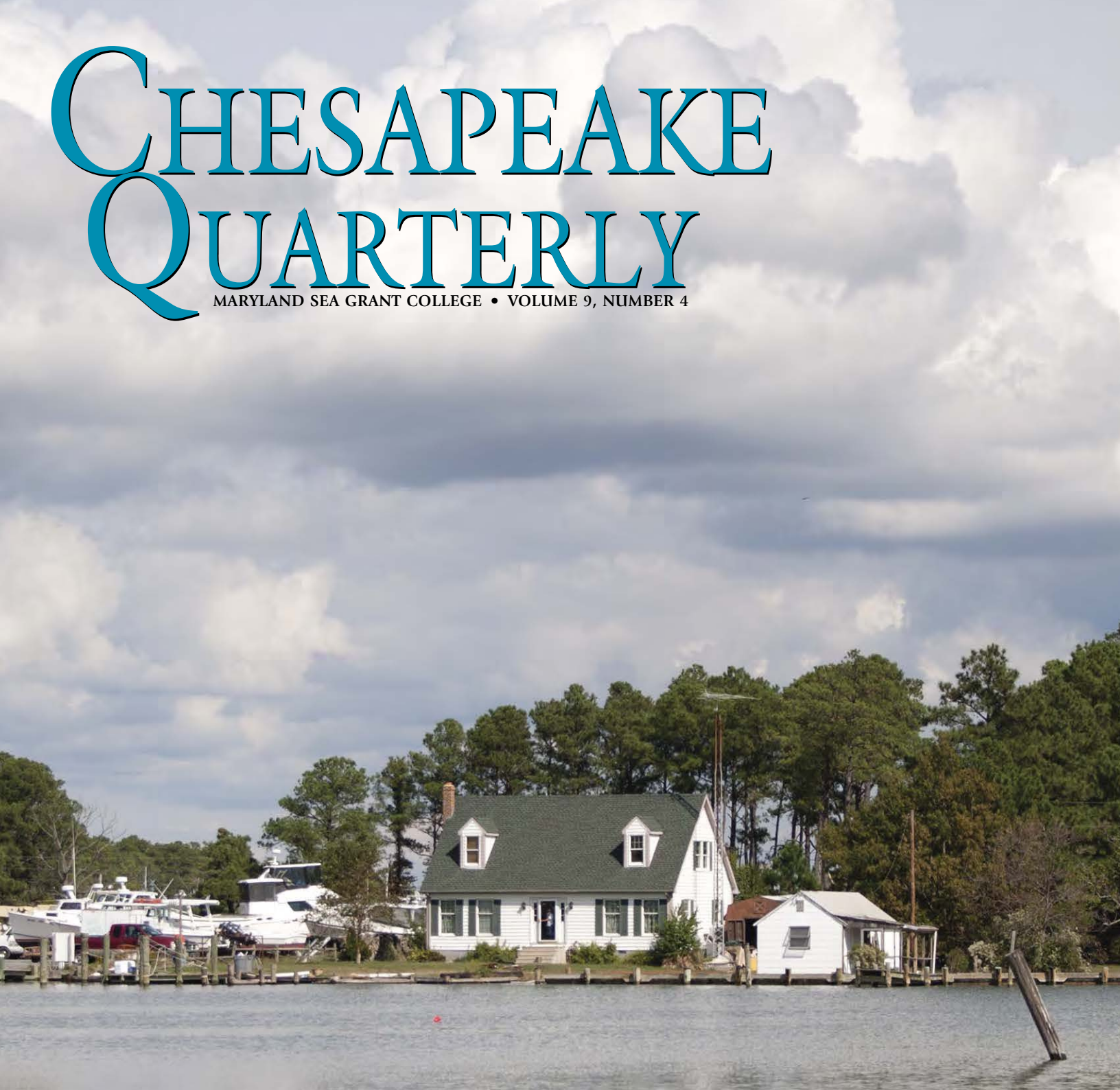

Ready for Rising Waters?

contents

CHESAPEAKE QUARTERLY *December 2010*

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

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Cover photo: *In the low-lying area of Maryland's Eastern Shore, houses on Hooper's Island are especially vulnerable to rising sea levels. After heavy rains and higher than average tides, water can pool in front yards and make impassable the one road that bisects this narrow sliver of land.* PHOTOGRAPH BY ERICA GOLDMAN. ***Above:*** *The Lincoln Memorial seen from the reflecting pool on the National Mall.* PHOTOGRAPH BY MICHAEL W. FINCHAM.

Down by the Levee

The nation's capital is not New Orleans. Washington, D.C., stands along the banks of the Potomac River, not the Gulf of Mexico. As with the city of New Orleans, however, part of Washington went underwater during past hurricanes. To keep it above water in the future, the city will start building new levees and a storm wall on the National Mall in hopes of keeping the Potomac River out of downtown D.C.

After the flooding of New Orleans from Hurricane Katrina, officials with the Federal Emergency Management Agency (FEMA) began re-examining its floodplain maps for Washington to figure out how the city could be protected from larger floods in the future. The dilemma facing Washington is familiar to state and local planners in the Tidewater regions around the Chesapeake as they have to redraw floodplain maps to allow their communities to participate in the National Flood Insurance Program (NFIP).

While the Washington wall is not a solution for the Tidewater — nobody is going to build a storm wall around Dorchester County — it's a handy symbol of the problem. Low-lying regions are at greater risk from future storm surges and flooding — thanks to global warming. And planning for those risks calls for tough tradeoffs. After all, city planners don't see a storm wall in the shadow of the Washington Monument as a wonderful aesthetic addition to the National Mall. But $9 million for a storm wall could avoid $200 million for damages to museums, memorials, and office buildings. Homeowners in the Tidewater aren't happy about hoisting their houses above a newly defined floodplain, but it does give them some protection — and it qualifies them for federally subsidized flood insurance.

In Washington, FEMA wants new levees and a storm wall, because of its experience with past hurricanes and its fear of future storms. According to FEMA, Hurricane Isabel created more severe flooding in 2003 than did the historic August Hurricane of 1933, the storm that is still considered the most destructive Chesapeake hurricane over the last century.

Why more flooding in 2003? According to FEMA, the extra flooding from Isabel could be a result of a relative sea level rise of one foot since the 1933 storm. If sea levels continue to rise as predicted, then future storm flooding in Washington could be even greater. The current forecast from the U.S. Geological Service predicts sea levels will rise another one foot in the Chesapeake Bay (and the Potomac River) over the next 100 years. And that might be an underestimate. So far the observed sea level rise in the Chesapeake is running twice the global rate.

Sea level rise is only one worrisome prediction about global warming. Another is the forecast for more ferocious storms capable of even stronger storm surges. Whether it's created by human pollution or natural cycles, the recent warming has raised sea surface temperatures in the oceans, the globe's great reservoir of heat and the engine that drives its weather patterns. Warmer waters, according to most scientists, will lead to more violent storms, bringing new floods to Washington D.C. and to homes across the Tidewater region of Chesapeake Bay.

— *Michael W. Fincham*

Going to Extremes

The Storm over Hurricanes

Michael W. Fincham

When storm waves came surging into the crab house, young Art Daniels started running for home. With the main road flooded, he headed for high ground, dodging a falling tree knocked over by gale force winds. The great August Hurricane of 1933 was hitting the Chesapeake Bay and Daniels would have a front-row seat. Reaching home he perched next to an upstairs window and watched storm winds and waters start to tear his world apart. His world was the fishing village of Wenona down on the southwestern edge of Deal Island, a pear-shaped island hanging like soggy fruit off the marshy wetlands of the lower Eastern Shore of Maryland.

He was 12 years old and here are some of the things he was seeing: The waters his father fished for blue crabs and oysters were crashing onto the island, driven north by the storm surge from winds blowing straight up the Bay. The garden his mother planted was flooding with saltwater, killing off her butterbeans and potatoes and onions and strawberries. The chickens the family kept for daily eggs were drowning under the house. In island cemeteries, coffins were floating out of their graves.

From his window, Daniels could see the big shucking house down the road start shaking apart as wave after wave hit, sending boards flying off the building. "I watched them big seas come in and tear that house down. The next morning there weren't but a few poles left standing," says Daniels, an 89-year old waterman getting ready for another oyster season. "That left an impression on me about the strength that the water has."

Storms leave memories, marking people as well as the land. Daniels remembers the gale of 1933 as the August Storm. Others called it "The Storm King," or the "Chesapeake and Potomac Hurricane," and by any name, it was clearly the storm of the century for Tidewater Maryland and Virginia. The devastation down on Deal Island was happening all around the Bay. In small villages the storm wrecked boats and bridges and businesses, and its storm surge flooded into Norfolk, Annapolis, Baltimore, and Alexandria, some ninety miles up the Potomac. At Ocean City, Maryland, it cut an inlet to the sea, separating the city from Assateague Island to the south. In its wake, it left forty-seven people dead. In all, the storm season for 1933 set a record with 21 tropical cyclones forming in the Atlantic.

Since 1933 Art Daniels has seen a number of famous storms roar though the Chesapeake region — including Hazel (1954) and Agnes (1972) — all of them bringing high winds, heavy

On its way to the Chesapeake Bay, *Hurricane Isabel makes landfall across the Outer Banks of North Carolina on September 18, 2003 (above), sending Bill Ackliss of Kitty Hawk scrambling for cover. A hurricane is a tropical cyclone that sucks its energy from warm oceans and moist air, cycling heat upwards and radiating it out to space. A huge storm cools off the ocean it passes over, leaving a cold wake and lowering the likelihood that a new storm will follow the same track. On land it leaves another kind of wake: property damage, death, and flooding.* PHOTOGRAPH BY DREW WILSON/THE VIRGINIAN PILOT.

Salisbury Daily Times/Patty Hancock Photo

Down on Deal Island, *skipjack captain Art Daniels has seen and survived all the famous hurricanes of the last 90 years. When Hazel came through in October of 1954, crabbers lost their pots, fishermen lost their nets, and Deal Island lost its bridge. By the time Daniels went oystering again, his boat had a new rudder — a heavy plank from the blown-apart bridge. It still steers his boat.*

rain and floods. Then in September of 2003, Hurricane Isabel struck. Matching the fury and flooding of 1933, Isabel raised questions and fears about future storms. What kind of extreme weather is coming and where is it going to hit? Those are the forecasts that officials need for identifying floodplains, that homeowners need for building or buying or abandoning houses, that emergency services need for hiring staff or acquiring equipment.

As the planet warms and sea levels rise in the Chesapeake Bay, what can current science now say about the storm next time?

These are hot-button issues in storm science and debate over them has been heating up since 2005. That was the year that broke the 1933 record for storms. It was also the year Hurricane Katrina tore apart the city of New Orleans. Shortly before Katrina struck, an atmospheric scientist named Kerry Emanuel published a landmark study in *Nature* that tried to chart how global warming might change hurricane frequency and intensity. His study stirred up a storm in both the popular media and the hurricane research community. It held some good news, some bad news, some worse news.

The good news: the warming of the planet may not create a greater number of storms for the East Coast. According to Emanuel, an atmospheric scientist at the Massachusetts Institute of Technology, there were no detectable trends in recent data that indicated storms would become more frequent, and the predictions from climate models were inconsistent on this question. His forecast for no increase in storm numbers was supported by other scientists, some of whom suggested that global warming could, in fact, lead to fewer storms.

The claim seems, at first, counterintuitive. For decades now, scientists have viewed hurricanes as heat engines fueled by water vapor evaporating off warm seas. Born as tropical cyclones, hurricanes suck heat out of the oceans, the planet's great heat reservoir, and cycle it upwards through convection into the cooler air of the upper atmosphere. The warming of the oceans should be releasing more water vapor into the atmosphere and more water vapor usually leads to more thunderstorms in the Atlantic.

More thunderstorms, however, may not lead to more hurricanes. The forces that organize thunderstorms into a rotating tropical cyclone are numerous, complicated, and highly variable. Heavy rainfall in the Sahel region of West Africa seems to precede storm formation and so do shifts in the North Atlantic Oscillation (NAO), an air mass that moves back and forth between Iceland and the Azores. More distant events also affect storm startups. In the Eastern Pacific, episodes of warming waters known as El Niños seem to suppress hurricanes in the far away Atlantic, and episodes of cooler waters in the Pacific known as La Niñas seem to encourage them. One of the strongest storm drivers is the recently discovered Atlantic Multidecadal Oscillation (AMO), a pattern of changing ocean currents. It alternates between warming episodes which feed tropical cyclones and cooling patterns which starve them.

When the August Storm of 1933 hit Deal Island and sent Art Daniels running for home, neither he nor any scientists of the day suspected that this roaring storm was shaped by forces like rainfall in Africa and cool waters in the Pacific. All these climate connections — unknown in 1933 — are the hard-earned discoveries of very recent decades. These discoveries began as statistical correlations, many of them first identified by William Gray and his protégés at Colorado State University. Correlations, however, are not an end point in science: they are a starting point for figuring out causal connections.

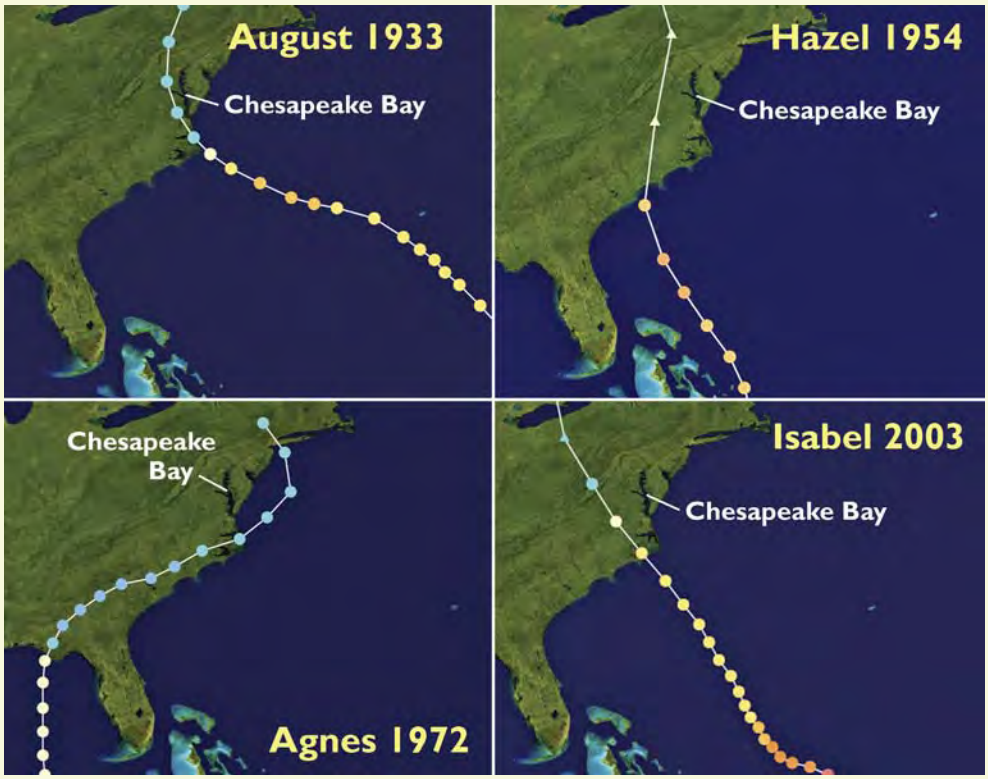
No wonder it's not easy predicting hurricanes. All these climate events vary over time, sometimes reinforcing each other to create busy storm seasons, sometimes undercutting each other to suppress storm formation. Since some of these large climate patterns can last for decades, busy storm seasons and slow seasons tend to come in clumps. The 20th century began with 25 years of slow storm seasons, followed by 40 years of busy seasons, then 25 years of quieter seasons.

Since 1995, the Atlantic region has been experiencing another era of busy storm seasons, an era we may be stuck with for a while. According to Emanuel and other scientists, the high number of hurricanes over the last decade was not the result of man-made global warming — it was served up by these long-standing natural patterns.

The bad news according to Emanuel: while future storms may not be more frequent, they will probably be more ferocious. The theory behind bigger storms came right out of the heat engine model. Global warming could be pumping more high-octane fuel into the cyclone engine. "In theory, warming would increase the energy source for hurricanes," says Emanuel. "That would increase the violence of hurricanes."

His grim forecast for bigger storms, however, is based on more than theory. Emanuel was citing statistical evidence that storms had been growing more powerful. After compiling an index of power dissipation based on wind estimates, Emanuel showed that storm power had already doubled over the last 30 years. Wind speeds were running nearly 50 percent higher since the 1970s, he said, and storms were lasting nearly 60 percent longer since 1949. His key finding: this trend in rising storm power correlated closely with rising sea surface temperatures. Future warming, he warned, could lead to even more powerful storms in the 21st century.

This bad news forecast was big news because it came from a well-respected researcher and it arrived right before Hurricane Katrina. Two weeks after he published his findings, Hurricane Katrina inundated New Orleans. His predictions — and his impeccable timing — seemed to elevate Emanuel into prophet and point man for a hurricane-global warming link. His forecast was not only featured in newspapers and magazines — it also showed up in Al Gore's movie *An Inconvenient Truth*. In the year of Katrina, Emanuel also published *Divine Wind: The History and Science of Hurricanes*, a non-technical book designed to explain hurricanes to the general public. The following year *Time* magazine anointed him one of the 100 most influential people on the planet.



Tracking the Bay's Biggest Hurricanes

Storm tracks tell a story. Hurricanes and tropical storms that create the most dramatic storm surges in the Chesapeake have one thing in common: they sweep northwards along the west side of the Bay's mainstem. Official records and human memories report strong surges and heavy flooding from these monster storms: the August Hurricane in 1933, Hurricane Hazel in 1954, and, most recently, Hurricane Isabel in 2003. In each case the eye of the storm stayed west of the Chesapeake Bay.

Hurricanes are tropical cyclones that spin with a counterclockwise rotation. According to oceanographer Bill Boicourt, cyclones moving up along the Eastern Shore of the Chesapeake drive water out of the Bay, but cyclones moving along the west side do the opposite: they drive water up the Bay. These "wrongside hurricanes" send their winds arcing out over the mainstem where their south winds can turn the long narrow fetch of the Bay into a funnel, driving a huge surge north against small coastal towns and islands and flooding downtown Annapolis and Baltimore.

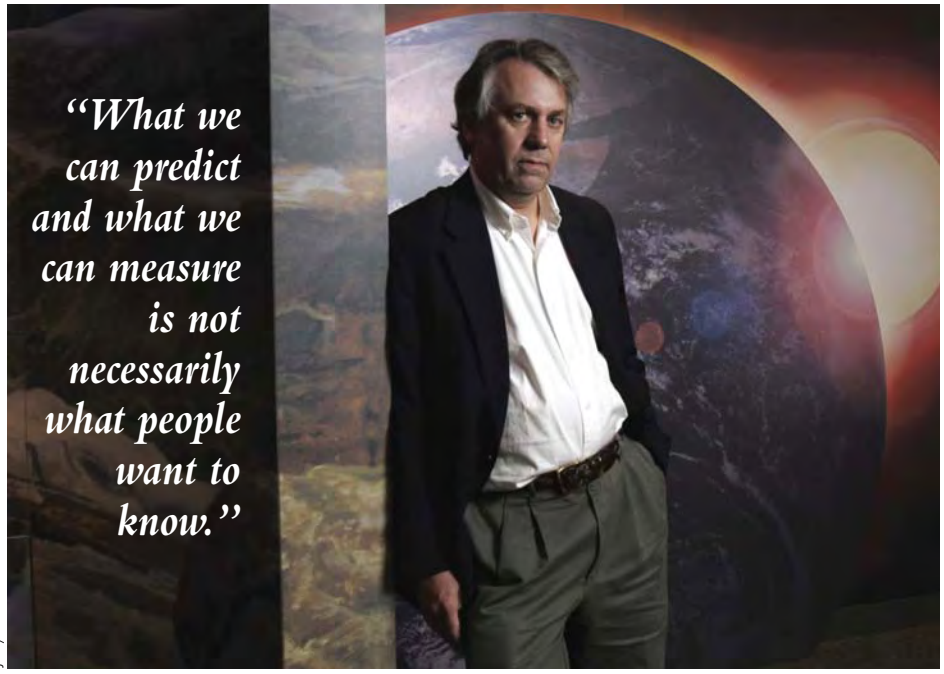
Western shore rivers are especially vulnerable during these storms. Winds curving around from the southeast can align with the long fetch of the James and the Potomac, turning these rivers into funnels and driving flood waters into cities like Richmond, Colonial Beach, Alexandria, and Washington, D.C. During the August Storm of 1933 and Hurricane Hazel in 1954, the storm surges coincided with astronomical high tides, driving water levels even higher.

The track for Tropical Storm Agnes tells a different story. Agnes was a "backdoor hurricane" that came ashore along the Gulf of Mexico, then weakened to a tropical depression as it traveled north overland. Just south of the Chesapeake, the storm passed offshore and began regathering strength as a tropical storm. When it curved ashore again north of the Bay, it combined with another low pressure storm to pour heavy rains into the Chesapeake watershed. The massive flooding and resulting runoff brought surges of sediment flowing down the bay, covering seagrasses, burying oyster beds, and lowering salinity levels dramatically. Agnes, though less dramatic, may have done more damage to the Bay's ecology than any other storm in recent history. — *M.W.F.*

Hurricanes were now launched into the popular media as another symbol of global warming, ranking right behind melting ice caps and stranded polar bears. The implications seemed clear: With global warming the great storms of the near future might become monster storms. Isabel in the Chesapeake and Katrina in the Gulf might have been harbingers that something really wicked this way comes. Instead of King Kong, think Godzilla, the creature from the deep that could wreak vengeance on whole cities.

In the storm science community, however, the debate over big storms had just begun. Scientists from different camps were already working to verify or disprove the alleged link between global warming and hurricanes. This critical back and forth is a natural part of science, a kind of slow, self-correcting machine that usually hums along barely noticed by the media, with claims and counterclaims launched in scientific and technical journals. Support for Emanuel's claims came quickly from research findings that Peter Webster of the Georgia Institute of Technology published in *Science* for September of 2005. Analyzing tropical cyclones in six ocean basins, Webster found that the proportion of storms reaching Categories 4 and 5 had doubled over the last 30 years.

Critical response to Emanuel was just as quick. Leading off with a critique also published in *Science* was Chris Landsea, who thought the intensity of recent storms could be explained by those natural climate forces. There was probably no long-term trend toward more powerful storms, says Landsea, now a meteorologist with the National Hurricane Center. If the storms of 50 years ago were measured with contemporary techniques, the older storms would probably prove just as powerful as recent storms. Earlier storms, said Landsea, may have been underestimated. There could also be "missing storms" that never made it into the record, he suggested, because scattered sightings did not produce reliable wind estimates. Until the historical record is reanalyzed storm by storm to create an accurate database, it will be difficult to identify real trends by looking at storm history.



Jody Hilton/*The New York Times*/Redux

Kerry Emanuel of the Massachusetts Institute of Technology *was one of the first scientists to cite evidence that warming oceans were fueling more ferocious storms. More bad news: global warming would also bring heavier rainfalls and greater flooding, dangerous threats in regions like the Chesapeake, which are already vulnerable to sea level rise.*

The dividing question in the debate: Were the powerful storms of recent years caused, at least in part, by global warming? Or were they largely the offspring of a warm phase in ocean currents caused by the Atlantic Multidecadal Oscillation? Emanuel would vote for Option A. Landsea would vote for Option B.

To make sense of the ongoing debate, the World Meteorological Organization last year brought Emanuel and Landsea together to meet with eight other researchers at Sultan Oaboos University in Oman on the Arabian Peninsula. Their charge: begin a review and evaluation of all the recent research in theory, observation, historical analysis, and climate modeling. Don't just pick strong findings and throw out weak ones, but highlight uncertainties and suggest levels of confidence. The goal was to provide guidance to national weather organizations who in turn advise state and county and city officials who need to make long-range plans for protecting people and property against extreme weather.

The final report from this team of experts, published this year in *Nature Geoscience*, represents the latest effort at a consensus on the hot-button questions in storm science. As such, its findings are as carefully worded as an international treaty on nuclear weapons. On the hottest question, the hurricane-global warming link, the experts found they could not "conclusively" link past storms to man-made contributions to global warming, a nod to Landsea's arguments. In a nod to Emanuel's claims, the experts agreed future storms will probably be more intense because of global warming, a projection based both on theory and on high-resolution models.

Are ocean waters warming up around the planet? Yes, agreed the experts, and the waters are warming faster in the Atlantic basin. Much of the global increase, they said, is probably due to greenhouse gases. As water temperatures are rising, so is total storm power as measured by wind power, a correlation that was a key finding in Emanuel's landmark 2005 paper in *Nature*. And both

water temperatures and storm power are rising faster in the Atlantic basin, the region that spawns the tropical storms and hurricanes that could hit the Chesapeake.

Would monster storms, like Isabel in the Chesapeake or Katrina in the Gulf become more frequent? "More likely than not," said the experts. And in this judgment they felt "a higher confidence level" than before. All that careful language is science-speak for "yes, probably."

In 1933 the roaring of the ocean could be heard eight miles inland along the main street of Snow Hill, Maryland. The roaring went on for two days and was one of the few warnings Marylanders had that the great August Storm was headed their way. So wrote Reginald Van Truitt, the scientist who founded the Chesapeake Biological Laboratory and later published *High Winds, High Tides: A Chronicle of Maryland's Coastal Hurricanes*.

Marylanders seem to have much more warning now — at least for the storm next week. For short-term alerts, the National Hurricane Center has two geostationary satellites hanging 22,000 miles above the earth and keeping constant watch on the tropical ocean regions where warm waters give birth to great storms. The National Weather Service also has a staff of scientists working up storm track forecasts to help city and state officials decide on evacuation alerts and homeowners decide on house protection. In 1964, the weather service began sending out three-day forecasts. In 2003, nearly 50 years later, the weather service began giving five-day forecasts. The next goal is seven-day forecasts.

Marylanders also have more warning about the storms next year. Scientists with the National Hurricane Center can be stunningly accurate with their seasonal forecasts, largely because they are able to accurately monitor and model those great shifts in air masses and ocean currents in two oceans that create hurricanes in the Atlantic. The 2010 season, for example, was one of the busiest on record with seasonal forecasts calling for 8 to 12 hurricanes, a prediction that proved dead-on when the storm season this year produced 12 hurricanes in the Atlantic.

But the warning Marylanders really want is this: When will those big storms of the future arrive in the Chesapeake? And where will they make landfall? That's the kind of forecasts planners and homeowners and businesses need — but it's the kind of help storm science cannot give. "When it comes to predicting regional events, people want answers," says Emanuel, "but science really doesn't have answers."

When storm scientists try to figure out future storm tracks and landfalls, they bump up against some fundamental forecasting limits. Storm theory, in effect, runs into chaos theory, the discovery of a meteorologist named Edward Lorenz who made "the butterfly effect" famous. Chaos theory shows that omitting or changing a few data points in a model — perhaps by rounding off decimals in wind estimates — will have a huge effect down the line on the model's weather forecasts. If your model leaves out the wind effect from the flapping of a butterfly's wings, for example, your long-term forecasts will be wildly off. Since computer models can never hold every data point, they will always miss the butterfly's wings. "Because of chaos theory," says Emanuel, "it is impossible to predict beyond two to three weeks."

Last storm season illustrates those limits. Scientists were able to predict months ahead of time how many storms would form in 2010. But to predict where storms would land, climate modeling has to segue into weather forecasting — which is the art and science of reading pressure systems and troughs and jet stream wanderings, all the short-term forces that can steer big storms toward the Gulf of Mexico or the Outer Banks or the Chesapeake Bay. Or out to sea.

Last season all the major hurricanes went out to sea or landed elsewhere. Though 2010 was one of the busiest hurricane seasons in half a century, few Americans noticed. Twelve hurricanes fired up in the Atlantic basin, but in a statistical rarity, not one hurricane made landfall in the U.S. "To the man in the street, it was a dead season," says Emanuel. "What we can predict and what we can measure are not necessarily what people would like to know."

If you would like to know whether future storms will be more intense, whether they will bring greater storm surges into floodplains, whether they will bring heavier downpours with greater flooding, Kerry Emanuel can tell you "Yes," and say it with a high confidence level.

But ask him whether those great storms will come to the Chesapeake, or to your county, or to your house — and he has no confidence beyond two to three weeks. "You can't do better than that," he says, "not if you threw all the resources in the world at it."

For local officials worried about floodplain planning and affordable insurance policies, Kerry Emanuel is willing to offer some advice, but when he does he sounds like one of those angry prophets out of the *Old Testament*. "I tell them to forget about climate change," he says, "and deal with the 800-pound gorilla that is staring them in the face." Federal caps on flood insurance rates and federal disaster relief for homeowners are encouraging people to live in risky places. "It taxes the rest of us," says Emanuel, "to subsidize people who are facing future catastrophes."

Wouldn't he like a house next to the water? His choice in that case, he told *The New York Times*, would be "the Fire Island option." Build a flimsy house you don't mind losing. When it gets flooded out or blown apart, simply build it again.

His solutions for the rest of us: Don't build in high-risk floodplains. If you have to live by the water, then build a fortress home that can withstand huge storms. Or elevate your home well above the floodplain. Or pay high insurance rates that reflect real risk, the risk that the monster next time might come to your door.

— *fincham@mdsg.umd.edu*

Before the Next Flood

Contending with Climate Change on Maryland's Eastern Shore

Erica Goldman

Up and out of the floodplain, *one painstaking inch at a time. Harriett and Bud Hankins added an additional four feet to the height of their house when they rebuilt after the devastating flooding of Hurricane Isabel. The process took nearly a year to complete.* PHOTOGRAPH COURTESY OF HARRIETT AND BUD HANKINS.

Nick Lyons remembers when tomatoes grew in southern Dorchester County, when bustling canning operations and crab plants made Crapo and Hogsville prosperous, back before farm fields and pastures became marshes.

He's seen the waters rise since then — freak floods that are no longer freak, normal high tides pushing higher and higher.

For more than 20 years, Lyons has served in the county's executive office — he's currently the codes administrator and floodplain manager, charged with inspecting properties and granting permits for new construction and structural renovations. For decades, he's given the same advice to homeowners that come to his office seeking permits. "Whatever you do, elevate your house out of the floodplain."

Since the 1990s, Lyons has argued that "freeboard" be incorporated into the county's building codes. Freeboard is a factor of safety, an increment of elevation above the base flood elevation, that can better protect against wave action, land subsidence, or sea level rise.

Legislation to incorporate freeboard has been introduced three times in the Dorchester County Council since the early 1990s — and three times it's been defeated. The bills have been voted down because of concerns over increased building costs, according to Lyons, who believes this concern is ill founded. He says the cost increases would likely never exceed one percent of the cost of the house. And incorporating freeboard could also lead to a large discount on federal flood insurance through the Federal Emergency Management Agency (FEMA), around 20 percent, Lyons explains. "The investment is priceless, in all honesty."

But freeboard has been a tough sell in Dorchester County.

This evening the council will conduct a public hearing on freeboard legislation, newly introduced in September. Lyons is optimistic. Bill 2010-20 would amend the Dorchester County Code (Section 155-37) by requiring all new construction and any substantial improvements to residential and commercial structures to elevate the lowest floor to a flood protection elevation that would incorporate a three-foot freeboard.

Lyons will be presenting the bill at the hearing. "I am going to try my best to get this through tonight," he says. "It will be a good thing for the county. Whether they see this yet remains to be seen."

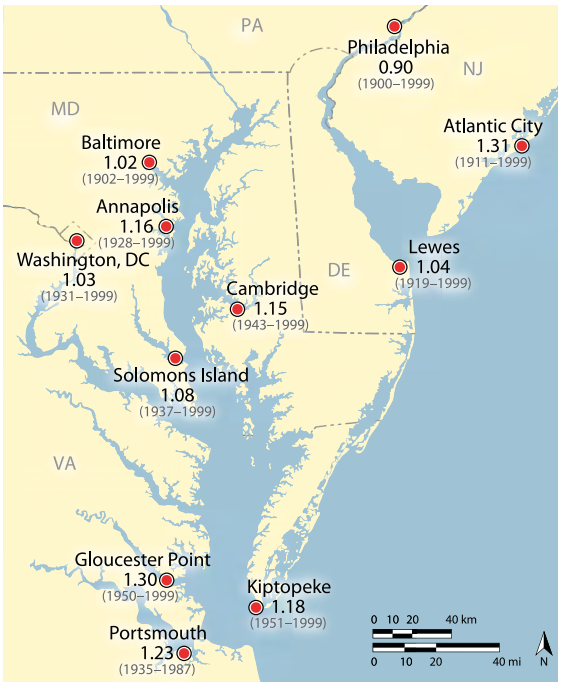
He hopes the political climate for passing freeboard legislation finally may be right in Dorchester County. This is the first time a freeboard bill has come up since Hurricane Isabel inundated the county in Fall 2003. Hundreds of houses in the county were damaged by the storm and flooding caused by the storm surge. While some have since been elevated and rebuilt, many others have been abandoned.

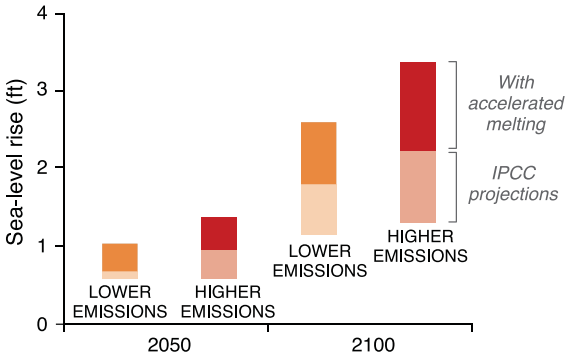
"I think I'll get it this time," he says. "Isabel will be my saving grace."

Lifting Up from the Flood Waters

Hurricane Isabel delivered over a foot of water to the house of Harriett and Bud Hankins. Located at the head of Fishing Creek, parallel to the Little Choptank River, the house was built in the late 1600s or early 1700s — a new foundation was constructed in the 1940s, though it still sat flat on the ground. When the Hankinses bought the house as their retirement home in 1985, the U.S. Army Corps of Engineers erected a bulkhead on one side of the property and put riprap in along the other — covering some 365 feet of waterfront. The Corps was worried about wave action and wear on the property because of its position at the head of the creek.

Sea Level Rise in the Bay





Climate change and sea level rise drive and exacerbate coastal hazards along Maryland's 3,000 miles of coastline. Shores are vulnerable to storm events and chronic hazards connected with erosion, storm surge, and inundation. In the last 100 years, Maryland's coastal waters have risen by more than one foot (see map above), reflecting a rate nearly twice the global average. This reflects the combined impacts of rising seas and regional land subsidence. The graph above shows projections for sea level rise, given a range of carbon dioxide (CO_2) emissions. In the scenario with the greatest emissions, relative sea level rise along Maryland's coasts could top more than three feet by the end of the 21st century, according to projections by the Intergovernmental Panel on Climate Change. *MAP AND GRAPH, FROM* THE REPORT OF THE MARYLAND COMMISSION ON CLIMATE CHANGE ADAPTATION AND RESPONSE WORKING GROUP, *JULY 2008.*

Nobody said anything about elevating the house.

Even when the Hankinses renovated their property in 1991, they heard no concerns about elevating the house, which is set back more than 30 feet from the shore. No one ever remembered water coming in.

Hurricane Isabel was another story. The water came and went quickly, according to Harriett Hankins, but left a big mark. The house flooded knee deep — after the waters receded, she and Bud began ripping sodden drywall from the sunroom. Black mold moved in immediately. They left the walls open to dry out.

Over the next week or so, the Hankinses brought in contractors who advised them not to do anything in a hurry, but to take time to dry it out completely. Many times, they were told, wood floors will go back into place. The contractors set up giant blowers near the foundation, while the Hankinses scrubbed the kitchen with the Clorox solution recommended by FEMA. Then they left to visit their son in Kenya and spend a couple of months on the island of Lamu. While their house back in Cambridge was drying out, they were deciding whether to rebuild.

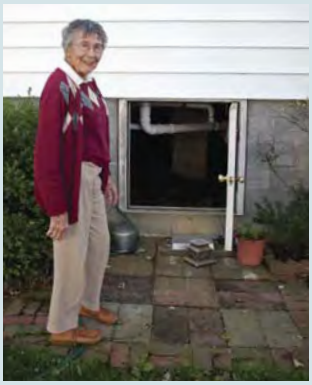
They knew the future would bring even more flooding to Maryland's Eastern Shore. A retired schoolteacher, Harriett Hankins, 81, serves as a citizen representative to the Coastal and Watershed Resources Advisory Committee (CWRAC), an independent advisory body to the Secretary of Natural Resources and to Maryland's Coastal Program — just one of several volunteer organizations she engages in. She's keenly aware of the regional predictions for sea level rise and inundation — and what these predictions are likely to mean for Dorchester County.

Projections forecast over a foot of sea level rise in the next 50 years. Closer to three feet in the next century, according to the Intergovernmental Panel on Climate Change (IPCC) — that is, if CO_2 emissions continue at their current high rate (see Sea Level Rise in the Bay, p. 9). In Dorchester County, some 25,000 acres of forest (nearly 40 square miles) and 60,000 acres of wetlands (more than 90 square miles) could be lost by 2050, according to a recent scientific study done at Towson University. Rising water will also intensify coastal flood and storm surge events. A one-foot rise in sea level translates to a one-foot rise in flood level. Hurricane Isabel already brought a 6-to-8-foot storm surge. Overlay sea level rise on top of warming impacts and houses on the coast grow more vulnerable each year.

Where Land and Water Meet

When the Hankinses returned from Kenya, they found that the damage to their house, although extensive, could have been much worse — the wood floors had indeed moved back into place. They decided to rebuild and to elevate above the minimum required by FEMA and the state of Maryland.

After Hurricane Isabel



The Hankins House

After Hurricane Isabel, FEMA required houses that sustained more than 50 percent damage to be raised above base flood elevation or they would not be eligible for flood insurance. And flood insurance is a necessity for houses located in a floodplain — federally backed mortgage companies will not issue loans for houses without flood insurance.

Elevating the Hankins house would prove no small feat (see photos on p. 10) and would take nearly a year. The age of the house precluded using heavy equipment to dig out the foundation, so contractors dug it out by hand until they could slide I-beams underneath to raise it up, one painstaking inch at a time. Then they brought in a sand-loam fill to make up the necessary height. The Hankinses chose to elevate their house by four feet. Essentially, they incorporated a voluntary two-foot freeboard, which corresponds with recommendations in Maryland's model floodplain ordinance.

The state of Maryland offered significant financial assistance to help county residents with construction costs, while mortgage companies offered very low rates. Still, for many, the costs were too high, and they abandoned their houses outright. To finance the rebuilding of their house, the Hankinses sold another property. They count themselves among the lucky ones.

How well are communities along the low-lying Eastern Shore readying for future storms with the power of Isabel? To answer this question, anthropologist Michael Paolisso and industrial economist Matthias Ruth have been studying coastal communities, among them, the community of Smithville in Dorchester County, roughly 13 miles southwest of the Hankins house. In this study, the University of Maryland researchers are exploring issues related to climate change and environmental justice in underrepresented groups.

Paolisso recruited members of the New Revived United Methodist Church to participate in a series of three workshops. Working with this small, African American congregation, Paolisso hoped to gauge their perceptions about climate change as it relates to their community. He began by asking participants to think about what words they associate with climate change and how those words relate to each other. He also provided maps with projections for sea level rise and coastal flooding that included Smithville and the church.

The participants were well experienced with heavy storms and floods, Paolisso found. They knew which areas are high and whose houses were likely to flood, and they had a sense for which roads might be cut off and which members of their community might need assistance.

But their concerns were on the here and now, not the future. Residents were interested in the maps showing projections for sea level rise and future flooding, but they never showed a sense of urgency,

Hooper's Island

PHOTOGRAPHS OF HOOPER'S ISLAND BY ERICA GOLDMAN.

Hurricane Isabel left a mixed legacy *on Maryland's Eastern Shore. Dorchester County residents like Harriett and Bud Hankins were able to rebuild and elevate their house after the 2003 flood that inundated their whole first floor. But even with financial assistance from the state of Maryland and the National Flood Insurance Program, raising and reconstructing their 17th century-era residence proved costly and time consuming for them. Further south in the low-lying areas of Hooper's Island, many houses were abandoned. Some residents who owned their properties outright did not have federal flood insurance and assistance from the state would not prove sufficient. Others have only just begun rebuilding now, some seven years after the storm.*

Paolisso says. "On the surface, I didn't get a strong reaction of, 'we're in trouble.' I didn't find them thinking 10 to 20 years out."

In the four communities that Paolisso and Ruth have studied, including two in Massachusetts, nobody talked specifically about adapting to climate change. Most people have a perception, says Paolisso, that climate change and sea level rise are in the future and there's not much that can be done about it anyway. "I don't think people are thinking about how they or their community can adapt to climate change. Many of them have more pressing needs."

Michael Paolisso

Are residents worried about *predictions for rising waters and coastal floods? In Smithville, anthropologist Michael Paolisso worked with members of the New Revived United Methodist Church (above) to gauge their perceptions and attitudes about climate change.*

Seven miles south, Smithville Road becomes Hooper's Island Road, eventually running between pools of water and marshes dotted with the charred-looking skeletons of evergreen trees — these trees were killed by saltwater intruding inland, driven by higher than normal tides and storm surges. The road descends and flattens out then arches high across the bridge leading away from the mainland.

More than a bridge and a road connect Hooper's Island with Smithville. Here too residents living on the low lip of the Bay seem not to worry much about future sea level rise.

On Hooper's Island, home to approximately 420 residents — many of them watermen and their families — Hurricane Isabel left a mixed legacy. Some were able to rebuild quickly, elevating their houses in the process. Roughly one-third now sport new cinderblock foundations and sit a few feet higher than before. Others are only now rebuilding and elevating their houses, more than seven years after the storm — construction sites abuzz with activity punctuate quiet streets. Meanwhile, dozens of other houses stand abandoned — paint peeling, black mold encrusting white shingles. On one side of the road, a streetlamp stands in water several feet deep. Next to it, a rusted-out metal shed. Up the road on the other side, trees and shrubs invade the façade of another house, weaving through the walls and windows an organic message of "Keep Out" to anyone who draws near.

Hooper's Island still houses two crab processing plants — Ruark's and Phillips. Jay Newcomb, who manages the Phillips plant, has lived on Hooper's Island all his life. He's currently serving his second term as Dorchester County Commissioner and also operates Old Salty's, a restaurant on the island that among much else serves outstanding lump crab cakes.

Newcomb relates to the struggles that people face on Hooper's Island. He knows that many cannot afford to rebuild or elevate their homes. Many own their houses outright and do not have federal flood insurance. For them, as sea level rises, abandoning the island ultimately may prove their only option. In terms of storms like Hurricane Isabel, he says that his constituents do not feel a strong sense of urgency. Most feel that Isabel was an unlucky chance event, he says, not a harbinger of worse things to come. The community is not yet thinking too much about how to adapt to changing climate conditions — how to prepare for more intense storms and rising waters. Life unfolds here one day at a time.

Planning for Rising Seas

If so few residents identify sea level rise and more intense storms as a growing risk, how can the state of Maryland help communities prepare for the future? For some time now, a number of state agencies have been working with county and local officials to incorporate the impacts of climate change in master plans of community development.

Gwen Shaughnessy, a coastal hazards and climate program specialist for the Maryland Department of Natural Resources (DNR), has helped develop the Coast-Smart Communities Initiative, a NOAA-funded program aimed at helping coastal communities plan for and adapt to climate change. The program is a direct response to recommendations in the Maryland Climate Action Plan, released in 2008 (see For More Information, p. 13).

Shaughnessy's efforts take a two-pronged approach. First, a technical mapping component helps pinpoint those areas most at risk — this process incorporates data on coastal topography and combines them with projections for sea level rise and storm surges. She then works directly with local governments to incorporate this information into the development planning.

The idea, says Shaughnessy, is that planning for climate change should not be separate from the overall planning process, but a practice of fitting it in to day-to-day business. "Local governments are charged every day with deciding where to develop, where to grow. We're trying to help them integrate into this planning the potential changes that climate change might bring."

Raising structures such as houses, utilities, and roads above the base flood elevation (freeboard) is a significant starting point, says Shaughnessy. Such practices build in a buffer, a factor of safety, especially because the projections of climate change are just that — projections. "It is difficult to draw a line in the sand and say that this is where the extent of the flooding is going to occur. So we are asking local governments to go above and beyond what is required."

Shaughnessy acknowledges that this is a tough sell — local governments already are contending with a number of environmental regulations, such as the new

requirements for compliance with Total Maximum Daily Load (TMDL) requirements to limit specific pollutant discharges by watershed.

One key is to recognize where opportunity fits without becoming an extra burden, says Shaughnessy. With funding opportunities through the Coastal Zone Management Act (CZMA), counties can apply for assistance to integrate climate change into the planning process. The town of Queen Anne on Maryland's Eastern Shore, for example, received assistance from the CZMA grant program (Section 309) to help complete their Water Resources Element. The Water Resources Element requires counties to analyze current water supplies, wastewater treatment capacity, and point and non-point source pollutants as part of their master plans. The town of Queen Anne will pioneer an attempt to integrate climate change planning into the process. The effort will include an examination of sea level rise and storm surge inundation to direct future growth out of high-risk coastal areas, as well as an assessment of climate change impacts on expected water resource demands and wastewater treatment and distribution.

Redrawing the Maps

Planning for the next great flood may soon gain new urgency for Maryland's coastal communities. For the past several years, the state, in conjunction with FEMA, has been systematically updating Flood Insurance Rate Maps (FIRMs). This effort is part of a nationwide initiative to complete a digital conversion of existing floodplain maps, explains Dave Guignet, the state coordinator for the National Flood Insurance Program. The new digital maps will be compatible with GIS (Geographic Information Systems) and greatly improve spatial accuracy for planning, permitting, and insurance applications.

But most states are still relying on flood elevation data from 1988 to complete the digital conversions. Maryland is out ahead, explains Guignet, in simultaneously upgrading the elevation maps as part of the digitization process — an effort that has generated new studies covering more than 3000 miles — inland and coastal. These studies use the optical sensing technology LIDAR (which relies on laser pulses to find range information of a distant target) to create high-resolution digital elevation maps. Updated data also account for rainfall, sea level rise, and erosion that have occurred in the past 20 years. They will not include any projections for future sea level rise, although these are planned for the future.

The Digital Flood Insurance Rate Maps (DFIRMs) are used to determine whether or not a homeowner resides in the 100-year floodplain, which then sets the availability and rate for federal flood insurance by FEMA. So far, the digital upgrades have been completed for inland areas in Maryland. The coastal maps for counties such as Dorchester are due to be released in 2012. They will likely reveal that the newly defined floodplain for the county will cover even more real estate — in a region where 60 percent of its residents are already living in a floodplain. More homeowners will find themselves facing high insurance rates or becoming ineligible altogether. That is without any accounting for sea level rise, which FEMA has funds to begin working on in the next two to three years.

"What do people do who find themselves in the newly defined floodplain? What does it mean for them and their house? We've never had to go through something like this as a society," says DNR's Shaughnessy.

The pending change in floodplain maps raises the stakes for Maryland's coastal communities. Thousands of homeowners may soon find themselves facing a choice with their own properties. The economic and social consequences could prove immense.

Standing before the Dorchester County Council at their October 19 meeting, Nick Lyons presents Bill 2010-20. He tells them that a three-foot factor of safety (freeboard) would have likely prevented a lot of the flood damage that county residents suffered during Hurricane Isabel. And in the past year, there have already been several days when the southern part of the county has experienced flooding, with floodwaters entering homes, according to Wayne Robinson, the emergency management director for county.

Lyons also tells the Council and public attendees that adopting freeboard would reduce flood insurance rates significantly — by up to 20 percent. And this cost savings would likely offset the added costs in construction. Bud Hankins is there to validate Lyons's statement about insurance rates. After having their house elevated, he says, they received a discount on their flood insurance. If the bill passes, Lyons adds, the Hankinses should receive yet another drop in their rates.

But the skeptics haven't been won over. County resident John Battista is

For More Information

Climate Change and Flooding

Maryland Commission on Climate Change
www.mdclimatechange.us/
CoastSmart Communities Initiative
www.dnr.maryland.gov/CoastSmart/
Digital Flood Insurance Rate Maps
http://mdfloodmaps.net/
Chesapeake Bay National Estuarine Research Reserve — Maryland Coastal Training Program
www.dnr.state.md.us/bay/cbnerr/ctraining. asp
National Sea Grant Climate Activities
www.seagrant.noaa.gov/whatwedo/climate/
Sea Grant Climate Network
http://sgccnetwork.ning.com/

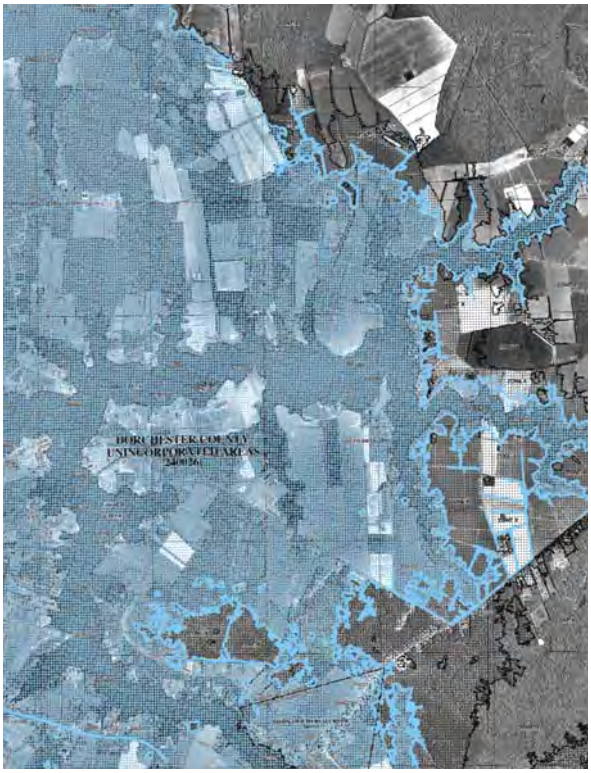
Climate Change and Storms

Emanuel, K. A. 2005. Divine Wind: The History and Science of Hurricanes. Oxford Univ. Press, New York, 304 pp.
Emanuel, K. A. 2005. Increasing destructiveness of tropical cyclones over the past 30 years. Nature 436: 686-688.
Webster, P. J., G. J. Holland, J. A. Curry, and H. R. Chang. 2005. Changes in tropical cyclone number, duration, and intensity, in warming environment. Science 309: 1844–1846.
Landsea, C. W. 2007. Counting Atlantic tropical cyclones back to 1900. Eos Trans. AGU 88(18):197-202.
Trenberth, Kevin E. 2007. Warmer oceans, stronger hurricanes. Scientific American 297(1):44-51.

worried about increasing the restrictions already placed on the use of resident-owned property. He would rather "risk the odds" than raise his home above base elevation. Property owners should be allowed to decide for themselves how much flood risk they are willing to take, he says.

Concerns also arise over increasing construction costs. Councilman William Nichols from District 2 argues that imposing a freeboard requirement would place too harsh an economic burden on residents. He suspects that the end result may be an increase in building costs that will negate the insurance rate decrease. "In the current economic climate," he says, "implementing a freeboard requirement will only burden a new homeowner."

Councilman Ricky Travers from District 3 and Councilman Rick Price from District 4 agree. Travers also echoes the sentiment expressed by Battista that the decision to elevate their home should be a personal one.



Digital Flood Insurance Rate Maps (DFIRMs), *such as this one for a subsection of Dorchester County, represent digitally converted flood insurance rates maps that are compatible with GIS (Geographic Information Systems). The state of Maryland, in conjunction with the Federal Emergency Management Agency (FEMA), is in the process of systematically updating Flood Insurance Rate Maps (FIRMs) for communities. The new maps, due out in 2012, will improve spatial accuracy and also include updated flood elevation data. Although DFIRMs currently do not include any projections for sea level rise, this is planned for the future.* MAP, STATE OF MARYLAND.

The time comes for a roll call vote. Four Council members opposed, only one in favor. The Council agrees not to proceed with Bill 2010-20.

Freeboard will not come to Dorchester County — at least not now. Nick Lyons is surprised and disappointed. This is the fourth time he's pushed for freeboard legislation before the County Council. This is the fourth time it has failed. He doubts that it will come up again during his tenure with the county and he's "pretty much out of steam on it."

A large number of houses already require flood insurance in Dorchester County, Lyons says. And that number will likely grow larger with the elevation upgrades in the new Digital Flood Insurance Rate Maps. Without freeboard, flood insurance premiums will remain high. In the end, the decision not to adopt freeboard could end up costing the homeowners of Dorchester County a lot of money.

Lyons suspects it will take another great storm like Isabel to stir up enough concern, to make people wish that they'd adopted the change when they'd had the chance. He hopes that a group of individuals will come together to bring momentum to this issue again for Dorchester County. And before it is too late.

— goldman@mdsg.umd.edu

Partnering

The third-floor library at the Maryland Department of Natural Resources (DNR) in Annapolis looks out over Tawes Garden, a patch of vibrant green in a complex of otherwise gray buildings. On a windy day in November, a group of "Climate Partners" gathers here for a kick-off meeting of sorts. Their goal is to take stock of the programmatic and funding landscape for climate change adaptation in the state of Maryland — starting with programs that receive funding from the National Oceanic and Atmospheric Administration (NOAA). They want to figure out how their programs align and how they can best collaborate to take advantage of each other's strengths and pool their resources.

Sasha Land called the meeting. She runs the Coastal Training Program for the Chesapeake Bay National Estuarine Research Reserve, a partnership between NOAA and the coastal states. She's about to embark on a 5-year strategic planning exercise for her program and wants to understand how key partnerships can factor in.

Vicky Carrasco, Coastal Community Specialist for Maryland Sea Grant Extension, sits at the table. She represents the growing role of Maryland and National Sea Grant in the climate change and climate adaptation arena. She's currently involved in two key projects around climate change adaptation, and she's eager to advance her efforts through collaboration.

Gwen Shaughnessy is also there. She works with DNR's Maryland Chesapeake and Coastal Program and represents the state's efforts in climate change adaptation, much of which comes as an outgrowth of the Maryland Climate Action Plan (see For More Information, p. 13).

First order of business: adopt a common mission statement that they can use

for Climate Action

Erica Goldman

to reach other players down the road. The partners agree to keep it simple. Their collective goal will be to "prepare local communities to adapt to and confront the impacts of climate change."

Next comes the hard part. The partners need to talk through and map the landscape of their programs to figure out how their efforts may align. Land brings out a flipchart and a set of different-colored markers. It will work better for them to see things laid out on paper — especially since there's likely to be a sea of acronyms.

Erica Goldman

***At a recent meeting, the Climate Partners** set their goal: to "prepare local communities to adapt to and confront the impacts of climate change." The team includes, from left, Sasha Land, Chesapeake Bay National Estuarine Research Reserve — MD; Vicky Carrasco, Maryland Sea Grant Extension; and Gwen Shaughnessy, Maryland Department of Natural Resources*

Land begins. She's responsible for outreach under the Adaptation Response Working Group — which emerged directly from the Maryland Climate Action Plan. She plans to develop a series of six training workshops per year for local governments and planners over the next year. The first step, she says, is a "needs assessment" to determine what local communities really require in terms of technical assistance.

Carrasco jumps in next. She's working on two projects related to climate change adaptation and has several others in the hopper. One is through the Coastal Community Climate Adaptation Initiative (CCCAI), funded by the NOAA National Sea Grant Office. It aims to enhance climate outreach efforts in Maryland and the Chesapeake Bay region. The project will fund regional meetings between local governments as a model for peer-to-peer interactions, to encourage communities to share information about challenges and opportunities related to incorporating climate change into community planning.

Maryland Sea Grant, in partnership with the Center for Watershed Protection, also plans to host a regional forum for those who do outreach on climate change — a "Who's Who and Who's Doing What." Carrasco is also working on a project that is part of a collaboration led by Oregon Sea Grant. The project, funded through the NOAA Sector Application Research Program (SARP), focuses on developing a survey instrument for Maryland's elected officials and planning staff to assess their needs in relation to adaptation to climate change.

Shaughnessy's program around climate change adaptation is already fairly extensive. As the lead from DNR on climate adaptation, she's responsible for administering the Coastal Zone Management Act (CZMA) Section 309 program, which awards competitive grants to communities for developing strategies that best integrate projected climate change impacts into their planning. Projects focus on reducing community vulnerability to sea level rise through modification of ordinances, codes, and plans. She's also developed the Coast-Smart Communities program, which combines technical mapping with outreach to communities (see Before the Next Flood, p. 8). Other projects on her very full plate include serving as the state lead for the Climate Change Task Force and collaborating on a project between the Mid Atlantic Regional Council on the Ocean (MARCO) and regional Sea Grant directors. Funded by NOAA, this effort connects Sea Grant to the governance structure for Coastal Zone Management to support projects specific to sea level rise.

The flipchart is beginning to fill up. Different colors — purple, green, and black — are assigned to each partner's programs. There are loads of acronyms and arrows to connect the dots. Land writes quickly, stopping from time-to-time to ask clarifying questions. A big picture for the Climate Partners collaboration is emerging. They decide that the first step will be a needs assessment to determine how the workshops that Land will be developing should be shaped. Shaughnessy points out that the workshops could serve as a roadmap of sorts. If developed in sequence, she says, the workshop series could help cue up a community so that it would be prepared to apply for funding under the Coast-Smart Communities Initiative (CZMA Section 309).

The Climate Partners huddle around the flipchart, focusing intently on their efforts to map out a set of next steps. They think that this collective approach will help everyone take advantage of each other's strengths and avoid duplication. At the end of the road, if all goes well, they hope that their efforts could enable real policy change — modifications in building codes or plans to make communities more resilient, better prepared to confront the climate challenges that lie ahead.

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Goldman Says Goodbye

Michael W. Fincham

After six-and-a-half years as a science writer, Erica Goldman is leaving Maryland Sea Grant. During her tenure, she wrote about Bay science, led enthusiastic forays into new media like blogs and Facebook, and most recently produced several short videos. In between all her work projects, she and her husband Joel managed to organize several epic travel adventures and welcome the birth of two energetic children.

Cairn Krafft

Arriving in 2004, Erica came well trained in science, writing, and policy. After finishing her Ph.D. in marine science at the University of Washington, she began exploring non-traditional science careers, first by working at *Science* magazine as a science writing intern, then by spending a year on Capitol Hill as a Knauss Marine Policy fellow. At Sea Grant she put all that experience to good use, writing magazine articles for *Chesapeake Quarterly* and co-authoring in-depth publications with scientists that examined topics like resilience and thresholds in estuarine ecosystems.

How did a scientist turn into a science writer? By trying to share her research with others — only to discover the big gap between scientists and non-scientists, a culture gap that can sometimes look like a canyon with scientists and laymen trying to yell across the void while speaking different languages. She was always surprised, she admits, when laypeople didn't see the importance of her work on "Non-Linear Mechanics in Jellyfish Locomotion," the topic of her dissertation. "Instead of getting upset," she says, "I tried to figure out ways to explain the science and show people how interesting it is."

To sharpen her skills she took courses in science writing during graduate school, then sought out science writing work with Washington Sea Grant. By the time she arrived in College Park, she had a new career and a new personal mission statement: she wanted to work full time on bridging the big gap between scientists and the rest of us through writing and synthesis and storytelling.

She brought to her mission a deep interest in science, an abiding curiosity about the people who do science, and an energy that scientists appreciated. "From when I first met her to the last meeting, she had this intense interest in understanding what we do," says Walter Boynton, a marine ecologist at Chesapeake Biological Lab and incoming President of the Coastal and Estuarine Research Federation. "Her goal was always to make science understandable and compelling to people who were not science geeks."

She leaves Sea Grant with a deeper understanding of Chesapeake Bay science and policy as well as skills in narrative journalism and new media. She wrote long-form pieces for *Chesapeake Quarterly* and online briefs for the web site's Science News and Marine Spotlight sections. She also started up Sea Grant's Bay Blog and Facebook page, and led a project to produce several short videos showcasing Extension work with rain gardens and stormwater management, videos that Angie's List, the consumer review portal, will soon feature on its website.

"We will surely miss those talents," says Jonathan Kramer, Maryland Sea Grant Director. "Erica's curiosity, scientific background, and interest in telling the story underneath complex issues is a rare combination, one that we truly valued here at Maryland Sea Grant."

Her next job won't take her far from College Park. Starting in January 2011, she will drive to the Silver Spring office of COMPASS, (Communication Partnership for Science and the Sea), where she will start work as the new Assistant Director for Marine Science Policy Outreach. Her new job builds on her old job. The goal is to communicate key marine science findings to policy makers, the public and the media, in large part by trying to turn scientists into good communicators. The tools COMPASS favors include briefings, meetings, and communications training. One tool Goldman brings is storycraft. "I want to help scientists tell compelling stories that resonate."

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