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Ripple Marks

The Story Behind the Story

BY CHERYL LYN DYBAS

Night-of-the-Nor'easter: "Century Storm" Turns Delaware Coastal Life Upside Down

By dark of night they howl across Delaware Bay, these winds that reach 60 miles per hour. The gales of a nor'easter in May—a winter storm that happens this late in the season only once a century—overturn everything in their path. Along Delaware's Pickering Beach, seaweed washed in with the tide scurries along the water's edge, its long tendrils chased by a whirlwind of sand grains.

A full moon lies hidden behind storm clouds. Nor'easter rains slice down like ice picks. Beach houses on Sandpiper Lane are dark; even the sandpipers have flown.

Everything—from birds to humans—has run for cover.

All species but one. It's called to Pickering Beach by forces far beyond the power of the storm, beckoned by moon and tide in an age-old dance between sea and shore.

On just a few nights each year, the nights surrounding May's full moon, magic happens. Ancient creatures—horseshoe crabs—crawl out of the ocean and onto land to mate during the highest of May's high tides. The crabs are joined in the pilgrimage by thousands of their kind. "Among the greatest marine spectacles on the planet," these nights have been called by a National Geographic guidebook.

This spring, the message from moon to ocean, tide to crab, is almost interrupted by storm waves. However faint, though, the crabs can still hear it.

The ritual has taken place for eons. Horseshoe crabs are often referred to as "living fossils"; similar species are found in the fossil record as far back as 250 million years ago. Four species of horseshoe crabs exist today, three in Indian and Japanese waters. The fourth species, *Limulus polyphemus*, occurs along the east coast of North America from northern Maine to the Yucatán Peninsula. More than 90% of this population lives along the mid-Atlantic coast, with the largest concentration in Delaware Bay. The four horseshoe crab species are the only living members of the Xiphosura, one of the oldest classes of marine arthropods.

In the United States, Delaware Bay's extensive sandy beaches are the crabs' preferred spawning habitat; sand beaches make up 54% of this shoreline, studies show, with the remaining 46% of the coast composed of eroding peak banks, salt marsh, and shores reinforced with stabilization structures.

Wind exposure is perhaps the most important factor in determining which beaches the crabs choose for spawning. Along Delaware Bay, New Jersey beaches are usually windier, and therefore have fewer mating horseshoe crabs than Delaware beaches, researchers have found. On this nor'easter night, with the entire bay whipped into a froth, there's no port in a storm for the crabs—on either side of the waters.

With each breaking wave, the crabs, stacked atop one another like rows of coins, fight their way to shore. Nor'easter winds notwithstanding, the clacking of shells is deafening. The crabs are bent on one goal, burying their eggs deep in the sand and ensuring the next generation.

Mission accomplished. Those that aren't irrevocably flipped over in the melee of wind and wave, a potential death sentence, slowly turn back toward the sea. The crabs heed the call of the ocean. Few are snared by the nor'easter.

Their return to Delaware Bay is a triumph. Horseshoe crabs have been overfished, caught for eel and conch bait and for their copper-based blue blood,

extracted to make Limulus amoebocyte lysate (LAL). Derived from the crab's blood, LAL is used to detect bacterial endotoxins. Horseshoe crab blood clots when exposed to these endotoxins.

The taking of horseshoe crabs is regulated by the Atlantic States Marine Fisheries Commission, which has imposed limits on the fishery to allow the crabs to recover.

Horseshoe crabs leave behind an average of 3,650 eggs in each nest. With thousands of nests on beaches all along Delaware Bay, some eggs are close to the surface—too close. Shorebirds—red knots, ruddy turnstones, and semipalmated sandpipers—feast on horseshoe crab eggs to replenish their energy reserves before continuing a northward migration to Arctic nesting grounds. Red knots are now threatened, however, as a result of the extensive horseshoe crab harvest and consequent fewer eggs available for food.

By day, shorebirds spear eggs as fast as they can partake of the crab buffet. But on the night of the nor'easter, crab eggs deposited on the sand's top layer are swept away by strong winds long before the birds arrive at sun-up.

The storm also scoops buckets of seawater and empties them into wetlands behind Pickering Beach, turning freshwater marshes into extensions of the ocean. By morning, salinity in the embayments of nearby Prime Hook and Bombay Hook National Wildlife Refuges has risen from a freshwater five parts per thousand almost to the level of seawater, 32 parts per thousand, says Prime Hook refuge manager Michael Stroeh.

Prime Hook National Wildlife Refuge was established in 1963 to protect coastal wetlands stretching from Slaughter Beach south to the Broadkill River. Centuries earlier, when Dutch settlers arrived in the area, they discovered abundant purple beach plums and called the area *Priume Hoek*, or Plum Point, hence the refuge's name.

Checking on Prime Hook's wetlands at dawn in an airboat, Stroeh and now-retired refuge biologist George O'Shea "fly" through plants called spatterdock. Stroeh and O'Shea get a first look at how the nor'easter has changed the refuge's 4,200 acres of freshwater marshes. As the airboat glides through aquatic grass-lined twists and turns, water and sky blend into one, a rippling silver-blue during this calm after the storm.

"The marshes likely will be a different place," says Stroeh, pointing to uprooted, drifting plants. "They can't experience an event like this and remain exactly the same. The wetland grasses, for example, belong more to the land than to the sea. Or did." Oystercatchers and snowy egrets now stalk their prey along a carpet of reeds dislodged from the bottom.

From an airboat, the refuge looks more like the Florida Everglades than the Delaware coast. In a flooded backwater creek surrounded by waterlogged trees, the scene is primeval. Huge snapping turtles sun themselves on logs along the banks. A sudden flapping of wings, and a great blue heron hidden in tall cattails takes flight. More herons watch Stroeh and O'Shea from branches overhead. Clearly, the birds' domain has been invaded.

Not all Prime Hook wetlands are freshwater marsh; salt marsh makes up some 2,300 acres. "With the inflow of seawater from the storm, the ratio of freshwater marsh to salt marsh may tip significantly toward salt," says Stroeh. Salt marshes are important nurseries for fish and crabs. "The fishing may get better yet for the many ospreys here," says O'Shea. As if on cue, an osprey swoops down, extends its talons, and plucks a silvery bass from the marsh. It lands in its nest atop a duck blind, there to partake of a piscine meal.

Refuge managers usually lower water levels in spring through a series of dykes and other water control structures. The shallower water allows marsh plants like wild rice and millet to grow. During spring and fall, the plants are feeding grounds for tens of thousands of migrating shorebirds. In summer, wild rice and millet serve as nesting sites for wading birds like least bitterns and black-necked stilts. Raised water levels in fall and winter offer the plants' seeds to thousands of migrating ducks and geese. More than 100,000 snow geese and 80,000 ducks visit the refuge during peak southward migration in November.

Months after the storm, "few freshwater plants are growing because of higher salinity waters in the marshes," says Stroeh. "The refuge has a different mix of birds, with coastal species more abundant."

Horseshoe crabs emerge from the sea by the light of May's full moon, shuttered last year by a "century storm," a late-season nor'easter. Shorebirds winging their way north to Arctic breeding grounds depend on horseshoe crab eggs for fuel. *Photos courtesy of Ilya Raskin, Rutgers University*




The night-of-the-nor'easter lingers along the Delaware shore.

"It's something to remember," says Elva Burrows, owner of Sambo's Tavern in Leipsic, Delaware. Overlooking a freshwater marsh along the Leipsic River, Sambo's has been known for 50 years for its blue crabs. "The marsh grasses laid flat-down in the storm," says Burrows. "I've never seen anything like it."

Closer to the coast, ocean swells lashed the beaches. "Many of the dunes were lost," says Stroeh. "Amazingly, most of the mating horseshoe crabs seem to have survived. Just a handful of broken crab shells remained."

Mudflats that replaced the beach dunes have been a field day for shorebirds like sandpipers, willets, and plovers. Black-bellied plovers, a treat for birdwatchers, were common last spring.

What of the next decade, or next century, for Prime Hook, Pickering Beach, and other Delaware Bay marshes and beaches?

The 2008 nor'easter may be a harbinger of things to come. "With sea-level rise already happening," says Stroeh, "shoreline erosion may decrease the amount of beach habitat available for horseshoe crab spawning, for example. This storm may have given us a glimpse into the future, a future very different for beach and marsh alike."

For now, he says, Delaware's coast has been turned upside down by a nor'easter that's the rarest-of-the-rare in spring—a once in a lifetime.

Global Warming: Sea-level Rise, Drought, and…Kidney Stones?

The news may be less well-known than sea-level rise and extensive drought, but a hot Earth could also increase the incidence of kidney stones, according to research by Tom Brikowski of the Geosciences Department at the University of Texas at Dallas, and Yair Lotan and Margaret Pearle of the Department of Urology at the University of Texas Southwestern Medical School.

The condition is caused by dehydration, a "desertification" of the human body in which stone-forming salts rise.

"An unanticipated result of global warming is the likely northward expansion of the present-day southeastern U.S. kidney stone 'belt,'" the scientists write in the July 15, 2008, issue of the journal *Proceedings of the National Academy of Sciences (PNAS)*. "The fraction of the population living in high-risk zones for nephrolithiasis [kidney stone formation] will grow from 40% in 2000 to 56% by 2050, and to 70% by 2095." Predictions based on a climate model with intermediate warming show an increase of 1.6–2.2 million cases of kidney stones by 2050, said Brikowski. Nationwide, the associated cost would be $0.9–1.3 billion annually (in year 2000 dollars), 25% above current expenditures.

"The impact of these changes likely will be geographically concentrated," said Brikowski. "Increases by 2050 are concentrated in California and along the Eastern Seaboard, as well as in a geographic band stretching from Kansas to Kentucky."

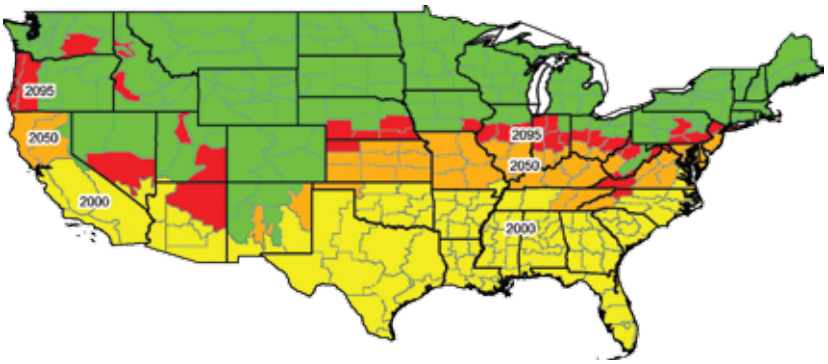
Kidney stone disease in the United States shows marked geographic variability. The disease in the Southeast is 50% greater than in the Northwest—for now. Mean annual temperature, because of its effect on fluids in the human body, accounts for 70% or more of this variability, said Brikowski.

Transient variations in kidney stone formation, such as in desert military workers deployed to hot places, can also be accounted for by temperature changes, he said. "The physiologic response time to heat is rapid, with the peak period for kidney stone development just 90 days after arrival in hot, arid conditions."

Similar climate-related increases in this disease may be expected worldwide, say the researchers, given predictions of long-term climate warming. "Kidney stone belts will expand not only in the southern U.S., but also in Europe and Asia," said Pearle. "This direct link between global warming and human health adds yet another challenge to the task of adapting to climate change this century."

For now, "drink your water," she recommends.

If you can find any, that is, in a warming world.



Predicted growth in high-risk stone area (stone belt; risk ratio: 1.2) vs. time, for 2000 (yellow), 2050 (orange), and 2095 (red); linear model. At 2000, 41% of the population is within a high-risk zone, 56% at 2050, and 70% at 2095, based on year 2000 population distribution.

Where's the Water? Look on Weekdays

Looking to collect some raindrops in a water-starved world? You might fare best on weekdays, recent research suggests.

Rainfall data recorded from space show that summertime storms in the southeastern United States shed more rainfall mid-week than on weekends. Air pollution from humans is likely fueling the trend.

The link between rainfall and day of the week is clear in data from NASA's Tropical Rainfall Measuring Mission satellite, or TRMM. Mid-week storms, the data show, tend to be stronger, drop more rain, and span a larger area across the Southeast, compared with drier weekends, said Thomas Bell, an atmospheric scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland. Bell believes the trend can be attributed to atmospheric pollution, which peaks mid-week. He and colleagues reported their results in the *Journal of Geophysical Research-Atmospheres* on January 31, 2008.

Rainfall measurements from ground-based gauges can vary from one site to another. To identify the weekday trend, Bell looked at a bigger picture—from Earth's orbit. Data from instruments on the TRMM satellite were used to estimate daily summertime rainfall averages from 1998 to 2005 across the entire Southeast.

Results show that it rains more between Tuesday and Thursday, than from Saturday through Monday. Summer 2007 data continued the mid-week trend, with peak rainfall occurring on Thursdays. Mid-week increases in rainfall were most significant in the afternoons, when conditions for summertime storms are in place. Saturdays experienced the least amount of afternoon rain.

Scientists have long wondered about a possible link between workweek pollution, such as emissions from traffic and factories, and weekly weather patterns. Clouds are "seeded" by particulate matter from these emissions. Water and ice form around the particles, creating more rain.

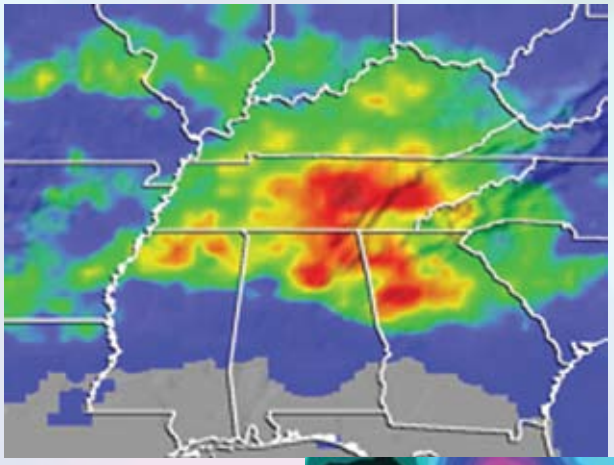
"With the influence of aerosols [suspended particles] on cloud development, and the weekly variation in aerosol concentrations, this evidence strongly suggests that air pollution invigorates storms," said Bell.

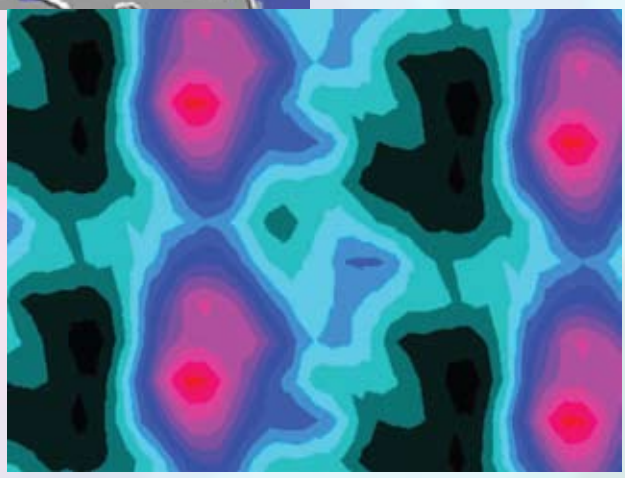
With a likely "weekday effect" of air pollution on storm development, Bell wonders how much error is made in forecasts of precipitation when models don't take into account the effects of aerosols.

The next step, he says, is to find out whether there's a weekly cycle in rainfall in areas of the United States not visible to TRMM.

A prior study, by Menglin Jin of the University of Maryland and colleagues, published in the *Journal of Geophysical Research* on April 27, 2005, showed that the millions of people who work in New York City not only alter the population density each weekday, they add to the amount of aerosols in the atmosphere. Jin discovered a workweek pattern of aerosols clouding the air, believed to be created by the comings and goings of those employed in the city. The research found that these urban aerosols were thickest on Wednesdays, affecting raincloud over New York.

"Rainmakers" do frequent Wall Street, at least during mid-week.





Left. Torrential rainfall from a 2003 storm in the Southeast resulted in massive accumulations of rain (red). Similar data from NASA's TRMM satellite has revealed that more rain falls midweek. *Credit: NASA*
Below. Tracking upward, this chart shows Southeast summer rain cycles of less rain (black) to more rain (red) over the period of a week, averaged from satellite data collected from 1998 to 2005. *Credit: NASA*

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