Chesapeake Bay MAGAZINE
BOATING AT ITS BEST
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HAPPENS EVERY YEAR, IN LATE SPRING and early summer. My husband and I will be working on the boat, and the kids will come racing up with the news: There are horseshoe crabs on the beach, and they're mating! And every year I walk to the postage-stamp-size beach, squeezed between the boatyard's haul-out slip and the riprap in front of the neighboring condos, and there they are—a female with a male clamped to her back, looking for a decent stretch of sand to deposit and fertilize their eggs. I don't get it. Perhaps this is natural selection at work and these are the world's dumbest (or unluckiest) horseshoe crabs. Annapolis harbor is painfully short of any sand; this pair has barely a beach to work with before it meets a bulkhead and the aforementioned riprap. You'd think they'd be a lot happier on the Eastern Shore or farther south in the Bay, where we've seen their kin on far more commodious spawning beaches. Or better still, over on Delaware Bay, where their brothers and sisters spawn by the hundreds of thousands at a time—more than anywhere else in the world.

by WENDY MITMAN CLARKE

Then again, who am I to question an animal such as this? An animal that predates Homosapiens by about 450 million years, an animal whose eyesight is so evolved that we have studied it for decades (and learned it is remarkably human). Its blue blood is the only substance on Earth we have found so far that can so quickly and effectively diagnose dangerous bacteria, and which makes it safe for my kids to get vaccinated and for astronauts to work in space. Its ancient ritual of hauling up on certain sandy beaches every spring and summer to spawn on the full and new moon high tides has fueled the epic migrations of billions of shorebirds. And it is undoubtedly one of the reasons juvenile loggerhead turtles come to the Chesapeake every summer to eat and grow.

Horseshoe crabs survived the events that wiped out the dinosaurs. They survived the 19th and mid-20th centuries, when they were caught by the millions in New Jersey and Delaware and used as fertilizer. In the last 17 years or so, they have struggled through a period of intense harvest by fishermen who use them as bait for eel and what's known as conch (actually a type of whelk). Only now are scientists and fisheries managers starting to see their population stabilize from what appeared to be a calamitous slide.

There are only four species of horseshoe crabs in the world, and the greatest concentration of one, *Limulus polyphemus*, is here in the Mid-Atlantic. Delaware Bay is the focal point, but the Chesapeake too plays its part in harboring horseshoe crabs. We don't eat them; they're not even really crabs. They resemble nothing so much as armored vehicles, and you probably won't find their bland, brown visages on greeting cards or little gold charms. Nobody's written a Pulitzer prize-winning book about them. They're slow, homely, and sometimes they get stuck upside down and meet their maker in utter helplessness. So why should my kids or I care about this seemingly hapless pair on this inhospitable scrap of sand amid the condos and boats and fuel docks and bulkheads of Annapolis? Let us count the reasons.

Fossil records show that arthropods like today's horseshoe crabs were certainly here somewhere around 450 million years ago.

Limulus polyphemus gets its name from the mythical one-eyed Cyclops Polyphemus, because a few of its 10 eyes (yes, 10) are clustered together in the middle of what looks like its forehead. The early European settlers of this region called them king crabs, because they looked like crabs (at least on the underside) and they were the biggest "crabs" out there. To most of us today they're known as horseshoe crabs, a name that derives from the horseshoe-shaped shell and perpetuates the crab myth. In fact, horseshoe crabs are more closely related to arachnids than crustaceans, despite their crabby looking undergear.

Just exactly how long they have been crawling around on Earth is open to a bit of interpretation, but according to Carl N. Shuster Jr., adjunct professor at the Virginia Institute of Marine Science (VIMS), fossil records show that arthropods like today's horseshoe crabs were certainly here in the Silurian period of the Paleozoic era, somewhere around 450 million years ago. Shuster, known to many as the granddaddy of horseshoe crab researchers, co-edited with Robert B. Barlow and H. Jane Brockmann the definitive text on *Limulus*, *The American Horseshoe Crab* (Harvard University Press, 2003). "Persistent," Shuster writes, "is an apt, one-word description of the survival of Limulids."

By most aesthetic standards, they're not pretty. In fact they look rather intimidating with the moveable spines along the sides of their opisthosoma (we can call it the abdomen) and their bayonet of a tail (scientifically known as a telson). Joe Grist, senior manager in fisheries management with the Virginia Marine Resources Commission (VMRC), often takes horseshoe crabs to the state fair to educate people about them, and invariably kids see that spike of a tail and are convinced this is the animal that killed the famed "Crocodile Hunter" Steve Irwin. Far from it. "It's a docile animal," he says. "It can't hurt you, it can't chase you, it can't even bite you. It's a very misunderstood animal because people look at it and it's scary, and that's part of its defense. But it can't hurt a flea."

It takes about ten years for horseshoe crabs to reach maturity, during which time they periodically shed their shells to grow. They can live to 20 years old. Once they reach adulthood they stop shedding, and their armor often becomes home to barnacles, seagrasses, limpets and other hangers-on.

Beneath all that armor, if you flip one over, you will find a rather spidery critter, with six pairs of legs. Five are involved in ambulating on the seafloor, where they spend most of their time rooting around for clams and worms, their primary diet. Two legs are for helping guide food into the mouth—which, believe it or not, *surrounds* the crab's brain (the same thing happens to us on Thanksgiving and other high feasting holidays). If the two foremost legs are shaped like boxing gloves then you have found a male crab; these modified legs let the male hang on to the female during mating.

Farther aft of the legs are the crab's gills, called book gills because they resemble the pages of a book. And then you get to that tail, which is used not as a weapon, but as a lever for righting themselves if they have the misfortune to be flipped over by a wave on the beach. It also helps them "see." That is, the tail has photoreceptors that, according to *horse shoecrab.org*, "keeps its brain synchronized with cycles of light and dark."

Scientists have been studying the vision and eyes of horseshoe crabs for nearly 90 years. Including the tail photoreceptors (which count as one "eye"), the crab has nine more located around its body. The two most obvious and largest are the lateral eyes on each side toward the top of the shell. Look closely enough into these eyes and you can see tiny black dots; they are individual receptors and each eye has about 1,000 of them. The cones and rods in these eyes are like those of humans, just 100 times larger. And it turns out the animal has killer night vision, thanks to a circadian clock in the brain that tells the eyes when it's dark and increases their sensitivity nearly one million times for night work.

Several times every spring and summer, on the high tides of the new and full moons, horseshoe crabs use these eyes to find one another. Males attach themselves to females, and, en masse, the females piggyback their mates onto the beach to

spawn. If the weather is poor and the seas are too rough, they will wait; they need calm water for this work, as breaking waves will flip them over and expose them to being devoured by gulls. (The only other predator, besides humans, of an adult horseshoe crab around here is the loggerhead sea turtle.) By the hundreds of thousands on the Delaware Bay's long, sandy beaches, and in lesser numbers on the Chesapeake, they crawl out of the water. The female burrows in the wet, soft sand several inches and lays bundles of about 4,000 eggs at a time, while the male on her back releases sperm to fertilize them. They repeat the process four or five times, then return to the water. On following maximum high tides they will return through May, June and July until all of the females' eggs are gone (each can lay about 100,000 per year).

"On a good beach and on a good night they could be four or five deep and going all the way down to the right and left as far as you can see," says Glenn Gauvry, president and founder of the non-profit Ecological Research and Development Group based in Lewes, Del., which is dedicated to the conservation of horseshoe crabs. "Slaughter Beach is the largest spawning site in the world. This past spring we counted 257,000 pairs on that one beach."

By all accounts the spawning is an astonishing sight: "The entire setting was like stepping out of the present into some prehistoric scene," writes Carl Shuster, describing the first time he witnessed it. Of each crab's 100,000 or so eggs, Gauvry says, there is about a 90 percent hatch-out rate, "which is a good thing since just about everything eats them." First to the smorgasbord, often ready and waiting even before the crabs show up, are the shorebirds that have traveled thousands of miles from Central and South America. En route to their summer breeding grounds in the Arctic, they gather here by the hundreds of thousands for just this event, because for thousands of years the crab eggs have provided the fuel and fat they need to complete their migration.

All of this is fascinating to scientists and birders, but few people would care about horseshoe crabs were it not for one more thing: their blue blood. Horseshoe crabs' blood is capable of the ultimate litmus test. At a few licensed labs (five in this country, regulated by the Food and Drug Administration), horseshoe crabs are placed in clear containers while their blood is drawn from the soft tissue of the hinge between the large forward shell and the smaller one sheltering its abdomen. The blood is a weird blue, and it is utterly unique. It contains Limulus amoebocyte lysate (LAL), a highly sensitive clotting substance. In the crab, LAL is rushed to the scene of any wound where there is a bacterial endotoxin. It is so attuned to detecting these bacteria—called pyrogens, says John Dubczak, operations manager of Charles River Laboratories based in Charleston, S.C.—that LAL has become the only substance the medical and pharmaceutical fields use to test for them.

Pyrogens, Dubczak says, are ubiquitous in our environment and in our bodies. Ordinarily, the body has methods of containing them, but if they are introduced into a person's blood system, they cause potentially fatal fever (hence the root of the bacteria's name "pyro"). "Anything that sees the blood system directly or indirectly has to be assured to be clear of pyrogens," Dubczak says. "The blood of the crab is extremely sensitive to these pyrogens." So sensitive, says the company's website, that it can detect one picogram per millileter of bacterial endotoxin, "equivalent to one second in 320 centuries or one grain of sugar in an Olympic-size swimming pool."

Companies like Charles River collect the crab blood (they release the crabs after bleeding them) and develop tests and systems to use LAL worldwide. If you got a flu shot this year, that vaccine and the needle used to give it were tested using LAL. If your mother just had her hip replaced, every aspect of that procedure—from the IV needle and fluids to the artificial hip itself—was tested using LAL. "Even if you've never seen a horseshoe crab before, if your dog or cat or child had a vaccination this year, you'd better thank the horseshoe crab," Glenn Gauvry says.

Last year, Charles River's new portable endotoxin detection system was blasted into space aboard the shuttle *Discovery*. Astronauts on the International Space Station are using it to culture space probes to ensure we don't contaminate space with Earth bacteria, to test their water systems, and in a variety of other ways, Dubczak says. "You've got this ancient creature, and you've got this blood that has already been proven to be amazing in the biomedical industry," he says. "And now it's helping people travel in space."

With all this going for it, not to mention millions of years' worth of evolution, you'd think the horseshoe crab would be in like Flynn in terms of survival. But there is always that human predator.

Of the four species today, three are found in southeast Asia. Only one, *Limulus polyphemus*, is in the Atlantic, found from as far north as Maine down to the Gulf of Mexico and the Yucatan. How many are out there, no one knows. Horseshoe crabs in Asia have been devastated by loss of spawning beaches. "Japan is the only country that reveres horseshoe crabs and doesn't use them for anything," says Gauvry, "They don't eat them, they have never used them for fertilizer, they've never used them for bait, they don't consider them predators [of] shellfish." But as Japan's shoreline has been "hardened" by development, the crabs simply have lost their spawning beaches. "And their population is maybe only two to three thousand spawning pairs in the entire country."

From the mid-1800s until the 1960s, horseshoe crabs were harvested by the millions in New Jersey and Delaware to be used as fertilizer. They would be held in open pens until dry, then ground into a meal that was added to a fertilizer mix, says Shuster. Into the 1940s and 1950s, they were steamed first and processed into food for chickens and livestock. "In the early years," Shuster writes, "the number of crabs must have seemed inexhaustibly large." He cites one example of a report of a person collecting 750,000 crabs from a half-mile of beach in lower Cape May County, N.J. But even as early as the late 1800s, people were finding it harder to catch the same enormous numbers of crabs.

As the "king crab" fertilizer industry petered out by the 1960s, it seemed horseshoe crabs were handed a reprieve; nobody much wanted them for anything, so they had some

decades to rebound. Then, in the early 1990s, the fishery for eel and whelk started taking off, and horseshoe crabs—especially females—were the ideal bait. According to the National Marine Fisheries Service, average landings of horseshoe crabs between 1971 and 1975 were about 44 million pounds annually from Maine to Florida; that shot up to an average of 1.6 billion pounds in the early 1990s, and up to 3.5 billion pounds by 1997. In 1996, Shuster notes, more than 800,000 crabs were taken in the Delaware Bay. "This is a level of harvest approaching that recorded during the king crab fishery industry a hundred years ago."

Scientists and others grew worried that if the crab population dropped far enough, migrating shorebirds wouldn't be able to find the eggs they needed to fuel up for their northbound trips. This could in turn affect the shorebird population, and, by extension, pocketbooks; thousands of people visit the Delaware Bay–Cape May area every spring to witness the spectacle of the migration and the spawning. The ecotourism industry related to bird migration is estimated at $10 million in the Cape May area alone.

More fundamentally, no one knew how many crabs were out there and what the population could endure in terms of harvest. "Most of the research since it started has been focused on the biology of the species and its value in various aspects of research, in the biomedical field, and the vision research," says Brad Spear, the Atlantic States Marine Fisheries Commission (ASMFC) horseshoe crab management plan coordinator. "There wasn't really a big harvest until the early to mid-1990s, and at that point people said, 'Hey, maybe we're over-harvesting this animal, let's put in some regulations.' "

In 1999, ASMFC imposed a horseshoe crab management plan that capped states' harvest at 25 percent below 1995–1997 levels. Gradually that cap was lowered; in Virginia it's now at 154,000 crabs per year, and in Maryland 171,000. Delaware and New Jersey were initially capped at 150,000 each, but in 2006 the commission made a new change restricting harvest there to 100,000 males only (at nearly the same time, New Jersey closed the fishery entirely, a controversial decision still in litigation).

Rick Robins, a conch processor based in Newport News, Va., and an advisor to the ASMFC, developed the males-only harvest strategy for the Delaware Bay states as the best compromise. "It's a way to manage the resource in Delaware Bay to maximize the availability of eggs for shorebirds while simultaneously allowing for the fishery," he says.

In Virginia, fishermen must document every crab and its sex, and no more than one in three can be female. Robins says the development of conch fishing bait bags, which contain chunks of horseshoe crab rather than whole ones left loose in the trap, makes it last longer and has dramatically cut the amount of bait needed. "The conch industry will survive because of the innovation of bait bags," he says. "Which is great, because if we're cut much further it would have a substantial impact on the fishery."

In Maryland, only ten fishermen are licensed to catch horseshoe crabs, and of them only one is on the Chesapeake, says Steve Doctor, a fisheries biologist with the Department of Natural Resources. The rest fish the Atlantic off the Maryland coast. As in Virginia waters, fishermen must document every crab by sex. Both states restrict the harvest to non-spawning months and to prescribed distances from the shoreline.

Scientists are also beginning to get a handle on how many crabs are out there. "Only in the last five to seven years have there been directed surveys set up specifically for horseshoe crabs," Spear says. "So just now are we starting to see trends that we're somewhat confident in, and it does appear the population has stabilized in most areas and there are signs of increasing juveniles. And that's kind of what we'd expect at this point. Horseshoe crabs take about ten years to mature and we put the regulations into place in the mid-1990s. So those crabs we protected in the mid-nineties are now having babies. And that's what we're seeing, so it's encouraging."

Although nearly all of the population surveys are focused on the Delaware Bay, Eric Hallerman, director of the Horseshoe Crab Research Center at Virginia Tech, says "it's a reasonable inference that the dynamics we're seeing in the Delaware Bay might be the same in the Chesapeake."

So, this spring, when the kids come running up to tell me the horseshoe crabs are back on the beach, I'll be ready. Not only to cheer on their remarkable persistence, but also to think about blue blood and birds on the wing, and to wonder at the connection between us and them. ■

OVER EASY

Sometimes you'll walk on a Bay beach and find a horseshoe crab flipped upside down. It may already be dead, eaten by an opportunistic gull or desiccated by exposure to the sun. But sometimes these crabs are alive, just plain stuck or exhausted. That's why Glenn Gauvry's Environmental Research and Development Group started the "Just flip 'em!" program. It encourages people to turn the crabs over, a simple act that can help save hundreds of thousands of crabs that die each year when they become stranded during spawning. The rules are easy: Just gently lift them by the large shell and turn them over. They won't bite, pinch or sting. And never lift or turn them by the tail, which despite its appearance is quite delicate.

For more information about the "Just flip 'em!" program, and about horseshoe crabs in general, including how to join crab counts and report sitings on spawning beaches, visit *www.horseshoecrab.org*. This excellent website has links to a variety of other horseshoe crab-related sites, including Charles River Laboratories, birding groups and various state and federal agencies involved in horseshoe crabs.

Here are other websites for more information:

Virginia Tech's Horseshoe Crab Research Center, *www.nmfs.vt.edu/HSCwebsite*

The Virginia Marine Resources Commission, *www.mrc.virginia.gov*

Maryland's Department of Natural Resources, *www.dnr.state.md.us/education/horseshoecrab*

The Cheapeake Bay Program, *www.chesapeakebay.net/info/horseshoe_crab.cfm*

The Atlantic States Marine Fisheries Commission, *www.asmfc.org* (click on managed species and then horseshoe crabs)