The Horseshoe Crab, our Environment and our Health

Lisa Jean Moore

Will we erase all animal diversity in the name of modernity, or will we follow the hints given by the study of the horseshoe crab? The entanglements of this ancestral animal with human activity point to the urgent need to accept the collective responsibility that comes with the Anthropocene era.

In North America, the ocean-dwelling horseshoe crab (*Limulus polyphemus*), a maroon prehistoric creature, crawls along the ocean floor with its helmet-like hard-shelled top and multiple appendages (legs and claws) underneath. A non-poisonous four- to five-inch hard tail called a telson drags from behind as it lumbers along the shoreline. Horseshoe crabs' fossil record dates back 480 million years. This is a testimony to this animal's exceptional ability to withstand the test of time on a geological scale, a trait that has attracted the attention of marine scientists and has earned it a decisive role in modern medicine. The crabs are able to survive and reproduce in versatile habitats such as Plumb Beach in Brooklyn, New York, a barrier protecting the teeming metropolis's crucial transportation route, a playground for neoprene-outfitted kitesurfers, a cruising locale for a variety of men, a site of variegated trash piles that double as domiciles for insects, and an aquatic habitat for flora and fauna, which beyond crabs includes varieties of seaweed, seagulls, fiddler crabs, hermit crabs, jellyfish, fluke and mud snails.

Today, however, the horseshoe crab habitat is threatened by human activity. How has human engineering of the shoreline in direct response to sea-level rise (SLR) affected the everyday habitat and reproduction of crabs? How have crabs' changes in reproductive practices affected the human enterprises of biological and ecological knowledge production?

Author holding two juvenile horseshoe crabs at Plumb Beach during summer 2014. On the left is a crab that is at first instar after hatching from the egg. On the right, a crab at fifth instar, or after molting four times. © Lisa Jean Moore.

A crab of all trades

In addition to this prehistoric status, horseshoe crabs' blood from species in the United States and Asia is synthesized to become a lysate test. In the 1960s, scientists discovered that horseshoe crab blood had great capacity for clotting, understood as part of their protective mechanism to avoid bacterial infection and sustain their epic survival. Through clinical trials, the crab's blood-clotting capacity essentially is used as a test to detect if harmful endotoxins exist on or in medical devices. If toxins exist and the device is deemed contaminated, a solution of blood will coagulate or firm up. In order to get FDA approval on a human pharmaceutical, injectable, or biological/medical device, a Limulus amebocyte lysate (LAL) test must be conducted. The species blood is used to create LAL through a process of bleeding the animal in laboratories in Cape Cod and North Carolina.

Beyond the biopharmaceutical, the crabs are also useful to humans in that there is a brisk trade in them as bait for commercially fishing whelk and eel. Besides the harvesting of horseshoe crabs for blood or bait, biologist Robert Loveland explains, horseshoe crabs are potentially endangered by "ongoing sea-level rise and our response to it." Environmental ecologist Jennifer Mattei admires crabs as "habitat generalists," creatures able to live and survive across a lengthy and varied terrain, from Maine to the Yucatan Peninsula. Despite this expansive habitat and ability to adapt to a variety of environmental stressors, Mattei and many other scientists worry that the crabs might face an "extinction vortex," a process that declining populations experience. Crabs need a critical mass to breed (Shuster 1979), and with harvesting and changing shorelines there is the potential for a lost generation. As the ecologist explains, "They can tolerate low numbers but there could be a tipping point where they have local extinction because they can't find each other."

Jamaica Bay, global warming and the Horseshoe crab

Ecologist Christina Colon agreed with this prognosis as we walked along the beach in Jamaica Bay, New York. "I worry that we see no new young ones coming up. There appears to be a break in the chain and if we miss a generation of juveniles, how will they find each other 10–15 years from now for mating?"

Plumb Beach is the site of ongoing multiple biological, ecological, and (my own) sociological research projects to understand how to manage the ongoing crisis of global warming. The "naturalness" of Plumb Beach is ironic, as it has been the site of concerted efforts at sediment management—or the combination of strategies to "re-nourish" shorelines. Primarily for the maintenance of the Belt Parkway (USACE 2012), threatened by heavy beach erosion and sea-level change, sand has been pumped, rubble added, grasses planted, dunes constructed, and jetties erected (Psuty *et al.* 2013). It is for the highway that "nature" was made to adapt. As historian Ted Steinberg (2014) explains, New York City's "growth imperative" of urban planners, real-estate developers and politicians pushed the city's expansion with landfill without forethought about the lurking repercussions.

Colon added, "Humans, like beavers and elephants, are really good landscape engineers and have changed the landscape to kill the shorelines and beaches through bulk heading and dredging." It is this threat to the crabs that my research at Plumb Beach attempts to measure and interpret.

The terraforming of Jamaica Bay

Plumb Beach was acquired as New York City park property in 1924, and also became part of the Gateway National Recreation Area created by Congress in 1972. It is both city beach and federal park. In its present form, Plumb Beach offers the dense metropolis of New York City a sort of natural refuge for humans and non-human animals through access to the beach and Jamaica Bay, a tidal estuary. The Rockaway Inlet that borders the three-mile Plumb Beach on the south and east is a

dredged navigation channel. The beach has been geomorphologically transformed over the years by tides, winds, dredging, sediment management and, perhaps most significantly, through the creation of the Belt Parkway in the 1930s and its ongoing maintenance. In the words of a research assistant, "the whole idea of beach nourishment was not for this habitat but for the Belt Parkway." Envisioned by the infamous urban planner Robert Moses, the parkway is a major access route between three boroughs of New York City and a storm evacuation route for all of Long Island's population of 7.5 million. Over 150,000 cars travel on the Belt Parkway each day, making it the busiest artery between Queens and Brooklyn (NYC DOT 2012).

Fighting sea-level rise: the belt parkway against the horseshoe crab

In the last two post-Hurricane Sandy years, nourishment projects at Plumb Beach have sought to protect the beltway from the effects of sea-level rise, one of the consequences of global warming. In practice, they have effectively dissected the beach into distinct geographic zones now referred to as *before the jetty* and *after the jetty*. A jetty is breakwater constructed of large rocks or cement positioned offshore to protect a coast by interrupting the waves. To protect the highway, 127,000 cubic yards (97,100 m³) of fill were added, in addition to the breakwater structures, to *before the jetty*, also referred to as the NYC Beach. *After the jetty*, also known as the "natural" beach, is maintained by the National Park Service and was not refilled.

Map based on images from Google Maps.

Because of this peculiar situation, the nourishment of Plumb Beach provides a laboratory for sociological and biological analysis of the *before* and *after* beaches. For the past six months, I've thus joined a team of local biologists and geologists from Kingsborough Community College and Fordham University on a census and assessment of the species. During three months of the summer of 2014, I made near weekly visits to Plumb Beach, where a team of field biologists introduced me to the species and showed me how to handle adults, locate juveniles, dig for eggs, evaluate the

quality of outer shells (carapaces), and identify anatomical differences to sex the crabs. I also learned how to appreciate the size of females ("She's a big one"), marvel at the skillful swimming ("Look at how he navigates with his telson, gliding in the water"), worry about their daily challenges ("Now she's trying to flip herself back over and she'll either dry out or get eaten by gulls if she doesn't right herself") and fawn over the young ones ("Come here, cutie, we just want to measure you"). Other humans mediated my understanding of the everyday life of the crab—its movements, routines, and struggles.

Horseshoe crab carapace measurement at Plumb Beach during summer 2014.
Mated pair with satellite male covered in barnacles. © Lisa Jean Moore.

One existing ecological research project at Plumb Beach seeks to determine what is the best sand habitat for the horseshoe crab to reproduce and thrive. When the beach is "nourished," rubble, cinder blocks and sand bags are added to the dune area, and dredged sand is pumped at the shoreline to create a new beach. The team of field biologists is measuring both the quantity and quality of crab eggs as well as the density and quality of sand at both the *before* and *after the jetty* beaches.

Based on initial observations, the team thinks the sand at the new beach is too fine and therefore too tightly packed for the crab's reproduction. As a biologist explained to me:

> Once nourishment was completed, the horseshoe crabs weren't too impressed with the newly restored beaches—and preferred the reference site after the jetty. In fact, in the summer of 2012, this area of nourishment had absolutely no ecological value for horseshoe crabs. After Hurricane Sandy, and once they put the breakwater [i.e. jetty] in and added more sand, these sediments here were harder. Crabs can discriminate between different sediment types, and they prefer the softer, the better-aerated sands.

He paused to assess the tides and winds, "but a policy recommendation could be that beach replenishment needs to do a better matching of the sand to the type that works for horseshoe crabs' reproduction. But then there are the financial constraints. The horseshoe crabs are never the priority." When the fiscal concerns of saving the beach for the highway for transportation come into play, crabs do not rank in most humans' considerations.

During the same period, horseshoe crabs were reproducing on the *after the jetty* beach consistently. Researchers determined that there were "not immediate ecological benefits to the horseshoe crab" from the nourishment project, possibly because "oxygen doesn't diffuse into the sediment."

Business as usual versus adaptation: Goliath versus David as the horseshoe crab

Based on egg counts for 2014, as the wind pushed the sand down the beach and the ocean currents turned over the beach before the jetty, crabs were beginning to return to the *before the jetty* beaches as the sand changed. Over time, as the sediment mixes up, they will readjust to breeding grounds that suit their needs. But if beach nourishment was practiced on the entirety of Plumb Beach, we can only speculate that the crabs could vacate the beach for the time it takes for sediment to become less uniform. Anyway, in the arms race against rising tides, beach nourishment will happen at a quicker pace, potentially hampering the crabs' ability to adapt at such a speed. As sea levels rise more quickly, beaches are nourished more rapidly. Horseshoe crabs may not be able to make the sped-up adjustments to spawn. While beach nourishment extends the "life" of the Belt Parkway, they steer the horseshoe crabs from new sediment and shrink the sites of reproduction.

There is a tendency to approach animal-studies projects with a sense of awe and wonder or as part of a narrative of prophetic guidance. If the horseshoe crabs, honeybees, sharks and cockroaches are our Darwinian betters, we might do well to try and learn something from them. They've weathered the storm, the story goes, so let's understand their adaptations, while we also come to realize we are their biggest threat, and develop "clubs" to "help save the _____." I am attempting to resist these sensational anthropocentric tendencies, however seductive it is to revel in the details of other species' habits or elevate oneself to savior—flipping over crabs.

Rather, as a sociologist, I call for a repositioning of the scientific narrator as actor, along with the objects of narration, so that we can understand multispecies social interaction as less about constructing a static narrative and more about being enmeshed in a dynamic dialogue. I also question in a real way the city's dependence on the parkway if we humans practiced intraspecies mindfulness and work to build environments with other species. New forms of engineering could be a win–win for (some) humans and the crabs if we found other ways to get through daily life than driving to and fro on a sinking strip of asphalt.

Reactions to sea-level rise through beach-nourishment interventions may save the parkway and maintain for a few more years our current car-driven way of life without questions asked. But the horseshoe crab, appropriated in part for research into markers of shoreline health, biopharmaceutical bleeding, and transnational bait use, shows us that this kind of reaction to global warming gets in the way of more scientific research and environmentally conscious policy intent on learning from the exceptional resilience of this ancestral animal.

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Lisa Jean Moore is a medical sociologist and Professor of Sociology and Gender Studies at Purchase College, State University of New York (SUNY). She lives in Crown Heights, Brooklyn. Her books include *Buzz: Urban Beekeeping and the Power of the Bee* (New York University Press, 2013, with Mary Kosut), *Gendered Bodies: Feminist Perspectives* (Oxford University Press, 2010, with Judith Lorber), *Missing Bodies: The Politics of Visibility* (New York University Press, 2009, with Monica Casper), and *Sperm Counts: Overcome by Man's Most Precious Fluid* (New York University Press, 2008), and the edited collection *The Body Reader: Essential Social and Cultural Readings* (New York University Press, 2010, with Mary Kosut). Her newest collaboration with Monica Casper is *The Body: Social and Cultural Dissections* (Routledge, 2014). Her most recent scholarship investigates the intraspecies relationships between humans and *Limulus polyphemus* (Atlantic horseshoe crabs).

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