2

Endangered

Anyone vaguely knowledgeable about horseshoe crabs immediately and dramatically proclaims that they are hundreds of millions of years old.[1] Even the popular media fetishizes time with respect to horseshoe crabs. For example, people interviewed for the National Geographic Wild film *Alien Crab* claim that "dinosaurs saw the same species I am seeing" and "these ancient mariners crawled under the feet of *Brontosaurus*." Truthfully, I have been told that horseshoe crabs have phylogenetic roots in the Cambrian Period and that fossils have been dated from the Upper Ordovician so many times that I have often feigned understanding the significance of this lineage and mustered what I thought to be the requisite astonishment. I have been shown charts to see what Cambrian means and how the geologic divisions of time—eons, epochs, eras, and periods—differ. During the Cambrian, horseshoe crabs—or more specifically, their distant relatives—were living among sponges and algae, some other marine invertebrates, and other arthropods, but there were no hominids. But once I walk away from these charts and my enthusiastic lecturers, I often quickly forget the ordering of this time, as if all were erased.

For me, understanding horseshoe crabs has meant getting a grip on my idiosyncratic, socially functional, and personally rewarding relationship with time. If we're going to consider the horseshoe crab, as I have often been told, we'll need to take a few steps back (and a deep breath) to understand the big picture and context of the crab's existence; the implications of a species being labeled vulnerable, threatened, or endangered; and the process of being identified as a species. This chapter examines how, in addition to understanding horseshoe crabs in geologic time, we are forced to confront the destroyer-rescuer role that humans play. I am

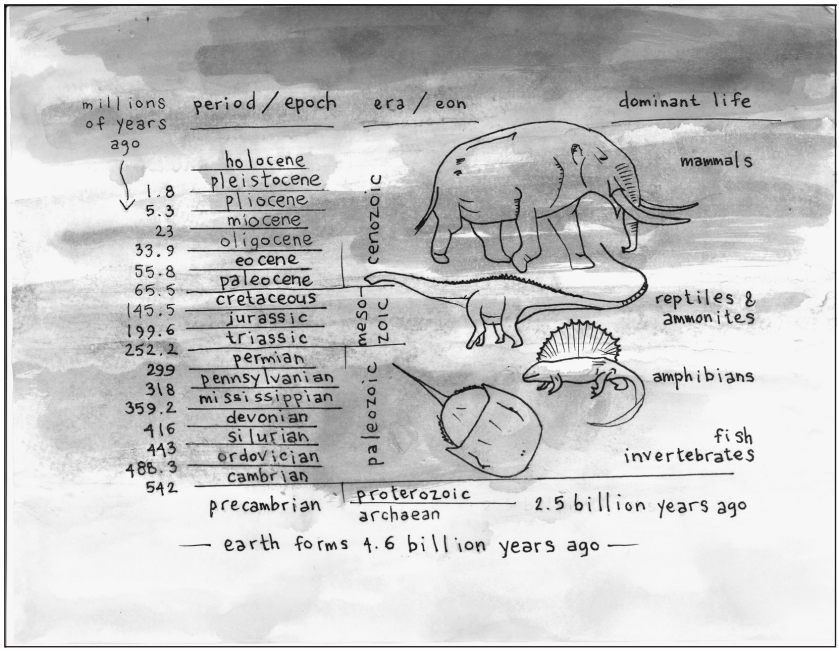

Illustration of the geologic time scale. Illustration by C. Ray Borck, 2016.

grappling here with geologic time and the contrasting time scales of the species—humans and horseshoe crabs. I argue that, in apprehending the horseshoe crab, humans experience enchantment, the magical interruption of route mindless repetition. At the same time I relate the crab directly to some very hard truths about our present ecological moment, including our being complicit in mass extinctions and horseshoe crab endangerment.

* * *

Since starting this project, I think of my life as before and after horseshoe crabs. Before horseshoe crabs, time was either immediately personal and measured in task-based increments or generational and measured in interactions with my parents, kids, or students. My everyday simplistic relationship with time was in the human, immediate, and egotistical sense, based on what I could personally experience. And it's a good

relationship from my perspective. My entire life I have been described as a fast person, a quick talker, an impressive multitasker, a speedy walker. I've always felt that time was similar to money: something to be thoughtfully spent, conserved for desired things, and managed to lead to optimal outcomes (e.g., doing laundry while making dinner as I entertained a toddler with pots and pans meant more time for reading a novel). Pride swells whenever someone says, "Whoa, you are such a good time manager," or "I can't believe how fast you are," or "You get so much done." And perhaps somewhat inhumanly, I've never truly empathized with the explanation "I didn't have enough time." In my more grandiose moments, I believe I can control time.

I admit that historical thinking, for me, has been of the generational nostalgic variety. I am susceptible to glamorizing a past as less complicated, kinder, slower. I drift into visions of an unspoiled, pastoral, bucolic landscape of harmony.[2] Yet this peaceable kingdom is always a past where humans existed and where I place my species-specific facsimile into a (not so) distant past. In the same vein, as part of my gender location and racial privilege, I can also lapse into idealizing decades or centuries ago as being so much safer and simpler.

There is also the familial time of experiencing and then watching childhood. Reflecting on the gendered norms of my own childhood, I often tell my daughters how I was able to be a lanky, boyish girl playing soccer with a bad perm, scraped knees, and tube socks well into my sixteenth year. Yet my daughters, at younger than 16 when I started this project, are negotiating Snapchat, thongs, bikini waxes, and midriff shirts. I don't think I could have handled the constant social media self-surveillance machine combined with hyperspecific tween/teenage body projects narrated in real time. Years ago, there seemed to be more places to hide and room for self-discovery without witnesses. Ironically, I don't want my girls to grow up too fast or for time to pass us by.

It is a personal paradox: In my everyday life I believe I have mastered time, but in geologic terms, I struggle. Geologic time is mind-blowing because of the limited capacities of human ontologies and epistemologies

to apprehend it. Like many people, it's hard for me to grasp concepts that have no solid measurements. Being properly socialized as human beings means we have to come to terms with how to communicate through measurement. These human inventions of measuring time have made it bend to our needs. Therefore understanding geologic time requires a completely different conceptual/affective apparatus.

In the case of time, we assign measurements to seconds, minutes, and hours. I cling to these measurements as if they are real and as if we didn't make this all up. I must be reminded that measurement of time is what humans concocted to explain phenomena such as aging or the rising and setting of the sun. Solid measurement of mass is materially more tangible because common sense dictates that an entity's mass is never going to change and that, in its stability, it is secure. But time is always changing, and we can never talk about the present, since once we have, it is already the past. Even though human measurement of time is constructed, it becomes naturalized and then applied to all living things; we place all other things on our time scale. We assign time to biology-specific orientation to orders, routines, cycles, or life spans in all biological entities. I have found that humans are supremely interested in the life span of other species. When sharing the fact that worker honeybees live for about 6 weeks, I've often heard a sort of tragic astonishment from humans—"It's so sad that their lives are so very short. They work themselves to death." This anthropocentric empathy doesn't consider time's relevance to the bee or even how "6 weeks" is experienced by the species. *Our* time becomes *all* time.

Deep time, alternately called *geologic time*, is defined as the time frame of the earth's existence, the multimillion-year time frame. At first, I though that the failure to understand deep time was actually an idiosyncratic, personal failure. But I have come to understand that it's not simply that I don't get it, it's that humans can't access it in the same way that we can access the intensity of our regular lived time, the immediate time we can experience. But there are consequences of not understanding geologic time. For example, despite overwhelming evidence, in everyday

life humans seem to be unable to fathom the enormity and catastrophe of global warming. The sociologist Kari Marie Norgaard expresses how we humans are unable to cognitively keep global warming at the front of our consciousness; we are collectively living in denial of climate change and manage our fear through emotional management strategies.[3] Maybe my (and others) lack of apprehending geologic time is part of this emotional management—it is very hard to confront how my species has completely, irrevocably harmed the planet for all living things. Part of the larger argument of this book is trying to come to terms with how humans come to care about things, ideas, objects, and animals. Time is one of those things. I am trying to understand how people care about time or become invested in deep time as a concept that enhances the value of horseshoe crabs.

As a species, we humans, it seems, are deeply wrapped up in our own embodied, affective relationship to time because we feel it. It's what we use to measure our own lives, our worth. We can't feel geologic time in the same way as we can immediate or experiential time. Being with the crabs helps me (and probably others) to approach and experience an affective resonance with deep time; perhaps this is why I (and others) have come to think they're magical. They blow our minds because they transcend our capacities for apprehending time. They push us to think of time differently. It's not that simply that I don't "understand" deep time—we all are challenged and make up myths, stories, sciences, and religions to address the idea of what's come before us and what remains after us. Deep time and immediate time are both measurements that I've learned, and as such both are constructions. For me the difference is not really cognitive but affective. I can connect my body to immediate time through my hunger levels, my sleepiness, my wrinkles, my kids' artwork. But I have a harder time connecting my affective self to the Cambrian.

Horseshoe crabs somehow make decisions as individuals and as a species in both immediate and geologic time. Individually, crabs practice going to the shoreline, burrowing in the sand, laying eggs and eating. But over vast millions of years horseshoe crabs as species have also

done these things on the changing terrain of earth. Their orientations are perhaps toward changes in light, seasons, water temperatures, tides, and geography. Do they remember through temporality or location? Are our almost theological beliefs in the separation of space and time even relevant to them? Are they nostalgic for another eon long ago when their companion species were different, when they didn't have to share the planet with grabby humans? It is these very questions that function like an ethnographer's fumbling "imponderabilia" of a crab's everyday life.[4] The founder of social anthropology Bronislaw Malinowski urges ethnographers to plunge into "natives' games" as a means of getting at the "culture" of other humans—the task is even more tricky when plunging with the crabs.

I am unable to speculate about the crabs' relationship to experiential time. When time is measured in meta or deep terms, it is challenging for me to grasp, and I am re-assured by the evolutionary theorist Stephen Jay Gould, who says that "deep time is so difficult to comprehend, so outside our ordinary experience, that it remains a major stumbling block to our understanding." He continues, "Deep time is so alien that we can really only comprehend it as a metaphor."[5] In geologic time, the extent of human's history is like a blade of grass on the far end line of a soccer field, and horseshoe crabs would be at about the top of the goal box.

Deep time is based on geologic theories extrapolated from evidence found in strata, rocks, or fossils. On this geologic time scale, I rarely admit that I don't really know if humans lived in Pangea (we didn't), or, more embarrassing still, I am not precisely sure when the Neolithic Period was (also known as the New Stone Age, it occurred around 10,000 BCE). We have existed for but the slightest fraction of time of the Earth's 4.6 billion years. In the case of deep time, part of why we want to know about the deep past is because it helps us to infer about the future. We want to understand the dinosaurs and their extinction because we want to infer things about ourselves. We interpret the geologic matter of dinosaurs to be a big clue for our essential questions: How did we get

here, and how might we endure? Horseshoe crabs precede dinosaurs by 200 million years, and as such they might harbor many clues. The paleontologist Richard Fortey wonders what has led them to be "ancient survivors." He asks, "Is being a survivor a question of having some very special features or nothing more than pure chance?"[6] Indeed, what, if anything, do horseshoe crabs tell us about the past and our future?

For the remainder of this chapter, I toggle back and forth between the descriptions of my fieldwork—the *being in it* with scientists—and my interpretation of how these scientific projects work to construct things. This toggling is between the actual work of making horseshoe crabs known through time, speciation, and counting and then the meta-analysis of what this knowing reifies about the singular and absolute concepts of Time, Species, and Census. In what follows, I am both engaged in the fieldwork and then telescoping out to interpret what the fieldwork, the science, constructs as foundational.

The Magic of "Geologic Time, Baby"

Walking though the halls of dioramas in New York City's Museum of Natural History, my youngest daughter pulls on my hand and whines, "When do we get to see the people?" She's bored with seeing taxidermied animals and wants to go to the exhibits of human scenes and especially the miniature renderings of human civilizations. Once we arrive she runs to her favorite "families" and makes up fantastic stories about what the people are doing, paying close attention to the babies and children.

Perhaps it is a sign of our ultimate anthropocentricism that there is something so difficult for us to conceive about time before humans. I suppose I am species-solipsistic when it comes to time—my species wasn't there, and so I somehow struggle with the time before humans existed. Yet I see how dangerously close this cleaves to creationism. Indeed, while studying horseshoe crabs, I came across photographs of a gigantic insulated foam and fiberglass model of a horseshoe crab temporarily owned by the Freedom Worship Baptist Church in Blanchester, Ohio. Erected

The World's Largest Horseshoe Crab in Blanchester, Ohio

in 2006, "Crabby", the 28-foot wide, 68-foot long model was originally part of a nautical museum. The church subsequently sold the structure when it declared bankruptcy, and it was re-assembled as a roadside attraction. When interviewed about the relevance of the horseshoe crab to his church, Pastor Jim Rankin stated, "The fossils found of the horseshoe crab are the same as they appear in the waters today. The crab never evolved, so the creation account must be true."[7] The ancient existence of horseshoe crabs and their stasis, or morphological stability over time, are both used as evidence among creationists to testify to Genesis and to intelligent design over evolution.

I am not a denier, though. Technologically sophisticated media shifts my consciousness and invades our senses. Hollywood pushes this along with the massively produced Jurassic-ish worlds that have further corrupted my ability to truly believe anything. I find myself uttering, "That's so fake," as if the scientifically grounded yet theoretical descriptions of

the past are some CGI-generated cinematic entertainment. Paradoxically these mediations, fantastic and scientific, produce increased skepticism about geologic time, making it imponderable for us. And why must we care about deep time and how long horseshoe crabs have lived?

My friend Pat gave me some insight. When she was teaching her daughter Ryan about geologic time, it both awed and reassured her. There is some odd existential comfort in the interpretation of deep time being profound and the revelation of our human existence as insignificant, repetitive, or mundane.[8] Our lives and the collection of ordinary worries are dwarfed by deep time; we might feel some liberation in understanding that our existence really is inconsequential. Pat recalled:

> I know this sounds simple, but we did one of those to-scale paper time lines. When you draw it all out, including both major extinction events, the scale of it is truly mind-blowing. And then how it has all been pieced together recently. The pure randomness and variety of what existed, and what persisted. Against all of it the unassuming horseshoe crab is a miracle that swam across a whole chunk of that time line. And yet, given the whole time line, they (and we) are a blink. And that means our blizzard is meaningless. This is what makes me happy. Not academic enough for any article or book, but the wonder of it exploded for me when I broke it down to teach a fifth grader. And I've been hooked on it ever since. "Geologic time, baby," is the shorthand phrase Liz and I use all of the time in our household. The emotional equivalent for me of that "Let It Go" dopey Disney song.

Pat's explanation triggers an *aha*. Yes, I was reminded that horseshoe crabs are an enchantment for so many humans. They are a magical reminder of something larger than the self and the endless worry about getting by in late capitalism. Life happened well before you, and it will go on without you. Unlike contemporary humans, horseshoe crabs have been able to exist and traffic outside of the systems of capital accumulation, though they are enrolled in capital enterprises all the time. For

humans, our recent time is not only culturally constructed, it is also powerfully fetishized by market forces. As the anthropologist Michael Taussig argues, human cultures tend to represent time as "elemental and immutable," a process he called *phantom objectivity*. "A commodity-based society produces such phantom objectivity, and in so doing, it obscures its roots, the relations between people."[9] If we build on Taussig's observations, perhaps humans are drawn to horseshoe crabs and deep time because this relationship reminds us that other ways of being are possible. Humans are not naturally or immutably forced to experience time in this way, as having particular use or exchange value.

When I teach, I spend a great deal of time on a present-day interpretation of Weber's theory of the iron cage of rationality and our collective disenchantment. Max Weber, a German sociologist working in the early 1900s, developed the theory of the iron cage in an attempt to explain the massive social, economic, and political changes brought by modernity. He was concerned with how rational calculation has come to order all of social life and how humans have become estranged from their own humanity. He wrote that humans have become "specialists without spirit, and sensualists without heart."[10]

Over the last 20 years, most of my students have been first-generation college students, middle-class to lower-middle-class, at a publicly underfunded college. They have a keen awareness of the effects of rational bureaucracy in late capitalism. Ironically, when we discuss how every minute interaction is a means to an end in their busy lives, they come to life. Sitting in a circle, I often feel like I am leading a support group for beleaguered millennial students. Speaking in turn, they are able to admit their own realizations that their lives lack imagination, meaning, and purpose. Slowly they admit that any affective or intimate human exchange seems to have some ulterior motive or rational calculation. These lessons depress us all in the collective acknowledgment that there is no magic, no enchantment. In my critical animal studies class, students often point out that even our domesticated animals are manipulating us to get us to do their bidding. It's all a means to an end—transactional, not transcendent.

There can be quite a sense of disillusionment and drudgery among my college students in their ongoing calculus of how to get from point **a** to point **b**—how to navigate an anxious life in perpetual estrangement. How do I get my degree while working a job, commuting to campus, doing an internship, and researching graduate school programs? Where has the wonder and magic gone? Where is that sweet playful abandon, getting lost in the moment?

It is striking to me that when I bring in the horseshoe crab carapaces for students to handle, a certain palpable giddiness, inexplicable joy, and visceral fear takes over the room. As they handle the crabs' carapaces, *time as usual* is interrupted, and something about this traveler through deep time undermines the dread. The short lecture in which I narrate my own burgeoning knowledge of the species can shock them—"Professor Moore, you are blowing my mind. They do look prehistoric. Older than dinosaurs?" I experience this breach of routine time even more fully when I am on the beach, holding a live crab, turning over its body. A pragmatist at heart, I am often taken with my own being overcome by the crab—and witnessing my students' gleeful rupture of the mundane is a delight.

I do believe my students and my friend Pat, and in some respects myself, experience a sort of hopefulness when considering horseshoe crabs. Thinking about them can be a break from everyday rationalized routines and an opportunity to linger in the wonder. I speculate that we find relief in the fact that nothing we have experienced in time as a species even compares to the horseshoe crab. There is something impressive about their durability, longevity, and constancy. Richard Fortey suggests we might owe our lives to horseshoe crabs in some ways. He claims that "we are all children of the Cambrian, whether we know it or not."[11] The Cambrian was a time of great primordial soup and a flourishing of life forms. Not all survived. So am I related to a horseshoe crab? Can an invertebrate become a vertebrate? Or is that a different branch of the tree?

Yet the enchantment is fleeting. We can't simply stay in a state of astonishment at the endurance of the crab—not because we are human

but because we are humans produced and reproduced under systems of global capitalism. There is a use value to be mined from the crab beyond their exchange value as blood, carapace fertilizer, and bait, and it has to do with time. Our desire to operationalize the crab's mastery of deep time for our own purposes co-opts the moments of magical transcendence. Theories abound about how crabs have accomplished this mastery—their 10 eyes that serve wide-ranging sensory-based functions, their ability to adapt to water with variable salinity and oxygenation, their compact bodies and hard-shelled exteriors, their copper-based blood that produces massive clotting, their scavenger-based diets.

The horseshoe crabs' experience of deep time leads them to become useful to humans in still another way. The crabs give us speculative power in explaining long-term survival, and as such they are dissected, measured, modeled, and sequenced to uncover the secrets of deep time. Over and over again we take from the crab, perhaps as we are primed by children's books like *The Giving Tree*. In this classic story, the apple tree is always giving to the boy—apples, branches, and trunk. It is clear she is happy in this sacrificial relationship. The human boy never gives anything to the tree, and the tree never asks for or takes anything.[12]

This act of placing the horseshoe crab on the rational geologic time line seems like an attempt by humans to steal some of its magical qualities. It's as if the awe and affective stimulation of this alien critter is something humans attempt to possess and "master," obscuring that very quality of wonder. Scientific scaffolding is constructed to determine if they are 450 or 510 million years old, or if they are cousins of trilobites, morphologically homologous or genomically related. The rational calculations squeeze out the mystical beauty, and my eyes glaze over.[13] In our efforts to know and categorize, we humans recast horseshoe crabs as valuable to natural history, evolutionary theory, and paleontology, and this intraaction thereby makes us both—crab and human—more rational, logical, and knowable and less irrational, unpredictable, and magical.

Becoming a Species

I look at the term species, as one arbitrarily given for the sake of convenience to a set of individuals closely resembling each other.—Charles Darwin[14]

Standing on the beach, horseshoe crab in hand, I've many times asked different scientists, "So is this the exact crab that existed over 400 million years ago?" They reply, "Not exactly. It's like a lineage." Or they launch into dense explanations that boggle my mind. There are "relatives in the fossil record," and they can be recognized as related to the modern species but not the same crab. Paleontology claims that horseshoe crabs are related to another ancient marine arthropod, the trilobite. There is evidence to suggest that trilobites emerged at about the same time as horseshoe crabs, but trilobites have been extinct for hundreds of millions of years. Over dinner one night, while we discussed geologic time and crabs, the marine biologist Mark Botton clarified that "relatives of *Limulus* were contemporaries of trilobites." They were similar in that they had larvae that were similar, they cast off their carapaces in the same way when they molted, and they had compound eyes that were part of the body—those eyes did not stick out above the bulk of the body.

Requiring more explanation about horseshoe crab and trilobite connections, I reached out to the paleogeologist Yumiko Iwasaki, who studies horseshoe crabs as a proxy for researching trilobites. During lunch and cheesecake at Junior's Restaurant in Brooklyn, Yumiko explained the relationship of trilobites to horseshoe crabs. Using our dining area as a map, Yumiko placed utensils as symbols across the table. "If you map out the phylogeny, you know the tree of life, the trilobites are on this end—a really, really far end here." She placed a fork. On the other far end of the table, she placed a spoon. "And this would be insects and crabs on this end. Next to them, the trilobites." She placed a knife down about 6 inches from the fork. "These would be scorpions and horseshoe crabs and ticks. They are more closely related if you compare trilobites

to crustaceans. You can say they, horseshoe crabs and trilobites, are distant relatives, but they did not evolve from one another—they share a common ancestor." Trilobites are important because they are used to gauge the rate of speciation—how species become differentiated or, as paleontologists say, how species *radiate*.[15] Trilobites were so prolific and covered such vast terrain of the Earth that they were literally everywhere. Speciation happens over vast and gradual time and creates new branches of the evolutionary tree. So horseshoe crabs and trilobites are different groups, but they have certain features that are the same—their mouths, for instance, are the same.[16] In my experience talking with biologists and paleontologists, I have gotten the impression that there continues to be a sense of surprise that trilobites went extinct and horseshoe crabs lived—a great deal of the research attempts to explain why this might be so.

A foundational organizing principle in biology, the concept of *species*, tries to wrangle biological life into different categories. The definition of species is not stable. At first *phenotypic* difference (the characters that make up the appearance of individuals in a group) was used to categorize groups and was soon refined into a criterion for defining a species. Then the *biological species concept* defined species as a group of individuals that can produce offspring that are themselves fertile and that are reproductively isolated from other groups.[17] Most recently, with the advent of genetic testing, defining species has become more complicated. Genetic testing of what were thought to be distinct species has shown that genetic lines are often blurred—what was considered a distinct species may turn out to be two different types of species or more. There are species that interbreed and produce viable offspring (those offspring can reproduce), and lots of genetic information is shared between these groups. Significantly, our techniques for identifying species change over time—but this identification does not necessarily result in any greater knowledge about the species.[18]

As a graduate student in the 1990s, I was trained in feminist science studies at a time when cultural studies was alive in the critique of any

discursive mechanism that naturalized differences. Everything that was purported to be of nature or natural was actually a discursive production that "naturalizes" what is really a cultural product. For example, alternative interpretations emerged against the standard linguistic and visual scientific representations of "sperm cells," a cultural view that reinforced that these cells were naturally programmed to fight one another to get to the passive egg.[19]

Species is another of these terms that is doing a type of hegemonic labor in the service of biological essentialism, built on the scaffolding of systems of stratification. However, the move toward feminist new materialism suggests that while discursive, the construction of *species* is still an important descriptive device because it allows social action to be organized. Rather than jettison the term, as suggested by Timothy Ingold,[20] the anthropologist Eben Kirksey argues for the need to understand discovering species as a project in becoming: "As entangled beings rediscover each other in intergenerational dances, species persist across time and space."[21] Rather than seeing the creation of a species as an exclusively anthropocentric dominating act of classification, creating and then recognizing a species, as the remainder of this chapter explores, can also be a potential exercise in its survival.[22]

Censusing, the procedure of counting and recording populations, is done for the formulation of policies and plans. Within contemporary life, census projects can involve humans, nonhuman animals, and plants, and they rely on the determination of species categories. In 2010, for example, the Census of Marine Life, an international effort to assess the diversity, distribution, and abundance of global marine life, released its results. The 10-year effort coordinated 540 expeditions and included over 2,700 scientists from over 80 nations and discovered over 6,000 new species. From its own description, "The Census investigated life in the global ocean from microbes to whales, from top to bottom, from pole to pole, bringing together the world's preeminent marine biologists, who shared ideas, data, and results. During their 10 years of discovery, Census scientists discovered new species, habitats, and connections

and unlocked many of the ocean's long-held secrets. They found and formally described more than 1, 200 new marine species, with another 5,000 or more in the pipeline awaiting formal description."[23]

On this grandest scale, to me, there is an absurdity to the choreography undertaken by a group of international human experts establishing criteria to count and measure the entire contents of the global ocean. Modern apparatuses of finding, catching, tagging, and counting offer humans some illusion of control. Now that we know what species exist, somehow we can reverse the hyperobject of global warming or rescue species that are disappearing—even tricky ones like the horseshoe crab that have demonstrated perspicacious versatility to all previous threats. The notion that making something knowable through scientific discovery, just as it is on the precipice of being lost, is a worthy use of resources suggests that the creation of a knowledge base about all marine species can lead to action plans. Or has, as Timothy Morton points out, global warming already happened; is our mobilization of massive international efforts to find out what we are going to lose really about other social processes? It brings to mind the human tendency when in the midst of a tragedy—be it global warming or an individual disease diagnosis—to scurry around in a frenzy of busy-ness, creating tasks and meanings to ground and comfort.

As explained above, at every turn there is potential controversy in classifying a species. Even at the very level of keeping track of biotic life on our planet, the term *species* is simultaneously very useful and vexingly partial. The historian Simon Pooley calls on us to problematize the notion of species when mobilizing the discourse and practices of conservation. "Conservation is the science and art of the possible, but when we decide what is endangered, and prioritize conservation action, we should be reflexive about the limitations of our fixation on species, and the role of our values in shaping our choices. So many living beings remain unclassified and beyond both our scientific comprehension and our ethical consideration. Essentialist conceptions of species may elide our interrelatedness and conceal our culpability in endangering life on

our planet."[24] As a counterpoint, Eben Kirksey suggests that "stabilizing the existence of species in techno-scientific worlds can help them endure hostile or indifferent political and economic forces. We are only dimly aware of how our own existence, as a species, is contingent on the lives and deaths of others. Abandoning the notion of species would mean losing a useful tool for grappling with other animate beings."[25] Horseshoe crabs come to matter as a species not just because of human use for capital accumulation but also for the sense that we are entangled with animals in liberation projects—if we save the whales, the bees, the horseshoe crabs, we can save ourselves.

The Making of the Anthropocene

My exercises in learning and relearning the meaning of human's categories of time and classifications of species are crucial to entering the sociopolitical ecological worlds of species conservation. Species and time are interrelated in conservation sciences: When did a species emerge? How long has a species existed? When did/will it be extinct? There is an irony about the relationship of deep time and horseshoe crabs as it is the story the improbable long-lived survival of such a non-threatening and clumsy species. They are one of the most vulnerable of creatures; during spawning season we can see them trying to turn themselves upright as each wave knocks them back and forth, seeing their carapaces, up and down the beach, insides ripped apart by birds, smelling their rot in the dry heat of a summer day. And yet, simultaneously, their hardiness extends across the supreme perils of deep time. How is it that this species is one that has survived when practically all other life has gone extinct? And how can we survive a lethal extinction event—even if we are creating the conditions that cause it? If we can save horseshoe crabs, can we save ourselves?

Herein lies another hook, capturing my attention and giving me more reason to care about time with respect to the species. The horseshoe crab has survived the previous five mass extinctions.[26] Mass extinctions are

Horseshoe crabs turned over in the shoreline waves at Plumb Beach during a spawning event. Photo by Lisa Jean Moore.

characterized by unusually high numbers of species dying out at the same time (greater than 50% of all species) and are caused by meteorologic or climate-related events. These five mass extinctions are the Ordovician-Silurian extinction, the Late Devonian extinction, the Permian extinction, the Triassic-Jurassic extinction, and the Cretaceous-Tertiary extinction. Yumiko suggests that "horseshoe crabs have lived so long because they are a generalized species; horseshoe crabs didn't specialize as much as trilobites which meant they were less vulnerable to threats from massive changes in the Late Devonian period. Horseshoe crabs are really so adaptable—and they have the blue blood, which is very efficient to survival."

As many scientists attest, we are in the midst of a sixth mass extinction with massive loss of global biodiversity.[27] To conclude that such a significant biotic crisis as a mass extinction has occurred, scientists use

the fossil record to calculate the changes in numbers of life forms on the planet caused by meteorological and geological events such as asteroids hitting the Earth and volcanic eruptions. Horseshoe crabs are one of a handful of species that have managed to survive despite these kinds of cataclysmic events. So to learn that we are in the midst of another mass extinction event and that horseshoe crabs might in fact be unable to make it through this time is distressing for humans, even more so because there is overwhelming evidence to suggest that we humans are the cause.[28]

What we are told is that the human use of the biosphere is unsustainable and that humans have induced habitat loss that deeply threatens terrestrial biodiversity. We humans have transformed the planet in ways unlike other those of other organisms. Until quite recently we have been living in the epoch called the Holocene, the last 11,700 years since

A recently dead horseshoe crab drying out on the shoreline. Photo by Lisa Jean Moore.

the "ice age," or the time "when evidence of significant human capacity for ecosystem engineering or niche construction behaviors first appear in the archeological record on a global scale."[29] Our domestication of plants and animals is the boundary of the Pleistocene–Holocene epochs.

Owing to "stratigraphic, atmospheric, and biotic variables,"[30] we are now considered to be in the Anthropocene, a heuristic device used to denote the epoch of geologic time that attributes climate change and species decline to human activities. It is forecasted that during the Anthropocene we will experience a mass extinction event that could wipe out 30%–50% of all living species.[31] Somewhat controversially dated at starting at AD 1800, typically the consensus date for the beginning of the Anthropocene is also called the Industrial Revolution (1760–1820). If we are "all the sons and daughters of catastrophe," as explained by Richard Fortey when discussing mass extinctions,[32] are we also the parents of catastrophe in the dawning of the Anthropocene? We claim that we are the first species to be aware of causing planet-wide environmental changes,[33] but our understanding of the Anthropocene is necessarily limited because it is still in process and might lead to our extinction. Or, as the historian Dipesh Chakrabarty suggests, there is a great irony in the Anthropocene in that humans can name and construct the dimensions this geologic shift and that "we can experience specific effects of crisis but not the whole phenomenon."[34]

The notion of the Anthropocene is promiscuous. Lists of contributors to species die-off and ecological degradation proliferate. These lists include the use of materials in modern agriculture, aluminum, concrete, plastic, nuclear fallout, landfill, urban structures, and dams. While theories abound about the precise timing of this epoch transition, Erle Ellis argues that anthroecological change is the best explanation of the Anthropocene, a time where humans first transformed global ecology in attempts to increase the environment's carrying capacity for human life.[35] Five different human activities are identified as potential sources of early anthropogenic methane, a gas that traps heat in our atmosphere: (1) generating human waste; (2) raising methane-emitting livestock

(e.g., from belches and flatulence); (3) generating animal waste from raising livestock; (4) burning seasonal grass biomass; and (5) irrigating rice paddies.[36]

As is the case with certain academic terms, *Anthropocene* is a "hot" term at this moment. It is well traveled and deployed in the humanities, social sciences, and natural sciences. People like the ring to it, and it seems to satisfy some species-specific sadomasochism—we can feel powerful in our self-destruction, attempt recovery, and relapse into demolition. While the Anthropocene may become the popularly accepted term for this epoch of time, and its acceptance may possibly (but probably not) lead to a sense of deeper human responsibility for global ecological sustainability,[37] it is not without problems. The term itself is anthropocentric in that it elevates humans to being the ultimate cause—the force—the supreme destroyer of the Universe. And in our self-anointed position as extinction maker (in the impressive company of asteroids and volcanoes), we can also consider ourselves the generators of the solutions. It is as if the Universe is waiting for the great human knight to come to the rescue. Simultaneously there is a counternarrative that we will cause our own extinction and be just a blip on the geologic time line.

Stated more academically, Kathryn Yusoff calls this phenomena of naming geological, temporal and social time as the Anthropocene a form of anthropogenesis. We have produced a mythic Anthropos as the geologic world maker/destroyer, or in Yusoff's words, "Anthropogenesis is the institutionalization of this originary moment (or genesis story) for humanity as an organism capable of geologic force on a planetary scale and of an epochal duration."[38] I have witnessed some of this bravado in my fieldwork, as humans describe saving honeybees or horseshoe crabs as a form of saving the self and temporarily interrupting the ecological crisis.

Working on *Buzz*, Mary Kosut and I frequently witnessed the circulation of this Anthropocene guilt through constant references to planetary destruction among beekeepers, honey lovers, and urban homesteaders.

They also suggested that there is potential hopefulness through species intraaction. Urban beekeepers spoke of their attempts to ameliorate apiary decline through making space for colonies on their rooftops, fire escapes, and backyards. The potential emergent and becoming of these intraspecies relationships quickly turn into humans believing they are stewards of the species. The deployment of their human status is somehow the key to species overcoming environmental threats even though the human species is also the most likely suspect in ecological destruction.

Obviously the alternative to species stewardship is a nihilistic acceptance of the inexorable forces of capital leading to inevitable ecological destruction. The hopeless might say, "Let's take, use, and waste, all we can while we still can." This approach is also deeply problematic. The anthropologist Anna Tsing, the theorist Donna Haraway, and the sociologist Jason Moore use the alternative term of the *Capitalocene* to express how the political economy belongs in the heart of the Anthropocene.[39] The Anthropocene is an explanation that is too easy, neat, or sewn up, and it relegates all humans as equally situated agents of destruction. Moore argues that, "above all, the Anthropocene argument obscures, and relegates to context, the actually existing relations through which women and men make history with the rest of nature: the relations of power, (re)production, and wealth in the web of life."[40] Capitalism is a particular way of organizing nature and has resulted in superexploitation of natural resources for the temporary benefit of a very select group of humans. Not all humans are equally to blame, and often humans are forced into systems of ecological harm.

Becoming Endangered? Humans to the Rescue

I'd like to shift the focus from horseshoe crabs in deep time punctuated by the repeated extinctions of other species to this particular moment of human–horseshoe crab intraaction. During these 4 years of fieldwork

with conservation biologists, ecologists, environmental scientists, and citizen scientists, I've wrestled with how we narrate humans' threat to the Earth and, in particular, the "rescue" of the horseshoe crab. When feeling exasperated during one particular conversation about time with Yumiko, I said, "Well, why should we care about these crabs, anyway?" She smiled and replied, "Oh, because we are the newcomers, and they are our seniors." These interactions are on the microsociological, but they exist on a meta level. From bureaucratic scientific quantification of massive swaths of data to manual labor on urban beaches, humans are imagining themselves to be working against their own historic legacies of destruction toward salvation for humans and the horseshoe crabs (and bees, and polar bears, and others).

Examining the work of biological conservation from the 1980s through the 2000s, the political scientist Rafi Youatt sums up a chief challenge of the task of how to identify and count all species as we are in the midst of "a major extinction event in which we do not even know what or how much is being lost."[41] He uses Foucauldian theories of biopower to explore these operations of classifying and categorizing to produce a sense of normative and healthy global biodiversity. Our project of categorizing and counting species is a part of national projects, as he concludes, "The rise of biodiversity as an object of global environmental governance has meant attachment to things well beyond conservation, biodiversity more clearly becomes a natural and economic resource, attached to national sovereignty."[42] Whose responsibility is it to count and assess the health of the species? Is it a national project? For the horseshoe crabs, if their survival (as examined in chapter 4) is of pharmaceutical and vital value, then their importance is calculated by both national and corporate actors. Furthermore, horseshoe crabs don't maintain geographic borders, which is depicted very clearly by the fact that the species *Tachypleus tridentatus* can be called the Chinese or Japanese horseshoe crab, depending on which human is speaking.

Getting on the List

On April 26, 2014, I entered a dingy, fluorescent-lit office space to join a team of concerned humans including marine biologists and microbiologists, ecologists and ecotoxicologists, as well as paleontologists, conservationists, and middle school science teachers. Dispensing with our introductions, we rolled up our sleeves and began the daylong workshop of the Horseshoe Crab Specialist Group of the International Union for the Conservation of Nature (IUCN) at the Center for Environmental Research and Coastal Oceans Monitoring (CERCOM) based at Molloy College. The IUCN is the oldest global conservation organization, and it "provides public, private and non-governmental organizations with the knowledge and tools that enable human progress, economic development and nature conservation to take place together. . . . [The Union is] organized into six commissions dedicated to species survival, environmental law, protected areas, social and economic policy, ecosystem management, and education and communication."[43] The IUCN Horseshoe Crab Specialist Group began in 2012. A primary objective of its work is to support efforts to study and conserve horseshoe crabs and their habitats.

To be more specific, at this meeting the agenda was to summarize the progress made in Red Listing the species of horseshoe crabs. The Red List is IUCN's comprehensive evaluation of global plant, animal, and fungi species and their relative threat of extinction. The procedure for assessing the risk of extinction of a species involves monitoring and compiling empirical data. These are measurements of species health that are also deeply dependent on longitudinal data. Scientists must demonstrate that over time a species has experienced a change in its population density in order to categorize its relative "health" in an ecosystem. Doing this work for the Red List is on a temporal scale that includes both immediate time as well as, in the case of the horseshoe crab, deep time.

The categories used by the Red List are Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, Least

Concern, Data Deficient, and Not Evaluated. Recall that globally there are four living species of horseshoe crabs. In 2014, the one in North America was deemed Near Threatened, and the three in Southeast and East Asia were deemed Data Deficient (meaning there has been no critical review of the species owing to lack of data). The IUCN's Species Survival Commission reviews reports submitted by species specialist groups to approve recommendations and create species designations on the Red List. While I was speaking to one biologist, he suggested that "it is really more like environmental law than science when you get to the level of convincing the Commission."

Red Listing doesn't guarantee species protection, but it informs policy makers of the situation and may add greater power to conservation efforts. There is no legal force behind the IUCN. Bureaucratic hoops are jumped through in a complicated series of forms and spreadsheets, and a species is given a designation somewhere on the continuum of Extinct to Least Concern. As Mark Botton, co-chair of the Horseshoe Crab Specialist Group, explains, there is a "paradox [in] that we have had meetings, and all people are telling us that the horseshoe crab population is going down the tubes all over Asia. So clearly we have to update the status, but there hasn't been a group to advocate for putting it in a higher level of threat, and this poses an impediment to conservation efforts. We need to have people to speak for horseshoe crabs with the best data we can obtain."

Beyond these regional meetings, every 4 years the International Workshop on the Science and Conservation of the Horseshoe Crab is held for scientists and educators to exchange information about the species. In July 2015, I participated in this conference in Sasebo, Japan, the largest to date, with over 130 presenters from Japan, the United States, Hong Kong, Taiwan, China, Malaysia, Singapore, India, the Philippines, Mexico, Denmark, and Poland. One of the main reasons for these meetings is to establish protocols for classifying horseshoe crabs on the risk of extinction.

Like much of this chapter and the entire book, my overarching question is with why some species are a concern for humans while others are

not. It has become somewhat of a given that humans care about charismatic megafauna, those large mammals of popular appeal like polar bears, pandas, and baby seals. Think of cuddly stuffed animals cementing our lifelong relationship with animals we'll never meet in the wild. We care about charismatic megafauna because we have done the cultural work to instill them in our consciousness as spiritually or emotionally valuable. But how do ugly, weird, spiny, or spiky animals comes to matter? How do we make them count? I often wonder how the crab could possibly compete with furry mammals and cute animal babies on kids' calendars, folders, and screensavers. While I am arguing that these campaigns to save animals (any animal) is based on a stratification system—vertebrate over invertebrate, furry over scaly—I also question the very idea that we can "save them." Polar bears and giraffes will become extinct. And it is not improbable to imagine that humans will die out before horseshoe crabs or honeybees. Nonetheless, there are people who have established ways to assess the horseshoe crab population's health and chart a rescue mission.

Importantly, and even ironically, this rescue mission of the crabs is happening during the persistent signs of the fragility of human life in myriad ways—the anthropologist Anna Tsing calls it "the global state of precarity—a state of acknowledgement of our vulnerability to others."[44] The use of precarity is a nod to the philosopher Judith Butler's observation that humans are predisposed to vulnerability; we have precarious subjectivity in that, since we are social beings, our lives are always in the hands of others—our companions, other drivers, and international politicians, for example.[45] I want to extend this idea beyond our human others.

Here are a few examples of our precarity with respect to nonhuman animals from just over the last couple decades. As I write this, the Zika virus, transmitted by mosquitoes, is threatening human reproduction in the Global South, and the range of infected mosquitoes is moving north. Every few years, there are health scares detailing how viruses jump species and are transmitted by through our raising, slaughtering, and

eating animals. Farm animals serving as vectors transmit avian or swine flu to humans. Mad cow disease (bovine spongiform encephalopathy, BSE), linked to the fatal brain disease variant Creutzfeldt-Jakob disease (vCJD), is caused by eating contaminated beef, and it has killed over 200 humans in 12 countries. Periodically since 1986, yet unpredictably, BSE has been confirmed in cattle (France in early 2016), and vCJD kills someone (Texas in 2014). Colony collapse disorder, a mass die-off of honeybee colonies that began in 2006, threatens the production of over 75% of the fruits and vegetables that Americans consider dietary staples.

This human precarity indicates our deeply enmeshed and highly dependent relationship with nonhuman animals. We rely on these animals to work for us, and yet we have created unsustainable labor conditions for them and for ourselves. We innovate factory farming to optimize profit and construct conditions for disease propagation. We employ animals for industrial pollination of crops and weaken their immune systems to the point of massive die-off of a generation of "workers." As we will see with the horseshoe crabs in chapter 4, we use them for health protection and deplete their hearty populations. Even when we manage them as pests, we pollute the environment through pesticides, thus increasing global warming and polluting their breeding grounds.[46]

Despite the current time replete with examples of ongoing and pending destruction, humans continue to construct a narrative of themselves as masters of the planet's welfare. We encourage younger generations to "take responsibility" for particular species. An educator from the New York Aquarium explained her strategies for teaching New York City schoolchildren about horseshoe crab conservation: "We explain to them they are surrogate parents of the horseshoe crabs. We are working to make a program where horseshoe crabs are released by elementary school and middle school children." Here we are passing the responsibility on to children—perhaps encouraging them to be ecologically minded and/or making them increasingly anxious about things they cannot control (which was illustrated by my 7-year-old daughter waking

me up one night to say she couldn't sleep, she was "worried about animals dying all the time").

In order for an existing species to be classified as endangered, human scientists must be able to document long-term persistent threats to it. Scientists must be able to articulate the species's taxonomy and geographic range, analyze its population, and determine what the major threats to it are. Yet managing an inventory census—that is, counting—horseshoe crabs is difficult because they are usually visible only when they are spawning. In the case of the upper regions of North America, this happens during about a 6-week period of time in late spring. Otherwise, their locations remain a bit of a mystery. Surveillance innovations are being beta tested where juvenile animals are tracked via passive integrated transponders, but there is limited longitudinal data (where the same population sample is tracked at different points in time over time).[47] Being able to track horseshoe crabs could provide information about where they go when they leave the shoreline—perhaps leading humans to identify their practices and create new means of counting them.

During the Japan meeting, Malaysian marine scientists unveiled their development of a smartphone application for geolocation tracking of horseshoe crabs.[48] That's right, horseshoe crabs have an app. After the initial explanation and astonishment from the audience for the app's ability to provide GPS location of crabs, people suggested that these apps might potentially aid those with poor intentions with respect to crabs. One scientist worried aloud, "There are those out there that would exploit this app and use it for harvesting horseshoe crabs. You know, telling people where to get the crabs."

Logistically speaking, horseshoe crab conservation is confronted with several challenges. The crabs themselves are difficult to find when they are not spawning. Their habitat spans far-flung regions of the continental shelf. There are vast differences in the presence of scientific experts in key locations and the lack of availability of resources for research in these regions. Among humans there are language barriers, disciplinary

differences, and cultural heterogeneity. Furthermore, the threats to the Asian species of horseshoe crabs are slightly different from those threats to the North American species. Again Mark Botton sums it up: "First, there is human consumption in Asia, second, there is massive habitat loss, similar to the beach hardening like we see at Plumb Beach but more intense, and unlike in the United States, there is 100% mortality rate when bleeding crabs for biomedical use [in Asia]."

During the Monitoring and Data Collection Workshop at the Japan meeting, our charge was to discuss

- What is the distribution of horseshoe crabs (past/present)?
- What is the rate of reduction? and
- What are the habitat requirements?

But before we could even get to operationalizing the measures and gathering the quantitative and qualitative data, we were met with issues of variability in the data. For example, some people were measuring the carapace from head to tail, others the width from side to side. This discovery led to much discussion of how to establish global guidelines for consistency of methods and standard operation protocols. Furthermore, there was a call to proselytize new scientists to care about crabs and join the struggle. Pleas were made to create local campaigns to raise lay and scientific awareness of horseshoe crabs. This turned to conversations about branding, slogans, and marketing—"What if we developed a global message about horseshoe crabs that could travel, similar to 'Save the whales'?" one scientist asked.

Another specific objective of this workgroup was to put together an international directory for horseshoe crab researchers by country that includes contact information like email and direct links to websites. The members of the workshop believe that this process would identify regional gaps in horseshoe crab data and representation. I was struck by my own fatigue at paying close attention, an ethnographer's most valuable tool, during these discussions and how I yearned to get back into

the field to actually be with the crabs. Global census-making is bureaucratic and tedious work.

Most of my fieldwork sites are in the United States, specifically in New York and Florida. As to be expected, North America is where the preponderance of horseshoe crab conservation data are gathered and analyzed. The members of the IUCN realizing this imbalance of data continue to strategize about how to best train human members of the international community to be partners in data collection. It was very clear from the Japan meeting that other countries support programs that monitor and release crabs (e.g., Japan- and Hong Kong–based laboratory-bred juvenile horseshoe crabs are released to suitable habitats). There has been such great success with integrating citizen science into outreach programs that the Singapore programs actually have had to turn away volunteers because human volunteers far outnumbered the horseshoe crabs to be counted and measured. But what type of work is done to measure crabs and standardize a system for counting and assessing populations?

Citizen Science

For the last 3 years, I have worked with the biologist Christina Colon and several of her undergraduate students on Plumb Beach. As a professor at City University of New York's Kingsborough Community College, she requires students to engage in fieldwork with horseshoe crabs through the Jamaica Bay Institute for Science and Resilience. Christina is an expert on citizen science and has written widely on the topic about the challenges and benefits from training laypeople in the methods of data collection.

With biodiversity declining and the pace of climate change increasing rapidly, ecologists are quickly seeing more and more connections between local species and global trends. The size, scope, and far-reaching implications of these connections necessitate long-term and geographically extensive studies. Such megastudies on wide-ranging or migratory species

This photograph shows me holding a horseshoe crab at Plumb Beach. This crab has been tagged as part of an Atlantic coast-wide tagging program organized in part through the U.S. Fish and Wildlife Service. See the "Horseshoe Crab Resighting Form" (posted at www.fws.gov) for the kinds of information collected on each crab. Photo by Paisley Currah.

take decades to complete and require a virtual army of researchers collecting data in perfect synchrony over thousands of square miles. Citizen science has the potential to provide that army of researchers to address large-scale questions.[49] Christina is one of several interdisciplinary horseshoe crab researchers who use these deputized scientists to assist in longitudinal and labor-intensive data collection.

As a means of educating and mobilizing individuals to understand the ecology of the Long Island Sound horseshoe crab, Jennifer Mattei, an evolutionary ecologist and professor at Sacred Heart University, founded Project *Limulus* in 1997. Mattei is concerned by what is happening to the ecological health of Long Island Sound and is specifically examining the

relative health of the horseshoe crab population. She articulated her reasons for caring about horseshoe crabs: "One day they were cockroaches of the sea, and what gets me going about it is that it would be a shame to lose a species like this due to overharvesting or habitat loss. They have survived these mass extinctions. We should care about these guys because they have survived all these things but [are] not surviving us very well. And if we have to wait for an animal to be listed on the endangered species list, then it is too late." There is a sense of futility in my conversation with Mattei, for she is correct that, once a problem is bureaucratically categorized as existing, it is probably too late. The frustration of trying to convince the public of the dire predictions for nonhuman animals is perhaps illustrated in the example of the polar bear. Many scientific experts suggest that, even if emissions of carbon dioxide decrease, certain endangered species like the polar bears are already likely to go extinct in the next few decades.[50] And yet humans are a stubborn species that innovates ways to ameliorate environmental threats (even the ones it creates itself).

Project *Limulus* is part conservation program, part scientific protocol for species census. Jennifer describes the early days of the project, when trying to tag horseshoe crabs. Initially she used a "T-bar tag like the kind you find in clothing, so we put up these little tags and punched a hole in the carapace." Unfortunately, this turned out to be the wrong tool for the job,[51] and as Jennifer shares, "The T-bar had a design flaw in that it got tangled. So we made cinch tag, and we ended up putting a hole in the shell and cinching it up." These cinch tags close up firmly on the body of the crab. Jennifer describes how, through trial and error and innovation, a process for tagging was created: "I contacted a company, and they gave me a discount—this was in 1997, and we put out like 50 tags. So we made this awl and we started conservation groups training. We would train people, laypeople, to become beach captains, you know, to be in charge of a beach, and we would have them take care of volunteers in their area because we couldn't do it all. We had hundreds of people working for us. It was fantastic."

As the program became increasingly successful, Mattei created partnerships with federal agencies such as U.S. Fish and Wildlife Service. But as she describes, owing to budgetary cuts, the program peaked in the early 2000s and is now in decline:

> Each cinch tag has a unique number, and we now have demonstrated a 10%–12% return. The U.S. Fish and Wildlife issued tags from about 2000 and asked if I wouldn't mind switching over to their protocol. It was to take a power drill out to the sea. Can you see me handing out power drills in saltwater and sand to children I have trained? All you have to do is design the opening of the hole so that they [the tags] can fit in, so we switched in 2006 to the federal tag system. But now they are losing money through budget cuts, so they are shutting down. They will only give us 3,000 tags a year. In the past, we have put out 14,000 per year with all our volunteers.

From these humble beginnings, about 15 years ago, thousands of volunteers and approximately 95,000 tags later, Project *Limulus* is an exemplar of a successful citizen science project. The project has a 22% recapture rate, providing data about the spatial and temporal patterns of horseshoe crabs in Long Island Sound in the United States.[52] These longitudinal data are crucial for establishing an assessment of the species population health.

My own experiences as a citizen scientist have taken place in New York, Connecticut, and Florida. In 2016, I joined a team in Cedar Key, Florida, led by the prominent horseshoe crab and marine biologist H. Jane Brockmann. She taught me how to tag a crab, and here are my descriptive field notes:

After I take the female from the bucket on the shoreline, I balance her on a makeshift table on the sand (an over turned cooler with a bath mat to keep the crabs from slipping). Facing the crab toward me, I pick up the awl and find the "meatiest" part of the crab to poke into—I am nervous

because Jane is standing over me, and I don't want to disappoint her. But I am not sure how firmly I should push in the tool. I place my left hand over the carapace of the crab and with my right I begin to push the awl into the shell. There is a slight popping feeling as I pierce her shell with the awl, and I spin it gently to make the hole a little wider. When pulling out the awl, the crab bleeds a little and I wonder what it must feel like. This is the blood that helps us, and I am wasting it to put in a tag. Plus, does it hurt? Jane reassures me that any bacteria I am introducing is probably not a problem for the crab given the wonderful qualities of her blood, but I feel guilty. And then an egg also pops through the hole. I quickly pick up the plastic tag and push it through her shell. I then kiss her and say sorry as I put her back into the ocean. She might be tracked if another person sees her—some weird new human/crab message in a bottle for future beachcombers.

* * *

From these data, scientists create working groups to establish reports for the Horseshoe Crab Specialist Group of the IUCN. The lead investigator on the team assigned to *Limulus* is Dave Smith, a biological statistician who works for the U.S. Geological Survey. During an interview with Dave, he explained the blend of mathematical calculation and social assessment that goes into determining a species' risk tolerance. He summed it up: "All species on the planet are on the risk of extinction. If you look far enough into the future, many, many species have some probability of risk, so many that you can't expend enough resources to figure it out. So there are other social concerns in addition to just the pure probability of extinctions that have to be taken into account. Even [with] endangered species, we must consider the values to things like ecosystems and recreation when making our assessments. So some species might get an additional bump in terms of worth. Some contribute to more value than others." I nodded rigorously since, for me, it was quite validating to hear Dave explain the procedure as if it were not just some purely scientific or statistical endeavor. Rather, he affirmed that

measuring the worthiness of a species is interrelated with a social assessment of its value.

He continued, "The question is, then, at what level of risk does it warrant protection as an endangered species to the IUCN? We have to figure out what threshold falls into the categories of Vulnerable, Endangered, and so on. That threshold is a normative in that it is the risk we are willing to tolerate in those categories." There is not some hard-and-fast objective number but a mixture of quantitative scientific assessment, statistically modeling, and psychosocial qualitative evaluation of worthiness and tolerance.

In July 2016, Dave Smith's team published with the approval of IUCN the new designation of *Limulus* as Vulnerable.[53] This significant development is an upgrading of the level of concern about the population of North American horseshoe crabs. According to the IUCN, the Vulnerable designation is appropriate when the animal meets particular criteria to be "considered to be facing a high risk of extinction in the wild." When I spoke with Dave about the report, he was very circumspect and explained to me that certain areas along the East Coast of North American had strong populations of crabs. It was at the geographical edges of their habitat where they are endangered. He added, "It would be a great tragedy if we lost them in the New England area or in the Gulf—any range contraction would be tragic." Even in the time that I have spent writing this book, the status of the horseshoe crab has been changed. This shifting status is meant to highlight the vulnerability of their time left as a species.

Hope in Unlikely Places

This chapter, and perhaps this book, is about the ambivalence of what it is that humans do when they come to realize and affirm that they have ecological interconnectedness with species and geographies. This ambivalence is combined with an unwillingness to give up hope—but it

is a deeply skeptical hope. I believe humans yearn to see their position in geologic time—what came before us—as a way to increase their human perspective. For others, including me, learning and teaching about objects like crabs brings back wonder and a sense of something larger than mundane existence and calculated rationality. When we play with horseshoe crabs, consider them, hold them, imagine their deep past, we experience the enchantment of a world that's hard to come by in late capitalism.

Across the globe, there are people working together to address problems that our species have caused—this activity of conservation, or husbandry, is hopeful, but at the same time it is also an anthropocentric thing in itself. Just as there are virtues and problems related to species classification, classifications of endangerment often elevate humans to be ultimate villains or heroic saviors. With respect to the Anthropocene, there lies an aporia of sorts—humans at least partially created the problem, and fixing the problem is part of our same old ways of self-aggrandizement. But, anthropocentrism itself is bad. It can provide some tools that offer us a way out of further destruction and maybe a way to fix some of it—an act of taking responsibility.

* * *

What does hope become when we talk beyond generational or human time (my kids' and students')? What does it mean to talk about endangered species and saving some of them within the *longue durée* of geologic time? Working through these ideas, especially for this chapter, has been fraught with greater-than-expected anxiety. As the philosopher María Puig de la Bellacasa explains, "The everyday experience of time is one of permanent precariousness: an ongoing sense of urgency and crisis calls to act 'now', while the present action is diminished, mortgaged to an always unsure tomorrow."[54] We have to act now to help save the horseshoe crabs, but these actions seem cumbersome, futile, and even preposterous in the wake of the inexorable crushing ecological destruction.

I am trying to figure out how to hold these seemingly contradictory ideas in my head—one is that we humans are just a speck in deep time, and our immediate time has come and gone, so it is ridiculous for us to go through this work of putting plastic tags on crabs and having international meetings to negotiate self-imposed bureaucratic minutiae. Or we humans can pull it off by counting, measuring, and tagging—we can get out of this mess through the processes of re-enchanting the world and making it thrilling and wondrous.

Much like the Earth is geologically formed from strata, this chapter attempts to negotiate the stacked material temporalities (personal, familial, generational, historical, human, crab, geological, deep) as a way of revealing how we co-habit the Earth. We are attempting to learn and live in times of catastrophe. This moral horizon is so complicated and frustrating in trying to figure out how to be a better resident of the Earth and neighbor to its other inhabitants while we are also so deeply enmeshed with them.