Multispecies Planning: Locating Nonhuman Entanglements in Oyster Restoration Policy on the Massachusetts Coast

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Abstract

Nature-based infrastructure (NBI) ties together ecology and planning. It is significant as an innovation and because it potentiates new and different human-environment relations. Drawing upon recent anthropological efforts to explore multispecies entanglements, this thesis considers the NBI work of the Massachusetts Oyster Project. It examines the ecological communities the organization joins in its efforts to restore the Eastern oyster, and it evaluates those relationships as indicators of potential shifts in state environmental policy. This thesis also elaborates multispecies planning as a concept. It incorporates evidence from ethnography, environmental science, philosophy, and political theory, and finds that the framework offers planners two lessons. First, it is now necessary to attend to many forms of knowledge in the planning process, not all of which are human. Second, entertaining such findings points to new ways of reasoning environmental matters of concern. Both lessons are given in the example of Massachusetts state shellfish policy.

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Introduction

One thought haunted the writing of this thesis more than others, and it's a strange but apt perception about time. I can't remember whose observation it was—perhaps that contributes to it swirling around unfettered—but the idea was that we (at least those of us who work in the field of climate adaptation) are starting to experience time differently. The 20th century was straight forward. Linear narratives made sense. Progress was measurable and correlated with moral behavior; good things happened because people worked hard to improve them. Time, then, moved in one direction: into a better future. In the Anthropocene, time is a different beast. It seems to be coming at us, relentlessly, from the future. There is constant urgency, and time hits us with all the pressure of a fire hose.

At a heightened time like this, slowing down seems foolish. There is no such thing as a slow Anthropocene; it is an oxymoron. The subject of this thesis—the work being done to restore ecosystems in the face of climatic instability—can seem quixotic, temporally out of joint. The ecologists consulted, however, value such novelty. Generally, in ecology, difference breeds productivity, and the ecological patches tended by restorationists are spatial metaphors for the sort of edge effects that abutting ecologies generate. A crack in pavement can start a process of turning a parking lot to a meadow. Opportunistic invasive species can make a cosmopolitan assemblage of biota from abandoned mine tailings. Birds of prey will make their nests atop twenty-story buildings. Living things can, and will, press back against the threatening onslaught of a future wracked by climate change.

This is no excuse for continuing business as usual, however. In fact, the ecologists consulted here demonstrate that the work of restoration in the Anthropocene is nothing short of a change in world view. By *world* view, I mean more than just a paradigm shift, though it requires that, too. I mean acting according to the perceptions of another. In the process of writing this thesis, one distinguished urban ecologist and professor once told me, to understand ecology, one must learn to see the world from the point of view of a plant. Another told me that grasping urban hydrology depended on your ability to approach the issue like a raindrop. The renowned 20th-century conservationist Aldo Leopold urged us to think like a mountain. Aphorisms like these abound in environmental thought yet are seldom taken seriously in political terms. This thesis, borrowing from developments in philosophy and the natural sciences, considers environmentalists' commitments to seeing the world otherwise as a starting point for policy. It takes as its evidence the work of humans mutually shaping climate adaptation infrastructures with nonhumans—not incidentally, but purposefully and in collaboration. This study examines the potentials of such relationships. I call this approach *multispecies planning*.[1]

The following will seem strange to planners and policy makers. Multispecies planning develops arguments that have provoked strong reactions in the planning field, including assertions that its two chief concepts are irreconcilable (Beauregard 2015). Indeed, as I describe in more detail below, the term itself

[1] I borrow the term *multispecies* from anthropology where it is used to connote the interconnectedness and inseparability of humans and other forms of life (Kirksey and Helmreich 2010; L. Ogden, Hall, and Tanita 2013).

might strike those familiar with anthropology and planning as inherently contradictory. The ecologists described here demonstrate, however, that this way of thinking human-environment relations not only holds lessons for policy, it is better suited to the task with which planners and policymakers are charged. Ultimately, climate adaptation is about our entanglement with nonhumans. It demands that we recognize the fact and manner of our relationships as we work together to improve our political ecologies. Fortunately, there are already trends in motion in policy and conservation practice that prefigure such changes.

Nature-based infrastructure (NBI) is one such trend. I understand NBI as a cross between environmental conservation and climate change adaptation planning. The field of environmental conservation seeks to preserve wilderness from human social forces whether modern, urban, or industrial. A subfield of conservation, environmental restoration, aims at revitalizing ecosystems once they have been so degraded. The practice of restoration joins conservation to climate adaptation planning, which is a broad set of practices that seeks to secure human habitation against the effects of climate change. This nexus can be seen in nature-based infrastructure, through which adaptation planning increasingly involves ecologies in mitigating threats and provisioning benefits. Nature-based infrastructure commonly involves some degree of environmental restoration[2]. Coastal examples include constructed wetlands or reefs for flood mitigation purposes, while inland

[2] This observation takes a broad view of restoration. There are at least two contending approaches to restoration. The first is to determine some historical benchmark and work toward achieving the same ecology that once was. The second is to consider the present ecology and improvements that could be made to it, often quantified in terms of ecological services. Both approaches are included in this definition because it is the nexus of the two that matters in Mass Oyster's work. See Marris (2011) for a discussion of this tension in restoration practice.

examples include reforested land or restored soils as a means of carbon sequestration. This thesis considers a specific instance of NBI: restoration of the Eastern oyster to the Annisquam River in Gloucester, MA as a climate adaptation measure by the Massachusetts Oyster Project.[3]

Mass Oyster is the sole organization in the state actively pursuing oyster restoration work. The human beings involved in this study are restorationists with Mass Oyster. The organization's site in Gloucester resulted from a 2017 partnership with Maritime Gloucester, a working waterfront museum with a newly-built pier on Gloucester Harbor and a staff member on the Mass Oyster board.[4] The pilot project to grow oysters in a shellfish incubator—an upweller—began on the pier during the summer of 2018. The organization succeeded in placing 60,000 baby oysters upstream that fall.

Oyster reefs are valued as infrastructure for their capacities to stabilize shoreline, improve water quality, and create habitat. Their value in these terms begins at birth. As juveniles, oysters attach to hard substrates, typically the shells of other oysters and, as the organism grows, it forms a shell that cements with other shells in a three-dimensional reef (Borsje et al. 2011). The reef grows up from the sea floor and dampens wave action. The slowing of the waters permits sediments to

[3] Throughout, the organization is referred to as Mass Oyster or the Mass Oyster Project.
[4] Mass Oyster is a small, all-volunteer organization run by its board. The organization has empaneled an advisory board in addition to its working board. Mass Oyster's structure differentiates them from other environmental nonprofits, as does the composition of their boards. Members have unique motivations for being involved. I spoke with two biologists with scientific rationales for their involvement, but I also heard from a financial advisor concerned about the water quality in the Charles River, a jeweler who loves pearls and wants to protect oysters (even though the Eastern oyster does not make pearls), and an urban planner working in a coastal town to address climate change impacts.

fall out of the water column and accrete on the seabed, building a calmer, more fertile area for vegetation to take root (Meyer, Townsend, and Thayer 1997; Walles et al. 2015). By breaking up wave action, the reef limits the extent of the floodplain; slower-moving waves lack the velocity to move as far inland. Oysters have been considered in terms of coastal flood protection infrastructure for this reason (Orff 2013). Water quality improvements result from oysters' feeding habits. Oysters filter water to ingest plankton and in the process also capture suspended solids and contaminants (Grabowski and Peterson 2007). These are sequestered in the oysters' excretions, which fall to the sea floor where they are further broken down by phytoplankton and microalgae (Newell 2004). This capacity can be likened to human-engineered water treatment infrastructure. Within the footprint of an oyster reef, hundreds of organisms find a home by attaching to, boring into, or living among the oysters (Wells 1961). Reefs aid in habitat creation (Peterson, Grabowski, and Powers 2003), restoration (La Peyre et al. 2014), and connectivity (Peterson and Lipcius 2003), all ecological supports from which humans benefit, perhaps most directly the fishing industry.

Mass Oyster Project's advocacy touches on all three issues described above—shoreline stabilization, water quality, and habitat creation—and it is often inflected with the urgency of climate change adaptation. They pursue oyster restoration explicitly as nature-based infrastructure. The small, all-volunteer nonprofit is the only such organization in Massachusetts. I have chosen Mass Oyster as an example of what environmental restoration portends in the context of climate adaptation, namely the development of multispecies infrastructures.

Compared with other forms, NBI most readily admits the hybrid and lively character of climate adaptation infrastructures. Unlike traditional conservation efforts, NBI does not seek to preserve a stable realm of nonhuman nature apart from human society, but to jointly produce ecologies that are dynamic and experimental[5]. In this sense, NBI is hybrid, a *natural-cultural*[6] composition. Other species are actively involved in continuously making the infrastructure, and the success of any project is predicated on the nature of the relationships amongst agents. NBI is thus lively; it involves the lives of other beings and our own ways of living. More than that, it combines and choreographs different ways of being in the world: as scientists, oysters, planners, among many others, involved in the same multispecies effort. In this case, that effort is the Mass Oyster Project.

Co-producing infrastructures with other species requires being open to other forms of knowledge and expertise, not all of which is human. The ethnographic research presented below considers how Mass Oyster remains receptive to multiple forms of knowledge in the field at their restoration sites. This work includes analyses of notes and recordings from conversations with Mass Oyster staff and board, as well as photographs of the sites, and readings of the landscapes and texts in which multispecies communities are expressed. I analyze how Mass Oyster Project volunteers interpret and use oyster restoration science to inform their work, and what other methods they employ to understand oysters' needs, including learning from the oysters themselves. I also consider Mass Oyster's

[5] The best description of the nature-culture divide in modern conservation work that I have found is in Lorimer (2015).
[6] I take this term from Bruno Latour (1993).

relationship to environmental policy in terms of how it currently applies to them and what changes could be made to better suit their work.

Restoration knowledge is administered as well as practiced, and this administration takes many forms, such as modes of scientific research and environmental policies (Lorimer 2015; Whatmore 2002; Kirksey 2015; Marris 2011; Braverman 2015). In what follows, I explore the types of knowledge produced in oyster restoration by looking at the scientific literature, and I treat scientific knowledge as one way among many of coming to know the experience of other beings. The purpose of this analysis is to understand how oyster restoration research has been conducted to date and how that knowledge might be differently administered in light of Mass Oyster's restoration practices.

I similarly consider how environmental policies inform the production of knowledge and practices of restoration work. In the context of oyster restoration, these include the Massachusetts Environmental Policy Act (MEPA), the Massachusetts Public Waterfront Act (Chapter 91), and the Massachusetts Wetlands Protection Act (WPA) at the state level. Federal policies also govern the development and implementation of state laws. I pay particularly close attention to the Massachusetts Division of Marine Fisheries Shellfish Planting Guidelines. I examine these policies to understand the technical, ethical, and political choices embedded in them, to highlight those choices that accord with the field practices of oyster restoration, and to suggest ways they might be adapted to better suit the active involvement of oysters in infrastructural projects.

My findings are unabashedly optimistic. There is a hopefulness to multispecies planning that is elided in other climate adaptation frameworks. One reason for this is that, in moving beyond our usual anthropocentrism, we can experience time neither as the march of progress nor the encroachment of the future into the present, but as something complex and multiple. The lifespan of another species, the cycles of multiscalar climate effects, the slow erosion of calcium into salt water to become an oyster shell—we experience all these timeframes in the multispecies communities described here, and those who work in this space come to know them viscerally. Reconceptualizing time in this way is a practice performed by restorationists involved in building climate adaptation infrastructures; it is a familiar language to them, not a high-minded idea but a pragmatic aspect of planning beyond the human.

Methods

This thesis draws from disparate fields, the most significant being anthropology and urban planning. I have also collected evidence from the natural sciences, specifically restoration biology, and there is some philosophy and political theory interspersed. These academic sources are complemented by ethnographic fieldwork.

Such a description might give the impression that these research methods were clearly delineated from the start and combined here to make an interdisciplinary argument, but that would not be true. My research began with the observation that NBI was a hybrid approach, uniting ecology and urban planning. As such, I sought out literature that described this nexus. The scientific literature reviewed here resulted from database searches in Web of Science and Science Direct. General and specific search terms were used to specify species (i.e "oyster reef" and "Eastern oyster," "Crassostrea virginica," and such other types of oyster as the Pacific and Olympia.) These terms were combined with words and phrases common to each subfield of research, such as "climate change," "infrastructure," "ecosystem services," "coastal vulnerability," and so forth. I conducted a separate line of inquiry for general information about the role of coastal ecosystems as flooding defense infrastructures, and this included searches in the same databases for such terms as "nature-based infrastructure" and "green infrastructure" in combination with the aforementioned terms. These searches yielded several dozen results, and others were cherrypicked from the databases' suggestion algorithm. The citations in this set of sources snowballed into another set of cross-referenced materials that were sought out directly.

This literature gave me grounds to explore further and my methods evolved with time. My ethnographic techniques especially sharpened as I learned more about Mass Oyster's work. I first visited with Mass Oyster restorationists on site in Gloucester in the fall of 2018. We also spoke by email and phone for follow-up interviews and spoke in person at related events. This pattern continued through the spring of 2019. I collected evidence from these interviews and the descriptive notes made on my site visit, including from photographs I took. I have also analyzed texts written by Mass Oyster and local journalists about the site.

The interview sample size is small. Mass Oyster is the only organization of its type in the state and it has an all-volunteer crew that fluctuated in number over the short course of my engagement with them. There are seven board members as of this writing, and in a state of seven million, they are easily classified in ethnographic terms as a hard-to-find population. The connection I was able to make with key members of the organization was critical to this study; it allowed me to be more attentive to the dynamics of their unique work and to develop a deeper analysis.

Mass Oyster's work was best explored as a multispecies ethnography. This new anthropological method seeks to include nonhuman perspectives in its findings. It requires that the researcher pay attention to evidence that is often ignored or overlooked, such as the experiences of agents who are not human, the interactions of those nonhuman agents, and their overall quality of life. Within multispecies ethnography, the nonhuman is generally narrowed down to biota (though there are notable influential exceptions), and examinations made at the species level, as is the case here. Experiences had by nonhuman species are frequently interpreted scientifically. I employ this method myself in researching oyster restoration biology, and I am attentive to it in Mass Oyster's practice.

Multispecies ethnography also examines interactions between agents and notices the contexts in which those agents are situated. Here, I rely on Anna Tsing's (2015) landscape analysis as a means of unpacking the agents involved in Mass Oyster's work. Tsing's method is tripartite. She describes the physical surrounds of multispecies phenomena in terms of assemblage, attunement, and contingency. These are simplified and interpreted, respectively, as the animals/plants/people/things in the landscape, their respective needs and the relationships built to meet them, and the temporal contexts in which they are situated.

Experimentation and a lack of commitment to a single methodology is appropriate given the issue at hand. Mass Oyster is engaged in exactly this type of fuzzy inexactitude. They translate across species lines. They develop ways of relating to existing law and policy while also demonstrating the insufficiency of those political modes to describe and regulate the multispecies relations that emerge in their work. I find that their approach is characterized by care and experimentation, and that involving other living beings in becoming infrastructure opens the door to new formulations of the political.

In the sections that follow, I elaborate on multispecies ethnography and its applications to climate adaptation planning. I root this exploration in Mass Oyster's work, and along the way demonstrate the technique I am describing; one of my methods was to personally *learn to be affected*, the same way I perceived my interlocutors to have done. The italicized term is Vinciane Despret's (2004), popularized by Donna Haraway (2007). It figures heavily in this thesis and is described at length in the following review of the multispecies ethnography literature. As a method it entailed developing an understanding of the lifeworld of the Eastern oyster, academically and *in situ*, and using that translated experience to reshape my own.

Oysters as Infrastructure: A Review of the Literature

First, it was necessary to understand what was known about oyster restoration and how the Eastern oyster is situated vis a vis climate change. Coastal ecosystems are increasingly recognized as integral elements of coastal infrastructures (Spalding et al. 2014; Sutton-Grier, Wowk, and Bamford 2015; Sutton-Grier et al. 2018; Saleh and Weinstein 2016; Borsje et al. 2011). Vegetated ecosystems have long been the focus of conservation and restoration efforts for their ecological functions but similar efforts for shellfish and coral reefs have lagged behind (Grabowski et al. 2012). Oyster reef restoration, where it has occurred, has focused on improving the availability of oysters as a fishery commodity (Peterson, Grabowski, and Powers 2003). Since 2011, however, oyster research has begun to focus on climate change impacts, including the role of oyster reefs as infrastructure (Guo et al. 2016). This review focuses on research into the potential role of oyster reefs (especially those of *Crassostrea virginica*, the Eastern Oyster) as combined ecosystem-based coastal protection and conservation structures.

Contemporary conservation and coastal engineering predominantly use the language of ecosystem services to evaluate problems, justify proposals, set goals, and assess the viability and success of a project. The ecosystem services framework, popularized in 2005, individuates the benefits people receive from ecosystems (Reid et al. 2005) and seeks to quantify their value in market terms (Grabowski and Peterson 2007). Such generalization allows for comparisons between disparate types of projects. The popularity of the ecosystem services framework coincides with the increased understanding of the value of coastal ecology as infrastructure. As such, oyster restoration and development as infrastructure are discussed in these terms.

The ecosystem services provided by reefs include shoreline stabilization, water quality improvement, and habitat creation. Their value in these terms is consistent throughout an oyster's lifecycle. Newborn oysters attach to hard surfaces, such as rocks or the shells of other oysters, and as the organisms develop shells, they articulate a three-dimensional reef (Borsje et al. 2011). The ecosystem services provided by oyster reefs are consistent across species and geography owing to their feeding and growing habits (Grabowski and Peterson 2007; Grabowski et al. 2012). The reefs reviewed in the literature are nearly all intertidal reefs that are regularly submerged and exposed with the tides, versus subtidal reefs that are always submerged. Still, both types of reef are seen to provide similar ecosystem services, varying only by degree. The popularity of intertidal reefs might owe to their visibility and proximity to other organisms whose ecological function is well understood in terms of infrastructure, such as marshes (Coen and Luckenbach 2000). It may also be that they are simply easier to study, owing to their location above water and near shore.

Shoreline stabilization studies investigate gains or losses in landward habitat and the changes to the local bathymetry that result from a reef. Wave action is dampened by a reef, and the slowing of the waters permits sediments to fall out of the water column and accrete on the seabed (Meyer, Townsend, and Thayer

1997). The slower waters prevent existing or accreting sediments from washing away, allowing the shoreline to maintain or expand and support new vegetation (Walles et al. 2015). These effects are seen from natural (Walles et al. 2015) as well as constructed reefs (Scyphers et al. 2011; La Peyre et al. 2015; Borsje et al. 2011; Meyer, Townsend, and Thayer 1997). The evidence found in shoreline stabilization studies is not strong and researchers treat the findings as generally positive but not unequivocal.

Notably, the same effect that likely results in shoreline stabilization—the breaking up of wave energy—also has the effect of shrinking the area subject to coastal storm flowage, especially from storm surge. Slower-moving waves lack the velocity to extend as far inland. Brandon et al. (2016) found historical evidence that the removal of oyster reefs from New York Harbor resulted in fast-moving waves reaching water bodies farther from the coast than previously.

Oysters are bivalves who feed by opening slightly to take in water, which they ingest, capturing plankton for food, but also filtering other suspended solids, including contaminants (Grabowski and Peterson 2007). They excrete contaminants and other waste in the form of feces or pseudofeces which sink to the sediment surface where they are sequestered. Nitrogen and phosphorous, both anthropogenic contaminants, can be effectively removed in this way, either symbiotically with microbes in the sediment or gradually released from the seabed to be consumed by phytoplankton and microalgae (Newell 2004). This process effectively limits the possibility of harmful algal blooms. Similar sequestration effects are seen for other contaminants. Limited data are available on the effect of reefs on chlorophyll a, but findings suggest shellfish also reduce its presence (Grizzle et al. 2006). Oysters' omnivorous diets include bacteria and other non-phytoplankton cells (Baldwin and Newell 1991) like viruses or anthropogenic detritus. Their feeding habits also have the effect of reducing turbidity, allowing seagrasses and other vegetation more light, and thus enabling the plants to move into deeper water, promoting shoreline stabilization and habitat development (Peterson and Lipcius 2003). Oysters also create calcium carbonate shells and for this reason reefs were initially thought to be carbon sinks that could potentially mitigate anthropogenic carbon emissions (Grabowski and Peterson 2007) but more recent studies show that this service is not consistent across all types of reef; intertidal reefs are actually carbon sources (Fodrie et al. 2017).

Reefs diversify the landscape by creating habitat and promoting synergies that allow other assemblages to flourish. Shellfish are unique in their environments as the only hard surface in areas where sediments and vegetation predominate (Lenihan 1999). Within the footprint of an oyster reef, hundreds of organisms find a home by attaching to, boring into, or living among the oysters (Wells 1961). Juvenile fish and crustaceans find shelter in oyster reefs, and marine species of all life stages find prey there (Peterson, Grabowski, and Powers 2003). Others make use of the reef as a refuge. Lenihan et al. (2001) identified and quantified the fishes associated with oyster reef habitat and found many that used the reef as an escape from human-induced stresses. Reefs are generally seen to be effective in terms of providing or restoring fish and invertebrate habitats, but the size, age, and/or complexity of a reef may limit its utility to other species (La Peyre et al. 2014). In addition to their role engineering habitats, reefs can connect different habitats, such as the marsh, intertidal, and subtidal zones, and serve as corridors that promote landscape-scale synergies and overall landscape diversification (Peterson and Lipcius 2003).

The foregoing list of oysters' capacities justifies the use of the descriptor "ecosystem engineer" advanced by Jones et al. (1994) and often used in the literature. Reefs have been recommended as alternatives to groins, revetments, and breakwaters (Borsje et al. 2011; Orff 2013; Scyphers et al. 2011) but if humans are to benefit from the coastal engineering done by oysters, a reef must have specific qualities that reduce coastal vulnerability. Human intervention is likely needed to achieve certain effects; a reef may not be optimally suited to these purposes if left to its own accord. The qualities a reef must have to function as coastal vulnerability infrastructure include biological viability, adaptability to climatic changes, and other physical parameters.

The long-term persistence and sustainability of any oyster population is a deciding factor in its success in terms of coastal protection (Walles et al. 2016). Suitable habitat for oyster restoration is requisite to any project and indices have been developed to guide decision-making in a variety of applications, including environmental impact, conservation, and restoration purposes (La Peyre et al. 2015). The indices name many of the same conditions, including a sufficient supply of food (Dame 1996), initial and successive recruitment of oyster larvae to the reef (Ridge et al. 2015; Baggett et al. 2014; Coen and Luckenbach 2000), availability and quality of substrate (Coen and Humphries 2017), and water quality, including nutrients, salinity, temperature, and hydrology (Pollack et al. 2012). In this way, a reef's ability to maintain will be determined by biotic as well as abiotic conditions (La Peyre et al. 2015). Temporal variation is an important factor in the delivery of services. Ridge, Rodriguez, and Fodrie (2017) found that young reefs may have the best adaptation potential; like other intertidal habitats, they grow fastest at immaturity. Older reefs, however, have larger larval populations and other benefits like thermal buffering and reduced desiccation stress. Additionally, as will be explored in more depth later in this review, provision of restored services is unlikely to be sequential or linear (La Peyre et al. 2014).

A reef's ability to maintain secures its role in coastal protection, but the demands on the reef, whether as infrastructure or simply in terms of survival, will change with accelerating sea level rise (SLR). Predictions range from 20 to 200 cm SLR in the next century, and this increase will portend predation, competition, and abiotic limiting factors (Solomon, Donnelly, and Walterst 2014). Oyster reefs, however, can outpace SLR. It appears that intertidal reefs are in dynamic equilibrium with fluctuations in sea level and resulting changes to the ecosystem from SLR have little effect on reefs, at least in the short term (Ridge et al. 2015; Solomon, Donnelly, and Walterst 2014). Their continued survival will be dependent upon on migrating landward or recruiting oysters to raise a reef's elevation at a pace that maintains optimal submersion times, which they have been shown to do (Solomon, Donnelly, and Walterst 2014; Rodriguez et al. 2014).

A key assumption in this review is that research into oyster restoration is equivalent to researching oysters as infrastructure. This is purposeful; the goal here is to examine restoration as a coastal vulnerability reduction technique. Further research may bear out that these purposes are divergent, however, and there are some indications to that effect already. For example, the relationship between reef health and oysters' role as infrastructure is not uncomplicated. Walles et al. (2016) considered the location of Pacific oyster reefs in the Oosterschelde estuary in the Netherlands and found that their placement in the intertidal zone considerably affected reef health. The study indicated that there may be a tension between oysters' ideal conditions and humans' infrastructure needs.

Little is yet known of the optimal physical qualities of oyster reefs for infrastructural purposes. The first study was conducted in 2018, also on Oosterschelde reefs, and analyzed sediment stabilization, finding that the effect is strongest on tidal flats under erosional conditions where there are relatively long and narrow dense, closed reefs (i.e. with few open patches) (Salvador de Paiva et al. 2018). These physical and morphological characteristics suggest a narrow range of parameters for reefs to optimally provide sedimentation effects, whereas habitat complexity is a goal for restoration projects (Perkins et al. 2015; Blomberg et al. 2018). The findings suggest a tension with restoration values and with other desirable ecosystem services provided by oyster reefs. Prioritizing one service may negatively affect others, or reef health generally. Indeed, in hybrid coastal defense systems like the Oosterschelde that combine reefs and traditional flooding infrastructures, such tradeoffs are anticipated (Sutton-Grier, Wowk, and Bamford 2015).

The lack of knowledge about oysters' potential role as infrastructure is compounded, or perhaps enabled, by gaps in the literature. The infrastructural capacities of oysters are under studied because engineers and restorationists only recently realized the application to climate concerns. This is not only true of infrastructure studies. Analyses of the impact of oyster reef restoration are generally lacking. There are few to begin with and those that exist suffer from considerable limitations. One such limiting factor is the length of study; only short-term studies have been conducted, up to a few years. As Bersoza Hernández et al. (2018) point out, studies also only focus on smaller plots, largely because few restorations have been done at scale. This remains true despite a common understanding that ecosystem services increase, and costs decrease exponentially with larger projects. The authors also point out the limited geographic scope of restoration projects; for the Eastern oyster, they are concentrated in the United States in Gulf of Mexico and Chesapeake Bay. Guo et al. (2016) confirm that the United States is a leader in this field of research.

While there is robust research into the effect of SLR on reefs, other climatic changes are not yet considered. More research needs to be conducted into how oyster reefs will fare against acidification, or extreme storms, to name just a couple factors. The interaction of these effects and their temporal arrangement will dramatically affect reef health.

Expanding research in this direction will be an important contribution to the field. Modern restoration science primarily relies on succession theory, the assumption that the restoration process will proceed linearly toward a stable state (e.g. toward pre-disturbance stability), but as La Peyre et al. (2014) point out, the actuality varies depending on ecosystem development or other variables like geography, scale, and/or time. Models will need to be considerably more complex to account for the interaction of multiple environmental factors. In one such attempt that considered Olympia oyster growth, Cheng et al. (2015) described the ways that multiple stressors can produce additive, linear effects—or the interaction could proceed nonlinearly, resulting in synergistic or antagonistic effects that vary with time. The implication of these multivariate studies is that delivering any ecosystem service is highly contingent and restoration or management strategies will need to consider more factors, including the ripple effects of their interventions.

Researchers in the field are aware of these shortcomings in the literature and wish to move beyond them. Even the criticism of succession theory is shared by authors whose work has assumed it in the past (e.g. La Peyre et al.). The ecosystem services framework is never questioned in the literature, however. Contrary to the heterogeneity of subject matter and complexity of research, studies largely focus on economic impacts and/or use market logics and motivations for restoration, rather than make the case in other terms.

Alternative motivations—and thus potential explanatory frameworks—are common amongst ecologists. David Takacs (1996) has documented the many motivations that inspire environmental research, noting that even when conservationists make their cases by way of commoditizing the species they are out to protect, they are inspired to do so by any number of personal, spiritual, and/or aesthetic reasons, not to mention economic ones. The rhetorical use of market logics does not always have a clear rationale guiding it, and neither is it as uncontroversial as it would appear from the literature. Evidence like Takacs has collected suggests that conservationists are ambivalent about embracing neoliberal solutions.[7] Suffice it to say for now that even those who do are familiar with seemingly contradictory impulses and are seeking a way to reconcile their environmental ethics and politics.

Multispecies Ethnography and Policy

Nature[8] is a difficult word. Canonical Western environmental discourse set Nature apart from human activity (Marris 2011). Nature was unitary, stable, and

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[7] The term *neoliberal* is used throughout my analysis to indicate the late-20th century modes of government (and subjectivation) that use market-based techniques to address ecological issues. It also characterizes the rationales that enable, through circumstantial alignment or direct advocacy, the state to manage environmental issues as though it were a business managing assets. The concept of ecosystem services was developed to achieve precisely this, to give Nature value in market terms, such that governments (and responsible citizens) could make ecological decisions accordingly.

[8] Nature with a capital *N* is used throughout to refer to its modern, canonical Western incarnation.

pure, an Edenic realm uninfluenced by society. In its alterity, it could be used as a resource, studied, known, and managed by means of rational and objective science. Humans were singular in their privileged position as Earthly living beings apart from Nature. This Enlightenment-derived conception of Nature was ambivalent and conflictual. It insisted that Nature's purity was to be both preserved and exploited, that human uses of the environment were *de facto* deleterious and to be kept separate from the wilderness, yet that wilderness spaces could be designated and maintained by human decision-making. Conservation toed the line against ever-advancing development, but whoever prevailed, Nature would be rationally ordered in pockets of wilderness and urbanity and prevailed over by science. This task was never complete. Nature continuously exceeded our rationalizations and interrupted our plans. To counter, we more energetically pursued our ideal ends and, in the process, exacted a nearly fatal toll on our adversary. Humans have still yet to succeed in their Promethean task (Latour 1993). We have, however, so altered Earth's processes that our signature can now be read in the fossil record.

Geologists refer to this new era as the Anthropocene, the age of humans (Crutzen 2002). While still scientifically contentious, the concept of a planet-spanning anthropogenic ecological force has been taken up swiftly and enjoys global appeal (L. Ogden et al. 2013). There is a growing consensus among conservationists, policy-makers, and even scientists that few places on Earth, if any, do not bear traces of human influence. Humans are now seen as everywhere influencing ecological processes, from the altered properties of molecules after nuclear testing to the global overabundance of greenhouse gases in the atmosphere. Quite often, in different ways, and with or without remorse, the end of Nature has been announced (McKibben 1989; Latour 1993; Cronon 1995). Even as it is thought subsumed, Nature itself is becoming metaphorically wilder, less predictable, less stable. With the advent of the Anthropocene, in other words, Western environmentalism's traditional orientation is challenged.

The purpose of this review is to examine ascendant strands of Western environmental thought over the last three decades and consider their relevance for environmental conservation and climate adaptation planning after the end of Nature. As will be shown, environmental conservation, restoration, and climate adaptation plans and policies depend on certain forms of administration of environmental knowledge. Definitions of Nature, what it is and how we come to know it, shape environmentalism. Science is instrumental here, and politically powerful in the way it establishes forms of expertise and organizes social practices. Nonhumans—living critters and things alike—are similarly influential, involved as agents in adaptation plans. In a direct and material sense, the way these elements assemble set the stage for conservation and climate adaptation planning, from the National Park Service's wildlife management strategy to The Nature Conservancy's climate policy advocacy. The sources included come from different fields, particularly geography, science and technology studies, and anthropology. Geography and anthropology especially are credited in the literature as having long been familiar with the issues at hand (Whatmore 2002; Latour 1993).

This review also serves a secondary purpose, which is to outline *multispecies planning* as a method continuous with and yet distinct from prevailing understandings of Nature. Challenges to the understanding of Nature, while seemingly academic, have been dramatic and public. Climate change deniers, for example, have used the opportunity to sow doubt about scientific facts, alleging that they are socially constructed and relative, and therefore suspect or untrue. An implication of multispecies planning is that the modern understanding of Nature has been deficient in addressing crises like climate change. Multispecies planning, working at the nexus between conservation and climate adaptation planning, is one means by which an expanded, renewed definition of nature could be instrumentalized. What would it look like to pursue conservation and adaptation from this different vantage, one that is neither purely social nor Natural? What would such a task necessitate, and what would it portend? Importantly, can we find hope in an alternative idea of nature, and what kind of hope is it?

How Do You Feel about Theories?[9]

Retracing our steps to the end of the 20th century, we can see in the Science Wars a first attempt to work out these questions. The Science Wars were an intellectual conflict between scientific realists and postmodernist critics who charged that scientific findings were socially constructed. Trends in science, including

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[9] I take this cheeky subheading from Vinciane Despret's "The Body We Care For" because I am aware that the following will seem too speculative at first but, like her, I see value in pausing to reflect on what is happening in contemporary conservation and climate adaptation work and in taking even the more speculative reflections seriously. In fact, *theory* is a misnomer. Rather, explanatory devices are presented and developed here, ones with material consequence, however strange they might initially seem.

increased computing power and global issues like climate change, introduced unforeseen complexity and uncertainty to established fields. Ecologists and others moved away from their classical Newtonian roots—focused on stability, prediction, and certainty—to embrace more nuanced understandings of the objects they studied and the justifications used in their discourse (Allen et al. 2001). Already primed by trends in philosophy, postmodernists took these changes as further evidence that science was a socially-constructed practice.

Some scientists and theorists, seeking to bridge the divide, offered different interpretive modes to accompany ever more complex research and findings (Ravetz 1999). Scientists began using terms like resilience, adaptation, risk, and others familiar to anyone attentive to climate issues today. These new framing devices, deployed by scientists in response to their postmodern critics, only strengthened the postmodernists' notion that science translated the separate, Natural world according to social custom.

The Science Wars had the effect of illuminating the indeterminacy of Natural phenomena and so demonstrating that some disciplines could no longer be described in their classical terms of stable, linear causality. The postmodern position importantly demonstrated that knowledge claims, including the ones scientists make about Nature, are always filtered through a social lens. While postmodern arguments successfully loosened scientists' grip on the modern conception of Nature, they ultimately reinforced the Nature-Society binary by claiming that Nature was determined by social forces. Postmodern definitions of nature still obfuscated the nonhuman, missing what Bruno Latour (1993) rightly observed: that Nature is constructed, but not just socially.

Largely failing to take the lessons of the Science Wars to heart, contemporary environmental thought cleaved in its reaction to the pronouncement of the Anthropocene and what it means for the Natural world (Lorimer 2015; Marris 2011). Some see it as license for total rationalization, an excuse to master Nature once and for all. The prospect of ecological collapse only heightens their urgency. We must reconcile the human and natural by way of geoengineering and sustainable development, the argument goes, and become "eco-modern." This is the dominant Western environmentalism, enshrined in market-oriented institutions. This line of thought is characterized as neoliberal (Collard, Dempsey, and Sundberg 2015). Others turn in the opposite direction and seek a more modest, respectful engagement with Nature that allows renaturalization of once unnaturally human-dominated spaces. These "deep green" approaches valorize wildness and indigenous knowledge, and demonize industrial, Western ways of knowing the world.

These simplifications—caricatures as they are—help to demonstrate the limitations of contemporary Western environmental imagination. As in the case of the Science Wars, implicit in both reactions to the Anthropocene there is still a separation between Nature and culture. The choice is to rewild Nature by removing society, or to naturalize society by taking over Nature. The Enlightenment-era categories remain intact, even as both framings concern themselves with the end of Nature. Both choices, too, maintain humans as central actors in a linear, progressive narrative of how the world is thought to function. That narrative is anthropocentric, and thus ignorant of the myriad ways in which nonhuman forces influence us, disrupt our plans, force us to respond to their own vibrant power. Such liveliness is easily demonstrated in the figure of flooding, to which major human settlements are increasingly, alarmingly prone. Floods upend all manner of rational human plans, from urban design to notions of security (Whatmore 2013). Worse still, this anthropocentrism proposes a common, undifferentiated "us," and in so doing erases the variety of human-environment relationships and knowledge practices, some more culpable than others for the damage we must all live amidst (L. Ogden et al. 2013; Collard, Dempsey, and Sundberg 2015). Political effects follow; the urgency of constant crisis justifies elite action, uncontested by alternate proposals and unencumbered by democratic process (Lorimer 2015). When environmental knowledge is kept rarified, a domain of specialists is designated responsible for managing life itself.

These critiques can leave one feeling rudderless. Neither the modern Nature-Society binary nor its Anthropocene variants offer tenable ways to envision environmentalism after Nature. Despite Western pretensions, however, natural/social hybridity has always been with us (Latour 1993; Whatmore 2002) and this observation offers some reassurance. Latour has been especially influential in demonstrating the countless banal ways the Nature-Society binary was constructed through an obfuscation of the influence of hybrid actors. His pivotal title *We Have Never Been Modern* explains how scientific interpretation is the means by which we have segregated the world into two spheres, Nature and

Society. Latour outlines instead how nature and culture were and are always hybrid; the convenient separation of the two spheres has been mere pretense. His insights gave rise to actor network theory (ANT), a theoretical and methodological approach that describes phenomena in terms of their relatedness, their *nature-culture* as Latour puts it, and which takes seriously the roles played by nonhumans (technological objects, especially, but others, too) in social arrangements. ANT and its variants have been popular in science and technology studies (Sismondo 2004), geography (Thrift and Whatmore 2004), anthropology (Law 2004), and urban studies (Farias and Bender 2010), among others. Sarah Whatmore's effort in *Hybrid Geographies* (2002) found exemplars of such hybridity from different historical periods: human-plant interactions, for example, or, extending the same logic to non-biological objects, humans and their tools. The two spheres could never have been separate because, Whatmore says, the social and the natural are always stitched together; humanity has always been a work in progress.

In light of such evidence, new political frameworks for expressing human-nonhuman entanglement are needed. Our reality is composed by many different forces, and it is time that our politics reflect that fact. The following section provides examples of environmentalisms that begin with the premise that we inhabit many natures, rather than one Nature.

An Ontological Turn

The Nature-Society binary is a quintessentially modern ontology (Latour 1993). An ontology is an understanding of what comprises a world, the things or categories in a world and how they relate. Latour's and other, subsequent analyses demonstrated how such an ontology has shaped issues in science, politics, conservation, and many other fields. Ontologies describe *a* world rather than *the* world because ontologies vary. One can describe a modern Nature ontology or one that is indigenous—or that of a nonhuman object or organism (Kohn 2015).

Contemporary environmental writer Brandon Keim (2017) summarizes such a multiplicity of organismal ontologies with a deceptively simple observation about a bug: "Whatever it feels like to be a bee, it feels like something." Keim's quip channels the influential concept of *Umwelt* put forward by Jakob von Uexkull that scientists and philosophers alike have elaborated: each organism has its own *Umwelt*, its world or environment, and the reality of that environment can be described as an ontology (Buchanan 2008).

An anthropocentric vision, then, is not the only way of conceiving of the environment. Other ways of world-making exist and each is hybrid, composed by social and nonhuman forms. Elaborating these is an important task because it demonstrates that the Nature ontology familiar to us is not the exclusive way of composing a world. We inhabit a world composed of many species worlds, one that is not merely Natural, but *multinatural.*[10] Multinaturalism is neither purely social nor Natural, but hybrid; not stable, but nonlinear and indeterminate; not singular and unitary, but multiple.

[10] This term originated with Eduardo Viveiros de Castro and has been used extensively elsewhere in the literature, influentially by Bruno Latour.

Changing environmentalism's ontological assumptions offers lessons for the practice of conservation and climate change adaptation. The most vital lesson is that an anthropocentric focus is insufficient. The number of ways of being in the world and knowing it far exceeds the one human variety, and as such the stakeholders involved multiply. This has the effect of diversifying the sources and types of evidence to be considered. Research that assumes a multinatural ontology is allied with planning efforts in several ways, as demonstrated below. Both share a commitment to translating amongst profoundly different groups and emphasize participatory, democratic practices.

Jamie Lormer (2015) advances a multinatural ontology that is almost perfectly amenable to multispecies planning. He develops the figure of wildlife that Sarah Whatmore (2002) first defined. Against the idea that the end of Nature equates to a domestication of the planet—an end to wildness, that is—Lorimer suggests that wildlife persists in our post-Natural world. He demonstrates the ways that Asian elephants in Sri Lanka cohabitate with humans and shows that the elephants' behavior influences how they are governed by conservation policy. The animals range freely and interact socially with their herd and humans alike. This means they are sometimes subject to being killed for trade or in conflict with humans. The elephants are not kept in designated wilderness areas but are charismatic (if imperfect) neighbors. Sri Lanka's Department of Wildlife codified joint human/elephant land use needs in their 2007 plan that did away with dualistic wildlife management area designations. The elephants were not just considered the object of policy, but agentic beings who mutually produced the landscape with humans, and the law was changed to reflect their entanglement.

Eben Kirksey (2015) takes a similar tack in *Emergent Ecologies*, but focuses instead on the niche ecologies that flourish despite anthropogenic degradation, or even because of it. Kirksey highlights the work of the Cloud Forest School in Monteverde, Costa Rica, to which he has close personal ties. This reforestation program is perhaps the principal example of his multinaturalism. Its director, Milton Brenes, articulates its goals in the language of neoliberal restoration efforts even as the program is financially exploited by international nonprofits. The program has a similarly ambivalent relationship to ecotourism, benefitting from it commercially but knowing it constrains their restoration work; tourists want to see a charismatic landscape with particular species in it, not a wild tangle of ecology. The school's efforts at restoring a dozen tree species were nevertheless successful, but other species that were not the intended beneficiaries also thrived—threefold more species than anticipated, in fact. Kirksey attributes this to the school's live-and-let-live approach; a more modern organization would have stifled the restoration in pursuit of Nature, whether in the form of a decided ecological baseline they had to achieve or ecosystem services (including scenery for tourists) they were bound to deliver. This is one of the promises of a multinatural ontology for Kirksey: thriving anyway.

Emma Marris (2011) uses the end of her popular book *Rambunctious Garden* to detail, like Latour, the myriad ways in which conservation efforts are already multinatural. Starting in Seattle's Duwamish River, she takes a global tour of restoration and conservation work in unlikely or unconventional settings. The Duwamish is a daylighted river that is “part habitat, part active industrial waterway” (Marris 2011, 133). Farther east, the Yukon Conservation Initiative attempts to connect wildlife corridors between Yellowstone and the Yukon, crossing borders and accommodating a host of human and wild land uses. She also reviews the UK’s Royal Society for the Protection of Birds advocacy for maintaining farmland for those species adapted to and dependent upon low-impact agriculture. For her, a multinatural ontology is not an excuse for further degradation but a compelling argument for introducing conservation efforts into emergent ecologies. This parallels Kirksey’s approach but is more structured. She suggests a role for human stewardship of a semi-domesticated planet.[11]

Irus Braverman (2015) outlines six aspects of contemporary conservation focused on developing Michel Foucault’s idea of biopolitics—the ordering and governance of life—in terms of wildlife. As such, she is more interested than others in the regulatory aspects of conservation. The promise of a multinatural ontology of nature for Braverman is the collaboration of human and nonhuman agents inside existing apparatuses of governance. Where she concludes that human collaboration is often insufficient, she finds there is potential—and hope—in valuing the interactions between technologies, objects, species, and humans.

[11] The argument Marris makes is akin to Michael Rosenzweig’s (2003) *reconciliation ecology* but more careful to allow nonhuman beings to compose their own worlds, at least partially. Rosenzweig’s work seems more amenable to an interpretation, however uncharitable, that human enterprise can run amok and the species who are able to follow will find their niche.

Lest one get the impression that consideration of the nonhuman is limited to individual biological organisms or species, Sarah Whatmore's (2013) work demonstrates similar capacities in a form more familiar to climate adaptation planners, that of natural hazards. She details the way that flooding events in Pickering, England, democratized local flood risk management. Periodic flooding forced a conflict between expert and vernacular understandings of flooding. Whatmore and others bridged that gap by forming a Competency Group—a mix of amateurs and professionals jointly collecting and scrutinizing flood data with the blessing of the UK's Rural Economy and Land Use Programme and the local Environment Agency. Pickering's flood waters forced a response; they became the locus of human activity. The benefit of adopting a multinatural ontology in this case was in recognizing the capacity of flood waters to raise a variety of social responses. This offered an opportunity to reconcile the political differences by working in concert with human and nonhuman agents to develop shared knowledge.

Making it a Practice

The multinatural examples offered by Lorimer, Kirksey, Marris, Braverman, and Whatmore are based on evidence collected in conversation with conservationists around the globe. Most note explicitly (and others imply) that conservation practice involves a process of learning about the world, an epistemology, that is shared amongst these practitioners. Epistemologies are systems of knowledge that establish how knowledge is considered legitimate and truthful. This process in conservation circles is almost necessarily a multispecies endeavor. Claims of fact are negotiated in context with more-than-human agents; conservationists attune themselves to the needs of other species with whom they share habitat and adjust their knowledge claims accordingly. One comes to know elephant land use practices, for example, by being with elephants in the landscape. This attunement is often more than a rote skill. Conservationists have an affective relationship with the landscape and other species in it. They enjoy the work for its aesthetic value and come to literally embody the fact of their relationships by tuning their senses to their surroundings.

Donna Haraway (2007) describes similar phenomena in lab scientists, dog trainers, and others in *When Species Meet*. She follows the foundational ethologist Vinciane Despret (2004) in describing this epistemology in terms of “learning to be affected.” This shorthand for the attunement described above is both affective and corporeal. The relationships Despret describes involve humans with other animals. She details the ways that the human actions—bodily movements, emotions, and learning, particularly—result from the influence of nonhuman actions, and vice versa. Her example of horse riding is clarifying. The horse interprets minor movements made by the human, some unbeknownst even to the rider. At the same time, the human rider is knowingly and unknowingly learning how to communicate what it wants the horse to do. Both are learning to be affected in this symbiotic relationship and, in so doing, they produce different kinds of knowing and being. While Haraway unpacks this capacity in more esoteric fields, others observe it in the work of conservationists. Lorimer (2015), for example, observed the ways that Scottish birders finetuned their senses to identify and count increasingly rare species.

The rich evidence collected by these authors has been anthropological. Within anthropology, the emerging field of multispecies ethnography provides methods for examining our entangled human/nonhuman lives. Multispecies ethnography offers an interdisciplinary opportunity to planners. Applying a multinatural logic, planners can examine their usual questions more roundly. By what means can multispecies planning potentially influence climate adaptation work, and what implications might this have for broader public sentiment? Multispecies ethnographic practices offer some insights into these questions.

Multispecies ethnography explores the entanglements of all manner of Earthly beings, "from humans to animals to plants to fungi to microbes" (Kirksey and Helmreich 2010). The methods of this type are manifold. For Haraway, it means examining companion species. By *companion*, she means not simply domesticated animals, but all those organisms "becoming with" humans—that is, in proximity and sometimes in affective relation to humans, however asymmetrically (Haraway 2007). Others take an orthogonal approach to Haraway and examine how unloved or underrecognized species, such as microbes (Helmreich 2009), come to be figured or reckoned with. Some go further afield and examine relationships involving spectral figures, such as Mario Blaser's consideration of Canadian wildlife management authorities interacting with the Innu Nation and the spirit that governs the caribou they hunt (Blaser 2016). Anna Tsing (2015) takes a more familiar, if also difficult, path tracing commodity chains over several continents in pursuit of knowledge about the matsutake mushroom and the histories of interspecies dependence it tells.

A form of anthropomorphism, or a methodological animism, is sometimes needed to collect and interpret evidence from these unorthodox sources. Multispecies ethnographers employ these methods strategically to think like other organisms and develop descriptions of their ways of being in the world. The practice goes a step beyond actor-network theory in this regard. ANT equivocates the human and nonhuman as actants but not as agents. A foundational ANT text by Michel Callon (1984) clarifies that the reasons for nonhuman conduct do not matter, they are simply considered to act. In multispecies ethnography, agency, however limited or nonvolitional, is typically perceived in the nonhuman and seriously considered. Philippe Descola has fully recuperated the concept of animism in describing his findings among the Amazonian Achuar (Kohn 2015) while others impute vitalism to materials, such as Jeffrey Jerome Cohen’s treatment of stone (Cohen 2015). These two examples are at the far end of the spectrum. Jane Bennett (2010) takes a sort of middle ground, exploring a vital materialism devoid of an independent animating force. Unlike in other ecological writing, such vitalism/animism/anthropomorphism is not to be feared. Rather, the danger of ignoring these nonhuman subjects and committing to anthropo*centrism* is seen as the greater sin (Connolly 2013). Many of these ethnographers draw from Vinciane Despret (2004), who points out that being anthropomorphic is less about characterizing the organism or object at hand than it is about extending the observer’s capacity to understand that object. Asking what matters to another organism, she explains, can activate their point of view. It is less about supposing (or claiming to know firsthand) what the organism experiences, but about posing the question and recognizing the nonhuman as a subject. Multispecies ethnographers witness that those they study learn to be so affected, or put another way, they become attuned to the organisms, species, and landscapes with which they work. One step further, Laura Ogden et al. describe multispecies ethnography itself as “a mode of attunement to the power of nonhuman subjects to shape the world” (L. Ogden, Hall, and Tanita 2013, 17). Its utility as a method, then, can be shared; multispecies ethnography can be a pedagogy, of sorts, of learning to be affected, one that can make traditional planning efforts receptive to new types of knowledge, which in turn help to develop a broader view of nature.

Applications to Adaptation: Nature-Based Infrastructure

So far, this review has considered the insufficiency of the modern conception of Nature, described examples of a multinatural ontology and its relevance to conservation and planning, and detailed multispecies ethnography as a method for coming to know things about the multiple worlds we inhabit. The remainder will consider the implications of these findings in the figure of nature-based infrastructure. It will follow that figure though ethnographic research into infrastructure and consider what a multinatural approach to infrastructure entails, especially in those instances where living organisms are involved in mitigating risk or provisioning benefits. This review concludes with an exploration of the political implications of multinaturalism and the relevance of these findings to policy.

Early ethnographic research into infrastructure established a few parameters for what the definition includes (Star 1999). Infrastructures are embedded in physical, social, and technological structures. They are largely invisible to their users, at least until they break down, because they are learned or culturally assumed and then taken for granted. They maintain their invisibility by being standard; they are meant to just work with everything. Nobody is really in charge of them, though, they are modular and get repaired incrementally. An infrastructure is not located in just one time or place, it extends beyond one event or location. At the same time, they are path dependent (or at least they have their own inertia) and inherit historical legacies. Perhaps most significantly for the purposes of this review, they shape and are shaped by conventions of practice. They are the present shape of the world—literally and materially, the objects we use, roads we travel, etc.—and they actively shape the world, continuously informing what is possible in it.

These criteria imply that infrastructure is the basis on which other things happen. Infrastructures are "things and also the relation between things," as Brian Larkin explains (2013). His survey of the field describes how such a framing sets up infrastructure as a system, and that systems thinking is held to be a necessary complement to ethnographic methods in such analyses. While these systems potentiate and constrain human action according to certain logics (usually the political rationality that birthed them), Larkin points out that infrastructures aren't just technical objects, they also have affective relationships. Modern hopes about the future were projected onto and shaped by highways, dams, and so on. Infrastructures continue to be both the repository and the wellspring of such fantasies. As such, politics is never far from the fray, and infrastructures serve to both inscribe and make invisible overt political decisions (Star 1999). When Robert Moses decided to make the bridges on Grand Central Parkway too low for buses, for example, he by design barred the poor from visiting the wealthy suburbs. The constraint was made part of the urban fabric, and the attendant consequences thus obscured.

Infrastructural systems get traced through all manner of categories: political, technical, financial, cultural. Ethnographers have often relied on actor-network theory in making a synthesis of these disparate elements, and many more analyses have proliferated in ANT's wake (Larkin 2013). Leaving a survey of other analytical frameworks in Larkin's capable hands, what is important for the purpose of this review is that ethnographers of infrastructure agree that infrastructures are shaped by conventions of practice. Susan Leigh Star (1999) first indicated the relational nature of infrastructures and Larkin (2013) recognized the ways that infrastructures are generative of those relations.

Casper Bruun Jensen and Atsuro Morita (2017) go one step further and explain these systems in terms of "open-ended experiments." For them, infrastructures generate and reconfigure social arrangements. Rolling daytime electric outages can lead to work at off hours, for example, or climbing gas prices limit vehicle miles traveled. These are "emergent systems that *produce* novel configurations of the world – new *practical ontologies*" (Jensen and Morita 2017, 4). Infrastructures, in their view, are not exclusively social, but also involve the nonhuman, including materials and objects, of course, but also the biological:

microbes, crops, and so forth. Their work has all the marks of multispecies ethnography but in the context of infrastructure. It shows the promise and potential of such methods. Their view of infrastructure brings together the various strands of thought discussed above so tidily that it is worth quoting at length:

> infrastructures hold the potential capacity to do such diverse things as making new forms of sociality, remaking landscapes, defining novel forms of politics, reorienting agency, and reconfiguring subjects and objects, possibly *all at once*. It is of course up to ethnographic elucidation . . . to pinpoint precisely whether and how this happens (Jensen and Morita 2017, 6)

Infrastructures are capable of all this because they are heterogeneous assemblages that choreograph the varying ontologies of their components. The fullest example of this can be found in nature-based infrastructures. In fact, the *all at once* that Jensen and Morita emphasize is precisely the potential of nature-based infrastructure. NBI, at its nexus with conservation, takes the nonhuman into account in a direct, material way. Examples of NBI include salt marsh restoration projects where the marsh's expansion over time is considered in terms of the zoning of human settlements, or the construction of oyster reefs, which can stem the flow of storm surge and readily adapt to changing ecologies. Organisms are nearly always involved in the making of nature-based infrastructure. To be successful as infrastructure, NBI projects necessarily puts humans into the affective relations with other species that multispecies ethnographers describe. NBI, as the site of such encounters, choreographs varying ontologies and produces new modes of companionship. That is, the more-than-human relations that NBI allows gives material bodies a chance to learn to affect one another. Perhaps more readily than others, nature-based infrastructures admit their entanglements and belie their choreographic function. That is, they compose multispecies worlds and provide an opportunity for us to rearticulate ourselves as members of multispecies communities. What's more, NBI is flexible and adaptable, allowing for continuous experimentation and involving ongoing encounters. It may catalyze other multinatured practices.

Still, the question remains, how can we reconcile the policy world and its ontologies to the multinatural? Not only that, how can we make policy in service of a multinatural world? We are inextricably linked with the nonhuman and it is only in partnership with the nonhuman that we can seek to develop a better world—as is evident in the example of nature-based infrastructure. To do this, as Jane Bennett suggests, we "need to devise new procedures, technologies, and regimes of perception that enable us to consult nonhumans more closely" (Bennett 2010, 64:108). This is the task of multispecies planning.

Usually, multinaturalism is held incompatible with the policy sphere in anthropological accounts. Its contingency, experimentation, and indeterminacy are mismatched with the stability of governance. More than that, its epistemology is frankly considered counter to the positivist approach often taken in policy (Larsen 2011). Like infrastructure, however, policy is as much a part of the creation of worlds as other factors. Different modes of conservation and environmental policy come to shape different worlds. Multispecies planning would take up the task Jensen and Morita set forward, to “pinpoint precisely whether and how this happens,” (2017, 6) and then encourage the mechanisms through which it happens. This is incumbent upon planners who hold such capacities and the social expectation to fill such a role because the nonhuman forces that are a part of the climate crisis are coming to matter politically, which is to say that across worlds, recognizing nature-cultures is becoming unavoidable.

Given the above, what would multispecies planning look like in terms of policy? Three parameters stand out. First, accounting for hybridity means that environmental policy must not take Nature as its object. A post-Natural perspective is paramount. The second is implied by the first, which is that policy needs to be distanced from its anthropocentrism. Regulating exclusively for human use is impossible in a multinatural framework. If planning is to retain its commitment to plurality and democratic process, it will need to recognize and interrogate the knowledge of nonhuman stakeholders. This will require a measured amount of anthropomorphism. Third, it will need to embrace a methodological indeterminacy and allow more room for the unexpected. More than adding new or different data to existing understandings, it will require that planning “open up the possibility of reasoning differently,” to use Sarah Whatmore’s (2013, 41) words. Multispecies planning offers an alternative spatial rationale. If NBI is a composition of relations that relies on a multinatural ontology, and its relations are expressed in space—literally forming the landscape—then it generates a form of politics that is topologically distinct. In what follows, I explore how this form of politics is realized in Mass Oyster's practice, and then how it might be brought to bear on environmental policy.

Choreographing Infrastructure: The Mass Oyster Project

As described above, beavers (L. A. Ogden 2018), mushrooms (Tsing 2015), frogs (Kirksey 2015), rice (Morita 2017), marine microbes (Helmreich 2009), and a host of other "animals, plants, people, and things" (L. Ogden, Hall, and Tanita 2013) have featured in recent multispecies ethnographies. Some have focused on human-nonhuman interactions while others have experimented with taking the perspective of nonhumans (Kirksey and Helmreich 2010; L. Ogden, Hall, and Tanita 2013). This ethnography mostly does the former. It principally responds to the following question: What is the relationship between oysters and humans in the environmental restoration work of Mass Oyster Project? I use anthropological methods to determine how Mass Oyster volunteers ascertain such knowledge from the oysters with whom they work. I also take seriously the volunteers' methodological anthropomorphism and use a similar approach to reason out the oysters' perspective. Many factors influence the relationship, and as such I explore the push and pull of other species, scales, and story lines on Mass Oyster's project, most notably the way that the restoration landscape is assembled.

Long before I met the volunteers at the heart of this study, I encountered Mass Oyster through their literature. The organization's argument for restoration leads with the fact of *Crassostrea virginica*'s water filtering capacity. The organization uses the storied and familiar Charles River in Boston in its literature as an example of the possibilities that oysters offer (Mass Oyster Project, n.d.). They claim that ten small reefs would be able to treat the full daily flow—300 million gallons—removing contaminants and clarifying the waters.

Mass Oyster also seeks to promote marine biodiversity. Restoration necessarily increases biodiversity by supporting and increasing the depleted oyster population. Additionally, reefs provide habitat for 200 other species (Mass Oyster Project, n.d.), as breeding grounds for fish or an attractive food source for birds, for example. This figure does not account for the ripple effects reefs have, such as promoting marsh habitat by slowing wave action.

Mass Oyster also talks about their work as advantageous to climate adaptation planning. This third argument involves elements of the two just mentioned. Oysters are like little water treatment plants; they are infrastructure. Healthy, biodiverse ecosystems are more resilient to anthropogenic impacts like climate change; the oysters can help us adapt. Mass Oyster additionally claims that their efforts will result in flood mitigation like has been suggested elsewhere.

These three concerns—water quality, biodiversity, and climate adaptation—are what Mass Oyster communicates at the organizational scale. Below, I explain how the organization’s commitments are contingent responses to contemporary and historical political and ecological circumstances.

A Question of Wilderness

The setting for this work is the Annisquam River in Gloucester, Massachusetts, along a small stretch of rocky bank near the center of the 4.5-mile estuarine waterway, on the pier of the town's historic working waterfront, and along the paths the oysters travel to become infrastructure.

Early on a windy Tuesday in mid-November, 2018, I met two of Mass Oyster's volunteers at Maritime Gloucester. Workers on the pier were winterizing their equipment, readying boats for dry dock after a summer spent sailing tourists. The Mass Oyster upweller was already out of commission, covered by sea-green tarps secured with nautical rope. I was the only visitor among a half-dozen workers. Although we were outnumbered by seagulls, the presence of humans was still plainly felt. Buildings jutted out over the water and piers extended into the inner harbor. What is a restoration effort doing in the midst of this environment? Why does it belong here?

Just in the fact of its location, Mass Oyster's upweller points to conflicting ideas about nature. Wilderness, in popular American conception, is separate from human activity (Cronon 1995). America has been divided into designated wilderness zones—such as nature reserves—and these are defined against human presence and influence; nature is distinct from human settlement. Nature can be found in the hinterlands, not on a working waterfront. Such a division has been historically popular in conservation circles, and separate apparatuses have been developed for managing nature and human settlements (Braverman 2015; Marris 2011). During my visit to the Gloucester site, one of my interlocutors remarked on Mass Oyster's relationship to this dichotomy. The organization's work, she said, could in some ways be likened to conservation programs run by zoos, where animals are born and raised *ex situ* (Latin for "out of place," or, in more contemporary terms, off site.) She explained that the cultivated oysters supplement the *in situ* population (meaning "in place," or on site.) This distinction maps on to the dichotomous understanding of wilderness in American conservation: *ex situ* is within the human domain, *in situ* is the site of wilderness. Spatially, however, the boundaries of Mass Oyster's work were fuzzier, and in evidence of this, my interlocutors that day defended the oysters' wildness. The larvae, or spat, that grew into oysters over the summer was harvested from a "wild population in Maine," they told me. Mass Oyster transported the spat and tended them in the upweller. The oysters were never considered captive or domesticated. Those were concepts they reserved for aquaculture projects. Instead, aided by human hands, they would eventually grow "wild" in the Annisquam, surrounded by human roads, bridges, boats, and houses. They never sought to make the site a reserve, nor did they treat the oysters as breeding stock to enhance a domesticated population for aquaculture. They were not in the business of setting aside *wilderness*, in other words, but rather worked to enhance the *wildness* of Gloucester's ecology. Theirs is a wildness without wilderness.

Other comments, too, departed from the modern view of conservation. Restoration work is traditionally a matter of establishing a baseline condition—what the ecology used to look like—and setting a goal to return the landscape to that condition. Often, the goal is to return to conditions prior to European colonization (Marris 2011). Such conservation goals assume that the precolonization geography was one of untouched wilderness.[12] These visions involve masculine national mythologies of land made for European exploitation. They also make use of a modern notion of Nature as both a past and future condition. My interlocutors, by contrast, made it clear that Mass Oyster's goal was not to return to a pre-development population of oysters—though reaching that number would be a major achievement—but rather to simply establish a self-sustaining population of *Crassosstrea virginica*. The work they expected the oysters would do was not to maintain a mythic landscape from the past, but to function as ecological infrastructure. In terms of both time and space, Mass Oyster eschewed the concept of wilderness in favor of introducing wildness to a variety of geographies.

Oysterscapes

It was low tide when the four of us gathered on Gloucester Pier. We had timed our arrival to improve our chances of finding oysters in the river; high waters would have frustrated our survey. With the tide gauge on the pier indicating that Atlantic waters would soon flood back into the Annisquam, we drove across town to the restoration site where Mass Oyster had recently seeded 60,000 spat. Downtown development gave way to dormant winter trees as we turned off pavement and on to rutted dirt roads. The site was nestled in a residential neighborhood with a small dirt visitors' lot for beachgoers. We headed down a

[12] This view of restoration also often presumes that it is *possible* to return to a historical baseline, i.e. that climatic and ecological dynamics are stable enough that the intervention would take hold and the ecology would be able to maintain itself as though it had reverted to an earlier time. Mass Oyster's approach is more pragmatic. Oysters in the Annisquam will be part of the ecology that emerges, however numerous they are, and whatever new (or old) roles they assume.

small path lined with rocks to the marsh, then weaved around huge rocks covered in seaweed and barnacles for a few hundred slippery, treacherous feet.

Our destination was on the banks of the Annisquam. At the water's edge there was a stark division between the riverbed and the forested hill that rises steeply to someone's home. The slow force of erosion was stark and immediate. To the south, the river wound and disappeared around a bend toward the ocean, its channel edged by tidal flats, marsh, and a few houses. The banks to the north were more heavily developed, and the Route 128 bridge loomed overhead, huge, pale green, and loud. Road noise and the wind interfered with our ability to communicate, but while we hunted for nickel-sized baby oysters in the water, we still managed to discuss how Mass Oyster came to understand the world of *Crassostrea virginica*.

My primary contact at Mass Oyster was responsible for choosing the restoration sites. She described the ways her undergraduate education in marine biology prepared her for the task. Her research didn't focus on mollusks, but she was nevertheless able to conduct and interpret empirical research that illuminated the oysters' needs. Science and technology scholars consider these processes forms of translation (Callon 1984; Tsing 2015). She knew about the oysters' preference for certain types of substrate (rocks and shells) and water quality (steady but calm flow with a lower salinity). Being sessile (attached to rocks and one another), individuals were subject to easy predation (by invasive green crabs especially.)

Interpreting all of this, my interlocutor was able to tell whether a given landscape would be a good candidate for hosting an oyster population. She could read the landscape and physically, sensually determine how an oyster would fare in it. She was able to develop and hone this skill using scientific techniques. The site selection process began with using software to identify, map, classify, and evaluate potential sites. My interlocutor drew from state databases that provided her with data like the river's flow rate and satellite images of the coastal bathymetry. She combined these data with her own evaluations and put together an assessment of how the landscape assembled. The restorationist I spoke with had sensitized herself to the site by accepting and considering knowledge produced by the Eastern oyster. In Vinciane Despret's terms, she had learned to be affected. In this way, my interlocutors described something I would hear develop as a theme in subsequent interviews: that their understanding of an oyster's needs was an understanding of its relationships.

An oyster's world was more than shell and tissue, more than the plankton they consume and the water they pass through their tiny bodies. It was constructed by the oysters, but also by their interactions. *Crassostrea virginica* was situated on the banks of the Annisquam with other animals/plants/people/things that gave their world definition. Oysters were as much a part of the landscape as they were engineers of it. Their world was a landscape phenomenon. Understanding the landscape in these terms put the restorationists well on the way to developing an alternative topology. Science and technology scholars have borrowed the concept of topology from mathematics, where it is a technique for determining the conditions under which geometric figures or spaces will change form. In geography, topology has been employed to show whether spatial relations conform to Cartesian expectations (Lorimer 2015; Hinchliffe 2008). Most frequently, descriptions are made of the ways that animals/plants/people/things defy the gridded and top-down structure of the topographical map. Informational networks form without regard for borders, wetlands don't care where the municipal boundary is, and so on. The relationality of this way of conceiving space implies mutability; as relations in space change, so too does the topology. I also mean topology in the more traditional sense of physical geography, as the literal (topographic) shape of the landscape as historically determined, because, as Anna Tsing emphasizes, that history shapes the potential of what is present.

Landscapes

What, then, can the landscape itself tell us about Mass Oyster's work? The landscape is more than just the background for this work. It is both a scale and an actor with its own history and connections. Counterintuitively, the best way to realize a landscape perspective is to drill further into the oyster's lifeworld. This section moves from the organismal to the ecological, from the relatively determined conditions for life to the contingent and experimental forms of relations amongst living beings. It engages much of the same evidence that my interlocutors encountered and follows a similar process of site selection. I am essentially building what ecologists term a habitat suitability index to better understand exactly how oysters achieve their infrastructural role (Pollack et al. 2012; Barber et al. 2009). This effort is exigent to the point I heard Mass Oyster volunteers make about wildness, that oysters are engineers of landscape assemblages—choreographers of infrastructure in their own right. The point is to get specific—to the extreme of being quite literal—about human-oyster entanglement, showing what my interlocutors learned in the process of learning to be affected. The evidence moves in the opposite direction, too, making the case for more general claims in support of the political case I am making, in so far as it demonstrates the mechanisms through which this more-than-human assemblage is realized.

Crassostrea virginica has an easier time than others at getting established within an ecosystem because they are colonizers; they create their own ecological niches and engineer the morphology, chemistry, and hydrography to improve their chances of survival. These oysters are often among the first species to get established in disturbed environments, and highly dynamic ecologies like coastal seas and estuaries—especially urbanized ones like the Annisquam, as will be shown—are thus well suited to their propagation (Eastern Oyster Biological Review Team 2007).

Ecologists refer to the specific traits that characterize biological behavior as an organism's life history. When it comes to the critical factors that influence a project like Mass Oyster's, namely whether a species will get established, ecologists look to the environmental tolerances of that species' life history. Researchers in private and government agencies monitor coastal waters for these factors, and Mass Oyster relied on those data to make its site selection.[13] Seven

[13] It should be noted, however, that no permanent monitoring stations are directly in the river, only at either end. The data they collect are not uniform. The little information available was gathered from studies that used direct observation, but in this case and Mass Oyster's alike, a fair amount of experimentation is involved.

relevant conditions influence the Eastern oyster's tolerances that are common across its range: depth, salinity, temperature, substrate, geomorphology, pH, and dissolved oxygen.

Here at the northern reach of the Eastern oyster's range, the oyster's preferred depths are shallower. The species can typically be found within 1 meter depth of the mean low tide mark (Sellers and Stanley 1984), in the area we walked along the Annisquam. Winter temperatures limit intertidal survival (Faherty 2011) and as such, populations in this region are subtidal.

Salinity affects disease and predation rates, as well as the availability of food, and so is critically linked to survival (Coen and Humphries 2017). The species itself thrives in salinities of 5-30 ppt, optimally between 10-28 ppt, but salinities over 40 ppt are common (Sellers and Stanley 1984). Outside of this range, feeding and reproduction become limited. Predation and disease rates rapidly increase at > 15 ppt (Coen and Humphries 2017). The waters around Gloucester are at the high end of the tolerance range for the Eastern Oyster. Gloucester Harbor, which feeds the Annisquam in one direction, was found to have a salinity of 30.6 ppt ("National Water Quality Monitoring Control" 2006), and that is fairly representative, with the lowest known recent direct observation of the Annisquam reporting 29.7 ± 3.3 ppt (Wilbur 2007).

The synergistic effects of temperature and salinity are relevant to every aspect of an oyster's biology. These include feeding, development, reproduction, interaction, predation, and distribution (Shumway 1996). The generally accepted temperature range for the species is between -2°C and 36°C, with the highest pumping rates between 20°C and 25°C, and low to inactive metabolic rates setting in around 10°C (Sellers and Stanley 1984). River temperatures are safely in this range for most of the year. The summer months see high surface temperatures of 21.1 ± 2.0°C (Wilbur 2007). Expected New England winter temperatures are at the low end, at -1.7°C (Sellers and Stanley 1984). Winters could be tough for the restored population. They will likely experience periods of freezing and thawing, which the sources cited here indicate is survivable but risky.

Crassostrea virginica is tolerant of many substrate types, ranging from hard surfaces like rock to soft bottoms made of mud, provided the bottom can support the organism's weight. Larvae must settle on a hard surface, such as shells of other oysters, but once attached, the oyster can mature on any substrate (Eastern Oyster Biological Review Team 2007). Substrates in the area of the Mass Oyster restoration site are majority silts and clays, as was apparent from our search through the storm-churned and turbid waters. About a quarter of the land under water is sand ("National Water Quality Monitoring Control" 2006), and rocky places can be found along the banks, including the site in question.

The pH tolerance range is between 6.75 and 8.75, at least for baby oysters (Eastern Oyster Biological Review Team 2007), and ranges in the Annisquam are consistently right in the middle: 7.6 ± 0.2 to 7.8 ± 0.1 (Wilbur 2007).

Finally, dissolved oxygen, a major contributor to overall water quality and a critical element supporting life, is far less critical to *Crassostrea virginica* than other organisms. The species can be intertidal, meaning that the reef is exposed to air during low tides, and so they are adapted to spend considerable amounts of time in fully-saturated oxygen conditions. As long as the waters are not hypoxic or anoxic (measuring a low-oxygen condition of <4 mg/L) submerged reefs will survive (Coen and Humphries 2017). All researched measurements of the Annisquam were in excess of 5 mg/L, with most in the range of 7 to 8 mg/L (Wilbur 2007).

The studies seem to indicate a suitable, if not easy, environment in which the Eastern oyster can establish itself. Their capacity as ecosystem engineers means that they will fashion their own niche and adapt to a wide range of environmental conditions, along the way constructing new habitat and changing the river's dynamics.

This rational way of knowing an oyster's world was how the volunteers learned to be affected, but their comments indicated that there was always something more to their understanding than mere functionality. *Crassostrea virginica*'s engineering was treated as agentic. The oysters were "gonna do their thing no matter what." Emphasizing nonhuman capacities, my interlocutors called attention to their role as caretakers. "We're assisting them in their survival," one volunteer told me. "They're doing all the work." They even attributed emotions, like desire and happiness, to the oysters, saying that the oysters "are happy where they are" and "want to be" in the conditions Mass Oyster created for them. Developing this affective relationship required the volunteers to give oysters considerably more credit than is usually afforded to nonhumans. Caring for oysters meant recognizing their agency and involving them as active participants in producing infrastructures.

Together with *Crassostrea virginica*, then, Mass Oyster's work is to fine-tune the coordinations in the estuary, to be involved in the making of wildness. A modern restoration effort might stop there, with a successfully reasoned plan to repopulate the species, but since Mass Oyster conceives of its work as infrastructural, there are still other relationships to consider. "Nature is out of whack," one volunteer told me. "You can't just let nature take its course. Or you can, but it won't be what's best for us or for the environment at the moment."[14]

The moment she described was the result of historical pressures and contemporary political realities. Enabled by biological capacities and affective relations, oysters and humans alike would need to assume roles that are both presently and historically defined. She, like all the Mass Oyster volunteers I consulted, used the figure of water quality to express how the organization coordinated a response to the issues of the moment. Their response is contingent, set in motion by Gloucester's historical relationship to the Annisquam.

The Annisquam estuary has been urbanized, with consequences for what is—and is not—in the water. The river's submerged aquatic vegetation has declined

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[14] This volunteer, like other Mass Oyster interlocutors and conservationists I have encountered outside of this study, sometimes employed Nature as a shorthand. Professional environmentalists, in my experience, do not often have a fully-formed analysis of their work in terms of multinaturalism or the other descriptive concepts employed here. Even if when they do, it is cumbersome and obstreperous to constantly qualify the term. It's an unavoidable colloquialism. A strong example of the term's residue can be seen in the name of The Nature Conservancy. The organization was an early adopter of a post-Natural environmentalism (Collard, Dempsey, and Sundberg 2015), yet Nature remains in its name. In light of all of the other evidence that this volunteer provided, I think this statement is not an indication that she is defending the modern concept of Nature but rather makes the case for involving human attentions in the making of wildness, for working with nonhuman biopower to constitute a world where both species can flourish.

(Wilbur 2007), likely from the variety of coastal development pressures, and with it, suitable oyster habitat. These general pressures include direct contributions of contaminated waters from sewer and stormwater systems, increases in runoff from impervious surfaces, and even the disturbance of passing recreational boats (Eastern Oyster Biological Review Team 2007). These pressures, combined with historical overfishing, likely also drove *Crassostrea virginica* out.

Pollutant contributions from Gloucester's sewer system are a legacy water quality concern. The city lacked a sewage treatment plant until late in the 20^{th} century (Hruby 1981), during which time the number of residences with on-site disposal systems grew to 2,500 (Angelo 1999). As we have seen, the Eastern oyster is adept at removing anthropogenic contaminants that result from sewage. We have also seen, however, that conditions in the Annisquam are only slightly above suitable for the species. The introduction of so much sewage could be reasonably expected to have synergistic effects that would further narrow the species chances at survival. The nutrient loads in sewage can be likened to fertilizer for algae. Whereas previously, nitrogen limited algal growth in the water column, the addition of sewage saturates the water with nitrogen and allows algal productivity to spike, especially in the summer months when higher temperatures spur the algae to be more active (Burford et al. 2012). The algae consume oxygen, leaving less for the shellfish and submerged vegetation. Already overfished for a century or more, and with slim chances at survival if it tried to reestablish, *Crassostrea virginica* was unlikely to return of its own volition.

The city was ordered to address the sewage issue as early as 1967, and 1,100 homes were brought into compliance, but raw sewage continued to be delivered into the harbor and river for decades (Angelo 1999). This pollution degraded as much as 30% of shellfish beds in the area past the point of human consumption (Hruby 1981). In the early 1990s, new septic regulations that required compliance at point-of-sale on real estate transactions forced Gloucester’s hand (Commonwealth of Massachusetts 2016). The city moved forward with a plan to implement an innovative system heralded in the press as “New England's first large-scale septic tank effluent pump,” with instantaneous effects that resulted in the improved health of 10% of previously affected shellfish beds (Angelo 1999, 20). The state continues to list the Annisquam as an impaired water body, however, and monitors to ensure that the level of fecal coliform does not exceed the allowable total maximum daily load (Massachusetts Division of Watershed Management Watershed Planning Program 2016).

Nitrogen, phosphorous, and other contaminants thus limited, Mass Oyster was able to make a case for *Crassostrea virginica* to engineer the finishing stage of the clean-up effort. The organization’s argument for nature-based infrastructure is heard and, in a limited way, honored by regulators because of the historical inheritance of contaminants in the water. It is the disturbance caused by human activity that makes their project possible—necessary, even.[15]

[15] Thinking of anthropogenic degradation in this light suggests a more contemporary ecological understanding of the term disturbance as normative and perspectival, like that embraced by Anna Tsing (2015). The introduction of sewage to the Annisquam allowed algae to proliferate at the expense of other aquatic life. Whether it was a harmful disturbance depends whether you are an oyster or algae. From the Eastern oysters’ perspective in this moment, certain

Infrastructures

Mass Oyster must also respond to present-day contingencies, and these responses help shape the politics of their project. The organization's work is sometimes described as a replacement or substitute for other infrastructures. This justification often comes in terms familiar to planners and politicians: ecosystem services. Given the neoliberal political environment the organization operates within, and faced with the right audience, Mass Oyster will argue in favor of nature-based infrastructure in terms of cost abatement. It would be cheaper and more convenient for ten oyster beds to clean the Charles River than to fund an enforcement apparatus or construct a wastewater treatment system, the argument goes.

Neoliberal uses of the nonhuman in these terms are plentiful: street trees improve health outcomes and raise property values, greenfields absorb floodwaters in place of costly flood management. Perhaps most analogous to oysters, the way that beavers engineer watersheds has been employed in resource planning (Woelfle-Erskine and Cole 2015). Using oysters in a similarly instrumental way would require that humans totally enfold oysters in the apparatus of government (Wakefield and Braun, n.d.). Oysters would be enlisted as workers—or worse, conscripted and exploited—to provide services the state has abdicated.

disturbances are a boon. Even the extreme act of dredging the channel of the Annisquam for navigational purposes, as the Army Corps of Engineers does periodically (Dugan 2019), can establish conditions that *Crassostrea virginica* can exploit. The oysters can establish as primary successional organisms and engineer habitat for themselves and other species.

Mass Oyster volunteers indicate, however, that there is something more to their understanding of infrastructure than this limited definition would imply. Oysters were not to be instrumentalized but to be cared for and related to "for environmental reasons." This vague turn of phrase was used in many settings to express that the project differed in meaningful ways from those that use commercial or neoliberal logics, however opportunistically these might be employed.[16]

The saying "environmental reasons" burgeoned with meaning in Mass Oyster's practice. It was a rejoinder, mostly, to distance their work from more familiar approaches, and even a pointed accusation at times, but it was also affirmative, a way of expressing the contingency of a properly ecological project. In the first sense, the phrase was offered as a rejoinder to the shellfish industry. Mass Oyster pushes back against being perceived as aquaculture. They are not growing oysters for consumption, neither are they establishing a self-perpetuating population of

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[16] James Ferguson (2012) offers an analysis of such opportunism that I think is useful to understanding Mass Oyster's approach. He asks whether the techniques of neoliberalism are specific to the logic through which they have been instrumentalized, and he decides that they are not. He provides multiple examples of neoliberal "governmental devices and modes of reasoning" being "peeled away from that agenda, and put to very different uses." I see something similar in Mass Oyster's approach to ecosystem services. The move is to appropriate the terminology of ecosystem services to describe other rationales in terms that can be readily understood. In the same way that Jedediah Purdy describes the knowledge claims advanced by 20th century environmentalists finding amenable audiences, I have witnessed multinaturalism expressed in terms of ecological services. The goal is not to develop further market-based approaches to ecological management, but to demonstrate the capacities and potentials of the nonhuman. The economic rationality and human-centered managerialism of ecosystem services is supplanted by ecosystem function. This is what is indicated when Mass Oyster says that they pursue their project "for environmental reasons." In fact, given David Takacs' research evincing the multiple motivations of environmentalists beyond commodification, I think that Mass Oyster's position is indicative of a more general move afoot in post-Natural environmentalism, and it is especially aligned with those projects that have recently coalesced around climate adaptation work.

oysters so that they (or others) can eventually profit from the harvest. Rather, Mass Oyster is seeding the Annisquam “for environmental reasons,” meaning in support of the local ecology.

The volunteers also put an ironic twist on the phrase and offered it in response to state bureaucrats when Mass Oyster was denied permits. In this way, they indicated that the agency that should be concerning itself with the livelihoods of shellfish was instead promoting industry interests. Mass Oyster argued for an exemption from the regulations that serviced those interests because they were not part of the industry; they were in it “for environmental reasons,” meaning in this case noncommercial ends.

They also argued that state agencies should be happy to have their help. By doing restoration work, they were growing the stock of wild oysters that could be harvested, and by doing infrastructure work, they were securing cleaner waters and thus more areas in which shellfisheries could operate. Still, they were adamant that their motivation was environmental, not industrial. “For environmental reasons” in this sense contained a recognition of the uncomfortable closeness between neoliberal governance and the organization’s wild topology. I liken Mass Oyster’s way of employing the phrase in this context to evidence found in other conservation settings by Jamie Lorimer (2015) and Eben Kirksey (2015). Both writers provide examples of conservationists promoting the presence of charismatic species, those critters like pandas and elephants that are well-known to a global public and often employed by environmentalists in service of their cause. Charismatic species can be easily commodified in trade or tourism, but environmentalists are ambivalent toward this role. On the one hand, it enhances their work to commodify a species; it provides much-needed funding. On the other, it debases the animal or species by supplanting their wildness with market logics. This phenomenon is close to the work done by Mass Oyster's "environmental reasons" phrase because in both cases, wildness is (at least in some degree) susceptible to regulatory capture.

Mass Oyster cannot be described as a neoliberal project, however, and this is borne out in the ways that the organization uses the phrase "for environmental reasons" to affirm their work. The form of knowledge they were employing was ecological, drawn from an entire landscape, rather than one commodified or instrumentalized organism. The Gloucester site, after all, was an experiment, in the sense that it was conceived of as a trial run, and because it was open-ended. Mass Oyster was working to fine-tune the coordinations of a system in which they were one among many agents. They never assumed that they could fit the oysters to a single role or logic of infrastructure; that would be impossible, because it would deny the oysters' agency. The phrase in this sense demonstrates that there are affective logics beyond commodified exchange value.[17] Valuing nonhuman forms of knowledge necessarily puts the project at odds with neoliberal efforts to service human needs with putatively ecological projects. Mass Oyster recognizes that there are multiple forms of environmental knowledge and value, some commodifiable, others impossible to commodify.[18] In process of learning to be

[17] This is the argument that Lorimer makes in his conclusion, as well.
[18] This argument is often heard in opposition to the use of an ecosystem services framework. Not all environmental processes or things have (enough) value to register.

affected, Mass Oyster volunteers found and fostered nonmarket relations between oysters and humans *for environmental reasons*.

Recalling Jensen and Morita's understanding of infrastructure, experiments like the one Mass Oyster undertook in Gloucester can "*give form* to culture, society, and politics" (Jensen and Morita 2017, 3). The last of these—the question of politics—is attended to in the following, final section.

Post-Natural Policy

Anna Tsing, whose landscape analysis methods I have just used to describe Mass Oyster's work on the Annisquam, would thoroughly object to the turn this chapter takes; she would see it as instrumentalizing her project in service of its opposite, which is to say codification and enforcement. Jedidiah Purdy, whose analyses of environmental thought and law I am about to use in this chapter, would object to my rendering of the evidence presented above as political in nature. He would say that it is "almost all ethics and aesthetics, and hardly a politics at all," as he has said of Tsing's work (Britton-Purdy 2015). I disagree with both of them and think they share more common ground than they perhaps realize. Potentially resolving this academic squabble is a happy side effect of the work done by multispecies planning: bringing the policy sphere around to contemporary environmentalisms as a means of augmenting approaches that can carry life through the Anthropocene.

This rapprochement—or maybe it's less successful than a rapprochement; an inharmonious comingling—takes its cue from Purdy's perception of American environmental legal history (Purdy 2010, 2013). This history is worthy of attention because it makes the case that these forces—politics and ethics—do comingle in ways that are easy to describe in broad strokes, and that they are not fixed but change with time.[19]

Earlier, I caricatured the driving force behind such law and policy as an Enlightenment-informed separation between Nature and Society. Purdy describes the different legal guises that this mentality has taken on over the years. Prior to the mid-20th century, it could be typified as Romanticist. Aesthetic visions of an Edenic landscape were generated as a palliative to social and technological advances that both benefitted and threatened human society. Frederick Law Olmsted found fame planning park systems to enhance public health. President Roosevelt made the national park system a preserve of critical national resources. Visions of the sublime, of a pure and beautiful unitary Nature, were expressions of an environmental ethic that found instrumentality in the progressive legal tradition. There was a legislature amenable to such knowledge claims. Purdy further explains the transition that followed as one to identity politics. Building from the progressive tradition, American environmentalists of the 1970s made claims about pollution and anthropogenic degradation that could be understood by policymakers in familiar terms. They also made vaguer claims about promoting

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[19] In what follows, I treat multinaturalism as an ethic—not just an ontology or empirical observation, but as a principle for right conduct in pursuit of flourishing and prosperity. This is a difficult philosophical move to make but I take my justification from Jane Bennett who, inspired by Bruno Latour, seeks to broaden the scope of democracy to "acknowledge more nonhumans in more ways" in order to "live the good life together" (Bennett 2010). She offers a materialist and disanthropocentric idea of "the good life" that I meant to embrace here.

ecological consciousness that Purdy claims had little legal impact.[20] Nevertheless, there was a public that was amenable to that second set of knowledge claims.

To these two eras, I would add a third: the postmodern notion that Nature is a social construction and the concomitant adoption of an ecosystem services framework. This paradigm shift can be seen in the restoration literature detailed previously. It extends the logic of markets to nonhuman phenomena by claiming an ethical position: making Nature visible by giving it value. The political framing that is often associated with this ethic is neoliberalism.

My claim, in light of Purdy's evidence, is that a politics can be nurtured to complement an ethic, and that nurturing a complementary politics can imbue the ethic with more potential.[21] The questions to answer in light of this claim are: What sort of politics might we find aligns well with multinaturalism? Or, better put, what kind of politics does multispecies planning advance? I don't mean to suggest here that the politics I elaborate are the exclusive match to multinatural environmentalisms, but that given strong historical examples, surely multinaturalism can find a way to surpass today's neoliberalism and find a suitable counterpart—or many, as the case might be. This task is important for articulating alternatives and actualizing them in practice, specifically in light of Mass Oyster's example. It is also important as a means of demonstrating the potential of planning beyond the human. To use a phrase from Sarah Watmore's work elucidating the politics of flooding in the UK, developing such a politics

[21] I think that Tsing would argue the same; she develops her own politics in *The Mushroom at the End of the World*.

"amplifies the matters that come to matter politically" (Whatmore 2013, 46). This might be the pivotal point of articulating alternatives: valuing other types of knowledge.

Rationalizing such a political shift in broad terms is less complicated than understanding its implications. The relationships I witnessed developing on the banks of the Annisquam drew from historical legacies and other landscape contingencies, but also current political realities that shape and are shaped by current conservation practices. Interviewees often commented that their work was most immediately affected in the political realm by the Massachusetts Division of Marine Fisheries[22] Shellfish Planting Guidelines. The guidelines, last updated in 2015, are Marine Fisheries' official policy framework for all types of shellfish planting activities, and one means by which the state maintains its compliance with federal shellfish regulations. This is the document I will scrutinize as an object of multispecies planning.

The guidelines are designed to suit a complex policy environment. Mass Oyster members spoke of the confusing, sometimes conflicting priorities and processes of state and local permitting agencies. On average, a half dozen agencies would need to agree before a restoration project could move forward; the number varied by project. These agencies administer state laws, including the Massachusetts Wetlands Protection Act (WPA), and the Massachusetts Public Waterfront Act

[22] Hereafter, the Division of Marine Fisheries is referred to as DMF or Marine Fisheries interchangeably.

(Chapter 91).[23] Marine Fisheries must also follow federal law. A general understanding these key legal concepts is needed to properly understand DMF's Shellfish Planting Guidelines.

The Wetlands Protection Act governs any area determined to be one of the more than 20 types of wetlands present in the state. It requires that any alteration to a designated wetland area undergo review by the Department of Environmental Protection. Environmental restoration projects enjoy some exceptions from the WPA, but oyster restoration efforts still encounter unique difficulties.[24]

Chapter 91 is the modern codification of the Colonial Ordinances of 1641-1647, which regulated private property to preserve public access to the waterfront. Under it, private property owners cannot exclude the public from exerting their "Riparian Rights" to fishing, fowling, and navigation. Chapter 91 has been broadly interpreted by state courts as preserving a right to recreation generally,

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[23] The WPA can be found at M.G.L. Chapter 131 Section 40 and its regulations at 310 CMR 10.00. Chapter 91 can be found at M.G.L. Chapter 91 and the related Massachusetts Waterways Regulations at 310 CMR 9.00.

[24] Few projects have been permitted under these ecological restoration exceptions. Practitioners have a general lack of understanding about what is possible under this part of the WPA. Instead, they expect that there will be no differentiation between types of projects. The same environmental site assessments required of real estate developers are required of oyster gardeners, irrespective of project size or impact. An often-cited example is the permitting process for putting oyster shells on the ocean floor, which is an area protected by the WPA. Placing shell is a common first step in restoration practice because oyster larvae attach to other oyster shells. This step is considered an alteration of a wetland, and so prompts a permitting process. Interviewees cited multiple examples of projects that were denied at this stage because administrators thought of the shells as fill, indistinct from other materials used as fill, like sand or debris. Even if a project made it past the WPA review, any shells that might be used are required by Marine Fisheries regulations to be aged on land for at least a year to ensure that the shells do not introduce novel or pathogenic biota to the waters. A restoration project must find suitable land on which to dry the shells, and the means to transport them. Some restorationists have considered engineered reef balls in place of shells, which avoids the fill problem but raises another. The Army Corps of Engineers shares jurisdiction in many WPA-protected areas to preserve and improve marine navigation. Any structure over 8" tall, which includes most oyster restoration apparatuses, triggers Army Corps review.

and so the definition of fishing includes aquaculture. Chapter 91 guarantees the public and the shellfish industry alike access to the waterfront for the enjoyment of oysters and other farmed or caught aquatic life.

State shellfish regulations must uphold the rights and responsibilities of the WPA and Chapter 91. They also need to conform to federal law. If a state wishes to engage in interstate commercial shellfishing, it must conform to the specifications of the National Shellfish Sanitation Program (NSSP) (U.S. Food and Drug Administration 2017). The NSSP is a set of public health criteria for the shellfish industry developed in the late-19th and early-20th century—as a way to control the sanitation of oyster production. The NSSP is a cooperative agreement amongst industry, federal, and state actors. It relies on state law, regulations, and enforcement; local authority is granted to several bodies, including, in part, to Marine Fisheries. While participation is voluntary, aspects of any state's program must concur with the federal Food and Drug Administration, the Interstate Shellfish Sanitation Conference (NSSP's parent organization), and the NSSP itself, or the state will be considered noncompliant. A potential consequence for noncompliance is the removal of the state's shellfish from interstate commerce.

The NSSP offers guidance on how to grant local authority to the responsible body in the form of its Model Ordinance. The ordinance outlines a classification system for waters where shellfish aquaculture occurs, graded by sanitary suitability. Marine Fisheries states in its guidelines that public health is the primary principle that it seeks to protect. The division conducts regular surveys of coastal water sanitation and uses these to determine whether the shellfish there are suitable for human consumption. Statewide, 303 areas are surveyed and classified, in line with NSSP guidelines, as one of five statuses: approved, conditionally approved, restricted, conditionally restricted, or prohibited. Any classification other than approved is considered contaminated. Because all shellfish must be made available to the public in Massachusetts under Chapter 91, DMF disallows plantings in contaminated waters and may resort to interventions where spontaneous self-perpetuating populations form. Exceptions can be made for research projects of a limited duration, but no such project will be approved if it would create a new self-sustaining population. Any shellfish who—facilitated by human activity or not—makes their home in areas designated unsuitable for aquaculture may be relocated to approved waters.

There are two related aspects of the Marine Fisheries policy's public health focus that concern multispecies planning: anthropocentrism and topology. Human concerns in the form of health and commerce are the chief motivation behind the shellfish planting guidelines. This is made evident in the NSSP's Model Ordinance, which requires environmental assessments only for areas where aquaculture is to be permitted. Overall environmental health—the number and strength of interactions—is discounted. Admittedly, the policy does help to buoy shellfish health. The vector for disease or toxicity is, after all, impaired shellfish, but it shows little concern for the self-determination of shellfish; their wildness, that is. Perhaps the most apparent show of this limitation is the document's spatial definitions.

The maps produced by Marine Fisheries as a product of their guidelines are not dissimilar to modern conservation geographies that uphold the Nature-Society binary by designating spaces on either side of that divide. The near-shore oceanic areas of Massachusetts are not sufficiently rare or unique enough to qualify as protected Nature. Rather, in DMF’s view, they qualify as Nature in another sense: to be exploited as a resource. Rather than seek to understand the contingent relations that comprise the landscape, and the topologies of the same, Marine Fisheries maps areas according to human management schemes that are delineated by jurisdictional boundaries. DMF’s understanding of the landscape is thus limited, and relatively static. Within those areas, there is no respect for the shifting assemblage of agents whose relations shape the landscape. Instead, interactions are purposely limited by banning aquaculture and eradicating shellfish.

This lack is only identifiable from a nonhuman perspective; it takes thinking like an oyster to realize the paucity of anthropocentric marine policy. By contrast, a multispecies planning approach would foster a different topology, a way of evaluating space that is not based exclusively on the topographical map. It would rely instead on what Mass Oyster developed along the Annisquam: a wildness without wilderness. As the restorationists I consulted know well, ecologies are complex, and they move. They change and adapt according to circumstance; they neither fit neatly within nor obey to the state’s 303 aquaculture area delineations.[25] Nevertheless, these ways of being in the world, moving through it, and forming relations that create and alter the landscape can be recognized in post-natural policy. The definitions used in multispecies planning would differ from DMF's in that shellfish would be defined as landscape agents, rather than a resource. Area delineations would follow from habitat suitability and observed species presence, which is to say the existing or potential relationships amongst agents, rather than jurisdictional or public health criteria. Compare the Marine Fisheries map of Boston Harbor, produced in accordance with the division's guidelines, with one I developed using species-specific criteria for the Eastern oyster (Appendix A).

The Oysterscapes map uses a different topology, one that interprets the needs and desires of the Eastern oyster vis a vis the best available science. The criteria for suitable habitat include depth, sediment type, slope, and competing uses (limited, in this case, to human uses.) DMF's map involves no species criteria, but instead shows where levels of contaminants were evaluated, and a status assigned to indicate whether shellfishing permits would be awarded. The sort of knowledge produced by attending to the topology of the Oysterscapes map offers different political potentials. It draws from the interactions of different landscape agents, human and nonhuman. It includes historical forces like urbanization, represented in the human land use layer, and its purpose is to address future concerns like climate change. Rather than being in the business of limiting interactions and

[25] Jamie Lorimer (2015) would describe this topology in terms of *nonhuman mobilities*, the interconnected and fluid geographies of more-than-human lifeworlds.

preventing changes, a Division of Marine Fisheries that relied on this form of knowledge would observe and assess ecological flux. This type of knowledge production is like that being generated by the conservation biology studies summarized above. It is multivariate, sensitive to contingencies, and, through an implicit assumption that landscape-scale interactions will continue to unfold, admits that its findings are not fixed or stable. Where the Marine Fisheries map is a modern planning document, the Oysterscapes map is a multispecies planning document.

Earlier I suggested that attending to multinaturalism in terms of policy would give it more strength as an environmental ethic. How do the changes just suggested achieve that broader goal? It is possible because policy is capable of structuring human-environment relations. Surprisingly, there is alignment between the two frameworks on this point. Under the planting guidelines, access to the coast is guaranteed in order to protect the rights afforded by Chapter 91. Commercial activity has been privileged among these rights, but the law also encourages a potential for human-oyster encounters. Many multispecies ethnographers, some cited above, have indicated that encounter is the most important component of learning to be affected. The task of multispecies planning in this context is to recognize in the guidelines structural elements that would offer opportunities for encounter, and to encourage those. Jedediah Purdy (2013) uses the figure of a public access right to explain the structural value of cross-species encounter. His example is of agricultural animals farmed for meat. He suggests that industrial meat production is rife with moral and legal issues. Legally-guaranteed public access to the farmyard (if not the slaughterhouse) could promote cross-species encounters and reveal their ethical potential. Public access would make the morality of the meat industry visible and facilitate a shift in the environmental ethic that informs meat production. "One might think of it as a legal subsidy for ethically relevant experience," he writes (Purdy 2013, 916). On the coast of Massachusetts, such encounters are currently abrogated by the Division of Marine Fisheries policy of discouraging human interaction with shellfish in contaminated waters. Multispecies communities cannot form where a species is absented. Marine Fisheries policy distorts the intention (and subsequent interpretation) of Chapter 91: a public right to the coast as a commons, a guaranteed geography of plenitude and wildness. Chapter 91, in other words, can be understood as a right to encounter, one that would be augmented by embracing a wild topology in a regulatory framework.

The obvious concern about public health in this context is still valid and should condition the right to encounter. It is still necessary, imperative, even, to consider these ramifications; they are, after all, the results of certain interactions, from which knowledge is generated. The Oysterscapes map discussed previously is incomplete; it would be better to include a layer detailing anthropogenic contaminants and the risk to human health from shellfish in those areas. Public health risks are topological considerations with political implications—matters that come to matter politically, to use Whatmore's refrain. The right to encounter should extend to some forms of entanglement and not others. Shellfishing activity in areas where those interactions would take place should remain limited;

multispecies planning is not relativist, and not all forms of knowledge are equal in the formation of multispecies communities.

To be specific, a multispecies planning perspective on DMF's guidelines would allow wild oysters to populate in contaminated waters, to permit humans to facilitate and steward the process, and to encounter oysters-as-infrastructure rather than exclusively as a commodity. It would also allow for the continued regulation of harvests to prevent public health harms. After all, choreographing ontologies is the work of infrastructure. Choreography involves making some moves, and not others.

Unsurprisingly, perhaps, given their fundamental differences, the relationship between Mass Oyster and state administrators has not been smooth. Members I heard from spoke of burned bridges and bad blood. It was a relationship that they were working to improve through a variety of means. Mass Oyster made changes in leadership, developed new partnerships, and worked with Marine Fisheries to find suitable ways of framing their project that wouldn't run afoul of the law, regulations, or guidelines. The Gloucester restoration site is one such effort. Constrained by state and federal law, DMF limited the purpose of the upweller—it could move forward as an education effort to teach about oyster ecology, not a restoration project—and oysters could mature in the upweller until they reached a given size, after which they would have to be released at designated sites, including at the desired Annisquam location.

While the project proved sufficiently amenable on these terms, Marine Fisheries has remained slow to adapt to changing regimes of environmental knowledge.

The department's 2015 guidelines only acknowledged "increasing interest" in the performance of infrastructural functions by shellfish, valued in terms of ecosystem services. The executive summary stated that the division was "interested in balancing the interest in shellfish restoration" with its own priorities. There is no discussion of climate change, its impacts on shellfish, or the social repercussions of those impacts. Compared against the findings of the Mississippi-Alabama Sea Grant Legal Program (2014), which surveyed the shellfish management regimes of the coastal states of the U.S., the guidelines did not substantially depart from prior policy.

In 2015, Mass Oyster managed to get its own legislation filed. A short bill was introduced by Massachusetts Representative Dan Ryan and referred to committee where it would die two years later. Its aim was to establish a new program called Oyster Restoration for Environmental Purposes (OREP), which would allow activities that DMF otherwise blocked. It uses language the organization still employs, and was commonly heard during interviews, such as the shorthand "environmental purposes" for the complexity of landscape phenomena. The bill can also be considered reactionary, the result of responding to a hostile policy environment. By Mass Oyster's own evaluation, it was too technocratic an approach. The bill failed to gain stakeholders because it was developed without public input and went directly to the floor of the State House.

The OREP bill is not exemplary of multispecies planning, but it would have achieved similar ends. OREP would have bypassed DMF, allowing Mass Oyster and others to work directly with municipal authorities to open contaminated waters to shellfish planting, but not harvesting. The effort was representative of the organization's approach to policy: a partial embrace of contemporary political rhetoric, ideas, and forms.

The start of this chapter contained a question: what sort of politics does multispecies planning embrace? The foregoing analysis of the Marine Fisheries guidelines gave shape to an answer: these are characteristics of a cosmopolitics.

Multispecies planning is a method through which differing ontological realities of diverse animals/plants/people/things can be negotiated. The planning process does not resort to an *a priori* metaphysical Nature but develops its justifications through experimentation; its causality is situated and emergent. Multispecies planning embraces nonhuman agency, however volitional, and—to put it squarely in the terms professional planners would use—it involves more stakeholders, translating amongst groups in a participatory decision-making process. This quality makes multispecies planning *dis*anthropocentric. Human knowledge is not the only kind that matters to the process. In fact, multispecies planning goes a step further than diversifying stakeholders and seeks alliances with more-than-human agents. It treats nonhumans as fellow subjects in knowledge production. The oysters involved in Mass Oyster's infrastructural work or described in the Oysterscapes map were not merely represented; neither Mass Oyster nor I spoke on behalf of the Eastern oyster species. Instead, in and through the facts of their being, they influenced political matters that affect them, translated, by way of science, into human action. They made a difference in the process of knowing, and the process of policymaking adapted accordingly, both of which are cosmopolitical acts. By bringing ontological politics into the sphere of environmental policy, multispecies planning gives structure to the collective endeavor of learning to be affected.

Conclusion

I make a claim at the beginning of this document that multispecies entanglements in the context of infrastructure allow us to reformulate our idea of politics. Between these two points, I intended to clarify what makes this reformulation possible and how I think it is best done. In summary, I want to return to that claim and enumerate the pragmatic and theoretical terms that allow us to recast politics. On the pragmatic side I demonstrated that the nonhuman can be already be found influencing policy matters and our careful attention to it will better address the complexities of the climate crisis. In terms of theory, I sought to expand the political imaginary to accept the proposition that the nonhuman has political things to say. Both of these approaches imply that the political involves far more than human subjects engaged in rational discourse, and so this description of multispecies planning has been an attempt to take strategic anthropomorphism seriously as a methodological commitment. The result has been the development of multinaturalism as an ethical and pragmatic commitment, an alternative topology with which to consider the development of environmental policy, and a concept of wildness as both an ontology and an epistemology around which to center post-Natural environmentalism.

Further, there have been specific lessons for policymaking. The first is that the process of making policy needs to engage more forms of knowledge than it presently does. Specifically, it needs to consider forms of knowledge beyond that of human knowledge. In the context of Massachusetts shellfish policy, that meant attending to species habitat determinants as a primary factor in DMF's jurisdictional area. The second lesson is more general. When we allow for the expression of nonhuman agency in policy terms, it's no longer a unilateral decision-making process. We don't know what they will do. Multispecies planning involves different forms of knowledge and new ways of reasoning environmental matters of concern. I summarize this ecologized approach as letting the landscape lead—drawing lessons from the relations that constitute a geography and allowing those lessons to dynamically inform how humans should engage that space. The state of Massachusetts already invests considerable time and effort in evaluating its coastal waters and revising its shellfish policies according to the findings. Letting the landscape lead in this context meant putting a stop to the policing and forced relocation of oysters who are deemed out of place.

Finally, extending beyond legal or regulatory concerns, I suggested that a multispecies approach to planning facilitates an ethic that we should be encouraging, especially in light of climate change. That is, policy and ethics have a reciprocal relationship where one can help the other take shape. I took preliminary steps in mapping the new DMF geography I proposed, and hinted at broader implications of such a change, like a shift in human-oyster relations. One mechanism through which this can happen is through encounter. Massachusetts has long deemed its coast to be a commons, and this is codified in state law under

Chapter 91. I suggested that Chapter 91, reconceived in multispecies planning terms as a right to encounter, would encourage public acceptance of oysters as infrastructure by identifying and promoting non-consumptive relations with oysters, and allowing the public to encounter the oysters' wildness at work. That is, it would make learning to be affected a collective endeavor.

Returning to my original claim about the political nature of multispecies planning, I concluded that both the difference that the Eastern oyster made in the process of knowing and the response had by multispecies planning were acts that put the framework on cosmopolitical terrain. This analysis acknowledges that questions of whose knowledge is valued in a landscape are not only political in nature but that multispecies planning extends the limits of what counts as politics.

Coda

In closing, I want to briefly admit some limitations and other potential fault lines in this analysis that could be explored in further research. The foremost among these is the charge that a concern for environmental ontologies is feckless in the face of climate crisis. Worse still, multinaturalism and cosmopolitics are not oppositional philosophies to neoliberalism. In fact, they look to go beyond it using similar techniques, and thus could be characterized as being in neoliberalism's service—in other words, contributing to the problems at hand while claiming to solve them. Anna Grear has rightly suggested that "familiar questions of injustice, in short, do not diminish" with the sheer recognition of ontological or epistemic plurality (Grear 2018).

Collard et al. (2015) powerfully assert that justice will not be found through a better composition of a common world (which I fear is how they would characterize my efforts here) but only by reckoning with the "ruination" of Nature, which is to say the results of a modern ontology that was forcibly imposed on those who did not share it. For them, an "abundant future" will only result from also seeking political justice for the "violence of settler colonialism"[26] (Collard, Dempsey, and Sundberg 2015, 326). What I have tried to do here instead is to show that political decisions can be made in a context of a non-modern ontology, and that those decisions matter to further developing an ethic that is antithetical to projects like colonialism and climate injustice. This might prove naïvely insufficient and I am open to furthering our understanding of how to better address such issues.

Another issue concerns the traditional orientation of planning. The act of planning faces the future and approaches it with a goal in mind, taming contingencies and rebuffing the unexpected. Is multispecies planning, with its roots in historically-defined contingency and openness to experimentation, simply not *planning*? There are three ways to respond to this question, two that approach it theoretically and one that considers it in terms of actual planning practice.

First, the multispecies/planning paradox is a lot like the paradox of a posthuman subject. Does the fact of my having distributed agency prevent me from acting as a subject? I'd say no, I'm continuously affecting and being affected by the world

[26] At the same time, the authors see a respect for animal autonomy as part of their decolonial agenda for "abundant futures," and I think this has been achieved through multispecies planning.

around me. In recognizing that my subjectivity is constituted by other subjectivities, I'm acting with the world, not erased by it. Similarly, does the act of planning become meaningless when faced with how variable the world is? I don't think so, but I do think we should better orient ourselves to that variability. The point isn't to control the contingencies but to embrace them as part of the planning effort, to allow more forms of knowledge to shape it. We might have to move so that a marsh can retreat, or so that birds can have critical nesting habitat, but we might also log in managed forests and eat shellfish from Boston Harbor. These planning and policy choices feel to me like the pragmatic exercise of encountering the world as it is and formulating a response that furthers our species' survival—the rudiments of a planning practice, in other words.

Second, following Whatmore and Latour and others, we have never been modern. If this division of the world into human/nonhuman binary categories is a convenient fiction, then what changes in recognizing the fact of it? ANT urban theorists, political ecologists, and others have done a good job detailing that planning was already suffuse with the nonhuman. These analyses, in my view, tried to observe nonhuman processes in order to harness them (e.g. mapping urban metabolism to promote growth, eliminate waste, etc.) whereas I suggest listening and responding to them. Those who do material flow analysis still treat the nonhuman as the object of human actions, where I level the playing field to make us all (literally in my example) creatures of the mud, as Haraway would say. In other words, I would counter this line of questioning with another. Aren't we already dealing with contingencies that exceed our best laid plans? Wouldn't our plans be better if we worked with them?

Third, we have a great example of relaxing the tight grip of expert-led planning in the effort to democratize the practice. Extending the planning process to more human actors is heralded as a way of improving its efficacy, of making it more just. I think this democratization tends in the same direction as multispecies planning and hints at some of the justice issues implicit in it, especially those with a degree of latent humanism in them. The arguments that get lodged against participatory planning sound like those against multispecies planning: it's unreasonable to consider so many perspectives, it'll take too long, it won't result in the best possible outcome, and (in the extreme) it takes away planners' power. Planners today are thought to counter each of these, and multispecies planning is a logical extension of those arguments to the nonhuman.

Finally, some might alternatively charge that multinaturalism does not directly address climate issues, but here I disagree. Multispecies planning in this instance will not lessen the presence of greenhouse gases, nor will it prevent the occurrence of superstorms or ocean acidification, but I argue that reshaping the fundamental assumptions on which environmental policy is based is in fact shaping the outcomes we seek. Respect for ontological difference breeds epistemic plurality and it is essential for addressing the climate crisis that we diversify the forms of knowledge we value in terms of policy. It seems to me that even the rationales we have used to date in service of a modern conception of Nature—the natural sciences—are moving in a direction that values epistemic plurality through observations and analyses of multiple contingent relationships. I also think that the practices of conservation and restoration are finding new expression in post-Natural terms, as I have evidenced in the case of the Mass Oyster project, and that these practices are actively responding to climate change. Far from being a distraction from practical matters, facilitating a shift in policy to be more responsive to the lively materialities that surround us is an exercise in climate adaptation.

Appendix A

MarineFisheries
Commonwealth of Massachusetts

Massachusetts Division of Marine Fisheries

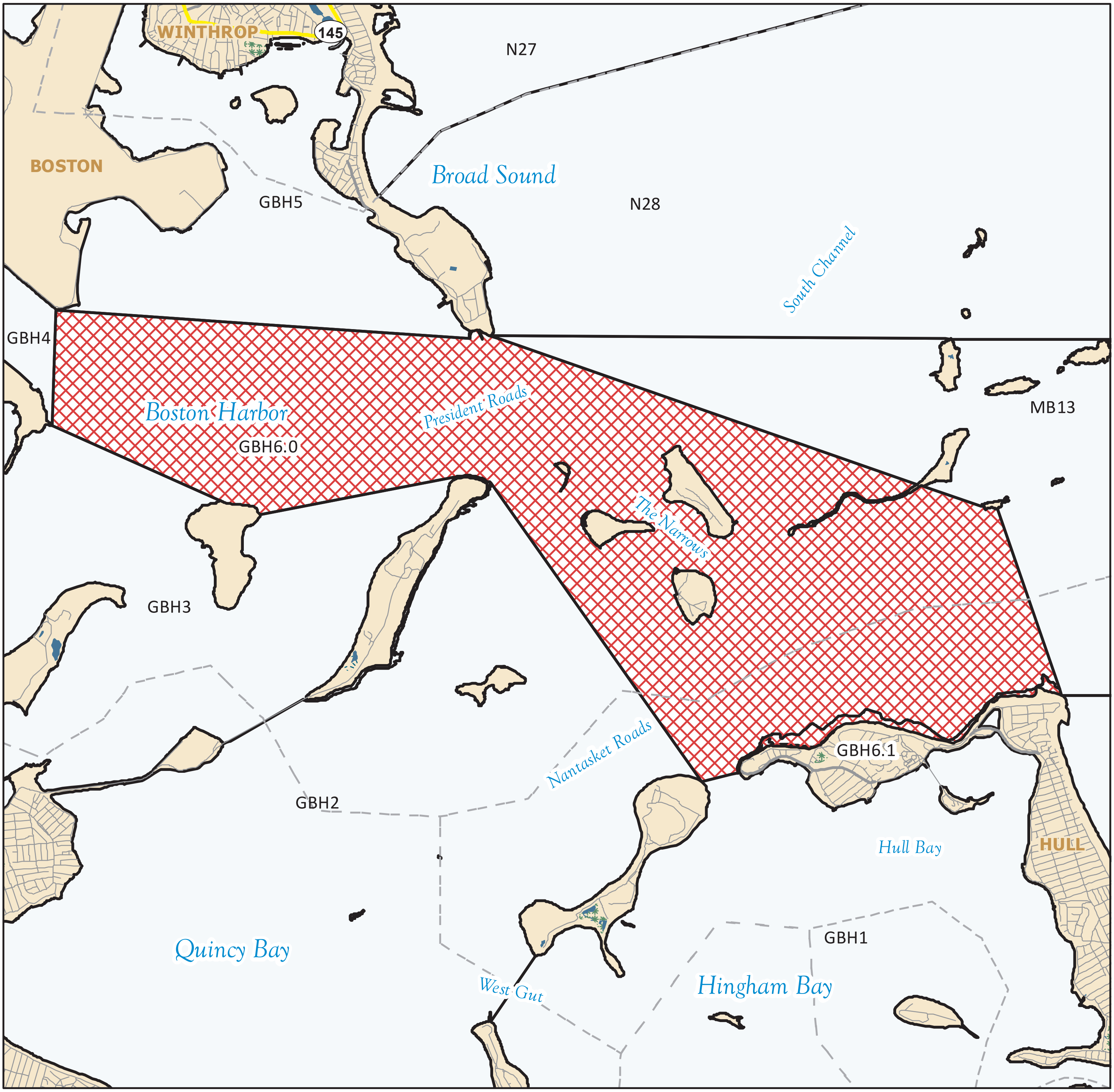
SHELLFISH SANITATION AND MANAGEMENT

Growing Area Code: GBH6
Area Name: NANTASKET ROADS
Area Town(s): Boston, Hull

Shellfish Area Classification

- Approved
- Conditionally Approved
- Restricted
- Conditionally Restricted
- Prohibited

Produced: 6/28/2013



This map depicts the MarineFisheries' sanitary classification of shellfish growing waters in accordance with the National Shellfish Sanitation Program. It does not indicate the current status, either "open" or "closed" to harvesting due to shellfish management or public health reasons. Always confirm the status with local authorities and/or MarineFisheries. Information on this map may be out-dated or otherwise incorrect, and should not be relied upon for legal purposes.

Marsh/Wetland — Saltmarsh — Pond/Lake/Reservoir
Town Boundaries — Stream/Ditch/Canal

NORTH
0 0.5 1 miles

Oysterscapes

Determining the Suitability of Oyster Reef Restoration in Massachusetts Bay

Oysters have recently become a prominent figure in climate adaptation planning. Their newfound role as infrastructure owes to their biological capacities. The Eastern Oyster moves 50 gallons/day of seawater through their tiny bodies in order to feed. While they feed on plankton, they remove anthropogenic contaminants from the water. Oysters are also reef builders. The solid structures they build with their shells break up wave action. The reefs act as living breakwaters and limit the flooding extent, especially during a storm. Finally, they are referred to as "coastal architects," not only for their reef building capacity, but for its ripple effects. Waters slow as they move over the reef, and the particles suspended in it fall through the water column, increasing sedimentation. The sediment accumulates, vegetation takes hold, and marshes develop.

Suitability analysis began with classifying effective depths for a subtidal reef: 10 meters or less. Depths were classified into five categories ranked lowest suitability to the highest. Slope was calculated using bathymetric data and sorted into five categories matching the depth analysis. Sediments were grouped into five categories according to the oysters' biological needs and also ranked. All layers were entered into ArcMap's Raster Calculator, weighted at 0.2 for sediments, 0.3 for slope, and 0.5 for depth. Sediments were ranked lowest to prioritize areas where a manufactured substrate could be deployed.

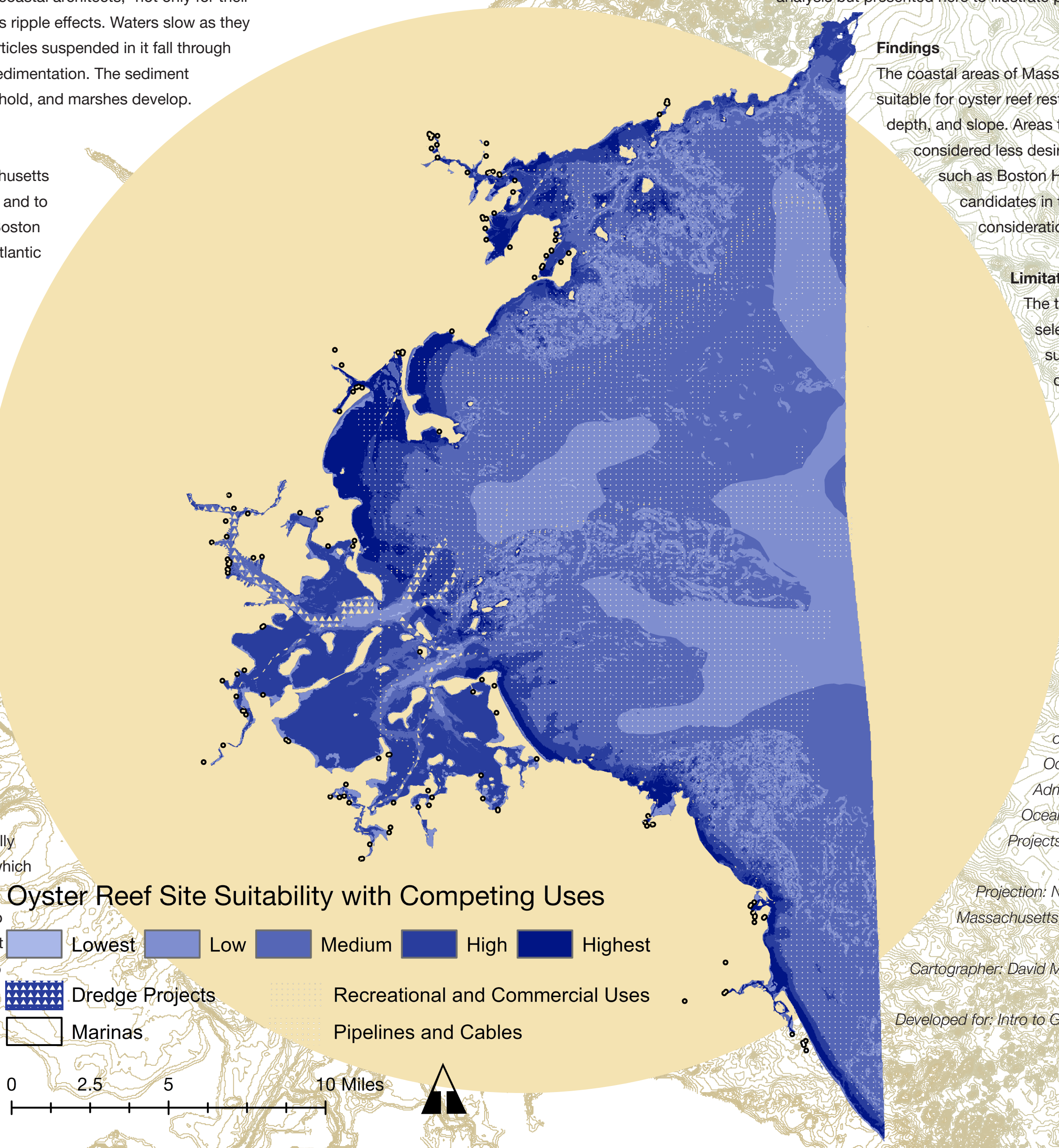
To ensure the least anthropogenic interference with the reef, human uses of Massachusetts Bay were mapped, surrounded with a 100 meter buffer. These uses included recreational and commercial activity (including boating and fishing), dredging projects, and existing pipelines and cables. These uses were not calculated in the suitability analysis but presented here to illustrate potential conflicts.

Area Mapped

The extent shown is of Massachusetts Bay from Rockport at the north and to Marshfield at the south. Inner Boston Harbor is to the west and the Atlantic Ocean to the east.

Methodology

This study began with a set of criteria for determining the suitability of sites in Massachusetts Bay for *Crassostrea virginica*, the Eastern Oyster. The scientific literature recommends considering many different variables in siting a restoration project. The priority of any given criterion depends on the restoration goals. The goal of this study was to identify potential sites for reef restoration, including where a deployed reef could complement flood control infrastructure. Such a reef would be composed partially of manufactured materials on which oysters would grow. The selected criteria are common to all oyster restoration efforts, but some priority has been given to locations where a reef could be deployed. The criteria included the composition of the seafloor sediments, the depth of the water, and the slope of the seafloor.



Findings

The coastal areas of Massachusetts Bay are highly suitable for oyster reef restoration in terms of sediment, depth, and slope. Areas that would otherwise be considered less desirable for oyster restoration, such as Boston Harbor, are considered candidates in this analysis owing to consideration of deployed reef options.

Limitations

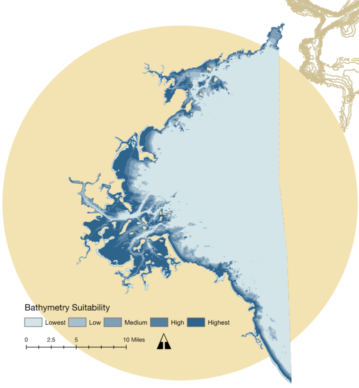
The three criteria considered are selected from among dozens of such indicators used in more detailed analyses of site suitability. Further research is needed into important factors like salinity, water quality, flow rate, and others. Additionally, while this study concerns the potential infrastructural role oysters can play, their effects in mitigating flooding are not examined here.

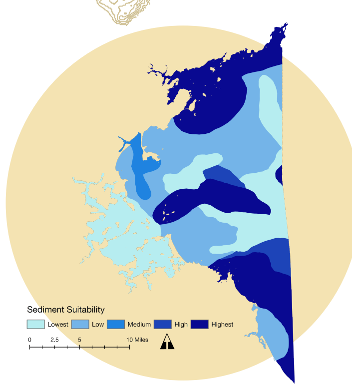
Data Sources: Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), Special Projects (SP)

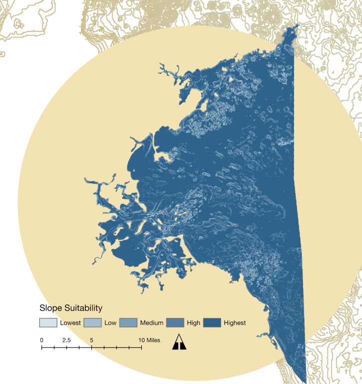
Projection: NAD_1983_StatePlane_Massachusetts_Mainland_FIPS_2001

Cartographer: David Morgan

Developed for: Intro to GIS, December 2018







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