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Making nature into infrastructure: The construction of oysters as a risk management solution in New York City

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Abstract

This paper investigates how nature is transformed into infrastructure through an examination of New York State's Living Breakwaters project, a $60 million risk management experiment to grow oyster reefs in order to better govern storm surge, rising seas, and coastal flooding. While oysters' infrastructural nature is portrayed by designers and planners as an inherent natural property which now simply needs harnessing, in reality making oysters into infrastructure requires extensive concrete work—by humans and oysters. Drawing on historical research, site observation, interviews, and media and design analysis, this article traces this work required to make oysters appear, and then function, as a risk management solution. In part one, I trace the narrative work involved in establishing the idea of oysters as infrastructure. In part two, I look at what it takes to build this idea in reality, to make oysters actually function within desired governmental parameters. Making oysters into infrastructure, I conclude, is a kind of biopolitics, both in the traditional sense of making certain forms of human life live, but also in which the goal is to make nature live in a particular way, albeit one imagined as natural to the oyster. While biopolitics forwards a dystopian view of human and nonhumans as vulnerable to threatening environmental processes and heavily secured, it may be undermined by the inability to make nature's imagined "vitality" appear.

Keywords

Oysters, ecological infrastructure, New York, Hurricane Sandy, biopolitics

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Introduction: Nature as infrastructure

As part of a $60 million joint effort with the US Department of Housing and Urban Development (HUD) and SCAPE Landscape Architecture, the State of New York (NYS) is building 2 miles of artificial oyster reefs along the south shore of Staten Island. While New York was once home to a large oyster industry based in the mass production and consumption of oysters, the oysters with which NYS is concerned are being viewed as something novel: a critical infrastructure to govern storm surge, rising seas, and flooding along New York City's coasts. One among six winning designs in HUD's Rebuild by Design (RBD) competition, "Living Breakwaters," as the project is named, is widely heralded as a cutting-edge infrastructure for the climate change "new normal" now faced by coastal cities (NYSGOSR, 2019). By mobilizing oysters' natural life processes (i.e. attaching themselves to each other and developing reefs that adapt to changing sea levels), the goal is to manage hurricanes and storm surges. For these capacities, oysters are now viewed as paradigmatic of the resiliency infrastructures needed in New York and a model for other coastal cities, a valued risk management solution within a broader assemblage of designs from sea walls to smart electrical grids to govern urban risk (Buckminster Fuller Institute, 2019; SCAPE, 2019).

While critical infrastructure typically refers to human-made technical structures such as bridges, roads, or electrical grids (Collier and Lakoff, 2008; Grubesic and Murray, 2006; Monstadt and Schmidt, 2019)—invisible yet vital lifelines for liberal capitalist urban orders (Carse, 2017; Coaffee and Clarke, 2017; Graham and Marvin, 2001: 56)—New York's experiment exemplifies a broader shift toward the idea of *nature* as infrastructure in cities. While nature has been used to solve urban problems since the 19th century, when parks and green spaces were seen by planners as a solution to urban congestion and social conflict (Gandy, 2003), the explicit idea of nature as infrastructure came into usage more recently. The term "ecological infrastructure" (EI) was forwarded in 1984, as one among five principles for ecological urban planning in a report of United Nations Education, Scientific, and Cultural Organization's (UNESCO) Man and Biosphere program (Cardoso da Silva and Wheeler, 2017; UNESCO, 1984). Rooted in biological conservation and landscape ecology (Forman and Godron, 1986), EI most often referred to the ecological conditions necessary for or conducive to a species' survival or movement across territory (Schrieiber, 1988; Selm, 1988a, 1988b) and referred to natural landscape features such as watersheds, lakes, or hedgerows (Yu et al., 2011). Tied to EI, the idea that ecosystems provide services and embody natural capital has also gained traction in recent years (Costanza et al., 1997; Daily, 1997; Millennium Ecosystem Assessment, 2005). Defined recently as "any piece of nature that provides important benefits to those in a city" (McDonald, 2015), EI is increasingly shifting away from conservation and biodiversity focuses and into the realm of disaster management, as cities seek new socio-ecological designs to govern climate change and build resilience via integration of complex systems models and EI (Bélanger, 2009, 2013).

Nature as infrastructure and attendant idea of ecosystem services are celebrated in the aforementioned fields as promising ecological solutions to modern nature/city binaries and new climate change risks. But as critical scholars have shown the governmental turn to social–ecological resilience designs is part of an historical shift in techniques of risk management in the Anthropocene (Braun, 2014; Dalby, 2013; De Block, 2016; Oels, 2013; Wakefield and Braun, 2014, 2018), which, rather than departing from liberal capitalist business-as-usual, constitute new modes of governing and reproducing, not transforming, existing social–economic relations amidst ubiquitous ecological crisis (Ekers and Prudham, 2015; Ernstson and Swyngedouw, 2019; Grove, 2018). In this vein critical scholars have

analyzed in depth how such practices rely on the commodification and financialization of nature (Adams, 2014; Castree, 2008a, 2008b; Sullivan, 2013) and the false promises of nature-based technologies (Goldstein, 2018; Swyngedouw, 2010). Sara Nelson (2015), meanwhile, has traced how the idea of ecosystem services arose in the 1970s as a specifically counterrevolutionary neoliberal response to environmental crises. More broadly, critical scholarship has explored resilience as a kind of neoliberalism (Chandler, 2014; Joseph, 2013; Neocleous, 2013; Walker and Cooper, 2011), exploring its political inequalities (Meerow and Newell, 2019) and production of subjectivities (Bohland et al., 2018; Evans and Reid, 2014).

What has not been explored enough in these critical perspectives however is *how* nature is made into infrastructure. After all, while in New York the idea that oysters' biological life processes contain valuable capacities or services that can be harnessed to govern environmental problems in the city has gained traction recently (Coen et al., 2007, 2011; Grizzle et al., 2013; Orff, 2010), and while today in New York oysters are seen as a risk management solution, it was not always this way. Before European arrival, the Lenape had used oysters as weapons and to cover burial sites (Pritchard, 2007: 91; Wissler, 1909: 8), while in New York's Gilded Age oysters were produced as commodities (Kurlansky, 2007), both of which remind us that oysters have not always been seen or used as infrastructure. How, then, have oysters come to be a valued risk management solution? Moreover, while nature as infrastructure represents a change in the representation and production of urban nature (Heynen et al., 2006; Smith, 1990), it is also a new definition of infrastructure. While studies *of* infrastructure abound (Carse, 2017; Easterling, 2014; Hetherington, 2019; Larkin, 2013; McFarlane and Rutherford, 2008; Star, 1999; Wakefield, 2018), likewise in this literature the question of how living beings are made to *be* infrastructure has not been explored.

Contributing to critical infrastructure studies, "vital materialisms" thinking, and Anthropocene governance and biopolitics literatures, this paper focuses on the making of nature into infrastructure in the context of New York's oysters. To do so, I follow the concrete work required to make oysters appear and function as a risk management solution. To explore these matters, I draw on geographers Pauline McGuirk, Harriet Bulkeley and Robyn Dowling's (2016) concept of "configuration." While recent scholarship has focused on how governing is enacted via complex, ad hoc human and nonhuman assemblages (Braun, 2014; Foucault, 1980; Müller, 2015; Wakefield and Braun, 2014), McGuirk, Bulkeley, and Dowling note that little attention has been paid to the specifics of how such elements are brought together and maintained as practices of governance. In response, the authors propose shifting focus onto the concrete work by people and things to configure diverse elements so they function as governance.

Extending and modifying this framework, this article draws on historical research, site observation, interviews, and media and design analysis to follow the process of making oysters into infrastructure. Whereas McGuirk, Bulkeley, and Dowling's concept focuses on configurations of humans and materials, making nature infrastructure requires work by humans—specifically designers, ecologists, and policymakers—and oysters. In part one, I trace the "narrative" work required to establish the idea of oysters as infrastructure. Articles, videos, policy documents, discourses, and models together create a new idea of nature as infrastructure, making it legible to diverse constituencies. In part two, I look at further work by designers, engineers, lawyers, ecologists, and oysters to make nature "be" infrastructure, by doing what it is imagined to do naturally. This "ordering" process, I show, draws together municipal regulations, surveillance, and engineered concrete, plus, most centrally, oysters and their living of life. Although designers, like many critical theorists, herald nature's inherent "vitality," configuring nature as infrastructure, my analysis shows,

ultimately entails a kind of Anthropocene biopolitics (Foucault, 2008). Nature as infrastructure, I argue, is biopolitical in that it enrolls oysters as a governmental technique to secure existing liberal, capitalist human life (Anderson, 2010; Dillon and Reid, 2009). But, I argue, it is also a biopolitics of humans trying to make nature appear and live in a particular way—not according to a social norm, but in the way they imagine is natural to oysters. Forwarded in this biopolitics, I argue, is a dystopian vision of both human and oyster life as perpetually vulnerable to threatening environmental surrounds and in need of security amidst an unchanging liberal capitalist urban order. However, I conclude, oyster infrastructure may not "work." Oysters, I suggest, may express their imagined agency in unexpected ways, including by failing to function as expected or to be lively at all.

Narrating nature as infrastructure

Critical infrastructure in the Anthropocene

Defined as "the vast, complex, and changing systems that support modern societies and economies," (Carse, 2017: 27), infrastructure typically refers to technical engineering and managerial projects including dams, bridges, highways, electrical grids, military installations, and computer networks. Infrastructure plays a key role in securing bodies, materials, and processes, providing the logistical undergirding of modern cities: roads to circulate commodities or pipelines to manage flows of drinking water and fossil fuels (Braun, 2005; Cowen, 2014; Hughes and Reimer, 2004), to name a few examples. As such they are not just neutral but also political (McFarlane and Rutherford, 2008; Winner, 1980), a biopolitical matter of producing and reproducing liberal capitalist life (Dillon and Reid, 2009; Easterling, 2014; Larkin, 2013; Wakefield, 2018), ensuring that the "vitality" and "productive powers" of human life are available to state and capital, as Bruce Braun (2014: 58) puts it. In the 19th and 20th centuries infrastructures were a key aspect of modern urbanism (Chattopadhyay, 2012: x), with large-scale engineering works providing evidence of humanity's power to order external, inert nature into productive flows for commerce and improve life quality (Braun and Castree, 2001; Gandy, 2003; Graham and Marvin, 2001; Hetherington, 2017; Kaika and Swyngedouw, 2000; Smith, 1990).

In the Anthropocene, however, the ordering promise of modern infrastructure and governance is now seen by many scientists, designers, and policymakers alike as a destructive humanist idea of mastery causing climate change and network fragility, among other crises (Dalby, 2013; Evans, 2011; Rosol et al., 2017). To govern these new urgencies—more specifically to maintain existing political and economic configurations amidst them (Coaffee and Clarke, 2017)—new resilience infrastructures like smart grids, anti-terror barriers, and surveillance are now deployed (Aradau and van Munster, 2011; Collier and Lakoff, 2008). But along with such traditional technical infrastructures, rather than reproduce modern approaches, to govern climate change threats urban actors are experimenting (Edwards and Bulkeley, 2018) with reinventing infrastructure itself.

Post-Sandy problematization of oysters as critical infrastructure

Nowhere was this discourse and "problematization" (Foucault, 1998) of modern infrastructure more apparent than in the governmental and design response to Hurricane Sandy's impact on New York City. When Sandy hit on 29 October 2012 the storm disrupted infrastructural networks citywide. In the storm's wake, a new view emerged of the city's technical and human systems as menaced by hurricanes and rising seas (City of New York, 2013).

This imaginary of ubiquitous crisis ushered in a search for new solutions to secure the city. Modern infrastructures with their city/nature binaries were immediately cast as outdated, the source of the problem, and the need to experiment with new infrastructures based in a view of the city as an interlinked social–ecological–technical system were forefronted as key to survival (Florida and Zolli, 2012). The infrastructure-imbued perspective was repeated by newspapers, reports, and speeches, quickly producing and naturalizing the new sense of crisis, and setting in motion a search for the kinds of infrastructures now said to be required (Rosenzweig and Solecki, 2014; Wakefield, 2018). While traditional approaches like storm walls were advocated initially, through repetition of the "resilience"/"we need new infrastructure" discourse, such designs were quickly dismissed as inadequate and outdated, while others, such as EI, as we will see, came to seem exemplary and were recast as appropriate (Florida and Johnson, 2012). Instead of continuing to "block out" nature or disorder, now sought were resiliency infrastructures that would welcome both (Bloomberg, 2012; Zolli, 2012). The *New York Times* summed up the new mantra: "the era of big infrastructure is over" (Feuer, 2012: n.p.).

This was the context in which oysters as infrastructure emerged. In the weeks and months after the Sandy, oysters were much discussed by city journalists, designers, and politicians, however, in ways different from those past. In the 19th and 20th centuries, oysters were mass produced and sold as commodities in the city's oyster industry, their shells ground down to make concrete. More recently oysters had been reimagined by Kate Orff's landscape firm SCAPE as a vital part of a future "green" New York. In SCAPE's proposal for "Oyster-tecture" at the Museum of Modern Art's 2010 *Rising Currents* exhibition (Bergdoll, 2011; Braun, 2014), oysters were hailed as a means of ecological remediation, human–nature coexistence, and a way to create a more sustainable urban future (Orff, 2010; Wakefield and Braun, 2019). Were it not for Sandy, oyster-tecture might have remained one idea among millions on a shelf. Critics after all called the project utopian (K Orff, personal communication, 29 May 2015). However this changed after the storm. As lead SCAPE architect Orff recounts, the firm had started getting calls about oyster-tecture after Hurricane Irene, but it was with Sandy that the project began to be taken seriously (personal communication, 29 May 2015). Amidst the climate of urgency and widespread search for radical design innovations the storm set in motion (Bloomberg, 2012; City of New York, 2013), oysters were again reimagined, now as a response to the problematization of modern infrastructure and search for new kinds of resilient infrastructures to secure the city against rising seas and storm surge.

In the storm's wake, oysters were narrated anew as the perfect infrastructural solution to the problem of governing risk in a new age of climate crisis. As defined by McGuirk et al. (2016), "narration" is one way in which diverse elements are configured as techniques of government. Narration, according to the authors, involves the defining of phenomena as problems in particular way—via everything from discourse and images to models and data—and the articulation of a specific governance project as the appropriate solution to the problem as it has been posed. In contrast to the standard definition of infrastructure described previously with its imposition of hard engineering structures on nature, in diverse venues, as we will see, SCAPE narrated a new idea of oyster infrastructure derived from natural bivalve life cycles themselves (Figure 1). This cycle begins as oysters release millions of eggs into water column. These tiny blobs of larva extract calcium carbonate from lime-rich waters, quickly grow thick, hard shells, eventually reaching a stable surface—usually other adult oysters or shells of dead oysters—where they attach and remain for the rest of their life (Brooks, 1996: 23–25; New York-New Jersey Harbor Estuary Program, Port Authority of New York & New Jersey, & US Army Corps of Engineers New York

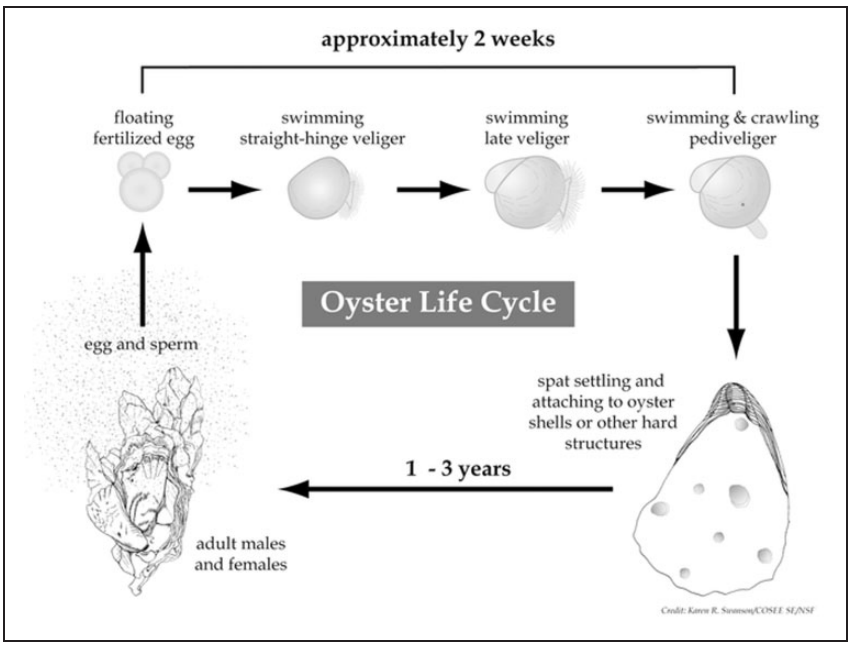

Figure 1. Oyster life cycle diagram. Source: Retrieved from http://score.dnr.sc.gov/deep.php?subject=2&topic=15. Copyright Karen R. Swanson/COSEE/NSF.

District, 2009). Reefs form as oysters attach and layer upon each other over time, in a cycle that continues as oysters mature and release more eggs of their own. Upon death, their shells remain on reefs acting as a point for the cycle to continue. Over time, in the course of their individual and collective lives and beyond into death, reefs grow in an ever-expanding self-agglomeration, growing up and out, older oysters inside and younger on the exterior, forming immense reefs.

This process of living and dying—creating reefs—as we will see was articulated post-Sandy as "living infrastructure," a natural, rather than a modern, technical design, that would grow dynamically along with sea rise to absorb, not stop, flooding and storm surge. The legitimation of this unorthodox definition of infrastructure was in part a product of SCAPE's forwarding it in serious terms with the right people. In a significant post-Sandy turn, SCAPE participated in the City's first large-scale response to the storm, the Special Initiative for Rebuilding and Resiliency commission on improving the resilience of city infrastructure to climate change, convened by then-mayor Michael Bloomberg (City of New York, 2016). The commission, an interdisciplinary team of planners, biologists, ecologists, CEOs, engineers, and politicians, modeled coastal protection strategies for sea level rise and storm scenarios (City of New York, 2016). SCAPE architects contributed a vision of soft coastal infrastructures, via "integrating natural systems as risk-reduction infrastructure" (SCAPE, 2016: n.p.), and helped draft a report, "PlaNYC: A Stronger, More Resilient New York," in which an image of the new New York was depicted. The report portrayed a city composed of interlocking infrastructural systems—"technical infrastructure," "green infrastructure," and "social infrastructure"—inundated by risk: hurricanes, rising seas, technical failures. Alongside standard proposals for how to govern these systems, wave-absorbing oyster reefs were included, situated seamlessly along smart grids, generators, and disaster response social media networks. Thus, in the City's first, most

comprehensive post-storm plan, oysters and nature were narrated as one risk reduction system alongside others, together composing a self-healing, resilient city.

RBD and storying oysters as infrastructure

Against this backdrop, in 2013 the Rockefeller Foundation, Hurricane Sandy Rebuilding Task Force, and HUD launched RBD, a competition seeking innovative resiliency designs for Sandy-affected regions (Jacobs, 2017). SCAPE submitted an oyster-themed proposal titled Living Breakwaters (LB), further pushing oysters into the post-storm crisis management context and refining the imaginary of nature as infrastructure. For their proposal, SCAPE put together a team of eight consultants, bringing many of the city's well-known figures working on oysters together into a coalition. Throughout the competition, the SCAPE team proposed something different from their 2010 oyster-tecture design—a more sober, serious reconceptualization of oysters as "living infrastructure." Among SCAPE's team were public proponents like Paul Greenberg (2012), a popular food journalist and early promoter of oysters as infrastructure, who published an editorial in the *New York Times* hours before Hurricane Sandy struck New York City in which he lamented,

> Down here at the end of Manhattan, on the border between evacuation zones B and C, I'm prepared, mostly. My bathtub is full of water, as is every container I own. My flashlights are battery-ed up, the pantry is crammed with canned goods and I even roasted a pork shoulder that I plan to gnaw on in the darkness if ConEd shuts down the power. But as I confidently tick off all the things that Governor Andrew M. Cuomo recommends for my defense as Hurricane Sandy bears down on me, I find I'm desperately missing one thing. I wish I had some oysters. (n.p.)

The team also included city oyster restoration organizations, including Harbor School and Billion Oyster Project (BOP), and other groups whose expertise was, as we will see, crucial to narrating the project.

Throughout the competition, the team wove together a series of narrative threads that told a new story of how oysters are, and have always been, infrastructure. Central to this story was the deployment of metaphors, vocabulary, and visual cues that redefined oysters in terms of their functions, reeducating New Yorkers on how they should be seen: "It's more like an engineering partner than something that will be on our dinner plate anytime soon," clarified Orff to *SI Live* (cited in Lavis, 2014). Imaginaries from the firm's MOMA exhibition were reprised but instead of "glamorous" (Orff, 2010: n.p) bivalves waiting to be eaten, as they were described previously, new terms like "living infrastructure," "physical-biological infrastructure," and "ecological infrastructure" were now used (Greenberg, 2014: 28; Orff, 2014; SCAPE, 2013b). These statements were confirmed visually by the team's project boards and cross-sectional diagrams, designed by Manhattan-based graphic design studio MTWTF, which transposed feedback loops onto the body of the oyster, so that the oyster's eating was reduced to a simple series of arrows and lines to describe the process of how oysters filter water as they feed (SCAPE, 2013b). In sum, the process involves the upper valve rising, as ciliated gills pump water in and water passes through gills; then microalgae and phytoplankton are separated and retained; in turn clean water is then released back into the water. In the images promoting LB, reefs were visualized as systems interconnected with their surrounds—ocean currents, waves, energies, fish—whose force they were shown to accept and modulate (Figure 2).

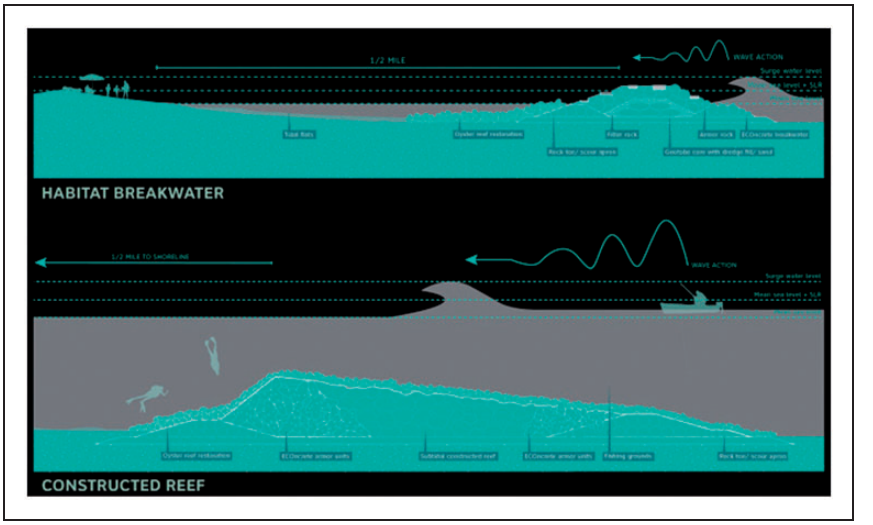

Figure 2. Rebuild by Design early proposal boards proposing oysters as wave-attenuating infrastructure. Source: Copyright: 2013 SCAPE/RBD.

In one of the team's key storylines, oysters' new infrastructural "nature" was naturalized and projected into the past, as something that "moderns" destroyed: "two centuries ago, reefs composed of 3 trillion oysters were a 'natural seawall' that created shallower bays and served as a first line of defense for Manhattan against storms as fierce or fiercer than 2012's Hurricane Sandy," asserted Greenberg (cited in Kane, 2014: n.p.). "We know," SCAPE's (2013c) report to RBD confirmed, "that in addition to being beloved fishing and recreational grounds, bay landscapes are crucial absorptive EI that help reduce risk for communities located along the water's edge" (15). Such statements of fact were followed by the repetition of those facts in other venues: "oysters," business magazine *Fast Company* explained in a 2013 article, "were once one of Manhattan's defenses against coastal erosion and storms sweeping up the Long Island Sound" (Coren, 2013: n.p.). Pundits portrayed oysters as "more intriguing" than modern infrastructures and labeled them the city's "natural allies for the next Sandy" (Fountain, 2013: n.p.). Each of these statements worked to naturalize the claim that oysters are infrastructure by asserting that oysters have *always* been infrastructure.

This narrative was extended further when the team's initial proposal—submitted alongside 148 other flood prevention concepts—was selected by the RBD jury as 1 of 10 finalists. SCAPE was directed to zero in on Staten Island's Sandy-impacted south shore. In this proposal, SCAPE narrated their assigned location like they had previously narrated oysters, now using bivalves to story Staten Island's shores as the site for the experiment, in hopes of persuading locals as well as RBD jury members to support it. Over old-timey paintings of oyster tongers and vintage postcards of beach-goers in seemingly simpler times (Figure 3), SCAPE's (SCAPE/RBD, 2014b) proposal video reminded viewers of the region's oyster past—"Tottenville... was once known as 'the town the oyster built!'" Viewers were also reminded of Staten Island's "deep cultural connection to the water" (SCAPE, 2013b: 3–4). Bringing together statements and images like this, SCAPE's materials painted a picture of better, simpler times based on a lost environmental connection.

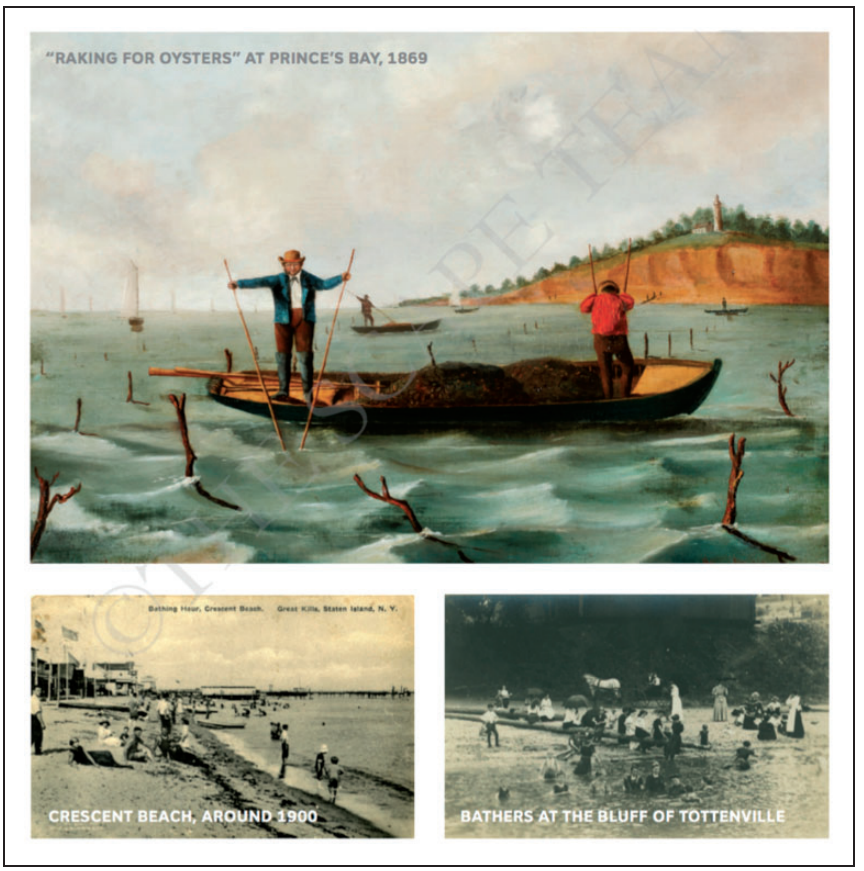

Figure 3. 'Ye Olde Bay Back in the Day': retro images of Staten Island used in SCAPE's RBD proposal. Source: From SCAPE (2013c: 4). Copyright SCAPE/RBD.

In narrating both site and project, SCAPE's materials played on nostalgia and hopes of reconnecting to nature, while simultaneously conjuring the same nature as a threat. "Wave... energy is deadly," Orff (cited in Lavis, 2014: n.p.) explained with a phrase repeated often in project materials. Instead of a remediated, albeit watery, world (as in 2010's MOMA exhibition), the LB proposal deployed presentations, booklets, and videos that, according to SCAPE (2013c), "aim[ed] to make risk legible and part of everyday life" (14). In them, the bay was reconceptualized as a threat facing the city, depicted in dark red waves moving toward the island. In a TED talk, Orff (2014a) showed a map of NYC featuring an array of arrows all listing "THREATS," describing a relationship that is "changing fast." Wave energy was conveyed in metrics of kinetic force, showcasing the intensity being discussed. "You are here," a second chart shows 2014 at the cusp of rapidly rising levels of storm intensity, urban population, temperature, and seas (Orff, 2014; SCAPE, 2013c: 14–15). Warning that "New York City faces a high degree of potential risk" (SCAPE, 2013c: 8), the report emphasized the additional concentration of risk on Staten Island, and reminded readers of Sandy's devastation there.

Proving that nature "works"

The SCAPE team's RBD entry process involved meeting with area residents, council members, and schools to generate support (L Elachi, personal communication, 23 October, 2015). A series of outreach programs translated oysters as infrastructure into different terms, showing those seeking solutions, especially residents living near the project's proposed site, that oyster-tecture was their appropriate response. Known as the "wetland bowl," south Staten Island had the largest number of Sandy-related deaths citywide (City of New York, 2013). Residents there continue to search for their own answers as to how to move forward, not all of which will be found by getting back in touch with nature. Much of Staten Island's southern population is indifferent to the water (Sam Janis, personal communication, 17 April 2015). Other residents meanwhile never lost their relation to the water—many Staten Islanders still harvest clams, run kayak clubs, and even grow oysters. The storm ruined many lives, and when the NYSGOSR launched their program to buy out residents living along the coasts—land they are now told never should have been inhabited—many accepted the offer, while other neighborhoods actually launched campaigns asking to be bought out together (Rush, 2015). For others who continue to live on the south shore, many feel anger due to lack of governmental response.

For many such residents and for investors, the question repeatedly asked was: "but how do we know if these systems work and how do they perform?" (Orff, 2014: n.p.). As Orff recounts, ever since an architecture critic had called SCAPE's 2010 Rising Currents proposal "utopian," her ambition had been to make people take the project seriously, so that it could be taken to the next level (out of museums and into the water) (personal communication, 29 May 2015). In this vein, responding to the question of what part of the project she would change, Orff noted, "incorporating data to describe the reef as essential to New York's new infrastructure would help fund the project and move it forward" (cited in Bergdoll, 2011: 98). It is one thing to *call* oyster reefs infrastructure, but it is another thing to prove that they "are" infrastructure. Infrastructure, after all, is supposed to work. Despite claims that oysters have always worked as infrastructure, as SCAPE team member Pippa Brashear explained,

> The science, modeling, and information needed to fully understand how they work and provide risk reduction benefits isn't there yet. That's the big hurdle: understanding that. From an infrastructure point of view this is what's critical. We had to prove it was infrastructure! (personal communication, 5 January 2015)

To move beyond the realm of representation and design, "it was imperative that the team tested [breakwater] performance using the latest scientific tools" (SCAPE, 2013c: 26). In collaboration with oceanographer Philip Orton at the Stevens Institute of Technology at the College of Staten Island, SCAPE's hypothetical models were tested using the ADCIRC/SWAN computerized storm surge and wave modeling system, to see what kind of wave height reduction and other risk management the reefs might achieve (Brashear, personal communication, 5 January 2015; SCAPE, 2013b, 2013c). In a summary of their findings in the LB promotional video available on RBD's website (SCAPE/RBD, 2014a), viewers are shown two charts, the first titled "Wave Height during Sandy - No Intervention" with waves cresting up to 6.2′, represented in bright yellow and red; next to a second chart, "Wave Height during Sandy - With Intervention" still red but projecting wave height decreasing to between 2′ and 4.7′, as Orton narrates, describing the objectivity of computer models (SCAPE/RBD, 2014b).

To communicate the value of said risk reduction, SCAPE collaborated with critical infrastructure consulting firm Parsons Brinckerhoff (PB) onto their team to analyze cost benefits, work on new ways of thinking about ecosystem services, and test and measure the potential effectiveness of reefs as EI in order to present them to regulators (P Brashear, personal communication, 5 January 2015). The firm's calculations, based on a 100-year storm event, which they advertised in proposal booklets and to stakeholders at project meetings, yielded a final monetized estimate of risk reduction benefits for the Tottenville Phase 1 Pilot at "$263 million in damages avoided, 52 acres of habitat created, 32+ species supported by the breakwaters, $15 million of potential economic generation annually, 550 students engaged directly annually, and 23,500 students engaged island-wide annually" (SCAPE, 2013c: 33, 100–101). Beyond convincing potential stakeholders, generated in these efforts to prove oysters "work" was a story in which measure provided a further layer of legitimacy to the idea of nature as infrastructure. This translation of oysters as living beings into inches of storm surge attenuated or not, buildings and property protected or not, gallons of water filtered was essential to proving that, in doing "its nature thing," so to speak, nature would function infrastructurally.

Ordering: Making life do "the stuff that living does"

Harnessing nature's "liveliness"

By taking into account loss and longing, fear and crisis, the critique of modern infrastructure and governance and attendant search for new forms of urban government overcoming nature/city binaries as well as investment opportunities, SCAPE narratively reiterated the broad resiliency infrastructure consensus that became dominant after Sandy, while translating their project into these terms, posing oysters as the perfect, inevitable solution for many otherwise different constituencies. Potentially conflicting threads such as reconnecting humans and nature and risk management were brought together and made sensible through the oyster, a "configuring device" and "cohering force" able to configure multiple needs into an implementable project (McGuirk et al., 2016: 11). These narrative strategies were successful, leading to a new notion of infrastructure that began to make sense. In 2013, SCAPE was awarded $60 million in Community Development Block Grant Disaster Recovery funding via the RBD competition (NYSGOSR, 2019). No longer a utopian vision in an art museum, LB is now being administered by New York State's Governor's Office of Storm Recovery and scheduled to be completed in late 2020 (NYSGOSR, 2019).

As discussed, the idea animating this project is that, in living their lives, oysters *are* infrastructure. As SCAPE architect Lauren Elachi explained,

> Ecological infrastructure is essentially just being able to recognize [that natural processes have a lot of functions] and use that for essentially twenty-first century purposes. It could be anything from oyster reefs to marshes. . . the stuff that the living does. (personal communication, 23 October 2015)

Moving beyond narration to actual construction however, the project encounters the fact that, despite all the work to *say* oysters have always been infrastructure, in reality, they have not. That is, oysters have not been infrastructures as they are now envisioned and being built. Oysters have existed on earth for 50 million years, since the Carboniferous period of the late Paleozoic Era (Kurlansky, 2007; Mann, 2013: 323; U.S. Geological Survey, 2015). Far older than humans, oysters survived the extinction event that wiped out the dinosaurs

(Parkinson, 2010: 53). During the early Holocene, oysters began to grow in waters around what is now New York. In the 1600s, wild reefs stretched through the Raritan Bay and its tributaries, the East River, and up the Hudson River as far north as Ossining, NY (MacKenzie, 1984: 38, 1992: 8). In the 18th and 19th centuries, rapid harvesting by European colonists for the sale of oysters left those reefs barren. During the Gilded Age, New York was the center of a global oyster industry, predicated on planting and harvesting oysters in a mass production process that had no regard for oysters' lifeworld, or the cycle needed for it to grow, and eventually led to the abandonment of the process altogether (Kurlansky, 2007; MacKenzie, 1984).

In contrast, NYS and SCAPE designers are actually trying to create oyster life cycles, seeing in them an astounding productivity and emergent potential to be deployed as the very basis of their redefinition of infrastructure. SCAPE team member Greenberg (2014) has conveyed his amazement at oyster fecundity numerically, typing out the estimated annual spawn of oyster larvae of the three trillion oysters thought to exist in colonial New York—"300,000,000,000,000,000,000 (three hundred quintillion)" (28). "Layer by layer," marvels Greenberg (2014), "the reef builds vertically, each new oyster generation building on the last... no other bivalve builds in 3 dimensions with such architectural zeal" (28). Orff (2010) echoes the amazement, stating "albeit a very small creature and very modest, this creature is incredible, because it can agglomerate into these mega-reef structures. It can grow; you can grow it..." (n.p.). Whereas traditional breakwaters will grow deeper and be less effective as seas rise, according to designers "this incredibly exciting animal can attenuate and agglomerate onto each other and form these amazing natural reef structures. They really become nature's wave attenuators" (Orff, 2010: n.p.). This, Orff (2011) says, is the design's "core concept": "'growing' climate-change infrastructure biologically now rather than relying on capital-intensive big construction projects in the distant future" (98).

In many ways this view of nature and the storylines crafted in the previous section bear resemblance to the "vital materialism" that has grown popular recently in geography (Braun, 2008). Seen as a corrective to anthropocentric modern thinking—the hubristic ethos embodied in modern infrastructure discussed in the previous section—these literatures reeducate readers to understand that far from an inert object, the nonhuman world is lively and *does things*. Donna Haraway (1988), for example, advocates acknowledging objects as active entities as part of overturning capitalist patriarchy and its view of nonhumans as resources. More recently Jane Bennett (2007) has sought to disrupt the modernist partitioning of the world into inert nonhuman matter and lively humans by lavishing attention on the "thing-powers" of nonhumans like worms or trash, which she argues constitute vibrant political actors in their own right, part of human collective publics akin to what Bruno Latour (1993) calls a "parliament of things." Likewise Anna Tsing (2016) argues that modern Enlightenment views of nature as a passive backdrop have blocked attention to lessons from entangled, lively natures, such as the matsutake mushroom whose "riotous colors and smells" (1) thrive in disturbed landscapes. In a similar vein, a plethora of recent works celebrate nature and nonhumans as inventive, emergent, and replete with life, construing animals, computer systems, or viruses as surprising, funny, or amazing (Braun and Whatmore, 2010; Callon, 1986; Heynen et al., 1996; Mitchell, 2002; Whatmore, 2002).

The SCAPE team and NYS, however, are not just interested in marveling at the "fecundity of bivalvency" (Kurlansky, 2007: 46)—they want to "harness" it (Orff, 2010: n.p.). Here the project of making oysters into infrastructure puts us in the realm of the neoliberalization of nature, ecosystems services, and biomimicry. Efforts to capitalize on nature and to extract its "services" have proliferated in recent decades (Bakker, 2010; Castree, 2008a, 2008b; Heynen et al., 2007; Heynen and Robbins, 2005; Katz, 1998;

Mansfield, 2008; Robertson, 2004, 2006). Many contemporary views on oysters fall under this rubric, specifically in that oysters are seen as providing ecosystems services like water filtration (Beck et al., 2011; Jones et al., 1994). Yet, while NYS does aim to harness "services" provided by oysters' life processes, it does so in a way that is different from the aforementioned examples. Oyster infrastructure is not primarily about profiting from nature's services or harnessing "natural capital" (Costanza et al., 1997). It is, rather, aimed toward making nature do its nature thing, as it were, in order to govern other natural processes, namely wave impact, so as to secure human life on land. As such the project is an experiment in a new kind of oyster "farming," in which what the city will harvest from reefs is no longer oysters, but capacities, that is the lives of oysters themselves. Unlike biomimicry efforts to replicate living processes, for example in military technologies (Johnson, 2015), NYS's oyster infrastructure endeavor does not seek to mimic life processes, but rather to produce and enhance actual oysters' life cycles, including into and beyond their deaths.

To do so, NYS must make oysters live. But making nature "do the stuff that it does," to paraphrase Elachi, making it *perform* in the way imagined, actually requires work by both nature and human experts. Required is what McGuirk et al. (2016) call "ordering." In contrast to narration, which works at a visual, emotional, and discursive level, ordering refers to the securing of desired socio-material arrangements, roles, and performances through which governmental aims can be achieved. This ordering is something that authors in the vital natures literature have not addressed enough. Implementing the idea of "nature as infrastructure," the following sections show, involves a kind of biopolitics (Foucault, 2008), in which it is humans trying to make nature live in a particular way—not according to a social norm, but in the way they imagine is *natural* to the oyster.

Anthropocene contexts and legacies

Here the story of configuring nature as infrastructure moves beyond the initial framework for configuration provided by McGuirk et al. (2016) in two ways. First, although the authors emphasize the importance of nonhuman things in governmental assemblages, their analysis focuses solely on sociotechnical systems and the work by humans to imagine, represent, or manipulate other humans or other things. Nature as infrastructure, however, as a risk management technique, requires making nature work too. This is not work in the traditional sense of the word but instead that of life doing "the stuff that it does." Oysters must be made to live, and moreover within desired parameters. Second, as McGuirk, Bulkeley, and Dowling note, ordering includes the need to hold projects together across situational frictions that arise, which they depict in terms of human issues (personnel conflicts, for example). But to make nature infrastructure, the urban landscapes and legacies of the Anthropocene are as important as the life of oysters themselves. Making oysters be infrastructure therefore entails what Jamie Lorimer (2015) calls a "wild experiment," which occurs in the "inhabited and thus political landscapes and ecologies of the Anthropocene" (Lorimer and Driessen, 2016: 48–49).

In this regard, the context of Raritan Bay presents challenges to making oysters infrastructure, not least of which is getting permission to put oysters in the water. According to Elachi (personal communication, 23 October 2015), this was one of the biggest challenges the firm faced, as New York's waters are strictly regulated. Since the 1940s, industrialization of the NY metropolitan region transformed Raritan Bay—which receives every major waterway connected to the NYC metropolitan area, and significant portions of its waste—into an open dump for trash, sewage, and chemical runoff (Greenberg, 2014: 35–37). The Clean Water Act was passed in 1977 in response, making dumping raw sewage illegal, but also making putting

anything in the water difficult. NYC's waters are under jurisdiction of the Department of Environmental Conservation (DEC), which prohibits filling in the water and decides if something can be put in the water and what controls doing so requires (L Elachi, personal communication, 23 October 2015).

The Raritan Bay is directly in the path of a main channel used to enter NY Harbor and New Jersey's petrochemical, and so is regularly dredged at ever-deepening depths to make room for container ships and oil tankers. Vessels heading for New Jersey's "chemical coast" or the New York Port cross the estuary via Ambrose and Sandy Hook Channel. According to Orff (personal communication, 29 May 2015), the Army Corps of Engineers (ACE) flagged this shipping channel as a key issue, out of concern for disrupting transportation to the oil plants on the other side in New Jersey. Designers have since received certification that the project will have no effect on ACE infrastructures, and an ACE permit to work in the area (K Orff, personal communication, 29 May 2015), which ACE now designates as suitable for oyster restoration (NYSGOSR, 2015).

Along with legal permissions, SCAPE architects and PB representatives emphasize that securing oysters is one of the project's biggest challenges. Oyster restoration was outlawed in New Jersey in 2010 (NY/NJ Baykeeper, 2016). The only place oysters are allowed to grow in NJ is on a Navy pier, where a small monitoring site is allowed due to the area's being already subject to 24 hour Department of Homeland Security surveillance (Parry, 2011: n.p.). Oysters found in NYC waters are classified by State law as a "beneficial nuisance" and, to prevent health crises or market disruption, harvesting or selling them outlawed (Elachi, personal communication, 23 October 2015; A Fitzgerald, personal communication, 13 November 2014). According to Elachi (personal communication, 23 October 2015) during their proposal stage, SCAPE's large-scale vision of oyster beds surrounding south Staten Island raised alarms with the City and DEC. To this end, the team worked extensively with the DEC to formulate a program for securing and keeping people away from oysters that would be acceptable to the regulators at DEC (L Elachi, personal communication, 23 October 2015), consisting of:

> Patrolling and monitoring, having eyes there, video surveillance that would limit manpower, someone watching cameras to make sure no one's going out there, or Physical interventions that make it harder for someone to get at the oysters, like cages or substrate being very large blocks under water, impossible for someone to go move a giant block underground... (Brashear, personal communication, 5 January 2015)

Making oysters live

But these legal and regulatory challenges are minor compared to the larger challenge of growing an actual reef. Oysters are functionally extinct throughout much of their original habitat (Beck et al., 2011: 107). The conditions in which they thrived historically—rocky substrate, non-toxic waters, wide shallow bathymetric shelves—are gone (Coen and Luckenbach, 2000; NY-NJ Harbor Estuary Program et al., 2009: 10–13). In their place is an ocean floor covered in toxic black goo, PCB, heavy metal, and algae bloom-laden water, replenished with 1.1 billion gallons of wastewater poured into the harbor daily (Ss Janis, personal communication, 17 April 2015; Gibbons and Yuhas, 2005; NYCDEP, 2004; NY-NJ Harbor Estuary Program et al., 2009: 8–34; Waldman, 1999: 56–57).

These challenges SCAPE and NYS face are familiar to the groups and individuals doing oyster restoration across the city. In these efforts—by high school science teachers,

conservationists, and residents—reefs are built according to simple methods, like "oyster gardening." Oyster gardening entails hanging mesh bags filled with larvae and shells into handmade cages from the edge of marina piers (New York Harbor School and New York Harbor Foundation, 2014). Other larger scale methods spread oyster spat by hand over a layer of rocks and shell (Grizzle et al., 2013: 3–5). Resulting oysters are often not the reefs imagined by conservationists; instead some are found attached to bridge bottoms, on shoes or bottles. And while some reefs have been successful, many have not (Grizzle et al., 2013; see also NY-NJ Harbor Estuary Program et al., 2009: 54).

While such oyster restoration projects take place in low wave climates, where water movement is minimal and reefs stand a chance of taking hold, NYS's project pushes the challenge further. In contrast to traditional restoration, LB is the first experiment utilizing reefs for their "protective function" rather than restoration, and are therefore designed along a different biopolitical and infrastructural criteria: they need to function, be sturdy, efficient, and able to confront "aggressive" waves. The construction site is thus situated further off coast, directly amidst of dangerous high wave climates. The depths of the Raritan targeted for reef construction are especially unfavorable for oyster development, as shells or spat can blow away with currents and waves before even starting a reef (Grizzle et al., 2013). As BOP's Restoration Program Director stated, there is a possibility that NYS will end up with a bunch of old shells washing up on shore (S Janis, personal communication, 21 February 2016). Furthermore, as there are no existing oyster reefs in the Raritan Bay, and despite the "fecundity of bivalency" heralded by the project's materials and supporters, starting now from oysters alone, it would take a long time for reefs sizable enough to "function" to form (Mann, 2013: 323). This is no small consideration, as reefs are intended to address risks now. Not only then is oyster life itself to be enhanced, but so too will its timescale need to be sped up.

Securing oyster life

Titled the "Tottenville Reach," the reefs that NYS is building are a pilot site, seen by designers as a large-scale experiment providing both opportunity for firms to engage in live trials of their designs, and to see whether or not oyster infrastructure (SCAPE, 2013a). RBD funding covers only this first test phase, which consists of an approximately 2.46 mile section of reefs around the southernmost part of Staten Island's Tottenville neighborhood (SCAPE, 2013c: 10).

The project is centered on new materials developed specifically for the demands of the high wave-action context. Here the SCAPE team worked with Tel Aviv-based coastal engineering firm SeArc. The firm designed "Ecological Armoring Units"—one meter by one-meter, multi-ton "modular building blocks of marine infrastructure, which provide coastal defense against hydrodynamic forces" (ECOncrete, n.d. a). Unlike traditional breakwaters—flat stone walls above water, where they knock down waves, or under water, where they bring down wave height—SeArc's units are designed as a support base for oyster life, and mimic the makeup of wild reefs in terms of composition, texture, and three-dimensional design, to "target and match biological needs" by "provid[ing desired biological parameters" (ECOncrete, n.d. b). Most coastal infrastructures are built using Portland cement, which, due to its high surface alkalinity is not favorable to ocean life (Perkol-Finkel and Sella, 2014: 1). In contrast, SeArc's armoring units are made of the company's ecologically engineering concrete product, ECOncrete ®, composed with recycled glass and engineered with reduced alkalinity to mimic chemical signals of old oyster shells. The hope is to maximize biogenic buildup of calcium carbonate from attached shells and

other sea life (Perkol-Finkel and Sella, 2014). In project designs, armoring units will be placed amidst piles of rocks at different intervals along the 2 mile span, some fully submerged, others rising above current sea level, where they will form reef building blocks. Armoring units will hold mesh boxes of oyster shells, be seeded with larvae from spat sanctuaries, or equipped with a rod onto which SeArc's donut-shaped spat-seeded ECOncrete discs will be loaded and locked in place (SCAPE, 2013c: 60–61).

According to firm director Shimrit Perkol-Finkel (personal communication, 16 April 2015), biogenic buildup is designed additionally as a form of "bioprotection," which aims to increase the size, weight, and stability of the structure—armoring unit and oyster shells—in "aggressive marine environments" where they are being built (Perkol-Finkel and Sella, 2014: 2–3). According to SeArc, biogenic buildup acts like "biological glue," strengthening connections between units, making them more stable and decreasing vulnerability to breakage (Perkol-Finkel and Sella, 2014: 2–3). And as SCAPE architects observe, armoring units' size will help secure reefs against theft (it is hard to steal massive concrete blocks underwater 200 meters off shore) (L Elachi, personal communication, 23 October 2015).

According to the project team, securing reefs is paramount (L Elachi, personal communication, 23 October 2015). While details of how reefs will be secured are still being worked out, noteworthy is how methods under discussion overlap with other aspects of the design. Alongside ECOncrete armoring units that blend biogenic recruitment with security (doubling the meaning of "bioprotection"), 24/7 video surveillance will be integrated as part of a Verizon Innovation Center and Powerful Answers Campaign-funded "Oyster Reef and Science Platform" (BOP, 2013). The platform, designed for the Harbor School and in testing stages there since 2014, will be attached to a 1200 pounds submerged cement block, and equipped with a water quality sensor, current profiler measuring water velocity and direction, and a live streaming HD video camera with pan/tilt/zoom and full spectrum lighting controls (BOP, 2013: n.p.; S Janis, personal communication, 17 April 2015). Attached to land by underwater fiber optic cables, Verizon's 4GLTE wireless network will transmit reef live-feed to lab computers onshore and public online interface (BOP, 2013). According to the Harbor School, "the platform will also include an interactive website that explains the components, visualizes the data and allows users to drive the camera, create experiments, and analyze results" (BOP, 2013: n.p.). Lastly, as additional security, reef armoring units may also be bolted and chained to the ocean floor (L Elachi, personal communication, 23 October 2015).

Conclusion

In the search for new modes of governing climate change and natural disasters in cities, infrastructure is being redefined. Unlike the past—when nature was seen as a resource or dump, and infrastructure defined in terms of brick-and-mortar technical projects evidencing humanity's power to tame nature—today designers define nature as infrastructure, seeing its biological processes as a valuable risk management solution. In valuing nature's emergent capacities this way—a view that mirrors depictions by critical theorists interested in "vital materialisms"—designers and city government seek to make nature "be nature." In this article I have explored the forms of narration and ordering required for oysters to be infrastructure, including discourse, visual representation, regulatory challenges, construction, and engineering. Ultimately what my analysis suggests is that making nature "be" infrastructure is a kind of biopolitics, both in the traditional sense of making certain forms of human life live (Foucault, 2007), but also in which the goal is to make nature live in a particular way, albeit one imagined as natural to the oyster. While critical literature on

ecosystem services and nature as infrastructure traces mechanisms through which nature is commodified, financialized, and made a "service provider" (Sullivan, 2013), the biopolitical nature of this project has not been explored enough.

Making nature infrastructure, my analysis here suggests, is biopolitical in a double sense. On one hand, rather than an apolitical solution to modern human/nature binaries, we saw that this new idea of infrastructure arose in the context of the recent Anthropocene problematization of modern infrastructure and search for new infrastructures to govern climate change and other crises. In its new role as a critical infrastructure, nature is being enrolled to support and secure the conditions for human life, to make it live. This, many scholars have shown, is the biopolitical role of critical infrastructures in liberal capitalist societies: to reproduce liberal life and undergird, as Braun (2014) puts it, the "vitality" and "productive powers of populations" (58; Dillon and Reid, 2009; Wakefield, 2018). Nature as infrastructure extends this role to nature. As past "modern" biopolitical techniques have come under criticism as the source of contemporary crises like climate change (Dalby, 2013), nature as infrastructure, like other eco-techno innovations, is forwarded as a new approach appropriate to the Anthropocene "new normal." But as is visible in the LB project's efforts to avoid disrupting existing industrial infrastructures, although heralded as a "state of the art technique" and "innovation" (NYS, 2015), the project does not replace past approaches or change existing socio-economic conditions. Instead it protects and maintains them by anticipating and managing environmental crises (Anderson, 2010; Swyngedouw, 2010) in new ecological ways. Viewed in this context, nature as infrastructure must be understood as a mode of biopolitical governance for new Anthropocene risks (Dalby, 2013; Oels, 2013), part of a more widespread reconfiguration of governmental technologies (Aradau and van Munster, 2007; Collier, 2009) to maintain business-as-usual via seemingly radical technological innovation (Ernstson and Swyngedouw, 2019: 6).

On the other hand, however, making nature infrastructure is a biopolitical project of making *nature* live, in a way imagined as natural to nature. Along with using nature-based infrastructure to secure vital productive powers of human life, now seen as required for governance of liberal capitalist cities in the Anthropocene is securing the vitality and life of nature as well. My analysis has shown that this is less a matter of commodification—although this might come later, once reefs are built and memorabilia or investment opportunities created—or the enrollment of an *existing* vitality, as vital natures theorists and governmental discourse both imagine. Instead—somewhat counterintuitively, since the idea is to let nature be nature—it requires both actively reimagining and constructing the life of oysters in specific terms amenable to government. This biopolitical reimagining of oysters, we saw, involved casting bivalve life processes in terms once reserved for technical infrastructure—measurable in terms of risk reduction, functions to govern environmental processes perceived as "aggressive" and "hostile"—while also playing on hopes and fears around urban nature. Examining the diverse narratives involved in this reimagining—expert metrics, government reports, graphic design, TED talks—shows how the new infrastructural imaginary of oysters is not a coherent or ahistorical unitary, as proponents suggest, but was created through the active drawing together of diverse and often seemingly contradictory visions: cuteness and toxicity, longing and fear, emergence and functionality.

Constructing oysters as infrastructure, we further saw, requires efforts to make "nature do what it does." Here I offered a riposte to vital natures literature which celebrates nature's liveliness, showing that in reality making this liveliness appear requires a governmental project of ordering. For all the modeling, we saw that the "function" of reefs is dependent on oysters living their lives, over time amidst complex Anthropocene landscapes and legacies and beyond into their deaths. But making nature infrastructure also requires securing a

specific version of life's living. From actually securing oyster reefs with video surveillance and chains (against theft and eating) and bringing back certain species (not other undesired ones), to making sure that life functions as modeled (actually creates reefs, breaks waves) and preventing it from going in unpredictable directions (oysters growing outside designated sites), securing an infrastructural telos for oyster life takes extensive work. While the work I have focused on is mainly that of policymakers and experts (ecologists, designers, modelers), as the project proceeds it will surely require laborers as well, to operate machinery, transport shells, and install monitoring equipment.

What my analysis of this biopolitical work suggests is that nature as infrastructure constitutes neither yet another Promethean mode of governance, as Frédéric Neyrat (2019) criticizes resilience, nor a promise of returning to stable Holocene natures, as do urban sustainability experiments (Edwards and Bulkeley, 2018). Instead, produced in this double biopolitics of configuring oysters as infrastructure is something more dystopian: a view of the city as perpetually vulnerable to threatening environmental surrounds, from which oysters and humans alike require militarized defenses: critical EIs to secure humans, ecological armoring units, and 24/7 surveillance to secure oysters. In their role as critical infrastructure, demanded of oysters is that they live the same life of unending crisis and productivity, surveillance and security, that defines neoliberal human life (Evans and Reid, 2014), albeit under water.

However, like other failed infrastructure projects, such as Paris's never-built automated train system (Latour, 1993), oysters simply might not function in their new governmental role. "If you build the Hoover Dam," said SCAPE's Orff, "you know if it will be there or not" (personal communication, 29 May 2015). The same cannot be said of nature, no matter how much it is called infrastructure. Oysters, after all, attach to and take on the shape of diverse surfaces (bottles, crab claws, boots…) (Brooks, 1996: 21). Just as introduction of wolves into Yellowstone Park created unexpected effects, so too might oyster experimentation in New York waters produce some unanticipated "future-natural state" (Lorimer, 2015: 48–49). Indeed as Orff imagines it in 2100, Staten Island may just be "dystopian … walls, towers, jellyfish" (personal communication, 29 May 2015).

This brings us to a different interpretation of vital natures theorists' point that nonhumans are active, autonomous agents, not raw material for human needs. Their agency includes refusing to work or be enrolled in governance, by living in ways that resist functioning as infrastructure. But acknowledging the autonomy of nonhumans also means recognizing the equal likely possibility of their *not* being lively, by not living at all. If oysters do not function, it might not be only because their "vitality" has no regard for governmental purposes, but because it is impossible to make this vitality appear in the first place. "What we're looking for," Orff explained, "is a spark, a critical mass enough to jumpstart life again in a place that is practically speaking dead" (personal communication, 29 May 2015). According to one design team member, the whole project might be a $60 million dollar failed experiment (S Janis, personal communication, 17 April 2015). Initially reefs will have to be replenished with a new round of 500,000 spat each year, at a cost of $30 million per year in oysters alone (S Janis, personal communication, 17 April 2015). And increasing ocean acidification may make reef-building impossible altogether. In response to this urgency, NYS's pilot site is on a fast track. The State hopes oysters will grow together, rising "elegantly" with the seas, but there is an equal chance that all the security cameras will capture is a bunch of shells washing up on the beach. No amount of ordering can force life to be lively. This is perhaps especially true in the Anthropocene, where governance takes on an additional dystopian dimension in that the natural vitality on which securing cities now

relies may be undermined by the effects of the very industrial, capitalist relations such governance techniques seek to secure.

Highlights

- Analyzes the concrete work required to create both the idea and materiality of nature as infrastructure.
- Argues that vital materialisms do not acknowledge the biopolitics required to make nature be "lively."
- Concludes that making nature into infrastructure is a biopolitical matter of making nature live in ways imagined to be natural.

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References

Adams RE (2014) Natura urbans, natura urbanata: Ecological urbanism, circulation, and the immunization of nature. *Environment and Planning D: Society and Space* 32: 12–29.

Anderson B (2010) Preemption, precaution, preparedness: Anticipatory action and future geographies. *Progress in Human Geography* 34(6): 777–798.

Aradau C and Van Munster R (2007) Governing terrorism through risk: Taking precautions, (un) knowing the future. *European Journal of International Relations* 13(1): 89–115.

Aradau C and van Munster R (2011) *Politics of Catastrophe: Genealogies of the Unknown*. Abingdon: Routledge.

Bakker K (2010) The limits of 'neoliberal natures': Debating green neoliberalism. *Progress in Human Geography* 34(6): 715–735.

Beck MW, Brumbaugh RD, Airoldi L, et al. (2011) Oyster reefs at risk and recommendations for conservation, restoration, and management. *BioScience* 61(2): 107–116.

Bélanger P (2009) Landscape as infrastructure. *Landscape Journal* 28(1): 79–95.

Bélanger P (2013) Infrastructural ecologies: Fluid, biotic, contingent. In: Hung Y, Aquino G, Waldheim C, Czerniak J, Geuze A, Skjonsberg M, and Robinson A (eds) *Landscape Infrastructure. Case Studies by SWA*. Basel: Birkhäuser, pp.20–27.

Bennett J (2007) *Vibrant Matter: A Political Ecology of Things*. Durham, NC: Duke University Press.

Bergdoll B (2011) *Rising Currents: Projects for New York's Waterfront*. New York: Museum of Modern Art.

Billion Oyster Project (BOP) (2013) Underwater Science Platform coming to NY Harbor. Available at: https://billionoysterproject.org/underwater-science-platform-coming-to-ny-harbor/ (accessed 24 April 2019).

Bloomberg M (2012) Mayor Bloomberg delivers address on shaping New York City's future after Hurricane Sandy. Press conference transcript, 6 December. Available at: https://www1.nyc.gov/office-of-the-mayor/news/459-12/mayor-bloomberg-delivers-address-shaping-new-york-city-s-future-after-hurricane-sandy (accessed 23 April 2019).

Bohland B, Davoudi S and Lawrence J (eds) (2018) *The Resilience Machine*. New York: Routledge.

Braun B (2005) Environmental issues: Writing a more-than-human urban geography. *Progress in Human Geography* 29(5): 635–650.

Braun B (2008) Environmental issues: Inventive life. *Progress in Human Geography* 32(5): 667–679.

Braun B (2014) A new urban dispositif? Governing life in an age of climate change. *Environment and Planning D* 32(1): 49–64.

Braun B and Castree N (2001) *Social Nature: Theory, Practice and Politics*. London: Wiley-Blackwell.

Braun S and Whatmore S (2010) *Political Matter: Technoscience, Democracy and Public Life*. Minneapolis: University of Minnesota Press.

Brooks W (1996) *The Oyster*. Baltimore and London: John Hopkins University Press.

Buckminster Fuller Institute (2019) Living breakwaters. Available at: https://www.bfi.org/ideaindex/projects/2014/living-breakwaters (accessed 20 April 2019).

Callon M (1986) The sociology of an actor-network: The case of the electric vehicle. In: Callon M, Law J and Rip A (eds) *Mapping the Dynamics of Science and Technology*. London: Macmillan Press, pp.19–34.

Cardoso da Silva JM and Wheeler E (2017) Ecosystems as infrastructure. *Perspectives in Ecology and Conservation* 15: 32–35.

Carse A (2017) Keyword: Infrastructure: How a humble French engineering term shaped the modern world. In: P Harvey, CB Jensen and A Mori (eds) *Infrastructures and Social Complexity: A Companion*. Abingdon: Routledge, pp. 27–39.

Castree N (2008a) Neoliberalising nature: The logics of deregulation and reregulation. *Environment and Planning A* 40(1): 131–152.

Castree N (2008b) Neoliberalising nature: Processes, effects, and evaluations. *Environment and Planning A* 40(1): 153–173.

Chandler D (2014) *Resilience: The Governance of Complexity*. Abingdon: Routledge.

Chattopadhyay S (2012) *Unlearning the City: Infrastructure in a New Optical Field*. Minneapolis: University of Minnesota Press.

City of New York (2013) PlaNYC: A stronger, more resilient New York. Report prepared by the Special Initiative for Rebuilding and Resiliency. Available at: http://www.nyc.gov/html/sirr/html/report/report.shtml (accessed 24 April 2019).

City of New York (2016) About SIRR. Available at: http://www.nyc.gov/html/sirr/html/about/about.shtml (accessed 23 April 2019).

Coaffee J and Clarke J (2017) Critical infrastructure lifelines and the politics of anthropocentric resilience. *Resilience: International Policies, Practices and Discourses* 5(3): 161–181.

Coen L, Brumbaugh R, Bushek D, et al. (2007) As we see it: A broader view of ecosystem services related to oyster restoration. *Marine Ecology Progress* 341: 303–307.

Coen L, Dumbauld B and Judge M (2011) Expanding shellfish aquaculture: A review of the ecological services provided by and impacts of native and cultured bivalves in shellfish-dominated ecosystems. In: Shumway SE (ed) *Shellfish Aquaculture and the Environment*. London: Wiley-Blackwell, pp.239–296.

Coen LD and Luckenbach MW (2000) Developing success criteria and goals for evaluating oyster reef restoration: Ecological function or resource exploitation? *Ecological Engineering* 15(3–4): 323–343.

Collier S (2009) Topologies of power: Foucault's analysis of political government beyond 'governmentality'. *Theory, Culture & Society* 26(6): 78–108.

Collier S and Lakoff A (2008) The vulnerability of vital systems: How "critical infrastructure" became a security problem. In: M Dunn and K Kristensen (eds) *The Politics of Securing the Homeland: Critical Infrastructure, Risk and Securitisation*. London: Routledge, pp. 17–40.

Coren M (2013) Can the lowly oyster protect New York City from floods? *Fast Company*, 11 September. Available at: http://www.fastcoexist.com/3017128/can-the-lowly-oyster-protect-new-york-city-from-floods (accessed 23 April 2019).

Costanza R, d'Arge R, de Groot R, et al. (1997) The value of the world's ecosystem services and natural capital. *Nature* 387(6630): 253–260.

Cowen D (2014) *The deadly life of logistics: Mapping violence in global trade*. Minneapolis: University of Minnesota Press.

Daily GC (1997) *Nature's Services: Societal Dependence on Natural Ecosystems*. Washington, DC: Island Press.
Dalby S (2013) Biopolitics and climate security in the Anthropocene. *Geoforum* 49: 184–192.
de Block G (2016) Ecological infrastructure in a critical-historical perspective: From engineering 'social' territory to encoding 'natural' topography. *Environment and Planning A* 48(2): 367–390.
Dillon M and Reid J (2009) *The Liberal Way of War: Killing to Make Life Live*. London: Routledge.
Easterling K (2014) *Extrastatecraft: The Power of Infrastructure Space*. New York and London: Verso.
ECOncrete – Concrete Ecological Solutions (n.d. a) ECOncrete. Ecological Concrete Solutions. Brochure. SeArc.
ECOncrete – Concrete Ecological Solutions (n.d. b) Econcrete ecological armoring units. Available at: http://www.econcretetech.com/technology/technology (accessed 24 April 2019).
Edwards GAS and Bulkeley HA (2018) Heterotopia and the urban politics of climate change experimentation. *Environment and Planning D: Society and Space* 36(2): 350–369.
Ekers M and Prudham S (2015) Towards the socio-ecological fix. *Environment and Planning A: Economy and Space* 47(12): 2438–2445.
Ernstson H and Swyngedouw E (2019) Politicising the urban environment. In: Ernstson H and Swyngedouw E (eds) *Urban Political Ecology in the Anthropo-obscene*. Abingdon: Routledge, pp.1–21.
Evans B and Reid J (2014) *Resilient Life: The Art of Living Dangerously*. Cambridge: Polity.
Evans JP (2011) Resilience, ecology and adaptation in the experimental city. *Transactions of the Institute of British Geographers* 36: 223–237.
Feuer A (2012) Protecting the city, before next time. *New York Times*, 3 November. Available at: http://www.nytimes.com/2012/11/04/nyregion/protecting-new-york-city-before-next-time.html?pagewanted=all (accessed 23 April 2019).
Florida R and Johnson S (2012) Making our coastal cities more resilient can't wait. *The Atlantic City Lab*, 1 November. Available at: http://www.citylab.com/work/2012/11/making-our-cities-more-resilient-cant-wait/3758/ (accessed 24 April 2019).
Florida R and Zolli A (2012) The rush to resilience: We don't have decades before the next Sandy. *Atlantic City Lab*, 9 November. Available at: http://www.citylab.com/work/2012/11/building-resilient-cities-conversation-andrew-zolli-and-jonathan-rose/3839/ (accessed 23 April 2019).
Forman RTT and Godron M (1986) *Landscape Ecology*. New York: John Wiley and Sons, Inc.
Foucault M (1980) The confession of the flesh. In: C Gordon (ed) *Power/Knowledge: Selected Interviews and Other Writings*. New York: Pantheon Books, pp.194–228.
Foucault M (1998) Polemics, politics, problematizations. In: Rabinow P (ed) (1998) Essential Works of Foucault. Vol. 1. New York: The New Press, pp.381–390.
Foucault M (2007) *Security, Territory, Population*. New York: Palgrave Macmillan.
Foucault M (2008) *The Birth of Biopolitics: Lectures at the Collège de France, 1978–1979*. New York: Palgrave MacMillan.
Fountain H (2013) Natural allies for the next Sandy. *New York Times*, 8 October. Available at: http://www.nytimes.com/2013/10/29/science/natural-allies-for-the-next-sandy.html?pagewanted=all (accessed 24 April 2019).
Gandy M (2003) *Concrete and Clay: Reworking Nature in New York City*. Cambridge: MIT Press.
Gibbons S and Yuhas C (2005) *Combined Sewer Overflows: What's Happening in New York City*. The Tidal Exchange. New York: NY/NJ Harbor Estuary Program. Available at: http://www.harborestuary.org/news/TEautumn05.pdf (accessed 23 April 2019).
Goldstein J (2018) *Planetary Improvement: Cleantech Entrepreneurship and the Contradictions of Green Capitalism*. Cambridge: MIT Press.
Graham S and Marvin S (2001) *Splintering Urbanism: Networked Infrastructures, Technological Mobilities, and the Urban Condition*. London and New York: Routledge.
Graham S and Thrift T (2007) Out of order: Understanding repair and maintenance. *Theory, Culture & Society* 24(3): 1–25.

Greenberg P (2012) An oyster in the storm. *New York Times*, 29 October. Available at: http://www.nytimes.com/2012/10/30/opinion/an-oyster-in-the-storm.html (accessed 23 April 2019).

Greenberg P (2014) *American Catch: The Fight for Our Local Seafood*. New York: Penguin Press.

Grizzle R, Ward K, Lodge J, et al. (2013) *Oyster restoration research project final technical report: ORRP phase 1: Experimental oyster reef development and performance results*. Report, Oyster Restoration Research Project, Hudson River Foundation, USA.

Grove K (2018) *Resilience*. Abingdon: Routledge.

Grubesic T and Murray A (2006) Vital nodes, interconnected infrastructures, and the geographies of network survivability. *Annals of the Association of American Geographers* 96(1): 64–83.

Haraway D (1988) Situated knowledges: The science question in feminism and the privilege of partial perspective. *Feminist Studies* 14(3): 575–599.

Hetherington K (2017) Surveying the future perfect: Anthropology, development and the promise of infrastructure. In: Harvey P, Jensen CB and Morita A (eds) *Infrastructures and Social Complexity: A Companion*. London: Routledge, pp. 40–50.

Hetherington K (2019) *Infrastructure, Environment, and Life in the Anthropocene*. Durham, NC: Duke University Press.

Heynen N, Kaika M and Swyngedouw E (2006) *In the Nature of Cities: Urban Political Ecology and the Politics of Urban Metabolism*. London: Routledge.

Heynen N, McCarthy J, Prudham WS, et al. (eds) (2007) *Neoliberal Environments: False Promises and Unnatural Consequences*. New York: Routledge.

Heynen N and Robbins P (2005) The neoliberalization of nature: Governance, privatization, enclosure and valuation. *Capitalism, Nature, Socialism* 16(1): 5–8.

Hughes A and Reimer S (eds) (2004) *Geographies of Commodity Chains*. London: Routledge.

Jacobs K (2017) Rebuild by Design's enduring legacy. *ARCHITECT*, 17 April. Available at: http://www.architectmagazine.com/design/rebuild-by-designs-enduring-legacy_o (accessed 24 April 2019).

Johnson E (2015) Of lobsters, laboratories, and war: Animal studies and spaces of encounter. *Environment and Planning D: Society and Space* 33(2): 296–313.

Jones CG, Lawton JH and Shachak M (1994) Organisms as ecosystem engineers. *Oikos* 69(3): 373–386.

Joseph J (2013) Resilience as embedded neoliberalism: A governmentality approach. *Resilience: International Policies, Practices and Discourses* 1(1): 38–52.

Kaika M and Swyngedouw E (2000) Fetishizing the modern city: The phantasmagoria of urban technological networks. *International Journal of Urban and Regional Research* 24(1): 120–138.

Kane M (2014) Why New York should become the city of oysters again. *New York Post*, 21 June. Available at: http://nypost.com/2014/06/21/why-new-york-should-become-the-city-of-oysters-again/ (accessed 24 April 2019).

Katz C (1998) Whose nature, whose culture? Private productions of space and the preservation of nature. In: Braun B and Castree C (eds) *Remaking Reality: Nature at the End of the Millennium*. New York: Routledge, pp.46–63.

Kurlansky M (2007) *The Big Oyster: History on the Half Shell*. New York: Random House Trade Paperbacks.

Larkin B (2013) The politics and poetics of infrastructure. *Annual Review of Anthropology* 42(1): 327–343.

Latour B (1993) *We Have Never Been Modern*. Cambridge, MA: Harvard University Press.

Lavis R (2014) Hurdles remain, but momentum builds for oyster reefs and breakwater project to protect South Shore. *SI Live*, 25 June. Available at: http://www.silive.com/news/index.ssf/2014/06/g_livinoyster_reefs_and_living_b.html (accessed 23 April 2019).

Lorimer J (2015) *Wildlife in the Anthropocene: Conservation After Nature*. Minneapolis: University of Minnesota Press.

Lorimer J and Driessen C (2016) From "Nazi Cows" to cosmopolitan "Ecological Engineers": Specifying rewilding through a history of heck cattle. *Annals of the American Association of Geographers* 106(3): 631–652.

Mansfield B (ed) (2008) *Privatization: Property and the Remaking of Nature-Society Relations*. Oxford: Blackwell.

McDonald RI (2015) *Conservation for Cities. How to Plan and Build Natural Infrastructure*. Washington, DC: Island Press.
McFarlane C and Rutherford J (2008) Political infrastructures: Governing and experiencing the fabric of the city. *International Journal of Urban and Regional Research* 32(2): 363–374.
McGuirk P, Bulkeley H and Dowling R (2016) Configuring urban carbon governance: Insights from Sydney, Australia. *Annals of the American Association of Geographers* 146(1): 145–166.
MacKenzie CL (1984) A history of oystering in Raritan Bay, with environmental observations. In: Pacheco A (ed) *Raritan Bay: Its Multiple Uses and Abuses*. American Littoral Society, New Jersey Marine Sciences Consortium, National Marine Fisheries Service – Proceedings of the Walford Memorial Convocation. Sandy Hook Laboratory Technical Series Report 30, pp.37–66.
MacKenzie CL (1992) *The Fisheries of Raritan Bay*. New Brunswick, NJ: Rutgers University Press.
Mann R (2013) Restoring nature's coastal architects: A reality check. *Ecological Restoration* 31(3): 323–324.
Meerow S and Newell J (2019) Urban resilience for whom, what, when, where, and why? *Urban Geography* 40(3): 309–329.
Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-Being: Synthesis*. Washington, DC: Island Press.
Mitchell T (2002) *Rule of Experts: Egypt, Techno-Politics, Modernity*. Berkeley: University of California Press.
Monstadt J and Schmidt M (2019) Urban resilience in the making? The governance of critical infrastructures in German cities. *Urban Studies* 56(11): 2353–2371.
Müller M (2015) Assemblages and actor-networks: Rethinking socio-material power, politics and space. *Geography Compass* 9(1): 27–41.
Nelson S (2015) Beyond the limits to growth: Ecology and the neoliberal counterrevolution. *Antipode* 47(2): 461–480.
Neocleous M (2013) Resisting resilience. *Radical Philosophy* 178: 2–7.
New York Harbor School and New York Harbor Foundation (2014) Oyster Garden Manual for Teachers and Schools. Staten Island Edition. New York: Billion Oyster Project.
New York-New Jersey Harbor Estuary Program, Port Authority of New York & New Jersey, & US Army Corps of Engineers New York District (2009) Comprehensive Restoration Plan for the New York-New Jersey Harbor Estuary. Available at: https://www.nan.usace.army.mil/Missions/Environmental/Comprehensive-Restoration-Plan-for-the-Hudson-Raritan-Estuary/ (accessed 23 April 2019).
New York State (2015, April 30) *Governor Cuomo Announces $60 Million Living Breakwaters Barrier to Protect Staten Island Shoreline and Habitat*. Press release. Available at: https://www.governor.ny.gov/news/governor-cuomo-announces-60-million-living-breakwaters-barrier-protect-staten-island-shoreline
New York State Governor's Office of Storm Recovery (NYSGOSR) (2015) Coastal and social resiliency initiatives for Tottenville Shoreline, Staten Island, NY Environmental Impact Statement Draft Scope of Work. Report, 1 April. Available at: https://stormrecovery.ny.gov/sites/default/files/uploads/coastal_and_social_resiliency_initiatives_-_tottenville_draft_scope.pdf (accessed 23 April 2019).
New York State Governor's Office of Storm Recovery (NYSGOSR) (2019) Learn more about the living breakwaters project. Available at: https://stormrecovery.ny.gov/learn-more-about-living-breakwaters-project (accessed 19 April 2019).
Neyrat F (2019) *The Unconstructable Earth: An Ecology of Separation*. New York: Fordham University Press.
NY/NJ Baykeeper (2016) Oyster Restoration Program. Available at: http://nynjbaykeeper.org/resources-programs/oyster-restoration-program/ (accessed 24 April 2019).
Oels A (2013) Rendering climate change governable by risk: From probability to contingency. *Geoforum* 45: 17–29.
Orff K (2010) Reviving New York's water – with oysters! TED presentation. Available at: https://www.ted.com/talks/kate_orff_oysters_as_architecture?language=en (accessed 23 April 2019).

Orff K (2011) Oyster-tecture. In: B Bergdoll (ed) *Rising Currents: Projects for New York's Waterfront*. New York: Museum of Modern Art, pp.90–99.

Orff K (2014) Rebuilding eco-infrastructure. TEDx Gowanus presentation. Available at: https://www.youtube.com/watch?v=NZPT5mgzOCU (accessed 23 April 2019).

Parkinson C (2010) *Coming Climate Crisis?: Consider the Past, Beware the Big Fix*. Lanham, MD: Rowman & Littlefield Publishers.

Parry W (2011) Navy has new role: Oyster protectors. *Philly*, 7 October. Available at: http://articles.philly.com/2011-10-07/news/30253683_1_baby-oysters-oyster-population-oyster-research (accessed 23 April 2019).

Perkol-Finkel S and Sella I (2014) Ecologically active concrete for coastal and marine infrastructure: Innovative matrices and designs. In: *Proceeding of the 10th ICE* conference: from sea to shore – meeting the challenges of the sea.

Pritchard E (2007) *Native New Yorkers: The Legacy of the Algonquin People of New York*. San Francisco, CA: Council Oak Books.

Robertson M (2004) The neoliberalization of ecosystem services: Wetland mitigation banking and problems in environmental governance. *Geoforum* 35(3): 361–373.

Robertson M (2006) The nature that capital can see: Science, state, and market in the commodification of ecosystem services. *Environment and Planning D: Society and Space* 24(3): 367–387.

Rosenzweig C and Solecki W (2014) Hurricane Sandy and adaptation pathways in New York: Lessons from a first-responder city. *Global Environmental Change* 28: 395–408.

Rosol C, Nelson S and Renn J (2017) In the machine room of the Anthropocene. *The Anthropocene Review* 4(1): 2–8.

Rush E (2015) Leaving the sea: Staten Islanders experiment with managed retreat. *Urban Omnibus*, 11 February. Available at: http://urbanomnibus.net/2015/02/leaving-the-sea-staten-islanders-experiment-with-managed-retreat/ (accessed 23 April 2019).

SCAPE/Landscape Architecture (2019) Living Breakwaters rebuild by design competition. Available at: https://www.scapestudio.com/projects/living-breakwaters-competition/ (accessed 20 April 2019).

SCAPE/Landscape Architecture PLLC (SCAPE) (2013a) *Rebuild by Design/The Shallows (Volume I, Bay Landscapes as Ecological Infrastructure). Rebuild by Design Competition Entry*. New York: Rebuild by Design.

SCAPE/Landscape Architecture PLLC (SCAPE) (2013b) *Rebuild by Design/Living Breakwaters (Volume II, Staten Island and Raritan Bay). Rebuild by Design Winning Competition Entry*. New York: Rebuild by Design.

SCAPE/Landscape Architecture PLLC (SCAPE) (2013c) *Rebuild by Design/Living Breakwaters (IP Report, Staten Island and Raritan Bay)*. New York: Rebuild by Design.

SCAPE/Landscape Architecture PLLC (SCAPE) (2016) NYC SIRR coastal protection planning. Available at: http://www.scapestudio.com/projects/nyc-sirr-coastal-protection-planning/#10 (accessed 23 April 2019).

SCAPE/Landscape Architecture PLLC (SCAPE)/Rebuild by Design (RBD) (2014a) Living breakwaters video summary for rebuild by design competition entry. Available at: https://vimeo.com/91648619 (accessed 23 April 2019).

SCAPE/Landscape Architecture PLLC (SCAPE)/Rebuild by Design (2014b) Living Breakwaters video summary for Rebuild by Design competition entry. Available at https://vimeo.com/91648619

Schrieiber KF (ed) (1988) *Connectivity in Landscape Ecology: Proceedings of the 2nd International Seminar of the International Association for Landscape Ecology*. Paderborn: Ferdinand Schöningh.

Selm AJV (1988a) Ecological infrastructure: A conceptual framework for designing habitat networks. In: KF Schrieiber (ed) *Connectivity in Landscape Ecology: Proceedings of the 2nd International Seminar of the International Association for Landscape Ecology*. Paderborn: Ferdinand Schöningh, pp.63–66.

Selm AJV (1988b) Ecological infrastructure on a national scale? In: KF Schrieiber (ed) *Connectivity in Landscape Ecology: Proceedings of the 2nd International Seminar of the International Association for Landscape Ecology*. Paderborn: Ferdinand Schöningh, pp.177–178.

Smith N (1990) *Uneven Development: Nature, Capital, and the Production of Space*. Athens and London: University of Georgia Press.
Star SL (1999) The ethnography of infrastructure. *American Behavioral Scientist* 43(3): 377–391.
Sullivan S (2013) Banking nature? The spectacular financialisation of environmental conservation. *Antipode* 45(1): 198–217.
Swyngedouw E (1996) The city as a hybrid: On nature, society and cyborg urbanization. *Capitalism Nature Socialism* 7(2): 65–80.
Swyngedouw E (2010) Apocalypse forever? Post-political populism and the spectre of climate change. *Theory, Culture & Society* 27(2–3): 213–232.
Tsing A (2016) *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*. Princeton, NJ: Princeton University Press.
United Nations Educational Scientific and Cultural Organisation (UNESCO) (1984) Programme on Man and Biosphere Report Series No. 57: International experts meeting on ecological approaches to urban planning. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000079017 (accessed 24 April 2019).
U.S. Geological Survey (2015) Geologic history of Raritan Bay. 20 January. Archived via Wayback Machine. U.S. Department of the Interior. Available at: https://web.archive.org/web/20060923233758/; http://3dparks.wr.usgs.gov/nyc/morraines/raritanbay.htm (accessed 23 April 2019).
Wakefield S (2018) Infrastructures of liberal life: From modernity and progress to resilience and ruins. *Geography Compass* 12(7): 1–14.
Wakefield S and Braun B (2014) Governing the resilient city. *Environment and Planning D: Society and Space* 32(1): 4–11.
Wakefield S and Braun B (2019) Oystertecture: Infrastructure, profanation and the sacred figure of the human. In: K Hetherington (ed) *Infrastructure, Environment, and Life in the Anthropocene*. Durham, NC: Duke University Press, pp.193–215.
Waldman J (1999) *Heartbeats in the Muck: The History, Sea Life, and Environment of New York Harbor*. New York: Lyons Press.
Walker J and Cooper M (2011) Genealogies of resilience from systems ecology to the political economy of crisis adaptation. *Security Dialogue* 14(2): 143–160.
Whatmore S (2002) *Hybrid Geographies: Natures Cultures Spaces*. Oxford: University of Oxford Press.
Winner L (1980) Do artifacts have politics? *Daedalus* 109(1): 121–136.
Wissler C (1909) *The Indians of Greater New York and the Lower Hudson* (Anthropological papers of the American Museum of Natural History, Volume III). New York: American Museum of Natural History.
Yu K, Wang S and Li D (2011) The negative approach to urban growth planning of Beijing, China. *Journal of Environmental Planning and Management* 54(9): 1209–1236.
Zolli A (2012) Learning to bounce back. *New York Times*, 2 November. Available at: http://www.nytimes.com/2012/11/03/opinion/forget-sustainability-its-about-resilience.html (accessed 23 April 2019).