Slow Down and Reach Out (and We'll Be There): A Response to "Shellfish as Living Infrastructure" by Kate Orff

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Historically New York Harbor supported hundreds of square kilometers of oyster beds, yielding perhaps 700 million harvested oysters per year at its peak in the late 1880s (Kurlansky 2006, Royte 2006, Bain et al. 2007). By the 1920s, the beds had become unharvestable because of depletion of the resource and closures from raw sewage contamination (reviewed in Kirby 2004). When the Hudson River Foundation took the lead in investigating the feasibility of restoring oyster populations and the reefs they form in the New York Harbor region, they assembled a team of scientists in 2009 from around the U.S. with expertise in oyster restoration, aquaculture, ecology, pathology, genetics, and other disciplines. The initial result was the Oyster Restoration Research Project (ORRP) which was designed to build upon previous studies in the region (e.g., Franz 1982, Bain et al. 2007, Starke et al. 2011) and assess oyster restoration potential at five sites, each with different environmental regimes, from the lower Hudson River to Staten Island. Phase 1 of this study was completed in 2012 (Grizzle et al. 2013) and Phase 2 is underway, focusing on larger scale restoration at one pilot site in the Bronx at Soundview Park. Orff briefly describes these efforts in her essay, and both of us have been a part of the project since before 2009. Based on our experiences in the region and elsewhere we are responding to Orff's essay "Shellfish as Living Infrastructure," providing some context from our restoration work and others. Our aim here is to comment on her proposed approaches in light of a shifting focus in the last few decades to oyster restoration for ecological reasons rather than mainly human harvest.

In her essay, Orff provides a vision of how to proceed with shellfish restoration in the region. It is a vision of ropes, nets, and pilings with oyster reefs underneath, all constructed in the shallow waters of an urban landscape. The ropes and nets colonized by mussels and other filter-feeders result in a complex biotic community dominated by filter feeding bivalves cleaning up the water and providing habitat for other species, as well as recreational (fishing, harvesting) and other benefits for humans. Orff also visualizes a hypothetical ". . . post superfund Gowanus Canal as a seeding ground for oyster spat, which could be cultivated . . . and maintained by community organizations" (page 318, *this issue*). Overall, her vision represents a ". . . hybrid 'eco-infrastructural' approach (that) brings together hardened shorelines, potential seawall barriers together with living ecological habitat systems to form a more resilient harbor landscape" (page 321, *this issue*). All this is conceptually appealing. However, to us its individual components resemble yet another coastal structure likely to be swept away by the next storm, or notions that are otherwise quite problematic. We agree that there is a need to make our shorelines more resilient, but Orff has in our view gone too far afield of possibilities in her conceptualization without a realistic ecological or administrative (shellfish and human health management) framework. We are writing this response and informative essay that we believe she could benefit from, especially with respect to seeking input from experts in other relevant disciplines.

Oyster restoration programs mainly concerned with sustaining a resource for human consumption have existed since the 1800s (Brooks 1891, Kirby 2004, NRC 2004, Lotze et al. 2006, Beck et al. 2009). During the 1990s, however, the notion that oysters also were important ecologically began to be more widely recognized (Kennedy 1996, Luckenbach et al. 1999). Subsequently, oyster restoration programs that included to some extent both of the roles that oysters potentially play (human food resource and ecological importance) were initiated in North America, Europe, and other areas (Brumbaugh et al. 2000a, b, Brumbaugh and Coen 2009). In the U.S., these programs are mainly administered at the state level, and there is quite a diversity of goals, metrics and success criteria among them (Coen and Luckenbach 2000, French-McCay et al. 2003, Coen et al. 2004, Brumbaugh et al. 2006, Beck et al. 2009, 2011, Baggett et al. 2013). Today, we are still grappling with how to manage oysters as both a food resource for human consumption and for their ecological importance.

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The eastern oyster, *Crassostrea virginica*, which is the native oyster on the eastern and Gulf of Mexico coasts of North America, is viewed as an "ecosystem engineer" because it forms a unique reef habitat for other species (Jones et al. 1994, Coen et al. 1999, 2007, Grabowski et al. 2007, Coen and Grizzle 2007, Beck et al. 2011). This is a result of two processes: shell growth of individual oysters, and repeated gregarious settlement and attachment of young oysters (larvae) onto older oysters. The result is expanding vertical height in the water column and in some cases expansion of the overall reef footprint through time. In the long-term, a complex, three-dimensional reef structure consisting of many oysters of different age classes attached to one another is formed. It is this complex reef structure that is essential for the various ecosystem services such as habitat provision and water filtration that oysters provide (French McCay et al. 2003, Newell 2004, Newell et al. 2005, Coen et al. 2007, Grabowski and Peterson 2007, Grabowski et al. 2012, Grizzle et al. 2008, Beck et al. 2011, Piehler and Smythe 2011, Carmichael et al. 2012, Dame 2012, Kellogg et al. 2013, zu Ermgassen et al. 2013a, b).

Oyster restoration projects aimed at restoring ecosystem services typically consist of one or both of two components: placement of hard substrate (usually seasoned oyster shell, but other materials are sometimes used) onto the bottom if substrate is limiting, followed by addition of young oysters (spat) already attached to dead oyster or clam shells (spat-on-shell). If natural wild stock oyster populations are sufficient to produce consistent numbers of larvae (recruits), as is typical in many estuaries in the southeastern U.S., only shells need be put out to begin the restoration process (e.g., Brumbaugh and Coen 2009). However, in areas where wild oyster populations are severely depleted to the point that little or no recruitment regularly occurs, as is thought to be the case in the New York Harbor region, both shell and spat-on-shell are required. The ongoing ORRP study mentioned above is aimed at determining those methods and geographic areas where oyster restoration with a focus on restoring lost ecosystem services might be feasible in the New York Harbor region.

The literature on what works and what doesn't work with respect to oyster reef restoration is still in its early stages (Coen and Luckenbach 2000, Barnes et al. 2007, Coen et al. 2007, Powers et al, 2009, Schulte et al. 2009, North et al. 2010, NRC 2010, Kennedy et al. 2011) despite what some may think. Phase 1 of the ORRP project and other work in the region (e.g., Levinton and Doall 2006, Starke et al. 2011) has shed some light on how to proceed, and research in other geographic areas is moving towards development of general goals and related restoration protocols and assessment methods (Coen et al. 2004, Brumbaugh et al. 2006, Baggett et al. 2013). The field is developing rapidly, however, there is much yet to learn about successfully restoring oyster reefs that are sustainable in the long-term (decades or more).

Some of Orff's ideas regarding oysters and mussels are in our view potentially reasonable, but others are not, particularly when considering our current level of understanding and related issues of public policy and resource management. For example, we cannot imagine all the issues that would have to be addressed to begin to culture oysters for wider distribution in even a "post-Superfund" Gowanus Canal. The notion that oysters clean the water through their feeding process is valid to some degree, but the pollutants (toxins, bacteria, viruses, etc.) removed from the water do not just disappear (see reviews in Capuzzo 1996, Leonard and MacFarlane 2011). Many can remain in the oyster's tissues for long periods of time, and are then passed along to consumers up the food chain including humans. Even designing a study to assess how the wide range of contaminants potentially present might affect oysters growing there, and where they might end up after being distributed to other areas, would be a difficult and expensive task. Thus, we cannot imagine beginning a restoration effort focused on the Gowanus Canal.

We also wonder if what Orff might consider "regulatory hurdles" (page 319, *this issue*) others would consider major and necessary safeguards for health and other regulatory concerns. Each state is different with respect to the permitting process for oyster restoration projects (Leonard and MacFarlane 2011), and the situation in the New York Harbor region is probably as complicated as any. The ORRP effort originally included an experimental reef in New Jersey, but this reef could not be constructed because New Jersey was in the process at that time (2009) of moving towards its present position of no oyster restoration projects in waters closed to human harvest (NY/NJ Baykeeper). A recent report prepared for the Interstate Shellfish Sanitation Conference describes the hurdles that exist for even pilot efforts, particularly when they are done in waters where harvesting for human consumption is not permitted (Leonard and MacFarlane 2011). It is a complicated situation, and we are far from working out all the issues involved (see reports listed by state in www.oyster-restoration.org/oyster-restoration-research-reports/). Every oyster restoration project we have conducted has been only after securing the necessary federal, state and local permits. At times, this has been quite daunting, but we recognize that it is an important part of the overall restoration and enhancement process. In light of our experiences and many others working on a variety of different kinds of oyster (and other habitats) restoration projects in many U.S. states (Beck et al. 2009, 2011), we think very little that Orff is proposing would be feasible or even permittable in the foreseeable future, particularly in New York Harbor.

Orff's vision is at its core part of the general movement towards constructing what are now called "living shorelines" intended to replace or at least augment "hard" structures such as seawalls and bulkheads that typically have been used in coastal areas (see www.oyster-restoration.org/livingshorelines/ website for examples, and www.habitat.noaa.gov/restoration/techniques/livingshorelines.html). The urbanized shorelines of New York Harbor have long been hardened by seawalls, bulkheads, docks and other structures as have so many other shorelines (e.g., Scyphers et al. 2011)—but in large measure these are structures that are essential for a working port. The hardened shorelines were designed to withstand the hydrodynamics and other conditions typical of busy harbors, and they have in large measure worked. These structures, however, were not designed to provide optimal habitats for plants, invertebrates or fish (see Able and Duffy-Anderson 2006 and references therein). Nor were they designed to withstand extreme storm effects, as was so painfully evident last year when Superstorm Sandy pounded the region. Yes, we need to make changes in our coastal zones to better withstand storms, and we are fully in favor of improving existing hardened shorelines so they also provide habitat for many species while supporting essential commercial uses and public safety. However, we have trouble envisioning where such a structure as that shown in Figure 1, (page 317, *this issue*), might be considered appropriate in New York Harbor. Neither of us has expertise in designing docks and related structures, but our experiences in designing, constructing, and sampling oyster reefs and living shorelines has made us quite aware of the importance of wind and boat generated waves and tidal currents to the success of a project (e.g., Crawford et al. 1998, Kennish 2002). Our perhaps naïve assessment is that the structures Orff is proposing are largely inappropriate for a working shoreline, and if placed in an open-water environment would likely be swept away by storms that regularly affect the region.

In conclusion, Orff certainly has raised the level of awareness for many with respect to shellfish restoration in New York Harbor, and advertising it through her TED lecture (www.ted.com/talks/lang/en/kate_orff_oysters_as_architecture.html) and excellent graphics and videos on her Scape Studio website (www.scapestudio.com/projects/oyster-tecture/). We think this is a good thing. We are grateful that someone has been able to focus so much attention on restoring shellfish populations in the region. We also, however, clearly have many concerns. We began with a brief description of how the Hudson River Foundation initially approached an assessment of the feasibility of oyster restoration in the region; they assembled a team of experts. This is exactly the suggestion we are making here—reach out to some experts in shellfish restoration, coastal engineering, permitting, and other areas needed to move forward—and count us among those willing to participate.

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