A Comparitive Case Study of Three Oyster Reef Restoration Projects

Cate Mingoya
Ecological Urbanism

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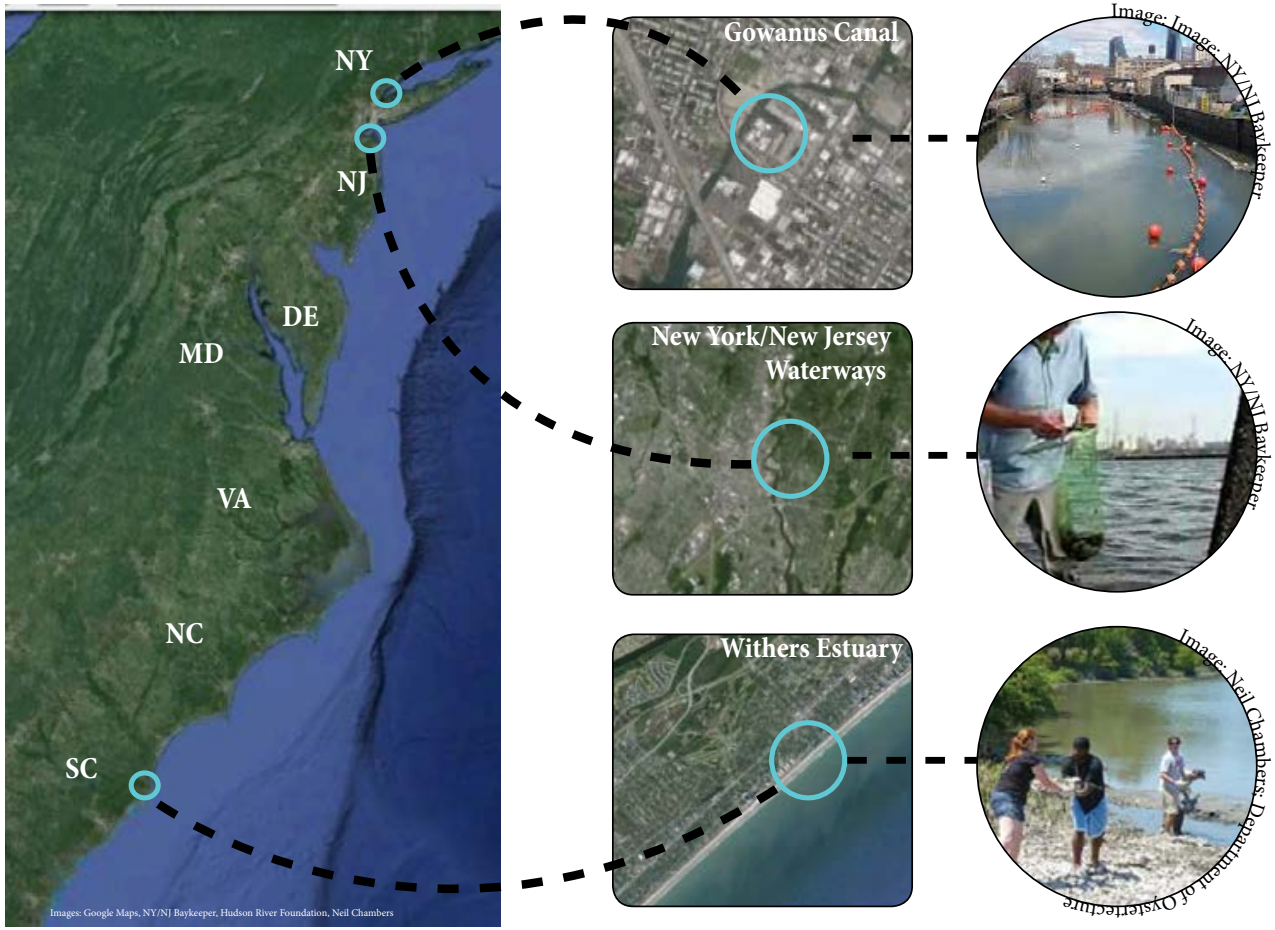

Oystertecture: A Comparative Case Study of Three Oyster Reef Restoration Projects

-Cate Mingoya

Abstract:

This case study investigates three oyster reef restoration projects: Withers Estuary in Myrtle Beach, SC; Gowanus Canal in Brooklyn, NY; and several sites in New York and New Jersey's waterways. Overfishing, ocean dredging, and pollution from human sewage, storm water and industrial manufacturing have dramatically reduced both the oyster population and human enjoyment of many east coast estuaries. Over the past 15 years, there has been an increased interest from municipalities, activists, architects and scientists in using natural methods to cleanse and restore these areas. Oysters, along with other mollusks, have tremendous filtering capacity and a single adult oyster is capable of cleansing bacteria, viruses and certain pollutants from between 20 and 50 gallons of water per day. Rebuilding and repopulating mollusk reefs adds a significant, natural cleansing mechanism to waterways. The three restoration projects presented in this case study approached reef development with significantly different methods in regards to materials used, participants engaged and scale of project. Successful projects capitalized on the support, or indifference of government officials and contributed to the greater landscape literacy of the estuary. Concerns arise, however, about mollusks' inability to filter out certain toxins such as lead, mercury and BPAs. These pollutants may lodge themselves in in the tissue and shells of the mollusks and it is not yet know what impact this may have on other organisms.

INTRODUCTION

Oysters belong to a category of organisms called mollusks and are commonly found in estuaries- ecologically unique areas where the ocean's salt water meets a fresh water source. In the United States, oysters have a long and important ecological and cultural role. In the northeastern United States, a significant industry grew out of harvesting and processing oysters for food, animal feed and fertilizer, among other uses. In New York, vendors would line the downtown areas selling oysters on the half-shell for a penny each- an early 19th century version of the hotdog cart (see figure 1.)[1] Historical accounts make mention of harvesting oysters from northeastern estuaries that were the size of dinner plates.[2] Not only were oysters large, they were prolific and capable of cleansing bacteria, viruses and other pollutants harmful to human health out of the water. In the 1600's, oysters were so numerous in the Chesapeake Bay that they were able to filter all 4,500 square miles of water in a single week.[3] Present day populations have dwindled so significantly, that it takes the oysters over a year to filter the bay.

Overharvesting, reef dredging to facilitate the movement of ships, pollution from industrial manufacturing, and human waste runoff took their toll on the oyster and by the mid-20th century, urban oyster reefs across the country were sparse or barren. The past twenty years have ushered in a renewed and vigorous interest in replenishing estuaries with oysters and other native mollusks. Municipalities, environmentalists, scientists and residents have rediscovered the environmental, social and economic benefits of long forsaken waterways and are looking for innovative, cost-effective ways to restore the health of their estuaries.

Image: Museum of the City of New York

Figure 1: New York street vendors sell oysters for a penny each

Water quality is of deep concern to municipalities, local residents and prospective developers. Many eastern estuaries that sit close to developed areas suffer from pollution, limiting the water's use as a spot for fishing, swimming or other recreational activities. Combined sewer overflows (CSOs) during wet weather can dump human waste into the estuaries, producing foul smells and spreading illness. When estuaries remain full of toxins and pathogens, cities and property holders stand to lose some of the earning potential associated with the use of healthy waterways.

Mollusks have an extremely high filtering capacity with adult oysters capable of cleansing between 20 and 50 gallons of

1 Orff, "Shellfish as Living Infrastructure."
2 Ibid.
3 Chambers, *Urban Green*.

water per day.[4] Oysters are particularly skilled at filtering out pathogens that are a threat to human health such as the bacteria and viruses frequently found in fecal matter. Oysters grow by adhering to hard surfaces in the water, including other oyster shells; because they latch tightly onto the rocks, wood and other hard-shelled animals, oysters can also help prevent soil erosion at the hands of waves or storm water. Estuary soil is important not only for preserving and protecting coastal lands for human use, but the low-saline soil also provides a home for estuary plants, which are known to effectively sequester carbon.[5] Overall, mollusk reef restoration stands as an intuitive option in the quest to protect coastal land and water.

CASE ONE: WITHERS ESTUARY

In the early 2000's, developer Neil Cambers was hired to work on a housing start in an area of Myrtle Beach known as Withers Swash- in reality the swash is an estuary and will be referred to as such throughout this case. Conversations with residents revealed to Chambers that the waterfront to this development was remembered as a prime spot for fishing and swimming;[6] older community members claimed that an afternoon of fishing could

Figure 2 Withers Estuary Community Collaborative Partners; Image by Neil B. Chambers.

provide a family their food for a week.[7] Overfishing and pollution produced an estuary with limited biodiversity; overflows from the city's sewer system resulted in the frequent closure of the waterway. Myrtle Beach is a popular destination for tourists seeking sun, sand, and swimming; Withers Estuary's contamination was not only a social loss, but also an economic one for locals and for the city.

Chambers, already interested in incorporating "green" practices into his developments turned to other reef and water restoration projects along the coast of South Carolina for inspiration. The government of South Carolina was keenly aware of the commercial, social and health and safety benefits of cleaning up the waterways and allowed non-governmental organizations to build reefs.

The process of rebuilding the estuary's reefs brought together a variety of nonprofit organizations and local residents into the "Withers Estuary Community Collaborative," affection-

4 Orff, *Reviving New York's Rivers -- with Oysters!*.
5 Pendleton et al., "Considering 'Coastal Carbon' in Existing U.S. Federal Statutes and Policies."
6 Hanscom, "Putting the Wilderness Back in Our Cities."
7 Chambers, *Urban Green*.

Figure 3: Volunteers build oyster reefs using mesh bags filled with oyster shells: Image Neil B. Chambers

Figure 4: A sign in WIthers Estuary informs visitors of the project and warns them to not consume the oysters. Image: Neil Chambers

ately known to some as the "Bureau of Oystertecture" (figure 2).

The process of rebuilding reefs using mesh bags stuffed with restaurant-discarded mollusk shells drew wide support from those living near the estuary. The hope, residents expressed, was that the project would clean the waters well enough to allow swimming and increase the water's biodiversity. Such a change might encourage further development, grow the area's tourism industry, increase housing prices and turn the estuary into the community resource it once was.

Volunteers organized to collect old mollusk shells from restaurants, place them into mesh bags and then seed them with oyster spats(young oysters) (figure 3). The heavy bags of oyster shells nestled into the soft sand and soil underwater mimic the natural development of oyster reefs. Spats will latch on to hard surfaces and continue to build off of the shells of other mollusks, creating a reef. The cost of the reefs placed in Withers Estuary was quite inexpensive; each reef carried a $200 price tag and resulted in 3,000-4,000 oysters added to the waterway.[8] Each reef has the potential to filter over 200,000 gallons of water each day. The Withers Estuary Community Collaborative placed 13 reefs in Withers estuary for a filtering capacity of up to 2,600,000 gallons per day.

The oysters in this reef are self-sustaining. Volunteers occasionally check in on the oyster beds to take measurements, assess oyster bed health and to estimate survival rates. Signage is erected at each reef site to inform the public of the project and to warn them, that for their safety and the safety of the reef, they should not yet consume oysters taken from Withers Estu-

8 Chambers, "Re-Imagining Infrastructure: Part 5."

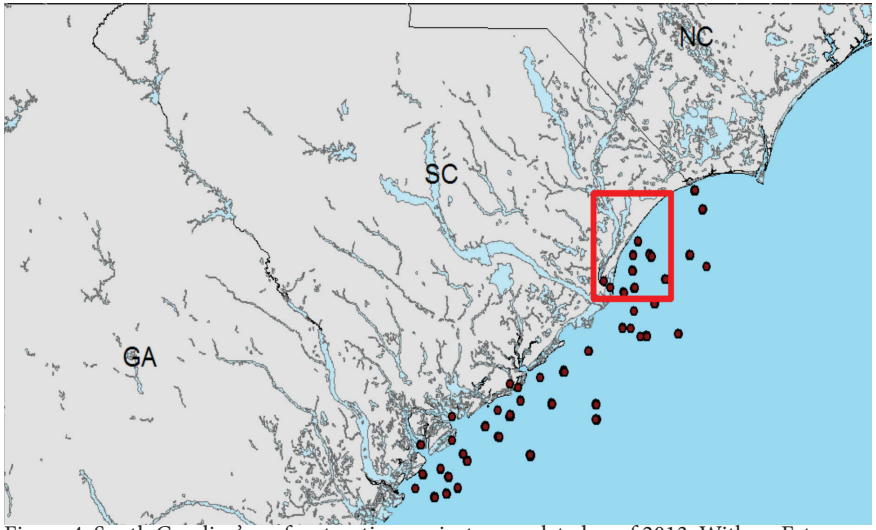

Figure 4: South Carolina's reef restoration projects completed as of 2013. Withers Estuary boxed in red. Data: South Carolina GIS: SC Department of Health and Environmental Control.

ary waters (figure 4).

A unique way in which the government's passive support has impacted this project is that individuals interested in oyster restoration projects can organize to complete reef restorations in their own communities without government approval or oversight. Several online resources exist that detail how South Carolina residents can evaluate and construct reefs in their local estuaries.[9] This wide reach ensures that, along with projects spearheaded by local and state governments, the reef restorations are not only done on a local, but on a continental scale (figure 4).

Since the installation of the oyster reefs, biodiversity has returned to Withers Estuary, with crabs, fish, raccoons and other species responding to both cleaner waters and the presence of a new food source- the oyster.

9 Green, "How to Do It: Oyster-Tecture."

The government of South Carolina and the city council of Myrtle Beach have welcomed the volunteer-led oyster restoration project and the Myrtle Beach city council has incorporated mollusk reef rehabilitation programming and funding into their long-term coastal management strategy.

SUCCESSES

The Withers Estuary Community Collaborative expanded the impact of their oyster reef restoration project through the use of cheap and free materials, the sourcing of volunteer labor via community involvement and a simple reef planting process. The shells sourced from restaurants added an interesting and easily accessible dimension to the project. The clam and oyster shells not only avoided the landfill, but also made the reefs inexpensive to build and easily accessible, both conceptually and physically, for volunteers interested in improving their waters. The government's passive support also went a long way towards the development of this project. Unlike in other states, the South Carolina Department of Health and Environmental Control saw the potential benefits of oyster reef restoration and weighed the potential costs to be minimal in comparison to the potential benefits. Finally, the increased biodiversity and filtering capacity add tremendously to the health of Withers Estuary

CHALLENGES

When evaluating the success of the Withers Estuary reef rehabilitation project, it is important to note that oysters are keystone species, meaning they interact with a variety of other creatures further up the food chain, including humans. Oysters are able to filter out many pollutants, but some, such as heavy metals and BPAs, may either pass through the oyster, back into the water, or become embedded n the flesh and shells of the mollusk.[10] It is not yet known if the oysters placed in Withers Estuary are carrying or passing on toxins to other organisms or to humans, and, if they are, what the consequences may be. Additionally, the incorporation of oysters into the landscape does nothing to change or control the behavior of pollutants further upstream. Materials harmful to humans, plants and non-human animals are still entering the estuary and must be controlled at the source.

10 Mitra, Bartel, and Volety, "Trace Organic Contaminants (PAHS, PCBs, and Pesticides) in Oysters Crassostrea Virginica, from the Caloosahatchee Estuary and Estero Bay, SW Florida."

CASE TWO: NY/NJ BAYKEEPER

PART ONE: NEW JERSEY REEF RESTORATION

The Hackensack River is one of the most polluted waterways in the country's history; it once stood as a major source of drinking water for surrounding cities, but demand quickly outpaced the supply of fresh water. In response, New Jersey built a dam at the top of the river, which decreased the amount of fresh water flowing towards the sea and allowed the salt water from the outlet's estuary to encroach, thus changing the biochemistry and reducing the biodiversity of the river. Simultaneously, industrial manufacturing dumped untreated waste containing heavy metals such as lead and mercury into the water. Pollution continues from municipal and residential sectors: cities used the river to carry away their untreated sanitary sewage and nearby lands became a dump for the major cities in the region- pollutants leached out of the garbage and into the watershed.[11] While the clean water act has prevented such egregious dumping of pollutants into the Hackensack River, CSO overflows continue to pollute the river (figure 5). Over the past 50 years there have been many nonprofit organizations dedicated to the restoration of this waterway such as the Hackensack Riverkeeper and the New York/New Jersey Baykeeper (NY/NJ Baykeeper). NY/NJ Baykeeper is a nonprofit organization founded in 1989 to con-

11 "Hackensack River History."

serve and restore the waterways and watersheds of New York and New Jersey. The nonprofit organizes and develops relationships with other nonprofits, city officials, state offices, residents and local universities to lead clean up, restoration, conservation and educational programing as well as influence state and city regulations and policy.

In 2006 NY/NJ Baykeeper and Hackensack Riverkeeper, in collaboration with Rutgers University professor

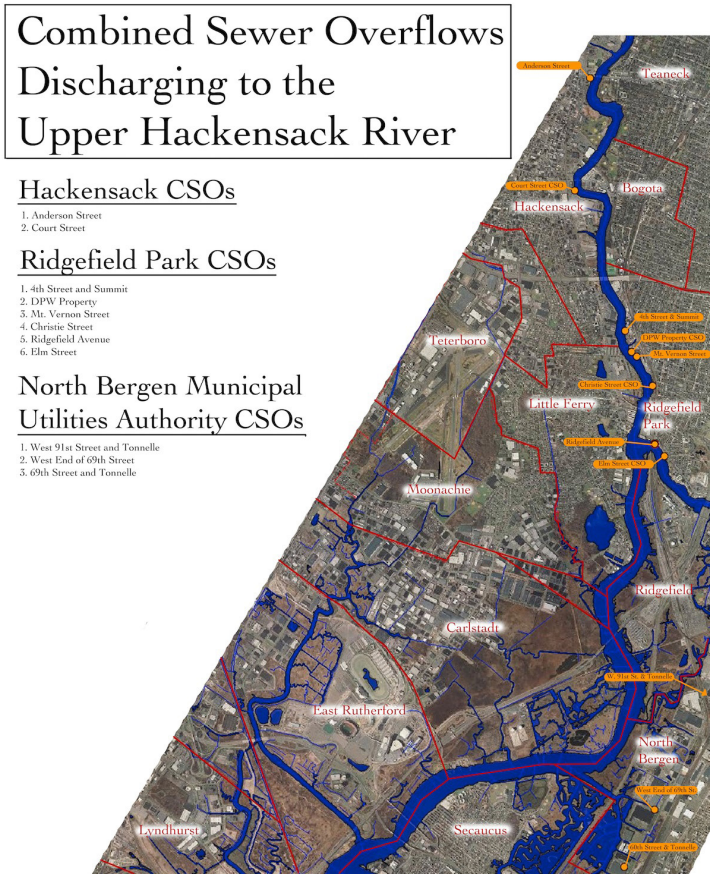

Figure 5: CSO Map of the Hackensack River. Decades after the clean water act, the Hackensack River remains polluted. Image: NY/NJ Baykeeper

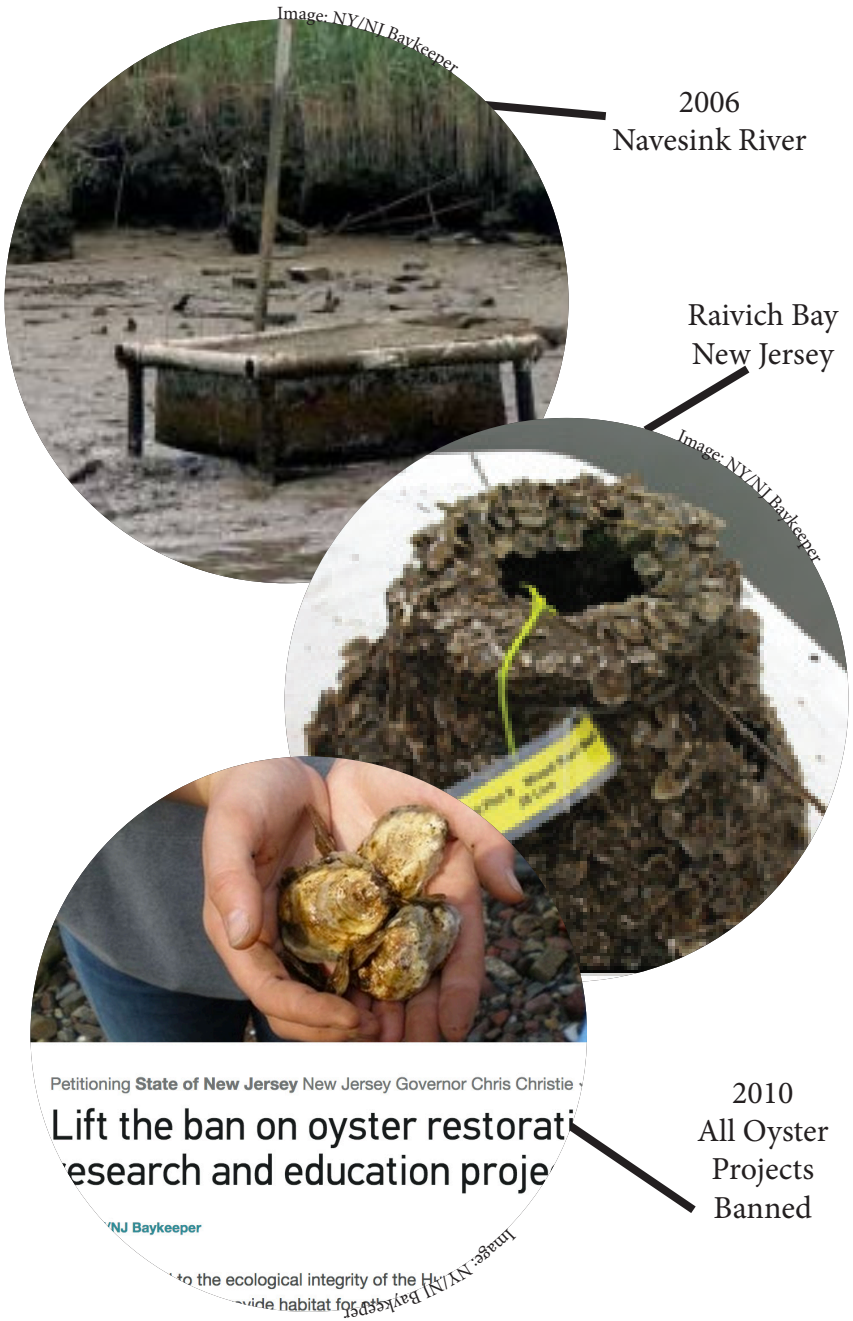

Figure 6: in 2010, all oyster reef restoration projects were cancelled in the state of New Jersey. NY/NJ Baykeeper continues to fight to reinstate the pilot projects.

Beth Ravit, launched a pilot program to use oyster spats seeded on PVC floats and metal sinkers to cleanse the river. By 2011, the pilot program failed. The river was too polluted; the oysters that had survived in the river grew numerous tumors, developed thin shells and were unable to switch genders upon maturity as oysters usually do.[12] Researchers from Rutgers pointed to the presence of PCBs, heavy metals, chromim, dioxins, naphthalene, dichorobenezes, benzene (a known carcinogenic agent) and other organic and inorganic pollutants as the cause of the oysters' poor development.[13] Identifying the Hackensack River as too polluted for a viable restoration project, NY/NJ Baykeeper and their university and non-profit collaborators turned to other New Jersey waterways and in 2006 launched pilot projects in the Navesink River and Ravich Bay to reseed oyster beds.

In 2010 the governor called for all of the program's oyster reefs to be removed (figure 6), citing fears that the good name of New Jersey shellfish could be tarnished and the industry harmed if a consumer were to become ill after eating mollusks poached from these pilot reefs.[14] All projects have been canceled and the establishment of any and all reef restoration projects has been banned. NY/NJ Baykeeper continues to fight, through petitions and proposed legislation, to have the projects reinstated, claiming "the possibility of poaching would be eliminated by New Jersey Department of Environmental Protection (NJDEP) doing a better job of patrolling closed waters with NJDEP Enforcement Officers… Baykeeper has numerous institutional controls to secure the oysters and make poaching extremely difficult."[15] As of December 2014, the NJDEP is reviewing a bill proposed by NY/NJ Baykeeper to reinstate the program.[16]

12 Ravit et al., "Improving Management Support Tools for Reintroducing Bivalve Species (Eastern Oyster [Crassostrea Virginica Gmelin]) in Urban Estuaries."
13 Ibid.
14 Star-Ledger, "N.J. Bans Oyster Restoration Projects after BP Oil Spill."

PART TWO: NEW YORK REEF RESTORATION

NY/NJ Baykeeper saw much more success on the New York side of the bay. Government officials from the mayor to city councilors are interested in the use of oysters not only for water filtration, but also to act as wave attenuators during storms.[17] In 2009, NY/NJ Baykeeper established the Oyster Restoration Research Partnership to better understand the viability of reef restoration in New York's harbors. In 2013, Baykeeper, the Hudson River Foundation, NYC Parks, Bronx River Alliance and The New York Harbor School established several reefs, including one at Soundview park in the Bronx and another, farther south, off of Governor's island (figure 7): each site was stocked with 50,000 oysters, adding the capacity to filter over 5,000,000 gallons of water per day to New York's waterways. The reefs vary in their complexity and access to the public, but both rely on a steady stream of "ecovolunteers" from local secondary schools and

15 http://nynjbaykeeper.org/resources-programs/oyster-restoration-program/NY/NJ Baykeeper, "NY/NJ Baykeeper: About Us."
16 Radel, "Oyster Bill Could Lift Ban on Research Related Reefs."
17 (For more information about the use of New York City's interest in oysters as a part of their urban resiliency strategy, see: http://www.scapestudio.com/news/press-release-buckminster-fuller-challenge-winner/?page=45)

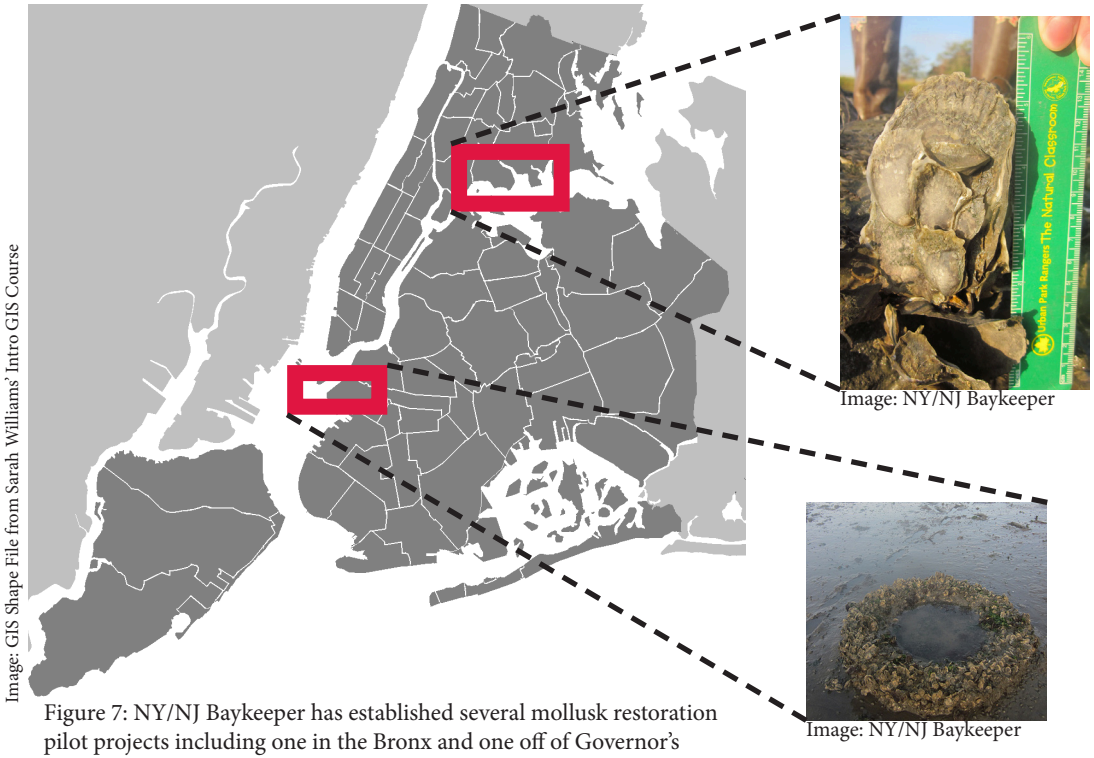

Figure 7: NY/NJ Baykeeper has established several mollusk restoration pilot projects including one in the Bronx and one off of Governor's Island.

universities as well as tourists and local residents to monitor the reefs, keep track of surviving spats, measure the length of adult oysters and note the presence of flora and fauna. Students from local schools and universities, tourists to the city, and local residents don wading boots, forge into the reefs with a NY/NJ Baykeeper employee, and proceed to collect data on surviving mollusks and learn more about the New York harbor's history and future.

As of writing, the oysters at these reef sites have successfully latched onto seeding materials and grown, not only on materials gathered and constructed for this reef restoration project, but also on garbage found in the harbor, such as glass bottles, aluminum sheeting and dozens of vehicle tires.

SUCCESSES

While the reef restoration projects will need continual monitoring to assess oyster health and impact, initial reports regarding oyster growth and mortality are promising. NY/NJ Baykeeper has seen success in their volunteer outreach program, passing on greater landscape literacy in exchange for time collecting data on the rebuilt reefs.

CHALLENGES

There are several challenges that arise in assessing the success of the NY/NJ Baykeeper reef restoration project. First, the use of non-natural materials such as PVC or man-made metals as an oyster seeding platform may leech chemicals into the estuaries or have unintended or unpredicted consequences on the health of the water and surrounding organisms. It should be noted that several of NY/NJ Baykeepers reefs are constructed from recycled mollusk shells and rocks that have been dumped into the harbor, although many spats within their reefs grow on man-made materials.

Second, the harbors of New York and New Jersey are still very dirty and continually receive a significant amount of contaminants from upriver sources. While oysters are able to filter out a number of organic contaminants, heavy metals and many endocrine-disrupting chemicals cannot be processed and may remain in the tissue or shells of oysters.[18] It is not yet known what impact an increase in oysters, a keystone species, will have on organisms further up the food chain in these polluted environments.

Third, materials seeded with spats offer varying levels of reef stability. For example, in some areas large piles of mollusk shells were dumped into the harbor and then seeded with oysters. As compared to bound and weighted bags of shells, these piles are more susceptible to foul weather, strong tides and human and non-human animal disturbances.

18 Mitra, Bartel, and Volety, "Trace Organic Contaminants (PAHS, PCBs, and Pesticides) in Oysters Crassostrea Virginica, from the Caloosahatchee Estuary and Estero Bay, SW Florida."

CASE THREE: GOWANUS CANAL RESTORATION PROJECT: "OYSTER-TECTURE"

Kate Orff, a landscape architect based in New York City, is interested in the reintroduction of mollusks to New York's waterways and has built a pilot project to test their cleansing power in one of America's most polluted urban waterways: the Gowanus Canal. The Gowanus Canal is a 2-mile canal in the borough of Brooklyn, New York that empties into New York Harbor. Once a major transportation route for industrial products, the canal remains stagnant, foul smelling and polluted with contaminants dumped into the water since 1869 by tanneries, chemical refineries and industrial mills. Hazardous pollutants include endocrine disrupting BPAs, PCBs, coal tar wastes, heavy metals such as copper, lead and mercury and other carcinogenic compounds. The Gowanus canal was added to the EPA's Superfund National Priorities list in 2010.[19]

Prior to establishing the Gowanus oyster reef rehabilitation project, Orff had participated oyster reef rehabilitation pilot projects in the Bronx River with scientists working with NY/NJ Baykeeper. In both the Bronx River and Gowanus projects, ribbed muscles were chosen to circumvent a regulatory issue, which prevents scientists from introducing non-native species into sections of the New York Harbor. Orff saw the promising

19 Environmental Protection Agency, *Gowanus Canal: Brooklyn, New York. EPA Record of Decision.*

results of the Bronx River pilot program and began designing a version to be submerged into the water of the Gowanus canal.

In consultation with biologists from Manhattan College, Orff developed a regular monitoring protocol to track the health and development of the muscles. At time of writing a detailed account of the project's success or failure in regards to muscle health and mortality is not known. A scientific investigation into the muscles' health will be undertaken in 2015. The New York government will then decide whether or not to allow and fund the development of larger and more comprehensive "oystertecture" infrastructure in the Gowanus canal.

COMMUNITY TIES

With both cost considerations and landscape literacy in mind, Orff chose a unique material to seed her spats, a material called "fuzzy rope." This inexpensive, flexible and easy to acquire material is hand-knit into a net structure- the industrious oyster, as well as other mollusks, can grow and propagate on the net. Orff intentionally designed her nets to be simple to make and held a "knitting party" in Brooklyn where community members were invited to come learn about the canal, the oystertecture project and participate in construction of the nets. Suspending the shellfish from nets along the sides of the canal may provide some level of protection for the ribbed muscles- the bottom of the Gowanus is covered in between 10 and 20 feet of toxic sludge and sediment.

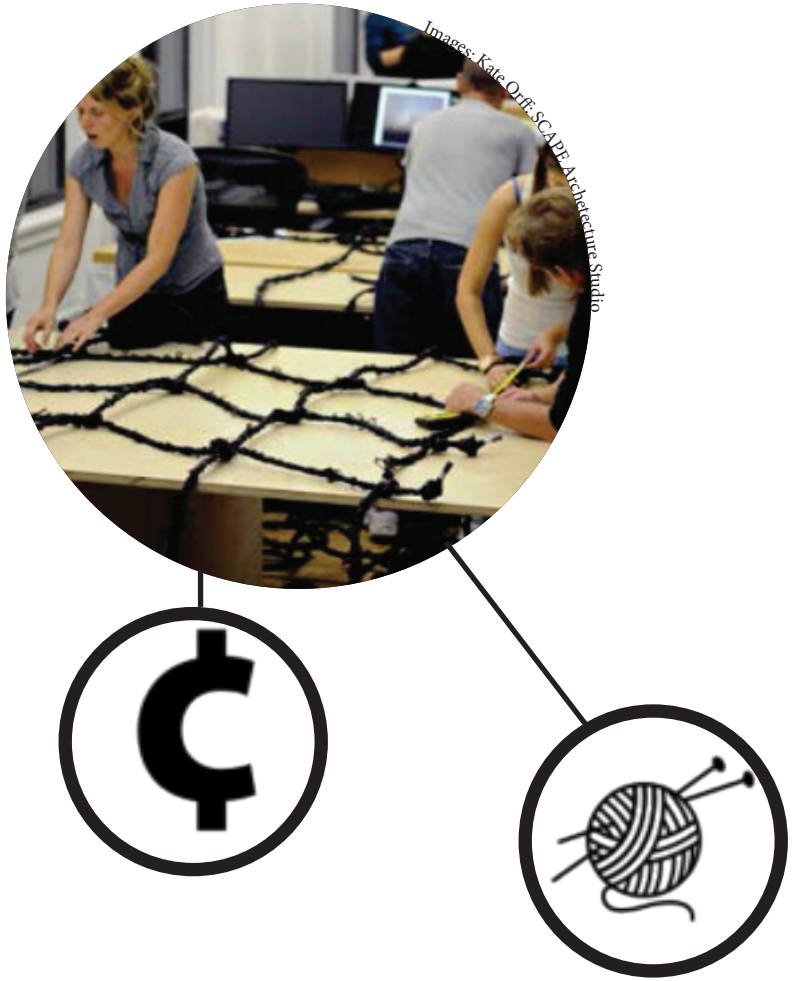

Figure 8: Fuzzy rope, a cheap, easy to aquire rope is knit into large panels by Brooklyn residents. The panels of knots will be used to seed mollusks in the Gowanus Canal.

SUCCESSES

While it is not yet known if the muscles are in good health or are successfully cleansing the waters around them, Orff's project has succeeded in further publicizing the many efforts to restore New York's mollusk reefs. Additionally, Gowanus is a small enough scale that a major difference in water quality can be undertaken with a relatively small investment into reef restoration. Finally, Orff's project is part of a larger, five-year, $506 million clean up plan spearheaded by the Environmental Protection Agency which will include dredging toxic sediment as well as increasing the biodiversity of the canal.[20]

CHALLENGES

A concern for many Gowanus residents, regarding the cleaning of the canal, is "green gentrification." Decades ago, the churning filter on the canal broke, causing waste to back up and stagnate. A canoe ride along the canal reveals seemingly endless amounts of trash bobbing in the water; the author's last paddle down the 2 miles of the Gowanus Canal took her through a sea of bottles, cans, plastic bags, slicks of iridescent oil, tied-off condoms, medical instruments and a bloated and floating rat upon which a family of maggots feasted- all within 25 meters of a small apartment block. Residents worry that with the cleaning of the canal will come higher rents; in response to plans to clean the canal, Wholefoods, an upscale supermarket, has purchased a nearby plot of land. Speculative developers have also purchased large, currently underutilized, plots of land for development.

Additionally, while the EPA and local officials do have a plan to clean the canal, it is currently so polluted and filled with organic and man-made toxins that if the muscles were to survive, there are concerns as to how their flesh would be incorporated into the ecology of Brooklyn. Native animals such as raccoons and seagulls eat mollusks and may be impacted by the pollutants. Similarly, humans may see the increased biodiversity and oyster health as a sign that it is safe to consume these organisms, mistakenly introducing the mollusks into their diet.

Critics such as Orff's former colleagues from a prior oyster restoration pilot project through the Hudson River Foundation, Reymond Grizzle and Loren Coen, argue that Orff's plans for the Gowanus are unreasonable because of the canals' complex toxicology, the instability of her proposed reefs in the face of storm surges and unaddressed regulatory hurdles regarding human interaction with the canal's oysters.[21]

20 Ibid.

21 Grizzle and Coen, "Slow Down and Reach Out (and We'll Be There)."

MOLLUSK REEF REHABILITATION

OPPORTUNITIES

In all three case studies, the driving forces behind the reef restoration projects have prioritized community engagement both for the purposes of garnering community support and for volunteer labor. Engaging locals in the history and restoration of their reefs leads to a greater understanding of the past, present and future of the area. Additionally, the creative sourcing of materials and labor kept costs low and opened up the possibility of wide and rapid mollusk plantings.

CHALLENGES

Oyster restoration projects undertaken anywhere in the United States should take into consideration several major challenges to their success.

First, government support, or at least indifference, is necessary to allow reef restoration projects to move forward. Engaging government entities for regulatory or financing purposes may propel the intervention forward more safely and smoothly, while opposition may, as in the case of New Jersey reefs, halt the restoration in its tracks. While the extreme government actions in New Jersey may be harmful to the scientific understanding of oysters' value in Atlantic waterways, the concerns around human health and wellbeing are legitimate. One under-discussed aspect of oyster reef restoration projects is its impact on human and non-human animals. Oysters and other mollusks hold onto toxins in their shells and tissue, which, upon their death, may be deposited back into waterways or be consumed by organisms higher up the food chain. While the government of New Jersey settled on an extreme end of the spectrum by banning all research to prevent potentially harmful consumption of unauthorized shellfish, there is a middle ground such as the research conducted by the university partners working to analyze shellfish development in the Gowanus Canal and NY/NJ Baykeeper pilot projects. While this research significantly slows the planting of oyster reefs, its cautious approach may keep humans and the local ecology safe.

Second, the hydrology of an area must be kept in mind when constructing stable reefs. The bags of oyster shells, metal and PVC buoys, and panels of fuzzy rope all respond to the hydrology of their locations to varying degrees of success. The slow moving tide in Withers Estuary provides a safe and stable place for spats to grow, where as the rapid movement of the Bronx or Hudson rivers would wash away the young oysters before they have the opportunity to develop on mesh bags. Likewise, Kate Orff's Gowanus project is under criticism from some scientists who claim the fuzzy ropes will be unable to withstand storm surges similar to the one that flooded south and central Brooklyn during hurricane Sandy- Orff's design keeps in mind the generally stagnant waters of the canal.

Finally, climate change is a threat to oystertecture's success. Rising water temperatures, especially during the winter

months, make oysters more susceptible to pathogens and parasites.[22] The planting of heterogeneous reefs that introduce a variety of mollusk types could protect the development and longevity of the restored tidal spaces.

22 Vogelbein, *Climate Change and Aquatic Animal Health in Virginia: Effects and Responses.*

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