REEFS OFF THE SHELF

READY-MADE SOLUTIONS FOR MAKING HABITATS AND BLUNTING TIDES.

BY KEVAN WILLIAMS

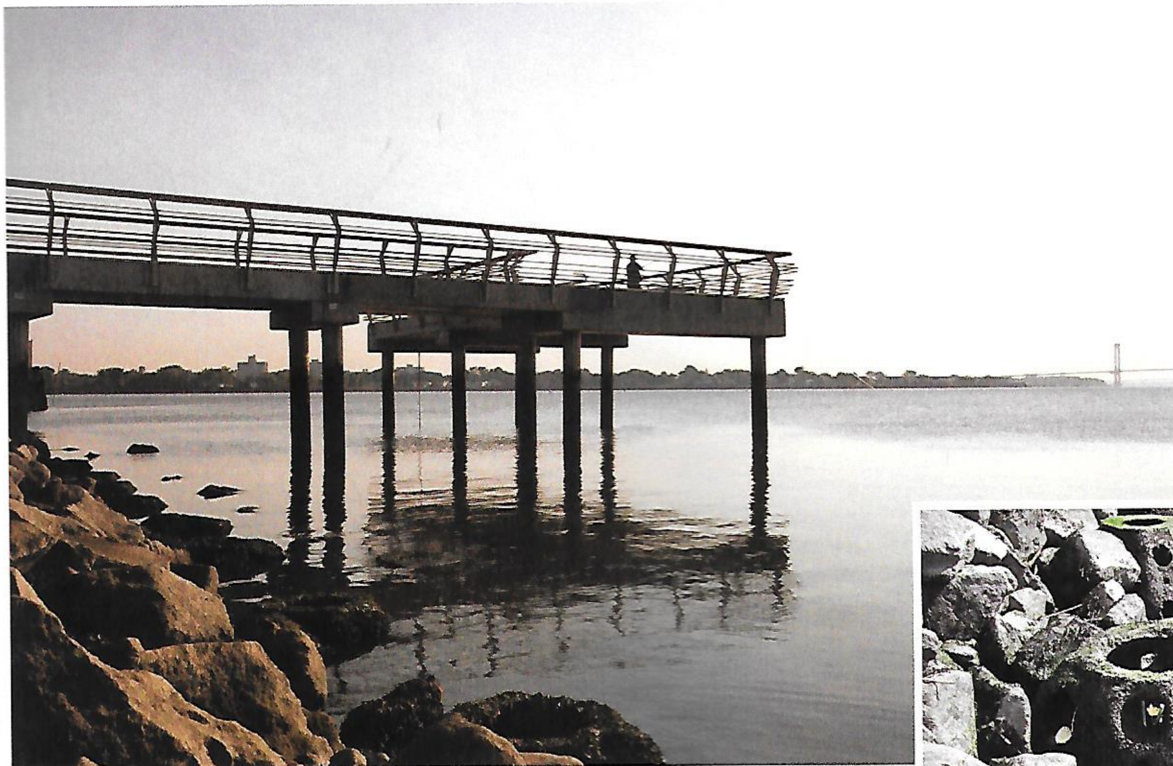
TOP
The surface and holes of artificial reefs are designed to encourage settling and growth of undersea plants and animals.

INSET
The largest reef balls weigh almost 7,000 pounds.

"Only the fish know they are there."

Barbara Wilks, the principal of W Architecture & Landscape Architecture, is talking about the artificial reef habitat structures next to the West Harlem Piers Park that her firm designed on the Hudson River. The domed structures are made of concrete and pierced with holes of varying sizes to provide safe refuge for fish. Wilks included the structures as a mitigation measure, to offset habitat lost by the construction of the park's namesake docks. "Other projects at the time, like the Queens West, used piles for mitigation," Wilks says. But those piles were considered unsightly by the neighborhood, which led Wilks to the more discreet domes, or reef balls. In hindsight, the West Harlem Piers project, recipient of an ASLA award in 2004, was an early step toward New York City's softer, greener shoreline, a vision that is now being championed by landscape architects and has gained increasing attention in the aftermath of Hurricane Sandy.

Projects like *On the Water: Palisade Bay* and SCAPE Landscape Architecture's "Oyster-tecture" proposal have reimagined New York City's waterways as lush environments where vegetated structures inspired by natural coastal ecosystems provide for flood control, storm protection, and cleaner water, replacing the hard edges of today's shoreline. "We were looking for softer infrastructures that were not the typical coastal



TOP
From the pier at Hunts Point Landing, park visitors can view wildlife inhabiting the structures and access a traditional fishing site.

INSET
Placed at the low-tide level, the reef balls also serve as an alternative to traditional breakwaters.

protection strategies," says Catherine Seavitt Nordenson, ASLA, a professor at the City College of New York's Spitzer School of Architecture and part of the multidisciplinary team behind *On the Water*. "There's a whole collection of things we used to create multiple layers of protection and redundancy," she says. Elements of the vision include a ring of new wetlands surrounding Lower Manhattan and a chain of artificial reefs in the upper New York harbor.

This interest in softer shorelines is also beginning to be reflected in federal shoreline policies. Nordenson points to a recent paper by the U.S. Army Corps of Engineers titled *Coastal Risk Reduction and Resilience: Using the Full Array of Measures* that argues for greater use of what the corps calls "natural and nature-based features," in addition to traditional hard infrastructure. "There's a very interesting shift in philosophy at the corps right now," she says.

Since West Harlem, other waterfront parks have been built that contribute to that vision of a softer coastline for New York. At Hunts Point Landing, a park on the East River in the Bronx, Mathews Nielsen Landscape Architects included several rows of reef balls as part of its design for the long, skinny park on a former street right-of-way. "The main reason that we used them was for oyster habitat. This section of the Bronx was historically—by Native American history—a wetland and was a very popular place for shellfishing," says principal Signe Nielsen, FASLA. The reefs are the last step in a gently descending sequence of wetland pools, excavated out of the once-steep riverbank.

"They also have a sidebar benefit of some wave attenuation," Nielsen says of the three lines of reef structures, which also serve as a breakwater, protecting the park. They performed well during Sandy, with no movement; however, the oysters they were to provide homes for have yet to arrive. "We're now two years in, and I can't say they're full of oysters yet," Nielsen says. "There does seem to be a water quality problem."

The Hunts Point reef is a small oasis in an inhospitable landscape of armored banks, providing a home to many crustaceans, including juvenile horseshoe crabs. But so far, it seems that no oyster larvae from the area's remnant oyster populations

→ have found the site. "We could plant oysters; in other words, give it a head start," Nielsen suggests, as a way to more quickly establish the Hunts Point oyster population. And though the oysters have been slow to arrive, Nielsen is optimistic: "Times are changing, and the East River is getting cleaned."

RIGHT
Though originally developed for coral reef restoration, reef balls are increasingly being used to develop and restore nearshore oyster habitat.

BELOW
Reef balls are being used to reestablish coastal mangrove forests in the Caribbean.

Artificial reefs for fish and oysters are part of a long history, going back millennia, of fishermen modifying habitat. But the artificial reef's modern history begins with junk. Since the 1960s and 1970s, people have been pitching just about anything into the ocean in the name of fish habitat: from smaller items like washing machines and tires to massive military hardware like the former USS *Oriskany*, a World War II aircraft carrier. And off the coast of Delaware, hundreds of New York City's iconic subway cars now form the heart of Redbird Reef, along with various tugboats, tanks, and barges. The federal government and several states also encourage the reuse of former oil derricks through "rigs-to-reefs" programs.

But these scrap metal reefs, though they do create habitat, have their drawbacks. Storms can shift the structures, creating hazards to navigation and damaging natural reefs. The Osborne Reef, built in the 1970s from two million tires, broke apart, scattering loose tires across the seafloor and triggering an expensive and slow-going cleanup process. Critics of these programs worry about the introduction of toxic materials into the ocean's food chain and the risks of corroding structures to divers.

As interest in artificial reefs and the funding for their establishment have grown, an increasing number of nonprofit and commercial manufacturers have emerged, developing products specifically for the purpose. Coral reef restoration was an initial focus, but product lines have expanded as interest in near-shore applications has taken off, and small demonstration projects have given way to more substantial commercial applications.

The designs of these products tend to come in two varieties, molded concrete or welded steel, and can overcome many of the drawbacks of reefs made from cast-off materials. Where the portholes of an old ship might have provided an unintentional niche for particular fish, these structures include openings and ledges scaled especially for target species. The surfaces of the structures can also be precisely textured, emulating natural coral and providing ideal sites for marine species to settle. Even the pH of the concrete units can be manipulated to better match the chemistry of the ocean.

THE REEF BALL FOUNDATION

TOP
To date, a total of six miles of ReefBLK structures has been installed along the Gulf Coast.

INSET
Each ReefBLK unit consists of a triangular steel frame containing bags of oyster shells.

The modular character of the units is also ideal for installation nearer to shore. "There are fairly limited, at least in the realm of landscape architecture, techniques and contractors for doing enhancements out in the aquatic habitat," says Steve Whitehouse, ASLA, of Starr Whitehouse Landscape Architects and Planners. The firm recently completed a design for a waterfront park at Hallets Cove in Queens that would include an artificial reef. The units can easily be molded on land and craned into place, a much more attractive option than working directly in the East River. "We came to the reef ball concept as a method that was feasible, that was manageable," he says, "and the construction of it was simple."

The reef ball, one of the more prevalent of concrete artificial reef structures, is the creation of the Reef Ball Foundation, a nonprofit group working globally on reef restoration projects. Founded in 1993, the organization has installed more than a half million of its units spread across 70 countries. Although initially focused on coral reef enhancement, the organization has expanded its range of products to include structures adapted to beach erosion control, oyster reef restoration, and restoration of coastal mangrove forests, with more than 20 different designs. "The sizes of reef balls range from a few pounds up to 7,000 pounds; we use the heaviest balls along coasts for breakwaters," says Kathy Kirbo, the executive director of the Reef Ball Foundation.

"We have a plant in Sarasota, Florida, that makes the molds and fabricates the reef balls for regional projects," Kirbo says, but community engagement is an important part of their mission as well. "That's really the beauty of the foundation and its work: The community involvement, the volunteers, and the kids...the kids are the real ambassadors," she says. The organization will often ship the molds to project locations and pour the reef balls on the site. "We like to train the locals how to do the work, so it stimulates the local economy," Kirbo says. "When we were designing the system to make reef balls we tried to use materials that would be available throughout the world to ensure that we could work anywhere." The organization also authorizes regional companies to supply its products, like the Roman Stone Construction Company, a New York-based manufacturer that fabricated the reef balls used at Hunts Point Landing.

An alternative to concrete structures like the reef ball are welded steel structures like ReefBLK. Each triangular "reefblock" unit, measuring five feet to a side, is composed of a steel frame that contains bags of oyster shells. Developed by Mark Gagliano, president of Coastal Environments, Inc., and his father, the ReefBLK is targeted more specifically at oyster growth and shoreline protection as opposed to offshore coral. So far, the company has installed almost six miles of reefs, with project sites along the gulf from Texas to Florida.

ABOVE
In a process called mineral accretion, an electric current encourages mineral deposits to grow around a steel frame.

Gagliano, a native Louisianan, got his start studying oyster farming. Traditional oyster culture in the Gulf of Mexico is what's known as "on the bottom culture," he explains. "They basically spread crushed oyster shell, crushed concrete, crushed limestone," he says. "I was more interested in how they were doing this in Australia and France—they were doing what's called 'off bottom culture.'" Experimentation with various forms eventually led to the development of the vertical ReefBLK structures. "There's a wall of oysters being held in suspension between these two metal frames."

And though the heavier concrete units have been similarly successful elsewhere, Gagliano believes his lightweight, steel structures are more appropriate for the challenging landscape of the Louisiana delta, pointing to previous efforts to protect shoreline with rock breakwaters. "Rock is not native to Louisiana; you're bringing a material down that doesn't exist here," says Gagliano. "You put them on sediment that can barely support a person to walk, you come back and the rock's sunk, so you put more rock," he says.

So far, the ReefBLK projects have been successful in protecting shorelines. "We started seeing a repeat pattern where, as the wave energy was breaking, the sediment that was suspended in the water column was falling out," Gagliano says. "In many of the projects we did, we started seeing considerable accumulation of sediment behind the units, to the point that it would convert the scarped bank line into a beach."

Another product, Biorock, takes the welded steel approach even further by applying a low-voltage charge to the metal, which invites limestone growth on the structure and improves coral health. "What we do is a living, growing structure; what everybody else does is a rusting, crumbling, and deteriorating structure," says Thomas Goreau, president of Biorock Technology, Inc. The current causes minerals suspended in seawater to stick to the steel structure, a process called mineral accretion. The architect Wolf Hilbertz, who developed the process, initially envisioned it as a way to grow building materials and structures for human habitation, producing an elaborate futurist vision for an island city called "Autopia Ampere," to be grown on top of a sea mountain in the western Mediterranean. The Biorock reefs haven't yet been used to form an entire island, but they do exhibit shoreline protection and creation benefits comparable to other artificial reef systems. As an example, Goreau points to a once rapidly eroding site in the Maldives. "We grew 50 feet of beach in a few years," he says.

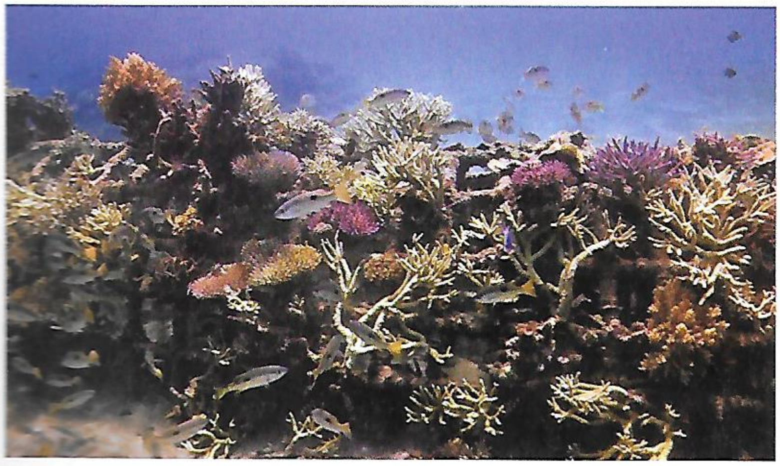
Hilbertz's ambitious utopian visions may never be realized (Hilbertz died in 2007), but the Biorock method does allow for a more creative approach to the form of artificial reefs, blending the best aspects of steel and concrete structures into a unique hybrid, with many opportunities for creating distinct configurations. At Pemuteran Bay, in Bali, the artificial reef is composed not of repeated identical units in neat rows but of a variety of shapes, including coral-encrusted ray and dolphin sculptures, as well as more abstract and undulating forms. "What we do is seascaping; it's landscaping underwater," Goreau says. And in places like Pemuteran Bay, where reefs bring snorkeling and diving ecotourists, that visually rich underwater landscape can be an added attraction that helps stimulate the local economy.

With rising ocean temperatures and changing ocean chemistry, coral reefs are increasingly stressed; bleaching

ABOVE
Welded steel structures are created on land, lowered to the seafloor, and implanted with coral fragments.

BELOW
Drawn by an electric current, corals rapidly colonize Biorock structures.

events that cause reefs to decline are becoming more common around the world. But Biorock's technique may offer some hope. "The electrical field that we're putting into these structures is doing something even more amazing biologically," Goreau says. "They have much higher rates of growth, branching, settlement, resistance to environmental stress, and survival," as compared to coral in other, unelectrified reefs. And coral on the electrified reefs can grow five times as fast as a natural reef.



Biorock, however, has an operational cost that other artificial reefs don't have. "We have to provide electricity; it is a limitation," says Goreau. But if the current does get turned off, whether because of cost, neglect, or storm damage, the reefs will behave like any other. "They won't have that benefit from climatic stress," Goreau tells me, but the effects can be reversed. "If you turn it back on, it starts working again right away."

Though Biorock hasn't had many commercial installations, despite hundreds of projects implemented through the nonprofit Global Coral Reef Alliance, which he also manages, Goreau is still optimistic about the future of artificial reefs. "We do see a huge commercial application, and we think landscape architects need to realize this is going to be a huge business; it's going to be forced on us by global warming and sea-level rise," he says.

And if large government entities like the Army Corps of Engineers begin encouraging the use of these kinds of products, he may be right. But with so many products and approaches emerging, each with its own strengths and drawbacks, it can be tough for designers and planners to determine the best approach. The potential for greenwashing in the industry is a concern for Gagliano. "You're starting to see big international firms that make big erosion-control products—they're coming over here," he says. "They slap a little adaptation on their product and say it grows oysters."

On the coast of Louisiana, several artificial reef products will soon be pitted against one another in a project known as the Living Shoreline Demonstration Project. The project will install 21 miles of artificial reef products along a stretch of coastline surrounding the Biloxi Marsh, in the eastern portion of the state. "We hope to use four or five different products," says Gasper Chifici, a project manager for the state's Coastal Protection and Restoration Authority (CPRA). "Since it's a demonstration project, we'd like for several miles of each of these to be used," Chifici says.

The demonstration project will provide the sort of empirical comparisons necessary as the state of Louisiana moves forward with its Coastal Master Plan, which identifies a number of sites along the coast for artificial reefs. That report, which evaluated and compiled previously proposed projects, will soon be updated. "We're working with different stakeholders, and over the next year we'll be developing a new set of projects," Natalie Peyronnin, a senior scientist with the CPRA, tells me. "I think moving forward, we will see a lot more of these incorporated as a restoration tool in the plan," she says. ●

KEVAN WILLIAMS IS PURSUING HIS MLA AT THE UNIVERSITY OF GEORGIA.