

# 有生命的防波堤 ——纽约沿海绿色基础设施

## LIVING BREAKWATERS — COASTAL INFRASTRUCTURE IN NEW YORK

SCAPE景观设计公司 / SCAPE Landscape Architecture DPC

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### 项目背景

纽约市在应对风暴方面面临着高度的不确定性，而斯塔滕岛恰好处于纽约湾的入海口，因而更易受到气候变化的影响。飓风等极端风暴事件及一般降雨日益侵蚀着海岸线。“有生命的防波堤”项目通过处理由极端事件导致的或长期积累的海岸侵蚀来降低海岸风险，以保护或拓宽海滩；同时削弱风浪，以提高安全性，并减少其对建筑物和基础设施的破坏。该项目还将帮助提升拉里坦湾水生生物栖息地的多样性——尤其是岩石或硬质结构栖息地，其功能与曾在该地区发现的牡蛎礁非常相似。最后，项目还提出有关海岸恢复和生态系统管理的教育专项活动，鼓励公众参与社区管理，推广公民科学，并开展娱乐、教育、研究和管理活动，让人们更加亲近水岸及近岸水域，并提升视觉上的联系。

### 公众参与

SCAPE景观设计公司<sup>①</sup>位于纽约，主要从事景观设计和城市设计，除在公共空间的

干预方面颇有声望外，其引发的关于建成环境、公共领域以及社会和环境公平的讨论更是影响深远且意义重大。SCAPE将景观设计拓展到各种形式的行动中，鼓励公众参与项目，旨在揭示设计方案如何融入自然的过程、循环和系统，以期为未来城市的塑造提供指导。SCAPE最新出版的《面向都市生态》<sup>[1]</sup>一书详细描述了这种设计方法，倡导设计师通过与基础设施系统、社区团体和政府部门间的协作，培养公众参与氛围，鼓励各方携手同心改变世界。在2009年于纽约现代艺术博物馆举办的题为“涨潮”的展览中，SCAPE针对纽约地区应对气候变化的措施进行了探索并提出了初步设计构想，“有生命的防波堤”理念即源于此。SCAPE在展览中提出“牡蛎结构2010”方案，旨在通过对生态的反思来重新构想纽约港复兴之策——将礁石和沙丘作为保护性基础设施，并与现有社会网络相连，协助重建这些系统。

2013年，美国住房和城市发展部（HUD）举办“为重建而设计”竞赛，意在探索飓风桑迪之后有关海岸恢复的前沿设计理念。为此，SCAPE进一步深化了上述初步方案，并建立模型、反复修改。“为重建而

### 摘要

我们如何将公众与其所处环境更直接地联系起来？如何在预测海平面上升和日益频发的风暴的同时修复水体，并将人们与海岸相连？“有生命的防波堤”是一个创新性的沿海绿色基础设施项目，是美国住房和城市发展部“为重建而设计”竞赛的获奖项目之一，意在为上述问题提供解决方案。该项目由纽约州政府风暴灾后恢复办公室实施，并获得了6 000万美元的社区发展补助灾后恢复专项资金。“有生命的防波堤”项目为拉里坦湾和斯塔滕岛量身设计，将水上基础设施与在岸教育和外展服务相结合，有助于降低灾害风险、提高生态系统稳定性，同时促进管理能力的培养。

### 关键词

生态设计；降低灾害风险；沿海基础设施；公众参与；滨水区；弹性

### ABSTRACT

How can we connect citizens more directly with their immediate environment? How can we anticipate rising sea levels and increasingly intense storms, but also revive waterbodies, and connect people to the shore? Living Breakwaters is an innovative coastal green infrastructure project that was selected as one of the winning projects of the U.S. Department of Housing and Urban Development (HUD) Rebuild by Design competition that aims to answer these questions. The project is being implemented by the New York State Governor's Office of Storm Recovery with 60 million USD of Community Development Block Grant Disaster Recovery (CDBG-DR) funding. Planned for the Raritan Bay and Staten Island, Living Breakwaters links in-water infrastructure with on-shore education and outreach, to help reduce risk, enhance ecosystems and foster stewardship.

### KEY WORDS

Ecological Design; Risk Reduction; Coastal Infrastructure; Civic Engagement; Waterfront; Resiliency

### 整理

田乐 孙一鹤 王颖

EDITED BY Tina TIAN

TRANSLATED BY Robin SUN Ying WANG

1. 防波堤的设计避开了濒危栖息地，而整合数个小型复杂结构，以为各类物种提供栖息地。

1. Breakwaters are designed to avoid critical habitat and integrate micro-complexity for a diversity of species.

**项目地址:**  
纽约市斯塔滕岛托滕维尔地区

**项目范围:**  
4km

**项目委托:**  
纽约州政府风暴灾后恢复办公室

**景观设计:**  
SCAPE景观设计公司

**项目费用:**  
6 000万美元

**首席设计师:**  
Kate Orff、Gena Wirth、Pippa Brashear

**项目合作:**  
SCAPE景观设计公司、纽约港口基金会、ARCADIS设计公司、海洋与沿海区域咨询公司、SeArc海洋生态设计咨询公司、Parsons Brinckerhoff工程与设计公司、LOT-EK鱼类监测公司、MFS投资管理公司、Prudent工程设计公司

**设计时间:**  
2013年至今

**建造时间:**  
2018-2020年

**所获奖项:**  
2015“为重建而设计”竞赛巴克敏斯特·富勒奖

**LOCATION:**  
Tottenville, Staten Island, New York

**AREA (SIZE):**  
2.5 miles

**CLIENT:**  
NYS Governor's Office of Storm Recovery

**LANDSCAPE ARCHITECTURE:**  
SCAPE Landscape Architecture DPC

**COST ITEM:**  
60 million USD

**CHIEF DESIGNERS:**  
Kate Orff, Gena Wirth, Pippa Brashear

**COLLABORATORS:**  
SCAPE, The New York Harbor Foundation, ARCADIS, Ocean and Coastal Consultants, SeArc, Parsons Brinckerhoff, LOT-EK, MFS, Prudent Engineering

**DESIGN PERIOD:**  
2013 to Present

**CONSTRUCTION PERIOD:**  
2018 - 2020

**AWARD:**  
Buckminster Fuller Award of 2015 Rebuild By Design Competition

- 2-1. 重新定义沿海地区的弹性  
2-2. 由SCAPE的Kate Orff撰写的《面向都市生态》
- 3-1. 该项目包含“有生命的防波堤”（即生态功能得到提升的防波堤，可搭建栖息地，在减弱海浪的同时实现牡蛎种群的恢复）、牡蛎养殖场、漂浮码头，以及为相关活动打造的活动中心。
- 3-2. “有生命的防波堤”削弱了风浪的高度，促进了海岸线上沉积物的沉降，有效保护了海边的社区，并将逐步减少存在已久的海岸线侵蚀，拓宽海滩。
- 2-1. Redefining coastal resiliency  
2-2. *Toward an Urban Ecology*, by Kate Orff, SCAPE.
- 3-1. The project will include Living Breakwaters (ecologically enhanced breakwaters that create habitat and support oyster restoration in addition to attenuating waves), oyster nurseries, a floating dock, and a Water Hub for related programming.
- 3-2. The Living Breakwaters reduce risk to communities on shore by decreasing the height of storm waves and by capturing sediment along the shoreline, reducing historic shoreline erosion and widening the beach over time.

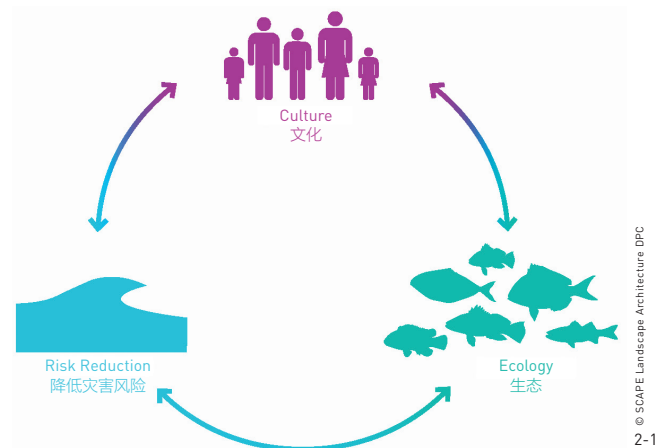
设计”竞赛为期一年，在此期间跨学科的设计团队与区域专家、政府实体、民选官员、非政府组织及当地社区团体合作，以为该地区受飓风冲击最严重的部分社区制定具有创新性的弹性方案。2014年6月，HUD公布获胜方案，“有生命的防波堤”成为获得HUD资金支持的6个项目之一。纽约州因此获得6 000万美元的社区发展补助灾后恢复专项资金来实施该项目。目前，“有生命的防波堤”项目正由纽约州政府风暴灾后恢复办公室实施。

## 分层策略

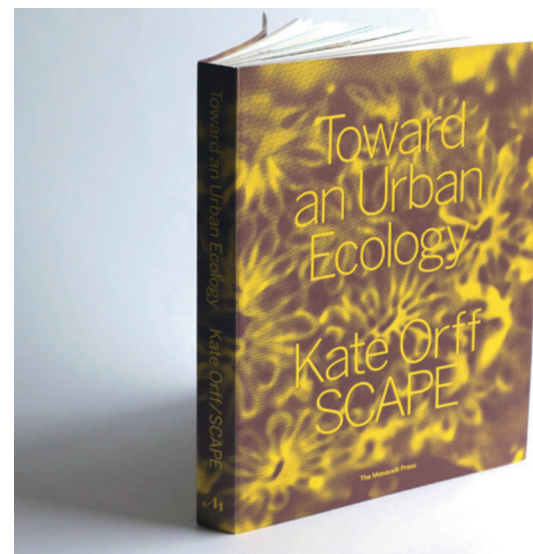
传统的沿海基础设施主要通过在人水之间建造堤坝等障碍来“保护”居民，这不仅阻隔了人们与海岸间的视觉联系，使人们难以亲近海岸，更可能加剧未来发生灾难性事故的可能性。而SCAPE的方案中所采用的防波堤策略则在降低灾害风险的同时，提高了对此类事故威胁的警觉性——它们并不将

海水阻隔在外，而是减缓水流，降低海浪冲击，促进沉积和海滩建设，这样的防波堤也成为一种对海上风暴强度的视觉警示。菲利普·奥顿利用ADCIRC/SWAN风暴潮和波浪模型系统对该策略进行了测试，结果显示在超级飓风桑迪期间，防波堤能够将海浪高度降低约0.9~1.8m。

“有生命的防波堤”超越了堤坝等功能单一的防洪基础设施，着重采用分层策略来降低风险，在缓和风暴中最危及生命和有害因素的同时，满足人们的日常亲水需求，并促进海岸线重建。该项目系统具有可复制性，构成其基础的“变化单元”具有多种用途——这一用于衰减波浪的链状防波堤，可减缓水流速度、减少侵蚀，有利于重建沿海栖息地，并通过具有教育功能的活动中心和全岛学校的参与来增强与沿岸社区的联系。“有生命的防波堤”系统适用于整个斯塔滕岛南岸，有助于与海水建立更为平和、安全和高效的关系。



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## 引导改变

尽管整个斯塔滕岛南岸均遭受着土地流失和侵蚀的威胁，其所涵盖区域的社区形态、土地利用方式和地理条件各不相同。因此，海岸线的每个区域或延伸地带的方案制定都需要因地制宜。“有生命的防波堤”提出了一个可复制的系统，使每个区域的设计均可优先考虑邻近社区的不同需求，包括海滨休闲、海滩拓宽、濒危生态系统保护、船只通航、渔业经济和贝类经济等。

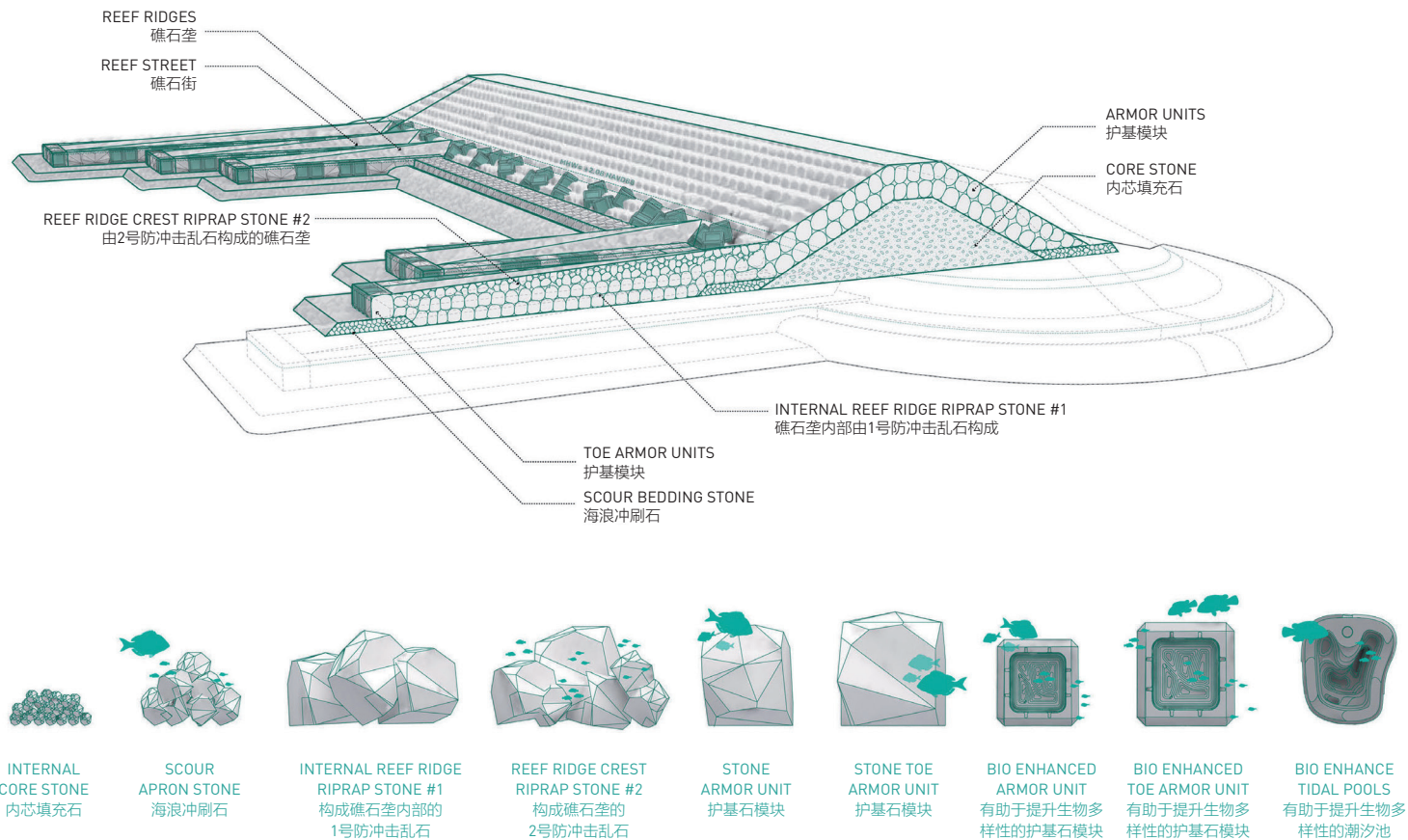
项目拟建于斯塔滕岛托滕维尔海岸沿线的拉里坦湾（下纽约港）海域。拉里坦湾是一个浅水入海口，曾推动了商业性渔业和贝类渔业的发展。但在过去的两个世纪中，由于过度捕捞和栖息地退化，其商业价值已消失殆尽。同样，托滕维尔海岸线也曾一度因丰富的水上娱乐项目而广受欢迎，但其在过去的几十年中遭受了高度侵蚀，部分原因可能是曾经占据大面积海湾的牡蛎礁已不复存在。牡蛎礁能够过滤水流，提高下海湾渔场的生物多样性和质量，缓解南岸因侵蚀严重而带来的波浪影响。斯塔滕岛的这一区域在超级飓风桑迪期间遭受了严重的浪损。

拉里坦湾和海滩的发展于斯塔滕岛岛民的身份认同和生计而言仍然至关重要。“有生命的防波堤”项目提出建立长约1200m的近岸“防波堤”系统，或在距岸边222~366m的海岸带建立部分水下结构，旨在缓和具有破坏性的风浪，减少或逆转长期的海岸侵蚀，通过建立目前拉里坦湾所缺乏的海洋栖息地结构来增强生态系统稳定性，并通过鼓励对海岸线和近岸水域加以使用和管理来增强社会应对风暴的能力。

## 提高生态恢复力

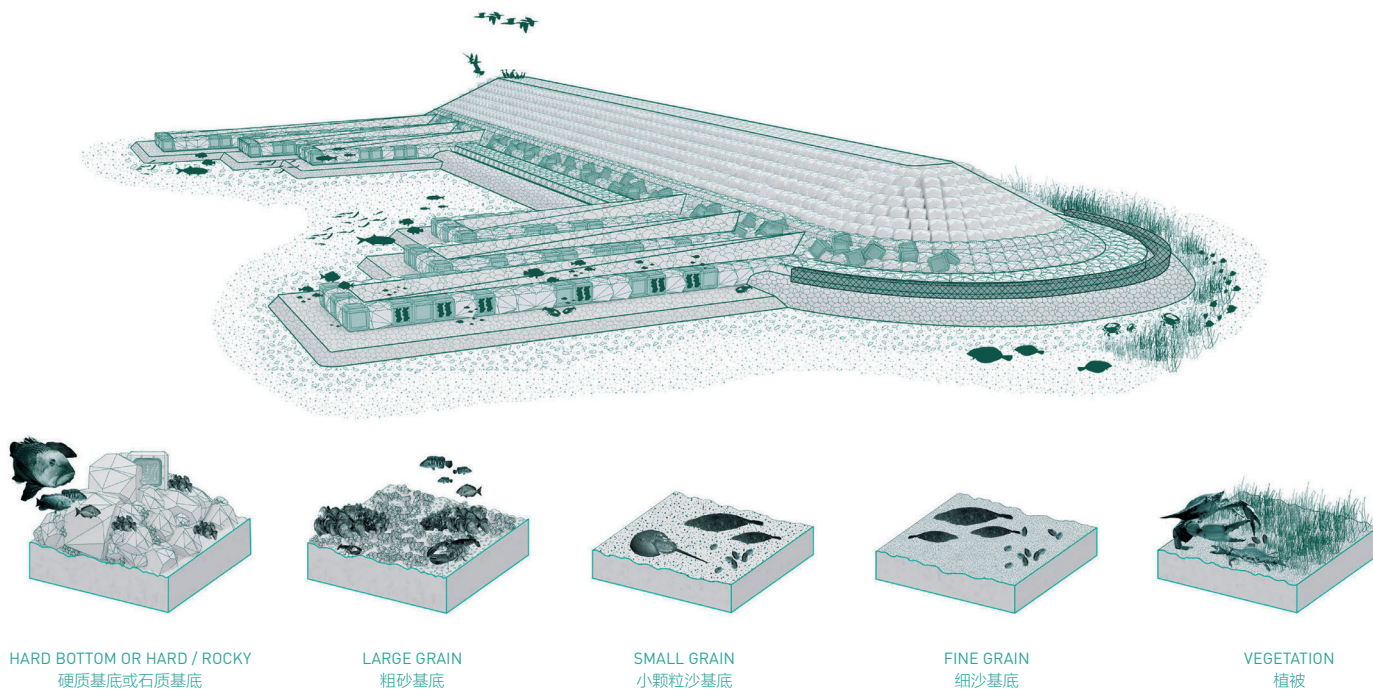
幼鱼在生长成熟游入大西洋之前，主要栖居于拉里坦湾。这其中的很多鱼类在生命的脆弱阶段均需要依赖岩石栖息地和微小孔隙空间的庇护。防波堤的设计能够最大限度地地为各类物种（如有鳍鱼类、龙虾和贝类）提供复杂结构和栖息地。一些被称为“礁石



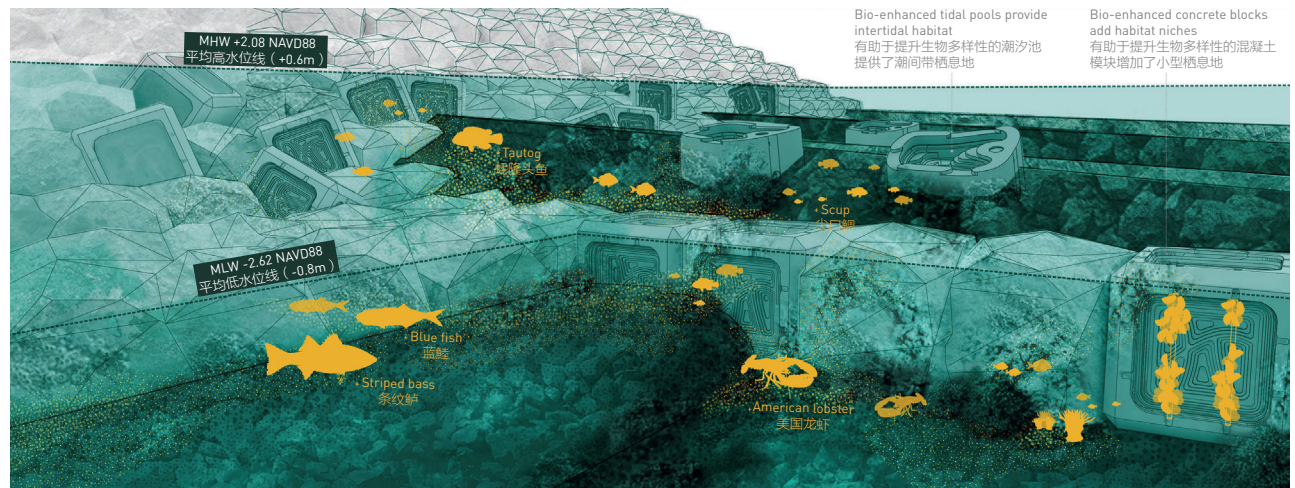
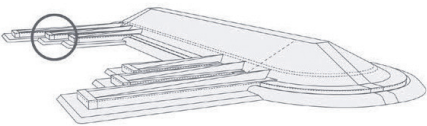
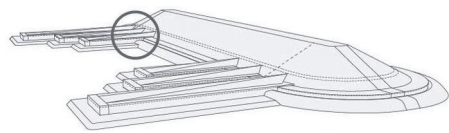


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- 4-1. 防波堤的建造材料包括岩石和应用于生物强化技术的混凝土。其外层经过特殊设计，能够吸引海洋物种，促进生物生长，提高防波堤的生态绩效。
- 4-2. 防波堤能够提供大量必要的水生栖息地，为生物活动提供场所，将牡蛎礁的恢复置于首位，呼应了现有区域规划的要求。
- 4-1. The breakwater will be constructed of combination of stone and bio-enhancing concrete. The outer armor layer is specifically designed to attract marine species and encourage biogenic buildup, enhancing the ecological performance of the breakwaters.
- 4-2. The breakwaters are designed to provide much needed aquatic habitat and support biologic activity, consistent with existing regional plans which identify oyster reeds as a restoration priority for this area.



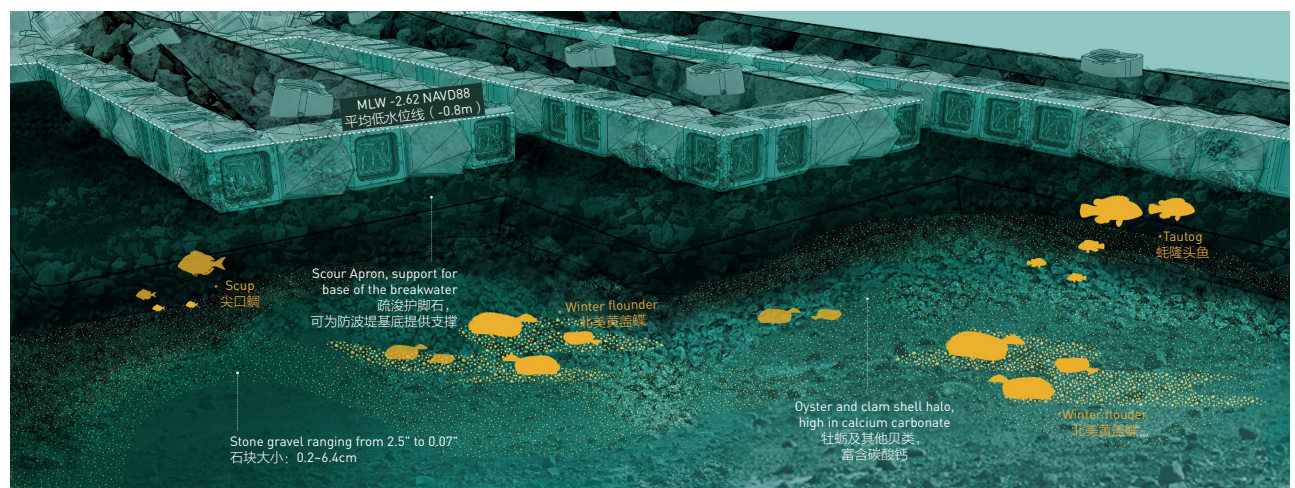
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Bio-enhanced tidal pools provide intertidal habitat 有助于提升生物多样性的潮汐池提供了潮间带栖息地

Bio-enhanced concrete blocks add habitat niches 有助于提升生物多样性的混凝土模块增加了小型栖息地

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Scour Apron, support for base of the breakwater 疏浚护脚石, 可为防波堤基底提供支撑

Stone gravel ranging from 2.5" to 0.07" 石块大小: 0.2-6.4cm

Oyster and clam shell halo, high in calcium carbonate 牡蛎及其他贝类, 富含碳酸钙

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- 5-1. 防波堤的潮间和潮下地带将为多种水生物种（包括鱼类、贝壳类和底栖无脊椎动物）提供多样而结构复杂的栖息地。
- 5-2. 据估计，由于海上构筑物周边的破损贝壳或其他碳酸钙碎片不断积累，毗邻防波堤的海底区域将形成更多的栖息地。

- 5-1. The intertidal and subtidal portions of the breakwater will provide diverse, complex structured habitat for a wide range of aquatic species including fish, shellfish, and benthic invertebrates.
- 5-2. It is anticipated that additional habitat will be generated on the seafloor surrounding the breakwaters due to the halo effect, defined as the accumulation of broken shells and other calcium carbonate fractions surrounding marine structures.

街”的复杂结构仿照过去拉里坦湾的礁石栖息地而建。生态混凝土结构和岩石为幼鱼提供了藏身之所，使其能够躲避其他物种的捕食，并在狭窄的具有保护作用的礁石街中觅食。

防波堤的设计避开了濒危栖息地，而整合数个小型复杂结构，以为各类物种提供栖息地。“有生命的防波堤”所提供的栖息地遍及由潮下带到陆上岛屿之间的整个水域。在水下，小规模礁石街与防波堤融为一体，为幼鱼提供觅食和掩蔽场所。在水面上，防波堤可为海豹和巢居鸟类提供不易遭受其他物种侵扰的栖息地。而其他一些钟爱底泥的生物（如大叶藻和厚蛤）则可以在防波堤背风处松软的沉积物中生长繁殖。

## 牡蛎幼虫的避风港

礁石和租赁的牡蛎养殖场曾广布于拉里坦湾的浅水层中，起到了减少风暴影响和净化水源的作用。历史影像记录了渔民在洛雷托山和柠檬湾附近海岸的租赁养殖场中收集牡蛎的场景，这里曾见证了南岸地区经济的迅猛发展。随着时间的推移，沉积、水体污染和航道疏浚等因素导致贝类种群不断减少，但目前海湾中重要种群的恢复工作正在稳步进行中。

重新恢复活力的牡蛎种群将有助于强化礁石系统，适应气候变化和海平面的不断上升，并净化富营养化的水体。该项目以海岸线为对象进行试验，以测试不同类型（包

括已经过验证的和正处于试验阶段的)恢复技术的效用。对于纽约市民而言,牡蛎或许是一种“迷人的麻烦”——由于港口水源被排放的污水所污染,牡蛎的质量很难得到保障。为此,方案提出通过监测策略与恢复技术双管齐下,防止牡蛎的非法捕捞。而针对牡蛎幼虫设置的生态混凝土结构可逐步促进牡蛎礁的生长。生态混凝土是由我们的合作伙伴——SeArc海洋生态设计咨询公司所开发的一种新材料,可通过表面纹理、混凝土配比和宏观设计来增强水下生物的修复能力。随着牡蛎的生长,其生物特性将促使碳酸钙沉积,从而巩固并延长人造基础设施的使用寿命。

## 海港课堂

牡蛎不仅是生态系统工程师,也可作为一种教育工具——人们对重视当地牡蛎养殖盛景的热情从未如此高涨。与本文所述方案相结合的“十亿牡蛎项目”期望通过长期的努力,为纽约港恢复十亿只活力满满的牡蛎,并培养千余名青年人参与纽约港的生态

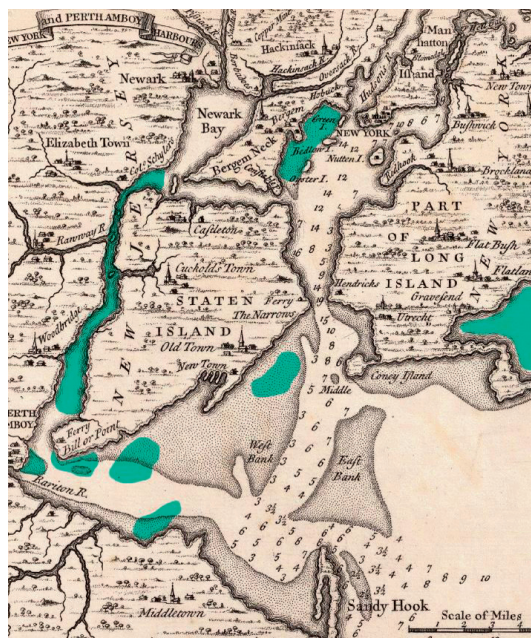
和经济重建。项目践行的首个可行性方案即是制作《牡蛎养殖手册》,以帮助学校将海岸线作为课堂展开教学工作。在“十亿牡蛎项目”和纽约港学校的协助下,斯塔滕岛的多所学校正在指导学生运用手册来监测整个项目区域牡蛎的生存、健康和增长率状况。该免费手册广泛分发于各个地区,项目的影响力因此不断扩大。

“有生命的防波堤”项目提议建立一系列可视化和程序化的户外教育空间,统称为“活动中心”。该中心包含各类陆上公共设施,为教育性项目、社区管理活动以及由当地社区团体运营的科学和监测工作提供场所。而得到“有生命的防波堤”项目直接支持的活动包括水产养殖教育、牡蛎恢复监测、水质检测和海洋通识教育,以帮助培养潜在的项目管理人员。

## 持续的管理

“有生命的防波堤”既是一项设计策略,也加深了社区交流。近海防波堤能够重建海滩,促进礁石生态系统修复,为沿海休

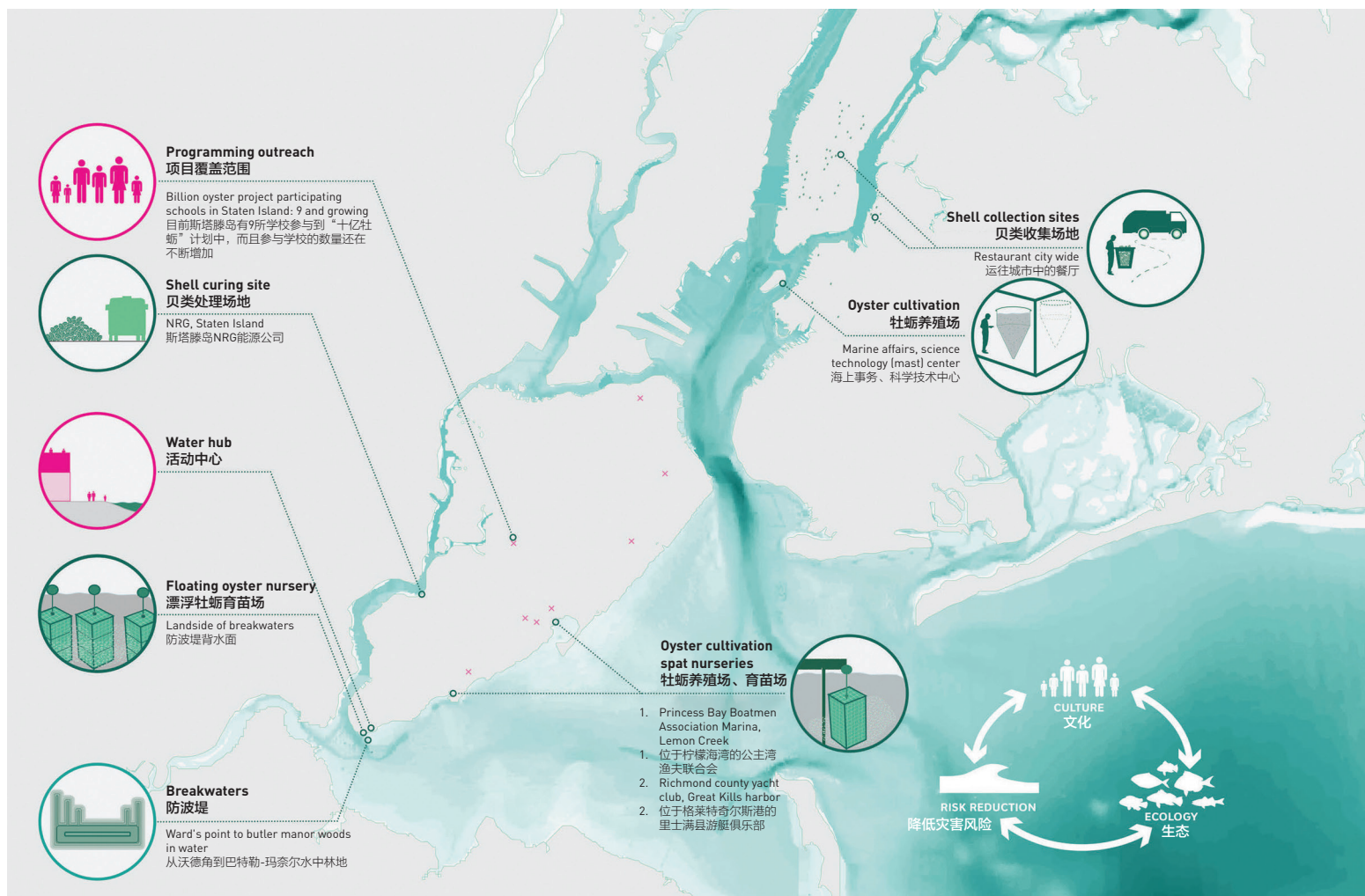
闲活动创造更为平静缓和的水体氛围。在岸上,针对社区而设计的活动中心将让人们切身感知海岸,并提供用水教育和海岸管理培训。社会、生态和物质环境的弹性是当代海岸基础设施建设过程中同等重要的因素。在项目的开发过程中,SCAPE团队与居民、捕蛤人、教育工作者、社区倡导者和海岸线使用者展开合作,不断修正和完善整个混合系统。在这一过程中,团队开发出了一系列独特的教学工具,包括制图、海岸考察、专家研讨和模型制作等,大大缓解了过去可能存在的邻避效应,以期建立共同的未来。项目也着重于为青年人开发教育推广工具,因为斯塔滕岛甚至全纽约市的孩子,未来都有义务参与到海岸线管理工作中。“有生命的防波堤”项目降低了灾害的风险,促进了生态恢复,并吸引教育工作者加入到海岸线的建设中,鼓舞青年一代参与港口管理,使之逐步成为一个更具弹性的区域。LAF



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① Please visit [www.scapestudio.com](http://www.scapestudio.com).

## Background

New York City faces a high degree of uncertainty when planning for future storms. Staten Island in particular is vulnerable to climate change threats due to its location directly at the mouth of the New York Bight. Extreme storm events, like hurricanes, and smaller everyday storms erode the shoreline. The Living Breakwaters reduce coastal risk by addressing both event-based and long-term shoreline erosion in order to preserve or increase beach width and attenuating storm waves to improve safety and reduce damage to buildings and infrastructure. The Living Breakwaters will also contribute to increasing the diversity of

aquatic habitats in Raritan Bay, particularly rocky / hard structured habitat that can function much like the oyster reefs that were historically found in this area. Finally, the project will provide programming activities around education on coastal resilience and ecosystem stewardship, foster and encourage community stewardship and citizen science, and increase physical and visual access to the water's edge and near-shore waters for recreation, education, research, and stewardship activities.

## Civic Engagement

A landscape architecture and urban design studio based in New York, SCAPE<sup>①</sup>

- 6-1. 图中绿色的区域表示历史上的牡蛎育苗场。
- 6-2. 一幅有关在普林斯湾捕捞牡蛎场景的画作
7. 牡蛎种群的恢复是“有生命的防波堤”项目的重要组成部分。除在防波堤上设置的装置外，该举措还包含牡蛎养殖活动（如孵化和远程控制）、贝壳收集与养护，以及牡蛎育苗场等。

- 6-1. The green areas represent the oyster nurseries in history.
- 6-2. A painting about oystering at Prince's Bay
7. Oyster restoration is an important component of the living breakwaters project. In addition to installations on the breakwaters themselves, this includes oyster cultivation activities (such as hatching and remote setting), shell collection and curing, and the installation of oyster nurseries.

is celebrated not only for its interventions in public spaces but also for the far-reaching and meaningful debates it engenders about the built environment, public sphere, and social and environmental justice. SCAPE has expanded landscape architecture into various forms of activism, creating projects shaped by collective engagement and revealing how embedded natural processes, cycles, and systems can help shape the cities of the future. The firm's new book *Toward an Urban Ecology*<sup>11</sup> describes this approach in detail and advocates that designers cultivate an ethos of civic participation by engaging with infrastructural systems, community groups, and government to empower all parties to help change the world. Living Breakwaters grew out of initial ideas explored by the SCAPE office in 2009 in a study of the New York region's response to climate change in an exhibit at the Museum of Modern Art titled *Rising Currents*. SCAPE's proposal, "Oyster-tecture, 2010" reimagined a revitalized New York Harbor driven by rethinking ecology in the form of reefs and dunes as protective infrastructure and linking to existing social networks to help regenerate these systems.

This concept was further developed, modeled, modified, and then further explored in the context of the the Rebuild by Design Competition, a design competition held by the U.S. Department of Housing and Urban Development (HUD) in 2013 to seek cutting-edge ideas for coastal resilience in the wake of Hurricane Sandy. The Competition was a year-long process during which interdisciplinary design teams engaged with regional experts, government entities, elected officials, nongovernmental organizations, and local community groups to develop innovative resilience proposals for some of the most impacted communities in the region. HUD announced the winning proposals in June 2014, and Living Breakwaters was one of the six projects

selected for HUD funding. As a result, New York State was awarded 60 million USD in Community Development Block Grant — Disaster Recovery (CDBG-DR) program funds to implement the project. Living Breakwaters is being implemented by the New York State Governor's Office of Storm Recovery.

### The Layered Approach

Conventional coastal infrastructures that "protect" inhabitants by erecting a barrier between people and water, like levees, ultimately sever our visual and physical relationship to the shore and potentially exacerbate the potential for catastrophic failure in the future. Breakwaters reduce risk while increasing awareness of these threats — they do not keep the water out; rather, they slow water, reduce wave action, encourage sedimentation and beach-building, and serve as a visual reminder to the intensity of the ocean. Philip Orton tested the strategy with the ADCIRC / SWAN storm surge and wave modeling system, showing that exposed breakwaters would have reduced wave heights approximately 3 ~ 6 feet during Superstorm Sandy.

Living Breakwaters is a proposal to move beyond single-use flood infrastructure, like levee walls, and focus on a layered approach to risk reduction, mitigating the most life-threatening and hazardous elements of a storm while encouraging water access and shoreline regeneration on a daily basis. The project is a replicable system where the infrastructural "unit of change" is multipurpose — a necklace of wave-attenuating breakwaters that reduce water speeds and slow erosion, designed for maritime habitat regeneration, and connected to onshore neighborhoods through an educational Water Hub and island-wide school engagement. The Living Breakwaters system adapted to the entire



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8. “牡蛎构筑”计划涉及水质、海平面上升、社区行动等议题，旨在重扬“礁石文化”，并在消减风暴灾害影响的同时鼓励公众与水亲近。
8. Engaging issues of water quality, sea level rise, and community-based action, the Oyster-tecture project aims to restart a “reef culture” that fosters public life near the water's edge while mitigating future storm events.

South Shore of Staten Island, envisioning a calmer, safer, and more productive relationship with water.

### Piloting Change

While the entirety of the South Shore of Staten Island is threatened by coastal land loss and erosion, it contains distinct and varied neighborhoods, land uses, and geophysical conditions. Each reach, or stretch, of shoreline requires a unique and adaptive approach. Living Breakwaters proposes a replicable system, where each reach is designed to prioritize different needs of the adjacent community, including waterfront recreation, beach growth, critical ecosystem protection, boat access, and fishing and shellfishing economies.

The project will be located in the waters of Raritan Bay (Lower New York Harbor) along the shoreline of Tottenville, Staten Island. Raritan Bay is a shallow estuary that has historically supported commercial fisheries and shellfisheries which have been depleted through overharvesting and habitat degradation over the last two centuries. Similarly, the Tottenville shoreline was once a vibrant destination for water-based recreation, but has suffered from high rates of erosion over the past decades, likely due in part to the loss of the extensive oyster



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reefs that once covered much of the bay, filtering water, enhancing the biodiversity and quality of the fisheries in the lower harbor and buffering the south shore from erosion-causing wave action. This area of Staten Island experienced significant wave damage during Superstorm Sandy.

The Raritan Bay and beach experience remain essential to the identity of Staten Islanders and their livelihoods. Living Breakwaters proposes a 4,000 linear foot long (approx.) system of near-shore

- 9. 海港课堂
- 10. 斯塔滕岛牡蛎养殖手册

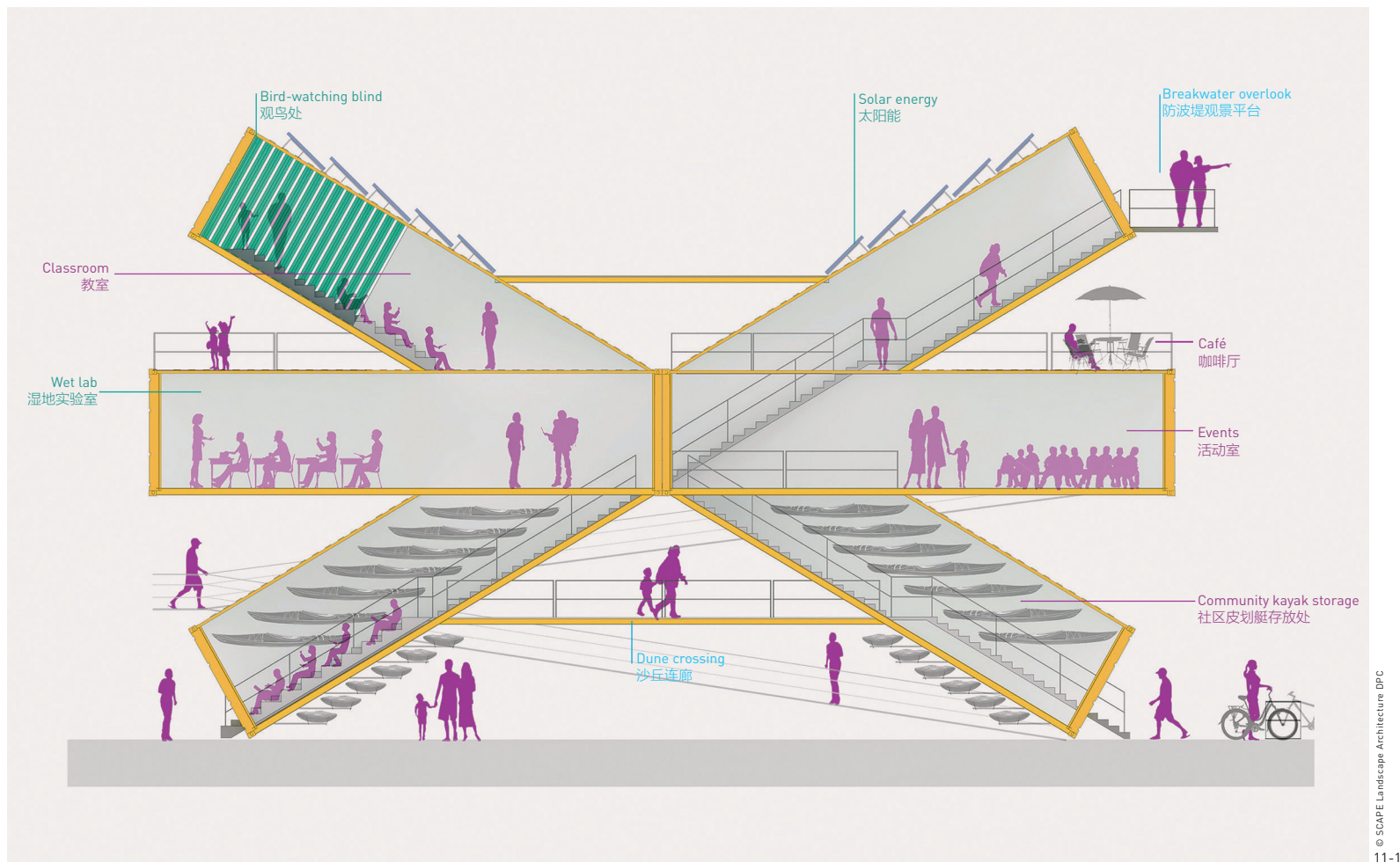
- 9. The harbor as classroom
- 10. Staten Island Oyster Gardening Manual



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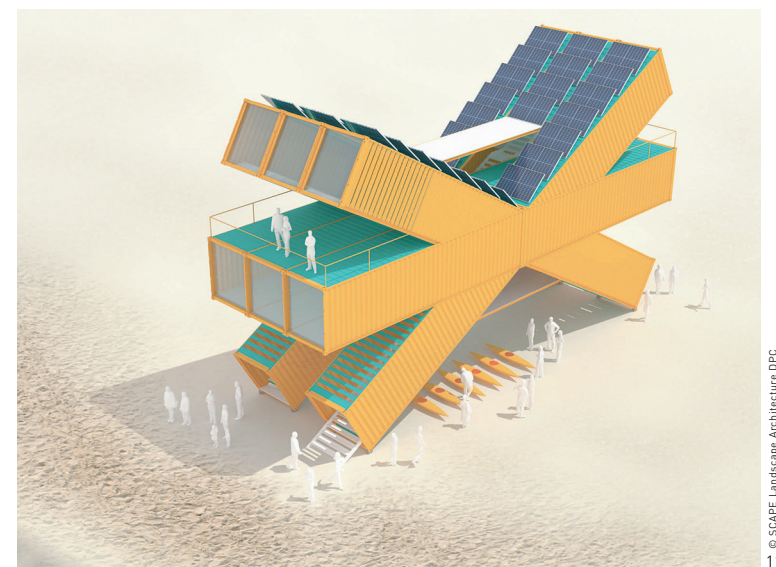
“breakwaters,” or partially submerged structures located between 730 and 1,200 feet from shore, designed to attenuate damaging storm waves, reduce or reverse long-term coastal erosion, enhance ecosystems by creating structured marine habitat currently lacking in the Raritan Bay, and foster social resilience by encouraging the use and stewardship of the shoreline and near-shore waters.

### Growing Ecological Resiliency

Raritan Bay is prime habitat for juvenile fish which grow to adult size in the bay

before venturing out into the Atlantic Ocean. Many of these fish species require rocky habitat and tiny pore spaces for shelter during this vulnerable phase of life. The breakwaters are designed to maximize complexity and habitat for a diversity of species, including finfish, lobsters, and shellfish. Pockets of maximum complexity, called “reef streets,” mimic the historic reef habitats of Raritan Bay. Juvenile fish will be able to hide from predators in the extensions of EConcrete and stone and will feed in the narrow and protected reef streets.

Breakwaters are designed to avoid critical habitat and integrate micro-



complexity for a diversity of species. Living Breakwaters provides habitat throughout the water column, from subtidal structure to upland islands. Underwater, small-scale reef streets are incorporated into the breakwater and provide foraging and shelter for juvenile fish. Above water, the breakwaters can host harbor seals and nesting birds, again providing habitat away from predators. Other species, such as muddy bottom-loving eelgrass and hard clams, thrive in lightly sedimented zones in the lee of the breakwater.

### A Sanctuary for Spat

Reefs and leased oyster beds once extended across the shallow-water flats of Raritan Bay, reducing storm impacts and filtering water. Historic images show

fishermen tonging for oysters in leased beds along the coast of Mt. Loretto and Lemon Creek, once a critical economy of the South Shore. Over time, shellfish populations declined due to sedimentation, water contamination, and channel dredging, though efforts are underway to restore this keystone species to the harbor.

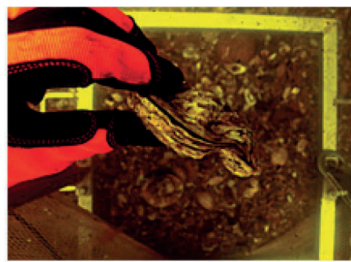
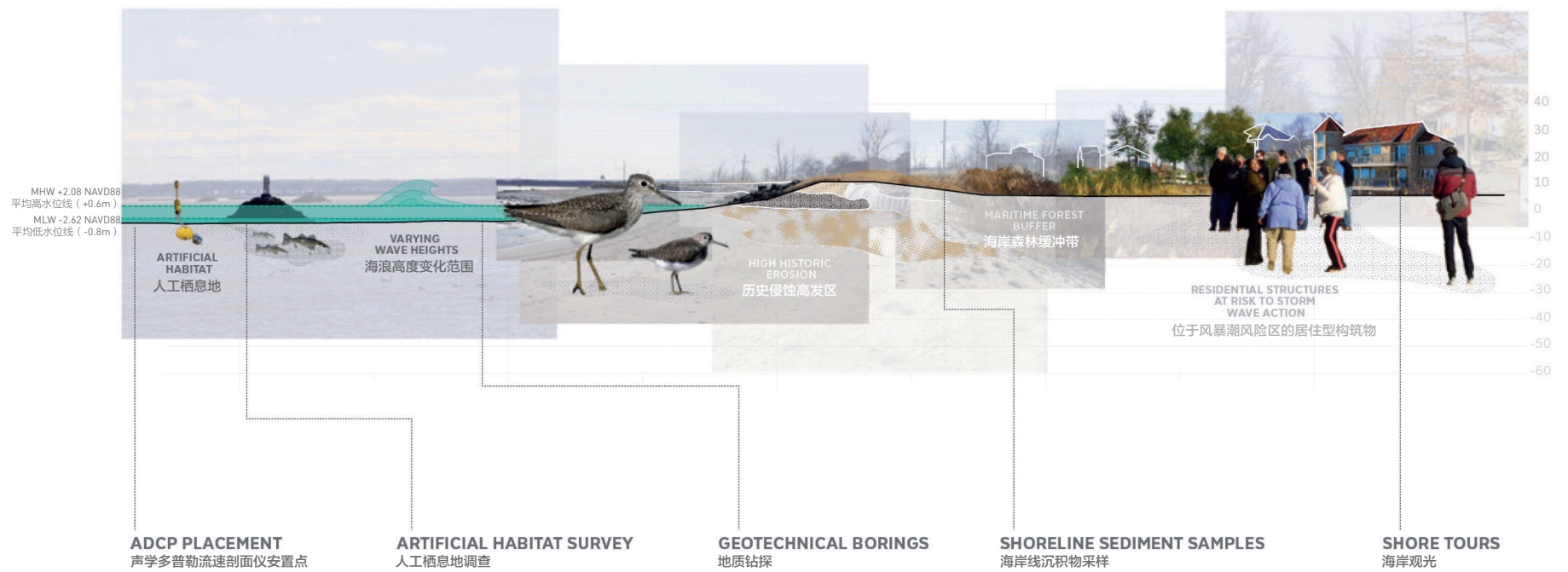
A rejuvenated oyster population would help strengthen the reef system, adapt to climate change and sea level rise over time, and filter nutrients out of the water. The breakwaters are a shoreline-scale experiment to test multiple types of restoration techniques, proven and experimental. In New York City, oysters are considered an attractive nuisance, as the harbor water is contaminated by sewage discharges and oysters are not safe for consumption. To prevent the

11. 活动中心包含各类陆上公共设施，为教育项目、社区管理活动以及由当地社区团体运营的科学和监测工作提供场所。
11. Water Hubs are on-shore public facilities to house educational programs, community stewardship activities, and science and monitoring efforts run by local community groups.



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11-3



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illegal harvest of oysters, surveillance strategies are designed in tandem with restoration techniques. EConcrete units set with oyster spat will catalyze oyster reef development through time. EConcrete is a new material developed by our partners at SeArc Consulting that enhances underwater biological recruitment through surface texture, concrete composition, and macro-scale design. As oysters grow, they biogenically build calcium carbonate deposits, strengthening and extending the lifespan of the man-made infrastructure.

### The Harbor as Classroom

Oysters are ecosystem engineers, but they are also an educational tool — enthusiasm for oyster restoration has never been higher. The Billion Oyster Project is a long-term initiative linked to this proposal to restore one billion live oysters to New York Harbor and train thousands of young people to restore the ecology and economy of New York Harbor. As a first, actionable step, the team created an Oyster Gardening Manual to help schools use the shoreline as a classroom. With the help of the Billion

- 12-1. 项目进行了大量的数据收集和现场调研，以更好地了解场地，使设计结合自然。
- 12-2. 各类教育活动也是“有生命的防波堤”项目的重要组成部分，居民和游客可以更加亲近海岸，同时学习与海岸恢复和生态修复举措相关的知识，更多地参与到海港的管理中。
- 12-3. 项目包含多项公共延展服务，以吸引更多利益主体的参与，包括召开公开会议和社区咨询委员会会议，组织漫步海岸、海岸清理等活动，此外还包括在斯塔滕岛及整个城市范围内举办活动，在会议楼公园中举办展览，以及联合学校开展项目等。
- 12-4. 教师培训

- 12-1. Extensive data collection and site surveys have been undertaken to better understand the project site and be able to design with nature.
- 12-2. Programming and education are a critical part of the Living Breakwaters project, enabling residents and visitors to engage with the shoreline, learn about resiliency initiatives and ecological restoration activities, and become stewards of the harbor.
- 12-3. Public outreach and engagement of diverse stakeholder groups has included not only public meetings and Community Advisory Committee meetings, but also community beach walks and clean ups, tabling at Staten Island and city-wide events, an exhibition at Conference House Park, and school outreach programs.
- 12-4. Teacher training

Oyster Project and the New York Harbor School, multiple schools in Staten Island are using the manual to monitor oyster survival, health, and growth rate throughout the project area. The manual is a free and widely distributed pamphlet that extends the project's influence far beyond its physical extents.

Living Breakwaters proposed a network of visible and programmed physical outdoor education spaces, called Water Hubs, which are on-shore public facilities to house educational programs, community stewardship activities, and science and monitoring efforts run by local community groups. Programming directly supported by the project includes education on aquaculture, oyster restoration monitoring, water quality testing, and general marine education that will help train potential project stewards for the future.

### Continued Stewardship

Living Breakwaters is equal parts design strategy and community conversation. Offshore breakwaters have the power to rebuild beaches and catalyze reef ecosystems, creating slower and calmer water for recreational purposes. On shore,

community-designed Water Hubs will provide a physical and perceptual link to the shore, creating a venue for water education and shore stewardship. Social, ecological, and physical resiliency are considered as equally critical elements of contemporary coastal infrastructure. Throughout the development of the project, the SCAPE team worked with neighbors, clambers, educators, community advocates, and shoreline users to revise and develop the hybrid system. A unique range of pedagogical tools were developed — including graphics, shore tours, charrette sessions, and models — to move past potential reactive “not-in-my-backyard” conversations and toward establishing a collective future vision. Particular attention went towards developing educational outreach tools for youth, as Staten Island's and all New Yorker's children will be responsible for shoreline stewardship of the future. The Living Breakwaters project reduces risk, revives ecologies, and connects educators to the shoreline, inspiring a new generation of harbor stewards and a more resilient region over time. **LAF**

### REFERENCE

- [1] Orff, K. (2016). *Toward an Urban Ecology*. New York: The Monacelli Press.



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