The Oyster Opportunity

Uncovering Solutions That Drive Reef Restoration In The Gulf Of Mexico

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by Future of Fish

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"The oyster fisheries of the Gulf of Mexico need to be managed for what they represent: likely the last opportunity in the world to achieve both large-scale reef conservation and sustainable fisheries."

—Shellfish Reefs at Risk: A Global Analysis of Problems and Solutions

EXECUTIVE SUMMARY

Oysters from the Gulf of Mexico were once named for the bays where they grew wild. Their abundance provided irreplaceable filtering, shoreline stabilization, habitat for juvenile fish, not to mention food and livelihoods for people. Today, that once-plentiful resource, and all it represented, is desperately depleted. In the U.S. and around the globe, an estimated 85 percent of oyster reefs have been lost.

In almost every coastal region across the country, dedicated organizations and tireless volunteers are working to reestablish viable oyster beds. Most projects are small scale, labor-intensive, high cost, and high risk. Scaling these efforts to a level that can meet the enormous need for restoration nationwide poses significant financial and logistical barriers.

The National Fish and Wildlife Foundation (NFWF), a long-time and primary investor in oyster restoration, commissioned Future of Fish to analyze the current state of oyster restoration in order to identify opportunities to reduce costs, increase efficiency, spur entrepreneurship, and leverage other non-conventional approaches that could drive and sustain large-scale restoration. Our launching point was this question: How can we drive more successful and efficient oyster restoration in the Gulf of Mexico?

The objectives of this project were to:

- survey the restoration projects funded by NFWF, as well as external projects, and distill from those a framework for understanding the full breadth of problems encountered and the attributes that distinguish successful solutions;
- recommend potential grantmaking strategies, which may enhance the effectiveness and efficiency of restoration efforts going forward (see Appendix I);
- identify opportunity areas that outline possible next steps to scaling, particularly options that include market-driven mechanisms, and where the NFWF could help invent and incubate a new solution.

Through the course of the study, we reviewed grant proposals and reports from 65 NFWF-funded restoration projects, and interviewed over 30 experts in the field. We solicited information about the challenges faced by restoration programs, and the innovative ways those challenges have been overcome. We identified more than 50 unique problems and 50 distinct solutions and clustered them into related themes. We then looked for patterns that pointed to overarching problems (Barriers) and the underlying strategies (Design Principles) used to solve them.

The four Barriers identified were:

- **Inconsistent policy:** Laborious permitting processes and obstructive laws hinder efforts to restore oyster reefs.
- **Resource scarcity:** Material costs, labor needs, and logistical challenges impede cost-effectiveness and scaling.
- **Inadequate planning for environmental factors:** Failure to properly assess sites and insufficient accounting for human and natural risks threaten project success.

- **Fragmented management:** Lack of information-sharing among projects creates cycles of inefficiency and redundancies that inhibit widespread progress.

The four Design Principles identified were:

- **Use what you've got:** Build on existing resources and relationships.
- **Share, share, share:** Develop ways to collect and share past successes and failures so future initiatives become more efficient and effective.
- **Find a champion:** Recruiting a person, organization or team to take ownership of a project can often single-handedly overcome an ostensibly insurmountable challenge.
- **Add spin:** Find ways to create public messaging with context, crafting, and follow-up to motivate people to care about oysters.

These Barriers and Design Principles create a Discovery Map, which includes organizational profiles for 53 projects and programs that employed unique solutions to overcome restoration challenges. From our observations we inferred the following System Insights:

- Policymakers and permitting agencies impede restoration to the detriment of their jurisdictions. (A summary of friendly and hostile policy and permitting practices related to oyster restoration can be found in Appendix II.)
- Many projects cite the ecosystem service benefits provided by their restoration projects, but no one has found a way to capitalize on this added value.
- Project resource management—simply pulling together the logistical and human components for reef restoration—is dauntingly complex. Best practice standards could go a long way in assisting first-time organizers. (As an example of how such BMP might be communicated, Appendix III outlines recommendations for attracting, motivating, rewarding, and retaining volunteers.)
- Organizations engaging in restoration projects don't have a collaborative platform for sharing ideas, insights, and experiences.
- Community support from citizens, businesses, and local government is critical to project success.

These insights led us ultimately to a set of seven Opportunities, each with the potential to shift the oyster restoration landscape toward greater efficiency, reduced costs, and scalability. These Opportunities included two strategies for enhancing existing restoration efforts, three market mechanisms for driving change, and two policy initiatives to support and incentivize restoration.

- **Opportunity 1: Expand the support base for restoration activities** by creating a national platform to connect local and regional restoration initiatives.
- **Opportunity 2: Facilitate information-sharing among restoration projects** through a single open-source, online collaboration and information-sharing tool.
- **Opportunity 3: Pair industry and restoration** in a way that taps into underutilized resources and builds on infrastructure and knowhow that exists in other industries.
- **Opportunity 4: Turn oyster farmers into reef stewards** by using sales of specially branded oysters to effectively generate restoration funds, raise public awareness, and bring higher profits for growers.
- **Opportunity 5: Name a new value and develop a market for it** through the use of environmental impact bonds or other strategies that use economic valuation to develop new funding vehicles.
- **Opportunity 6: Streamline the permitting processes** to significantly accelerate the initiation of projects, save time and money, and encourage more organizations to pursue restoration activities.
- **Opportunity 7: Increase the supply of shell to decrease the cost of restoration** by enacting widespread shell recycling and recovery legislation and launching related businesses.

Of the seven opportunities identified, we choose four paths (Opportunities 2, 3+7, 4 and 5) that we believe are both feasible and have potential to deliver significant impact. These opportunities have the greatest promise for serving NFWF's restoration priorities, and deserve consideration for deeper evaluation in a subsequent phase of work with Future of Fish and other partners.

Photo: Chesapeake Bay Program

“I’ve always been interested in living structures that provide support for a whole galaxy of living organisms.”

—Betsy Peabody, Executive Director
Puget Sound Restoration Fund

INTRODUCTION

Oysters from the Gulf were once named for the bays where they grew wild: *Grand Bayou, Bayou Cook, Lake Washington, Lake Grande Ecaille*. Their flavors ran salty, grassy or sweet based on the unique "meroir," the distinctive blend of water salinity, mineral content, and other attributes absorbed from their reef homes. Their abundance provided irreplaceable filtering of delta waterways and the Gulf itself, shoreline stabilization, high-quality habitat for juvenile fish and crustaceans, and the foundation for ecosystems in which other flora and fauna could thrive, not to mention providing food and livelihoods for humans. Today, that once-plentiful resource, and all it represented, is desperately depleted. Estimates are that less than 20 percent of the Gulf's historical oyster population remains. Shockingly, these are some of the most robust reefs we have left. Oysters in the Chesapeake Bay are down to 1 percent of former abundance, and around the globe, 85 percent of oyster reefs have been lost.

Despite these dramatic declines, many suggest that the Gulf of Mexico is the last place in the world where significant reef restoration, conservation, and sustainable harvest of wild oysters might still be possible. As such, the National Fish and Wildlife Foundation (NFWF), a long-time and primary investor in oyster restoration, has drafted a ten-year recovery plan for reversing oyster decline in the Gulf, with three main goals: (1) rebuild oyster populations to 25 percent of historic levels; (2) create sustainable systems of wild oyster harvest and management; and (3) establish "living shorelines" to mitigate shoreline erosion and protect coastal wetlands.

Currently, in almost every coastal region across the country, dedicated organizations and zealous volunteers are working to reestablish viable oyster beds in depleted areas. Most of these projects are small scale, labor-intensive, high cost, and high risk. For many, the long-term outcome remains unknown; for some it's unknowable. Nearly all are implemented by resource-strapped non-profits dependent on limited funding from government and foundation grants. Scaling these efforts to a level that can meet the enormous need for restoration nationwide faces significant financial and logistical barriers.

The opportunity is to reach beyond known solutions to ask: How might we discover new ideas, new funding mechanisms, or new leverage points that will be harbingers of a breakthrough?

We believe that possibility resides in a methodology that blends the lessons of experience with a fresh perspective, and deep systems empathy with entrepreneurial zeal. This is an approach we have honed at Future of Fish through more than four years of convening scores of designers, fishermen, economists, businesspeople, anthropologists, investors, journalists, and social entrepreneurs in the service of crafting new solutions to the global overfishing crisis. The same approach that has yielded the FoF cohort—a portfolio of businesses working on market disruption on behalf of sustainability in the seafood industry—can also potentially reinvent the future of oyster restoration.

How It Works

The effectiveness of our approach is derived from the combined 20 years of experience in complex systems analysis of the team that designed it. Its strengths include:

It is inherently optimistic. Our analysis begins by identifying what is working and succeeding in a given space, and then we look for ways to build on that success.

It relies on the wisdom of those in the trenches. The gap is significant between theories of academics or consultants, and what is practiced as a solution on the front lines of the fight to solve any environmental or social challenge. Within that gap are insights and adaptations—flashes of brilliance—that often do not get captured by high-level views of the system.

It distills patterns not otherwise visible. Those insights and adaptations from the field, when knit together, provide new possibilities: ways for players working on entirely separate aspects of a multidimensional challenge to potentially collaborate, segments of the problem that have been inadvertently ignored, successful insights that could be more widely applied.

It reframes challenges to allow for new thinking and new participants. The definition of a problem shapes not only the types of approaches applied, but also the expertise invited to the conversation. Ultimately, multiple framings are necessary and compelling. For example, seafood sustainability is a marine science issue. But it is also an investment issue and a business issue. Without investors and entrepreneurs in the room, important voices are left out of the solution set.

This report is the first phase of our approach, which encompasses latter phases of convening, field research (possibly ethnography) and strategic design. The analysis here sets the stage for these next steps and provides NFWF with multiple options. Our analysis is qualitative in nature, not quantitative. It is meant to generate a framework for understanding and a set of viable assumptions to shape the path forward, rather than a statistically derived proof.

Project Scope

The National Fish and Wildlife Foundation commissioned Future of Fish to analyze the current state of oyster restoration in order to identify opportunities to reduce costs, increase efficiency, spur entrepreneurship, and leverage other non-conventional approaches to drive and sustain large-scale restoration.

The objectives of this first-stage analysis were to:

- Survey the restoration projects funded by the National Fish and Wildlife Foundation, as well as external projects, and distill from those a framework for understanding the full breadth of problems encountered and the underlying attributes that distinguish successful solutions;
- Recommend potential grantmaking strategies, which may enhance the effectiveness and efficiency of restoration efforts going forward (see Appendix I);
- Identify opportunity areas that outline possible next steps to scaling, particularly options that include market-driven mechanisms, and where NFWF could help invent and incubate a new solution. This last deliverable lays the foundation for Future of Fish's next phase of work proposed with NFWF.

To these ends, our work included the following activities:

- Evaluating restoration projects funded by NFWF and making observations around problems affecting successful restoration and the solution-oriented approaches to those problems;
- Analyzing objective project attributes and estimating the comparative cost-effectiveness of different restoration methodologies, where possible;
- Conducting interviews with experts engaged in restoration projects nationwide in order to capture insights and context that may not be revealed within a typical grant report;
- Evaluating particular policies or regulations that serve to promote or impede restoration success;
- Researching analogous solutions in other industry sectors in order to surface potentially transferrable strategies.

The Discovery Map: Understanding The Wisdom Of The Solution Designers

The Discovery Map is an integrative approach to understanding the multi-faceted nature of a problem and how its different components (Barriers) might be overcome. By parsing the problem into Barriers, we acknowledge the complexity of the challenge and the need for strategies on several levels (Design Principles) to engage with those problems.

The Discovery Map highlights how these varied solutions work in concert across the dimensions of a problem to bring about real and lasting positive change—much like success in extinguishing a forest fire requires complementary, but diverse, tactics on multiple fronts.

We began by reviewing documents submitted by past and present NFWF grantees engaged in projects related to oyster restoration. To that group we added external projects and interviews with field experts. We scoured the reports and interview notes for explicit and implicit problems and successful solutions. Our criteria for a successful solution was that it needed to entail progress toward its intended goal, and that it needed to contribute toward the ultimate goal of large-scale and widespread oyster restoration. The insights presented are based on the apparent success of solutions included in our analysis, rather than on statistical significance or impact metrics.

We sifted through the problems and solutions, clustering them into related themes. We then looked for patterns that pointed to overarching problems (Barriers) and the underlying strategies (Design Principles) used to solve them. These Barriers and Design Principles frame the Discovery Map.

Unveiling Opportunity

The Discovery Map allowed us to gauge what was working and what was missing among current oyster restoration efforts. Those observations led us to identify a number of potential opportunity areas where new ideas or inventions could accelerate progress, increase efficiency, improve success rates, or scale those endeavors. We narrowed the opportunity areas to three categories: Policy Opportunities; Non-Profit Opportunities; Business Opportunities. We outline seven of these opportunity areas in this report, from which we recommend four paths for further consideration by NFWF.

Envisioning The Power Of Partnership And Entrepreneurship

The factors that have contributed to the widespread loss of oyster reefs in the U.S. and around the world are a combination of tragedy-of-the-commons circumstances, unfavorable environmental conditions, and large-scale manmade disasters, like the Deepwater Horizon oil spill. The challenges are significant. But our research found that the story of oysters and their many beneficial services is one that inspires hope, imagination, and confidence among the people involved. Real, actionable solutions for scaling restoration efforts are within reach.

The opportunities we present in this report identify some specific paths for NFWF to consider as they launch their ten-year recovery plan to scale restoration efforts in the Gulf of Mexico and around the country. With NFWF's fourteen-year history of investing a total of over $13 million in oyster restoration, the organization is well-positioned to lead other partners and stakeholders, as well as incentivize entrepreneurship, toward large-scale, cost-effective and long-term restoration.

"What is needed is just more intersection of design-type folks who have the greater vision, and the folks on the fieldwork side who have the practical knowledge."

—Meredith Comi, Oyster Restoration Program Director
NY/NJ Baykeeper

DISCOVERY MAP

Development of the Discovery Map involved identifying more than 50 unique solutions addressing problems that hinder successful oyster restoration. Some of the restoration solutions we analyzed were distilled from reviewing proposals and final reports from NFWF grantees (65 total). We added other solutions to our analysis base by researching external reports and conducting first-hand interviews with on-the-ground participants in government agencies, academia, research institutions, aquaculture, and non-profit organizations (34 total). We discerned the insights behind each solution, specifically when an idea was coupled with an identified problem. In all, we noted over 50 distinct challenges in the current system. The matching total quantities of problems and solutions is purely coincidental; problems and solutions were not one-to-one matches. Some problems were addressed by multiple solutions, and some solutions addressed multiple problems.

The Discovery Map includes the following components:

- **Context:** The external conditions or climate that influence the current situation within a system.
- **Tensions:** Social, political, economic, and behavioral trends and biases that perpetuate a problem, but that might also be openings for new solutions.
- **Barriers:** The core challenges of a problem which, if successfully resolved, could pave the way for real progress. Barriers are not immutable conditions or context; they must be moveable and changeable.
- **Design Principles:** The underlying ideas or observations beneath the surface of a solution. Principles are not tools or solutions themselves, but ways to understand the mechanism a solution is addressing. They reveal truths about a system and insights to address longstanding stuck points.
- **Project Profiles:** Brief descriptions of the solutions and the organizations behind them.
- **System Insights:** Observations of patterns, trends, and holes, which lead to our subsequent recommendations and identification of opportunity areas.

THE QUESTION

How can we drive more successful and efficient oyster reef restoration in the Gulf of Mexico?

CONTEXT

The largely static background or climate that influences the current situation within a system.

Nearly every coastal state in the U.S. has pursued some form of oyster restoration to achieve ecological outcomes. In most cases, the work is performed by NGOs, government agencies, academic institutions, or a partnership among these groups. Where budgets allow, professional contractors are hired to do the manual work. More often than not, project plans are carried out largely by unpaid volunteers who are overseen by program managers with varying levels of experience and expertise. While always initiated and executed with the best intentions, for a variety of reasons, these efforts have produced mixed results.

Establishing an oyster reef that is self-sustaining and grows over time is no easy feat. Significant time and energy are required before restoration activities even begin, such as obtaining the proper permits, which can be a laborious process, draining resources from limited budgets. Initial site assessments are recommended to ensure that the appropriate methods and materials are selected for a given locale, as what works in one location may not work in another. But the scientific and technical expertise needed to perform these assessments can be difficult to obtain or cost-prohibitive. Some project managers choose to forgo this step in the process, which can be detrimental to the success of the project.

Ideally, preliminary site information is available to inform the particular restoration strategy. That strategy involves multiple decisions, including substrate type (e.g., shell, spat-on-shell, artificial substrate), planting method (e.g., shell mats, bags of shell, loose shell), planting density, and timing. Some materials and methods may be more expensive or labor-intensive than others, so the ultimate strategy chosen might be more a function of the project budget than what nature requires.

The plan is then executed in the selected site by project managers and, quite often, an army of volunteers. Because of limited resources, many projects are forced to cut corners and fail as a result, while the fates of other projects are never evaluated; funding for long-term monitoring is difficult to secure.

Oftentimes successful projects can be linked to those employing contractors with the experience and knowhow to do the physical work. However, a lack of competition among contractors for reef restoration projects drives costs ever higher.

Despite the tens of millions of dollars invested over the past two decades, the restoration progress to date is small relative to the total magnitude of oyster reef loss. The field currently lacks capacity to meet the enormous need for restoration work, as well as a process that envisions how scaling scale oyster restoration might be possible.

The core question underlying the framework we've developed is: How can we drive more successful and efficient oyster reef restoration in the Gulf of Mexico?

TENSIONS

Social, political, economic, and behavioral trends and biases that perpetuate a problem, but that might also be openings for new solutions.

Tension #1 **Oyster reefs are among the most important marine ecosystems in the world; They have the lowest public profile of any endangered marine resource.**

As far as public awareness of marine ecosystems goes, oyster reefs are obscure. They're not typically associated with charismatic or sympathetic marine creatures, and they rarely receive national press. With a few exceptions in regions that have explicitly adopted oysters as part of their cultural heritage, individual knowledge of oysters rarely goes beyond the experience of eating them. That general lack of awareness is partly because, until recently, oyster reefs had been overlooked as an important marine ecosystem worth preserving. This could prove to be a tactical advantage moving forward: The combination of an historic lack of public exposure, the 'newness' and urgency of the issue, and the ability to provide tangible engagement activities for the general public, creates a rare and meaningful feel-good experience for people overwhelmed by the panoply of ocean degradation issues. That experience, if nurtured, could create broader public support for all issues and policies related to ocean protection.

Tension #2 **Short-term cultivation is a thriving, profitable business; Long-term restoration is a bust.**

Oyster aquaculture, a $117.6 million (2010) industry, makes up 90 percent of the 28.1 million pounds of oysters harvested domestically each year. Like natural reefs, cultivated oysters are beneficial to their home water bodies, offering important water-purifying services. However, unlike natural reefs, farmed oysters are temporary. Within a couple of years of being

planted, they grow to commercial size, are harvested, and sold. Thus, they are not adequate substitutes for the permanent, three-dimensional structures that provide the gamut of ecosystem services for marine life and coastal communities. Because those benefits are still not adequately valued, short-term oyster aquaculture receives precedence—including far more public funds, resources, and political support—over long-term reef restoration. The fact that an industry of this magnitude is built on oyster cultivation, while restoration work has languished, suggests that if market incentives could be applied to restoration, affordable capacity to execute would follow in time.

Tension #3 **Oyster shell is valuable; The easiest and most efficient thing to do with an oyster shell is throw it away.**

Oyster shell is the best substrate for restoration. Yet, the need for shell far outstrips supply. In addition to demand for shell by other industries (e.g., construction, oil drilling, cosmetics, poultry, etc.), the transport of oysters to inland restaurants results in a net loss of shell from coastal regions. In the absence of adequate recycling programs and a coordinated logistics network, these valuable shells are ultimately tossed into landfills. As a result, restoration projects are forced to purchase shell—which can consume a significant portion of their overall restoration funding—or use an inferior, but slightly less expensive, substrate alternative. The unmet demand for shell in the face of these wasteful practices suggests a latent force that could drive collection and recycling activities, if properly harnessed.

BARRIERS

The core challenges of a problem which, if successfully resolved, could pave the way for real progress. Barriers are not immutable conditions or context; they must be moveable and changeable.

Inconsistent Policy Oyster restoration projects require permits. But the permitting process is complex, time-consuming, and varies wildly across states. In many places the same process designed for polluting-activity permits is used for restoration, which results in false assumptions that derail approval. Projects can require authorization from multiple agencies holding jurisdiction over a single site. For novices, that complication can be a significant hurdle. In some cases, the hard substrate used for oyster cultivation is framed as ocean-dumping, and permits are denied. In other cases, projects fail because concern arises over the potential poaching and selling of oysters from restored reefs, which if contaminated, could result in the shut-down of the state oyster industry.

Resource Scarcity Successful restoration efforts require significant resource inputs and support. Of primary importance (and highest cost) is the substrate or cultch (most commonly empty oyster shells) on which new larvae can settle and grow. Logistical challenges and costs include transportation, storage, and cleaning of substrate. Human resources, such as scientific expertise, technical skills, and raw labor, are also needed for project design, building reef structures, and/or filling bags with shell. In some cases, the presence or absence of public support (and, therefore, manual labor availability) can be the determining factor for whether a project gets off the ground.

Inadequate Planning for Environmental Factors Once deployed in a bay, estuary, or gulf, a restoration reef is at the mercy of nature and human influence. Finding a suitable site is paramount if the oysters are to survive, grow, and reproduce. Disease, water quality, native oyster larvae recruitment, predators, soft sediment, wave action, boat wakes, poaching, and inclement weather can all threaten the success of a project. In many cases, this risk can be mitigated with proper site-assessment and planning, as well as regular monitoring. But often, adequate risk planning either falls to the wayside because of cost, or because of ignorance of historical failures that should inform an analysis.

Fragmented Management While there is no universal formula for restoration, as the conditions and resources available can vary from site to site, the knowledge and know-how gleaned from project experience is not readily shared or available. Thus, a fair amount of inconsistency exists with respect to how restoration projects are executed, as well as to how success is measured. There is a tendency to re-make the same mistakes. The nature of funding and grant cycles hinders efforts to engage in long-term monitoring to determine the ultimate success or failure of projects and the contributing factors to these outcomes.

DESIGN PRINCIPLES

The underlying ideas or observations beneath the surface of a solution. Principles are not tools or solutions themselves, but ways to understand the mechanism a solution is addressing. They reveal truths about a system and insights to address longstanding stuck points.

Use What You've Got Identify and leverage existing resources that are aligned with restoration efforts to overcome resource and logistical challenges. That could mean tapping into local organizations with ready-made volunteer bases, creating shell recycling programs alongside restaurants with existing supply chains, or utilizing local suppliers for materials, handling, shipment, and storage needs.

Share, Share, Share Overcome inefficient and ineffective approaches to restoration by sharing information, knowledge, and resources among projects and programs. Currently the learnings are lost or become siloed in stand-alone reports or conference proceedings, many of which are not easily accessible publicly. This lack of dissemination makes for unnecessarily steep learning curves, constant wheel reinvention, redundancies, and the perpetuation of mistakes that could be otherwise avoided through better communication and collaboration.

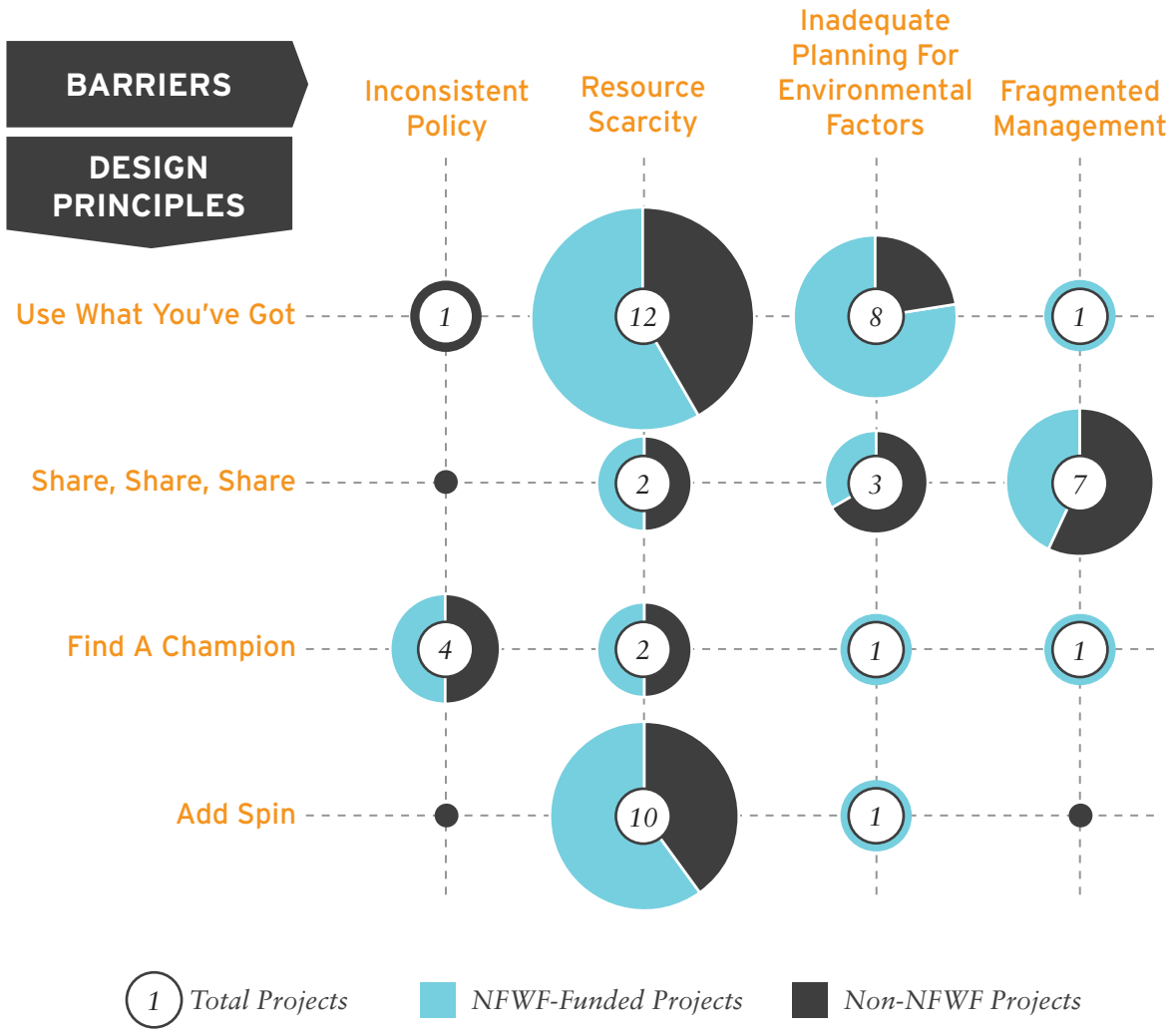
Find A Champion Recruit a person, organization, or community to take ownership, create enthusiasm, and motivate others. Whether those champions are individual volunteers, aquariums, branches of the military, dock owners, or even private clubs, they can often single-handedly overcome an ostensibly insurmountable challenge.

Add Spin Find ways to motivate people to care about oysters. That is no easy task, given the non-charismatic and immobile nature of these often unfamiliar invertebrates. But public perception can greatly influence the ease with which a project is implemented. Messages to rally volunteer and community support require context, crafting, and follow-up. Tactics can include targeted educational programs, marketing campaigns, appeals to people's self-interest, or linking a restoration project with another topic of high value or concern.

Photo: Chesapeake Bay Program

DISCOVERY CHART

Each circle represents the number of solutions employing the given Design Principle to address the specific Barrier. The proportion of NFWF-funded projects in each area is represented in blue. The proportion of non-NFWF projects is represented in black.



PROJECT PROFILES

Design Principle One

Use What You've Got

Build on existing resources and relationships.

100-1000 Restore Coastal Alabama Mobile Bay, AL The 100-1000 Restore Coastal Alabama project is the brainchild of several major conservation organizations that joined together in the wake of the Deepwater Horizon oil spill to determine how best to create effective restoration on the Gulf Coast. The goal of the project is to restore 100 miles of oyster reef—which would provide protection and support for recovery of 1000 acres of saltmarsh and seagrass habitat—to revive local fisheries and protect shorelines against continued erosion. The scaled-up restoration effort (1/4 mile already deployed) required assistance from local contractors who innovated new technologies for automating shell-bagging in order to increase the efficiency of the process. This bold effort is now supported by over 35 public-private partnerships and has spurred development of a living shoreline general permit within the Army Corps to streamline the permitting process. Environmental and economic studies related to the project show the ecological and job creation potential of the larger project vision. ***Barrier:*** Resource Scarcity

Alternative Substrate Research, Harte Research Institute Corpus Christi, TX Researchers at Harte Institute have begun experiments to test the feasibility of using new substrates for oyster reef restoration projects. Namely, they're interested in whether ceramic and porcelain (from caps on telephone poles as well as sinks and toilets) could be viable alternatives to shells, which are becoming increasingly more expensive, despite their successful shell recycling program. If these substances turn out to effectively attract and grow oysters, a program could be developed to divert them from landfills, saving disposal fees and providing free substrate to restoration projects. ***Barrier:*** Resource Scarcity

Biloxi Bay Oyster Habitat Restoration, The Nature Conservancy Biloxi Bay Estuary, MS (EZG 29044, 2012) The objective of this active project (as of Fall 2012) is to construct an additional 15-20 acres of sub-tidal oyster reef in Biloxi Bay, as part of ongoing restoration activities in this estuary. Prior to this project, 19 acres of sub-tidal reef habitat had already been created. The oyster reefs restored by this project are not only constructed by an organization with experience and expertise, but they're located in areas that are currently closed to commercial and private oyster harvest. As such, these reefs are protected from poaching by the State of Mississippi. One of the key goals of the restoration activities is to re-establish viable sport-fishing grounds in areas decimated by Hurricane Katrina and, thus, demonstrate the benefits of oyster restoration to users of the preserve. ***Barrier:*** Inadequate Planning for Environmental Factors

Copano Bay Reef Restoration, Harte Research Institute Corpus Christi, TX Nearly four acres of oyster reef habitat were restored using over 1,600 cubic yards of recycled shell and crushed concrete in Summer 2011. The scientists used clean, crushed concrete to form the base of each reef mound, and then topped each with the recycled oyster shell collected from area restaurants through Harte's shell recycling program. These structurally complex, high-relief reefs were expected to be less subject to sedimentation, allow higher oyster densities, and support larger fish populations. Within a month after the Copano Bay project's completion, fish had found the new reef. Within six months, new oysters were growing. ***Barrier:*** Inadequate Planning for Environmental Factors

Deadman's Island Restoration Project, City of Gulf Breeze Pensacola Bay, FL (EZG 5863 & 2385, 2008 & 2009) The Deadman's Island Restoration Project established a natural, sustainable breakwater to protect an eroding shoreline in Pensacola Bay. The 1,240-foot breakwater was made from natural shell with structural support provided by welded rebar. Students from a local technical school were enlisted to weld the reef units using school equipment, instructor time, forklifts, etc. They then helped fill the breakwater units with shell and transport them to the restoration site. Through the process of learning about and building the oyster breakwater, project directors noted that the students, many of whom were avid anglers, became particularly motivated to participate when they learned that new oyster habitat would enhance fish populations in Pensacola Bay. Thus, in addition to supplying thousands of dollars of free labor and equipment, the student volunteer program created a new community of advocates for oyster reef restoration. ***Barrier:*** Resource Scarcity

Delaware Bay Oyster Habitat and Population Enhancement, Rutgers University Delaware Bay, DE and NJ (EZG 1001, 2009) The restoration of natural oyster beds in Delaware Bay is an ongoing project that began in 2005 and primarily focuses on the timely planting of fresh clean shell cultch on natural oyster beds in order to provide a suitable substrate for maximizing larval oyster settlement and survival. The Haskin Shellfish Research Laboratory at Rutgers University works with local government agencies and fisheries to conduct an annual area-wide survey of oyster populations and spawning conditions in order to inform oyster harvesting quotas, as well as to determine the best locations and times to plant shell to enhance existing populations. For this

project, cultch was planted on 38-acres of the Silver Bed in Delaware Bay, which subsequent monitoring suggests has contributed to restoring the site's carbonate balance, which is critical for maintaining natural oyster beds. It is expected that this shell will continue to provide a substrate for spat settlement for many years, thereby expanding abundance and biomass of oysters on the Silver Bed. ***Barrier:*** Fragmented Management

Mosquito Lagoon and Intertidal Reef Restoration, University of Central Florida Indian River Lagoon System, FL (EZG 4600, 2002) This project involved the restoration of six intertidal oyster reefs in Mosquito Lagoon by constructing 360 oyster mats, where shells are tied to mesh screens. An alternative to other shell deployment methods, shell mats not only utilize fewer shells per unit area, but they mitigate damage from boat wakes, which can cause shell movement, dislodging of oysters from their reefs, and sediment resuspension. In Mosquito Lagoon, this process has resulted in the formation of dead zones and piles of broken oyster shells accumulating on the seaward edges of the reefs. After six months of monitoring, recruitment and survival were high, and only one of the 360 reef mats had sustained damage. This success rate led Canaveral National Seashore's resource management officers to approve the relocation of some of the mats to areas most in need of restoration.***Barrier:*** Inadequate Planning for Environmental Factors

Olympia Oyster Recovery in Puget Sound, Puget Sound Restoration Fund Puget Sound, WA (EZG 18671, 2010) The primary objectives of this project were to install shell enhancement projects on 7.25 acres at selected sites in Puget Sound in order to augment remnant Olympia oyster populations and accelerate the recruitment process for new populations. All shell enhancement sites were surveyed for natural oyster set, but some showed little to no recruitment over several years. Considering that contemporary Puget Sound oyster beds were estimated at 4% of historical abundance and recruitment was low, project partners turned their focus toward advancing the conservation use of hatchery-propagated native oysters. Hatcheries can be an important restoration tool to restore source populations in historic habitat areas where a sustainable source population is absent in the water body. As a result of the project, genetic protocols were developed and a collaborative effort began in Washington State to establish a hatchery facility to produce restoration-grade Olympia oyster seed. This will enable project partners to rebuild Olympia oyster populations in Puget Sound in order to restore ecosystem services provided by native oyster habitat. ***Barrier:*** Inadequate Planning for Environmental Factors

Oyster Habitat Restoration in the Cape Romain National Wildlife Refuge, South Carolina Department of Natural Resources (SCDNR) Awendaw, SC (EZG 26426, 2011) Through relationship-building and clever use of resources, this project, implemented through SCDNR's community-based South Carolina Oyster Restoration and Enhancement (SCORE) Program, successfully restored 75 square meters of oyster habitat. The US Fish and Wildlife Service (USFWS) provided boats for site selection and monitoring, as well as storage and security for stockpiling of shell bags. USFWS staff and the South Eastern Wildlife and Environment Education Association assisted in volunteer recruitment for bagging, water monitoring and reef building through their contacts with ~1,500 area volunteers. Reefs were constructed of recycled oyster shells, collected by volunteers and DNR staff from local restaurants, caterers, and public events. Reefs consisted of 600 volunteer-filled shell bags, which were loaded onto boats donated by the Coastal Conservation Association. Volunteers were transported at no cost to the restoration sites aboard the Bulls Island Ferry, courtesy of Coastal Expeditions, a project partner. Through the course of the project, additional relationships were forged, which are expected to contribute to the ongoing success of this and future projects. For example, a teacher workshop, which was developed during the project phase, has been submitted to the Education Department for approval as continuing education credit. ***Barrier:*** Resource Scarcity

Oyster Reef Restoration in Charlotte Harbor, Florida Gulf Coast University Lower Charlotte Harbor, FL (EZG 14191, 2003) This project focused on creating, training, and mobilizing an intergenerational citizen group to construct 12 reefs at 12 demonstration sites over two years. Over 200 volunteers participated in site preparation, shell bagging, reef construction, and monitoring of water quality, reef development, and oyster growth. The project was supported by the Charlotte Harbor National Estuary Program, a partnership of citizens, elected officials, resource managers and commercial and recreational resource users working to improve the water quality and ecological integrity of the greater Charlotte Harbor watershed. Many of these partners also financially support the program, which affords the program opportunities to fund projects such as this. ***Barrier:*** Resource Scarcity

Oyster Restoration in St. Mary's River, Sustainable Development Institute St. Mary's City, MD (EZG 5494, 2006) The St. Mary's River oyster gardening program tested the use of "floats" with oysters that had been selectively bred by the Circle C Oyster Ranch, as an alternative to the less-than-successful conventional practice of reviving native oyster beds by fortifying old oyster reefs with extra shell, and planting seed oysters raised by volunteer amateur farmers. The main problem

with the latter approach is the presence of pollution and disease (MSX and dermo), which tend to attack and kill young oysters before they are big enough to harvest. The Circle C oysters are raised close to the surface on floats (to reduce susceptibility to disease) and bred for their fast growth rates. After a number of controlled and field experiments, researchers found that the Circle C oyster (called the Linebacker) was found to remove significantly more algae and sediment than the wild-type species. The results provided support for the possibility of utilizing specially bred oysters to enhance wild reefs. An ancillary benefit of the project was the fact that it converted 10 waterfront homeowners, who had agreed to host a Circle C float, into private oyster growers. ***Barrier:*** Inadequate Planning for Environmental Factors

Oyster Shell Drillers, Royal Caribbean Cruise Lines Indian River Lagoon, FL The Nature Conservancy's Mosquito Lagoon oyster restoration project utilized "oyster mats"—18-inch square mats with 36 oyster shells vertically attached with zip ties—as starter reefs for intertidal restoration. To build the mats requires oyster shells that are drilled with holes where zip ties can fasten. Previously a bottleneck for the project, TNC found a reliable and efficient source of oyster shell drillers in the crew of Royal Caribbean's *Mariner of the Seas* ship. While out to sea, the crew drill holes in the shells and then, when in port, they swap buckets of drilled shell for undrilled. The partnership has made it possible for the project to meet the demand for mat-building projects among the many community and school groups that now engage in volunteer efforts to restore the reef. In addition to hands-on labor, Royal Caribbean has also awarded money to the project. ***Barrier:*** Resource Scarcity

Perdido and Pensacola Bay OYSTER, Florida Department of Environmental Protection (DEP) Escambia County, FL (EZG 4160, 2006) New restored oyster reef habitat in non-harvestable waters was constructed with recycled shell from local restaurants and volunteers from community organizations (e.g., churches, Boy Scouts). Boats to transport the shell to the site were loaned at no-cost from DEP and a volunteer. The project drew on past restoration experience to modify deployment techniques on soft sediment, which tend to cause berms to sink and scatter. To prevent that, they used coconut fiber matting to disperse the weight, and jute netting to prevent loose shell from scattering. ***Barrier:*** Resource Scarcity

Plowing Oysters, Texas Parks and Wildlife Department Galveston Bay, TX One of the major threats to oysters along the Texas coast is burial from sedimentation, especially after large storms and hurricanes. After hurricane Ike, Texas Parks and Wildlife utilized side-scan sonar to determine which areas of reef had the least sediment and instead of planting cultch, they employed local commercial fishermen to drag their rakes/dredges over the areas and re-expose the hard substrate. Analysis showed they were able to successfully re-expose almost 30% of the area (1100 acres out of 3800 acres assessed). Factoring in this success rate drove the cost of "restoration" down from nearly $36,000 an acre to $740 an acre. Though limited in application, this partnership shows that shallow sediment deposits can be efficiently removed to re-expose oyster reef. ***Barrier:*** Inadequate Planning for Environmental Factors

Project PORTS (Promoting Oyster Restoration Through Schools), Rutgers University Delaware Estuary (EZG 5881 & 7471, 2007 & 2008) Project PORTS is a strategic effort to raise awareness of the importance of oysters to the local environment and economy. Since its NFWF-funded inception, Project PORTS has worked with more than 2,000 local fourth-through eighth-grade students in 14 area schools. Each year, teachers and students receive classroom instruction on the role of oysters in their local environment and economy, then spend an afternoon filling mesh bags with shells, which eventually make their way to oysters beds within a 10-acre plot designated for restoration in the Delaware Estuary. As an initiative of the Rutgers University Haskins Shellfish Lab, Project PORTS leaders work with Haskins scientists to determine the precise location and volume of oyster restoration to be carried out each year. Project PORTS conducts restoration at sites that are permissible based on approval of New Jersey state agencies involved with water quality and shellfisheries, thus streamlining the permitting process. As a result, Project PORTS has been able to carry out restoration projects each year without needing to apply grant funding to either the permitting process or toward determining where or how to conduct the restoration. ***Barrier:*** Resource Scarcity

Rapid Oyster-bagging, J&W Marine Enterprises, Inc Mobile Bay, AL Laying down and stacking bags of oyster shell is one of the main methods used to construct three dimensional oyster reefs. Creating these sacks of shell is a herculean effort, often requiring large numbers of volunteers to hand-stuff the bags. Normally, one volunteer can fill two or three bags in an hour. When tasked with filling 80,000 sacks for a TNC Alabama project, Wayne Eldridge knew he had to innovate a new, faster way to bag shells. He modified his conventional conveyor machine to accommodate oyster shells so that a six-person team could fill 300 bags per hour. Operating two machines at once and employing 12 people, Eldridge successfully created 150,000 shell bags for the expanded project. Such innovation offers promise for supporting larger-scale restoration efforts. ***Barrier:*** Resource Scarcity

Restoring the Olympia Oyster in Southern California, KZO Education, Inc Long Beach, CA This program represents one of only two scientific pilot studies to determine the feasibility of oyster restoration in Southern California waters. KZO Education founders Phil Cruver and Debbie Johnson leveraged their personal connections with key players (yacht club members, government officials) in the Long Beach City Council to secure permission for the project within the uniquely city-owned Jack Dunster Marine Reserve, thereby bypassing the "byzantine" permitting process that otherwise hampers restoration efforts in the region. Partnership with local oyster restoration scientist Danielle Zacherl with CSU Fullerton overcame the insurance barrier faced by many small non-profits. The project seeks to raise public awareness of the value and need for native oysters as part of a healthy coastal ecosystem through KZO Innovation's novel learning platform (originally designed to help with increasing education in Pakistan). It will also establish scientific baselines for best practices for native oyster restoration in the region. ***Barrier:*** Inconsistent Policy

San Francisco Bay Native Oyster Habitat Restoration, The Watershed Project San Francisco Bay, CA (EZG 2786, 2009) This project was initially intended to restore and monitor a ¼ acre oyster reef in the San Francisco Bay. However, because matching funding did not materialize, a new goal was set. Organizers recognized that much of the shell planted during a restoration project does not result in live oyster growth. This is largely because fouling agents (algae, sediment, etc.) prevent oyster spat from settling. So, in lieu of establishing new reef, local volunteers cleaned shell from previously restored reefs, in order to increase their chances of long-term survival and growth. Follow-up monitoring revealed that the process of removing fouling agents allowed oyster density on washed shells to rival that of newly-planted shell. Washed shells also dramatically outperformed shell on reefs that had not been washed. In the end, the Watershed Project created significant new oyster habitat without the use of new shell, and without the need for more funds. ***Barrier:*** Resource Scarcity

Shell Recycling Alliance, Oyster Recovery Partnership Chesapeake Bay The Shell Recycling Alliance collects used oyster and clam shells on a weekly basis from restaurants, caterers, and seafood wholesalers throughout Maryland, Virginia, Washington, D.C., and Delaware. Shells are deposited into shell collection containers distributed throughout the region, and then delivered to the University of Maryland's Center for Environmental Science Horn Point Hatchery for use as substrate for spat raised to replenish the Chesapeake Bay oyster population. A program begun in 2008 with a Chesapeake Bay oyster community that was frustrated to see oyster shell thrown away at shucking events, currently more than 100 restaurants and seafood distributors participate in the program and tens of thousands of bushels of shell are collected per year. As the program has grown, efforts have succeeded in getting distributors to backfill their trucks with empty shell as they deliver fresh product to restaurants, making use of existing supply chains. ***Barrier:*** Resource Scarcity

Shellfish Restoration, Coastal Steward, Inc Port Jefferson Harbor Complex, NY (EZG 5546, 2006) The objective of this project was to raise 98,000 oysters from seed and to release 250,000 adult oysters into four selected sanctuaries and harbors, where the population of oysters has fallen to 1% of its historical high. While the explanations of the methodology were sparse, and success was anecdotal, one notable characteristic of the project was that all replanted oysters had been bred to have a black stripe, which distinguished them from wild-type oysters. Such genetic markings could be utilized in future projects to deter poachers from harvesting and selling restoration oysters. ***Barrier:*** Inadequate Planning for Environmental Factors

Photo: File Photo, Coastal and Aquatic Managed Areas, FDEP

Shellfish Restoration Hatchery, Puget Sound Restoration Fund Puget Sound, WA As part of the Washington Shellfish Initiative, the Puget Sound Restoration Fund has engaged in a unique partnership with NOAA's Manchester Lab to build a hatchery to support

growth of seed (spat on shell) specifically for restoration purposes. Prior to this development, all seed came from commercial aquaculture, which focuses its efforts oyster characteristics that are good for production (such as fast growth), not necessarily for natural population survival. The Manchester Lab facility will work not only to provide more seed in order to meet scaled-up restoration goals, but utilizing the genetic expertise of lab staff the hatchery will also work to build diversity of seed population and ensure appropriate strains are matched with the right environment. ***Barrier:*** Inadequate Planning for Environmental Factors

Whale Island Oyster Reef Creation, Tampa Bay Watch Whale Island, FL (EZG 2244, 2009) Tampa Bay Watch, in partnership with the Pinellas County Environmental Fund, Crabby Bill's Restaurant, and 510 local volunteers, created approximately 550 linear feet of oyster shell bar along the northern shoreline of Whale Island in the Pinellas National Wildlife Refuge. Much of the success of the project was attributed to Crabby Bill's donating roughly 40 tons of recycled oyster shell for the construction of the shell bar. Tampa Bay Watch, thus, chose to extend its partnership with the restaurant for the continued use of recycled oyster shell in reef restoration projects around Tampa Bay. ***Barrier:*** Resource Scarcity

Photo: Chesapeake Bay Program

Design Principle Two

Share, Share, Share

Develop ways to collect and share past successes and failures so future initiatives become more efficient and effective.

Community-based Restoration Matching Grants Program, The Nature Conservancy and NOAA Nationwide The Community-based Restoration Matching Grants Program is a partnership between TNC's Global Marine Team and NOAA's Restoration Center with the goal to bring together local non-profit, public, private, and tribal groups to implement habitat restoration projects by providing technical and monetary support at a community level. The partnership began in 2001 and has funded several oyster reef restoration projects around the country. TNC works with project sites and regional programs to promote information exchange and coordination across projects. NOAA staff are also available to provide site-specific guidance on project design and engineering, environmental compliance, and science-based project monitoring. This type of coordination helps to reduce project redundancy and promote sharing of best practices for reef restoration. ***Barrier:*** Fragmented Management

Development of National-Scale Oyster Reef Restoration Goals, The Nature Conservancy Nationwide (EZG 1047, 2009) This project developed quantitative estimates of the extent and health of native oyster habitat in 72 current and historical bays across 8 eco-regions in the continental U.S. It established standard terms for describing individual oyster reefs and oyster reef systems, as they have been described and catalogued using a range of measures and terms, making comparison of the health and status of oyster reefs in different areas difficult, if not impossible. For example, the researchers confirmed that the extent of an oyster reef is not necessarily a good proxy for oyster abundance. Data were used to produce maps of existing and historical reefs, and to develop models for estimating the provision of ecosystem services provided by oyster reefs in U.S. estuaries. These tools are intended to enable new restoration projects to be located in optimal areas, and to help project managers and agencies establish realistic budgets and goals for oyster restoration in specific regions. ***Barrier:*** Fragmented Management

Gulf of Mexico Coastal Resilience Tool, The Nature Conservancy Gulf of Mexico The Gulf of Mexico Coastal Resilience tool is a computer-based resource that includes ecological, social, and economic data from each of the five Gulf states. The data are organized in layers on a map, allowing the user to analyze and overlap a range of information — everything from pipelines and shipping fairways to oyster reefs and seagrass beds. Designed by a team of TNC scientists and senior marine conservation planners, the system compiles and projects myriad data across the region (i.e. environmental, biological, infrastructure, socioeconomics, future restoration scenarios, etc.) and provides an online oyster restoration suitability dashboard-style planning tool for stakeholders and managers to visually interpret a range of restoration possibilities. With this dashboard, users can develop the best possible project by examining different restoration scenarios while factoring in ecological, social, and economic conditions. ***Barrier:*** Fragmented Management

Impacts of Oyster Restoration on Jamaica Bay Water Quality, The Research Foundation of State University of New York Jamaica Bay, NY (EZG 20703, 2010) This study provided essential data for evaluating the feasibility of oyster restoration in Jamaica Bay, and for predicting the effects of oyster restoration efforts on water quality. Results showed that despite a lack of natural recruitment and the presence of large inputs of sewage-derived pollution, oysters can grow vigorously in Jamaica Bay. There were, however, survivorship problems that occurred, which were not seen at the cleaner-water control site. Extrapolating from tissue samples and other lifecycle factors, researchers estimated that restoring 50 percent of the suitable habitat in the Bay (15 billion oysters) would result in the removal of one-third of the nitrogen pollution—but likely only if the oysters were harvested. The cost of nitrogen removal via this method was estimated at $167/kg/yr compared to $31/kg/yr with a wastewater treatment plant. Other ecosystem benefits were not measured. The variety of data collected through monitoring (e.g., survivorship, shell growth, tissue growth, nitrogen content of soft tissue, and environmental parameters) was analyzed and shared with other stakeholders to help guide decision making and environmental planning for Jamaica Bay, as well as evaluate the costs and benefits of oyster restoration at this site. ***Barrier:*** Inadequate Planning for Environmental Factors

Marine Aquaculture Learning 2.0, KZO Education, Inc Long Beach, CA Oyster Recovery Partnership Chesapeake Bay The Oyster Recovery Partnership (ORP) works with individual experts and management agencies, including NOAA, the Army Corps of Engineers, and the Maryland Department of Natural Resources, to assist with the monumental task of oyster restoration, monitoring, and adaptive management in the Chesapeake Bay. These experts include scientists from the University of Maryland Center for Environmental Science who have substantially increased oyster hatchery production, environmental organizations, and Maryland watermen, who have the necessary boats, equipment and knowledge of the Bay to bring local experience and expertise to ORP projects. Since its inception in 1994, ORP has steadily built its oyster recovery capabilities and capacity. It has incorporated more metrics and analytics, reduced the cost of oyster seed by 75 percent, implemented a successful shell recycling program, adopted more mechanized equipment and automation, and reduced costs and time where possible. As a result, the Oyster Recovery Partnership and its coalition of partners have planted nearly 4 billion oysters on 1,500 acres of bay bottom since 2000. The main limitation is still money, however. ORP has the capacity to plant 1-2 billion oysters per year, but financial constraints restrict them to planting about 600,000. ***Barrier:*** Resource Scarcity

Oyster Restoration Research Partnership New York/New Jersey Harbor This partnership of not-for-profit organizations, federal, state and city agencies, citizens, and scientists is working together to research the feasibility of restoring oysters in the NY/NJ Harbor Estuary, and to determine the potential for oyster reefs to provide desired ecological benefits. The program leverages the strength of partnership, utilizing New York Harbor School's hatchery program and student divers to help provide and deliver spat on shell to restoration plots, the Army Corps to deliver large loads of local surf clam shell as substrate, and university scientists and local non-profits for designing and monitoring the experimental reefs. The project aligns with the consensus vision, master plan, and strategy put forth in the Comprehensive Restoration Plan (CRP) for the future ecosystem restoration of New York/New Jersey Harbor. By constructing experimental reefs in different areas and monitoring how oysters respond to environmental conditions around the harbor, the project provides important baseline information to support future restoration goals. ***Barrier:*** Inadequate Planning for Environmental Factors

Oyster-restoration.org, Oyster Restoration Workgroup Nationwide The oyster-restoration.org website was established in 2004 as an outgrowth of a workshop of experts addressing how to assess reef restoration success as well as best practices for both subtidal and intertidal oyster reef restoration. The Oyster Restoration Workgroup consists of university, government, and non-profit researchers working to establish common metrics for conducting reef restoration in order to better compare and contrast results from different projects. The website's goal is to provide a hub for researchers and the public to find information about projects and best practices. A new website is set to roll out in fall 2012, including maps, links to a new manual on metrics for long-term monitoring of reef projects, and a YouTube channel showing project development at different locations. Funding for this website has been particularly difficult to secure, limiting the scope of this platform. ***Barrier:*** Fragmented Management

Pontoon Vertical Profiler, YSI Integrated Systems & Services St. Petersburg, FL Housed on a small floating platform, the Pontoon Vertical Profiler features customized sensors that measure a variety of water quality parameters—including dissolved oxygen levels, salinity, algal concentrations, and pollutants—throughout the water column. Data are wirelessly transmitted to managers every 15 minutes, which allows them to view real-time water quality status and trends. One such device was installed by the Maryland Department of Natural Resources at Harris Creek, the site of a large oyster restoration project, with hopes that it would provide a better understanding of how water quality affects the settlement, growth and survival of oysters throughout their life cycle. This information is also available to the public via the Maryland DNR Eyes on the Bay website, which posts up-to-date water quality and habitat conditions from all monitoring stations in the Chesapeake Bay watershed. ***Barrier:*** Inadequate Planning for Environmental Factors

Restoring Oyster Reefs in Louisiana and Across the Gulf, The Nature Conservancy Acadiana Bays, LA (EZG 281, 2009) Pilot oyster restoration projects utilizing novel bio-engineering technologies were conducted to test the efficacy of numerous restoration strategies and included substantial research to identify the geographic-environmental, socio-economic, and political constraints on oyster restoration in the Gulf of Mexico. In addition to restoring 670 linear feet of bioengineered reef, the project resulted in the development of a comprehensive monitoring program by Louisiana State University Agricultural Center (LSU AgCenter) to assess the physical and biological response of the reefs, and the development of scientific tools (e.g., Gulf-wide GIS database, socio-economic study, Louisiana Dashboard, and Decision Support Tool User Guide to prioritize and plan Oyster Restoration Gulf-wide). This goal is that these tools will help site future restoration projects in areas that have the greatest probability of long-term success. ***Barrier:*** Fragmented Management

San Francisco Bay Native Oyster Working Group San Francisco Bay An informal partnership among all entities involved with research or restoration on Olympia oysters in the San Francisco Bay, the Working Group, includes nonprofits, academics, and representatives from management agencies, who recenty coordinated their research efforts and standardized their methodology to get an idea of recruitment patterns in the Bay. They realized that they all had limited budgets to do limited work, but that if they could employ the same methods, they could compare findings and maximize their understanding of oyster growth processes. Currently there is no dedicated website, but the goal is to put these data online so that patterns can be observed from year to year. ***Barrier:*** Fragmented Management

Shell Budgets as a Tool in Oyster Restoration, College of William and Mary and Virginia Institute of Marine Science Breton Sound, LA (EZG 23855, 2011) This collaborative research effort between the Louisiana Department of Wildlife and Fisheries and five university-based shellfish research laboratories studied the conditions that determine the shell requirements for successful oyster reef restoration. Given that shell typically represents the largest expense in a restoration project and in many areas oyster shell is in short supply, one of the most important considerations in planning a successful restoration project is the volume of shell required to establish a self-sustaining oyster habitat. The researchers developed a shell budget model that incorporates local oyster recruitment, growth, mortality, shell loss, and (where appropriate) harvesting. The budget is intended to provide a long-term management tool to maximize both survival of the resident oysters and prudent maintenance of the underlying substrate, thereby maximizing both ecological benefits from a healthy reef and the availability of harvestable product where desired. While the budgeting tool was developed for a Louisiana restoration effort, the scientists who developed it are confident that the tool can be deployed immediately nationwide. ***Barrier:*** Resource Scarcity

Design Principle Three

Find A Champion

Recruiting a person, organization or team to take ownership of a project can often single-handedly overcome an ostensibly insurmountable challenge.

Apalachicola Bay Shoreline Restoration, Apalachicola Riverkeeper Indian Creek Park, Eastpoint, FL (EZG 7454, 2007) This shoreline restoration and public education project was intended for the Lanark Reef area. However, the permitting criteria placed liability on homeowners, which discouraged most of them from participating. A proposal to move the project offshore was denied by the permitting agency. The ultimate success of the project hinged on its being moved to county-owned land at a different location in the Bay, as well as to the county engineer's efforts to obtain proper permits and orchestrate the design of the shoreline and new two-acre park adjacent to the restoration site. The restored shoreline increased populations of invertebrates, which attracted birds and fishermen alike. Local residents began using the new fishing pier and enjoying the park, which also became a key boat launching area utilized by hundreds of fishermen and boaters. News of the success of this project led an RV park at Lanark Reef (the initial restoration site) to contact Apalachicola Riverkeeper about the potential to install a shoreline restoration and breakwater at its commercial facility. In response, the county agreed to incorporate its 60-foot property adjacent to the RV park into the project, increasing the size to 470 feet. The joint venture with the county changed the administration and commissioner's attitude toward the "Living Shoreline" concept as a means of protecting property from erosion. ***Barrier:*** Inconsistent Policy

California Oyster Gardening Legislation Effort, KZO Education, Inc Long Beach, CA Oyster Gardening is the community-based effort to grow baby oysters on privately owned docks, piers, and other structures until they reach escape size from predators. Oysters are then added to restored reefs (or in some cases, consumed). In fall 2012, Phil Cruver with KZO Education will introduce legislation, modeled after North Carolina's successful Under The Dock Oyster Culture program, to allow Oyster Gardening in coastal California waters as a step towards providing oysters for restoration purposes. KZO Education will help administer the program by mapping the participating docks, provide education and community awareness, cage construction assistance, cultivation care, and will provide and distribute native Olympia oyster spat from Taylor Shellfish Farms. (Future plans include developing a southern California hatchery for producing local spat). ***Barrier:*** Inconsistent Policy.

Oyster Castles, Gus Lorber Charlottesville, VA Developed by Allied Concrete Co. president Gus Lorber, oyster castles are concrete structures that can form interlocking shapes to create tiered reefs. Lorber developed the design after recognizing a design flaw with the traditional reef ball structures commonly used for restoration, namely their inability to be mass produced. Lorber's castles are built from a simple block design that allows for stacking to create multiple tiers and shapes; they can be mass-produced at 15,000 units per day. They are also easier to maneuver and do not require the use of heavy machinery. Oyster castles have been gold certified by MBDC, a global sustainability consulting and product consulting firm, because they are "manufactured using 100% renewable energy and do not contain any problematic materials." Lorber currently donates all castles used for restoration projects. ***Barrier:*** Resource Scarcity

Lafayette River Wetland Classroom, Virginia Zoological Society Norfolk, VA (EZG 18293, 2006) This project involved the establishment of layers of oyster shells along a section of the Virginia Zoo's Lafayette River shoreline in an effort to improve the health of the Chesapeake Bay's watershed in the Lower James Tidal area. The restored site benefitted from the Zoo staff's expertise in designing and developing wildlife habitat, as well as its location within the zoo grounds, which provided protection from poachers and ongoing maintenance. This effort also fostered stewardship among local school groups, who served as volunteers and continue their support with on-going oyster gardening and cleanup. For the general public, the zoo created an exhibit featuring the restored reef and the importance of restoring and protecting oyster habitat. ***Barrier:*** Fragmented Management

Nanticoke River Community Oyster Restoration, Oyster Recovery Partnership Nanticoke River, MD (EZG 18890, 2009) In an effort to meet Maryland's goal of expanding citizen involvement in Bay restoration projects, this program enlisted 26 pier owners on the Nanticoke River to grow oysters in cages hung from their private docks for eventual deployment on the Roaring Point Oyster Sanctuary. That number was lower than the initial goal of 40 pier owners. Vital to the success of the program was having a local citizen volunteer who was willing to take a leadership role in engaging and being the central contact point for neighbors with questions. While ORP provided a lot of the leadership and the needed logistics and the Nanticoke Watershed Alliance provided local insight and support, it ultimately came

down to the local volunteer who was able to rally his neighborhood. This individual also opened up his home for volunteer events. In the course of the program, volunteers received "Shells Angels" t-shirts to honor their participation, and pier owners were provided signage to indicate their contributions. ***Barrier:*** Resource Scarcity

Oyster Reserve Establishment in Mississippi Sound, Auburn University Portersville Bay, AL (EZG 23400, 2011) This program intends to establish the first oyster reserve within Alabama's coastal waters. A difficulty in restoration efforts has been the instructions from the Marine Resources Department and the Alabama Department of Public Health to not site oyster restoration projects within waters closed to harvest for public health reasons. The success of this project hinges on the generosity of a private riparian-rights holder of a 10-acre site, who has agreed to a 20-year sub-lease agreement at no cost. Using a private lease allows the siting of the effort within waters that are considered safe for the public, while allowing the restriction of harvest. The location will serve as an ongoing research and education platform for collaborators in the region. This effort is part of a larger project to establish and maintain a productive oyster reserve that can serve as a regional source of larvae to benefit local oyster populations, and improve coastal habitat by establishing new oyster reefs. ***Barrier:*** Inadequate Planning for Environmental Factors

Oyster Restoration Research Project at Naval Weapons Station Earle, NY/NJ Baykeeper Sandy Hook Bay, NJ Navy support was key to the success of a scientific study conducted by NY/NJ Baykeeper in partnership with Rutgers University to determine oyster restoration feasibility in local waters. A state ban on oyster restoration in closed waters forced prior restoration projects to be removed due to fear of poaching. But the 24/7 patrol of naval base waters made it an ideal location to test oyster survivorship and best practices for restoration without the risk of contaminated oysters reaching the marketplace. By partnering with the Navy, NY/NJ Baykeeper persevered with their oyster research and preliminary findings showed 90% survival rates for oysters over winter. The project is now set to expand to ¼ acre to test effectiveness of different structures for promoting reef growth. The Navy continues to lend full support to the project. ***Barrier:*** Inconsistent Policy

San Francisco Estuary Habitat Restoration for Salmonids, Marin Rod & Gun Club San Francisco Bay, CA (EZG 6244, 2008) The objective of this project was to construct oyster reef/eelgrass systems at two sites in the San Francisco Bay, and to monitor salmonids, water quality, and the biomass of prey organisms. For the first site, in San Rafael, CA, the city and county required no permits or provisions because the Marin Rod & Gun Club (MRGC) owned the subtidal land used in the study. For the other site, owned by the City of Berkeley, it took a full year to obtain all necessary permits because of the need for a lease, bond, construction insurance, Categorical Exemption, business license, and city wide consensuses that the project was good for the community. Permits were also needed to eliminate perceived potential risks to city employees and property, and to guarantee that the reef would be removed at the end of the study. MRGC, one of California's largest outdoor sporting clubs, was formed for the purpose of conservation, preservation, and propagation of fish and game in Marin County, CA. ***Barrier:*** Inconsistent Policy

Photo: Chesapeake Bay Program

Design Principle Four

Add Spin

Find ways to create public messaging with context, crafting, and follow-up to motivate people to care about oysters.

Hands on Tampa Bay (Tampa Bay Stewardship Initiative), Tampa Bay Watch, Inc Tampa Bay Area, FL (EZG 6939, 2007) The goal of the Hands on Tampa Bay restoration and education initiative was to integrate coastal restoration projects with educational opportunities for students throughout the Tampa Bay area. Local schools and youth groups were contacted about opportunities to incorporate salt marsh restoration and oyster reef enhancements into school field trip experiences and summer camps. The year-long initiative reached over 800 teachers and aides, and over 4,000 students, leading to the restoration of three acres of coastal salt marsh habitat, 75 new oyster domes, and approximately 200 linear feet of new oyster shell bars. ***Barrier:*** Resource Scarcity

Jekyll Island Oyster Reef Restoration, CDR Environmental Specialists Jekyll Island, GA (EZG 3722, 2006) The major objectives of this project were to restore 245 square meters of intertidal oyster reef habitat at Clam Creek, located on the north end of Jekyll Island, to promote community awareness of the critical function that oysters serve as a keystone species in the coastal ecosystem. The implementation of the project was due primarily to the promotion of a shell recycling program and volunteer work, which succeeded because of a massive public outreach campaign. The shell recycling program was advertised through local newspapers, billboards, and bus ads, and volunteer bagging events were publicized through newspapers and magazines, websites, and list-serves. All advertisements included sponsors' and partners' names and logos. Presentations were offered throughout the coastal community at nature centers, club meetings (e.g., Lions, Rotary, 4H, etc.), festivals, and to student groups to promote the restoration efforts. Promotional items printed with a "Got Shell?" slogan and program contact information were distributed coastwide. The work was also covered in several local news and magazine articles, as well as on the television show "Southern Outdoors." ***Barrier:*** Resource Scarcity

Lynnhaven Watershed (VA) Education Program, Lynnhaven River 2007 Virginia Beach, VA (5798, 2004) The main objective of this program was to implement a comprehensive community education initiative to improve water quality in the Lynnhaven River. To this end, project activities included: Holding an oyster restoration training workshop for 15 area teachers in order to grow the student oyster restoration program; partnering with the Chesapeake Bay Foundation to execute two citizen oyster restoration workshops, which resulted in expanding the citizen oyster gardening network by 100 families; transplanting 175,000 oysters raised by the students and citizen gardeners to sanctuary reefs within the Lynnhaven River; starting a community lecture and workshop series on land use and water quality, which reached 480 citizens and 900 students, and involve approximately 40 landowners in workshops on land use and water quality. ***Barrier:*** Resource Scarcity

Marylanders Grow Oysters, Maryland Department of Natural Resources Chesapeake Bay Tributaries, MD Initiated by Maryland Governor Martin O'Malley in September 2008, Marylanders Grow Oysters is managed by the Maryland Department of Natural Resources in conjunction with the Oyster Recovery Partnership, the University of Maryland Center for Environmental Science, and local organizations as a program to involve pier owners in oyster restoration and stewardship of their waterways. Participation is free to interested pier owners, who each receive four cages and instructions on how to keep the cages free of debris. Prison inmates produce the cages for the program. There are currently 24 areas in the program (rivers and creeks), up from just one in 2008, for a total of 7,500 cages. After the 9-month grow-out period, each cage yields roughly 300 oysters, which are planted on DNR-selected sites on firm bottom that were, in most cases, an historic oyster bar. While the program is small compared to the need for oyster restoration in the Bay, the Governor's main objective is to motivate people to begin noticing, caring about, and acting on behalf of the environment. ***Barrier:*** Resource Scarcity

Mississippi Sound Reef Restoration, The Nature Conservancy St. Louis Bay, MS (EZG 7006, 2005) The Nature Conservancy, in partnership with the Mississippi Department of Marine Resources, successfully planted 2 acres of oyster cultch in St. Louis Bay, Mississippi in efforts to restore healthy oyster reef habitat. Two volunteer hook-and-line fishing surveys were conducted at three months post-restoration and 18 months post-restoration. Each of four boats fished for 1.5 hours on the reef and 1.5 hours in a designated control area off of the reef. Both volunteer surveys resulted in a great catch per unit effort on the restored sites when compared to the adjacent control sites, indicating that the restored reefs were providing habitat for many species of finfish. This type of personal experience may be effective in winning fishermen support for oyster restoration. ***Barrier:*** Resource Scarcity

Mobile Bay Oyster Gardening Program, Auburn University Marine Extension and Research Center Mobile Bay, AL The Mobile Bay Oyster Gardening Program is a partnership among its gardeners, adopters, associations, businesses, and agencies, with the goal of getting community members involved in oyster restoration efforts. Oyster gardeners are volunteer waterfront property owners residing along conditionally open waters as classified by the Alabama Department of Public Health. People wishing to be involved that cannot manage their own garden can adopt an oyster garden for $25 per year. Corporate sponsorships are also available. All participants of the program, which functions like a community organization, are invited to receive regular newsletters, go on trips to oyster hatcheries, attend workshops, and join in oyster-growing competitions. The adoption option is in its third year and is expected to fund at least 25% of the Mobile Bay Oyster Gardening Program's 2012 budget. ***Barrier:*** Resource Scarcity

Oyster Reef and Salt Marsh Restoration in Choctawhatchee Bay, Northwest Florida State College Foundation, Inc. Choctawhatchee Bay, FL (EZG 454, 2008) The Choctawhatchee Basin Alliance (CBA) created 1.19 acres of oyster reef and .29 acres of salt marsh habitat at 5 sites in Choctawhatchee Bay. A total of 31 educational volunteer events yielded 1,118 volunteers. CBA staff also developed and printed the Grasses in Classes curriculum and workbooks, which included 8 monthly lessons on estuarine topics. The inclusion of additional science lessons, which were correlated to Florida education standards, and the printing of the curriculum in workbook form was much more appealing to teachers and administrators than a previous CBA-designed curriculum that did not have these attributes. The project proposal set a target of reaching 250 schoolchildren. However, once the curriculum was in place, the entire 5th grade of each school (780 students) wanted to participate. ***Barrier:*** Resource Scarcity

Oyster-tecture, SCAPE/LANDSCAPE ARCHITECTURE PLLC New York Harbor, NY Oyster-tecture is an urban landscape design project spearheaded by Kate Orff of SCAPE that utilizes living oyster reefs as part of a "watery-regional park" for New York Harbor. Oysters grown on fuzzy-rope structures are the foundation for water filtration to clean up Brooklyn's Red Hood and Gowanus Canal (a Superfund site). The designers envision a future site where boardwalks and dive platforms provide access to thriving oyster and mussel reef and eelgrass bed ecosystems, promoting fisheries, recreation, and biodiversity. This project is currently in design phase, but its debut at the MoMA Rising Currents Exhibition in 2010 garnered significant media attention and created buzz around the use of oyster reefs to clean up New York Harbor. ***Barrier:*** Resource Scarcity

Paradise Creek Plan, The Elizabeth River Project Portsmouth, VA (EZG 4836, 2005) This plan of the Elizabeth River Project did more than plant new oyster shell in Paradise Creek. Project volunteers went door-to-door to meet creek-front property owners and promote restoration of the creek shore. Through their efforts, 17 property owners pledged their support as "Creek Heroes." In addition, organizers held a contest to give away two Backyard Makeover Riparian Buffer Restorations. The makeovers re-landscaped the yards of two riverfront property owners, providing model environments that were used by the project to publicize the beauty and ecosystem benefits of natural, sustainable waterfronts in the hopes of attracting more property owners to do likewise. ***Barrier:*** Resource Scarcity

Schools Restoring Oysters to the Chesapeake, Oyster Reef Keepers of Virginia Chesapeake Bay This 15-year-old program provides teachers with the knowledge and tools they need to engage their classrooms in oyster gardening. Children learn about the biology and environmental issues facing oyster reefs in the Bay, and participate in growing out baby oysters—cleaning cages, measuring mortality and growth rates of their oysters, and then replanting their oysters on sanctuary reefs. The program engages over 7,200 students from 145 K-12 classes each year. As of 2005, the program had reached 48,500 students and contributed over 2.7 million oysters to the bay. ***Barrier:*** Resource Scarcity

Swimmable and Fishable Lafayette River, Chesapeake Bay Foundation, Inc. Norfolk, VA (EZG 18761, 2009) Recognizing that even the best-planned, most comprehensive oyster restoration projects would fail if the waterways continued to be polluted, the Swimmable and Fishable Lafayette River program hired a professional PR firm to help develop a social marketing campaign to enlist local riverfront property owners to comply with environmentally sound practices to keep the river clean. The program engages local citizens through its website, as well as events such as the annual RiverFest, which celebrates the local natural environment. Local property owners who sign on to become RiverStars receive an attractive yard sign with which to display their RiverStar status. Volunteers also removed over 12 tons of debris from the creek bed, helping to create water quality conditions in which the newly restored oyster populations could thrive. ***Barrier:*** Inadequate Planning for Environmental Factors

Photo: Chesapeake Bay Program

"It's easier to tear the planet apart (from a permitting standpoint) than it is to put it back together. Permits are designed to facilitate habitat loss, in fact. This is not a knock on permitting programs; they are designed to encourage economic investment. But there are no similarly structured and facilitated permitting approaches that make it easy to do that right thing for the habitat."

—Rob Brumbaugh, Restoration Program Director
The Nature Conservancy, Global Marine Team

SYSTEM INSIGHTS

What We Learned From The Discovery Map

Policymakers and permitting agencies impede restoration to the detriment of their jurisdictions.

With few exceptions, the process of obtaining the proper permits for reef restoration projects can be grueling, sometimes taking over a year. Some projects never get off the ground because of permit denials or indefinite delays. Once approval is obtained, there can be caveats requiring the reefs to be removable or, in some cases, harvestable within a certain amount of time. In at least one instance, a fully installed reef that had been undergoing monitoring was targeted by a regulatory body that demanded it be removed. Another project noted that, in at least one state, oil spill remediation funds cannot be used for applied research in the service of restoration.

Such circumstances reveal a lack of understanding on the part of governing bodies of the advantages of permanent reef restoration, many of which have the potential to bolster waterfront economies, mitigate the risk of costly natural disasters, and improve the overall health of the coastal ecosystem. Yet, because these benefits are temporally distant, if not uncertain, they are disregarded or devalued, often in favor of short-term economic, political, or social gains.

Of all 53 programs and projects profiled, only five had developed solutions to problems around permitting. Most of these involved circumventing the permitting process altogether by finding an individual or entity with private property, or by knowing someone with the connections or expertise to streamline the process. The absence of any collaborative or spin-related solutions to overcome this barrier highlights the potential for new innovations to drive change in this arena.

Until restoration programs are perceived differently from other environmental modification or development projects, the permitting process will remain an uphill battle, and cash-strapped organizations will continue spending scarce resources to navigate labyrinths of red tape. Where permitting processes have been streamlined for restoration activities, there is clear recognition of the significant value permanent oyster reefs can provide.

A summary of friendly and hostile policy and permitting practices related to oyster restoration can be found in *Appendix II*.

"Getting permitting done is like poking needles in your eyes every day."

—Danielle Zacherl, Associate Professor of Biology
Cal State Fullerton

Many projects cite the ecosystem service benefits provided by their restoration projects, but no one has found a way to capitalize on this added value.

Nearly every program involving oyster restoration lists the multitude of services healthy reefs offer: shoreline stabilization, habitat for juvenile fish, water filtration, pollution mitigation, seagrass expansion, among others. While these may seem like theoretical benefits only realized by the massive reef systems of recent history, several NFWF-funded projects reported evidence—via experiments, photographs, or observation—that these services were already occurring in their restored reef areas within just a few months of completion. Most commonly reported was an increase in fish and crustaceans, which benefitted fishermen fishing near the reefs. Expanding shorelines and new seagrass habitat were also observed in areas where severe erosion had been occurring prior to oyster reef restoration.

There's no doubt that these services have real economic value, as summarized in a recent study by Duke University (Stokes et al., 2012). Yet from the projects we evaluated, there was little effort made to quantify this value. There were also few attempts to convey the value of these services to those who might benefit from them most. Whether the beneficiaries are fishermen, coastal municipalities, tourism boards, waterfront property owners, or like-minded environmental groups, excluding potential stakeholders from reef restoration projects is a missed opportunity for garnering support, increasing awareness, augmenting funding, and leveraging collective efforts to secure permits and project resources. Continued research is necessary to specifically quantify the economic value of restored reefs in particular regions in order to offer convincing evidence to these interest-groups.

"I love that oysters can filter 50 gallons a day. And when I share that fact with all the yacht club people, they are fascinated. So I want to take it to the next step."

—Phil Cruver, President and CEO
KZO Sea Farms and KZO Education

Project resource management—simply pulling together the logistical and human components for reef restoration—is dauntingly complex. Best practice standards could go a long way in assisting first-time organizers.

Nearly half of the projects and programs we evaluated overcame significant barriers by using existing resources. The most commonly reported free or low-cost inputs were labor from already recruited volunteer bases, recycled oyster shells, donated boats and other equipment, local businesses or skilled workers, and media coverage from area newspapers, radio, and television. Projects that did not rely on such resources tended to be significantly more expensive, but potentially more streamlined, as they used skilled consultants, hired manual labor, rented transport and equipment, and purchased shell and other materials. However, some projects discovered after the fact that they could have saved substantially by conducting preliminary assessments and using what was already available—including upgrading existing reefs in need of rehabilitation, as opposed to building new ones.

Depending on a piecemeal process with free local resources creates the risk of having little control over quantity or quality, which can reduce efficiency. That risk is exacerbated by a lack of proper planning and management. For example, one project that used recycled shell failed to assess the costs of curing, storage, and processing. In the end, using recycled shell was just as expensive—and much more time-consuming—than buying shell. Other projects underestimated the amount of labor needed, and were therefore short on volunteers, which extended the project timeline.

Given adequate planning and management, utilization of local resources seems to be one of the best tactics for maximizing cost-effectiveness. Future projects could benefit from the practical methods of past projects for finding innovative ways to meet needs. In some cases, best practice primers may be appropriate. For example, one of the most critical resources—and one of the most difficult to manage—is volunteers. Over 60 percent of projects relied on volunteers. Yet this is an area where best management practices (BMP) are currently lacking.

As an example of how such BMP might be communicated, *Appendix III* outlines recommendations for recruiting, motivating, rewarding, and retaining volunteers.

"Making this all work is not a biology issue. It is a materials handling issue. That is why we need all these volunteers. Bagging is so laborious. I always say it is the answer to teenage crime in America—just get those teens to bag shells for a day. They will straighten up right away."

—John Supan, Director
Louisiana Sea Grant Oyster Program

Organizations doing restoration projects don't have a collaborative platform for sharing ideas, insights, and experiences.

Oyster restoration seems to be highly localized on many levels. And while site-specific factors require that each project be assessed individually to determine the appropriate methods to employ, a tremendous amount of information generated from these efforts could benefit future programs, but is not disseminated.

More often than not, difficulties reported through the course of one project were either also encountered elsewhere, or had been already accounted for by other projects that were able to circumvent them, usually through prior experience or expertise. Similar redundancies were observed in the creation of educational materials—student workbooks, lesson plans, and curriculum. While the need to individualize these materials for particular locales is noted, an online open-source library where these resources could be used by future projects could prevent the need to constantly re-create. Overall, the lack of a platform for knowledge- and experience-sharing increases expense and decreases the chance of success.

On a more technical level, a few NFWF-funded grants did involve the creation of computer models intended to help organizations select sites and estimate restoration outcomes. And others resulted in the generation of peer-reviewed journal articles and graduate theses. However, these tools and reports, while theoretically available to the general public, are not disseminated in an accessible fashion, nor are they typically user-friendly enough for non-scientists or non-engineers. Thus, they are likely too complicated for many restoration projects taking place today. A more practical tool might include decision-modules for project managers to select best practices or estimate restoration costs given certain known parameters.

"Ecological restoration involves many complex factors, and the best laid plans often go awry. We were delayed by property ownership issues, the BP oil spill, weather, low tides, and equipment failure. I see now why [professional reef building] contractors charge so much—they build these contingencies into their fees. However, with each delay, we either found a way to overcome or we just waited it out."

—Alison McDowell, Program Coordinator
Choctawhatchee Basin Alliance

Community support from citizens, businesses, and local government is critical to project success.

Although oysters currently have little charismatic appeal to the general public, we observed that efforts to raise the status of oysters, illustrate their clear value, and show their connection to people, places, and things of value, have succeeded in driving local support for restoration. In some regions—in the Chesapeake Bay, for example—oysters have been made to be surprising loveable, and local residents are more than willing to participate in oyster restoration projects. Where public buy-in has not occurred, restoration is an uphill battle or, in some cases, stalls altogether. For example, one NFWF project was completely shelved because the public opposed the replacement of ornamental landscape with a natural seagrass habitat, which was perceived as unkempt and uninviting. Another project focused on shoreline stabilization encountered resistance from coastal property owners, who preferred their white sandy beach (the product of erosion) to a reef and seagrass waterfront.

The most successful projects not only made the case for restoration through public awareness efforts and targeted educational campaigns, but they catered to people and organizations that had a vested interest in the project. Such outreach resulted in, for example: participation from property owners who became oyster gardeners along critical tributaries; partnerships with restaurants to collect used shell; support from recreational fishers who provided boat transport of shell and technical assistance; and donated public land by municipalities looking to enhance coastal areas and increase tourism. For some projects, news of success led to other potential partners (e.g., commercial landowners, state shellfish growers, school districts, etc.) wishing to be involved in future efforts.

"Oysters are like the poster child for the Bay. You'd think it would be blue crab, but people are turned on by oysters. I have no lack of interns; there is no lack of volunteers. People love doing things that help oysters. And it is not like they are warm and cuddly, but people rally around them and things happen."

—Tommy Legget, Oyster Restoration and Fisheries Scientist
Chesapeake Bay Foundation

"There have been strong attempts by all these [researchers] and folks at NOAA to bring groups together to get us to coordinate more. The motivation is there to learn from each other, but my impression is it's still piecemeal."

—Danielle Zacherl, Assistant Professor
Cal State Fullerton

OPPORTUNITIES

Our research focused on identifying and distilling the experiences of people on the ground with oyster restoration projects: Who are they? What defines their work? What obstacles have they encountered? How have they hatched solutions? From this discovery process, we synthesized our findings into four Barriers that constrain efficiency and effectiveness in oyster restoration projects, and four Design Principles that can successfully overcome those Barriers.

We mapped those solutions and made observations about where new energies and resources could be directed: Pressing problems required smarter solutions; small, localized solutions begged to be scaled; innovative ideas needed serious support.

Through conversations with experts in the field, and idea generation sessions from within our team, we looked for the biggest challenges and the changes that would yield the greatest impact. Together, we devised roughly 35 ideas—some realistic, some blue-sky—that could help to advance and scale oyster reef restoration. We clustered those into seven broad Opportunities, which fall into three categories:

1. Strategies for enhancing the efficiency and effectiveness of current and future restoration efforts

2. Market mechanisms to scale restoration activities

3. Policy initiatives to support and incentivize restoration

OVERVIEW OF SEVEN OPPORTUNITIES

The following pages summarize the seven Opportunities we identified. In each summary, we describe the contextual landscape of the core challenge being addressed. We assess each Opportunity by considering three essential questions: What forces could push this idea forward? What are the sources of push-back? What is the potential for this idea to gain traction if the challenge is met with innovation, public and organizational support, and adequate resources?

GROUP I: STRATEGIES FOR ENHANCING THE EFFICIENCY AND EFFECTIVENESS OF CURRENT AND FUTURE RESTORATION EFFORTS

Opportunity 1: Expand the support base for restoration activities

Idea: Create a national platform to connect regional initiatives

Landscape Most oyster restoration projects are regionally focused efforts that employ community volunteers, operate on limited funding, and rely on local resources. As such, the scopes of these projects are typically small, and the extent of their reach is limited. Even though latent support may exist in untapped areas, very few programs target individuals, communities, or businesses outside of their immediate watersheds. And while widespread outreach may make little sense for a single relatively minor project, such a strategy could be highly successful if it represented projects nationwide through a national platform. Similar to how other broad environmental and social issues have gained traction, such a platform could involve branding campaigns, reef-adoption programs, volunteer and resource needs for specific projects, and other crowd-sourcing initiatives.

The Push A national platform to connect local and regional restoration initiatives could raise public awareness of the importance of oyster restoration, alert people to restoration activities, and provide opportunities for lending support—financial and otherwise.

The Pushback Banking on the charity of individuals and businesses to offset current restoration costs can be a slow and risky investment, especially considering the myriad other issues competing for peoples' hearts and purse-strings in today's overly messaged world. Scaling this sort of change requires brilliant marketing, accurate targeting, and near-flawless execution.

The Potential Inventing a fundraising strategy that goes beyond the traditional non-profit campaign is possible, and much can be learned from the successes of other organizations that raise significant sums of money from small contributions from individual donors. While unlikely to completely alleviate the financial and resource challenges faced by oyster restoration programs today, the ancillary benefits in terms of raising public awareness could create ripple-effects that result in the diffusion of other barriers to scaling.

"There's a 'David and Goliath' aspect to the native oyster story that appeals to people. A vision of future plenty when the native oyster population may be healthy enough to support harvest also helps advance the overall conservation cause."

—Betsy Peabody, Executive Director
Puget Sound Restoration Fund

Opportunity 2: Facilitate information-sharing among restoration projects

Idea: Develop an online collaboration tool for scientists and program managers

Landscape The independent and siloed nature of most small-scale restoration efforts results in multiple layers of inefficiency due to a lack of information- and data-sharing. Knowledge and lessons learned from research and experience are rarely disseminated from one organization to another. Even programs active within the same watershed lack an effective way to learn from one another, although some forms of collaboration have been attempted in the past. While methods and results from some monitoring programs are published in peer-reviewed literature or on program websites, no centralized database or repository exists. Some large organizations have ongoing programs in multiple regions, but many funded projects are stand-alone; they have no history and few connections. Of specific usefulness to these projects in particular could be layman-friendly how-to guides for implementing certain programs (e.g., shell recycling), tips and tricks for permitting (organized by state, region, or watershed), pros and cons of different planting methods, options for securing materials and equipment, best management practices for filling resource needs (including volunteers), etc. Yet even for more established programs, the availability of searchable research libraries, databases for uploading results, discussion boards, etc. could be of great value to scientists and project managers alike.

The Push A single open-source, online collaboration and information-sharing tool could benefit every oyster restoration project in the country by immediately eliminating some of the common pitfalls associated with planning, management, and technology. Nearly every oyster restoration expert we interviewed agreed that a collaborative platform was sorely needed. Until such a tool exists, scarce financial, material, and human resources will continue to be wasted on ineffective restoration methods, redundant learning curves, and avoidable mistakes. One possibility for populating the database would be to work with NFWF, NOAA, and other main funders of restoration projects on specific data requirements of future grantees. For example, a similar requirement applies to genetic work; newly mapped genes must be added to GenBank so other researchers can see what has been decoded, avoid repeating that exercise, and use the code for future research.

The Pushback As with any online tool, the effectiveness of this platform will only be as great as the effort and commitment put forth by its users. Convincing restoration scientists and project managers to adopt and regularly update a new online data-sharing resource may be difficult, so its creation will require the skills of a seasoned collaboration facilitator who can involve potential users and other stakeholders in its design and content. One or more managers to vet and organize newly uploaded information will also be necessary.

The Potential Considering the degree of inefficiency attributed to preventable gaffes, the time and resources saved by each individual project could be substantial. Additionally, by flattening the learning curve, projects may find that they have more opportunity to innovate, which could further accelerate the path to scaling.

"Because there are so many people and entities working in the nation's bays with many different funding mechanisms, it is almost impossible to know who is doing what where and why. There is no over-arching entity that keeps track of projects and there is no clearinghouse to coordinate all the activities."

—Dorothy Leonard and Sandra Macfarlane
Best Management Practices for Shellfish Restoration

GROUP II: MARKET MECHANISMS TO SCALE RESTORATION ACTIVITIES

Opportunity 3: Pair industry and restoration

Idea: Tap into existing business ideas and supply chains

Landscape Restoration is expensive. The cost to restore an acre of oyster reef based on project budgets from NFWF grantees can be anywhere from the thousands to millions of dollars. Because the aggregate costs of shell, transportation and storage, project management, and scientific assessment and monitoring are so high, most restoration projects remain small because of a shortage of cash. While some programs have found innovative and budget-friendly ways to meet project needs, others continue to rely on pricey inputs provided by relatively few suppliers, which further drives up costs. One solution to this bottleneck is to look to other industries for existing technologies, methodologies, supply chains, and resources that could improve efficiency while reducing restoration costs. As we saw from the projects profiled, opportunities might include creating substrate from waste materials otherwise bound for a landfill, backfilling seafood distribution trucks with empty oyster shells, borrowing undeveloped lots for shell curing, or employing specialized tools or equipment to facilitate time- and labor-intensive processes. Other specific takes on this idea could involve creating a Craigslist-type tool to match potential substrate material with projects, or for unused trucks or storage facilities with capacity needs.

The Push By tapping into underutilized resources and building on infrastructure that's already been created, reef restoration can emerge from the limits of its current market niche into a more competitive market space where many of the logistical problems facing these projects have already been solved.

The Pushback Identifying and testing what this opportunity looks like in action would be time-consuming, and some ideas might not turn out to be as cost-effective as hoped. Viability will depend on profitability, which must be modeled for each specific idea.

The Potential The chance to align oyster restoration with business interests and processes opens the door to an elegant momentum that the market itself would drive.

"The ongoing efforts of the various entities working with oysters should be coordinated and consolidated into a cohesive partnership."

—Hudson River Foundation, et al.
Oyster Restoration Feasibility Study

Opportunity 4: Turn oyster farmers into reef stewards

Idea: Create consumer-oriented strategies that profit commercial growers while financially supporting restoration

Landscape Aquaculture is the predominant source of commercial oysters today, making up 90 percent of domestic production. While commercial oyster farming can be at odds with restoration efforts, especially when competing for substratum or when restoration is perceived to mean conversion of potentially harvestable areas into no-take sanctuaries, the two are not mutually exclusive. Both endeavors could benefit from collaboration. In fact, we found that shellfish growers in certain parts of the country were actively seeking ways to be involved with restoration because they recognized the value of healthy non-harvestable reefs to their operations.

The Push: With few exceptions, oysters are not differentiated in the marketplace, despite the fact that their regional and local differences are as diverse as those of wines. Additionally, the mark-up on an oyster can be 5-10 times higher than the price paid to the oyster grower. The creation of a special "restoration oysters" brand could give growers better margins while incentivizing participation in restoration. For example, special branding could be offered to growers who commit to donating (tax-free) a portion of sales to restoration. In return, the brand would provide marketing, highlight the uniqueness of the region and the grower, and garner a premium oyster+story price. Comparable business approaches to solving social issues have succeeded in other industries. For example, TOMS shoe company is famous for its One for One™ program; for every pair of shoes purchased, a pair is donated to a child in need. A similar model could be applied to oysters: For every oyster you eat, ten are replanted.

The Pushback: Infiltrating an established market and creating a new, pricier brand for a well-known product—especially when there is no quality difference in the branded product—will be difficult if not accompanied by an innovative marketing campaign.

The Potential: The use of sales to effectively generate restoration funds would simultaneously contribute to reef-rehabilitation, public awareness, and higher profits for growers.

"There are lots of benefits to having sanctuaries—they serve ecological functions, for example—but waterman and the State are reluctant to give up good bottom because you can't harvest on sanctuary reefs. And if we reduce the wild fishery, where are shells going to come from for restoration? That is the fear. And it causes quite a bit of conflict."

—Tommy Leggett, Oyster Restoration and Fisheries Scientist
Chesapeake Bay Foundation

Opportunity 5: Name a new value and develop a market for it

Idea: Create an environmental impact bond to fund restoration

There are many types of value in this multi-dimensional challenge not being adequately named, captured, or attached to a dollar value. Changing that can create opportunities for investment and for markets where that value is traded, which will lure private dollars.

For example, we know that oysters deliver value to shoreline communities: water purification, erosion prevention, and an economic boost to fishers' livelihoods. These services generate savings for local regions that could be issued as municipal bonds backed by a bank. That, along with a loan guarantee from one or a consortium of foundations, could set the stage for a multimillion-dollar investment, in which profits are linked to the success and impact of restoration. These type of bonds have been pioneered already in the social impact field. Bringing this innovation to a restoration project would require both quantification and attracting the right partners, but is entirely feasible.

Another type of value-based market could look at providing nutrient credits to corporations who contribute to oyster restoration. Those credits could be applied against their current pollution tab. As many regulatory bodies allow some level of effluent disposal into waterways, this could become a standard part of that permitting process.

The Push Until we find ways to attach dollar value to this equation, we're limited in the number of investment options we can develop. If we can quantify the impact, well, the world is our oyster.

The Pushback The value of ecosystem services of oysters is subjective. In many ways, it is impossible to know the true savings that a municipality or any group would experience as a result of restoration.

The Potential All investments are subjective. Combined with the right risk protections and reasonable science, a deal can be made. The accuracy of the science is less important than the structure of the deal. A successful deal of this nature could set a replicable example for communities and investors worldwide.

"As more restoration efforts are initiated, it is important to document and publicize the broader ecological and economic returns from restoration activities to garner the long term support necessary for large scale restoration efforts."

—A Practitioner's Guide to the Design & Monitoring of Oyster Restoration Projects

GROUP III: POLICY INITIATIVES TO SUPPORT AND INCENTIVIZE RESTORATION

Opportunity 6: Streamline the permitting processes

Idea: Work with agencies to create policies and permits specifically for restoration

Landscape One of the greatest barriers to successful reef restoration is permitting—a long, complicated process (or lack of process) that drains time and resources from any organization attempting to construct reefs in the intertidal or subtidal environment. Often, multiple agencies have jurisdiction over a single site, and each has its own permitting idiosyncrasies to navigate. Some agencies are not equipped to handle requests for restoration activities, as they're geared solely toward permitting for the type of coastal development that involves environmental harm. In some states, the placement of shell in coastal waters is regarded as "fill" and, thus, is not allowed unless it can be removed—which defeats the purpose of restoration.

The Push Several agencies have created streamlined permitting processes to help alleviate this problem. Washington State recently revised its Joint Aquatic Resources Permit Application (JARPA). Federal (US Army Corps and Coast Guard), state (Department of Ecology, Department of Fish and Wildlife, and Department of Natural Resources) and city/county agency permits can all be applied for through this one application, available online. A similar JARPA is in effect in San Francisco Bay. Such streamlining in other regions would free up more resources that could be devoted to actually restoring reefs.

The Pushback Getting city, county, state, and federal agencies to work together—much less agree—is no small task.

The Potential Eliminating one of the greatest barriers to current restoration efforts could significantly accelerate the commencement of projects, save time and money, and encourage more organizations to pursue restoration activities. The by-product of this process would be better educating civil servants at multiple levels of government about the importance of reefs. It may take time up-front, but models to create streamlined permits already exist.

"In summary the permitting process puts our reefs through a process no different than that of a major shoreline engineering project like a marina or community dock."

—Alan Power, Ph.D. & Erica LeMoine
University of Georgia Marine Extension Service

Opportunity 7: Increase the supply of shell to decrease the cost of restoration

Idea: Incentivize shell recovery and recycling

Landscape Demand for oyster shell far outstrips supply. The result is high shell prices and competition between restoration and commercial uses. This scarcity is largely due to shell loss after harvesting; shells being discarded after shucking, specifically by restaurants, often wind up as landfill. Both carrots and sticks have been used in other industries to dissuade the disposal of certain valuable materials. For example, deposit-refund programs for aluminum, plastic, and glass significantly increased recycling rates for beverage containers and created markets for recycled materials. Anti-dumping laws have stimulated the birth of entire industries around the collection, transport, storage, and proper disposal of toxic materials. In both cases, market forces took over after the policy was enacted. Similar regulatory drivers could spark markets around shell recovery and recycling. If it were illegal to discard shells in garbage dumps, or the fees to do so were heavy enough, business pathways to reclaim and recycle shells would develop.

The Push State and local shell recycling and recovery initiatives have already proven effective at diverting shells bound for the landfill back onto reefs. Incentivizing shell recycling, and/or facilitating a used-shell market, would serve to further increase shell supply and, presumably, drive down costs. Associated fees (from illegal dumping) and un-refunded deposits could be applied directly to reef restoration.

The Pushback As with new taxes, new regulations that require businesses to change practices and incur costs are typically met with resistance. Pushing them through the proper channels to become law is a difficult battle. Further, the historic loss of shell is so enormous, and the need for substrate is so great, fully recycling all shell might not be enough to meet demand.

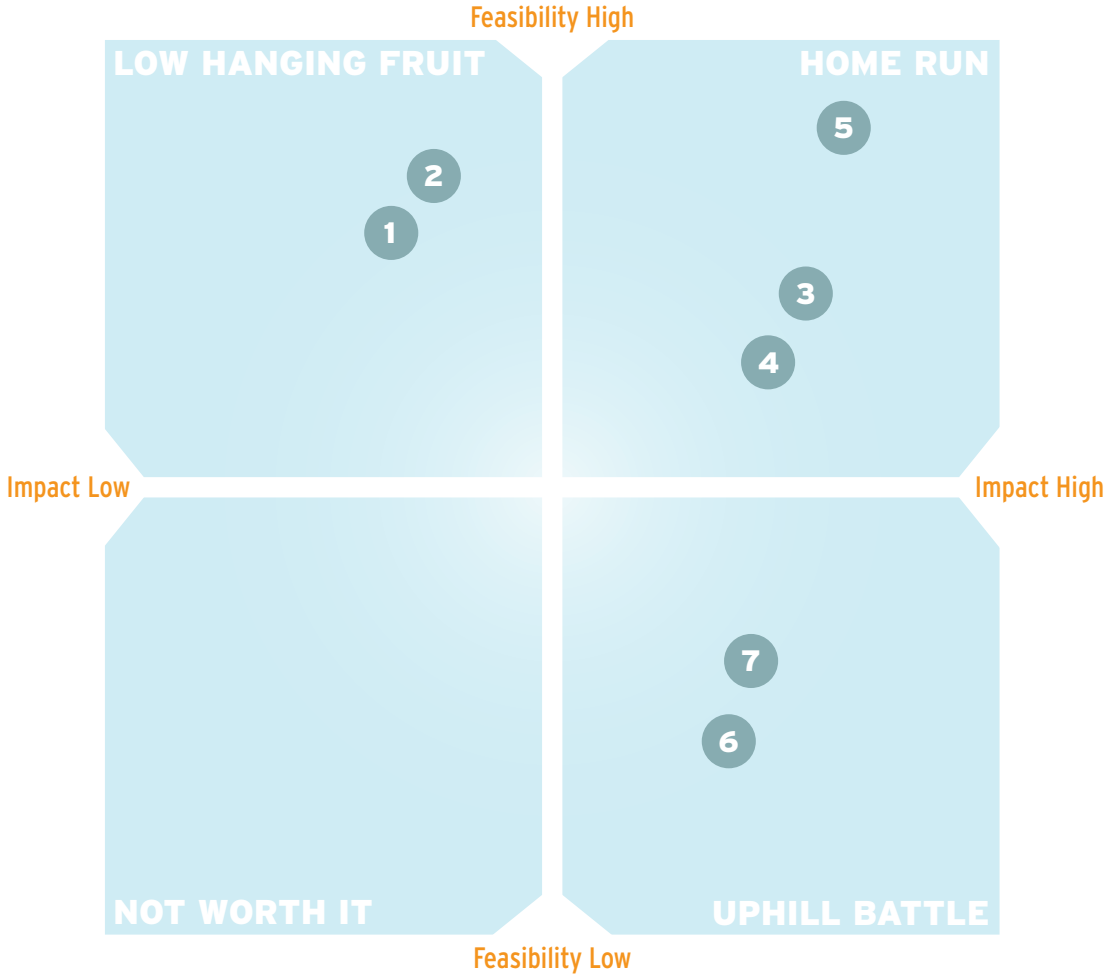
The Potential The development of a market for recycled shell—a material perceived by some to have little to no value—could significantly improve the cost-effectiveness of future restoration efforts.

"Things that aren't working are because of a lack of oyster shell. Our oyster harvest in the Bay is 25,000-250,000 bushels per year. Most of this shell is reclaimed and reused for restoration, but it's a drop in bucket compared to what is needed."

—Tommy Leggett, Oyster Restoration and Fisheries Scientist
Chesapeake Bay Foundation

OPPORTUNITIES MAPPING

We evaluated these seven Opportunities along two important continuums: feasibility and impact. FEASIBILITY is the likelihood that the idea can be implemented, given resource requirements, regulations, social norms, learning curves, and other practical realities. IMPACT captures the ability of an idea to significantly drive restoration efforts to scale, through widespread adoption or influence.



1. *Expand the support base for restoration acivities*
2. *Facilitate information-sharing among restoration projects*
3. *Pair industry and restoration*
4. *Turn oyster farmers into reef stewards*
5. *Name a new value and develop a market for it*
6. *Streamline the permitting processes*
7. *Increase the supply of shell to decrease the cost of restoration*

“Cultural support for oyster restoration here [in the Chesapeake Bay] is huge. People care about oysters in a way they don’t care about other bivalves.”

—Keryn Gedan, Smith Conservation Research Fellow
Smithsonian Environmental Research Center

CONCLUSION

Our Recommendations: Where do we go from here?

Our goals for this report go beyond merely offering a survey of the field. We designed our process to support action: incubating a set of new initiatives, companies, or collaborations to further the National Fish and Wildlife Foundation's goals to increase the efficiency, cost-effectiveness, and scaling potential of oyster restoration efforts. The opportunities we've named create a roadmap for subsequent phases of execution.

Of the seven opportunities described, which are both highly feasible and have potential to deliver significant impact? Since the decision must rely on prediction rather than on data, we've offered some useful considerations for selection, and share our thinking as to why some opportunities seem riper than others.

We first evaluated each opportunity against the core Barriers facing successful and scalable restoration. In this way, we considered not just the feasibility and impact of each opportunity area, but also its relationship to the most pressing aspects of the problem. A second contributing factor to our evaluation was an assessment of anticipated challengers and drivers. What or who are the likely sources of opposition? How much influence do they wield? What or who might support and spur this opportunity? How powerful is that impetus? These last two questions can be translated: Who might fund or invest in this concept?

In light of these criteria, we have outlined the opportunities that we believe have the greatest promise for serving NFWF's restoration priorities, and which deserve consideration for deeper evaluation in subsequent phases of work with Future of Fish and other partners.

Opportunity 2: Facilitate information-sharing among restoration projects

Idea: Develop an online collaboration tool for scientists and program managers

One of the main themes inferred from our research was the tendency for projects to struggle because of inexperience, inadequate planning, and/or lack of access to useful information and ideas. An online support tool for restoration projects to share, consult, learn, and collaborate has the potential to overcome challenges within all of the Barriers we identified. Building and expanding collective know-how could substantially improve the efficiency and cost-effectiveness of future efforts.

One major feature of the tool would be up-to-date information, advice, and other resources around obtaining appropriate permits for particular regions or water bodies. Other features could tackle project planning and management, including (but not limited to) how-to guides for preliminary site assessment, recruiting volunteers, finding and using different types of substrate, creating shell recycling programs, and post-project monitoring. Discussion boards, calls for funding proposals, job positions, volunteer opportunities, and Craigslist-type indexes of free and for-sale equipment and resources would add further value.

After an initial investment to build the database and online interface—a process that would involve consultations with stakeholders and input from restoration experts and other potential users—the fact that it would rely on open-source, user-generated information means it has the potential to be self-propelling. Once the site is built and populated with relevant content, web ads, sponsorships, or other sources of revenue might partially or fully sustain it financially.

We learned from our expert interviews that such a tool is sorely needed, and several ideas for online information-sharing have been discussed in the past. The current website that comes closest to what we propose here is oyster-restoration.org. A collaboration among several NGO and government agencies, this website serves as a hub for networking, research reports, and other relevant resources. However, its organization and interface require a patient user with the time to sift through a potentially overwhelming amount of information—most of which is contained in broadly catalogued electronic documents. If it enjoys a large number of users, it may be worth exploring whether this current website would be amenable to morphing into the online tool described by this opportunity.

Opportunities 3 & 7: Pair industry and restoration & Increase the supply of shell to decrease the cost of restoration

Idea: Tap into existing business ideas and supply chains & Incentivize shell recovery and recycling

Jointly, these two opportunities addresses two key challenges: the difficulty projects have in meeting resource and logistical needs, and the fact that oyster shells, despite their value, usually go to waste.

We see the implementation of policy to incentivize shell recovery and recycling to be a catalyst for industry becoming more involved in restoration. For example, deposit-refund programs or policies that prohibit the landfilling of shells could spark the creation of an entire shell-recycling market, complete with new opportunities for innovation and entrepreneurship. The increase of shell supply could drive down costs, which would presumably benefit restoration efforts, although the cost of recycling might leave the price unchanged. Whether or not this recycled shell ultimately goes back into water, funds generated from fees and unrefunded deposits potentially could be dedicated to restoration.

The idea of tapping into "waste" resources extends beyond shell. Other potential substrate materials (e.g., concrete, porcelain, ceramics, etc) for which companies currently pay disposal fees, could be repurposed for restoration if the logistics challenges around transport and storage could be overcome. Financial modeling may be in order to determine true costs and potential savings over more conventional approaches. One logistical solution involves exploring dormant resources with latent value: Abandoned, gated lots could be used for storing and curing substrate; distribution trucks could transport substrate in unused trailer space; fishing vessels or oil barges that are empty when leaving port could haul substrate to off-shore reefs. While the practicality of each of these examples varies, the concept is one that deserves further investigation.

Several of the projects we reviewed were successful because they benefited from resources beyond the conventional restoration supply chain. For example, one effort used the crew of a Royal Caribbean ship to drill holes in shells for oyster mats while they had free time at-sea. Another project benefitted from a volunteer businessman who redesigned a conveyor machine he owned to increased shell-bagging efficiency

by 20-fold compared to hand-baggers. We observed that most new-found resources are discovered by a chance meeting or event. The potential to completely revolutionize restoration methodology through more efficient processes and techniques might lie in intentionally finding these resources and introducing them to the oyster restoration community.

Opportunity 4: Turn oyster farmers into reef stewards.

Idea: Create consumer-oriented strategies that profit commercial growers while financially supporting restoration

Like the previous opportunity, this one aligns itself with market drivers to increase restoration funds. Currently, few oyster farmers are involved with reef restoration. In fact, farmers are sometimes threatened by restoration efforts that compete for favorable substratum or seek to create no-take sanctuaries. However, farmers could potentially benefit from the water-filtering capabilities of reefs, and some have expressed interest in finding ways for the industry to support restoration.

In an industry where oysters largely lack differentiation, this opportunity explores the possibility of creating a "restoration oysters" brand or certification label that could accompany oysters grown by farmers participating in restoration. The advantage to the farmer would be higher margins—either from a higher price for the brand, or the ability of the brand to disintermediate the supply chain and market directly to restaurants and retailers. The return would be in-kind or financial contributions to a restoration fund. An ancillary benefit would be increased consumer awareness, as every branded oyster would come with a story about the importance of oyster reefs and the valuable services they provide to the environment and society.

A partnership among farmers and one or more restoration programs or foundations would be needed to further flesh out this idea. And its development would surely require some financial modeling and market research. At the heart of this opportunity is the system tension we identified earlier in this report: A fleet of experts are already successfully cultivating and executing some degree of short-term restoration for profit. The chance to scale that work with the right incentives and partnerships is enticing.

Opportunity 5: Name a new value and develop a market for it

Idea: Create an environmental impact bond to fund restoration

This opportunity offers a potential breakthrough in how restoration is funded. The elements of the specific idea—establishing an environmental impact bond—have been proven in other fields. The remaining work is substantial to be sure: collaboration between marine scientists, oyster experts, economists, and investment bankers to put a price on the value of restoration. But this challenge is best understood as an exercise in deal design, rather than in scientific or economic certainty. The invention of investment tools to mitigate risk and generate reward are ultimately more important in this context than whether the valuation is off by an order of magnitude.

An initial pilot of this approach, if successful from an investment point of view, could seed multiple replications and, ultimately, put the future of oyster restoration in the hands of a creative model of public/private partnership that catalyzes both funding and local enthusiasm.

Final Thoughts

It is worth noting that all these opportunities represent areas for exploration. The specific ideas we have suggested are merely examples of how various areas might be targeted, but are by no means the only options. The narrowing of one or more of these opportunities into actual viable solutions, with outcomes and goals, is the next step in this discovery process. We fully expect the ideas to evolve (based on feasibility and difficulty, among other criteria) as more stakeholders are invited to participate, and a deeper exploration into execution and impact ensues.

We hope that this report will spark fruitful and impassioned discussions in the field about the opportunities outlined here, and also about this approach to effecting change. Ultimately, any insights we have discovered here can be traced back to the hard work and expertise of those involved in on-the-ground restoration. The hallmarks of their approach—noticing what's working and why, building on experience, and moving from a standpoint of what is possible (rather than what is broken)—could prove transformative for the thinking of the field, and are at the heart of the oyster opportunity.

"I think we are on the cusp of a real maturation of the field and, in a way, I think oyster reef restoration will have come further faster than other types of habitat improvement."

—Rob Brumbaugh, Restoration Program Director
The Nature Conservancy, Global Marine Team

APPENDICES

Appendix I • NFWF Oyster Restoration Grantmaking Analysis and Recommendations

Future of Fish was given access to electronic copies of grant proposals, mid-term reports, final reports, and/or supporting documents for 65 oyster restoration-related projects funded by NFWF during the past 10 years. Our objective was to better understand the landscape of oyster reef restoration and the attributes that distinguish successful projects. From that, we needed to generate opportunities for market intervention. The bulk of our report focused on this core objective.

But based on subsequent requests from mid-term conversations with the Program Director, we also compiled a number of potentially interesting descriptive statistics that characterize the oyster-related NFWF projects funded to date. Our hope is that these data will be useful to NFWF in better understanding and refining its grantmaking process.

A separate goal pertained to estimating the true impact and relative efficiency and cost-effectiveness of particular oyster restoration approaches. Unfortunately, widespread variability in methodology and unstandardized outcome metrics precluded us from generating accurate results from this attempted analysis. However, the challenge created an opportunity to identify and summarize the types of information that could be required from NFWF grantees in the future to make such an analysis possible.

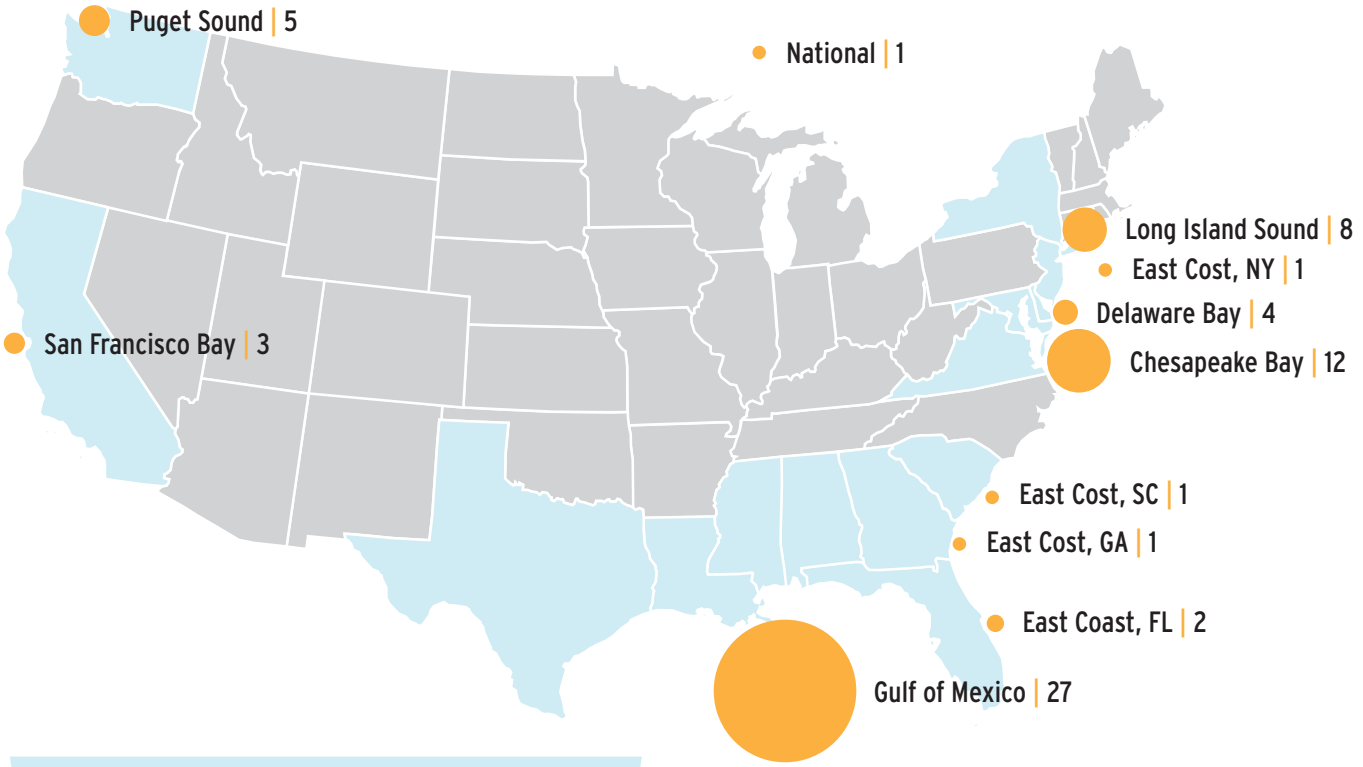
The following sections pertain to the NFWF grants reviewed and evaluated for this report. Where appropriate, supplemental interviews were conducted to fill gaps or to verify results.

NFWF-FUNDED OYSTER PROJECTS AT A GLANCE

The purpose of the following data illustrations is to provide NFWF with a snapshot of what's been done, who's doing what, where they're located, and the types of reporting measures that are typical for grantees. Wherever possible, we summarized outcome metrics and cost-comparisons; however, as noted previously, variation in data-reporting prevented us from drawing firm conclusions.

The 65 grants reviewed were funded between 2002 and early 2012; not all information was available for all grants. The infographics that follow provide visual interpretations of these data and, where appropriate, additional details are noted.

Where are NFWF restoration projects located?



In which states do NFWF-funded restoration projects occur?

State	Projects	Total NFWF Funding	Average NFWF Funding
Alabama	3	$650,344	$216,781
California	3	$386,680	$100,000
Delaware	3	$63,000	$128,893
Florida	19	$1,607,278	$21,000
Georgia	1	$20,000	$84,594
Louisiana	4	$1,218,376	$20,000
Maryland	5	$484,936	$304,594
Mississippi	4	$312,168	$96,987
New Jersey	3	$135,813	$78,042
New York	9	$593,548	$45,271
South Carolina	1	$30,658	$65,950
Texas	1	$47,999	$30,658
Virginia	9	$622,641	$47,999
Washington	5	$324,328	$69,182
National	1	$100,000	$64,866

Many grants involved multiple states. For this estimation, budgets were allocated evenly among states identified in the grant. Total NFWF funding covered by these grants, $6.61 million. Average NFWF funding per grant, $102k.

385

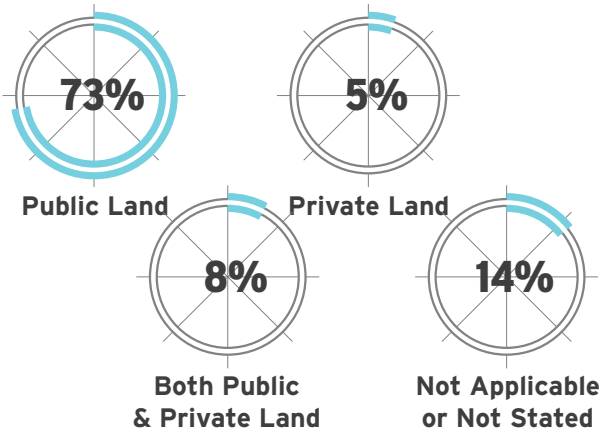
Avg Total Volunteer Hours Per Project

81

Avg Number of Volunteers Per Project

Where did restoration projects occur?

Restoration occurred on private land for projects located in Alabama, California, Maryland, and Washington.



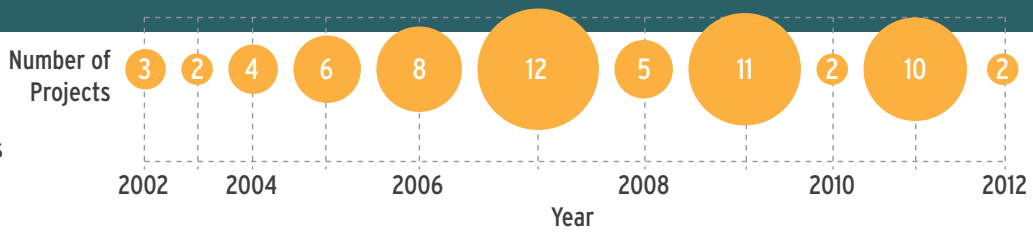
	NGO	UNI	GOV
NFWF Funded Projects	37	15	13
Total NFWF Funding	$4,434,347	$1,341,995	$833,927
Avg Funding Per Project	$119,847	$89,466	$64,148
Avg Matching Dollars	$98,483	$191,698	$189,495
Avg Total Dollars	$218,330	$281,164	$253,643
Percent from Matching	45	68	75

Grand Totals

Avg Matching Dollars	Avg NFWF Dollars	Avg Total Dollars
$135,288	$191,698	$189,495

Average Percent from Matching: 57%

When were these projects funded?



Note: The most recent projects reviewed were funded before May 2012.

Harvesting: Were restoration oysters harvestable or not?

Note: The few harvestable areas were in Chesapeake Bay, Gulf of Mexico, Long Island Sound, and Puget Sound

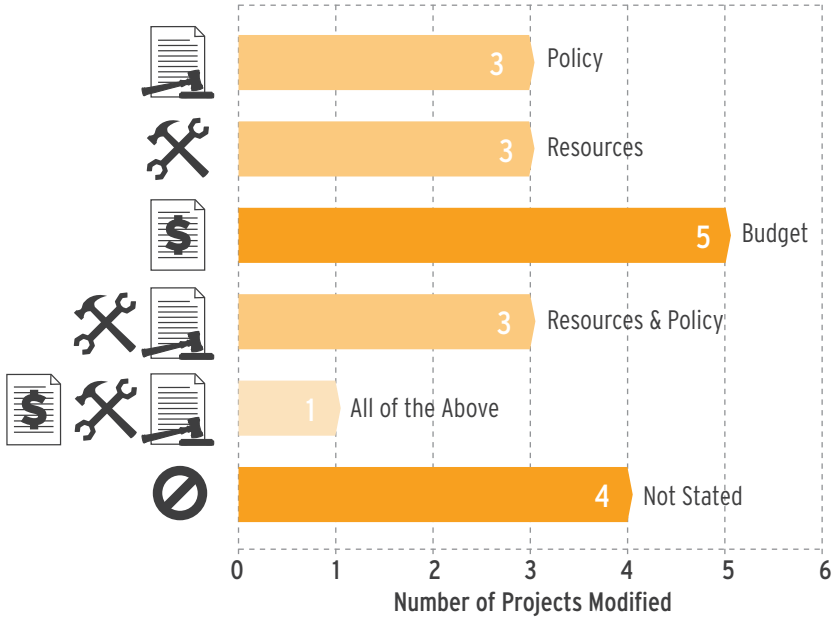
55% Not Harvestable

18% Harvestable

29% Not Applicable or Not Stated

15 of 65 (23%) projects indicated that they were required to modify the plans stated in their original proposals. What were the reasons?

Projects located in Puget Sound (3 of 3 projects) and the Gulf of Mexico (6 of 27, 22%) were most likely to require modification of the original project plans. None of the 15 projects run by Universities required modifications to original plans.



9 Total number of projects using a shell recycling program

Percentage of area covered by restoration reported using this measure

- **Sq Meters** 4%
- **Mounds** 4%
- **Cubic Yards** 4%
- **Acres** 54%
- **Linear Feet** 19%
- **Sq Feet** 15%

Percentage of volume of restored area reported using this measure

- **Shell Bags** 25%
- **Bushels** 37%
- **Tons** 19%
- **Shells** 19%

Note: Grantees reported results in area restored or volume of substrate used; some grantees reported both and many did not report either.

Projects run by government entities were less likely than others to engage corporate sponsors (8%), compared to projects run by NGOs (20%) and Universities (22%). Sponsors were most often used in the Chesapeake Bay and San Francisco Bay regions.

82% Did not use corporate sponsorship

18% Did use corporate sponsorship

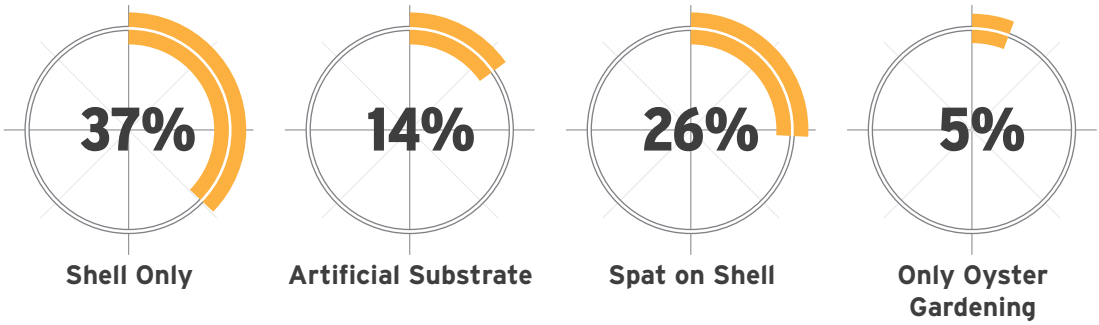
Percent of projects that used oyster gardening

35

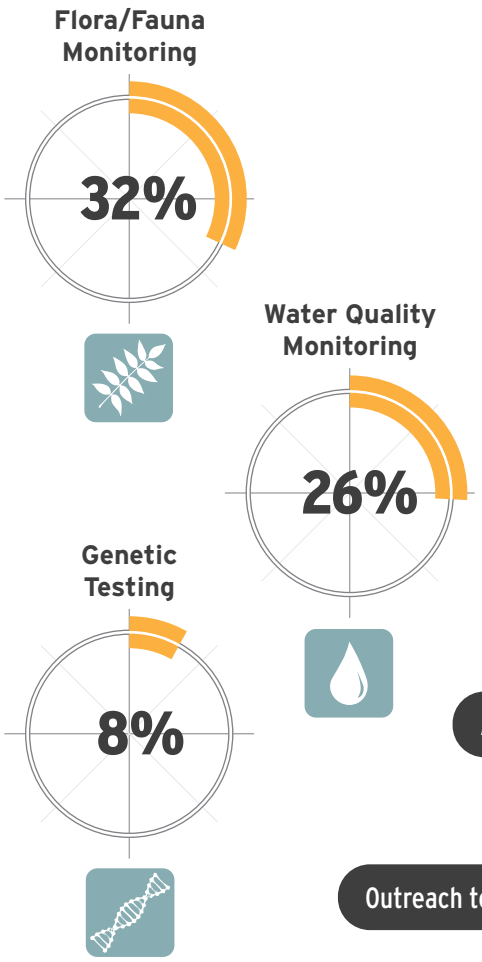
Note: Oyster gardening was utilized in 75% of Chesapeake Bay projects, but only in 26% of projects in the Gulf of Mexico.

What type of substrate was utilized in these restoration projects?

Projects utilizing artificial substrate received nearly 2.5 times the NFWF funding (average = $240,000) than projects that did not use artificial substrate.

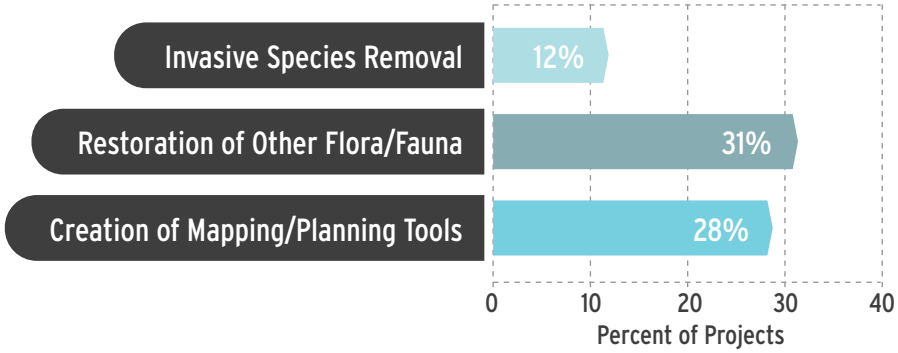


Monitoring: What assessments were involved?

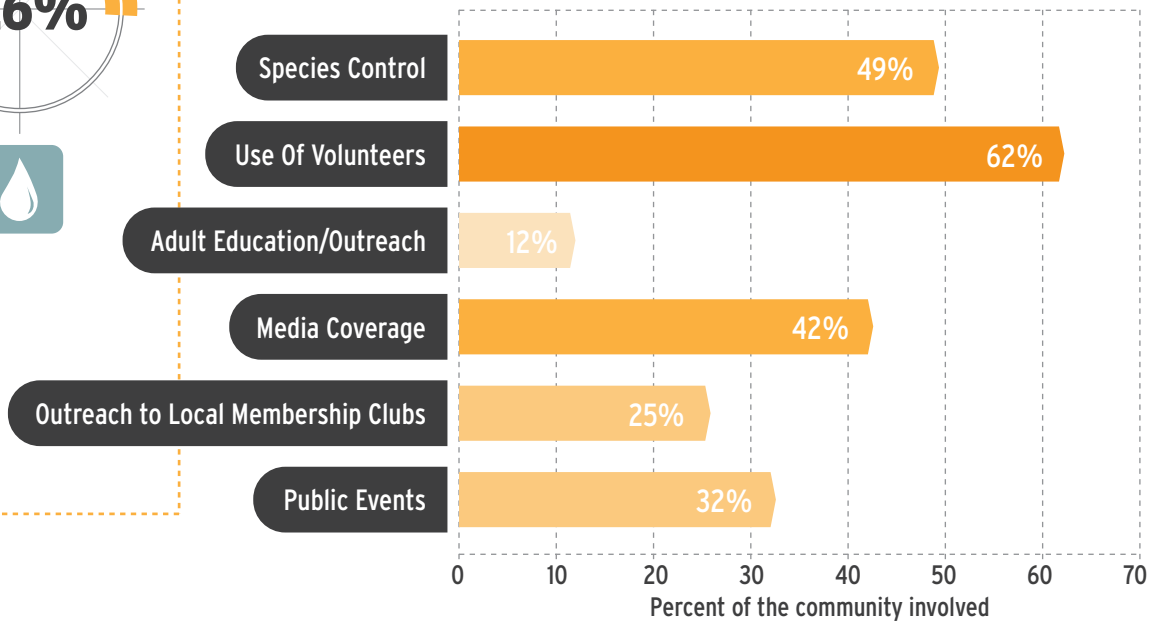


What other activities were funded in addition to restoration?

Universities were least likely to include restoration of non-oyster habitat (7%), and government entities were most likely (46%).



How did projects engage the community?



GRANTEE PROJECT PLANNING CHECKLIST

The following checklist is meant as a starting point for a guide that might be provided to potential grantees during a planning and consideration process for all of the important facets of an oyster restoration project.

This checklist is not meant to be exhaustive, but rather suggestive of important details that some NFWF projects seemed to have overlooked, which resulted in complications. If NFWF were to be interested in moving forward with this sort of resource, more in-depth research would be needed, as would ideas and feedback from restoration experts and NFWF program officers, about how to maximize the value of such a guide.

If a completed checklist (along with data) were submitted with grant proposals or mid-term reports, this information could be extremely useful in not only populating an online data-sharing platform, but also in helping NFWF determine important characteristics of funded restoration projects. If organized in an accessible manner, these data could be further analyzed to give more insight into best practices and the attributes that propel or hinder success.

Restoration Site Biogeochemistry *Please indicate whether assessment of the following site characteristics is planned, completed, or not applicable. If already completed, please provide details.*

	Planned	Completed	Not Applicable
Salinity	[ ]	[ ]	[ ]
Water temperature	[ ]	[ ]	[ ]
Disease prevalence	[ ]	[ ]	[ ]
Water quality (N, P, CBOD)	[ ]	[ ]	[ ]
Natural spat settlement	[ ]	[ ]	[ ]
Substratum condition	[ ]	[ ]	[ ]
Inter- or subtidal	[ ]	[ ]	[ ]
Ideal planting season	[ ]	[ ]	[ ]

Restrictions And Permitting *Please provide the following information about the restoration site. Where possible, include relevant details.*

Site ownership	[ ] Private	[ ] Public	[ ] Other	[ ] Unknown
Size restrictions	[ ] Yes	[ ] None		[ ] Unknown
Permits required	[ ] Yes	[ ] None		[ ] Unknown
Permissible activities	[ ] Fishing	[ ] Boating	[ ] Shellfish harvest	[ ] Unknown
Required notifications	[ ] Signage	[ ] Public Announcements		[ ] Unknown

Oyster Gardening *Please indicate whether the following are planned, completed, or not applicable.*

	Planned	Completed	Not Applicable
Secure waterfront volunteers	[ ]	[ ]	[ ]
Identify pier-gardening regulations	[ ]	[ ]	[ ]
Obtain permits	[ ]	[ ]	[ ]
Obtain insurance	[ ]	[ ]	[ ]
Assess risks from poaching	[ ]	[ ]	[ ]
Assess risks from eating shellfish	[ ]	[ ]	[ ]
Volunteer training	[ ]	[ ]	[ ]
Regular assessment of growth, mortality	[ ]	[ ]	[ ]
(Oyster Gardening Continued)	Planned	Completed	Not Applicable
Cleaning, defouling of bags, cages	[ ]	[ ]	[ ]
Testing for disease	[ ]	[ ]	[ ]
Out-plant of cultivated oysters	[ ]	[ ]	[ ]

Substrate And Out-Planting Method *Please indicate whether plans have been made with respect to the following activities, methodology, and inputs, or whether options are still under consideration. Provide details where relevant.*

Primary activity	Planned	Considering
New reef construction	[ ]	[ ]
Shell placement on existing wild reef	[ ]	[ ]
Shell placement on existing restored reef	[ ]	[ ]
Cleaning or defouling existing wild reef	[ ]	[ ]
Cleaning or defouling existing restored reef	[ ]	[ ]

Substrate options	Planned	Considering
Loose shell	[ ]	[ ]
Spat on shell	[ ]	[ ]
Shell bags (fill method _____)	[ ]	[ ]
Shell mats (attachment method _____)	[ ]	[ ]
Reef balls [ ] constructed [ ] purchased	[ ]	[ ]
Oyster castles [ ] constructed [ ] purchased	[ ]	[ ]
Oyster rings [ ] constructed [ ] purchased	[ ]	[ ]
Concrete	[ ]	[ ]
Limestone	[ ]	[ ]
Other _____	[ ]	[ ]

Substrate sources	Planned	Considering
State shell reserves	[ ]	[ ]
Shell recycling program	[ ]	[ ]
Substrate donations	[ ]	[ ]
Purchased (source _____)	[ ]	[ ]
Other _____	[ ]	[ ]

Transport and logistics	Planned	Considering
Truck	[ ]	[ ]
Boat	[ ]	[ ]
Barge	[ ]	[ ]
Crane	[ ]	[ ]
Other transport _____	[ ]	[ ]
Handling method	[ ]	[ ]
Storage method	[ ]	[ ]

Paid personnel	Planned	Considering
Manual labor	[ ]	[ ]
Technical consulting	[ ]	[ ]
Scientific/research consulting	[ ]	[ ]
Project management consulting	[ ]	[ ]
Other _____	[ ]	[ ]

Volunteer personnel	Planned	Considering
Manual labor	[ ]	[ ]
Technical consulting	[ ]	[ ]
Scientific/research consulting	[ ]	[ ]
Project management consulting	[ ]	[ ]
Other _____	[ ]	[ ]

Outcomes monitoring and reporting *Please indicate whether plans have been made with respect to monitoring and measuring the following outcomes, or whether options are still under consideration. Provide details where relevant*

Reef and ecosystem quality	Planned	Considering
Oyster survival	[ ]	[ ]
Attachment to substratum	[ ]	[ ]
Sedimentation	[ ]	[ ]
Fouling	[ ]	[ ]
Disease	[ ]	[ ]
Number, diversity of other fauna (compared to baseline)	[ ]	[ ]
Water quality (compared to baseline)	[ ]	[ ]
Other _____	[ ]	[ ]

Reef growth measurements	Planned	Considering
Reef size (area or volume compared to baseline)	[ ]	[ ]
New spat per unit area	[ ]	[ ]
Average shell size	[ ]	[ ]
Other _____	[ ]	[ ]

OYSTER RESTORATION GRANT REPORTING RECOMMENDATIONS

Consistent details and standardized units in grant reporting are needed to understand the relative efficacy or cost-effectiveness of restoration approaches. NFWF's move to require specific information be included in grant proposals and reports in recent years has resulted in an increase of valuable information about project details, including challenges and successes. Still, the data reported were not sufficiently uniform to enable the types of analyses initially planned for this study. The following sections outline some possible approaches for soliciting the level of detail required for such analyses.

Line-item budgets for all restoration elements

Many restoration projects involve activities that go beyond actually restoring oyster reefs (e.g., outreach, curriculum development, wetlands restoration). Thus, it is not possible to assess the cost-effectiveness of different restoration methods and approaches if budgets are not differentiated by expense type. Additionally, a clear understanding of how funds are allocated across needs and activities will help identify areas where cost-cutting measures may be appropriate, and also facilitate targeted efforts to encourage greater efficiency.

We recommend that costs for the following budget areas should be specified in final reports both to enable project comparison, and to accurately calculate total and average budget allocations for each area.

Project Stage	Budget Area	Line-Item Examples	Considerations
Varies	Staffing	Planning manager Project manager Coalition builder Volunteer manager Scientist Researcher Specialist Technician Engineer	If the grantee has paid staff, what portion of regular salary is allocated to the project?
Planning	Permitting/ Insurance	Permitting experts Permitting fees Lawyers fees Insurance premiums	If using pro-bono services, what is the market value of those services?
Assessment	Equipment/ Services	Data-loggers Water quality kits Lab analysis Other equipment/services	If equipment or services are donated, what is their market value?
Restoration Activity	Materials	Substrate Spat Spat-on-shell Flora/fauna Bag/Mat supplies Recycling supplies Other materials	What type of substrate? What is the unit cost?
	Logistics	Materials storage Hired transport of materials Hired transport of personnel Vehicle rental/purchase Boat rental/purchase Other rental/purchase Fuel costs	If boat, vehicle, or equipment usage is donated, what is the market value of the donation?

Continued on following page

Project Stage	Budget Area	Line-Item Examples	Considerations
Outreach/ Education	Events/ Meetings	Space rental Food/refreshment Swag Signage Flyer/pamphlet creation Printing Website Other promotion	Any costs related to special events should be estimated as a separate line-item.
Education	Classroom training/ Seminars	Curriculum development Printing Space rental Food/refreshment	Donated time spent training or developing curriculum should be accounted for and the value estimated based on an appropriate hourly rate.
Monitoring	Equipment/ Services	Data-loggers Water quality kits Lab analysis Other equipment/services	If equipment or services are donated, what is their market value?
Miscellaneous	Other Expenses	Other costs not included in example budget areas.	

Matching Funds Allocation

When matching grants are also funding some of the program, the funding source for each line item should be determined in advance. Not only does this inform NFWF of how grant monies are being spent, but it facilitates the calculation of impact metrics, especially when a project has multiple aims (e.g., restoring a wetlands preserve, which includes living shoreline, recreational viewing areas and oyster and finfish habitat). Further, if matching funding is only partially realized (or not realized at all), which is not uncommon, assigning funding sources to specific activities allows NFWF to insure that funds are spent as intended.

Standardized Measures for Restoration Goals and Reporting

The metrics used for reporting on project goals, accomplishments, and outcomes are not currently standardized across projects. As a result, even when there are budget line-items for specific restoration activities, projects cannot be directly compared with one another, nor can cumulative impact be estimated. For example, it is impossible to calculate the total amount of restoration accomplished to date when methods vary significantly, and measures are reported in disparate units (i.e., tons of shell, bushels of shell, quantity of spat-on-shell, number of mesh bags, number of oyster rings, acres, linear feet, cubic feet, etc.). An alternative to requiring a single one- or two-dimensional unit of measure from all projects, may be to request that grantees report as many estimates of project size as are relevant:

(a) Project footprint (m2): How much area is directly restored or enhanced by the project? For example, if 200 artificial structures each with a footprint of 2 m¬2 are deployed over ¼ acre of bay bottom, the project footprint would be 400 m2 (.10 acre). If loose cultch were spread evenly over 1 acre, the project footprint would be 1 acre (4047 m2).

(b) Total project area (m2): Total area within which small reef structures are distributed. In the artificial structure example above, the total project area would be ¼ acre (1012 m2). In the loose cultch example, the total project area would be 1 acre.

(c) Reef volume (m3): What is the three-dimensional project footprint (i.e., project footprint x vertical dimension)? If loose cultch is used, what was the initial volume? If artificial oyster structures are used, what is the height of the structure?

(d) Project surface area (m2): Total functional area over which spat can attach and grow. While not impossible to estimate, this is one of the more onerous calculations.

Results Monitoring and Reef Maintenance

Planted area alone is not an adequate indicator of the long-term success or lasting effects of a restoration project. Some reefs thrive and grow; others sink into the mud. If NFWF desires to track the ongoing impact of restoration funds, we recommend that all restoration projects include a plan for monitoring, upkeep, and annual reporting. Without planning for and implementing appropriate monitoring and maintenance activities (e.g., cleaning, shell enhancement, repair, etc.), it's unlikely that a resto ration effort will produce a self-sustaining reef.

The specifics of what is monitored and reported could include any number of reef attributes and services, and may depend, to some degree, on the project goals. Sample metrics include:

- Reef size (area or volume compared to baseline)
- New spat per unit area
- Oyster survival
- Erosion mitigation and shoreline growth (compared to baseline)
- Water quality (compared to baseline)
- Number and diversity of marine fauna (compared to baseline)

It is not necessary that results be catalogued for all possible benefits if some are not relevant, but there should be consistency in how results are scored for each type of result.

Appendix II • Policy Summary For Oyster Reef Restoration

Through the course of our research, we discovered a number of state policies that served to support reef restoration efforts, and several that hindered them. Below is an outline of those findings, along with examples. This summary is not a comprehensive overview of all policies relevant to restoration, but rather a sample of how current laws on the books can not only substantially affect the success of restoration endeavors, but also how they vary from state to state. Specific permitting rules and procedures were beyond the scope of this synopsis.

REEF-FRIENDLY

Policies that support or facilitate oyster reef restoration

Sanctuary Reefs Successful restoration of oyster reefs requires long-term protection in order for restored reefs to be able to grow and become self-sustaining living reefs. If harvesting is allowed, it might not only reduce capacity for the reef to self-seed and grow, but also reduce its three-dimensional structure, subjecting it to sedimentation and diminishing many of the ecosystem services it provides. Nearly every state permits oyster sanctuaries—restored reefs that are closed to any extractive activity to some degree, as a means of facilitating reef restoration.

Example

- North Carolina not only allows for sanctuary reefs, but since 2005 has a state-run Oyster Sanctuary Program operated by the Division of Marine Fisheries. It has created 10 sanctuaries to date and has a dedicated biologist to monitor sanctuary reefs.

- Virginia and Maryland also allow for sanctuary reefs.

Streamlined Permitting Systems One of the greatest barriers to successful oyster reef restoration is permitting—a long, complicated process (or entire lack of process) that drains time and resources from any organization attempting to construct reefs in the intertidal or subtidal environment. Several agencies have created streamlined permitting processes to help alleviate this problem.

Examples

- Washington State recently revised its Joint Aquatic Resources Permit Application (JARPA), an online form for which Federal (US Army Corps and Coast Guard), State (Department of Ecology, Department of Fish and Wildlife, and Department of Natural Resources) and City/County agency permits can all be applied.

- San Francisco Bay has a similar permit application process, which "consolidates federal, state, and local permits and simplifies the permit process for applicants proposing construction, fill placement, public access impingement, and other development activities in or near aquatic environments and wetlands in the San Francisco Bay Area."

Let Oyster Shells Lie Oyster shell is one of the best substrates for recruitment of new oysters and thus, for building reefs. However, historic removal of oyster shell and current export of oysters out of state, mean that total shell volume has decreased and oyster shell

for restoration is in limited supply. Policies mandating that shells remain where they are found help to slow the net loss of shell from local habitats.

Examples

- Alabama has instituted a code (Section 9-12-42) that requires individuals or corporations to replant 50 percent of all oyster shells removed from public reefs, beds, or bottoms within state waters. In lieu of replanting, an individual or corporation can pay the Department of Conservation and Natural Resources "reasonable" market value of such shells plus the cost of replanting.

- Florida shucking houses must return half of the shell from state-harvested oysters. The Bureau of Marine Resources handles all pick up, storage, and replanting activities.

- Mississippi incentivizes local processing by a two-tier tag fee system. Oystermen pay 15 cents per sack for oysters sold to Mississippi processors, but 50 cents per sack for oysters shipped to out-of-state processors.

- Maryland and North Carolina require that oysters harvested from natural beds are culled on site, depositing all attached shell or undersized oysters back to the bottom.

- Washington State requires that all wild oysters are shucked on the beach. The Pacific oyster shells are not only good habitat for recruitment of more juvenile Pacific oysters, but also great habitat for the native Olympia oyster.

Shell Fees Another potential source of funding for restoration can be found in the form of fees imposed on sacks of oysters. These fees can be directed toward construction of new reefs, though often they are use by state-run cultching programs to enhance wild reefs.

Examples

- Alabama has a fee imposed on all bags of oysters taken from state waters. Fees are deposited in an "Oyster Management Fund" for the replanting of oyster cultch material on the public reefs, or for otherwise managing the state's oyster resources.

- Mississippi (Section 7.2.3.1.7.1), New Jersey, and Texas also have shell fees. In Texas, every bag of shells is taxed 20 cents, with all funds dedicated to shell recovery or cultch replanting.

Managing The Commons Through Collaboration Marine life does not heed state or municipal boundaries. Even though reefs are discrete and stationary structures, the larvae that settle upon them can come miles away. Likewise, pollution from one region can be swept by currents onto reefs located in another region. In some cases, such pollution may originate in states without coastlines—agricultural runoff can be carried through watersheds from inland farms. Multi-state oyster management plans help to address some of these problems by providing a large-scale perspective that encompasses the biology and ecology of reefs, rather than arbitrary state or county lines. These efforts have the potential to help coordinate best practices and negotiate the use of common resources for long-term sustainability.

Examples

- The Chesapeake Bay Oyster Management Plan is probably the most well-developed. Other regional groups with potential to create or advise management plans include the East and West Coast Shellfish Growers Associations. Through the Federal government, there is also the Gulf States Marine Fisheries Commission Oyster Fishery Regional Management Plan.

Oyster Gardening Several states permit the practice of "oyster gardening", growing baby oysters off private docks, piers, and other structures, until they reach a size at which they can be transplanted onto restored reefs. In addition, gardening programs can be used to collect important baseline data on oyster growth and survivorship among different coastal locations. The community outreach and engagement such programs lend to oyster reef conservation is significant. These programs educate thousands of individuals about oyster conservation, helping to create awareness and public support for legislation to support restoration activities. Major oyster gardening programs current exist in several states.

Examples

- Virginia allows the grow-out of native shellfish species by waterfront property owners, exclusively for private, noncommercial purposes. The Chesapeake Bay Foundation's Oyster Gardening Program has engaged about 300 volunteers per year and transplanted over 3 million oysters on to restored reefs since 1998.

- Marylanders Grow Oysters, managed by the Maryland Department of Natural Resources, transplanted over 2 million oysters to sanctuary reefs in 2011.

- NY/NJ Baykeeper's Oyster Gardening program has volunteers monitor survivorship and growth of oysters as a means of collecting baseline data on where oysters survive best in the New York Harbor region.

States that do not support oyster gardening programs include New Jersey (just shut down all programs this past year) and California (has no permitting/legislative system in place to allow for oyster gardening).

Reduced Pollution Policies One of the major causes of oyster decline, besides overharvesting, is poor water quality. In many locations, even if millions of oysters were transplanted onto perfect reef substrate, the oysters would die due to harsh nutrient loads, the result of coastal development and agricultural runoff. Policies that address this fundamental threat support restoration efforts by giving new reefs the best chance of survival from a water-quality perspective. Recent legislation to clean up water quality has passed in several states.

Examples

- New Hampshire (HB1418) requires fertilizer sold at retail stores to contain at least 20% slow-release nitrogen, which should help reduce nitrogen loading from residential runoff.

- Washington State's Shellfish Initiative includes millions of dollars of dedicated funding to fix residential septic systems, boat holding tanks, and address runoff from livestock and pet waste, with the specific goal of improving and protecting water quality to ensure the health and safety of shellfish.

Relaying or "Field Depuration" Many water bodies are closed to harvest because of water quality issues that result in contaminated shellfish. Yet, some of these closed water bodies have the potential to support restored reefs. Some states allow for oysters grown in closed water bodies to be "relayed" to clean public bottom or private leases where the oysters, through natural filtration processes, purge themselves of contaminants and become safe for consumption. Through tight management that ensures testing of relayed oysters, this process utilizes and creates value from an otherwise restricted resource. This system could be employed by the restoration community if a portion of oysters on reefs restored in closed water bodies were relayed to public reefs as a direct supplement to wild oyster harvest.

Example

- States that currently allow for relay/depuration include: Connecticut, Florida, Virginia, Texas, North Carolina, and Louisiana.

Shell Recycling Several states have implemented oyster shell recycling programs in order to increase retention of oyster shells harvested from local waters. Where this has not occurred at a state-level, or where the public program falls short, non-profits often step in to fill the gap. Upping license fees or lease payments to support recycling programs could serve to increase the supply of shell for restoration significantly in many states.

Examples

- South Carolina's shell recycling program is funded by fees from recreational fishing licenses.

- North Carolina has a recycling program that relies on people bringing their shells to designated drop-off points; the state does not have the funding to support pick-ups from restaurants or other locales.

Federal and State Shellfish Initiatives Addressing the economic and ecological benefits of shellfish, the National Shellfish Initiative aims to increase populations of bivalves in coastal waters as a means of improving water quality, creating jobs, meeting seafood demand, protecting shorelines, and helping to recover threatened species. Oyster reef restoration, along with aquaculture, is a major focus of this initiative. The initiative offers hope of leveraging existing funds and expertise to maximize success of restoration programs. It also has served to inspire state-level shellfish initiatives, helping to direct state funding and resources to similar goals.

Example

Washington State is currently the only state to create a shellfish initiative, but there is talk of a similar effort in California. Current initiatives can serve as models for future state participation.

REEF-HOSTILE

Policies that hinder oyster reef restoration

Lack of Sanctuary Reefs Several states have no oyster sanctuary designation on the books.

Examples

- In Massachusetts, a restored reef must be opened to public harvest after three years, making long-term restoration very difficult.
- Texas has no official sanctuary reefs, but they do have State Scientific Areas. Efforts to use these research reefs as sanctuaries have proven somewhat successful, mostly due to the use of structures that make harvesting difficult. Texas Fish and Wildlife has also worked with private landowners to establish restored reefs in their properties as "default" reefs, because private property is closed to public harvest.
- Maine does not have any official sanctuary reefs; it also appears to lack reef restoration efforts.

Closed Waters Closed to Restoration State Departments of Health determine which waters are safe for oyster harvest and which need to be closed. Closed waters, however, are often those that would benefit most from restoration; not only could oyster reefs help purify the water column, but they also would not compete for space with wild fisheries or aquaculture. Many states allow for non-harvest sanctuary reefs in closed water bodies. Those that do not argue that the risk of poaching potentially contaminated oysters threatens the state shellfish industry and, thus, outweighs the benefits of restoration. If states provided appropriate enforcement, poaching would not be an issue and sanctuary reefs could lend water filtration capacity and more larvae to the states waters.

Examples

- New Jersey has revoked all permits for oyster restoration in contaminated waters and has forced the removal of previously sited projects in these locations.
- In Alabama, construction of restored reefs is allowed in closed waters only if the project is considered a "living shoreline" project and if there is little oyster shell used in building the base for the reef.
- In Florida and Delaware restoration is generally required to be done in areas that are conditionally approved for harvest.

Oil Over Oysters In the Gulf, the oil and gas industry often competes with oyster fisheries for access to bottom areas. In some cases, oil and gas are given precedent over reefs, even when the reefs were there first. Where pipelines trump reefs, restoration is doomed.

Example

- In Texas, the oil and gas industry can be granted permission to place pipelines beneath existing reefs. But, if that reef becomes fouled from sedimentation due to hurricanes, or declines from other causes, the law forbids its restoration. That is, no restoration can occur on top of a pipeline, even if a historical reef existed there.

Owning Oyster Shells When an oyster is harvested from a public or private reef, there are two products that can be sold: the meat and the shell. Certain states have laws governing who owns the shell and how it can be used. Laws that mandate that shell remains property of the state can help prevent problems with net shell loss, but enforcement is difficult.

Examples

- Texas gives the rights of ownership over both shell and meat to dealers, who can then sell the shell to other industries for the highest price. This incentivizes dealers to remove shell from the water and drives up shell prices.
- In Maryland, oysters cannot be collected for the purpose of converting the meat or shell into lime, chicken feed, or road construction materials unless a person is granted specific permission from the state.
- In Florida, oyster shell collected from leased grounds can be sold by harvesters and processors.

Clean Water Act Attacks Water pollution is one of the main drivers for oyster decline. The Environmental Protection Agency's total maximum daily loads (TMDL) under the Clean Water Act are a primary incentive for spurring innovation to clean up waters and rebuild reefs. Thus, laws that seek to undermine the Clean Water Act directly threaten oyster reef recovery. Currently, H.R 4153 and H.R. 4337 seek to remove core Clean Water Act protections and state accountability for not meeting water quality standards. Such legislation, should it be passed, would represent a significant setback for oyster reefs and water quality around the country.

REEF INDETERMINATE

Policies that may help or hinder reef restoration depending on application

Leased Grounds Privately owned seafloor can be a boon or a bust for restoration. Where organizations such as The Nature Conservancy can lease seafloor and create sanctuary reefs, the policy of privately leased state seafloor works to enhance restoration efforts. Restoration efforts could also be supported if a portion of permit fees were designated to create sanctuary reefs.

On the other hand, privately leased seafloor for shellfish aquaculture often means that suitable areas for reefs are used for farming that fails to provide most of the ecological benefits of a three-dimensional structure. Some states are working on large-scale oyster restoration plans that partition out leased seafloor to include both sanctuary and aquaculture areas.

Examples

- A New Hampshire law has increased permit lengths for leased grounds from 1 to 5 years, offering greater security to oyster farmers. If fees from these leases were dedicated towards sanctuary reefs, the increased security would also be transferred to restoration projects.
- In Virginia and Maryland, leasing seafloor is extremely cheap and does not generate significant income compared with the costs of restoration. Increasing leasing fees would be one way states could generate more funds to support restoration activities.
- Connecticut has 3-10 year leases and uses a competitive bidding process. Leased areas are limited to a minimum of 50 acres and a maximum of 200 acres per bid.
- Louisiana and Texas have moratoriums on new leases and lease applications.
- In Mississippi and Alabama, obtaining a new lease can be difficult because much of the suitable habitat is already leased for oyster farming.

Appendix III • Best Practices For Volunteer Management

Oyster reef restoration projects tend to rely heavily on volunteers. However, the success with which volunteers are recruited, trained, and retained varies greatly. Some programs find that local residents are more than willing to give of their time and energies to help rebuild a reef. Other programs encounter great difficulty in rallying citizens to lend a hand. The following recommendations draw on insights we inferred from reading final grant reports and in conversing with project managers.

The most fruitful volunteer programs are those that focus on community-building—a mindset and practice by which volunteers are not simply temporary laborers deployed on myriad tasks, but rather are invited to become part of a meaningful mission alongside others who share their values and aims. To the extent that volunteers feel as though they belong to a like-minded group, their roles and contributions are valued, and that they have a stake in the outcome of a project, they will be intrinsically motivated to participate, stay connected, and to encourage friends and family to join as well.

We highlight below the tactics that we have observed to be most effective at attracting and retaining employees, volunteers, and donors. We emphasize the importance of creating feedback mechanisms for participants that clearly link their contributions to the larger outcomes and impact of a project. Such information is educational, good for publicity, and can help with recruitment and retention.

Laying the groundwork

For projects requiring substantial volunteer support, a fair amount of planning with respect to messaging, designing roles, and recruitment strategy is necessary before actually beginning an outreach campaign.

Adopting A Volunteer Statement A volunteer statement clearly and convincingly conveys the importance of an organization's mission and the volunteers' roles in realizing that mission. Such a statement may include:

- The organization's mission and how volunteers contribute to that mission:
    - Our organization is committed to…
    - Our volunteers contribute to this important mission by…
- The organization's commitment to its volunteers to provide a gratifying experience:
    - Safety (e.g., a safe environment, protective gear, ample water and refreshment, etc.)
    - Community (e.g., an energetic team of like-minded people, etc.)
    - Feedback (e.g., periodic updates on project progress, etc.)

Designing Volunteer Tasks And Roles A list of specific volunteer tasks and roles allows organizations to plan for the types of people needed, and also provide potential volunteers with examples of how they can participate. Creating a spreadsheet can be

a logical way to organize the following aspects to be considered for each listed task:

- Required skills, abilities, or knowledge
- Objectives
- Goal
- Risks
- Number of people needed
- Time requirement (total or per person)
- Contribution to the project outcome or ultimate goal

Recruiting Volunteers To avoid wasting money, time, and other resources, outreach should be a targeted effort. For example, some of the most successful projects reviewed tapped into already convened pools of volunteers at community clubs (e.g., Lions, Rotary, Junior League, etc.), churches, other non-profits, schools, etc. If flyers, posters, or advertisements are used, it is important that they are distributed strategically, and that their effectiveness is tracked through volunteer surveys. That is, when volunteers show up to a project, successful organizations ask them how they heard about it. When no one comes because of a flyer or bus ad, it may be worth trying other recruitment tactics.

The following questions can serve as a guide for identifying particular locations, organizations, and demographics where volunteers might be concentrated. Knowing these answers can also be useful for preparing written materials or talking points when recruiting groups or individuals.

- Who are the ideal volunteers for the organization?
- What is known about such people?
    - What interests might they have?
    - What other activities might they be involved in?
    - What kinds of jobs might they have?
    - What are their potential motivations for volunteering?
    - What needs might they have (e.g., transportation, childcare, language support)?
- What benefits are there to being a volunteer?
    - What new skills might they gain?
    - How will this volunteer experience be valuable?
    - How will they contribute to a larger outcome or goal?
- What is the story of the people in the organization?
    - Why are those currently involved committed to the organization?
    - What makes the organization or this particular project compelling?
    - What attracted them in the first place?
    - What keeps them coming back?

Volunteer Management

Keeping It Local Known and trusted local volunteers can be critical for attracting new volunteers and for understanding how best to communicate the goals and needs of a program to area residents. In the case of the Nanticoke River Community Oyster Restoration project, engaging a dedicated, local citizen to be the primary point of contact was key to keeping volunteers connected and motivated.

Knowing The Volunteers Successful organizations make an effort to get to know their volunteers. They ask new recruits why they're volunteering, what they want to get out of their participation, what their capabilities and interests are. They also make an effort to learn names. Most organizations will agree that knowing a volunteer's name can be the determining factor in whether someone chooses to stick around. Sometimes, distributing a short volunteer survey prior to starting the project can facilitate this information-gathering effort. Additional considerations related to volunteer psyche and motivation include:

- **Recognizing contributions.** Some volunteers feel they have specific value to offer. They will become disillusioned if that is not acknowledged.

- **Identifying talents.** There may be experts among a pool volunteers able to innovate solutions to an organization's most pressing problems.

- **Providing feedback.** Some volunteers really believe in the work they're about to take part in. Thus, it is important to provide feedback on how their particular roles contribute to the ultimate goal.

Setting Volunteers Up For Success Volunteers will be happiest and most productive when they know exactly what to do, and when they feel confident that they have what they need to get it done. People also want to know how they fit in to the organization as a person, and how their work contributes to the organization's mission. The following insights relate to how organizations can get the most out of their volunteers, and how volunteers can get the most out of their participation.

- For every job, paid or volunteer, it is critical that workers be able to strongly agree with the following statements:

    * I know what is expected of me.

    * I have what I need to do what is expected of me.

    * I know the mission of the organization.

    * I understand how my role fits into the organization's mission.

    * I feel that someone in the organization values me and what I contribute.

- Supervision and proper planning are essential, as volunteers will become frustrated if they are given a job to do and then are unable to do it for reasons beyond their control.

- Providing proper equipment, safety gear, and other materials volunteers need to accomplish their tasks is imperative.

- Organization staff should always be available to troubleshoot and problem-solve should obstacles arise.

- Seemingly small details like the presence or absence of refreshments can make or break a volunteer's experience. Providing volunteers with ample water and nourishment will keep them motivated while on the job, and will make them more likely to rate the experience as a good one.

Participant Recognition Volunteer time, energy, knowledge, and expertise are valuable. And while volunteers are willing to provide these resources pro bono, they still deserve appreciation and appropriate recognition.

- **Immediate thanks.** An email, text, or note of appreciation can be sent within a week or two of a specific volunteer effort.

- **Public shout-outs.** Social media (e.g., mentions on Facebook or Twitter) is a way to publically recognize the individual efforts of volunteers.

- **Appreciation events.** A party to recognize staff and volunteers can be planned for the end of the project, season, or year. It doesn't need to be extravagant. Ice cream sundae parties have proven very successful in the past.

- **Swag.** Donated items or coupons from local businesses, or special project-branded products can be given as thank-you gifts to volunteers. For example, the Nanticoke River Community Oyster Restoration project created "Shells Angels" t-shirts for volunteers who helped stuff shell bags.

- **Signage.** Attractive signage can recognizes property owners who participate in oyster gardening or oyster-friendly property management.

- **Naming rights.** The Mosquito Lagoon and Intertidal Reef Restoration project granted its volunteers the opportunity to name the areas they were involved in restoring.

Volunteer Feedback When people contribute toward a goal, they want to know whether or not the goal was achieved. We found that when volunteers receive specific feedback concerning the outcome of their work, they are more likely to value their experience, recommend that experience to friends and family, and repeat the effort themselves. For example, some programs install cameras or have photographers visit and record sharable images. Feedback can be easily distributed via email newsletters, social media, or a project website. In most cases, the reporting provided to funders can be repackaged for volunteers.

Community Building

Creating A Community Around The Organization

In general, people want to belong to something larger than themselves. They also have an inherent desire for social connection and, perhaps, to make new friends. Often, it is for these reasons, and not the specific mission of an organization, that people choose to get involved in volunteer work. Recognizing and serving these motivations can help smooth the road to community-building.

- **Social events.** Providing times and places for volunteers to get to know one another can help cement their commitments to an organization. This may be possible as part of the volunteer work, but it may not. Social gatherings (e.g., at the organization's headquarters or a local park or coffee shop) provide a relaxed, unhurried opportunity for people to get acquainted.

- **Outreach.** Judiciously distributing newsletters and group emails about upcoming events, project progress, or other important news keeps volunteers connected. Using social media like Facebook and Twitter can be useful for disseminating quick bites of information, including photos and reminders about upcoming events.

- **Input.** Setting up a process to solicit input from volunteers on what is working and what they would like to see changed can be done an online survey (Survey Monkey is free) or a paper-based questionnaire. Both Twitter and Facebook can be used to poll volunteers as a way of getting input or feedback.

Case Study: Mobile Bay Oyster Gardening (MBOG) Program

The following case study examines the Mobile Bay Oyster Gardening Program, which has created a volunteer- and donor-centered experience that provides participants with a sense of accomplishment and community.

Like many organizations working to restore oyster populations, MGOB enrolls local waterfront property owners in oyster gardening. In most gardening programs, volunteer gardeners tend their hanging gardens by occasionally checking the bags or cages for fouling materials (sediment, barnacles, etc.), and cleaning them as needed. Thus, through their efforts, these gardeners can directly affect the health and abundance of their gardens.

Each year, MBOG holds a popular competition to determine who grew the most and healthiest oysters. MBOG program coordinator PJ Waters reports that gardeners take great pride in this recognition. In addition, participants receive newsletters and are invited participate in outings and activities related to restoration, which further connects them to the oyster gardening community.

In addition to their local oyster gardeners, MBOG has developed an adopt-a-garden program, which allows anyone in the country to participate in the restoration of Mississippi Sound's oyster habitat. Simply by signing up and paying a $25 adoption fee, participants become members of the Mississippi Sound Oyster Restoration community. As of its third year running, Waters expects the adoption program to provide nearly 25% of the MBOG operating budget.

Appendix IV • Interviewees

Stephan Abel
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Oyster Recovery Partnership

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Tampa Bay Watch

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Debbie Johnson
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Tommy Leggett
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Chela Zabin, Ph.D.
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Danielle Zacherl, Ph.D.
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Appendix VI • Project Team

Cheryl Dahle

Strategist

Cheryl is the founder and executive director of Future of Fish. A journalist and entrepreneur who has worked at the intersection of business and social transformation for more than a decade, Cheryl Dahle conceived and co-led the effort to found Future of Fish. Prior to her work with fisheries, Cheryl was a director at Ashoka: Innovators for the Public, where she distilled knowledge from the organization's network of 2,500 fellows to provide strategic insight to foundations and corporations. As a consultant, she has served leading organizations in the space of hybrid business/social solutions, including Humanity United, Nike, the Robert Wood Johnson Foundation, the David and Lucile Packard Foundation and the Center for the Advancement of Social Entrepreneurship at Duke University. Cheryl spent 15 years reporting on social entrepreneurship and business for publications including Fast Company, The New York Times and CIO magazine. Cheryl founded and led Fast Company magazine's Social Capitalist awards, a competition to identify and recognize top social entrepreneurs. Before her work with nonprofit organizations, she was part of an incubation and startup team for which she helped secure $12 million in venture funding to launch an online environmental magazine.

Colleen Howell, Ph.D.

Project Lead

Colleen is the research manager at Future of Fish, and was a principle researcher for its initial discovery phase. As an environmental consultant, science writer, and eco-solution designer, she has worked with both established companies and non-profits to promote environmental sustainability in tandem with efficiency, profitability, and personal and societal well-being. Specializing in technical and nontechnical writing, scientific investigation, project management, and data analysis, Colleen's interdisciplinary approach to environmental issues has led her to projects ranging from resource-use policy and ecosystem modeling, to writing for New York Times bestsellers and popular websites. With a degree in Biology from Westmont College, she earned both an M.S. and Ph.D. in Environmental Sciences from UC Riverside. She continues to coauthor academic papers with colleagues within the areas of environmental economics and subjective well-being.

Marah Hardt, Ph.D.

Researcher

Marah is a marine ecologist, keeping one foot wet in the field while the other roams the world of creative problem solving around ocean conservation issues. Founder of OceanInk, Marah is a hybrid thinker, bringing scientific expertise and imaginative thinking to help organizations and individuals develop science-based solutions to diverse challenges, from overfishing to climate change to watershed restoration. Marah received her doctorate from Scripps Institution of Oceanography and was a research fellow at Blue Ocean Institute where she developed their climate change program. She has worked previously with Future of Fish on their pioneering study, serving as a scientific advisor and stakeholder engagement strategist. Throughout her career, Marah has maintained a focus on turning science into stories that make a difference. She is a contributing author to several books and her articles have appeared in academic and popular media, including Scientific American and The American Prospect. She is currently working on her first book.

Kerry Cunningham, M.S.

Researcher

Kerry is a published author of fiction and a former business executive with more than 15 years of senior and executive management experience in the direct marketing industry. A recent M.S. graduate in Industrial-Organizational Psychology at San Francisco State University, he uses his process- and evidence-based approach to help businesses and non-profits improve their organizational effectiveness. In addition, Kerry is the lead blogger for the consumer behavior research website, BeyondthePurchase.org, where he contributes a weekly column summarizing and interpreting the latest research in consumer behavior, with the aim of helping consumers better understand the psychological forces that influence their spending decisions.

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