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RESTORATION WORKS

Highlights from a Decade of Partnership between The Nature Conservancy and the National Oceanic and Atmospheric Administration's Restoration Center

PREFACE

Chesapeake Bay Watershed © Helmuth Humphrey, Apertures, Inc.

Healthy coastal habitats are essential to the economic and social well-being of coastal communities, and indeed they propel our economy far inland, away from the sea's aroma and the sound of waves breaking on the shore. Coastal wetlands and the rivers that drain the continent produce the fish and shellfish that are caught in U.S. coastal bays and consumed around the world. Salt marshes, oyster reefs, seagrass meadows and coral reefs all help to prevent erosion and in some places provide a vital buffer between storm waves and human communities. Benefits like these have real value in our daily lives. And as scientists do an ever better job at documenting these benefits, the value of coastal habitats as an essential part of the nation's "natural capital" becomes ever more clear.

The bad news is that over the nation's history we have lost much of this natural capital, simultaneously losing the vital services coastal systems provide in the process. The loss of oyster reefs, seagrass beds and salt marshes means that coastal bays produce fewer fish and crabs now and don't have the capacity to filter the pollutants that they did a century ago – outcomes that make a difference in our quality of life and the economic well-being of coastal communities. The good news is that we know how to bring these systems back and investments in their restoration makes good economic and environmental sense.

Starting in 2001, The Nature Conservancy and the NOAA's Community-based Restoration Program have been working in a formal National Partnership to do just that. Through the 124 community-based projects supported in the first decade of partnership, we have made a difference in those places PLUS we've learned how to do coastal restoration right, building a solid knowledge and capacity base for the next generation of even larger scale restoration projects. Of course, it hasn't just been Conservancy and NOAA staff at work here – research scientists, environmental managers from all levels of government, tribes, school classes and community organizations of all kinds have all contributed time and talent to the projects described here. The more than 100,000 volunteers who contributed their time and talent to these projects have shown that coastal communities are committed to restoring and stewarding their vital coastal resources. The impact of these projects has been multiplied in many places as they have inspired policy changes that enable more and better coastal restoration and habitat protection.

This report aims to capture some of what has been accomplished and learned. Of more importance, it aims to tell "stories of restoration;" what can be accomplished when communities come together around shared goals for environmental and community restoration. I hope you find these stories from across our nation—from Alaska to Hawaii, from New York to California, from Virginia, Florida and the Gulf of Mexico as compelling and inspiring as I do.

Investing in nature to conserve the lands and waters upon which all life depends is what we do at The Nature Conservancy. Working in partnership with NOAA, the nation's Ocean Agency, we have made tremendous strides in this first decade of restoring our nation's coasts, and I'm even more excited about what we can and will accomplish together in the decade to come.

Mark Tercek

Mark R. Tercek

President and CEO
The Nature Conservancy

ACKNOWLEDGEMENTS

Pelican Trail at sunset on Santa Cruz Island off of the California coast. © Miguel Luis Fairbanks

This document was prepared by members of the Core Program for the partnership between TNC and the NOAA Restoration Center: Mike Beck, Rob Brumbaugh, Kerry Crisley, Boze Hancock and Elizabeth Schrack. It provides examples of marine habitat restoration projects funded through the partnership with NOAA. The restoration projects themselves touch on a variety of habitats including marshes, rivers and streams, seagrass meadows, and oyster and coral reefs, and would not be successful without the support and involvement of scores of public agencies and conservation organizations, countless academic institutions and talented scientists, as well as tens of thousands of volunteers. In this document, we highlight the many larger benefits that can accrue beyond a restoration project's original footprint and these additional benefits are described under the categories of "Influencing Ecosystems," "Engaging Communities," and "Informing Policy."

In addition to the multitude of people who have been involved in implementing projects in the first decade of the National Partnership, we wish to acknowledge a number of Conservancy staff who are not only managing many of the exciting projects highlighted as examples, but who also provided valuable insights and comments that improved this document: Ann Birch, Rob Bosworth, Brian Boutin, Mark Bryer, Jennifer Carrah, Edwin Hernández-Delgado, Kim Hum, Carl LoBue, Caitlin Lustic, Corinne Smith, Barry Truitt and Ryan Wells.

Importantly, we wish to thank the many individuals and foundations from across the country who provided essential private support for this National Partnership including support for its more than 100 restoration projects. Through this commitment and support, our nation's bays and estuaries are being vastly improved. We look forward to continuing to work together for the next decade of coastal restoration success.

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For more information, please contact us at marine@tnc.org.

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EXECUTIVE SUMMARY

The Nature Conservancy (TNC) and the National Oceanic and Atmospheric Administration (NOAA) have been working together since 2001 through a National Partnership to restore a diversity of habitats in our nation's coastal waters. In the past decade, some $8 million in federal funds have been matched by more than $10 million in additional state, local and private funds to implement innovative restoration projects yielding tangible results that improve the condition of coastal waterways around the United States.

The partnership's projects and the science advanced by project teams and through a central technical and management team have resulted in three overarching outcomes. First, we have **influenced ecosystems** with more than 120 projects that have been implemented along the coast and waterways of the United States. These projects have yielded tangible, lasting improvements to oyster reefs and clam beds, underwater grasses, salt marshes, mangroves, coral reefs, and other important habitats that provide valuable benefits to coastal communities. Even more important, through these projects we have developed the technical knowledge to do coastal restoration right, building a solid knowledge and capacity base for larger projects funded through the American Recovery and Reinvestment Act, National Resource Damage Assessments, and other means. Second, we have **engaged communities and developed new constituencies** through a huge and diverse group of volunteers in coastal restoration, bolstering the demand for coastal conservation and restoration. Third, the outcomes from the partnership have **informed state and federal policy frameworks** that enable more and better coastal restoration and habitat protection.

In this report, we showcase a number of projects that help to illustrate these larger outcomes, as well as the work of the partnership's central technical and management team that provides important underpinnings to all of the partnership's work. A few highlights are listed here:

Influencing Ecosystems: Community-based restoration projects are often small, proof-of-concept undertakings that individually have limited overall influence on the larger ecosystems they belong to. Yet, there are places where sufficient numbers of projects have been implemented that, collectively, have tremendous and measurable impacts, sometimes leading to ecosystem-level shifts that help move entire ecosystems back to more desired conditions. Likewise, projects funded through the TNC-NOAA Partnership have often served as platforms for addressing important questions about the function of our coastal ecosystems. These questions are addressed through well-designed monitoring efforts implemented with the help of world-class researchers.

- TNC's Florida chapter and the University of Central Florida have developed an innovative mechanism for reversing decades of declines of oyster reefs in Canaveral National Seashore caused by the harmful impacts caused by boat wakes.
- Dr. Bob Orth and colleagues at the Virginia Institute of Marine Science, along with TNC staff, have developed new techniques for restoring seagrass to the lagoons of Virginia's eastern shore within TNC's Virginia Coast Reserve. The grasses disappeared more than 70 years ago and now are once again flourishing in the bays.

- In addition to the projects where multiple awards or very high level leverage as led to ecosystem scale impacts there has recently been an important additional opportunity to increase the scale of restoration outcome. In 2009, TNC was awarded eight of the 50 Recovery Act projects funded by NOAA. These large scale habitat restoration projects all expand on lessons learned and techniques developed as TNC-NOAA Partnership projects.

Engaging Communities: Restoration projects can inspire the formation of new and sometimes unanticipated partnerships and alliances that help to advance TNC's conservation agenda more rapidly than might otherwise occur.

- TNC's oyster reef restoration efforts with University of Central Florida and communities in the Indian River Lagoon, Florida, involved well over 20,000 volunteers and is now being lead by the Brevard County Zoo.

- TNC's efforts to engage communities to remove alien algae in Hawaii is leading to larger watershed restoration activities, such as the development of taro fields that trap sediment and nutrients and protect coral reefs in Kane`Ohe Bay.

- TNC´s restoration work in the Gulf of Mexico has expanded from pilot scale projects and is now at the point where over 500 volunteers turned out over a weekend to help build the first section of oyster reef in Mobile Bay for the Alabama 100/1000 project.

Informing Policy Decisions: TNC's active involvement in restoration projects has increased the organization's credibility and allowed us and many of our partners to help inform important policy decisions and agency priorities related to coastal habitat restoration and conservation.

- TNC staff has participated in Virginia and Maryland blue-ribbon oyster panels in 2006 and 2007 that charted the course for large-scale restoration of native oysters in the Chesapeake Bay and elevated sustainable aquaculture practices as a viable means of reviving the region's fabled oyster industry.

- TNC's strong focus on restoration of shellfish beds and reefs helped to make oyster reefs one of four habitat priorities for restoration funding within the NOAARestoration Center. Oyster reefs and bivalve beds are now well represented among projects funded through the Community-based Restoration Program and among the 50 projects supported with NOAA Recovery Act funding in 2009. More recently, NOAA's new Aquaculture Policy calls for development of a National Shellfish Initiative that will better link sustainable aquaculture and restoration projects for delivery of ecosystem services.

- TNC's experience with clam restoration on its submerged 13,000 acre Bluepoint Preserve provided credibility and standing for development of a hard clam fisheries management plan for all of Great South Bay.

- North Carolina's Division of Marine Fisheries has developed an oyster sanctuary restoration program after TNC's early work on oyster reefs in Pamlico Sound demonstrated the utility of three-dimensional reef structure and a sanctuary-based management approach.

INTRODUCTION

A Partnership for Restoration

The fragile, green edges and intricate tapestry of habitats along the coast are what make estuaries and coastal waters so productive—providing fish and shellfish for food and fueling our coastal economy. These habitats also protect our communities from storm surges and provide a restful place to enjoy when the weather is calm. As more people settle along the coast and those communities expand, many of these habitats suffer, and the level of habitat loss is alarming. Studies from around the world show that approximately:

- 30 percent of underwater grasses (seagrasses) are lost
- 50 percent of coastal wetlands are filled, ditched or drained
- 75 percent of coral reefs are threatened and 25 percent are degraded
- 85 percent of oyster reefs have been overfished, dredged away, buried with sediment or made unproductive by pollution, diseases and changes to river flows

As alarming as these statistics are, we now know that restoration works. Communities from every coastal state in the U.S. are taking action to restore these vital resources and habitats, and the National Partnership between TNC and the NOAA Restoration Center provides vivid examples of communities in action and lessons that can be applied almost anywhere in the world.

A Sea Change for Restoration

In recent decades, huge strides have been made in raising public awareness about the importance of our critically imperiled coastal habitats. Salt marshes provide a vivid example - once perceived merely as swamps and breeding grounds for mosquitoes, they are now focal points for bird watching and other ecotourism activities. Their role as nurseries for juvenile shrimp, crab and fish is well documented and is a key consideration in coastal management. Recent studies documenting the role of salt marshes as a buffer against storm surges and waves further reinforce awareness of their value for protecting life and property in our coastal communities. Accordingly, federal, state and local laws have been enacted to protect salt marshes, and mitigation is usually required to repair damages caused by unavoidable or accidental impacts.

Other habitats such as underwater grasses (seagrasses) and corals are also increasingly protected from direct impacts from activities like channel dredging operations and "propeller scarring" by recreational boaters attempting to navigate across shallow flats. Indeed, regulatory measures resulting from the federal Clean Water Act and other state and local laws have helped to stem damage to these habitats, but the millions of acres that have been lost urgently need restoration so that our coasts can continue to feed and protect communities and support local economies.

Since 2001, this partnership has worked to raise the profile of habitats created by shellfish such as oysters, mussels, clams and scallops, and the public now recognizes much more the importance of the "ecosystem services" provided by shellfish. These services include water filtration, which clears suspended particles from the water; removal of nitrogen that pollutes many waterways; provision of habitat and food for many important recreational and commercial fish; and stabilization of sediments and shorelines in the face of sea level rise and storms. A very tangible result is that bivalve reefs and beds are now recognized as a priority habitat within NOAA, making them one of four priority marine habitats recognized by America's lead marine resource management agency.

Restoration as a National Priority

With increased public awareness of the importance of coastal habitat and stunning rates of loss, a restoration ethic emerged in the 1990s and has been growing ever since. People in coastal communities want more than mitigation that simply slows the rate of loss.

In 1996, NOAA created the Community-based Restoration Program (CRP), overseen by the NOAA Restoration Center. In the ensuing years, the program has provided funding and technical support for thousands of projects around the United States. Through partnerships with organizations like TNC, Restore America's Estuaries, American Rivers and others, the NOAA Restoration Center has shown that even modest projects can further galvanize community support to open entire rivers to migrating fish, to clean up polluted waters so that bivalves thrive and are safe to consume, and to restore habitats lost generations before. It is fair to say that through these partnerships, restoration of coastal habitat rapidly became a priority for many communities.

Recognizing that coastal habitat restoration is emerging as a national priority, Congress passed the Estuary Restoration Act in 2000, creating a federal interagency Estuary Habitat Restoration Council and an additional new funding stream for mid-scale habitat restoration (defined as projects costing up to $1 million for implementation). The Council leverages resources and expertise from different agencies to help restoration practitioners—mostly local and state agencies, tribes and nongovernmental organizations—implement projects.

Structure of the National Partnership

The TNC-NOAA National Partnership provides funding to support innovative habitat restoration projects throughout the US and its territories. Projects are selected on a competitive basis through an annual request for proposals and are typically in the $25,000 to $85,000 range, though in recent years even larger projects have been supported. The partnership also supports a Core Program that provides cohesive support for the suite of partnership projects, and represents the partnership both within and outside TNC. The core program also serves the critical function of advancing the science that underpins habitat restoration at a national scale and improves the restoration community's capacity to implement on-the-ground restoration projects, particularly in the field of shellfish restoration. Examples include:

- Publishing *A Practitioner's Guide to the Design and Monitoring of Shellfish Restoration Projects: An Ecosystem Services Approach.*
- Supporting the development of the *Caribbean Acropora Restoration Guide: Best Practices for Propagation and Population Enhancement.*
- Initiating the first global assessment of oyster reefs: *Oyster Reefs at Risk and Recommendations for Conservation, Restoration and Management.*
- Supporting an oyster restoration goal-setting project that has quantified historic and present-day oyster reef areas and conditions for 27 US bays, and enables practitioners to predict the water filtration, fish production and nitrogen removal benefits provided by restored oyster reefs in different areas of the country.
- Supporting the development of *Best Management Practices for Shellfish Restoration* in areas of various water quality classifications, including unclassified areas and waters otherwise closed for harvest.
- Developing standardized monitoring metrics for oyster restoration projects to facilitate comparison of projects nationwide.

Scaling Up Restoration

The American Recovery and Reinvestment Act (Recovery Act) of 2009 provided NOAA with $167 million for mid-scale habitat restoration projects. It represented a dramatic increase in the funding made available for coastal habitat restoration and a significant step toward the one million acre restoration target set by the 2000 Estuary Restoration Act. In its public call for proposals for projects to support with Recovery Act funding, NOAA received more than 800 proposals from organizations across the country totaling more than $3 billion in requested funding. This overwhelming response demonstrated that the need and capacity to carry out restoration of our coasts and oceans far surpasses NOAA's current annual budget for coastal habitat restoration projects or the one-time funding made available through the Recovery Act.

Out of the more than 800 proposals received, NOAA was able to support 50 projects with Recovery Act funding. Many of these were expansions of projects that had previously demonstrated the effectiveness of their restoration techniques and the capacity of their management teams through projects at the scale of the TNC-NOAA Partnership. Eight of these 50 mid-scale Recovery Act projects were awarded to TNC. In Alabama, TNC's Recovery Act project restored 4 miles of oyster reefs in order to protect 30 acres of saltmarsh and seagrass habitat by acting as natural, living breakwaters. This project gained an enormous momentum which helped catalyze the "Restore Coastal Alabama 100/1000 Project". This dramatic expansion to an ecosystem-wide scale aims to install living oyster reef breakwater to protect 100 miles of the region's eroding coastline and in so doing protect 1,000 acres of salt marsh and seagrass. Expansion to this scale is possible only because of the development of capacity and underpinning science that accompanies the Recovery Act project and those funded through the TNC-NOAA National Partnership.

Habitat Restoration Priorities

All habitats supporting the marine species found in the NOAA Trust Resources are considered for funding through the partnership. These habitats tend to fall into five broad categories developed by NOAA to categorize and prioritize projects for funding.

Fish Passage: Dam removals; installation of fish ladders or nature-like fish passageways; construction of bypass channels; and replacement of existing culverts with bottomless arch culverts or bridges.

Hydrologic and Tidal Reconnection: Breaching of berms and levees; culvert removal/replacement to allow tidal or natural flooding of wetlands; complete removal of levees and dikes or other impediments to historic natural flow or hydrology; floodplain reconnection; and restoration of in-stream habitats.

Shellfish Restoration: Restoration or rehabilitation of historic bivalve shellfish habitat through addition of materials (shell, rock or other hard substrate) that enhance the settlement of young bivalves and foster creation of healthy bivalve reef communities.

Coral Recovery: Mitigation of land-based pollution sources; supporting recovery from disturbance; promotion of recruitment and recovery through enhancement and protection of existing populations and natural systems; controlling overgrowth of invasive species and other factors that cause the loss of recruitment habitat.

Coastal Resilience: Salt marsh and barrier island restoration; prevention of erosion through living shorelines; other methods leading to increased resiliency and protection of coastal communities while supporting ecological goals.

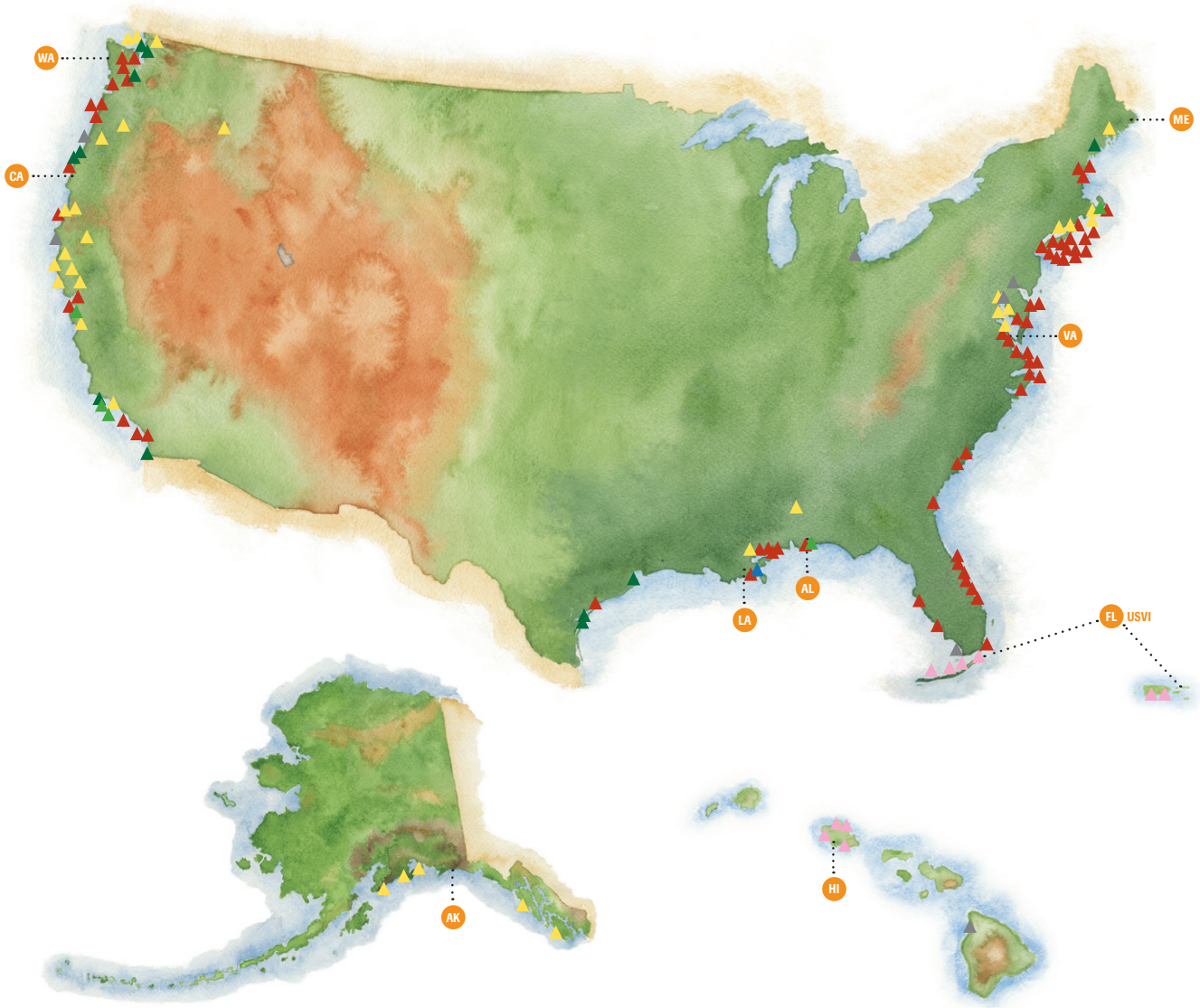
A Look Back at the TNC-NOAA Partnership

Between 2001 and 2011 the partnership funded 124 projects in 20 of the 23 coastal states as well as the Great Lakes and Puerto Rico. The eight TNC-led Recovery Act projects were also largely extensions of the proof-of-concept work supported through the partnership.

History at a Glance

Number of projects	124
Federal funds provided to projects	$7.24 Million
Non federal matching funds	$10.18 Million
Funding ratio, Federal $$:Match $$	1:1.58
Additional targeted funding (no match required)	$0.81 Million

Restoration Target



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- Shellfish reefs & beds
- Migratory fish habitat
- Salt marsh
- Seagrass
- Coral
- Mangrove
- Other
- Recovery Act project

Locations of TNC-NOAA Partnership Projects (triangles) and Recovery Act Projects (boxes with arrows to restoration sites)
Map Illustrations©Cheryl Graham

In this report, we showcase a number of projects that help to illustrate these larger outcomes, as well as the work of the partnership's central technical and management team that provides important underpinnings to all of the partnership's work. We hope you find these stories both enlightening and inspiring.

Influencing Ecosystems:

Photo © Jeff Yonover

The Florida Keys' Staghorn Coral Restoration

Location: Initial efforts within an underwater nursery three miles off Key Largo, Florida, later expanded to Biscayne, Broward County, and Lower Keys nursery sites; now including nurseries in the Middle Keys, Dry Tortugas, and St. Thomas and St. Croix, US Virgin Islands.

Focus species: Staghorn coral (*Acropora cervicornis*) and Elkhorn coral (*Acropora palmata*)

Partners: Nova Southeastern University, University of Miami RSMAS, Coral Restoration Foundation, Florida Fish and Wildlife Conservation Commission, Mote Marine Laboratory, Penn State University, Florida Keys National Marine Sanctuary, Florida Department of Environmental Protection, National Park Service, University of the Virgin Islands, US Virgin Islands Department of Planning and Natural Resources.

Changing the Paradigm for Coral: Perhaps the most fundamental importance of the Florida Keys Staghorn Coral Project is how it influenced what "reef restoration" really means.

"In the past, and certainly still today, many people think of restoring acutely damaged pieces of reef by putting Humpty Dumpty back together again. Our work with this project is restoring a keystone species that is largely absent from all reefs, acutely damaged or not, at the scale of the entire reef ecosystem. To extend the analogy, we are working on the entire carton of eggs and trying to make their shells tougher and more resilient to the impacts of the fall by restoring a missing element of the system." — Chris Bergh, Florida Keys Program Director.

Within the Florida Keys National Marine Sanctuary, in the wider Caribbean region and in locations worldwide, scientists and recreational divers alike have witnessed dramatic declines in living coral coverage in just the last few decades. Local, regional and global threats, including overfishing of the herbivorous fish that clean the reef and destructive fishing practices on reefs; hurricanes; introduced coral diseases; ocean acidification and sea surface temperature rise due to global climate change—all are culminating in a multiplicative fashion to degrade and destroy coral species. In the Florida Keys two coral species in particular have suffered serious declines, *Acropora cervicornis*, or staghorn coral, and *Acropora palmata*, elkhorn coral. These species are two of the most important structural, reef-building, and fish habitat components of a coral reef system, and were listed as threatened under the Endangered Species Act in 2006.

To address the widespread loss of fundamental structure-forming coral species, a dramatic intervention was required. Scientists and conservationists working in coral reef systems are accustomed to small-scale restoration of localized or site-specific damage such as boat groundings. Typically, those efforts involve the reattachment of broken and damaged corals to reefs using epoxy or other adhesives. Using direct restoration to tackle a large-scale problem such as a species' range-wide decline was, until this effort, largely unfamiliar territory.

Acropora nursery stand. © Diego Lirman, University of Miami

Acropora fragments.© Ken Nedimyer, Coral Restoration Foundation

In 2005, a number of young staghorn corals settled onto a privately owned and permitted "live rock" farm in the Upper Keys, run by Ken Nedimyer. After some experimentation with growing and propagating these colonies, he suggested an outside-the-box idea for reef restoration to TNC--use coral farming and natural propagation techniques as a lifeline to a species threatened with extinction.

Creative thinking and novel ideas turned former "spawner sanctuaries" into naturally dynamic and active coral restoration systems.

The Florida Keys Staghorn Project, first supported in 2005 by the TNC-NOAA Partnership and, after 2009, by NOAA's Recovery Act funding, aimed to restore populations of staghorn coral to reefs in the Upper Keys by growing fragments of naturally occurring and wild coral in nurseries and transplanting these fragments back onto reefs once they had grown to a suitable size and been quarantined for disease.

The idea of using coral gardening techniques to replicate natural stocks was a novelty for coral restoration: the method was to both restore and create discrete breeding populations of genetically diverse colonies at strategic locations throughout the reef system. Then, scientists would wait to see if the corals naturally spawned, in essence taking over the work of repopulating the rest of the reef system.

Using common propagation techniques, adult coral colonies were clipped or "fragmented" to increase the number of fragments that could be grown out for restoration. Using epoxy, each separate coral fragment was attached to a small cement platform on the seafloor within Ken Nedimyer's live rock nursery. As the fragment grew to a larger adult size, it was clipped again to generate yet more coral fragments. Ultimately, an entire crop of new coral colonies was produced, ready for the actual restoration work.

In early November 2006, corals were outplanted from the coral nursery to restoration sites that were chosen based on their survivorship history, current growth rates, genetics, and overall health as reefs. By May 2007, 120 coral fragments were outplanted to each restoration site, with each site receiving 15 different genotypes. Amazingly, after one year the survivorship of these staghorn fragments was 97% within the inshore habitat, 97% in mid-channel habitat, 73% in offshore habitat and 97% on the reef margin habitat. A year later, the overall survivorship of the out-planted corals was 91%.

Changing the Ecosystem: If keystone corals like staghorn and elkhorn can be restored, other corals, fish, invertebrates, and ultimately people will benefit.

Through the initial funding from the TNC-NOAA Partnership, this project tested a novel restoration idea and improved techniques in order to create a sound method that could be used in other locations throughout the Keys and the Caribbean. Project staff were able to test variables such as the optimal time to propagate corals and to monitor for disease and bleaching, and they determined appropriate amounts of coral tissue to collect. They also improved maintenance procedures for the nursery, methods for predator removal before and after outplanting, established a tracking and labeling system, and fine-tuned measurement techniques for propagation and outplanting.

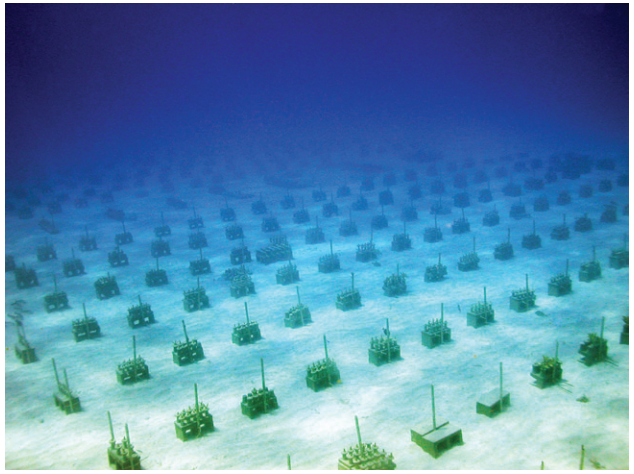
Besides growing and propagating staghorn colonies, Conservancy staff worked with Penn State University to sequence genotypes, a step toward identifying genotypes resistant to heat and other stressors. The location of outplanting within the reef tract was observed to influence survival of the fragments. Outplanting was designed to compare genotypic fitness of staghorn colonies for placement in various exposure regimens across the reef. These genotypic characteristics could then be used to improve overall reef resilience to mass bleaching events that are increasing in frequency and severity with global climate change, and would allow scientists to selectively outplant corals better suited to withstand these pressures.

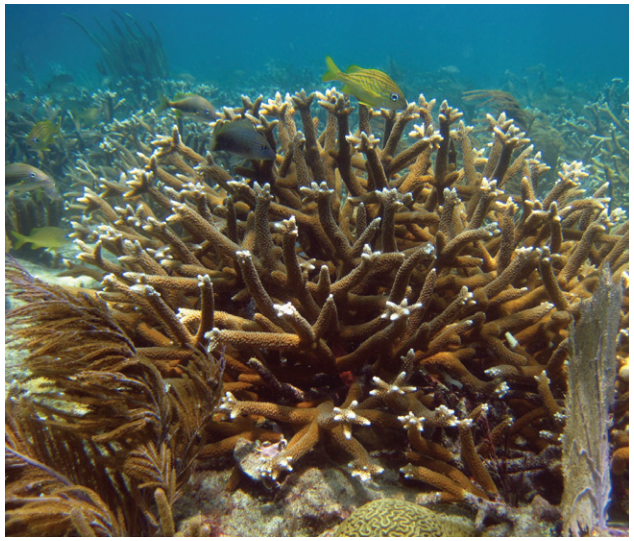
In the face of the many threats that cause degradation of these reefs, active transplantation of resilient corals was a priority in creating reef sites that provide habitat for fish, turtles, lobsters and other marine invertebrates. Coral bleaching is not only a threat to the survival of corals, it is a threat to the entire coral reef ecosystem and all of the biodiversity that depends on it.

Expanding the Restoration Footprint: A second round of partnership funding allowed this small proof-of-concept project to aid in the revival of 11 coral reefs.

In late May 2007, a second phase of the project was funded that allowed it's proof-of-concept techniques to be scaled upwards and achieve even greater restoration outcomes. The Staghorn Restoration Project was expanded to three more subregions within the south Florida reef tract, with underwater nursery sites located in Broward County,

Outplanted corals on reef. © Ken Nedimyer





Coral nursery with recently established propagules, greatly expanded in size with ARRA funding. © Ken Nedimeyer, Coral Restoration Foundation

Healthy staghorn coral in Broward County, Florida.
© Meaghan Johnson, TNC

Biscayne National Park, and the Lower Keys. Partners involved in this expansion were Nova Southeastern University, University of Miami RSMAS, Biscayne National Park and Mote Marine Laboratory. During the second stage of this project, a South Florida staghorn restoration network was established between universities, management agencies and local non-governmental organizations to better coordinate future work.

The success of this pilot-scale work led to an expanded restoration project that greatly boosted success at degraded reefs throughout the Florida Keys reef tract. In a report to the TNC-NOAA CRP Partnership core team, Florida Keys marine science coordinator, Meaghan Johnson, discussed that "by supplementing 11 reefs with more than 360 staghorn coral fragments and 28 different genotypes, we have increased the likelihood of staghorn larval production and genetic diversity."

The Conservancy and its partners were recognized for the success of this novel restoration technique. TNC was placed on the NOAA Fisheries Recovery Planning Team for *Acropora* species, and Conservancy staff presented the project at a conference of the Association of the Marine Laboratories of the Caribbean. The project received media attention, including an article in the *New York Times* and coverage on NBC's Miami affiliate and the NBC Nightly News with Brian Williams.

Scaling Up: In 2009, this project was selected as **one of fifty** to receive the American Recovery and Reinvestment Act funding.

With NOAA Recovery Act funding, the staghorn project grew into an undertaking titled "Threatened Coral Recovery and Restoration in Florida and the U.S. Virgin Islands." The new project expanded yet again the size and number of shallow in-water coral nurseries, also moving into further locations along coastlines in Florida and the US Virgin Islands. Altogether, 14 large nurseries, located in Broward County, Biscayne National Park, Upper Keys, Middle Keys, Lower Keys, Key West, the Dry Tortugas, and St. Croix and St. Thomas in the USVI, aim to produce 12,000 colonies of the staghorn and elkhorn corals that are under threat and to transplant those fragments onto 34 reefs throughout the region—making an enormous impact on the strength, resilience, and health of these degraded coral reefs.

Significant increases in staghorn and elkhorn populations will brighten the chances for these corals to spawn, cross-fertilize and maintain genetic diversity among colonies. With increased genetic diversity, these threatened species will gain resilience and be better able to withstand the threats of seasonal warming, physical damage from storms, and disease outbreaks.

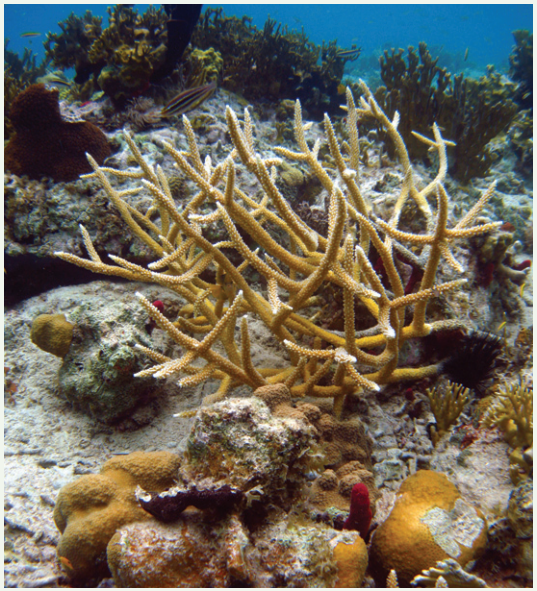
This Recovery Act project created and directly supported 60 jobs related to restoration work, bolstering the reef ecosystem that supports the tourism and fishing-based local communities of the Florida Keys and US Virgin Islands.

Using the experience gained through their involvement in pioneering coral restoration, project staff from TNC's Florida Keys Chapter developed and published the *Caribbean Acropora Restoration Guide: Best Practices for Propogation and Population Enhancement.* This guide book, funded by the TNC-NOAA Community-based Restoration Program, is already widely-distributed and exerting great positive influence on new staghorn coral restoration programs that are beginning in many countries throughout the Caribbean region.

Puerto Rico's Coral Aquaculture and Reef Rehabilitation Program

Coral reefs have suffered a widespread decline throughout the Atlantic in recent decades. They have lost ecological functions, socio-economic value, and ecosystem resiliency.

To address this problem in Puerto Rico, the Community-Based Coral Aquaculture and Reef Restoration Program was launched in 2003 through a joint effort between the University of Puerto Rico (UPR) and three NGOs: Sociedad Ambiente Marino (SAM), Coralations, and the Culebra Island Fishermen Association. With the support from the TNC-NOAA Partnership, SAM, UPR, and partner NGOs, have expanded coral farming and reef rehabilitation efforts in Puerto Rico. A total of 1,400 new fragments of threatened staghorn coral, *A. cervicornis*, were transplanted to new coral farming units in Culebra, elevating the population in farms to about 5,000. Survival rate reached 90–98% during the first three months of the project. In addition, an expanded low-tech culture and replanting effort was launched for the threatened elkhorn coral (*A. palmata*). This involved setting up experimental farms for 180 fragments of opportunity at Vega Baja and Manatí, with a 100% survival rate over the first month. By the end of 2011 we expect to have produced nearly 5,000 fragments of staghorn corals to repopulate depleted reefs. Cultured elkhorn corals will also be used to restore the reefs. Not only have these low-tech efforts been successful for coral restoration, they have been a tool to engage local community members in hands-on educational experiences aimed at fostering meaningful behavior changes. — Dr. Edwin Hernandez-Delgado, University of Puerto Rico.



Low-tech coral farm ready for harvesting in Culebra Island, PR. © Dr. Edwin Hernandez-Delgado

Far right: Transplanted staghorn coral colony harvested from coral farms in Culebra Island. © Dr. Edwin Hernandez-Delgado

Location of Garcia River Forest. © Jennifer Carah, TNC

TNC ecologist Jen Carah records water temperature data in the Garcia River watershed. © Bridget Besaw

California's Garcia River Watershed Restoration

Location: Inman Creek, Garcia River watershed, Mendocino County, California, approximately 120 miles north of San Francisco

Focus species: Coho salmon (*Oncorhynchus kisutch*) and Steelhead trout (*Oncorhynchus mykiss*)

Partners: The Conservation Fund, California State Coastal Conservancy, California Wildlife Conservation Board, Felton Family Foundation, California Department of Fish and Game Fisheries Restoration Grant Program.

Located in the North Coast region of California, the Garcia River was once well known for its abundant runs of anadromous fish, including coho salmon and steelhead trout.

Salmon and trout have adapted through time to historic conditions of streams in northwest California. The clean, shaded waters, low in temperature and sediment, and the logjams formed by downed trees, offered deep pools for juvenile fish, protective cover from predators for adults and juveniles, abundant beds of clean gravels for fish to make nests and deposit eggs, and a perfect environment for juvenile rearing. The wood that collected naturally in these streams over hundreds of years also served to trap nutrients and increase availability of food for salmon.

This watershed is part of a large expanse of old-growth redwood and Douglas fir on the North Coast that was intensively logged during the post–World War II period. Loggers used tractors and trucks to build roads that opened up many inaccessible parts of these watersheds, making it possible to remove giant old-growth trees on an industrial scale. Logging practices included the removal of streamside forests, removal of downed in-stream logs (or "large woody material," LWM), and construction of poorly designed and maintained logging roads that caused large-scale erosion into the rivers. This degraded water quality with excessive fine sediment that clogged fish nesting sites, altered stream channels, increased water temperature and reduced pool depth. The removal of downed logs and logjams eliminated much of the habitat complexity and the stream's ability to maintain the shaded cooler waters, deep pools and gravel nesting grounds necessary for salmon and trout survival.

The populations of coho salmon on the North Coast of California currently stand at just 1% of 1940s levels, and they are now on the state and federal lists of endangered species. Without serious intervention and improvement of natural habitat conditions, coho salmon are threatened with extinction in the coastal watersheds within the next 25–50 years.

Working together, partner organizations joined forces to address negative environmental impacts on an ecosystem and restore a watershed.

The Garcia River Forest Project is one part of a larger, watershed-wide effort between conservation partners including private landowners, an industrial timber company, community activists, nonprofit organizations and state and federal regulatory agencies. These groups have one common goal: to restore the health of the Garcia River watershed through sustainable timber management, restoration and responsible land stewardship.

In 2004, the Conservation Fund purchased the Garcia River Forest in partnership with TNC, the California State Coastal Conservancy and the California Wildlife Conservation Board. This property spans 23,780 acres of former industrial forestland representing a third of the Garcia River watershed. The Conservation Fund owns and manages this land, while TNC holds a conservation easement that designates a third of the property as an ecological reserve. This conservation easement also protects the Garcia River Forest from development and unsustainable timber harvesting practices.

Significant work to decrease upslope erosion has been completed by the Conservation Fund by way of decommissioning, upgrading or repairing old forest roads that contribute fine sediment to streams. TNC and the Conservation Fund have joined forces to address the threat of extinction facing coho salmon with rapid and efficient methods to re-grow shade-providing streamside forests and reintroduce downed trees and woody material into creeks.

Juvenile salmon from Garcia River. © Bridget Besaw

Garcia River Forest. © Ivan Shive

Unanchored logjam on the Inman Creek, Garcia River Forest. © Jennifer Carah, TNC

"Cutting trees to save the streams": This project is influencing the field of restoration using innovative techniques to protect endangered fish and restore the habitat they need to survive.

Reintroduction of fallen trees into these streams is ranked by federal and California state agencies as one of the most urgent actions needed for the recovery of coho salmon. To enhance conditions necessary for survival of these species, restoration efforts focused on influencing river processes by adding large woody material (LWM) and logs. Once reintroduced, these wood pieces form logjams that increase natural scour, create new pools and deepen existing ones, provide slow-water refuge for juvenile fish, create gravel nesting meadows, trap nutrients in streams and increase food availability.

Historically, most projects that reintroduced LWM into natural streams and rivers on the North Coast used a more traditional approach of building and engineering wood jams and anchoring them in place. This approach is appropriate in many situations, for instance in urban settings or where there is significant risk to downstream bridges or infrastructures from loose wood. However, these anchored wood jams are expensive and time-intensive to install. To increase the pace and scale of this urgent restoration work, TNC and partners decided to implement a new and innovative "unanchored" wood-loading approach at the Garcia River Forest in Inman Creek.

This dynamic strategy includes adding appropriately sized, unanchored wood and letting natural stream processes move and place the wood, building wood jams organically. It supports natural wood transport, accumulation and storage processes in the stream, and avoids disturbances to the stream by installing engineered structures.

In 2009, the Conservancy added 65 trees or wood pieces across the lower two miles of Inman Creek using these cutting-edge techniques. Nearly 6,000 cubic feet of wood has been added across nine placement sites, increasing the in-stream wood volume by 46 percent and LWM by 202 percent.

Furthermore, the wood has amplified the natural scour, increasing the number and depth of pools and boosting average pool cover by 71 percent. Best of all, using the "unanchored" technique, these goals were achieved faster and implemented at approximately 25% of the cost of traditional wood-loading methods.

"One of the primary benefits of the Inman Creek project has been the support built amongst agency staff and project partners for using the 'unanchored' wood loading approach on the North Coast." – Jen Carah, TNC

Initially, TNC staff and partners had to build support for the experimental approach of applying unanchored wood pieces to Inman Creek, as there was skepticism surrounding whether this technique could deliver the desired results to coho habitat. However, following winter floods in 2009–2010, effectiveness monitoring demonstrated a 90% retention rate of placed wood pieces within the two-mile treatment reach of Inman Creek, despite the wood being loosely placed and unanchored. These monitoring data also indicated significant movement of the wood within this stream at high-velocity flows, with mobile logs becoming wedged, naturally creating four wood jams greater than seven pieces in size and two more jams over three pieces in size.

"This project demonstrates that the 'unanchored' approach to wood loading can be a highly efficient, effective and inexpensive way to improve habitat in coastal coho streams, and has been instrumental in building support for the approach on the North Coast," says Jen Carah of the TNC California San Francisco office. By demonstrating success, the project has changed perspectives and generated much enthusiasm for the approach in the rural watersheds of the North Coast. This approach won't be appropriate for every situation—for example, in an urban environment where loose wood presents risks to downstream infrastructure. However, in priority watersheds for coho recovery on the North Coast, mostly located in rural timberlands, this can be an appropriate and cost-effective way to rapidly increase wood cover on a large scale.

TNC and key partners are working with federal and California state regulatory agencies to identify streamlined permitting pathways that will motivate private landowners to take on similar projects. Working together, these major conservation groups hope to influence policy to accelerate the pace of salmon habitat restoration work and other urgently needed projects.

Inman Creek, Garcia River Forest. © Bridget Besaw

Redwood trees marked for selective harvesting and used in unanchored logjams. © Bridget Besaw

To date, two miles of key salmon and trout habitat at the Garcia River Forest have been enhanced using these techniques. Due to the immense success of this work, the project has attracted additional grant-based funding from major agencies, including another TNC-NOAA Partnership grant for 2010 and the California Department of Fish and Game Fisheries Restoration Grant Program. By 2012, it is anticipated that another 10 miles of aquatic habitat in the Garcia River Forest will be restored using these methods. The initial funding from the TNC-NOAA Partnership has not only catalyzed development of at least five other near-term projects on Conservation Fund–owned lands in Mendocino County, it has gone a long way towards building support for this efficient approach region-wide. "And that is what's important," says Jen, "because we need to implement key restoration actions as widely and quickly as possible in order to save coho salmon from extinction in California". A fast and relatively low-cost restoration technique has been added to the suite of salmon recovery techniques nationwide.

California's Salmon Habitat Restoration

Together, three independent projects in California are making significant impacts to improve the habitats essential for three different life stages of salmon.

Along the Northern California coast, three types of restoration projects in three unique watersheds have been funded through the NOAA-TNC Partnership. At first glance, the projects appear to have little to do with one another—not only are they in different watersheds, they have been undertaken by different organizations. Collectively, however, these projects most likely will have a BIG impact on coho salmon habitat, showing how this ecologically and economically important fish can be saved from extinction in California.

In the Freshwater Creek watershed of Humboldt Bay, the Garcia River Forest in Mendocino County, and Salmon Creek in both the estuary near Bodega and the upstream main stem, scientists are battling threats to coho salmon in distinct habitats, each one critical for a different life-history stage of these fish. As anadromous fish, coho salmon require saline conditions of the open ocean during adulthood but the fresh waters of inland streams for rearing and juvenile years.

- As coho salmon swim upstream to breed, or "spawn," they must find clean gravel beds free of mud to make their nests called "redds" and lay their eggs. The **Garcia River Forest** project has introduced natural logjams into streams to recreate these beds while providing cover from predators as well as pools and eddies out of the main current for juvenile habitat and a refuge during periods of high flow. The Gold Ridge Conservation District is adding large wood to the Salmon Creek main stem.
- During their months as juveniles, it is important for salmon to find lower-velocity channels close to brackish water to grow and store energy that help ease their bodies into higher-salinity environments. The Northcoast Regional Land Trust **Freshwater Creek** project is restoring pastureland back to its historic state as brackish marsh with backwater pools by removing tide gates and digging channels, reintroducing tidal inundation to the landscape. The backwater pools are relatively small but proving to be highly valuable coho-rearing habitat, supporting high densities of juvenile coho and very high growth rates.
- To enter or re-enter the ocean, coho salmon must swim through open estuary reaches, where cover from predators, including seabirds, is critical. Cover is particularly important in estuaries where a sandbar forms across the channel connecting the estuary to the ocean and only opens infrequently. The Occidental Arts and Ecology Center **Salmon Creek Estuary** project has installed large root-wad structures with floating willow "rafts" to promote growth of fish and to decrease predation rates while fish wait for the sandbar to breach and they can move out to the ocean.

Thus, despite the different locations and organizations involved, together these TNC-NOAA Partnership–funded projects are developing methods to restore habitats important for different stages in the coho life history—methods that could change the course of decline of an entire species.

The Virginia Coast Reserve's Oyster and Seagrass Restoration

Location: The Virginia Coast Reserve (VCR)—14 undeveloped barrier islands and approximately 20,000 acres in the Virginia portion of the lower Delmarva Peninsula.[1]

Focus Species: Eastern oyster (*Crassostrea virginica*), eelgrass (*Zostera marina*), bay scallops (*Argopecten irradians concentricus*).

Partners: VA Marine Resources Commission, VA Institute of Marine Sciences, VA Coastal Zone Management Program/Seaside Heritage Program; others include VA Aquatic Resources Trust Fund/ US Army Corps of Engineers, Hampton Roads Community Foundation, VCR Long Term Ecological Research Project, Allied Concrete, New Inlet Seafood, Terry Bros. Seafood, Shorekeeper, Norfolk Southern Foundation, the Volgenau Foundation, the Campbell Foundation.

During the early 20th century, the coastal bays of Virginia supported some of most productive oyster reefs and seagrass meadows along the entire east coast of the United States.

In that same century, the Virginia coastal bays suffered two drastic changes that affected the state of the ecosystem. In the 1930s, a wasting disease paired with hurricane damage led to the loss of the entire population of native eelgrass (*Zostera marina*) in the coastal bays. Additionally, a disease in the mid-1990s devastated much of the region's population of native eastern oyster (*Crassostrea virginica*). With no hope for the end of this disease, Virginia's seaside oyster industry overharvested the eastern oyster to commercial extinction.

Native oyster reefs and seagrass beds in the Virginia coastal bays are keystone species for the area. Oyster reefs provide clean water through filtration, habitat for fish and other marine life, and biomass and biodiversity. Seagrasses supply nursery habitat for many marine species as well as trapping sediments and dampening wave energy. The loss of functional oyster reefs and productive seagrass meadows resulted in the disappearance of these critical ecosystem services, and in some case, led to the loss of

Oyster reef in the Virginia Coast Reserve.
© Diana Garland

Oyster castle deployment at Long Bar in 2010.
© Bo Lusk, TNC

[1] www.nature.org/vcr

Oyster Castles after one year. © Bo Lusk, TNC

Oyster castles showing oyster recruitment and growth three years after deployment. © Barry Truitt, TNC.

species dependent on them. One such species was the bay scallop (*Argopecten irradians concentricus*), which disappeared from the Virginia coastal bays in 1932 in conjunction with the loss of the eelgrass population.

Influencing Restoration Protocols: Oyster castles, reef balls and seed harvesters are a few of the numerous adaptive approaches bringing oysters and eelgrass back to the coastal bays.

By the mid-1990s, the once-booming eastern oyster population in the coastal bays was commercially extinct. The main goal of restoration was to re-create functional reefs, with good vertical height and diverse ages and sizes of oysters. Initially, restoration techniques involved dredging and planting fossil oyster shells to provide the substrate needed for recruitment of young oysters. Although this method was highly successful, the availability of suitable shell for substrate was a limiting factor and posed a problem for increasing the scale of restoration efforts. Therefore, an alternative substrate was needed.

In 2006, the Conservancy was contacted by the head of Allied Concrete Co. with an offer to work with students of the Tandem Friends School to produce an alternative substrate called an "oyster reef ball." The reef balls proved difficult to make, and Conservancy staff and Allied Concrete worked together to design a marine-friendly, stackable, interlocking concrete block providing vertical relief and interstitial space for the recruitment of oyster spat. Five hundred "oyster castles" were produced and donated to the Virginia Coast Reserve and deployed at four locations for experimental purposes. After two years, the oyster castles displayed very successful recruitment, survival and vertical growth of oysters.

"Oyster castles were viewed as the most viable alternative to natural substrate," says Barry Truitt, chief conservation scientist of the TNC Virginia Coast Reserve. Not only did the oyster castles prove successful as an alternative substrate, the process to create and deploy the structures was relatively simple and inexpensive. Furthermore, oyster castles deployed one or two years ahead of restoration activities could be used as a tool for evaluating potential sites for future reef construction with fossil shell. To date, a total of 3,000 oyster castles have been produced and donated to the Virginia Coast Reserve, and they have been used in other Conservancy restoration efforts in Massachusetts and South Carolina.

The native eelgrass found in the Virginia coastal bays once thrived up and down the Atlantic coast, until a pandemic slime mold occurring in the 1930s led to its

disappearance from the Virginia coast. While eelgrass beds grew back naturally in less saline environments, it was not until Dr. Bob Orth of VIMS developed a method for collecting and planting the seeds that the eelgrass began returning to the Virginia coastal bays. With the assistance of TNC's Virginia Coast Reserve and other partners, the restoration of eelgrass in this area has proved an outstanding success.

With funding provided by the Hampton Roads Community Foundation, the project partners were able to increase the harvest of eelgrass seeds on an exponential scale. Ten 1,000-gallon tanks were created for the collection, storage and curing of eelgrass seed, with the capacity to hold up to 20 million seeds in each tank. Shoots are stored in the tanks for one to three months until seeds ripen and fall out of their shoots, collecting at the bottom of the tank. The mature seeds are then gathered and are ready to germinate wherever they are seeded.

Volunteers made a great impact during this portion of the project, with 184 community volunteers contributing 928 hours to collecting and dispersing seed. With this added support, the project may represent the largest and most successful seagrass restoration in history. In areas including Hog Island Bay, Spider Crab Bay, Cobb Island Bay and South Bay, 317 acres were planted with eelgrass by 2010, using 38 million eelgrass seeds. In the few years since restoration began, seagrass beds have exploded in size. Over 4,500 acres in the Virginia coastal bays are now covered with eelgrass.

Changing Perspectives: "We have been able to prove, contrary to what the watermen say, that you don't have to harvest an oyster reef for it to survive… and that sanctuaries work." – Barry Truitt, TNC

More than 10 years ago, a small partnership of public and private coastal managers, marine scientists and local community volunteers came together to plan the first marine restoration projects in the coastal bays. These projects focused on restoring functional oyster reefs and seagrass meadows for their ecological value as habitat and their provision of ecosystem services. In 2002, the partners were awarded a grant from the TNC-NOAA Partnership to restore oyster reefs through proof-of-concept methods involving the dredging and placement of oyster shells for natural recruitment. "Everyone said we were crazy," says Barry Truitt, chief conservation scientist of the TNC Virginia Coast Reserve, "and that this was not going to work."

Volunteers stirring the maturing eelgrass seed heads. © Bo Lusk. TNC

Eelgrass seeds after processing. © Barry Truitt, TNC

Aerial photo of seagrass emerging from seeds. © Bryan Watts, Center for Conservation Biology

Using the TNC-NOAA Partnership grant to double the funding provided by the state of Virginia for oyster restoration, the Conservancy and VMRC hired contractors to dredge and strategically plant fossil oyster shells. After two years of growth, the reefs were blooming in oysters—nearly all of them three inches, the legal market size. This proof-of-concept approach had "more success than anyone could have imagined," said Barry Truitt.

The success of these techniques did much to change perspectives of partners, local watermen and state agencies on the utility of restoration. It also led to the awarding of six TNC-NOAA Partnership grants and an Army Corps of Engineers grant for the partnership to restore the native oyster reefs and surrounding native seagrass beds. Along with direct restoration successes in the field, with the support of the TNC-NOAA Partnership, Conservancy staff were able to develop innovative monitoring techniques and a database spanning seven years of all restored and reference reefs in the Virginia Coast Reserve.

In an area with a historically active and lucrative oyster market, however, poaching continued to be a threat to the success of the partnership's restoration work. With clarification from the Virginia State Attorney General on the protection of privately owned oyster grounds, Conservancy staff worked with VMRC's law enforcement division to begin to stem the tide of poaching.

Efforts continue to go beyond the restoration of functional oyster reef and seagrasses to the coastal bays, aiming to conserve and protect these species in hopes of ensuring sustainable populations for the future health of the ecosystem. In 2009, the Conservancy and VMRC signed a memorandum of understanding to facilitate cooperation in the restoration, management and protection of oyster reef sanctuaries adjacent to or upon the riparian lands of TNC in the coastal bays.

To date, five oyster sanctuaries have been designated and placed under joint management between the Conservancy and the state of Virginia, and another three are under development. More than 90 acres of oyster reef are now in designated no-harvest sanctuaries, with two-thirds of

the sanctuaries having joint ownership (TNC and the Commonwealth of Virginia) and the other one-third owned entirely by the state. Through the success of this restoration work and partnerships with the state of Virginia, TNC, a private organization, is able to act as the primary manager of the sanctuary oyster reefs in the seaside lagoons. Currently, the Conservancy and partners are working to implement a Special Area Management Plan (SAMP) under the auspices of the NOAA-funded Virginia Coastal Zone Management program. The SAMP process is a form of coastal and marine spatial planning that involves zoning certain areas in the coastal bays for aquaculture, restoration, birds and more.

Scaling Up: With NOAA Recovery Act funding, the Virginia Coast Reserve and its partners were able to take proof-of-concept techniques to a scale necessary to effect ecosystem state changes.

"Initially, the Virginia Coast Reserve and its partners implemented restoration techniques that were proof-of-concept methods," said Barry Truitt. "With the help of hundreds of community volunteers and funding from public and private sources under the NOAA-TNC Community Restoration Program and the Seaside Heritage Program, the partnership has grown over the past eight years, expanding and developing needed infrastructure and testing new innovative techniques and concepts." To date, and with the funding provided over six years by the TNC-NOAA Partnership and others, the partnership has:

- Actively restored 47 acres of functional intertidal oyster reefs
- Harvested 38 million seagrass seeds and planted 317 acres of eelgrass in four coastal bays
- Restored functional oyster reefs, providing ecosystem services to the coastal bays
- Created no-harvest sanctuaries in the coastal bays
- Restored seagrass to over 4500 acres of the coastal bays.

Restored oyster reef at VCR. © Danny White, TNC

Dredged shell being placed on restoration sites in VCR.
© Boze Hancock, TNC

These restoration techniques proved so effective that the partnership was awarded a grant from NOAA's Recovery Act funding in 2009. With this great increase in funding, the Virginia Coast Reserve and its partners were able to dramatically scale up their goals to:

- Restore 20 acres of functional oyster reefs at nine sites in the coastal bays of Virginia
- Plant an additional 100 acres of eelgrass meadows in Spider Crab Bay
- Test reintroduction of bay scallops in South Bay
- Maintain 57 jobs and 59,927 labor-hours, supporting research scientists, students, marine contractors, boat and barge operators, seagrass curing facility operators, divers and watermen.

The NOAA Recovery Act grant ultimately allowed the restoration partnership to increase its oyster reef restoration from two to three acres of reef per year to over 20 acres of reef in 18 months. This project is now at the threshold of getting oyster reef and seagrass restoration to the scale necessary to effect positive ecosystem state changes in these bay areas. Ensuring healthy ecosystems in the coastal bays will serve as an effective adaptive management strategy for maintaining the resiliency of these coastal systems in the face of anticipated climate changes.

Alaska's Mat-Su Basin: Colter Creek and Little Susitna River Culvert Project

Location: Little Susitna River and tributaries of the Matanuska-Susitna Basin, roughly 24,500 square miles in southcentral Alaska.

Focus species: Coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*Oncorhynchus tshawytscha*), Chum salmon (*Oncorhynchus keta*), Pink salmon (*Oncorhynchus gorbuscha*) and Sockeye salmon (*Oncorhynchus nerka*).

Partners: US Fish and Wildlife Service, Mat-Su Borough, Aquatic Restoration and Research Institute, Wasilla Soil and Water Conservation District, Alaska Sustainable Salmon Fund, Wallace Foundation, Lovelace Foundation, Mat-Su Basin Salmon Habitat Partnership and ConocoPhillips Alaska, Inc.

In the fastest growing region in Alaska, culverts along tributaries of the Little Susitna River were causing migration barriers for rearing salmon.

The Little Susitna River and its tributary creeks compose a watershed that boasts a myriad of healthy fish populations, including several species of salmon. Providing abundant food, habitat that serves as a refuge from winter ice, and cool, clean waters for growing, the watershed supports migrating coho, chinook, chum, pink and sockeye salmon, as well as residential fish species such as dolly varden and rainbow trout. With countless migratory routes and historically productive spawning and rearing habitats for salmon, this watershed produces the second largest freshwater harvest of coho salmon in Alaska and the sixth largest number of harvested chinook salmon in Northern Cook Inlet.

The Little Susitna watershed, however, is located within the Matanuska-Susitna (Mat-Su) Borough, the fastest growing region in Alaska. Increased development in the region has led to many improperly designed and poorly maintained roads, driveways and culverts, which often intersect with these fish-bearing creeks. Many culverts function as barriers and interfere with the upstream movement of juvenile salmon, negatively affecting the survival and future population size for salmon species.

"Adults and juveniles spend time within the tributaries of Little Susitna River throughout much of their life history and the stages most important to spawning and rearing," comments Corinne Smith, the Mat-Su Basin program director, in her proposal for partnership funding. "While adult salmon spend only a few weeks in these waters, juvenile salmon may live here for up to five years, from the time they emerge from eggs until their journey back down the Little Susitna River." Coho salmon, among other species, face the threats of increasing development, as adults must migrate up and juveniles must migrate down these tributaries to reach the habitat necessary for each different life stage. A study conducted by the Aquatic Research and Resources Institute (ARRI) reported that "migration barriers can have significant effects to fish production as access to large areas of spawning or rearing habitat can be eliminated or reduced."

Among these migration barriers, improperly designed and maintained culverts pose the greatest risk to salmon populations, as conditions at culverts can include high water velocities, inadequate water depth, elevated outfall and sedimentation, and high water turbulence. The Alaska Department of Fish and Game inventoried 320 culverts located under state, borough and private roads in the Mat-Su Basin, finding that 40% of culverts were inadequate for fish passage. Furthermore, among the 35 inventoried culverts on Little Susitna tributaries, 23 culverts (66%) were inadequate for juvenile fish

Placing arched pipe on Colter Creek driveway. © Corinne Smith, TNC

Revegetation project with volunteers at culvert on Little Creek. © Corinne Smith, © TNC

passage. The replacement of culverts to restore fish passage and accommodate high water flows became the focus of restoration activities proposed by TNC's Alaska Chapter and its many partner organizations.

In collaboration with the US Fish and Wildlife Service, TNC began the Little Susitna Salmon Passage Restoration Initiative in 2008.

In 2008, TNC's Alaska Chapter received its first TNC-NOAA Partnership funding to replace four undersized culverts located on Colter Creek, the second largest tributary along the southern flank to the Little Susitna River. All four culverts on Colter Creek impeded migration of juvenile salmonids. Working with the Mat-Su Borough and the US Fish and Wildlife Service, the existing culvert round pipes were removed and replaced with arched pipes that were sized based on stream simulation studies.

After culvert construction and replacement, streambeds were actively revegetated to enhance fish habitat, stabilize banks and decrease potential erosion and sedimentation during floods. Revegetation efforts included planting disturbed areas with native grass and plant seeds, live-staking dormant willow cuttings, laying large vegetation mats, root wads and spruce revetment along channel banks, and re-sloping channels to a more natural embankment. The project's restoration activities at Colter Creek were tremendously successful, as juvenile fish passage and migration were restored along this tributary for the foreseeable future. The project also enhanced fish habitat and improved the stream's ecological function by returning the creek to its natural width and increasing the creek's capacity to handle flood events.

An additional benefit of the Colter Creek Restoration Project was the body of knowledge gained from these pilot activities, including a study done by the ARRI that helped show where young salmon are rearing and how culvert replacements affect distributions of adult and juvenile salmon. ARRI was contracted to monitor fish distribution and habitat characteristics before and after the replacements. In order to assess whether the distribution of juvenile salmonids changed as a result of culvert replacement, salmonids were trapped above and below each culvert site before and after replacement.

Results of the study revealed the extent to which the restored culverts acted as velocity barriers to juvenile fish. Although adult salmon were able to migrate upstream to spawn, high water velocities at culvert sites far exceeded the abilities of juvenile salmonids. In

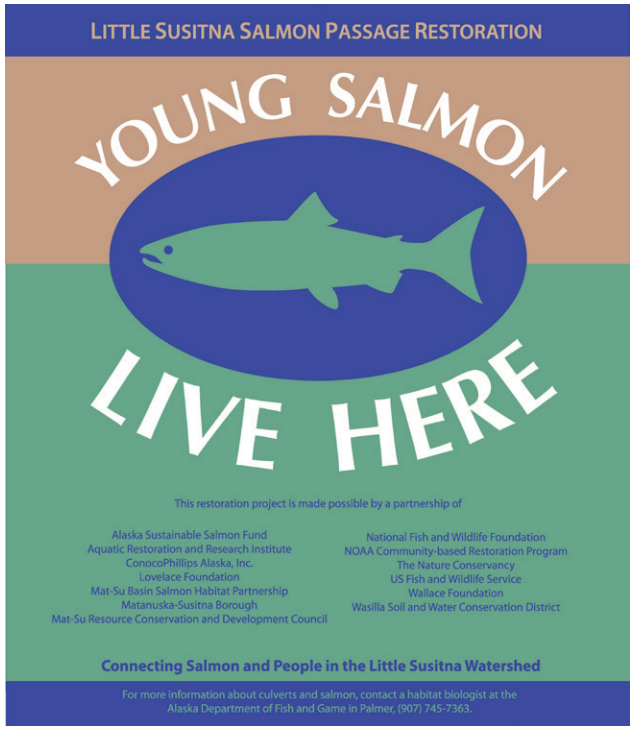
fact, the average swimming speed of juvenile coho salmon is one foot per second, while water velocities as high as seven feet per second were measured at some culverts. Prior to reconstruction, total coho salmon catch rates of both size classes were significantly higher upstream. Following site restoration, there was a decrease in coho salmon catch rates upstream of the crossing and an increase in catch rates below the crossing. Therefore, observations from this project showed that juvenile coho salmon emerging from spawning nests or "redds", upstream of culvert crossings were restricted from migrating downstream to rearing and overwintering areas.

Building on the success of the Colter Creek culvert replacements and documented fish impacts, TNC proposed a program to the TNC-NOAA Partnership to replace a series of culverts with the goal of improving fish passage throughout the Mat-Su Basin and Little Susitna watershed.

By leveraging results beyond the habitat restored, TNC staff was able to work creek-by-creek, combining funds, to make an impact throughout a watershed.

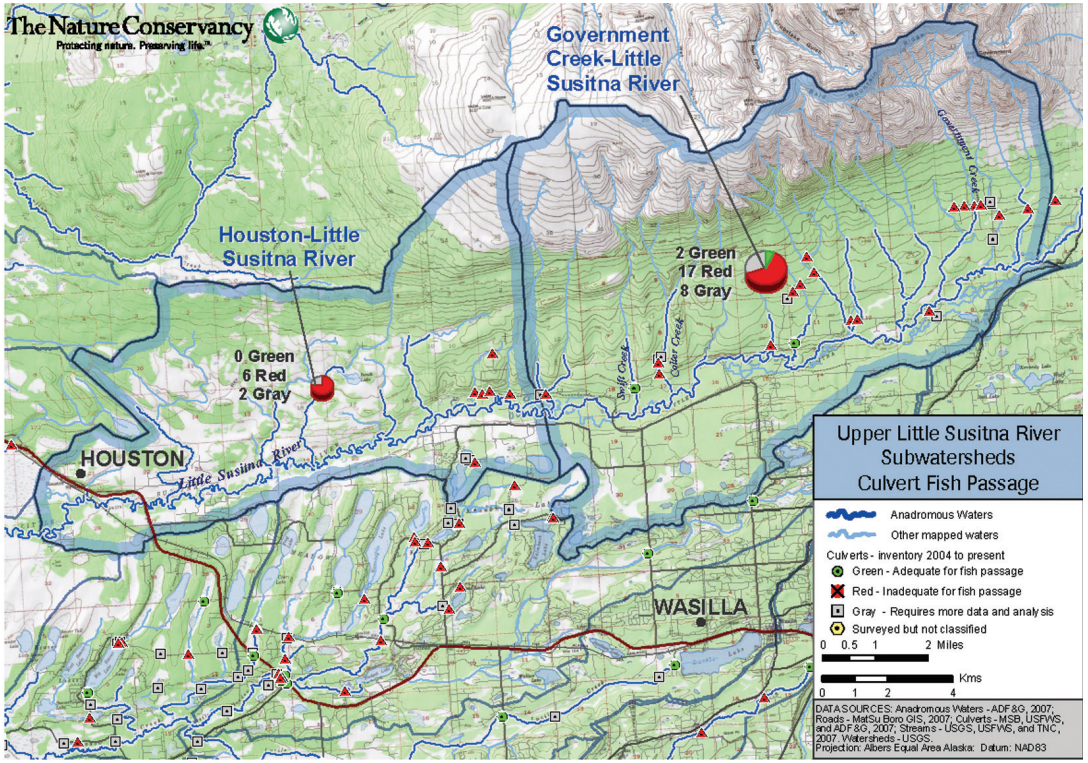
During the fall of 2008, TNC worked with partners to prioritize fish passage restoration efforts in the Mat-Su Basin. Conservancy staff convened government agencies, nonprofit organizations, and others to form the "Mat-Su Basin Fish Passage Improvement Plan." With representatives from the Alaska Department of Fish and Game, Alaska Department of Transportation, Alaska Railroad, Natural Resources Conservation Service, Aquatic Research and Restoration Institute, Mat-Su Resource Conservation and Development Council, US Army Corps of Engineers, US Fish and Wildlife Service, and Wasilla Soil and Water Conservation District, the group prioritized culverts needing replacement in the Mat-Su Basin. Through field surveys and interviews with landowners, partners identified multiple private culverts on Little Creek and Elk Creek as candidates for fish passage restoration, and field surveys completed in 2009 located further culverts on Poddle Creek and Coyote Creek.

Partners of the Colter Creek Restoration Project expanded their collaboration, winning a second grant from the TNC-NOAA Partnership to expand their restoration impact to other tributaries of the Little Susitna watershed. Restoration activities continued to focus on restoring juvenile fish passage and migration as well as improving stream functionality and habitat. Additionally, the project also added a new goal of emphasizing development of public and private partnerships to address restoration throughout the Mat-Su Basin.



Tracking devices are used to monitor salmon spawning activity in the Mat-Su River Basin. © Bridget Besaw

Sign placed at fish passage restoration sites on Little Susitna tributaries. © TNC



Map of culverts needing replacement in the Mat-Su Basin.
© Bridget Besaw

From 2009 to 2010, the second TNC-NOAA grant for the Little Su Restoration Project, in combination with other funding from partners, made possible the replacement of eight culverts on Little Creek and Elk Creek. Furthermore, project staff assisted the Mat-Su Borough in replacing an additional four culverts on these two creeks. In 2011, the Little Su Restoration Project has planned for construction and replacement of the culverts located on Poddle and Coyote Creeks. To date, the Colter Creek and the Little Su Restoration projects combined have replaced 18 culverts in five creek tributaries and ensured free fish passage access to over six miles of habitat for rearing salmonid fish.

The success of the two partnership grants and the combined efforts of partners involved have enabled TNC Alaska employees to address fish passage restoration on a large-scale, and use this as leverage to work on an entire watershed. The strengthening of partnerships and expansion of support has created the possibility of leveraging these results to attract other funding opportunities for this project. The US Fish and Wildlife Service funds helped partners leverage a grant from the Pacific Salmon Recovery funds, and TNC-NOAA partnership funding assisted the Conservancy with leveraging additional funds from the Lovelace Foundation and the National Fish and Wildlife Foundation.

Over this multi-year project, most of the inadequate culverts in the Mat-Su Basin will be replaced with arched pipes to restore natural stream widths that allow for continued migration of adult and juvenile salmon. Under the sustained funding from the partnership, TNC's Alaska Chapter and its many partners will restore fish passage in the watershed, expand knowledge about salmon movement in freshwater, and educate the public about the importance of maintaining healthy fish passage for the future.

Linking Salmon and People: The Mat-Su Basin Salmon Conservation Partnership worked to protect both the watershed's salmon populations and human communities.

As the foundation of many of Alaska's ecological systems, salmon species are naturally an important focus for restoration efforts and funding in this region. Salmon play a critical role in ecosystems because they bring nutrients from the ocean into freshwater systems. "Replacing a poorly designed or installed culvert allows salmon to return to their spawning and rearing grounds, thus completing their life cycle and fulfilling their role in the ecosystem," explains TNC Mat-Su Basin Program Director, Corinne Smith, highlighting how the replacement of individual structures can impact the health of other organisms, populations, and processes in the system.

Not only are salmon a necessary component of natural ecosystems and communities, but they are essential to surrounding human communities as well. "Salmon are a basic staple of life for many residents, particularly Native peoples, and a foundational element of the local economy" says Smith. Increasing the fish populations will ultimately help provide more food, as well as sport and commercial fishing. Furthermore, replacing culverts with larger structures and revegetating stream banks for enhanced stabilization will help reduce property damage associated with flooding and increase public safety, as flooding will be mitigated at stream-road crossings.

While restrictions have been imposed on fishing, such as the 2011 closure of sport fishing for chinook salmon, salmon species in the Mat-Su Basin are not yet threatened or endangered. But given their pivotal role in driving the ecosystem's health and providing for a local economy, restoration actions help to ensure that this status does not change as communities in this watershed continue to grow. In 2005, community members and organizations formed the Mat-Su Salmon Partnership, also recognized by the National Fish Habitat Board, with a common goal of addressing the impacts on salmon from human development and land use in the Mat-Su Basin. The Mat-Su Salmon Partnership brings together nearly 40 local communities, landowners, agencies, businesses and nonprofit organizations, including TNC, the US Geological Survey, and NOAA Fisheries. With this diverse set of organizations and stakeholders, the larger partnership seeks to ensure sustained fish productivity in balance with healthy human populations through aquatic habitat protection, enhancement and restoration.

Replaced culvert at Little Creek, during construction.
© Clark James Mishler

Across the Gulf of Alaska, CRP Partnership funding and an ARRA grant is conserving salmon populations in the Prince of Wales Island, Alaska.

In 2009, The Nature Conservancy's Alaska Chapter was selected as a recipient of the American Recovery and Reinvestment Act to implement salmon restoration work in the Klawock River estuary on Prince of Wales Island, Alaska. The village of Klawock sits adjacent the Klawock River watershed, which contains 132 miles of streams that serve as important spawning habitat for pink, chum, coho and sockeye salmon, as well as steelhead, cutthroat trout, and Dolly Varden char. Approximately half of the population of Klawock is Alaskan Native, predominantly of the Tlingit and Haida Tribes, for which salmon comprise a strong contemporary and traditional importance, both culturally and economically.

A highway was constructed to Klawock in 1964 along a causeway that partially blocked hydraulic connectivity and estuarine mixing between the Klawock River lagoon and Klawock Bay, and also created a barrier to migrating fish. Declines in fish populations are believed to have resulted from the causeway blockage; while adult salmon were constrained from reaching important rearing habitat, juvenile salmon were forced to migrate out of the lagoon and into a raceway with little protective cover. From the late 1880s through the 1950s, sockeye salmon harvests of more than 30,000 fish were typical, however since the 1960s, sockeye salmon harvests have seldom exceeded 20,000. In fact, sockeye salmon counts have dwindled to a mere 10,000 fish—an occurrence that has happened in only 6 of the past 50 years.

The goal of the Alaska Klawock River Salmon Restoration project was to install a 100-foot long, fish-friendly culvert through the causeway that served to:

- Enable free salmon passage through the causeway that continued to support the highway
- Provide access to more than 65 miles of stream and lake spawning habitat for adult salmon
- Provide access to 460 acres of eelgrass beds necessary for vulnerable juvenile fish out-migrating to the ocean

Ultimately, these restoration activities will have much larger impacts on the ecosystem and community. By allowing for the exchange of seawater and freshwater and the restoration of natural estuarine conditions, the distribution of eelgrass will improve overall salmon population size by providing food, cover and protection from currents. Juvenile salmon will be larger as they leave the estuary, increasing their survival rates in the ocean and sustaining future population levels.

Local residents desire that the highway once again allow fish to access natural rearing habitat and salmon stocks to return to historic levels, as salmon are the principal subsistence food of the Tlingit people of Klawock. A coalition of agencies, elected officials, fishermen, and conservationists, including the Klawock Watershed Council, first joined together nearly a decade ago to address the need for opening the causeway, and this restoration project will fulfill the goals of this community partnership.

Ultimately, opening the causeway and ensuring the health of the estuary provides the community with recreational and sport fishing and associated tourism opportunities, fishing and tourism jobs, clean water and protection of coastal infrastructures, and a source of food and a deep cultural value for many Alaska residents and Alaska Native people.

Construction of a larger culvert at the Klawock Highway. © Rob Bosworth, TNC

Engaging Communities:

Dr. Linda Walters surveying oyster growth at Pineapple Reef.
© Anne Birch, TNC

Florida's Indian River and Mosquito Lagoon Oyster Restoration

Location: Canaveral National Seashore (CANA) within the Mosquito Lagoon, Florida, the northeastern most sub-basin of the Indian River Lagoon system

Focus Species: Eastern oyster (*Crassostrea virginica*)

Partners: University of Central Florida, Brevard Zoo, Canaveral National Seashore, Indian River Lagoon National Estuary Program, Disney Friends for Change, Disney Worldwide Conservation Fund, Florida Department of Environmental Protection, NOAA's Coastal Restoration Program, Royal Caribbean International, SeaWorld, St. Johns River Water Management District, US Fish and Wildlife Service, Volusia County Mosquito Control

Building on What Works: Restoration of Oyster Reefs in Florida's Indian River Lagoon

Designated as an Estuary of National Significance, the Florida Indian River Lagoon (IRL) is one of the most diverse estuaries in North America. Part of the IRL system, Mosquito Lagoon supports one of the last remaining large expanses of natural oyster reefs, many of which are within the boundaries of Canaveral National Seashore and the Mosquito Lagoon Aquatic Preserve. These ecologically and economically important oyster reefs provide habitat for more than 140 species, including blue crabs, stone crabs, shrimp, red and black drum, and spotted sea trout, and they provide feeding grounds for the bottlenose dolphin, American oystercatcher, American bald eagle, osprey, brown pelican and many wading bird species.

Oyster reefs, including those in Mosquito Lagoon, are among the most impacted and degraded marine systems on the planet. Reefs in the lagoon are rapidly declining, primarily due to boat wakes which dislodge live oysters from reefs and push them towards the shore in large piles of shells, creating "dead margins." These margins not only cause oysters to die, but the dam-like structures restrict water flow over the surrounding reef and seagrasses, resulting in major losses to these systems. Despite their location mainly within protected areas and preserves, the reefs of Mosquito Lagoon still face disturbance from increasing recreational boating activities. "Creation and enforcement of 'no wake' zones for oyster reefs is not a viable solution; thus, there was a need for an alternative restoration strategy," says Anne Birch, director of coastal restoration for TNC's Florida Chapter. Oyster reefs provide many critical benefits, for instance:

- Oysters improve water quality and clarity by filtering water as they feed.
- Oyster reefs provide food, shelter and nursery grounds for many economically important species, such as shrimp, crab, and fish.
- Oyster reefs are natural buffers, protecting shorelines from erosion and storm surges.

In 2005, funding through the national partnership between TNC and NOAA's Community-based Restoration Center kicked off a collaborative effort between the Conservancy and the University of Central Florida (UCF). The goals were to restore reefs and reverse their decline by using "oyster mats" in an innovative approach developed by UCF professor Dr. Linda Walters. Together, partners and community volunteers created the mats by firmly attaching oyster shells to aquaculture-grade mesh material, such that shells were resistant to water movements caused by boat wakes and were oriented vertically to provide a natural representation of a healthy oyster reef. These mats were deployed on top of leveled dead margins and anchored to the bottom of the lagoon with small cement weights.

Because the shell mats provide stationary substrate and vertical shell orientation, recruitment of oyster larvae onto the mats is successfully restoring reefs to their natural condition. In fact, oyster mats were blanketed with live oysters in as few as two to three years after deployment. Results from annual monitoring show that an average of 47 live oysters settle on each mat—and some mats have garnered over 200 live oysters in less than one year in the water. The great scale of the project's success, however, is due to the enormous volunteer effort associated with this project. Between 2005 and 2010, TNC's Florida Chapter organized an army of volunteers, nearly 18,000 people in all, to help assemble and deploy more than 19,800 mats necessary to restore 42 degraded reefs.

"Throughout the life of this project we've touched tens of thousands of volunteers through schools, community events and civic organizations in the Indian River Lagoon system." – Anne Birch, TNC

A critical component of this project was the involvement of community volunteers in nearly every aspect of the restoration efforts. In addition to making and deploying oyster mats, volunteers transported oyster shells from shucking houses, drilled holes in shells and prepared materials used in mat-making, including cutting the mat material into oyster mat squares. Through many forms of advertising, including newspaper, radio and internet announcements—as well as the tremendous efforts of a full-time volunteer coordinator—project partners were inundated with requests from community groups to make oyster mats. The project's volunteer coordination efforts were immensely successful; an initial estimate of 300 volunteers over the first two years was crushed when the project reached over 5,000 volunteers, by 2007. Anne Birch, Director of Coastal Restoration for TNC's Florida Chapter, was able to report, "Since 2005, more than 500 mat-making events have been held in which more than 16,000 people devoted over 21,000 volunteer hours." Some of these volunteers are regulars, helping time and again over the years. In addition, more than 700 volunteers, logging over 6,500 hours, have helped deploy and monitor the mats in the lagoon since 2007, when the first mat was deployed.

School groups, community groups and civic groups alike have enthusiastically created over 19,000 oyster mats. Eagle Scouts and project partners, such as the Marine Discovery Center and Brevard Zoo, also contributed significant time towards mat-making. Additionally, Mariner of the Seas recurring public mat-making events were arranged at locations throughout Brevard County to accommodate the great volunteer enthusiasm towards this activity. The events were held at sites operated by the Brevard County Parks and Recreation Department, and were free of charge to the public. Another important aspect of community engagement was educating the public on the importance of oyster reefs, the biology of the marine system they're helping restore, and the reasons behind active restoration. Before each event, project leaders gave a presentation on the ecological benefits of oyster reefs in the lagoon and the goal of the restoration project. In 2009, the Brevard Zoo, an important partner of this project, opened an exhibit about the Indian River Lagoon system with educational displays including oyster mats as well as a dedicated area for volunteers to drill shells and make mats.

Volunteers making oyster mats. © Anne Birch and Michele Peters-Snyder, TNC

Engaging with Schools: By going into the classroom, the Mosquito Lagoon Oyster Project got children inspired and involved in the restoration of oyster reefs.

Project partners set out to make an impact inside the classroom. Teachers, from grade 4 to college level, were eager to arrange classroom mat-making sessions. As local economies faced budget cuts, many schools in this region were no longer able to fund field trips, and teachers enthusiastically regarded these mat-making events as an excellent hands-on alternative that could be used to enhance lessons on estuarine and marine biological systems. In just one year, from 2008 to 2009, approximately 2,970 mats were created in classrooms by schoolchildren in Brevard, Volusia, Orange, Seminole, Osceola and Indian River Counties.

Additionally, in 2008 Dr. Walters of the University of Central Florida organized an educators' workshop at Canaveral National Seashore. As interest in the project grew, the meeting introduced educators to the project and provided them with information needed to make oyster mats and to discuss the importance of oysters with their students. An outcome was the creation of a K-2 level book on the Mosquito Lagoon project, entitled "An Afternoon in the Mosquito Lagoon," available in print and online. Later in 2008, Dr. Walters hosted the first "Science Café for Families" at the Orlando Science Center, where participants made mats and learned about the lagoon's ecology. Her husband, dedicated project volunteer Dr. Paul Sacks, also presented this project at the Florida Association of Teachers Conference in Orlando.

Royal Caribbean and Disney emerged as novel and unexpected partnerships that provided invaluable assistance and service.

Groups of all kinds became engaged in the effort to restore Mosquito Lagoon. Throughout the project, novel partnerships arose that helped make possible the scale of restoration success. One unexpected and critically important partnership that evolved was with the Royal Caribbean cruise ships *Mariner of the Seas* and *Freedom of the Seas*. The crews of these ships devoted hours of their time to drilling holes in hundreds of thousands of shells while out at sea, enabling the shells to be attached to the mesh mats.

The lack of sufficient drilled shells to accommodate mat-making requests had been a project bottleneck, and the service provided by Royal Caribbean crews was vastly important in accomplishing the scale of restored reefs reached by this project. The process required much logistical prowess, and was only possible with the full cooperation of the ships' captains and environmental officers. When shells were drilled, the ship's environmental officer would contact TNC and arrange to exchange buckets of undrilled shells for drilled ones at Port Canaveral. *Mariner of the Seas* received the prestigious Environmental Ship of the Year Award two years in a row and donated $10,000 each year to the Conservancy to advance the Mosquito Lagoon project.

In the fall of 2008, *Mariner of the Seas* left Port Canaveral and was replaced the following spring by *Freedom of the Seas*; however, the efforts of the environmental officer of *Mariner of the Seas* helped continue the partnership with Royal Caribbean. When it won the Environmental Ship of the Year Award, *Freedom of the Seas* donated $15,000 to TNC in support of this project. "This donation solidified the *Freedom*'s commitment to this project even before they began to assist us with shell drilling in August 2009," reported Anne Birch.

Volunteers deploying oyster mats in Mosquito Lagoon. © Anne Birch, TNC

Crew from the Royal Caribbean's Mariner of the Seas ship honored with prestigious Environmental and Innovative ship of the year awards, in part for their work assisting in this restoration project through drilling oyster shells during week-long cruises. © Ed Garland, SJRWMD

Volunteers from Disney's Friends for Change VoluntEARS Program make oyster mats. © Disney Corporation

Brevard Zoo staff, now leading the organization of community outreach activities, unload mats ready for deployment. © Anne Birch, TNC

Another large corporate partner emerged through Disney. As part of the celebration of the 20th anniversary of the Disney VoluntEARS program, a group of Disney employees adopted this project in 2008 as their community service. The Disney group assisted in making oyster mats, resulting in 632 completed mats, and assisted with logistical support in mat-making events. In 2010, the project received a big boost with support from the Disney Friends for Change Program. Children and families voted on projects to win the top award of $100,000. "We were competing against projects to protect tigers and other 'glamorous' species. Imagine our surprise and excitement when our project won the top prize, proving that the small grey oyster is also a charismatic species." said Anne Birch.

Building Capacity to Ensure a Lasting Impact: The Mosquito Lagoon Project shifts community outreach to the Brevard Zoo.

With this project, TNC and the University of Central Florida were able to show that oyster mats were an effective method of restoring oyster reefs, as they stabilized degraded reefs and provided a substrate for recruitment of young oysters to re-colonize the reefs. The project also showed the ability of a community to dramatically influence the outcome for restoration projects. By the end of 2010, a total of 42 reefs had been restored with the help of more than 18,000 volunteers who made and deployed 19,654 oyster mats.

To ensure sustained community involvement in this work, however, project partners looked for assistance from the Brevard Zoo. In hopes of fully realizing a mature community-based restoration effort that will grow beyond the Conservancy's initial investment of resources and leadership, the Conservancy is working to empower a long-time local partner to take over the community outreach activities associated with this restoration effort. In 2010, the Conservancy's Florida Chapter established a formal partnership with the Brevard Zoo, and by August 2012 the responsibilities of community outreach will be fully managed by the Zoo. With its mission of "Wildlife Conservation Through Education and Participation,"the Zoo will continue to encourage a new project baton to and help spawn a new generation of conservationists. The Zoo's existing knowledge and experience with this project enables it to continue TNC's tradition of community involvement by holding mat-making events with civic organizations and schoolchildren at the Zoo and public parks.

Naming the Reefs: A tribute to volunteers.

"My husband, Paul, and I have led hundreds of days of oyster restoration deployment in the Indian River Lagoon," says Dr. Linda Walters, professor of biology at the University of Central Florida. "With 42 reefs restored, the aspect that stands out most to me is that every restored reef has a unique name, and its own very personal story of the team that helped create it."

She continues, "Many of the reef names come from volunteers on site, an honor resulting from many hundreds of hours of effort preparing beforehand, or to thank those who have made the project possible. A few reefs remind you of Florida weather: Lightning and Rainbow. Others illuminate the amazing biodiversity of the Indian River Lagoon, including the Sirenia, Dolphin, Spoonbill, Oystercatcher, Seahorse reefs and three adjacent fish reefs, named Mullet, Redfish and Needlefish reef. Some of the reefs tell of the adventure of the day, boasting names such as Mt. Everest, Victory, and Phoenix—arising from the ashes.

"There is also Snook Tag Reef, named by the Indian River Lagoon NEP; Mosquito Reef, named by Volusia County; Wildcat Reef, named after the mascot of a nearby high school; Wonder Reef, named by the crew of the Disney Wonder cruise ship; and Pegasus and Knightro, named in honor of UCF volunteers.

"Finally, there are reefs named just for fun (and usually associated with food), including Pineapple, Picnic, and Milk and Dark Chocolate Reefs. There are reefs to honor special occasions, like Memorial Reef, where volunteer efforts started on Memorial Day weekend in 2008, and Freedom Reef, which was restored by dedicated volunteers over the July 4th weekend in 2007.

"As you can see, oyster reef restoration is a very personal effort for all involved, especially my family and the community. And most importantly, we know it will continue to be successful in the Indian River Lagoon, because we are all committed to this goal."

Hydrolic excavator rakes down dead margin in preparation for oyster mat deployment. © Anne Birch, TNC

Volunteers leveling a dead margin. © Anne Birch, TNC

Dr. Walters with a pile of mats ready for deployment. © Anne Birch, TNC

Oyster Reef Restoration Expands in the Gulf of Mexico

Location: Various coastal bays in Mississippi, Louisiana, and Texas

Focus Species: Eastern oyster (*Crassostrea virginica*)

Partners: Mississippi Department of Marine Resources, Louisiana Department of Fish and Wildlife, Texas Department of Parks and Wildlife, Nichols State University, Harte Research Institute, University of Southern Mississippi and the Gulf of Mexico Marine Research Institute

Through a series of pilot-scale projects supported with partnership funding, TNC and its partners have advanced the field of oyster reef restoration in the Gulf of Mexico.

In addition to direct site-based ecological benefits, these projects helped participants to evaluate new restoration techniques ranging from the three-dimensional subtidal reef structure in places like Biloxi Bay and Bay St. Louis, Mississippi, to intertidal oyster reefs for buffering shorelines and salt marshes from the erosive effect of storm waves and ship wakes. Importantly, these projects helped provide the political, ecological and social frameworks that underpin new, large-scale initiatives to restore oyster reefs in the region.

Reviewing these projects collectively and examining the near-term outcomes is a good way to illuminate the three kinds of outcomes we are able to achieve through the TNC-NOAA National Partnership: policy leverage, ecological influence and community engagement.

The Northern Gulf of Mexico ecoregion has the last large-scale wild fisheries for oysters on the planet.

These fisheries are culturally and economically still very important to the coastal communities that punctuate the coastline from Texas to Florida. A recent global assessment of oyster reefs conducted by TNC and external scientists revealed that the region stands out as a globally significant place for conservation of reefs for their ecological function. Ensuring that the region's oyster reefs are well-conserved and managed for their long-term benefits requires a longer-term perspective than has been evident in most of the world's oyster fisheries.

The restoration projects undertaken in the Gulf through the National Partnership were catalysts for a broader conversation with managers and the public in general about the ecological value of oyster reefs in the region. A 2008 poll of voters in coastal counties of Louisiana and Texas revealed that 81% support oyster reef conservation as a priority for state management agencies, and more than 90% support the use of shellfish sanctuaries as a management tool by state agencies.

More recently, these projects helped pave the way for even larger projects funded through the American Recovery and Reinvestment Act (Recovery Act) in 2009 that are further demonstrating the importance of reefs as a form of coastal infrastructure that can protect shorelines and associated habitats like salt marshes and seagrass meadows. This is helping to bring about a paradigm shift in the way reefs are perceived by the public in general and within the wider coastal management community. In addition to creating demand for more reef restoration, the National Partnership and NOAA

More than 500 volunteers converged on Alabama to help create oyster reefs in Mobile Bay. © Erika Nortemann, TNC

Recovery Act projects that TNC and its partners have implemented to date will also inform restoration efforts that occur as part of the Natural Resource Damage Assessment (NRDA) in the wake of the Deepwater Horizon oil spill.

Using the links between salt marsh and oyster reef, oyster reef restoration projects are helping slow the loss of ecologically important marshland and protect coasts.

Salt marsh loss is an enormous concern in the region, particularly in the Mississippi Delta. The projects that TNC has implemented with NOAA and other partners in the region are extremely valuable for illustrating the linkages between oyster reefs and shoreline protection. Seagrass meadows, as with oyster reefs and salt marshes, are productive and important habitats that help produce ecologically and economically important fish. More than 30% of seagrasses have been lost globally, and it is becoming clearer that oyster reef restoration can contribute to stemming this loss by stabilizing sediments and filtering suspended material from the water.

Volunteers across the nation worked to restore oyster reefs with 16,000 bags of oyster shells. © Erika Nortemann, TNC

Generating Public Support: In a region closely tied to the natural resources provided by the Gulf, hundreds of community volunteers have shown their support for restoration.

The projects undertaken through the TNC-NOAA Partnership, as well as the two NOAA Recovery Act projects that TNC is managing in Louisiana and Alabama, provide abundant evidence that the public has an appetite for restoration in the region. Moreover, these projects illuminate the benefits of habitat restoration, both from an economic standpoint through job creation as well as from an ecological standpoint. As a result, TNC and its partners are well positioned to contribute substantively to discussions by state and federal authorities about how best to restore the Gulf of Mexico's coastal habitats in the wake of the Deepwater Horizon oil spill.

In January 2011, more than 500 people volunteered to help restore a quarter mile of oyster reef along Alabama's coastline. The 100-1000 Restore Coastal Alabama initiative is a tangible and profound extension of the oyster reef restoration work that has been done across the region. Building on the momentum of the Recovery Act projects has created a groundswell of public support for using "green infrastructure" like oyster reefs to protect coastal habitats, such as marshes. The "100-1000 Restore Coastal Alabama" effort aims to use 100 miles of newly created oyster reefs to protect as much as 1,000 acres of salt marsh and seagrass habitat in Alabama's coastal waters. The enormous community support for restoration that has been generated through this work is helping to reinforce the new broader management paradigm within a region of exceptional importance for oyster reefs.

Hawai`i's Invasive Species Removal and Watershed Restoration

Location: Kāne`ohe Bay and Maunalua Bay, O`ahu, Hawai`i

Focus Species: Corals and coral reef-associated organisms

Partners: State Division of Aquatic Resources, University of Hawai`i (UH), Coordinating Group on Alien Pest Species, Hawai`i Coral Reef Research Initiative, UH Sea Grant College Program, Waikīkī Aquarium, Hawai`i Community Development Authority, State Office of Planning, Hawai`i Tourism Authority, US Fish and Wildlife Service, National Park Service, US Army Corps of Engineers, National Fish and Wildlife Foundation, Hawai`i Community Foundation, Kāko`o `Ōiwi, Hui kū Maoli Ola, Paepae o He`eia, Ko`olaupoko Hawaiian Civic Club, Reef Check, Alliance Trucking, Island Divers Hawai`i, Tesoro Corporation.

In 2003, TNC Hawai`i and local community groups set out to remove invasive macroalgae that were smothering coral reefs on O`ahu.

In healthy coral reef ecosystems, reefs are dominated by structure-building coral species. However, "phase shifts" can occur in which macroalgae outcompete corals for space, light and nutrients, often supported by anthropogenic influences such as increased nutrients or decreased reef herbivore abundance (algae-eating fish and sea urchins). These phase shifts can ultimately lead to the degradation of coral reefs, as macroalgae can overgrow coral and smother it from the sunlight needed for photosynthesis.

Over the last sixty years, many invasive alien algal species have become established in Hawai`i. Many of these invasive species proliferated rapidly and caused significant negative impacts to reef ecosystems and the local economy, and, in some instances, created concern for public health when tons of algae were left rotting on public beaches.

In 2003, the TNC-NOAA Partnership awarded its first grant to the Hawai`i Invasive Algae Removal project. This project included community-based algae removal by hand,

Watershed and Kāne'ohe Bay. © Manuel Mejia, TNC

Super Sucker and barge. © Kanako Uchino

and the development of other, more efficient methods of algae removal and recycling. The project also focused heavily on increasing awareness in local communities of the threats posed to nearshore reef and estuarine systems by invasive algae, while increasing community engagement and management capacity. Over the course of four partnership grants totaling $533,890 ($233,098 NOAA funds, $300,792 TNC and partner matching funds), the project drew thousands of volunteers and engaged more than a dozen local communities in identifying and removing invasive algal species.

Innovative Restoration: Creation of the Super Sucker barge made it possible to remove invasive algae in areas and at rates impossible with manual removal methods.

The Conservancy's alien algae program began as a community-based volunteer effort to manually remove algae along the beaches and shallow waters on O`ahu's coast. Initial small-scale experiments with manual removal of invasive algae, along with efforts to increase the level of native herbivorous fish and sea urchins, were shown to be successful in reducing the biomass of invasive algal species such as *Gracilaria salicornia, Acanthophora spicifera, Avrainvillea amadelpha,* and the *Kappaphycus/Eucheuma* complex. While communities provided thousands of volunteer hours and removed algae from large expanses of shallow nearshore reef, project staff needed to find ways to remove algae from deeper reefs farther from the shore.

Within the first years of this project, TNC Hawai`i staff worked with the state Division of Aquatic Resources and the University of Hawai`i to create the "Super Sucker," an innovative mechanical system that removes algae by sucking it up off the reef and sending it through a large tube onto a barge. Next, trained staff sort out native species and bag the invasive algae for transport onshore to local farmers for fertilizer. With this new approach, project staff were able to exponentially increase the amount of algae removed per person and reach reefs in more remote locations in Kāne`ohe Bay, which were too deep for manual removal efforts by community members.

"One of the greatest attributes of the Super Sucker is that it can be strategically deployed to restore high-priority areas that are more remote, where manual removal efforts would be impractical or impossible," said Kim Hum, Marine Program Director for TNC in Hawai`i. "Substantial and consistent funding from programs such as NOAA's Community Restoration Program enabled us to develop and then improve the Super

Sucker, significantly increasing the amount of algae removed per person hour over time." In the past year alone, the Super Sucker removed over 100,000 pounds of invasive algae from more than 10 acres of reef.

The success of the Super Sucker throughout the four partnership grants prompted the development of additional "suckers," including the "Junior" and the "Mini Sucker," which were funded and built by the State of Hawai`i Department of Land and Natural Resources (DLNR) in 2006. These smaller, more versatile versions of the Super Sucker were designed for shallow nearshore areas, where a small group of community members could collect much larger amounts of invasive algae on larger spatial scales. Together, the Mini Sucker and Junior helped communities remove tens of thousands of pounds of invasive algae from several locations in Kāne`ohe Bay and Maunalua Bay on O`ahu. These successes have led TNC Hawai`i and partners to be at the forefront of invasive algae control,and assist others at a global scale, including managers in France and the state of Florida.

Outreach and Education: Communities built capacity and gained valuable knowledge about the importance of coral reefs and the identification and removal of alien algae.

From the beginning of the invasive alien algae removal project, partners have made education and involvement of local communities a major component in the long-term management of Hawai`i's coral reefs. Project staff worked with several communities within Maunalua and Kāne`ohe Bays, and traveled to the other major Hawai`ian islands to speak with interested communities about alien algae removal efforts, establishing biological baselines in affected areas, and beginning removal activities.

Education and outreach efforts focused on raising awareness about the threat and impact of invasive algae on Hawaiian coral reef ecosystems, and the biological and cultural importance of native algal species. Community members also learned about the impacts to reefs from land-based pollution and runoff, which oftentimes feed the invasive algae, and how overfishing of herbivorous fish and sea urchins can exacerbate the problem. Project partners discussed how invasive alien algae can overwhelm fringing reef environments and displace native coral communities, which in turn decrease the survival of other reef-dependent native species and the viability of the coral reef ecosystem as a whole.

Using the Super Sucker to remove invasive algae directly from coral. © Kanako Uchino

A volunteer helps remove invasive algae. © TNC

Students learning about the marine environment while helping restore reefs through invasive alien algae cleanups. © Manuel Mejia, TNC

In order to help communities build the capacity to carry on invasive algae removal efforts after the project was over, Alien Algae Toolkits were developed that included 1) instructions on monitoring local nearshore areas for invasive algal species; 2) waterproof cards for identifying alien algae; 3) contact information to use when invasive alien algae are discovered; 4) information on removal methods; and 5) methods for using removed alien algae for fertilizers or food consumption. With these materials, TNC Hawai`i and partners enabled communities to continue monitoring and restoration efforts beyond the project and partnership grant.

Encouraging Community Action: Much of the project consisted of establishing trust with community groups and empowering them with the necessary skills and materials.

The greatest education for local community members and volunteers was through hands-on experience removing invasive alien algae. It was important to the future of the project to offer an outlet for community residents who wanted to participate in stewardship activities relating to coral reefs and native marine resources.

Diverse groups of community volunteers, including neighborhood residents, school groups and educators, local business owners, and university students, all participated in removal events. In more than 20 community-based removal events held throughout the Waikīkī area from 2003–2004, 1,600 community volunteers removed more than 91 tons of the invasive algae *Gracilaria salicornia*. A second TNC-NOAA Partnership grant in 2004 allowed project partners to continue coordinating and supporting community-based efforts in Kāne`ohe Bay, Maunalua Bay, and Ewa Beach. In Kāne`ohe Bay alone, 100 enthusiastic community members removed more than 3,800 pounds of *Gracilaria salicornia*, proving so efficient that their restoration plot was expanded twice.

Efforts continued to scale upwards during the third partnership grant, awarded in 2006, and the fourth grant, awarded in 2008. From 2006 to 2009, 116,000 pounds of algae were cleared by the community from two-thirds of an acre in Maunalua Bay. From 2009 to 2010, 300 community volunteers removed more than 27,300 pounds of invasive algae over three acres of Kāne`ohe Bay. TNC Hawai`i also led many community removal events in Waikalua Fishpond with local partner Waikalua Loko Fishpond Preservation Society, where 8,400 pounds of invasive algae were removed.

Many species of native algae, or "*limu*," are central to native Hawaiian culture, for consumption, medicinal uses, and ceremonies. The outplanting of native algal species in areas where invasive alien algae had been removed was not only important to shift competitive advantage back toward native species, but also to build greater community involvement. At Ewa Beach, native *limu* culturing facilities were built at Campbell High School to support this restoration project. In Kāne`ohe Bay, re-planting of native algal species was conducted in partnership with the state, and many local community officials and organizations, including Paepae o He`eia, the Ko`olaupoko Hawaiian Civic Club, and Kāko`o `Ōiwi.

Ensuring Future Restoration Success: Tackling the problem from other angles, TNC staff worked to increase herbivorous urchins and decrease predatory alien grouper fish.

After the removal of invasive algae, TNC Hawai`i staff needed a mechanism for ensuring that the ecosystem recovery would persist and alien algae would not regrow on coral reefs, which would require continued public and private funding for additional removal events. Although the Super Sucker and community removal efforts proved to be very effective, they were not long-term solutions. In fact, state biologists confirmed that the aggressive invasive algae could regrow over an entire reef in only five to six months if there were no additional control mechanisms in place.

A natural and effective mechanism for minimizing the regrowth of invasive algae on cleared reef areas is the native sea urchin, *Tripneustes gratilla*, which actively feeds on invasive algae. In 2010, state aquatic biologists set up an experiment to test the efficacy of urchins as invasive algae control agents by outplanting urchins on a plot of reef on which they had just removed invasive algae with the Super Sucker. In comparison to an adjacent control site, within which no urchins were placed and where algae (both native and invasive) were left to grow naturally, the urchins were a stunning success. While the area of patch reef left without urchins had invasive algal regrowth of 35% cover in six months, areas outplanted with urchins were kept to 3% invasive algal cover over the span of the entire 12-month experiment.

Grade school students examining invasive algae during removal event. © Manuel Mejia, TNC

Grade school students learning about marine ecosystems at their local reef. © Manuel Mejia, TNC

Caption: Pono Pacific contract fishermen Brian Thomas and Kawika Auld measuring invasive roi grouper recaptured in removal area. © Chad Wiggins, TNC

Invasive roi grouper eating oama fish. © Lois Bisquera, TNC

Currently, the State of Hawai`i's Division of Aquatic Resources raising native sea urchins with the goal of producing tens of thousands of urchins for outplanting onto reefs after algae removal. Conservancy and state scientists believe the urchins will continue to play a significant role in algae control while the community looks for ways to increase natural herbivore populations in the bay. By feeding on invasive algae, native sea urchins and herbivorous fish can help restore and conserve Hawai`i's reefs for the future.

In a related conservation program, TNC in Hawai`i was awarded a awarded a TNC-NOAA Partnership grant in 2010 to test the impacts of the invasive alien peacock grouper *Cephalopholis argus* (or "roi") on native reef fish populations. The abundance of this aggressive predator is rapidly increasing in the islands, in part because they are not targeted by local fisherman due to a high incidence of ciguatera poisoning. The ultimate purpose of the project is to determine the extent to which native fish species benefit from removal of roi, and perhaps increase the native herbivore populations on reefs in the absence of roi. By engaging more than 200 local volunteers, this project has boosted local stewardship through "Roi Round-Up" spearfishing tournaments and roi tagging efforts.

Taking Restoration to the Scale of a Watershed: Taro fields are being cultivated in upland areas in order to save Hawai`i's coral reefs.

Kāne`ohe Bay is the largest bay in the main Hawaiian Islands, containing fringing reef, patch reef and barrier reef systems, and supporting some of the greatest diversity of fish and corals left on the island of O`ahu. "Unfortunately, algae removal alone does not get at the root causes of the algae invasion," says Kim Hum. From 2004 to 2010, project staff worked with community members to remove algae from reefs by hand and by using the Super Sucker. In order to ensure that O`ahu's coral reefs would remain free of invasive algae, TNC Hawai`i and community groups began to focus on watershed management strategies, targeting land-based sediment and nutrient pollution.

In 2009, TNC Hawai`i began working with the community group Kāko`o `Ōiwi to start reducing sediment loads entering Kāne`ohe Bay. The bay is the ocean end of the He`eia ahupua`a (the He`eia watershed), a 2,000-acre land division extending from the mountains to the sea. Launched by the Ko`olaupoko Hawaiian Civic Club, a unique partnership began with the goal to remove mangrove forest and swamp and restore native wetland and traditional taro ponds, or lo`i kalo, creating a sediment-trapping marshland full of native wetland species.

To control sediment loads entering the bay, the He`eia community obtained a 38-year lease on 404 acres from the Hawai`i Community Development Authority and developed a plan to reduce sediment flow while creating jobs and food for the community. According to Kanekoa Kukea-Shultz, TNC Hawai`i's manager for the He`eia ahupua`a project, the community anticipates converting 200 acres of wetlands into taro fields, building the lo`i walls higher than usual to help the ponds capture storm flows and act as sediment traps. The community is also restoring fresh water fishponds to reduce the amount of sediment flowing onto reefs.

Kāko`o `Ōiwi anticipates much of the initial work will be performed on community work days by a range of volunteers, including prisoners, school groups and the general community. "The Conservancy's goal is to protect and restore the bay's marine resources," says Kim Hum. "We support the He`eia community's broader efforts as a way to do that while strengthening their ability to serve as stewards of the region."

The community also hopes to restore taro fields to feed community members, as He`eia traditionally served as the breadbasket of Oahu. "This area in the old days would feed the rest of the island in times of drought," says Māhealani Cypher, a longtime community advocate in He`eia. "We want to repair the environmental damage, and feed people again." For the He`eia community and TNC Hawai`i, the project is designed to transfer knowledge of traditional Hawaiian land stewardship practices to a new generation. While working to restore a functioning native wetland to help coral reefs recover from invasive algal blooms, the project will also strengthen the connection between people and the area in which they live. "By managing He`eia as an ahupua`a, an interlinked series of environments running from mountain to sea, the community hopes to treat the various parts and heal the whole," said Cypher.

He`eia taro lo`i (field). © Sean Mars, TNC

He`eia as a breadbasket, 1920s.
www.nature.org[1] © Kāko`o `Ōiwi

[1]http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/hawaii/explore/the-nature-conservancy-in-hawaii----taropy.xml

Santa Cruz Island coastline at Santa Cruz Island Preserve. © Harold E. Malde

Sea lion near Santa Cruz Island, California, where seagrasses support a wide array of surrounding aquatic habitats and species. © Andrew Drake, TNC

California's Santa Cruz Island and Santa Barbara Channel Islands Eelgrass Restoration

Location: Scorpion Cove, in the Santa Barbara Channel near Santa Barbara/Santa Cruz Island

Focus species: Eelgrass (*Zostera marina*)

Partners: Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), Santa Barbara Channelkeeper (SBCK), Channel Islands Research Program (CIRP) of the Tatman Foundation, Channel Islands National Marine Sanctuary, Channel Islands National Park Service

With increased development in Santa Cruz Island, eelgrass beds largely disappeared from the Santa Barbara Channel

Eelgrass beds are regarded as one of the most important habitat-forming species of seagrass and a critical component of the nearshore environment of California's Santa Barbara Channel. Eelgrass meadows are extremely productive communities, providing substrate, shelter and food for diverse species of associated fish, invertebrates, mammals, birds and plants. In the Santa Barbara Channel Islands, the number of species thriving in eelgrass beds is nearly twice as high as the surrounding sand habitats, and they act as nursery grounds for many commercially important fish, such as giant kelp fish, six species of surfperch, senoritas, olive rockfish and kelp bass.

While eelgrass meadows create a habitat capable of supporting many marine organisms, they also provide a host of other ecosystem services. Eelgrass beds form extensive rhizome networks, which stabilize coastal sediments and recycle nutrients in the water column, improving overall water quality. However, seagrasses occupy the nearshore environment, and this habitat is highly vulnerable to the impacts of human development, as expanding communities live disproportionately on coastlines.

In Santa Cruz Island and the Santa Barbara Channel, eelgrass is in decline due to development as well as storm damage, pollution, boating damage and increased grazing

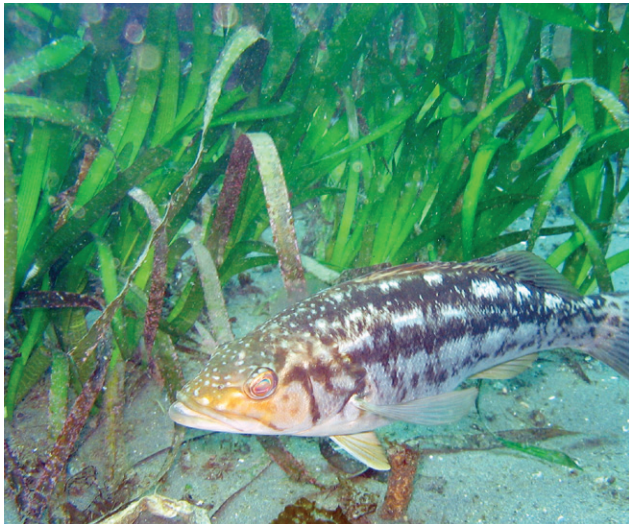
by urchins. Decades of fishing pressure resulted in the removal of natural predators of the white urchin. Without predators, the urchin population exploded in the late 1980s, resulting in severe overgrazing and destruction of eelgrass beds from Anacapa and the eastern Santa Cruz Islands. Since then, eelgrass beds have been identified by the Sanctuary Advisory Council as a critical habitat for restoration and placement within marine reserves in the Channel Islands. The return and preservation of these plants to the Channel Islands would restore a habitat for adult and juvenile species, an important source of detritus for large-scale food webs, and increase the quality of the nearshore habitat.

The Santa Barbara Channelkeepers (SBCK) eelgrass project set out to begin an active restoration program at Little Scorpion, a pilot site on the northern end of Santa Cruz Island. Working jointly with the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), the project focused on seed collection, seed culturing, selection and preparation of outplant sites, and seedling outplants. Beginning in 2005 with the first of two TNC-NOAA Partnership grants, the project transplanted 150 eelgrass plants from nearby locations to Little Scorpion. The involvement of the community and a suite of volunteer divers was critical to the success of this project's restoration work, as volunteers of all ages helped to grow eelgrass seedlings, transplant grasses into natural habitat sites, and monitor restoration locations.

Engagement and Education: "Ultimately, the best approach to ensure the continued health and productivity of eelgrass is one of prevention, rather than cure." – Jessica Alstatt

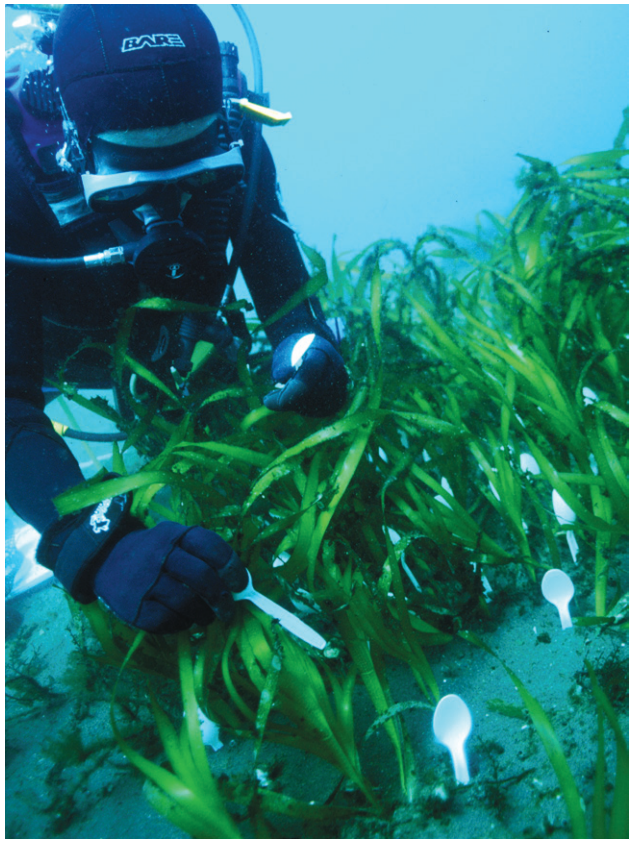
A central component of the SBCK eelgrass project was to educate the community about the ecological importance of seagrass ecosystems. Project partners set out to create a shift in the public's perception of eelgrass and ignite enthusiasm in protecting and preserving these habitats. "Seagrass researchers around the world agree that the greatest overall challenge facing seagrass ecosystems is the need for increased public awareness about seagrasses, the values they provide and the need for their protection," comments Jessie Alstatt, science director of the Santa Barbara Channelkeeper.

Project partners reached the community using diver training pamphlets, a project website and seagrass restoration informational materials for local marine science centers. A brochure highlighting the restoration project and potential threats, and showing a map of



Chanel Islands eelgrass bed. © Jessica Altstatt

ivers preparing eelgrass for outplanting. © Jessica Altstatt



Volunteer diver measuring eelgrass growth at restoration site. © SBCK

seagrass beds around the Channel Islands, was given to marine chandleries, dive stores, boats and clubs, Channel Islands Park and Marine Sanctuary outlets, recreational and commercial fishing supply stores, and marinas.

Alongside educational materials, SBCK and UCSB scientists and staff gave many presentations to the community throughout the years of project funding. Presentations were given to dive clubs and boating groups, community events and festivals, including the Santa Barbara Earth Day celebration, the first Santa Barbara Harbor Underwater Clean-Up in 2006, Patagonia Inc.'s Salmon Run and the Santa Barbara Seafood and Harbor Festival in 2007. Project partners also presented information at the Career Days event at Santa Barbara City College and Cal State Channel Islands, as well as to a team of 80 enthusiastic ocean swimmers during the project's "Channel Swim" event.

The University of California Santa Barbara installed a large eelgrass ecosystem tank for display to visitors touring the Research Experience and Education Facility (REEF). Undergraduate students worked as guides for school groups and the public. REEF used the eelgrass seedlings grown in local school classrooms from the SBCK project's "eco-tank" program. In total, the UCSB REEF facility reached nearly 6,000 students in a one-year span from 2004 to 2005.

Involving Volunteers: Restoration success of this project was strongly linked to the participation of volunteer divers and student groups.

Active participation of volunteers was a critical component of restoration efforts. Volunteers manned booths at community festivals and events, including three Earth Day events and the Wonders of Water festival at the Santa Barbara Zoo, and helped run the SBCK's Annual Ocean Film Festival. The diving community was especially active in restoration activities. With the advent of marine reserves at the Channel Islands, attractive habitats such as eelgrass were anticipated to be popular eco-dive destinations for the recreational diving industry, and dive shops and their clientele were targeted as potential community stewards. The project also worked with UCSB's Research Diver program for both student outreach and education, and to recruit new highly trained volunteers to assist in restoration and in monitoring dives. During the project, volunteer divers worked alongside SBCK staff and scientists to outplant eelgrass seedlings in designated sites at Little Scorpion and to perform numerous

monitoring sessions aimed at evaluating the project's outplanting techniques. Through the project, divers and field volunteers donated nearly 500 hours to this project.

Nature in the Classroom: "We wanted to train young, environmentally aware students to appreciate and understand eelgrass environments through participating in restoration."

Educational activities associated with this project were targeted toward children and grade school classrooms in the area. SBCK education staff initiated visits to local classrooms to lead students in exercises designed to teach them about marine ecology, water quality and eelgrass bed communities. Another successful project, the "eco-cart," allowed children throughout southern California schools to gain hands-on experience with eelgrass restoration while learning about these systems. The eco-carts were self-contained aquaria in which schoolchildren grew eelgrass from seeds to be outplanted in the Little Scorpion restoration site. During 2004 and 2005, SBCK and UCSB placed eleven eco-carts in different schools. Students maintained the eco-carts by monitoring temperature, salinity and eelgrass growth, and performed water changes when needed. An educational curriculum for middle-school classes was also developed to coincide with the eco-cart labs.

Volunteer diver measuring eelgrass growth at restoration site. © SBCK

In addition to eco-carts and the accompanying lessons, SBCK staff visited classrooms several times to give lectures and provide support for eco-cart maintenance. In the spring, the juvenile plants were taken from the eco-carts, and the outplanting of the seedlings was videotaped for each school group, giving the students a real sense of the restoration process and a feeling of true involvement in the project's success. From 2006 to 2007, eco-carts and eelgrass lesson plans went to 31 classrooms at 11 schools, reaching an additional 835 students. Project partners were also able to update their education modules to focus heavily on seagrass biology, the importance of seagrasses to the ecosystem, and the threats facing seagrass ecosystems, particularly in the local Channel Islands area.

From 2005 to 2007, SBCK biologists worked with education staff from UCSB's Marine Science Institute to present eelgrass ecology and reproduction to kids and their parents at several local "science nights" at schools throughout Santa Barbara and Goleta. During this time, project partners introduced 1,435 students to eelgrass habitats and marine ecology. Additionally, for the four years of this project, SBCK sponsored a juried marine-themed student art show and contest for the community, with the theme "What the Channel Means to Me."

"The educational component of our project really was a winner," said Alstatt. In fact, over the course of the entire SBCK eelgrass restoration project, education staff worked with approximately 2,300 schoolchildren in classes ranging from grade school through junior high and high school. By giving students a chance to interact with biologists from the Santa Barbara Channelkeeper, UC Santa Barbara, Channel Islands National Marine Sanctuary, and Channel Islands National Park Service, project partners hoped to instill a sense of value in restoring and maintaining the natural systems of the area and to create a new generation of biologists and conservationists.

California's Freshwater Creek Estuary Rehabilitation Project

In the face of growth and conversion, this program will encourage involvement in the protection of the Humboldt Bay watershed.

Identified as a priority watershed in the California Coho Recovery Plan, Freshwater Creek supports some of the largest populations of coho salmon in the Humboldt Bay watershed. Coho smolts and juvenile salmonids use backwater side-channels and tributaries to feed and grow before entering the more saline environment of Humboldt Bay. Much of the natural tideland of this area has been converted to pastureland, which has severely limited fish passage and survival due to the reduced habitat, lack of tidal exchange, lack of connectivity to side- and backwater channel habitat, and lack of channel connectivity to lower reaches and floodplain. The Freshwater Creek Estuary Rehabilitation Project, run by the Northcoast Regional Land Trust (NRLT), is a cooperative effort between community partners working together for the common goal of restoring tidal estuarine habitat to 35 acres of former tideland.

The project was committed to educating the local community. "We believe that a successful outcome on this project will encourage other landowners to consider public-private partnerships to protect, restore and steward the diverse natural resources of Humboldt Bay and its tidelands," comments project director Ryan Wells. NRLT developed a public education program to increase public awareness, including:

- Monthly guided walks—led by local naturalists, highlighting sustainable management, bottomlands agriculture, wetlands ecology, estuarine ecology, and native plant and wildlife conservation.
- Wetland Stewards of Tomorrow—engages high school students with inquiry-based learning opportunities in the field.
- Canoe the Slough Recreation Days—provides public access to Freshwater Slough at the furthest navigable point from the bay (launch site on NRLT property).

NRLT also uses this restoration project and property as an outdoor classroom, hosting multiple education tours for elementary through high school classes, as well as university-level courses. Topics include restoration project management, natural resources planning, multi-agency partnerships, ecological principles, and navigation of regulatory obligations.

- Tours given to classes at Humboldt State University include Applied Ecological Restoration, Natural Resources Planning Methods, Forestry, Wetland Ecology and Management, River Engineering, and Wetland Restoration.
- NRLT has an educational partnership with Six Rivers Charter School that started in 2007, in which habitat restoration, scientific inquiry, and field data collection and analysis are introduced to 9th through 12th-grade students in the classroom and on site.
- NRLT conducted hands-on restoration activities at the project site during the fall and winter for Freshwater Middle School, with activities including revegetation, invasive plant management, and informal assessment of site response to restoration.
- NRLT engaged local organizations and the community during the revegetation phase of the wetland restoration project. Over the course of two months, NRLT tracked nearly 600 volunteer hours at the site, which included planting native wetland plants at the restoration site and planting native willows along the bank of Wood Creek. Each of these volunteer events included an educational presentation, introducing participants to elements of habitat enhancement and sustainable agriculture.

Top left: Post-restoration aerial view of natural tidal inundation into former pastureland, © Lindsay Magnuson. Top right: Tidal inundation providing habitat to juvenile salmon, © Aldaron Laird. Bottom left: Slough channel excavation during project, © Linda Serrano. Bottom right: Applied Ecological Restoration tour to student group, © Rob Holmlund.

Informing Policy:

Shellfish Restoration, Long Island, NY.
© John Pinderhughes

New York's Great South Bay Hard Clam Restoration

Location: Great South Bay, Suffolk County, New York

Focus Species: Hard clam (*Mercenaria mercenaria*)

Partners: New York Sea Grant, Fire Island National Seashore, NYS Department of Environmental Conservation, South Shore Estuary Reserve Office, Suffolk County, Town of Brookhaven, Town of Islip, Town of Babylon, former Bluepoints Company, Brookhaven Baymen, Cornell Cooperative Marine Extension, NYS Department of State, School of Marine and Atmospheric Science at Stony Brook University, Environmental Defense Fund, Functional Ecology Lab at Stony Brook University's Ecology and Evolution Department, Citizens Campaign for the Environment, many local citizens and businesses.

When the most important hard clam fishery in the United States collapsed, a way of life and more than 6,000 jobs were lost.

In New York's Great South Bay (GSB), shellfish species, including hard clams, were an important part of the community's economy and culture well before European settlers made Long Island their home. In the 1970s, the shallow waters of Great South Bay were known as the "clam factory," as they supplied over half of the clams eaten in the US. At its peak, the commercial fishery's annual reported harvest surpassed 700,000 bushels of clams, which supported thousands of harvesters and many clam-related businesses. Unfortunately, however, this harvest exceeded the natural recruitment levels of this species, and the population of hard clams plummeted. Between 1976 and 1984, the reported commercial harvest declined by 80%.

As certified shellfishing areas became depleted, poaching became problematic in areas that were deemed 'uncertified' for commercial fishing due to pathegens and other environmental problems. Therefore, clams were intentionally removed from many areas and relocated to

Building from the Partnership

The partnership between the NOAA Restoration Center and the Long Island Chapter of TNC has facilitated the thoughtful evolution of a large-scale, long-term restoration project that is leveraging significant private and local public support via funding and policy commitment. With early awards focused on demonstration and proof of concept, the program is adapting and expanding to encompass a holistic ecosystem-based approach, which can serve as a model for other estuaries in similar settings. Consistent support from NOAA's Restoration Center has been essential to advancing this innovative approach. The engagement of the Long Island Chapter in the GSB project has also been an important catalyst for attracting additional funding and advancing TNC's marine conservation work in other areas.

Marci Bortman, TNC Long Island Chapter. © Carl Lobue, TNC

Hard clams in Great South Bay. © Carl LoBue, TNC

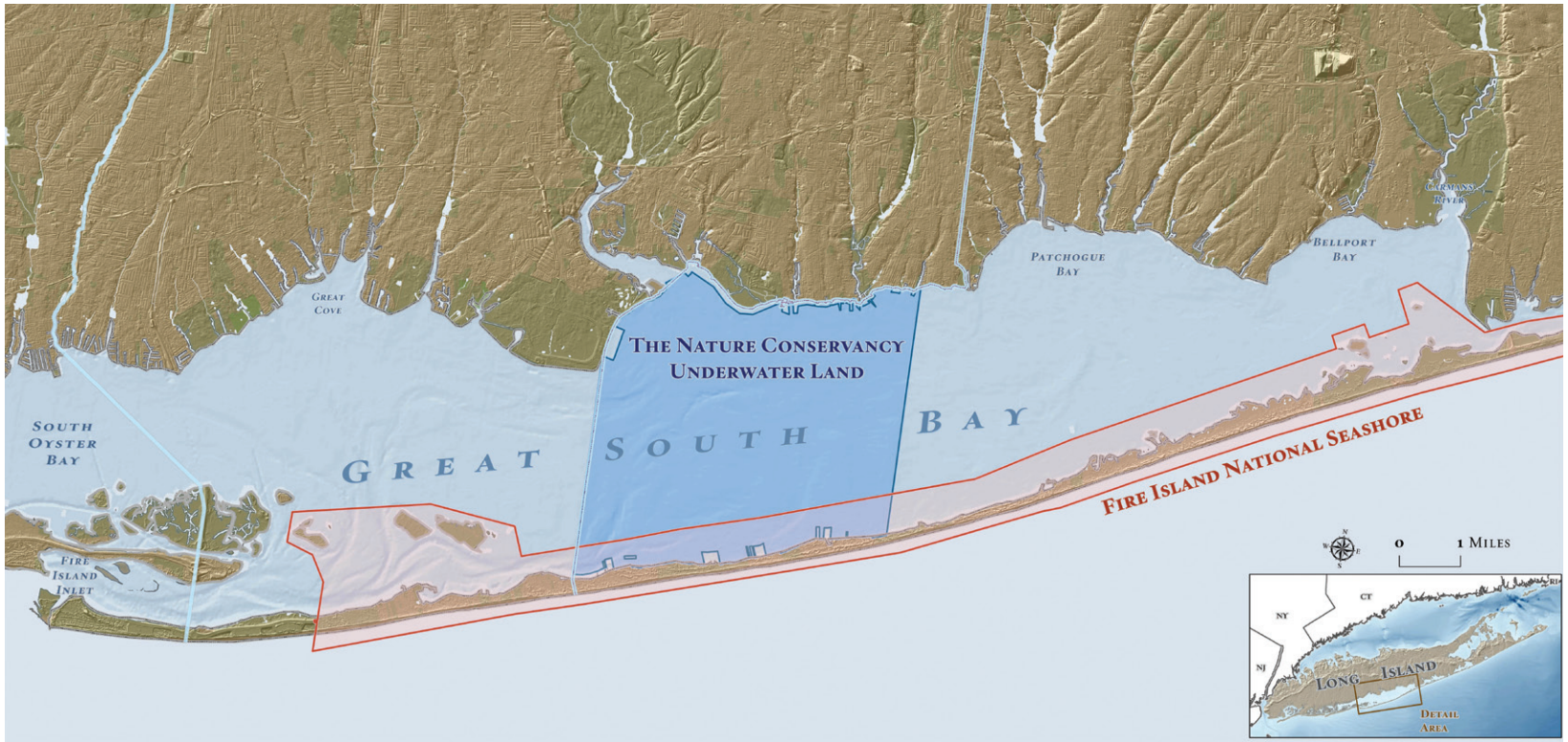
certified waters, where they were rapidly harvested. Although many now acknowledge that this practice depleted the last population strongholds, it was popular at the time because it mitigated the risk to human health while providing short-term economic opportunities to struggling baymen. Over the last decade, the diminished Great South Bay clam population has supported the commercial harvest at only about 1% of its peak in 1976. Although several hundred commercial shellfishing licenses are still sold each year by the three Great South Bay townships of Brookhaven, Islip, and Babylon, industry estimates show that there are currently only 12-14 full-time commercial clammers in Great South Bay.

In addition to economic and job-related losses, the depletion of hard clams has contributed to the deterioration of the bay's ecosystem health. It has been estimated that during their historic abundance clams were capable of filtering the entire Great South Bay in 2.5 days, while the current depleted population would need approximately 100 days to filter the same volume of water. Loss of the clam population's filtering capabilities, combined with elevated nutrient levels from coastal communities, has promoted phytoplankton growth. When combined with limited oceanic flushing, these conditions are favorable to algae blooms, in particular brown tides caused by microscopic algae (*Aureococcus anophagefferens*). These blooms, which are a poor food source for most shellfish, outcompete all other forms of phytoplankton, and the algae shades eelgrass beds that are important habitats for juvenile fish, crabs and other bay species.

Recent research indicates that when abundant, feeding clams can actually prevent brown tide blooms. In fact, restoration of native shellfish was one of the recommendations put forward in a 20-year research synthesis as a mechanism for making Long Island bays more resistant to brown tide blooms. Nearly a decade ago, however, TNC's New York Long Island Chapter and several partners changed the course of this 35-year decline of hard clams with a creative land acquisition deal.

Innovative Approaches: The acquisition of the Bluepoints property created an unprecedented opportunity to explore management and restoration methods that had not been possible in the past.

In 2002, TNC's Long Island Chapter secured a deal to acquire fee title to 5,432 of the roughly 24,300 hectares of bay bottom in Great South Bay. The subtidal land was purchased from the parent corporation of the Bluepoints Company, which had



used the land for shellfish aquaculture over generations. This deal created a unique situation. Removing the large-scale shellfish dredging operations in the central bay made possible, for the first time, bay-wide approaches to restoration and management.

The first public financial support for the Great South Bay Hard Clam Restoration Project came from the TNC-NOAA Partnership in 2003. The baseline surveys and monitoring conducted through that project have laid the groundwork for what is now a long-term, estuary-wide, multi-partner effort to restore hard clam populations, ecosystem health and, ultimately, a sustainable clam fishery. With creative partnerships and unique opportunities, this project offers the chance to recover hard clams to a self-sustaining level and to promote an ecosystem-wide management approach with improved stewardship from citizens and policymakers alike.

Location of the Bluepoints property acquisition, Great South Bay, New York. Carl LoBue, TNC

TNC staff with clams for re-stocking spawner sanctuaries. © Carl LoBue

Bringing Back the Clam: By establishing a network of no-harvest areas, or "spawner sanctuaries", TNC set out to rebuild the reproductive potential of the Great South Bay hard clam population.

Baseline shellfish surveys of TNCs newly acquired submerged lands, which once represented some of the most productive shellfishing areas in the bay, showed that the area was largely devoid of hard clams, with 70% of the area having no clams at all. Research and modeling funded as part of New York Sea Grant's hard clam research initiative showed that at this level, the population was lower than the threshold for successful reproduction and recruitment. This evidence, combined with observations that the clam population showed no signs of recovery in over a decade, suggested that without intervention, the clam population had little chance to recover on its own.

In 2004, an advisory council consisting of 15 different stakeholder groups and agencies, including the NOAA Restoration Center, developed a long-term, bay-wide adaptive management plan with the objective of increasing the abundance of clams to an average density of six clams per square meter, the threshold for achieving ecosystem health and sustainable harvest. The plan aims to reach this milestone by 1) addressing recruitment limitation through on-the-ground stock enhancement; 2) minimizing population bottlenecks for transplanted, wild-born, and hatchery-born clams; 3) improving the knowledge required to reduce other human impacts to water quality that are effecting phytoplankton composition and promoting harmful algae blooms; and 4) adjusting municipal hard clam harvest rules to assure that overharvest is not repeated when restoration success takes hold.

Since the development of that plan, TNC has assumed a lead or coordinating role on many aspects of these recommendations, with tremendous cooperation from other agencies and groups involved in developing and implementing the Bay's recovery plan over the past nine years. A centerpiece has been a TNC-led clam stock enhancement effort involving relocation of more than 5 million adult clams from nearby estuaries into a network of spawner sanctuaries within the TNC-owned lands. The submerged lands in central Great South Bay is a temporary tool to jumpstart natural processes and increase the number of wild-born juvenile clams.

This component of the project has shown that Great South Bay is still capable of producing large sets of juvenile clams. Clam surveys in 2008 revealed a 4,000% increase in numbers of juvenile clams compared to previous surveys. At the ecosystem level, this translates to 2,000 hectares that have clam densities at or above five clams per square meter surrounding the hard clam spawner sanctuaries. It is, however, the less celebrated initiatives of this plan, often administered by agencies and local governments, that will combine with restoration work to turn the tide and restore the estuary for nature, and for future generations of people.

Informing Policy: Early success in Great South Bay combined with growing appreciation of the ecosystem services provided by shellfish have catalyzed expanded collaboration and support for this project.

The collaboration of policy and decision makers has been critical to the project's success—whether that comes from the local townships of Brookhaven, Islip, and Babylon or leaders at Suffolk County, or from state and federal agencies. Financial commitments and outreach by TNC and NOAA in the initial years created an upwelling of excitement, inspiring additional funding support by Suffolk County and New York State. The continued support of multiple awards from the TNC-NOAA Partnership has shown participants that the approach has met or exceeded NOAA's rigorous performance standards.

New information achieved through research and monitoring, combined with early results of the on-the-ground restoration supported through these combined investments, have increased overall knowledge and understanding of the system, informed the direction project partners need to work towards and created optimism. The desire to protect public and private investments already made, and the willingness for stakeholders and managers to work as partners, has led to some important policy advancements:

- In 2006, with the support of TNC and local fishermen, New York State Department of Environmental Conservation (DEC) passed oyster toadfish harvest restrictions that aimed to rebuild this once-abundant crab-eating fish. This was key to restoring a historic balance of shellfish and predators, and therefore increasing the survival of juvenile hard clams (and bay scallops).

TNC Long Island staff and volunteers in Great South Bay.
© John Pinderhughes

- In 2006, so that NYS DEC could achieve regulatory consistency between local towns concerning the hard clam harvest, the New York State legislature passed a law granting DEC regulatory authority over hard clams.
- In 2009, the town of Brookhaven passed a resolution designating all TNC- owned submerged lands as a Shellfish Management Area, effectively creating the largest shellfish conservation zone in New York State.
- In 2009, through a coalition of stakeholder interests and partners, Great South Bay and the entire South Shore Estuary Reserve were designated as a "no vessel-discharge zone" by the US Environmental Protection Agency (EPA).
- In 2009, Suffolk County passed its first set of regulations aimed at reducing the amount of fertilizer and pesticides that enter waterways. This is an essential step toward reducing plankton-bloom-inducing nitrogen loads to the Bay and groundwater.
- Leaders of the three Great South Bay townships, New York State, Suffolk County, Fire Island National Seashore, TNC, and Citizens Campaign for the Environment—as well as commercial shellfish harvesters and dealers—developed interim hard clam harvest management recommendations. These were adopted by all three Great South Bay townships in 2010.
- In 2010, supported by monitoring data collected, TNC lead a successful petition to add Great South Bay to the EPA's 303(d) list of nutrient-impaired water bodies. This was aimed at facilitating federal assistance to mitigate nutrient impairments and harmful algal blooms.
- In 2010, upon receiving feedback from the Bluepoints Bottomlands Council and others, the town of Islip withdrew a proposal to cease its shellfish hatchery operations and is instead looking to partnering with Suffolk County to update its facilities.

Then-Senator Hilary Clinton supporting the Great South Bay restoration efforts. © K. Williams

Senator Charles Schumer showing his support for Clam Power with NY GSB Project Director Carl Lobue. © K. Williamsa

Generating Political Will: Partnerships with local, state and federal agencies, elected leaders, scientists, environmental advocates and stakeholders have been essential to this project's achievements.

Advancing meaningful policy changes to reduce ecosystem degradation requires that we meet different kinds of challenges. Some of these challenges, such as the elimination of the dredge fishery in central Great South Bay, were met with creative, nontraditional solutions. However, many other actions have, and will, require garnering support from elected leaders at all levels. The desire to protect investments already made, results of site-based work that prove success is within reach, and the overwhelming public support for project goals are the factors that will address the most challenging issues faced by conservation practitioners. These challenges include updating on-site wastewater treatment with twenty-first-century technology to reduce the impacts of medium- and high-density development on our estuaries, as well as to protect Suffolk County's sole source of clean drinking water.

Long Island is not unique in this problem, as is evident from many estuaries around the country, and lessons learned through the Great South Bay project can be instrumental in developing approaches for other estuaries. Without the support for this project by the TNC-NOAA Partnership, initial successes would not have moved this effort so far along. A March 2009 letter to TNC from a Sayville marina owner, Mark DeAnglis, conveyed the renewed sense of promise felt by communities around the bay:

> "The most important thing you have provided is hope. Stories of how the bay supported the livelihood of thousands of baymen and their families were a thing of the past. Fish stocks, eelgrass beds, water quality and clarity were all on the decline. The bay's reputation was as a dead estuary; now the stories out of the bay are of increasing clam stocks, of better water clarity, and of a renewed recreational sector. Due to your efforts, people are once again talking of the bay as having the possibility of rehabilitation, and of a return to the health of years past. Of course this is only the beginning, but people feel that for the first time in many years, things are improving, that we are on the right track, that there is light at the end of the tunnel."

Poster to gain community support, featuring actress Isabella Rossellini. © John Pinderhuges.

Oyster shell bags ready for deployment into NC Pamlico Sound. © Aaron McCall, TNC

North Carolina's Pamlico Sound Oyster Reef Restoration

Location: Pamlico Sound, the largest lagoon of the US East Coast, situated between the North Carolina mainland and the Outer Banks

Focus Species: Eastern oyster (*Crassostrea virginica*); other species include blue mussel (*Mytilus edulis*), ribbed mussel (*Geukensia demissa*) and hard clams (*Mercenaria mercenaria*)

Partners: US Fish and Wildlife Service, North Carolina Department of Environment and Natural Resources and Divisions of Marine Fisheries (NC DMF) and Coastal Management, North Carolina Sea Grant, University of North Carolina Institute of Marine Science, Carteret County Community College

Between coastal North Carolina and the Outer Banks, the vast oyster reefs of the Pamlico Sound are now only a small fraction of their original size.

Located less than 150 miles from the Chesapeake Bay, the Pamlico Sound historically supported an extensive network of oyster reefs between the Outer Banks and the North Carolina Inner Banks. These reefs supported Native American communities and early North Carolina coastal residents as food supplies and material for bartering. The demand for oysters grew steadily, resulting in establishment of the first oyster harvest restrictions in the 1820s. However, the oyster market in North Carolina continued to expand following the Civil War as oysters became more popular in northern markets and the development of railroads allowed for larger and more frequent shipments of oysters. Furthermore, as oysters were depleted in Maryland and Virginia, oystermen came into North Carolina for these harvests. Signs of overharvesting became apparent in this region as early as 1900. Today, the oyster population in North Carolina, including Pamlico Sound, is a small fraction of historical levels.

Oyster reefs are critical components within the Sound's ecosystem, as they provide water filtering and cleaning, which helps control nuisance algal blooms and excess nitrogen in the water column. Oyster reefs parallel coral reefs in providing structure that supports an amazing array of other species, including adult and juvenile fish, crustaceans and

Oyster Sanctuary

The Typical sanctuary consists of mounds of rip rap, with each mound containing about 100 tons of material.

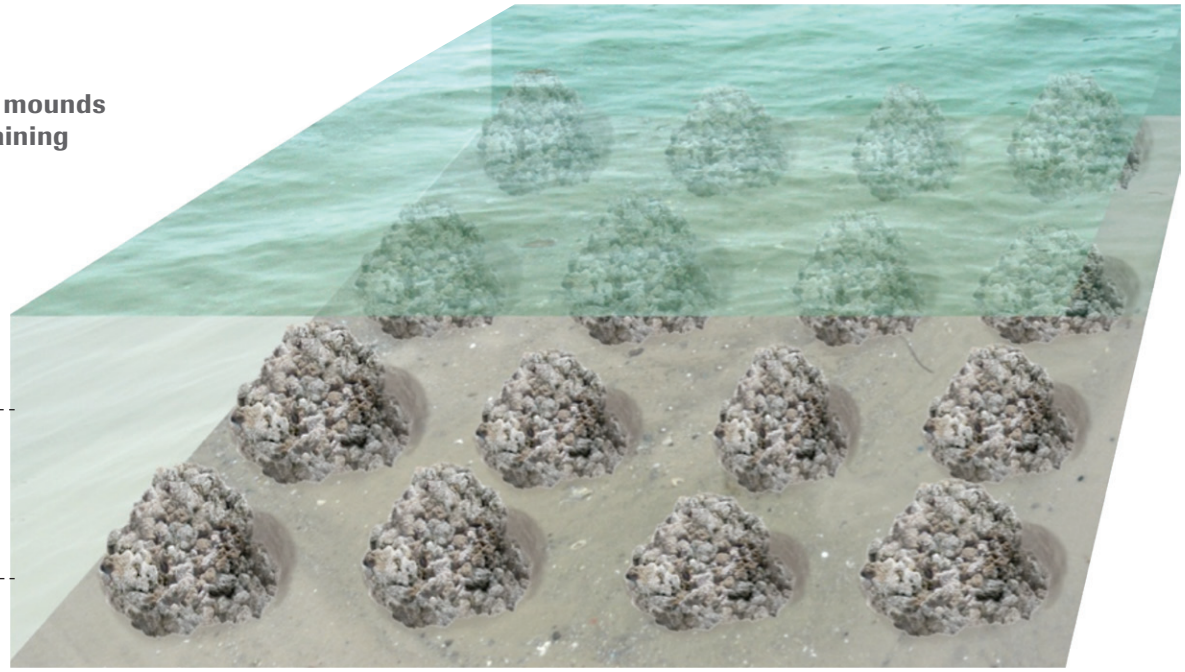


Diagram of sanctuary construction. © NC DMF

birds. Oyster reefs provide important habitat which increases the survival of juvenile fish, and forage habitat which encourages the growth of many recreationally and commercially important fish species.

In 2001, TNC's North Carolina Chapter received its first TNC-NOAA Partnership grant to begin restoring oyster reefs in the Sound. Restoration had previously been attempted through development of "put-and-take oyster fisheries," which proved unsuccessful in the long term. "The situation is pretty grim," Jeff DeBlieu of the North Carolina Chapter told a local newspaper. "As far as I can tell, we don't have any healthy wild oyster reefs. All we have are remnants of the put-and-take oyster fishery that has emerged, in the absence of any real restoration, where you build an oyster reef, wait a few years, and then harvest it all out. Until we have a system of undisturbed sanctuaries that we can advance at a meaningful scale, we won't have true restoration of the habitat and services that oysters provide."

From the restoration project's start in 2002, TNC worked with NC DMF to test novel restoration techniques for creating self-sustaining populations of oysters within three-dimensional spawner sanctuaries. These proof-of-concept techniques helped in developing later restoration projects that worked to create shallow-water habitats such as seagrasses and conditions which increase shallow-water and shoreline ecosystem resilience to the impacts of climate change and sea-level rise. Since 2002, and continuing today through the state-funded Oyster Sanctuary Program, a series of artificial, high-relief oyster reefs has been constructed throughout the Sound.

NC DMF vessels delivering marl to restoration sites. © Jeff DeBlieu, TNC

Oyster Sanctuaries: Working with the NC Division of Marine Fisheries, TNC staff created sanctuaries by building reef mounds from natural shell and limestone riprap marl.

In 2001, TNC, NC DMF and the University of North Carolina secured a 125-acre site in southeast Pamlico South for oyster reef restoration. It had been set aside as a "fish haven" in 1985, when thousands of rubber tires were dumped to attract fish; however, the site was never maintained or monitored. Project partners first worked to locate and remove the tires before monitoring the site for their own restoration work. The site is protected from harvesting and from the use of bottom-disturbing gear, including dredging and trawling. This allows for restoration of the sea floor without disturbances so that a breeding population of oysters can develop.

The summer of 2002 marked the creation of the first shellfish sanctuary with high-relief reefs created for oyster restoration in North Carolina, using 200 tons of limestone marl. Oyster sanctuaries were created by building six-foot-tall reef mounds in locations where oysters had historically thrived. Mounds were constructed from limestone marl with small seed oysters, or broodstock, placed on these mounds to spawn and provide natural settlement. By developing and protecting broodstock in sanctuaries, the project hoped to increase native oyster populations and attract clams, juvenile fish, crabs and other marine organisms to this natural system. No established sanctuaries had been created prior to this project, despite earlier experiments by the state with "put-and-take oyster fisheries" and an artificial reef program. TNC worked with NC DMF to develop this restoration strategy, and in 2003 another sanctuary was created using funding from NC DMF to supplement the materials provided by TNC and increase the number of reefs in the new sanctuary.

Through a series of grants from the TNC-NOAA Community-based Restoration Program, partners were able to develop experimental oyster reefs as pilot projects that tested several areas of oyster reef restoration, including sanctuary-based management, oyster shell recycling, construction of shallow-water reef habitat, remote setting of oysters, using shell over limestone marl in reef construction, and the development of monitoring approaches for subtidal reefs. The reefs were investigated numerous times throughout the year for recruitment levels and the succession of newly placed material. By the spring of 2006, these original oyster reefs were teeming with life, attracting large numbers of fish. Oyster abundance ranged from 250 to 500 oysters per square meter.

Recorded trends of use and survival showed that oyster abundance increased and oyster diseases decreased with height in the water column, supporting the rationale behind using high-relief reef mounds for restoration. "We have accomplished this significant goal, by demonstrating that deep water sanctuaries with high-relief artificial reefs are a successful restoration technique," commented Aaron McCall, the conservation steward of TNC's North Carolina Outer Banks office. "By providing this type of material and safe haven in the Pamlico Sound, you can get multi-year recruitment and survival starting the development of functioning oyster reefs."

Working with the State: In 2005, success of this project created so much public excitement and political will that the state legislature created the NC DMF Oyster Sanctuary Program.

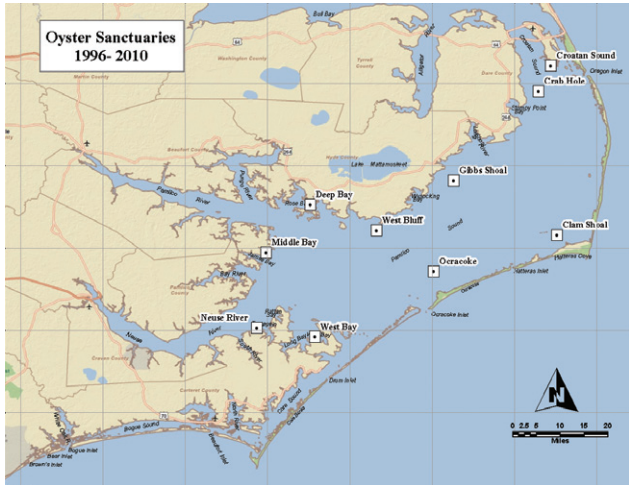
Since the project's inception, the NC DMF embraced TNC's approach of creating shellfish sanctuaries with artificial reefs in order to increase the number and size of popular fish species that require this type of habitat. "From the early stages of this project, we saw NC DMF picking up the momentum of oyster reef restoration as a critical habitat beyond just a natural resource," reported McCall. TNC worked alongside NC DMF from 2001 to 2005, developing oyster restoration strategies, testing the effectiveness of techniques and assisting in creation of three oyster sanctuaries in Crab Hole, Clam Shoal and Ocracoke.

The early success of the sanctuaries increased public awareness of the importance of oyster reefs. Seeing this success achieved by the TNC-NC DMF partnership, the North Carolina legislature decided in 2005 to invest in a permanent oyster sanctuary program within DMF. State support for the program demonstrated that North Carolina decisionmakers recognized the economic and ecosystem-wide benefits to restoring their natural oyster reefs. As McCall noted in a report to the TNC-NOAA CRP core program, "As the reefs we've constructed continue to evolve and become established as living, self-sustaining oyster reef ecosystems, they will produce many benefits such as enhanced water quality, increased oyster spawning biomass throughout the estuary, higher rates of fishery productivity and continued growth in public support for long-term estuary conservation."

With the advent of the state program, TNC handed the project over to NC DMF, which continues to administer it today. To date, the NC DMF Oyster Sanctuary Program has created ten sanctuaries in Deep Bay, Middle Bay, Neuse River, West Bay, Bluff Point,

NC DMF vessel deploys riprap marl to restoration site. © NC DMF

NC DMF Vessel *RV Long Bay* delivering marl to restoration sites. © Jeff DeBlieu, TNC



Map from the NC recreational fishing web site, highlighting the oyster reefs as productive fishing destinations. © NC DMF

Okracoke, Hatteras, Croatan Sound and Crab Hole, with the Conservancy assisting in the creation and monitoring of three sites. These sanctuaries encompass over 200 acres of estuarine habitat in total and provide the area with 64.5 acres of restored three-dimensional reef habitat with over 50,000 tons of riprap material.

Increased state funding for oyster reef habitat restoration has also led to the hiring of a state-funded shell recycling coordinator and a sanctuary biologist, as well as creation of a planning committee for a state-supported hatchery. A very significant outcome of this multi-year community-based project has been the development of strong partnerships between TNC, NC DMF, and local businesses and community members that will propel restoration work for many years to come on the North Carolina coastline.

Funding for the Future: The successful TNC and NC DMF collaboration resulted in expanding restoration efforts to the entire Pamlico Sound.

As oyster reef restoration activities and sanctuary building had been adopted by the state of North Carolina, TNC was able to obtain a partnership grant to focus on utilization of oyster reef ecosystem services for shoreline protection. With partners including US Fish and Wildlife Service as well as NC DMF, in 2008 TNC initiated a long-term project in the Albemarle-Pamlico Peninsula to increase the resilience of natural systems to stresses caused by climate change and by sea-level rise in particular. “By restoring natural systems on and around the peninsula and reducing human-induced threats,” explained McCall, “we hope to give those systems on and around the peninsula and reducing human-induced threats, we hope to give those systems time to adapt to a future much different than today”.

Using proof-of-concept techniques developed with NC DMF in the earlier oyster sanctuary project, TNC and its partners built a series of high-relief artificial reefs using limestone marl along the Albemarle-Pamlico Peninsula shoreline. TNC is working to use these techniques not only to restore oyster populations but to reduce wave energy on shorelines, reduce erosion and build resilience to the coastline in the face of climate change.

In 2010, TNC began an additional project funded by the the TNC-NOAA Partnership to build oyster reefs in the Nags Head Ecological Preserve, a 1,200-acre preserve managed by TNC that is experiencing significant shoreline erosion. “Sea-level rise, wave action, and storm surges have effectively extirpated the protective fringing marsh, converting the vegetated shoreline into an eroding high sediment bank devoid of

Shoreline protection reef after deployment of bagged oyster shells. © Aaron McCall, TNC

wetland and maritime salt shrub vegetation," commented Brian Boutin, Climate Adaptation Project Director for the TNC North Carolina Chapter. Working with the town of Nags Head, TNC is undertaking a pilot restoration project to stabilize shorelines and build resilience to sea-level rise. The project aims to stop erosion from impacting a historical access road and adjacent properties. TNC will demonstrate natural alternatives to hard shoreline stabilization by building oyster reefs and fringing marsh, which will buffer wave energy, reduce erosion and foster the gradual development of a sheltered, shallow-water habitat of seagrasses that will further stabilize the substrate near shorelines.

The success of NC DMF's Oyster Sanctuary Program also paved the way for restoration work on a much larger scale, as the program was awarded NOAA Recovery Act funding. With the grant of $5 million, state and partner organizations are continuing to develop new sanctuary reefs throughout Pamlico Sound and to address sites that had been difficult for NC DMF to access. The project is also providing 140 jobs to the quarry, trucking companies and others involved in producing and moving reef materials.

Another outcome of this long-term effort was the formation of the Northern Oyster Work Group, including members from TNC, NC Sea Grant, NC Conservation Foundation, NC DMF, and US Army Corps of Engineers. The group produced the "Subtidal Region Long-Range Oyster Conservation Plan for 2008–2018" in the winter of 2006, an aggressive long-term plan for native eastern oysters with the goal of constructing 500 acres of limestone marl reef in designated sanctuaries by 2018.

Live oyster spat being deployed to the newly restored Burton Point reef, Piankatank River, VA. © Mark Bryer, TNC

Virginia's Piankatank River Oyster Reef Restoration

Location: Piankatank River and the wider Chesapeake Bay watershed within the states of Virginia and Maryland

Focus Species: Eastern oyster (*Crassostrea virginica*)

Partners: Virginia Marine Resources Commission (VMRC), the Virginia Institute of Marine Science (VIMS), Chesapeake Bay Foundation and the Smithsonian Environmental Research Center

As nearly 99% of its native oyster population vanished over the last two centuries, new methods were needed to tackle oyster restoration in the Chesapeake Bay.

The native eastern oyster is a keystone species in the Chesapeake Bay and in the Virginia Coast Reserve (VCR) on the Atlantic Ocean, and populations of these oysters have sustained the economy, the culture and the ecology of both ecosystems for centuries. Numbers of oysters have declined dramatically since the 1800s, and current estimates place the Chesapeake's native oyster population at or below one percent of its historic levels. As a result the critical water filtering, fish habitat and fishery functions once provided by this resource have been largely lost.

TNC in Virginia has had extensive marine restoration experience with its longstanding work at the VCR. This did not, however, translate to the Conservancy's Chesapeake Bay watershed program initiated in 2005. The ecology of the bay system, the partners willing to be involved in the project, the industry and the socioeconomics in the Chesapeake Bay area are fundamentally different from the Virginia seaside bays.

In 2006 and 2008, TNC's Virginia Chapter received TNC-NOAA CRP Partnership grants to restore oyster reef habitats in the Piankatank River, a western tributary to the Chesapeake Bay and historically a critical river for oysters, both economically and ecologically. These projects focused on ecological outcomes associated with small reef habitat restoration, but with a long-term goal of restoring key ecosystem processes

provided by large-scale oyster reefs in the river. At the same time, essential to the Piankatank project was the creation of new partnerships with state agencies, local communities, industry stakeholders, other nonprofit and NGO organizations, and federal agencies.

Working alongside partners such as the VMRC, the Virginia Institute of Marine Science (VIMS), the Chesapeake Bay Foundation and the Smithsonian Environmental Research Center, the projects restored two sanctuary reefs—the Bland and Burton Point reefs – in the Piankatank through the addition of more than 70,000 bushels of oyster shell. The projects focused on restoring suitable habitat for larval oyster settlement and ensuring vertical complexity of the reef habitat, increased oyster settlement rates and an increased density of reef-affiliated fauna.

Through 2009, nearly 39,000 bushels of oyster shells were used to restore three-dimensional habitat at the Burton Point sanctuary reef, which had the lowest oyster biomass and density of recently settled oyster "spat" of any of the sanctuary reefs in the Piankatank. During the course of the projects, more than 117,000 bushels of

Oyster spat on shell to be deployed on Burton Point Reef. © Mark Bryer, TNC

Restoration to Policy in Chesapeake Bay

"TNC's seat at the table as a full-fledged partner in policy discussions regarding oyster restoration is the result of our initial investments made possible by the TNC-NOAA Partnership. The partnership has helped to leverage significant improvements to habitat and ecosystem health within the Chesapeake Bay. These improvements have gone, and will continue to go, well beyond the footprint of the original Piankatank River project, and will function as the setting for some of the bolder oyster restoration goals and restoration projects seen in the United States"- Michael Lipford.

TNC Virginia state director, Michael Lipford at the Rappahannock River © Daniel White, TNC.

oyster shells were also contributed by VMRC to enhance more than 100 acres of two-dimensional habitat in areas adjacent to this and other sanctuary reefs in the river. And by 2011, through many coordinated restoration efforts, more than 17 million new oysters were planted on the newly restored Burton and Bland Point reefs.

Influence in the Bay: Beginning with funding from the TNC-NOAA Partnership, the Piankatank River project set the foundation for TNC's influence in the Chesapeake Bay.

The timing of the two partnership grants turned out to be critical for outcomes of Chesapeake Bay restoration, as significant changes to oyster policy and management were approaching in Virginia and Maryland. The partnership projects provided TNC with credibility and standing in these new policy dialogues in three key ways.

First, the Piankatank River project gave TNC staff relevance within discussions about the health of the Chesapeake Bay watershed, as TNC had on-the-ground projects and federal funding in place. Secondly, TNC staff became trusted as conservationists and field researchers, expert scientists and key partners worth working alongside during restoration projects. Lastly, the Conservancy demonstrated that it had developed further ideas from these projects that were relevant to the policy dialogues. These ideas included bringing restoration to larger scales to impact more of the Chesapeake Bay's watershed, restoring oyster reefs for ecosystem services, and connecting TNC's land conservation with restoration efforts in the water, as successful restoration in Chesapeake waters are highly dependent on the successes of reducing watershed impacts from land.

Leverage as a Team: The Virginia Blue Ribbon Oyster Panel united scientists, policymakers and industry partners to restore the Chesapeake Bay's oysters.

Through participation in three key policy arenas, TNC has been able to leverage the partnership-funded projects and help reshape oyster reef restoration policy and management in Virginia and the Chesapeake Bay.

First, in 2006, TNC's Virginia State Director, Michael Lipford, was offered a seat on the Virginia Blue Ribbon Oyster Panel by Virginia's Secretary of Natural Resources.

The panel's function was to provide key policy recommendations to the Virginia General Assembly, and TNC became part of the group framing these recommendations in large part because of the field-based investments made in the VCR and the Piankatank River through the TNC-NOAA Partnership. Recommendations from the panel reflect the balanced approach to economic and ecological restoration that TNC has promoted through its conservation and restoration projects. The Blue Ribbon Panel was also tasked with advising the Marine Resources Commission on how to spend Virginia's financial resources to counter losses of the eastern oyster.

Secondly, Conservancy-led restoration efforts in the VCR and the Piankatank, alongside other restoration projects on the Atlantic coast, were tangible investments that faced a threat from proposals to introduce a non-native oyster species, the Asian oyster, to the Chesapeake Bay. TNC's involvement in these projects and the exposure of these projects to impacts from an introduced species gave TNC added credibility to its input on whether or not to approve the introduction of the Asian oyster.

Finally, TNC staff were able to influence policy through the Executive Order on the Chesapeake and Virginia implementation plans. TNC's participation and assistance in forming Chesapeake Bay-wide goals and metrics for oyster restoration through the President's Executive Order were built upon the experiences gained from the Piankatank project. Recent negotiations to align state and federal interests in oyster restoration in Virginia have been assisted by TNC, and in 2011 the Conservancy was asked to initiate Coastal Marine Spatial Planning (CMSP) work with targeted funding through the TNC-NOAA Partnership.

Elevating Shellfish Reefs and Beds as a Priority Habitat within NOAA

Location: NOAA Office of Habitat Conservation and Office of Aquaculture

Focus Species: Habitat-forming bivalve molluscs, primarily oysters, mussels, clams and scallops

Partners: National Fish and Wildlife Federation, US Army Corps of Engineers and others

Recognition of the keystone function of bivalves in the coastal and estuarine ecosystem has come a long way in the last decade.

Since its inception in 2001, the TNC-NOAA Partnership has recognized the importance of bivalve shellfish in maintaining a functioning coastal ecosystem and has focused on restoring bivalve habitats to these nearshore environments. While many habitats are represented through TNC-NOAA Partnership projects, around 50% of the projects have focused on bivalve shellfish. In fact, 59 out of 124 projects awarded up to the year 2011 focus specifically on restoring bivalve habitat.

An early outcome of the partnership was the formation of a "shellfish network," a loose coalition of shellfish restoration practitioners that met periodically to discuss strategy. An early recommendation was to conduct a global assessment of major habitat-forming bivalves to document the extent of their decline. The resulting study, led by Mike Beck of TNC and a large group of collaborators, found that the global extent of oyster reefs had declined by about 85%, mainly due to over-exploitation. This makes the oyster reef among the most imperiled marine habitats on earth.

Along with assessing this decline, TNC has documented the importance of key ecosystem services provided by oyster reefs, using those services as a means to set restoration targets in individual bays around the US. These services include water filtration, removal of nitrogen, production of finfish and crustaceans important to commercial and recreational fisheries, and protection of shorelines from erosion. This work has been supported by NOAA through the National Fish and Wildlife Federation and also through the partnership.

These ecosystem services are critical to the human population as well as to nearshore bays and estuaries. For example, measures of the amount of particles in the water (of both phytoplankton and sediment) upstream and downstream of an oyster reef detect significant decreases, and models suggest that even modest growth in oyster biomass could significantly increase the depth that light can penetrate and the viability of seagrass meadows. Both seagrass and oyster reef is important nursery habitat for the many crab and fish species that support key fisheries. The direct filtration of particles improves water clarity, but many of these particles contain biologically available nitrogen, the driver of phytoplankton blooms and often the root cause of poor water quality. This nitrogen is filtered and deposited on the sediment, where it can enter the chemical pathways in the sediment, and a portion is reduced to inert nitrogen gas, removing it from the system and further improving water quality.

Demonstrating the importance of bivalve habitats and the success of restoration has led to growing recognition and expanded restoration efforts.

NOAA's recognition of the importance of the habitat created by bivalves, or the importance of the services bivalves provide, has developed during recent years with the number of successful demonstration projects, many of them through the TNC-NOAA Partnership. In 2007 the NOAA Restoration Center added shellfish to its list of priority habitats. The NOAA Restoration Center currently has four priorities for restoring coastal habitats: protecting corals, opening fish passage barriers, reconnecting wetlands, and rebuilding native bivalve shellfish populations[1]. In 2008 the National Fish and Wildlife Federation followed suit by including shellfish in its list of priority habitats. In recent years, with momentum building for shellfish restoration, the Army Corps of Engineers, the Environmental Protection Agency and an increasing number of state resource management agencies have all funded projects.

Collaborating with the Nation's Marine Resource Management Agency to create a National Shellfish Initiative

Through the TNC-NOAA Partnership, the Conservancy has enjoyed a longstanding relationship with the aquaculture industry. This industry, like TNC, recognizes the ecosystem services provided by shellfish and promotes good water quality and ecosystem health in aquaculture growing areas. Aquaculturists have been crucial partners in many restoration projects, providing the hatchery capacity for seed shellfish, offering shellfish growout advice, and in many instances partnering to do the growout of seed to produce broodstock.

In 2010, when the new NOAA Office of Aquaculture began listening sessions in preparation for drafting its aquaculture policy, it was the Pacific and East Coast Shellfish Growers Associations, along with the Gulf Oyster Industry Council, that collectively requested that NOAA launch a National Shellfish Initiative with the release of their updated policy for public comment. TNC supported this position and has been providing input to the agency to help shape some of the initiative's direction. This request, along with the NOAA Restoration Center's shellfish priority, resulted in NOAA's announcement of a National Shellfish Initiative. The goal of this initiative is to increase the environmentaly sound production and the conservation of native shellfish, thereby stimulating coastal economies and improving ecosystem health[2]. The focus of the initiative is fivefold:

- Support innovative shellfish restoration, farming and research and increase the sharing of information and technology between these activities;
- Engage in marine spatial planning to support the science-based siting of shellfish farms and conservation projects;
- Improve coordination to facilitate timely permitting, while ensuring effective protection of coastal resources;
- Expand scientific information regarding the nexus between shellfish and the environment (e.g., factors limiting growth, ecosystem services, and impacts on adjacent resources); and
- Further coordinate funding priorities, and explore innovative financing and valuation of ecosystem services.

These closely allied goals would not have been proposed without the working relationship that developed from the two groups' long association, a relationship born largely from on-the-ground projects, including many fostered through the TNC-NOAA Partnership.

[1] http://www.habitat.noaa.gov/restoration/approaches/index.html (2011).

[2] http://aquaculture.noaa.gov/us/shellfish_initiative.html (revised Dec 9, 2011)

CONCLUSION

Schooling jacks, © Daniel & Robbie Wisdo

Over the last 10 years, the TNC-NOAA National Partnership has helped to develop the field of habitat restoration to a point where it is a fundamental approach for achieving conservation goals of The Nature Conservancy and many of its partners. The innovative projects supported through the National Partnership have touched a variety of habitats including marshes, rivers and streams, seagrass meadows, and oyster and coral reefs, and they have demonstrated that restoration can indeed influence ecosystems. In some instances, the projects help to provide a vital safety net for threatened or endangered species, providing habitat necessary to bring them back from the brink of extinction. In other cases, the habitat is helping to produce fish and shellfish that are highly prized by recreational and commercial fishers. In all cases, they have helped to make our nation's coasts and coastal communities more resilient.

The partnership's projects have yielded other outcomes that extend well beyond the restoration project's original footprint. Engaging communities was, by design, a central objective of the partnership but the depth and breadth of engagement has exceeded our expectations. The sheer number of volunteers – more than 100,000 in this initial decade of partnership – speaks volumes about the public's appetite for healthier coasts, and their willingness to contribute their time and talent has provided tremendous leverage for the public funds used in this partnership. Novel constituencies and partnerships have also emerged that are helping to propel restoration at ever larger scales. The high level of community engagement demonstrates that restoration of coastal habitats is a worthwhile investment.

The outcomes of the partnership projects, collectively and individually, have been helping to inform policy that improves restoration and coastal conservation. The increasing priority placed on restoring oyster reefs for a multitude of ecological benefits is an exciting example, with state-level restoration plans and a new National Shellfish Initiative offering great promise.

Restoration is also emerging as an important part of the "green economy", providing jobs and many indirect economic benefits to communities near and far from the coast. This has been amplified by the projects funded under NOAA's Recovery Act program, many of which grew out of TNC-NOAA Community-based Restoration funded projects. The experience and new methods developed by these projects will undoubtedly inform efforts to restore the Gulf of Mexico after decades of habitat loss compounded by impacts from the recent Deepwater Horizon oil spill.

Lastly, the success of the partnership has also enabled The Nature Conservancy to promote habitat restoration internationally. The partnership's projects are being showcased in international conferences and well-respected journals and are inspiring oyster reef and bivalve conservation in South America and Europe. TNC's "Global Oyster Reefs at Risk" assessment provided inspiration for a 'Red List' assessment by the International Convention for Conservation of Nature's (IUCN) Global Marine Species Assessment program, and bivalve reef is about to be elevated as an important wetland type under the Ramsar Convention.

Following this first decade of exciting progress, clearly restoration works and is certain to be a key element of ensuring vibrant communities and coastal economies. We look forward to many more years of working in a productive partnership with NOAA and our many community partners with a shared vision for healthy, resilient coasts.

APPENDIX 1

Collecting eel grass chutes at Virginia Coast Reserve. © Mark Godfrey, TNC

TABLE OF PROJECTS, 2001–2011

Partnership I Projects: 2001	Location	Habitat
Santa Clara River Arundo Removal for Steelhead	CA	Migratory Fish Habitat
Pickering Beach Nourishment for Horseshoe Crab in Delaware Bay	DE	Other
FL Keys Diadema antillarum Restoration - Phase I	FL	Coral
Pamlico Sound Subtidal Oyster Reef Habitat Restoration - Phase I	NC	Shellfish
Shellfish Restoration and Monitoring in Long Island Waters: Hard Clam Spawner Sanctuaries	NY	Shellfish
Early Detection and Control of Spartina patens in the Siuslaw Estuary	OR	Marsh
Enhancing Estuarine Hydrology - Croaker Hole, Mustang Island, TX	TX	Marsh
South Padre Island Marsh Restoration and Education Project	TX	Marsh
Quantitative Assessment of Beaver Dams in Chesapeake Bay	VA	Migratory Fish Habitat

Partnership I Projects: 2002	Location	Habitat
Mission Valley San Diego River Restoration	CA	Marsh
Carpinteria Salt Marsh Restoration	CA	Marsh
Parke Pond Fishway Restoration	CT	Migratory Fish Habitat
Project Green Shores Oyster Reef & Saltmarsh Creation (Pensacola)	FL	Shellfish, Marsh
Pamlico Sound Subtidal Oyster Reef Habitat Restoration - Phase II	NC	Shellfish
Sandy River Riparian Habitat Restoration	OR	Migratory Fish Habitat
Dickinson Bay Habitat Restoration Project	TX	Shellfish, Marsh
Chesapeake Bay Beaver Dam Assessment - Phase II	VA	Migratory Fish Habitat
North Puget Sound Spartina Seagrass Eradication	WA	Marsh

Partnership I Projects: 2003	Location	Habitat
Silver Salmon Creek Restoration	AK	Migratory Fish Habitat
Sacramento River Floodplain Restoration	CA	Marsh
Santa Cruz Island Eelgrass Restoration	CA	Seagrass
Hawaii Coral Reef and Native Algae Restoration	HI	Coral
Mike's Island Restoration	MS	Migratory Fish Habitat
Pamlico Sound Subtidal Oyster Reef Habitat Restoration - Phase III	NC	Shellfish
Great South Bay (Bluepoints) Spawner Sanctuaries	NY	Shellfish
Upper Joseph Creek Steelhead Restoration	OR	Migratory Fish Habitat

Partnership II Projects: 2004	Location	Habitat
Santa Cruz Island, Santa Barbara Channel Islands Eelgrass Restoration	CA	Seagrass
California Sacramento River Floodplain Restoration	CA	Marsh
Florida Keys Diadema and Coral Reef Restoration - Phase II	FL	Coral
Hawaii Coral Reef and Native Algae Restoration	HI	Coral
Bridge Creek Salt Marsh Restoration - Phase II	MA	Marsh
East Mississippi Sound Oyster Reef Restoration	MS	Shellfish
Pamlico Sound Subtidal Oyster Reef Habitat Restoration - Phase IV	NC	Shellfish
Great South Bay (Bluepoints) Spawner Sanctuaries - Phase II	NY	Shellfish
Siuslaw Estuary Spartina Detection and Control - Phase II	OR	Marsh
Olympia Oyster Restoration in Woodard Bay Puget Sound	WA	Shellfish
Marsh Restoration Using Large Woody Debris in Port Susan Bay	WA	Marsh

Partnership II Projects: 2005		
Zemco Dam Removal	CT	Migratory Fish Habitat
Ecological Impacts of Zemco Dam Removal	CT	Migratory Fish Habitat
Staghorn Coral Restoration in Florida Keys National Marine Sanctuary	FL	Coral
Restoration of Intertidal Oyster Reefs in Mosquito Lagoon, FL	FL	Shellfish
Intertidal Oyster Reef Restoration in Grand Bay National Estuarine Research Reserve System (NERRS)	MS	Shellfish
Enhancement of Oyster Reef Development at Fifi Island Using Cultch Material as Veneer on Breakwaters	LA	Shellfish
Oyster Reef and Mussel Restoration in Great Bay - Phase I	NH	Shellfish
Hard Clam Restoration in Long Island Estuaries	NY	Shellfish
Olympia Oyster Restoration in Netarts Bay	OR	Shellfish
Oyster, Scallop and SAV Restoration on Virginia´s Coastal Bays	VA	Shellfish, Seagrass
Oyster Restoration in Piankatank River	VA	Shellfish

Partnership II Projects: 2006	Location	Habitat
Sal Creek Habitat Restoration - Phase I	AK	Migratory Fish Habitat
City of Arcata Native Oyster Project	CA	Shellfish
Scaling Up Staghorn Coral Restoration Across the Florida Reef Tract Using Reef Resilience Principles	FL	Coral
Rebuilding Hard Clam Populations in the Indian River Lagoon, Florida	FL	Shellfish
Native Reef Restoration and Invasive Algae Threat Reduction	HI	Coral
Sherman Marsh Restoration and Monitoring: A Serendipitous Opportunity	ME	Marsh
Restoring Hard Clams and Bay Scallops in the Peconic Estuary and South Shore Estuary Reserve	NY	Shellfish
Netarts Bay Native Oyster Restoration Project, Phase II	OR	Shellfish
Intertidal Oyster Restoration in the Coastal Bend, Texas	TX	Shellfish
Partnership for Adaptive Intertidal Oyster Reef Restoration in Smith Island Bay	VA	Shellfish
Oyster Restoration in Liberty Bay	WA	Shellfish
South Sound Oyster Restoration	WA	Shellfish

Partnership III Projects: 2007	Location	Habitat
Colter Creek Culvert Removal Project	AK	Migratory Fish Habitat
Harris Watershed Fubar Creek - Phase II	AK	Migratory Fish Habitat
Richardson Bay Oyster Restoration	CA	Shellfish
Freshwater Creek Estuary Restoration Project	CA	Migratory Fish Habitat
Garcia River Forest Watershed	CA	Migratory Fish Habitat
Restoration of Intertidal Oyster Reefs in Mosquito Lagoon, FL - Phase II	FL	Shellfish
Oyster Reef Restoration in Loxahatchee River, FL	FL	Shellfish
Living Shoreline Restoration in Georgia Tidal Creeks	GA	Shellfish
Wellfleet Bay Oyster Restoration	MA	Shellfish
Mill River Dam Removal and Fish Passage Restoration	MA	Migratory Fish Habitat
Penobscot River Sturgeon Spawning Habitat Restoration	ME	Migratory Fish Habitat
Netarts Bay Native Oyster Restoration Project - Phase III	OR	Shellfish
Coastal Pond Shellfish and Seagrass Restoration	RI	Shellfish
Oyster Restoration in Liberty Bay - Phase II	WA	Shellfish

Partnership III Projects: 2008	Location	Habitat
Salmon Creek Estuary Habitat Structures Project	CA	Migratory Fish Habitat
San Francisco Bay Nursery-Propagated Eelgrass Project	CA	Seagrass
Chicken Island Oyster Restoration in High Impact Boating Areas	FL	Shellfish
Increasing Nearshore Marine Restoration, O'ahu	HI	Coral
Barataria Basin Black Mangrove Habitat Restoration	LA	Mangrove
Bay St. Louis Oyster Restoration Project	MS	Shellfish
Oyster Reef Restoration to Increase Shoreline Resilience	NC	Shellfish
Oyster Restoration: A Scalable Pilot Project	NH	Shellfish
Great South Bay: Expanding Hard Clam Restoration	NY	Shellfish
Yaquina Bay Native Oyster - Phase I	OR	Shellfish
Oyster Reef & Sea Grass Restoration in the Virginia Coastal Bays	VA	Shellfish
Piankatank River Oyster Reef Habitat	VA	Shellfish

Partnership III Projects: 2009	Location	Habitat
Little Susitna Salmon Passage Restoration (ORI)	AK	Migratory Fish Habitat
Upper San Vicente Creek Backwater Pond Restoration	CA	Migratory Fish Habitat
Big Lagoon Turtlegrass Restoration	FL	Seagrass
Sanibel-Captiva Oysters & SAV Restoration	FL	Shellfish
Sarasota Bay Oyster Habitat Restoration	FL	Shellfish
Florida Keys Shallow Sponge Communities	FL	Other
Mill River Dams Narragansett Watershed - Phase III (ORI)	MA	Migratory Fish Habitat
Great South Bay Hard Clam Restoration	NY	Shellfish
Jeremy Island Oyster Reef and Finfish Concrete Castles	SC	Shellfish

Partnership IV Projects: 2010	Location	Habitat
Restoring Connectivity Between the Gulf of Mexico, Alabama River and Cahaba River	AL	Migratory Fish Habitat
Garcia River Forest Salmonid Habitat Restoration, Mendocino County	CA	Migratory Fish Habitat
Native Oyster Restoration in Mugu Lagoon, Ventura County	CA	Shellfish
Southern California Abalone and Kelp Forest Habitat Restoration	CA	Shellfish
Restoring Intertidal Oyster Reefs in Mosquito Lagoon	FL	Shellfish
West Hawai'i Invasive Fish Removal	HI	Coral
Demonstrating the Value of Natural Communities for Shoreline Protection	NC	Shellfish
Scaling-Up Oyster Restoration in Great Bay Estuary, New Hampshire	NH	Shellfish
Hard Clam Restoration in Great South Bay	NY	Shellfish
Puerto Rico Low-Tech Coral Aquaculture and Coral Reef Rehabilitation	PR	Coral
Substrate Enhancement in Ninigret Pond – Oyster Restoration	RI	Shellfish
Chesapeake Bay Fish Passage Study	VA	Migratory Fish Habitat
Livingston Bay Pocket Estuary Restoration	WA	Migratory Fish Habitat
National Fish Habitat Action Plan - West Coast Coordinator	OR	Other

Partnership IV Projects: 2011	Location	Habitat
Pt. Pinole Regional Shoreline Native Oyster Restoration	CA	Shellfish
Save Our Salmon (SOS) – Salmon Creek Instream Habitat Enhancement	CA	Migratory Fish Habitat
Bay St. Louis, Mississippi Oyster Restoration Project	MS	Shellfish
Hard Clam Restoration in Great South Bay	NY	Shellfish
Salmon River Aquatic Habitat Restoration Project	OR	Migratory Fish Habitat
Puerto Rico Low-Tech Coral Aquaculture and Coral Reef Rehabilitation	PR	Coral
Continuation and Expansion of Oyster Reef Enhancement Efforts Using Oyster Castles on Jeremy Island	SC	Shellfish
James River Atlantic Sturgeon Restoration Spawning Reef	VA	Migratory Fish Habitat
Maintaining the Momentum for Scale: Marine Restoration in the Coastal Bays of Virginia	VA	Shellfish
Linking Structural and Functional Characteristics of Restored Oyster Reefs: A Restoration Project in the Virginia Coast Reserve	VA	Shellfish
Upper Quinault River Restoration Project	WA	Migratory Fish Habitat
Puget Sound Restoration Fund advancing Puget Sound oyster restoration	WA	Shellfish
Great Lakes Maumee Area Of Concern	Great Lakes	Other
Fisher Slough Recovery Act Project Support	WA	Migratory Fish Habitat
Chesapeake Bay Marine Spatial Planning	VA	Other

“The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased and not impaired in value.”

~ Theodore Roosevelt

CITATION

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Contact

Boze Hancock PhD.
TNC-NOAA Partnership Coordinator
The Nature Conservancy
Global Marine Team
URI Narragansett Bay Campus
South Ferry Road,Narragansett, RI 02882-1197
bhancock@tnc.org

nature.org

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The Nature Conservancy

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The Nature Conservancy
Worldwide Office
4245 North Fairfax Drive, Suite 100
Arlington, VA 22203