Expanding Oyster Reefs and Populations in Great Bay Estuary, NH
2014 Annual Program Report

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Executive Summary

The eastern oyster (*Crassostrea virginica*) in New Hampshire's Great Bay Estuary has declined in the past decades, with local populations reduced due primarily to disease, excessive siltation, and past over-harvest. The loss of filtering oysters results in diminished ecological benefits for water quality, nitrogen control, and other services that healthy oyster populations provide. In support of management objectives to restore oyster populations, The Nature Conservancy (TNC), University of New Hampshire (UNH), and oyster farm operators from Wagon Hill Oysters and Choice Oysters have combined for another year of progress rebuilding oyster reefs and populations. Since 2009, we have "planted" seasoned shell, primarily surf clam and oyster mix, on channel bottom as a hard substrate foundation to recruit spawn from nearby native populations. Constructed areas are amended to supplement recruitment with laboratory-raised and volunteer-grown "spat-on-shell" from remotely set larvae. Following six consecutive years of reef building, 2014 was another year of progress. We successfully constructed 4.5 new acres of oyster reef in the waters of Greenland in an area of Western Great Bay. In addition, community engagement through the volunteer Oyster Conservationist program reached another all-time high with seventy-five families participating, including three sites participating for the first time across state lines in Maine. Over the past six years, our efforts have added over 18 acres and more than 3M oysters to the ecosystem as part of a continued resurgence in Great Bay Estuary oyster populations.

Background

Growing problems with excess nutrients, wastewater and siltation in Great Bay Estuary require a multi-faceted response that includes improved point and nonpoint source controls, stronger advocacy for estuary protection policies, accelerated coastal land conservation, and innovative in-the-water habitat restoration and pollution control strategies. Sustainable populations of our

native eastern oyster (*Crassostrea virginica*) are a keystone of the long-term health of the estuary, however by the early 2000s we had lost hundreds of acres of oyster reefs due to disease, excessive silt pollution, and past harvest (see Figure 1 for historic/present reef comparison). Loss of vital services followed. Healthy adult oysters provide significant water quality benefits by each filtering about twenty gallons of water per day. These resilient bivalves serve as the estuary's water purification system, controlling nutrients and clearing suspended solids that are harmful to eelgrass beds. Reef aggregations also provide rich habitat and feeding grounds for estuarine fish and other invertebrates. To recover lost services and return the system to balance, managers now recognize that restoring oysters is one of the best direct actions we can take to improve the overall ecological health of the estuary.

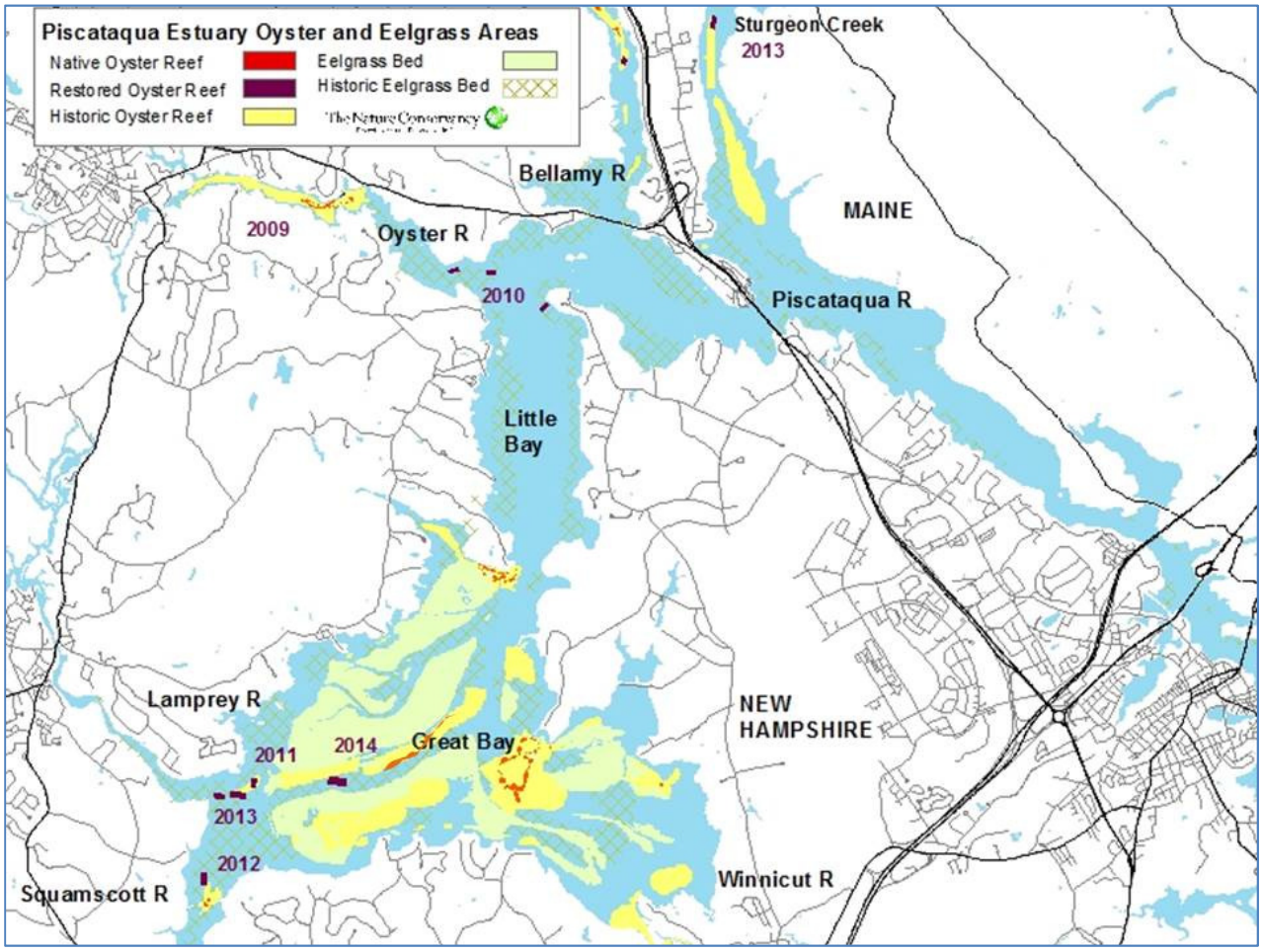

Fig 1. Map of historic NH oyster reefs (circa 1970), current reef, restoration sites, and eelgrass areas

After several years of experimentation by the Grizzle Lab at UNH, TNC and UNH together began to develop methods to restore oyster reefs by "planting" shell on firm channel bottom using primarily surf-clam shell (*Spisula solidissima)* acquired in bulk from a seafood processor. To maximize filtration benefits and to create "spawner sanctuaries", we often work in closed-to-harvest areas in proximity to municipal wastewater outflows. In 2009, we constructed a small (0.2 ac) pilot reef in the Oyster River tributary to assess the shell-based construction method.

Assessments from the pilot reef led to improvement, replication and eventual expansion of the reef restoration efforts. While the clamshell reefs were shown to provide adequate substrate for spat recruitment, annual levels of natural spawn in the estuary were inconsistent and often very low. Long-term observations from NH Fish and Game annual monitoring of native reef areas produced an average annual recruitment of only about 10 spat m^{-2}. Since our sustained native reef areas have an average density of about 50 oysters m^{-2}, we recognize that remote-set seed supplements are necessary to jump-start constructed reefs. Beginning in 2010 the TNC-UNH collaboration was joined by several independent oyster farmers with support from Farm Bill funds. The collaborative began to implement an annual series of oyster reef construction and seeding efforts, now in a sixth year. The restoration efforts are further enhanced by our community-based volunteer program, the Oyster Conservationists, who raise oysters on their private docks as a contribution to restoration reef areas. Annual results of oyster reef construction metrics and most recent recruitment assessments are summarized as follows:

Year	**Restoration Site**	**Acres**	**Project Proponents**	**Shell Used (yd^3)**	**Seeding (spat)**	**Most Recent Recruitment Observation (spat m^{-2})**
2009	Oyster River	0.2	TNC-UNH	20	none	45 m^{-2} (2013)
2010	Oyster River-Fox Point	3.0	TNC-UNH-Farmers	125	201K	4 m^{-2} (2013)
2011	Lamprey River	2.5	TNC-UNH-Farmers	225	489K	13 m^{-2} (2011)
2012	Squamscott River	2.0	TNC-UNH-Farmers	83	96K	>400 m^{-2} (2013)
2013	Lamprey River Piscataqua River	3.5 1.5	TNC-UNH-Farmers TNC-UNH	280 150	836K 354K	59-191 m^{-2} (2013) 6 m^{-2} (2014)

2014 Program Goal and Objectives

Goal

Our 2014 overall program goal is to increase vital ecosystem services provided by oysters (i.e., filtration capacity, nutrient sequestering, and fish habitat). The restoration team of TNC, UNH, and two oyster farmers combined for a total restoration goal of 4.5 acres. We also sought to increase community awareness and engagement through our volunteer-based Oyster Conservationist program and other outreach efforts.

Objectives

Specific 2014 project objectives include: 1) 4.5 acres (180,000 ft^2) of shell-planting area, 2) minimum of 25% bottom cover using a pump/hose shell deployment method, 3) initial reef density of 50 live spat m^{-2} from a combination of natural recruitment and spat-on-shell seeding on the 2.5 acres of TNC reef, and 4) expanded community outreach with 50 private homeowner sites as Oyster Conservationists in New Hampshire and a new pilot initiative in Maine.

2014 Results

The following sections described 2014 project results for site selection, pre-construction staging, reef construction, remote setting, volunteer seeding, monitoring results, and outreach:

Site Selection

The 2014 work site was located in the primary channel at the mouth of the Lamprey rive…r, near an intact live reef and our successful restoration reefs constructed in 2011 (Fig 2 right). The sites were delineated into three reef areas designated as TNC/UNH (2.0 acres), and two farmer-supported reefs for Granite State Shellfish (1.0 acre), and Choice Oysters (0.5 acre). Previous video monitoring from the site associated with the 2011 reefs identified suitable hard substrate along the channel bottom and around a rocky outcrop, with scattered shell and no eelgrass.

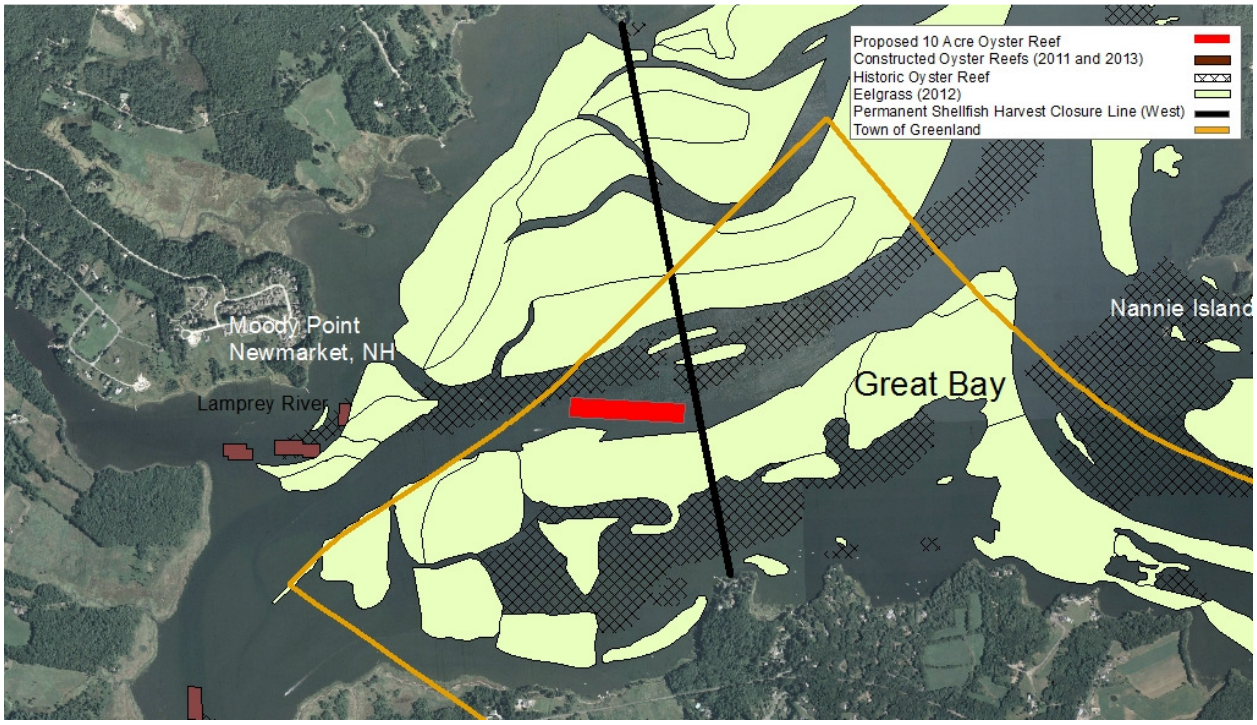

Fig 2. Western Great Bay restoration site TNC 10 acres

Wetlands permits for shell planting from NH DES were secured for the Western Great Bay site area (#2013-0052) in March 2013. Scientific permits were acquired by UNH from NH Dept of Fish and Game for remote set operations and by TNC to distribute spat-on-shell (#MFD 1325).

Staging

The same staging system was implemented this year to move bulk clamshell from our supplier site to the barge. Through our barge contractors, Riverside Pickering Marine, we were able to work with the industrial salt and sand processor on the Piscataqua River to accept the trailer truckloads of shell and provide loading services for the barge. The Granite State Minerals facility provided an outstanding operations and staging area for the project (Fig 3).


Fig 3. Staging operations at Granite State Minerals, Portsmouth, NH

Beginning in early June, TNC received a total of 8 full trailer truckloads of seasoned surf-clam shell (each about 33 yd^3) from M&W Livestock's shell facility in West Wareham, MA. Choice Oyster and Wagon Hill Oysters revieved a total of 6 trailer truckloads. In total, we stockpiled about 448 yd^3 of clam shell for base reef construction.

Reef Construction

Between June 23 and July 3, shell was loaded onto the barge and ferried out to the reef areas. Two barge trips were needed to move the clam shell out to the Western Great Bay site. On location, the barge operator deployed the shell with a deck-mounted 150-HP diesel pump and fire hose assembly attached to a small barge platform that could be re-positioned. The barge was moved into location, spudded down, and the pump engaged to spray. The operator sprayed methodically to push the shell over the edge of the barge in a fairly steady stream. Another operator on the barge also used a clamshell bucket on a crane winch to supplement the shell spreading further out from the barge to reduce the number of spud relocations needed. The operators worked over the course of two weeks to distribute the shell, sometimes anchoring the barge down overnight when conditions were not suitable for safe deployment. Across both sites, a total of 200,000 ft^2 (5 acres) of tidal river bottom was shelled as reef foundation.

Remote Setting Operations and Seeding

To enhance reef development, UNH laboratory staff conducted remote setting operations to produce spat-on-shell amendments and seed the newly constructed reefs (Fig 5). Starting in May, UNH staff, TNC staff, and volunteers worked to prepare recycled oyster shell for remote setting. As in past years, our oyster shell supply was procured through the Coastal Conservation Association (CCA) Restaurant Recycling Program (www.ccanh.org). Due to the unprecedented need for spat, Ray Grizzle and Krystin Ward expanded operations from two to six setting tanks, each loaded with wire mesh cages filled with power-washed oyster shells. In total, we used 187 mesh cages each filled with about 350 shells for an estimated 65K total shells used. John McLean from the NH Agricultural Experiment Station located at UNH Kingman Farm again

helped load oyster shell from our composting site for transport to UNH Jackson Lab. In total, we estimate that about 15 yd^3 of oyster shell was used for spat-on-shell substrate.

On June 21, we received 10M oyster eyed-larvae from our long-time provider Muscongus Bay Aquaculture (Bremen ME) for remote setting. Larvae were dispersed into six setting tanks with the clean shells in cages. Six days later after setting, cages were taken from the tanks and ferried out to the nursery raft for further growth. UNH staff conducted systematic sampling of on the raft from late June until mid-August to track survival and growth. During the weeks of August 19 and 26, cages were untied from the raft, loaded on service boat, ferried to the Lamprey and Piscataqua sites and dispersed by hand across the constructed reef areas.

Oyster Conservationist Program and Seeding

2014 marked the ninth consecutive year of the NH Oyster Conservationist program, a volunteer program for homeowners to grow oyster spat on their private docks for restoration. This was our biggest year ever for community engagement, expanding to 70 homeowner sites and 75 families.

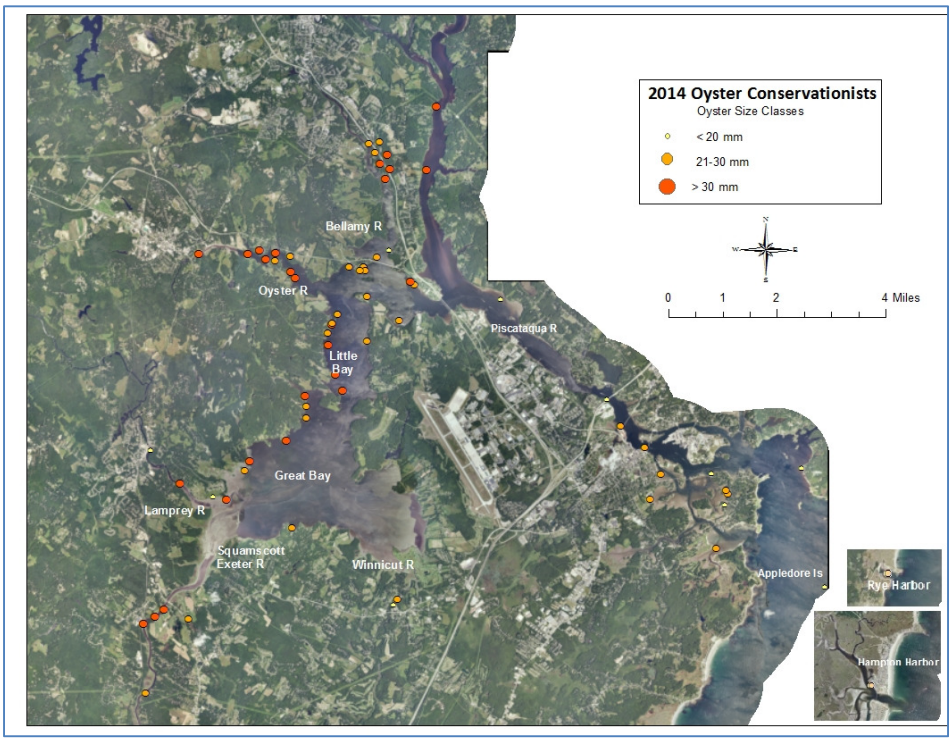

Fig 4. Distribution of 2014 NH OC program sites and summary oyster size results

Homeowners and supporting volunteers received training, data collection materials, and oyster cages for growing and monitoring spat. In all, we engaged 84 volunteers this year and operated in eleven towns around Great Bay Estuary, Rye Harbor, and Hampton Harbor (Fig 4). Our program participants contributed a total of 1500 volunteer hours of labor during the ten-week season. By the end of the season, our volunteers had raised 7K healthy oysters, more than triple our biggest annual production. In late September, the volunteer-raised oysters were spread on the Lamprey reefs. The 2014 OC Final Report is available on www.nature.org/nhoysters at

http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/newhampshire/oyster-restoration/nh-2013-oyster-conservationist-report-for-web-1.pdf

Reef Monitoring Results

UNH conducted post-construction reef monitoring to assess project performance relative to program objectives for 1) shell coverage, 2) recruitment, and 3) seeding operations on created reef.

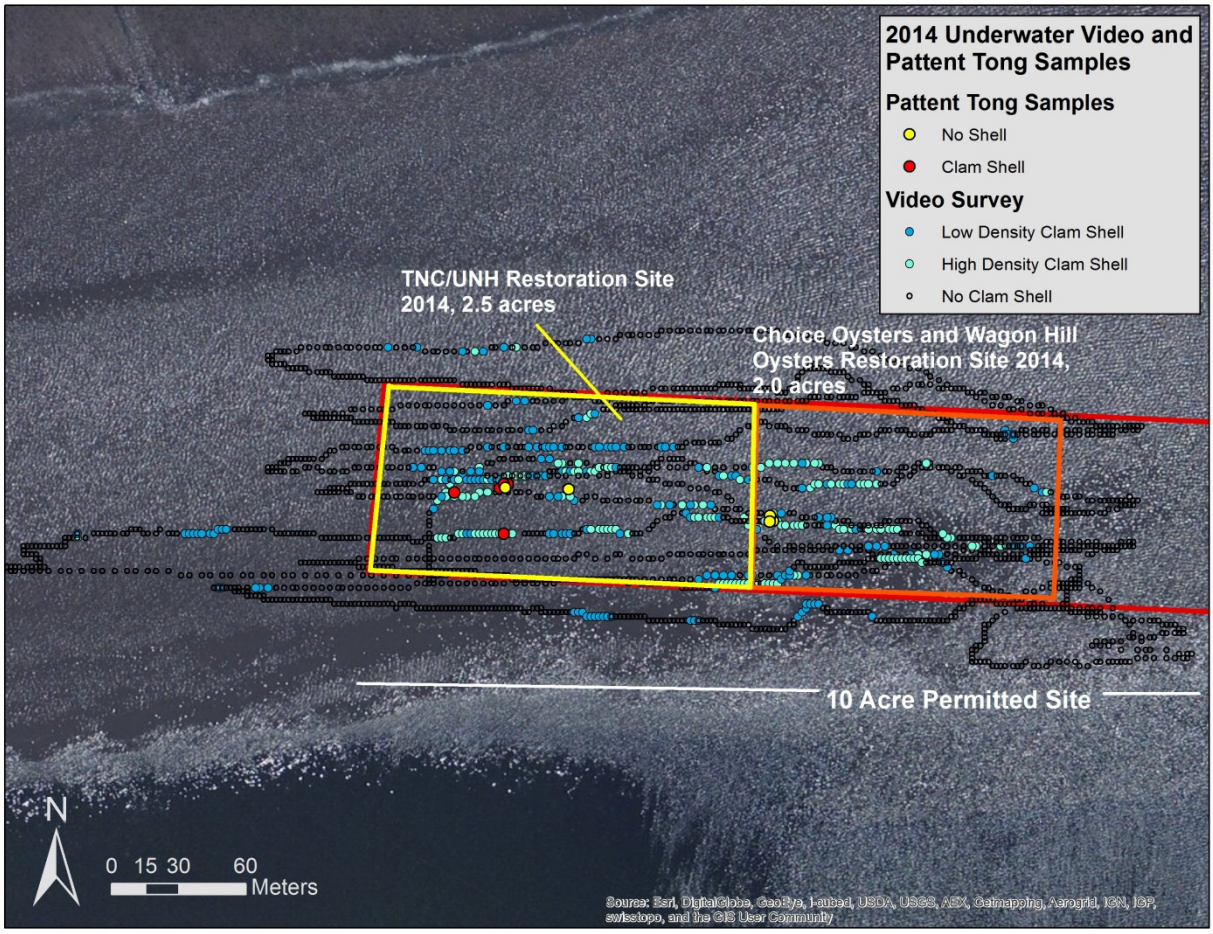

Fig 5. Video surveys of Western Great Bay restoration site TNC 2.5 acres (left) and Choice Oysters & Wagon Hill Oysters 2.0 acres (right)

Across all 4.5 acres of construction, we achieved a weighted average shell cover of 36%. Our results exceed the NOAA Restoration Center minimum metric of 25% shell cover, and at full shell allocation, validate the new method as an effective technique for distributing bulk shell. We recognize that results will vary from site to site due to, among other factors, shell loss in areas of soft sediments, presence of tidal currents that redistribute shell, and variability in the amount of shell hosed overboard at a spud location that produced deep piles in some areas. Going forward, we will continue to use the new technique and adaptively seek improvements.

1. Recruitment. Reef clamshell substrate was sampled between September and November 2014 to assess first-year natural oyster recruitment on deployed shell. The patent tongs are calibrated to retrieve 0.16 m^2 of reef area, which allows us to estimate density of live oysters recruited per square meter of constructed reef. The monitoring team used the shell distribution maps from the video monitoring to target shelled areas for stratified random sampling within a reef block area. Multiple patent-tong samples were secured but no live spat were collected from surf-clam settlement.

2. Remote Set Seeding.
   Including volunteer seeding, our remote set efforts produced 37K oysters that were spread on the newly created reef in September 2014.

Outreach

Building and sustaining connections with the community at large continues to be a major objective for our program. We increasingly recognize that the ever-popular oyster is perhaps the best way to relate tangible estuarine values to the average citizen. As in past years, our outreach efforts include a broad array of activities and actions that communicate the strong connections between oysters, healthy estuaries, and vibrant communities. In particular, the expanding Oyster Conservationist program leads our outreach activities through direct engagement with a growing community of oyster enthusiasts. This year, volunteerism reached a new level of engagement as the Oyster Conservationist program established itself as perhaps the largest community-based volunteer program in Seacoast NH.

Outreach events and activities in 2014 include our busy outreach tents at the Piscataqua Oysterpalooza in September, the UNH Know-The-Coast Day, and as guest speakers on a public cruise aboard our partner's Gundalow Company educational vessel and at a popular Portsmouth Brewery as part of the Sustainable New Hampshire series. Collectively, it was a highly successful year of raising public awareness through the charismatic powers of our native oyster.

Conclusions

Looking collectively at the past six years, we can begin to make some assessments of the overall impact of our program on oyster populations in Great Bay Estuary. Known areas of oyster beds have been monitored continuously in GBE since the early 1990s but there has been no comprehensive survey of the entire system to estimate the total footprint of live oyster reefs. However, there is increased effort for survey work in 2015 and a picture of native reef area is emerging as more reef areas are delineated. The most recent survey results are still being complied but it appears that a reasonable estimate of live native oyster reef may be on the order of 120 acres. Using a long-term observed survey density of 50 oysters m^{-2} on native reefs we can infer that these natural reefs harbor about 24M total oysters. Our restoration efforts in the past six years have established 18 new acres of reef and added an estimated 3M oysters to the system. If we make the assumption, and this is yet to be fully established, that our constructed reefs maintain fairly stable populations (i.e., annual mortality balances annual recruitment), our restoration efforts have expanded by at least 10% the reef acreage and native oyster populations of the entire GBE ecosystem in the past five years. Long-term monitoring is most certainly needed to better understand population dynamics but results to date demonstrate that our reefs

are capable of recruiting spat and maintaining adults for at least four years post-construction. Clearly, more extensive monitoring efforts will be required to show long-term sustainability of restored reefs and dynamics of native reefs in our system.

Each year, we build on past efforts and gain insights and encouragement for future restoration. We learn much from our evolving techniques and methods, all in the context of constantly changing complex ecosystem. We are pleased with recent results and continue to build momentum for oyster restoration as one of the best ways to restore the health of Great Bay Estuary.