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2016 Oyster Reef Restoration Project Funded by the Aquatic Resources Mitigation Program

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Oyster Reef Restoration in Great Bay Estuary

Subaward to the University of New Hampshire from The Nature Conservancy

Funded by the New Hampshire Aquatic Resources Mitigation Program

FINAL REPORT - March 31, 2017

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Introduction

This report describes the results of the construction and initial monitoring phase of an oyster restoration project conducted in 2016 by the University of New Hampshire (UNH) and The Nature Conservancy (TNC), funded by the New Hampshire Aquatic Resources Mitigation Program. The overall goal of the project was to construct 5 acres of new oyster reef habitat in an area adjacent to a live natural reef northwest of Nannie Island, in the Town of Newington, NH, off Woodman Point (Fig. 1). The report is organized according to the four major tasks listed as deliverables in the subaward to UNH from TNC.

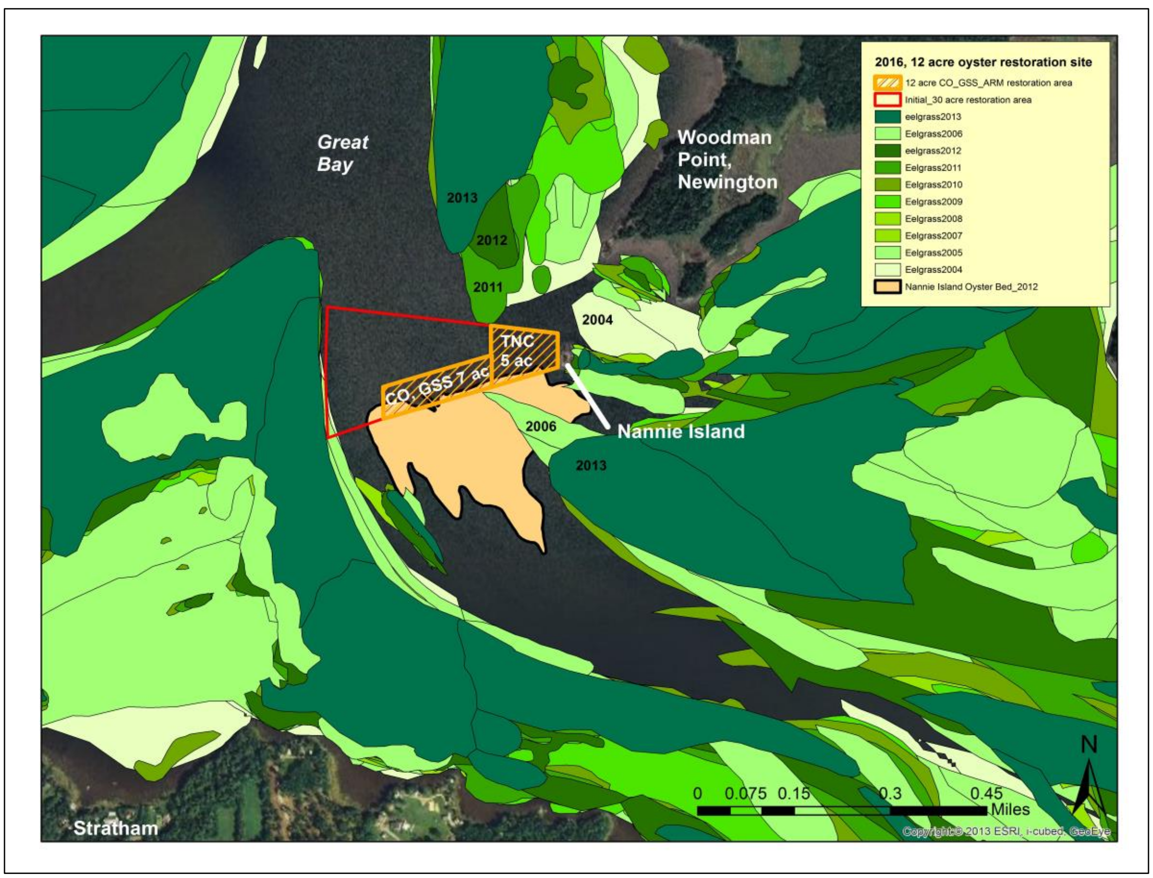

Fig. 1. 5-acre ARM restoration site (yellow cross-hatched area "TNC 5 ac") adjacent to Nannie Island and live natural reef (tan polygon) in Great Bay with historical mapping of eelgrass shown.

In addition to the four major tasks, all required permits were secured by UNH from the NH Departments of Environmental Services (DES) and Fish and Game (F&G) for three major activities involved in the overall project. A Scientific Permit which authorized monitoring and sampling of oysters on the constructed reef was obtained from F&G on February 19, 2016. An Importation of Wildlife permit which authorized the use of 12 million oyster larvae from Muscongus Bay Aquaculture hatchery in Maine to produce the live oyster spat-on-shell used in "seeding" the constructed reef was obtained on May 6, 2016. Finally, a permit was obtained on July 21, 2016 from the DES Wetlands Bureau to place 500 cubic yards of seasoned mollusk shell used in construction of the reef base on the 5-acre site.

Task 1: Pre-construction activities

- Conduct pre-construction site survey
- Place buoys on site to mark site for barge
- Produce sketch of shell deployment plan for shell piles throughout the 5-acre area

The restoration site was surveyed using towed underwater video on July 11, 2016 following the methods in Grizzle and Ward (2013). The video imagery was classified into three bottom types (Fig. 2): mud, shell, and eelgrass. Approximately 4 acres of the overall 5-acre site consisted of mud bottom that was most suitable for constructing the shell base. Scattered clusters of live oysters were observed in a ~0.5-acre area in the southwest corner of the overall site, and scattered eelgrass shoots were observed in a ~0.5-acre area in the northwest corner. It was determined that some shell should be deposited into the scattered oyster area, and no shell in the eelgrass area. However, it should be noted that it was not possible to determine from the imagery if any of the observed eelgrass was rooted; floating/drifting eelgrass shoots were observed in the area during the time of the survey. The resulting map was used to develop plans for placement of the shell (Fig. 2), and the boundaries of each of the three different shell treatment areas were marked with buoys.

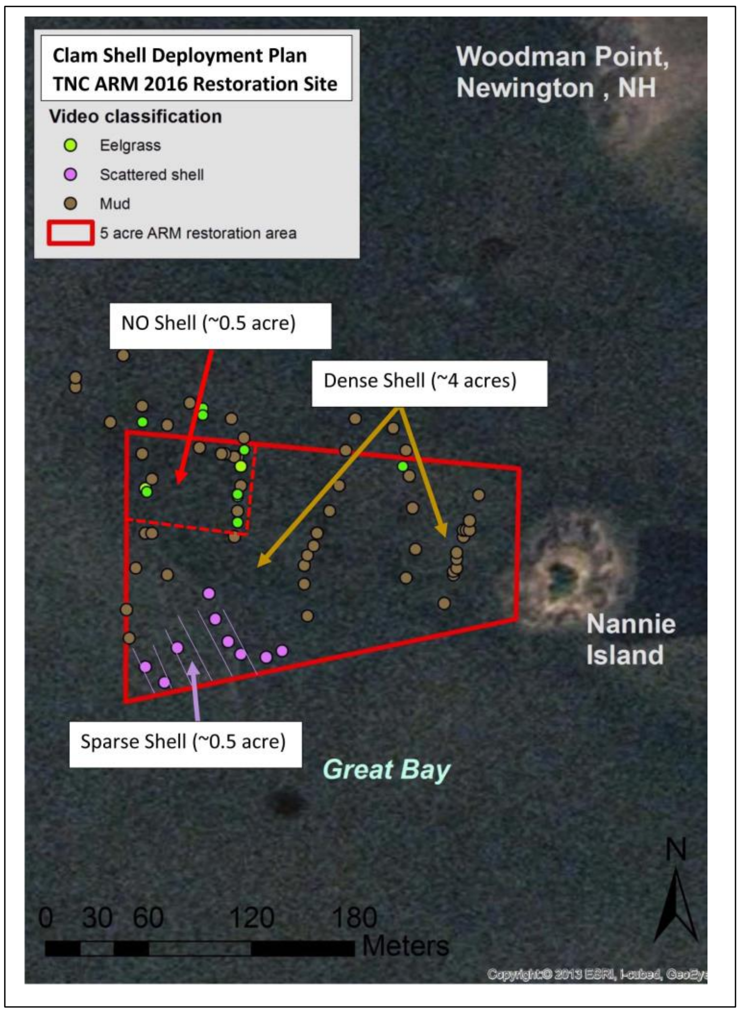

Fig. 2. Bottom types in project area based on underwater video imagery indicating overall mollusk (surf clam) shell deployment plans ("No Shell", "Dense Shell" or "Sparse Shell") for reef base construction.

Previous oyster reef restoration projects in Great Bay have indicated that the shell base can become covered (via subsidence or sediment deposition) with soft sediments, thereby preventing natural recruitment to the constructed reef base material (Grizzle and Ward 2016). This suggests that the reef base should be constructed in a manner that results in as much vertical relief as practical. Based on the fixed amount of shell available for the project (500 yd^3), it was decided that the shell would be deposited in 20 - 25 mounds each extending ~0.5 m above the bottom across the 4-acre mud bottom area, and only a thin layer of scattered shell in the 0.5-acre oyster area (Fig. 2). A map indicating this general plan for shell deposition was provided to the marine contractor to guide reef base construction.

Task 2: Reef base construction

- Obtain two marine contractor estimates for shell base construction
- Assist TNC in arranging the logistics and scheduling of shell base construction
- Assist in the field in reef construction process

Bid requests were received from Riverside and Pickering Marine and Pepperrell Cove Marine on May 20, 2016. The award for construction of the reef shell base subsequently was made to Riverside and Pickering. Arrangements were also made with M&W Livestock for shell delivery, and with Granite State Minerals for temporary shell storage and handling. Approximately 500 yd^3 of seasoned (6 months) surf clam shell was delivered to Granite State Minerals, and reef base construction occurred on July 18 - 21, 2016 (Fig. 3).

Fig. 3. Shell delivery by truck at Granite State Minerals, and reef shell base construction by Riverside and Pickering Marine.

Task 3: Oyster spat-on-shell (SOS) production and deployment

- Receive and grow 12 million eyed oyster larvae (purchased by TNC) to produce an estimated 0.75 to 1.0 million oyster spat on shell
- Assist TNC in accessing oyster cages at Jackson Estuarine Laboratory (JEL)

- Coordinate with Alyson Eberhardt, Coastal Restoration Volunteers, to enlist and schedule volunteers to assist in cleaning oyster shells, and provide a suitable area onsite at JEL for this work
- Deliver SOS from JEL rafts and from Oyster Conservationist Program to the constructed oyster reef

Preparation of seasoned, recycled oyster shell and the remote setting tanks at Jackson Estuarine Laboratory occurred on June 15 – 21, 2016 (Fig. 4). Approximately 12 million oyster larvae were received on June 22, 2016 and placed into the remote setting tanks. The resulting live oyster SOS were moved from the remote setting tanks to the nursery rafts in Adams Cove on June 27, 2016.

Fig. 4. Overview of SOS production showing remote setting tanks with seasoned shell in cages (upper photos) and maintaining spat on nursery raft (lower photos).

Initial counts (after the third day) of live SOS in the remote setting tanks indicated successful settlement of ~4.6 million of the 12 million larvae originally placed into the tanks (=38% setting success). After 9.5 weeks on the nursery rafts, the SOS were removed from the rafts and deposited onto the shell base at the restoration site on August 30, 2016 (Fig. 5). At that time, live SOS averaged 11.8 (±1.14; 1 SE) spat per individual dead oyster shell (cultch) yielding a total of ~660,000 live oysters (SOS) with a mean size (shell height) of 15.7 mm (±0.31; 1 SE) placed onto the restoration site. The target SOS "seeding density" was 150,000-200,000 spat per acre of constructed reef; assuming 4.5 acres (0.5 acre was not seeded due to possible presence of eelgrass; see Fig. 2) of "seeded" bottom, the actual "seeding density" was ~147,000 spat per acre. Additional live SOS were also distributed from the 85 participating sites in the 2016 Oyster Conservationist (OC) program.

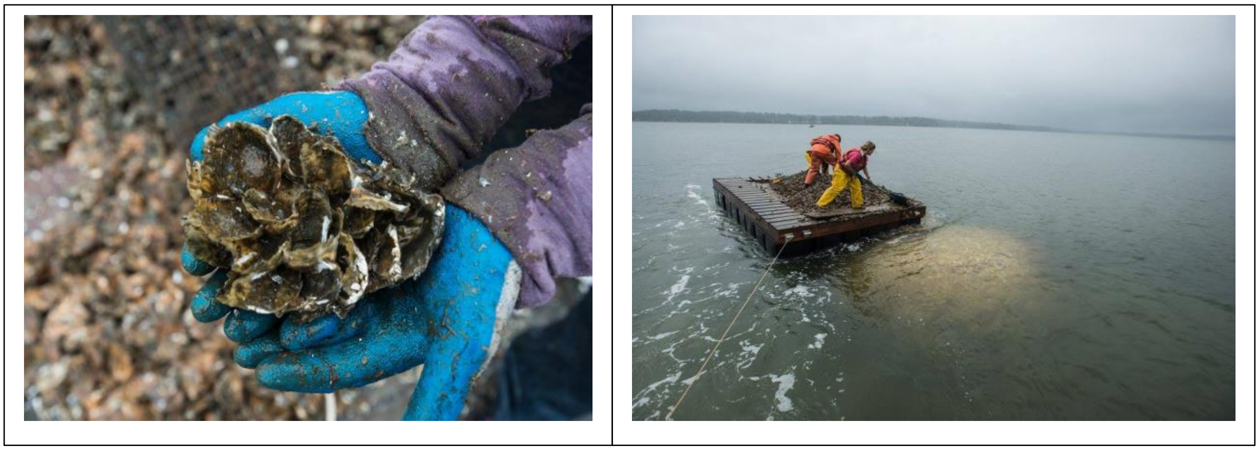

Fig. 5. Spreading SOS onto the shell mounds.

***Task 4:* Monitoring and assessment**

- Conduct verification monitoring of reef construction in fall 2016
- Submit summary report of verification assessment results

Initial (2016) monitoring and assessment consisted of four major activities: quantitatively characterizing the clam shell reef base; confirming the presence on the reef base of live SOS from the remote setting and nursery raft process; quantifying any natural spat set occurring onto the clam shell base; and characterizing oyster disease burden of oysters (remotely produced SOS and natural spat set) at the restoration site. The aim was to provide data on all four "universal metrics" recommended for monitoring oyster restoration projects (Baggett et al. 2015).

Towed underwater video following the methods described in Grizzle and Ward (2013) was used on October 6, 2016 to characterize clam shell coverage of the restoration site. Video imagery indicated that ~15% of the entire 4.5-acre shelled area was covered with shell (Fig. 6; Table 1). After the video mapping was conducted, Google Earth posted online satellite imagery dated October 5, 2016 that clearly showed major bottom features in the entire restoration area, including the surf clam shells that had been deposited in July. Visual inspection of the two maps indicate very similar locations and bottom area coverage by clam shell (Fig. 6). The restoration site was also visited and inspected on several occasions during August and September 2016. Direct measurements at low tide on several of the clam shell mounds using a marked rod indicated they ranged from 0.5 to 1.2 m height above the bottom.

The amount of bottom area coverage achieved (15%) was less than the 25% level which typically has been the target for previous restoration projects in New Hampshire. Additionally, the height of several of the mounds was well above the design criterion of 0.5 m. Shell base design criteria included construction of multiple shell mounds across the restoration area, and all criteria were met by the marine contractor. However, it was difficult to determine how well the mound height criterion was being met because there was no inspection of the shell mounds until the project was completed. Future projects will need to include better on-site construction monitoring to insure all design criteria are met.

Fig. 6. Left: Surf clam shell bottom area coverage (pink polygons) indicated by towed underwater video imagery recorded on October 6, 2016. Right: Surf clam shell mounds (polygons outlined in white) visible in online Google Earth satellite imagery taken on October 5, 2016.

Patent tong (0.1 m^2 surface area) sampling of five mounds (one sample per mound) following the methods described in Grizzle and Ward (2016) was conducted on October 11, 2016 and all live oysters were counted and measured (shell height to nearest mm). Wild (natural set) spat density on the clam shells used to construct the reef mounds averaged 28.0/m^2 (Table 1). This level of recruitment is relatively low compared to historical spat densities on New Hampshire's oyster reefs, but compares well to the fall 2016 Fish & Game data from the adjacent Woodman Point reef (NHF&G 2017).

A total of 35 live oysters (14 SOS from the remote setting process [11 – 25 mm shell height] and 20 spat [13 – 33 mm shell height] from natural settlement onto the surf clam shells) were collected from the restoration site on October 16, 2016 and shipped to the Haskin Shellfish Laboratory for disease testing. No *Perkinsus* spp. (Dermo) or *Haplosporidium nelsoni* (MSX) infections were detected in any of the oysters.

Table 1. Summary of initial monitoring data from restoration site.

Date	Amount of shell used in reef base construction (yd^3)	Total restoration area (acres)	Shell cover achieved (% of area)	Shell base height range (m)	Total remotely set oyster spat-on-shell added to reef base
2016	500	4.5	15%	~0.5 - 1.2	660,000
2017					
2018					

Date	Remotely set spat (≤40mm shell height) density[1, 2] (#/m^2; ±1SE)	Remotely set adult oyster (>40mm shell height) density[1, 2] (#/m^2; ±1SE)	Wild spat (≤40mm shell height) density[1, 2] (#/m^2; ±1SE)	Wild adult oyster (>40mm shell height) density[1, 2] (#/m^2; ±1SE)	Total live oyster density[1, 2] (#/m^2; ±1SE)
2016	72.0 (±60.0)	0	28.0 (±10.2)	0	100.0 (±60.1)
2017					
2018					

[1]Data based on patent tong sampling; wild vs. remotely set determined by attached substrate: all remotely set oysters were on oyster shell, all wild set were on clam shells used in reef base construction.

[2]Represents samples taken only on shell mounds used to construct reef base.

Conclusions and Next Steps

Two major conclusions can be drawn from the initial monitoring results. First, the constructed clam shell reef base caught a spat set from wild oysters comparable to the 2016 spat set on the nearby natural reef at Woodman Point. The restoration site for the present project was chosen based on recent research indicating that most natural spat set can be expected within 1 km of a natural reef with reproducing adult oysters (Eckert 2016; also see discussion and site selection implications in Grizzle and Ward 2016). Thus, the initial monitoring data support the notion that the chosen site has good potential for continued natural spat sets.

A second conclusion is that the initial field observations and sampling data suggest that the constructed clam shell base may have good potential for long-term persistence. As already noted, one of the major limitations to oyster reef restoration in some areas of Great Bay has been sedimentation resulting in burial of the constructed reef base (Grizzle and Ward 2016). Although the design for the present project (i.e., multiple shell mounds extending well above the bottom) appears to have been a good choice in this respect, some sediment build-up observed around a few of the shell mounds also indicates that sediment movement is occurring at the site. Future monitoring efforts at the study site will be needed to determine if additional shell substrate is needed.

The overall implication of the above initial conclusions is that future monitoring efforts will be essential for documenting reef development as well as determining if additional restoration activities are needed to enhance the probability of long-term sustainability of the constructed reef.

Acknowledgments

We thank the following individuals for their help with the project. Doug and Ken Anderson and their staff at Riverside and Pickering Marine constructed the shell base. Justin Sunderland at Granite State Minerals managed temporary storage of the shell and loaded the shell barge. Wayne Moniz of M&L livestock supplied and transported the shell used in reef base construction. Tonie Simmons and staff at Muscongus Bay Aquaculture provided the larvae used in the remote setting process. John Mclean and Evan Ford at Kingman Farm helped with storage and transport of the recycled oyster shell used in remote setting. Through her Coastal Research Volunteers program, Alyson Eberhardt coordinated the many volunteers who helped with the remote setting process: Brittany Bivona, Jace Porter, Mike Stockdale, Kellyam Valle-Cancol, Jose Perez, Heather Gilbert, Aleece Mount, Debra Kam, Joe Rankin, Rebecca Segelhurst, Lee Pollack, Sylvia Pollack, Sue Kaufmann, Denis Beaulieu, Lauren Anderson, Judy Matthews, Steven Lake, Hannah Slarherty, Jody Thomas, Cas Donovan, Karen Erlandson, Roger Lawrence, Marianne Rork, Katherine Woolhouse, Sarah Chapman, Ayshah Kassamali-Fox, Andra Welch, Bill Radford, Tamara Harner, Maren Crabill, Zhenhui Jiang, Amana Vander-Hayden, Michelle Elbert, Holly Oliver, Shea Flanagan, Austin Huntley, Olivia Ellis, and John Davis. Dave Patrick, Ellie Baker and Amanda Moeser of The Nature Conservancy assisted in several activities. We also thank Nate Perry who helped with spat-on-shell deployment. And finally, we thank the 170+ volunteers who participated in the 2016 Oyster Conservationist Program. These citizen scientists are from schools and local businesses as well as individual families that continue to do their best to make our oyster reef restoration projects successful.

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