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Oyster Reef Restoration Project for the City of Dover, Grizzle

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Oyster Reef Restoration Project for the City of Dover

A Final Report to

The New Hampshire Estuaries Project

Submitted by

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NewHampshire EstuariesProject

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Executive Summary

This project was conducted as a contract between the City of Dover and the University of New Hampshire, with additional funding supplied by the New Hampshire Estuaries Project. The overall goal was to restore as much bottom area as possible (with available funds) of formerly productive oyster bottom in two areas, the Bellamy River and Pomeroy Cove (Piscataqua River). The restored areas were intended as a contribution to the long-term NHEP goal of restoring 20 acres of oyster bottom by 2010 (Trowbridge 2003). Five objectives were addressed: (1) site surveys, map production, and final restoration protocol development; (2) remote setting of oyster larvae; (3) bottom "seeding" with spat; (4) assessment of restoration success; and (5) education.

Site surveys found substantial amounts of "shell bottom" (but only two live oysters) along a 1.2 km stretch of the Bellamy, and no oyster bottom off Pomeroy Cove. Hence, restoration efforts were designed only for the Bellamy. "Spat seeding" involving deposition onto the existing bottom (i.e. no bottom improvement via placement of additional hard substrate or other methods) of spat (young oysters) attached to shell substrate produced by remote setting was chosen as the primary reef restoration method.

Larvae from native Great Bay oysters were set in tanks at UNH's Jackson Estuarine Laboratory (JEL) in July 2005, and held on a nursery raft at JEL until reef construction in November 2005. Approximately 300,000 spat-on-shell were used to construct 12 "mini-reefs" (total surface area ~0.1 acre) within a 1.5-acre overall restoration area. On 26 July 2006 (9 months post-construction), 32,000 live oysters remained on the mini-reefs and no live oysters were found in adjacent natural reef areas. When considering only the 0.1 acre area covered by the mini-reefs, live oysters occurred at $64/m^2$, which is similar to oyster densities in other areas in Great Bay. When considering the entire 1.5-acre restoration area, live oysters were at $\sim 4/m^2$.

The entire 1.5-acre area was considered "restored" in the short-term. Longer-term restoration success will be dependent upon successful natural recruitment to the mini-reefs as well as the adjacent bottom areas. Diver observations in July 2006 indicated that very little oyster shell (other than what was put out with the spat in November 2005) remained in the restoration area. This suggests that longer-term restoration success may require placement of additional shell onto the bottom. Longer-term success will be assessed by future sampling as funds become available.

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Introduction

The present project was conducted as a contract between the City of Dover and the University of New Hampshire, with additional funding supplied by the New Hampshire Estuaries Project. The overall goal was to restore as much bottom area as possible (with available funds) of formerly productive oyster bottom in two areas, the Bellamy River and Pomeroy Cove (Piscataqua River). The restored areas were intended as a contribution to the long-term NHEP goal of restoring 20 acres of oyster bottom by 2010 (Trowbridge 2003).

Project Goals and Objectives

The overall goal of oyster bottom restoration (see above) was met by addressing the following five objectives: (1) site surveys, map production, and final restoration protocol development; (2) remote setting of oyster larvae; (3) bottom "seeding" with spat; (4) assessment of restoration success; and (5) education.

Methods

Objective 1. Existing oyster bottom in two areas, the Bellamy River and Pomeroy Cove (Piscataqua River), were surveyed with a towed underwater video system with differential GPS that provides georeferenced bottom imagery, using the standard protocol developed by our laboratory (Grizzle and Brodeur 2004; Grizzle et al. 2006). The Bellamy River site was visited in November 2004, on 12 May 2005 and 22 September 2005; Pomeroy Cove was visited on 13 May 2005. Geo-referenced video imagery from all site visits was combined into a single dataset for bottom mapping. In addition to the video, samples of the bottom were taken in the Bellamy River in May and September 2005 with oyster tongs to ground-truth the video imagery.

The video imagery was classified by visual inspection into "non-reef" (<10% bottom coverage by oyster shells), "low density reef" (10% to 25% coverage by oyster shells), "moderate density reef" (25 to 50% shell cover) or "high density reef" (>50% shell cover) for all areas surveyed. The classification types were then plotted along the shiptracks on a base map (nautical chart of the area) and polygons were constructed manually, drawing each boundary line approximately midway between bottom type classes.

The final design protocol for reef restoration consisted of bottom seeding with spat-on-cultch material (Objectives 2 and 3), but no use of additional substrate for building up the bottom. Therefore, spat seeding was restricted to areas with moderate and high density shell cover to try to provide maximal stability for reef construction.

Objective 2. Two 2,000 gallon capacity setting tanks at Jackson Estuarine Laboratory (JEL) were used to remotely set (15-20 July 2005) hatchery-reared larvae from native Great Bay (near Nannie Island), New Hampshire broodstock to produce spat for reef restoration. Mollusc shells (mainly native oyster shell with some hard clams) were used as cultch material following techniques that have been developed at JEL and based on general protocols in Castagna et al. (1996) and Supan et al. (1999). The spat were held in suspension on a nursery raft in Adams Cove, adjacent to JEL for approximately 15 weeks until removal for reef construction (Objective 3).

Objective 3. Reef construction was accomplished by transferring spat from the nursery raft to the study area and depositing them on the bottom. This occurred on 3 and 4 November 2005 in the Bellamy River (Pomeroy Cove was not restored; see below). The spat were concentrated in 12 "mini-reef" areas, each circular in shape and 5 to 10 m diameter.

Objective 4. Initial restoration success was assessed by sampling "on" (within constructed mini-reef areas) and "off" (on natural reef bottom only) constructed reef areas on 26 july 2006 using replicate 0.125 m^2 quadrats. All oyster shell was removed from each quadrat by divers, returned to the boat where live oysters were counted and measured (shell height to nearest mm using calipers).

Objective 5. Two educational components were incorporated into the overall project. The first was two independent studies on oyster ecology and oyster reef mapping techniques by undergraduate students at the University of New Hampshire. The second was collaboration on a marine biology classroom teaching and field experiences project at Dover High School.

Results and Discussion

Pre-restoration (2005) location and condition of oyster reefs

Oyster shell bottom was only found in the Bellamy River; no oysters were found in Pomeroy Cove. Hence, all mapping and restoration activities were restricted to the Bellamy River. Based on presence and distribution of oyster shells on the bottom in 2004 and 2005, the Bellamy reef occurred mainly in the channel (subtidal waters) in three separate areas along about 1.2 km (0.75 mi) of the river (Fig. 1). Sampling with oyster tongs in about fifteen locations only yielded two live oysters; the reef was essentially dead in 2005.

Reef restoration protocol

Although the Bellamy reef was dead, there appeared to be sufficient densities of shell in several areas ("medium and high density" shell areas in Fig. 1) to allow spat seeding directly onto the existing bottom without adding shell or other hard substrate. A 1.5-acre area in the southern end of the historic reef area consisting mostly of medium and high density shell bottom was chosen as the overall "restoration area" (Fig. 2).

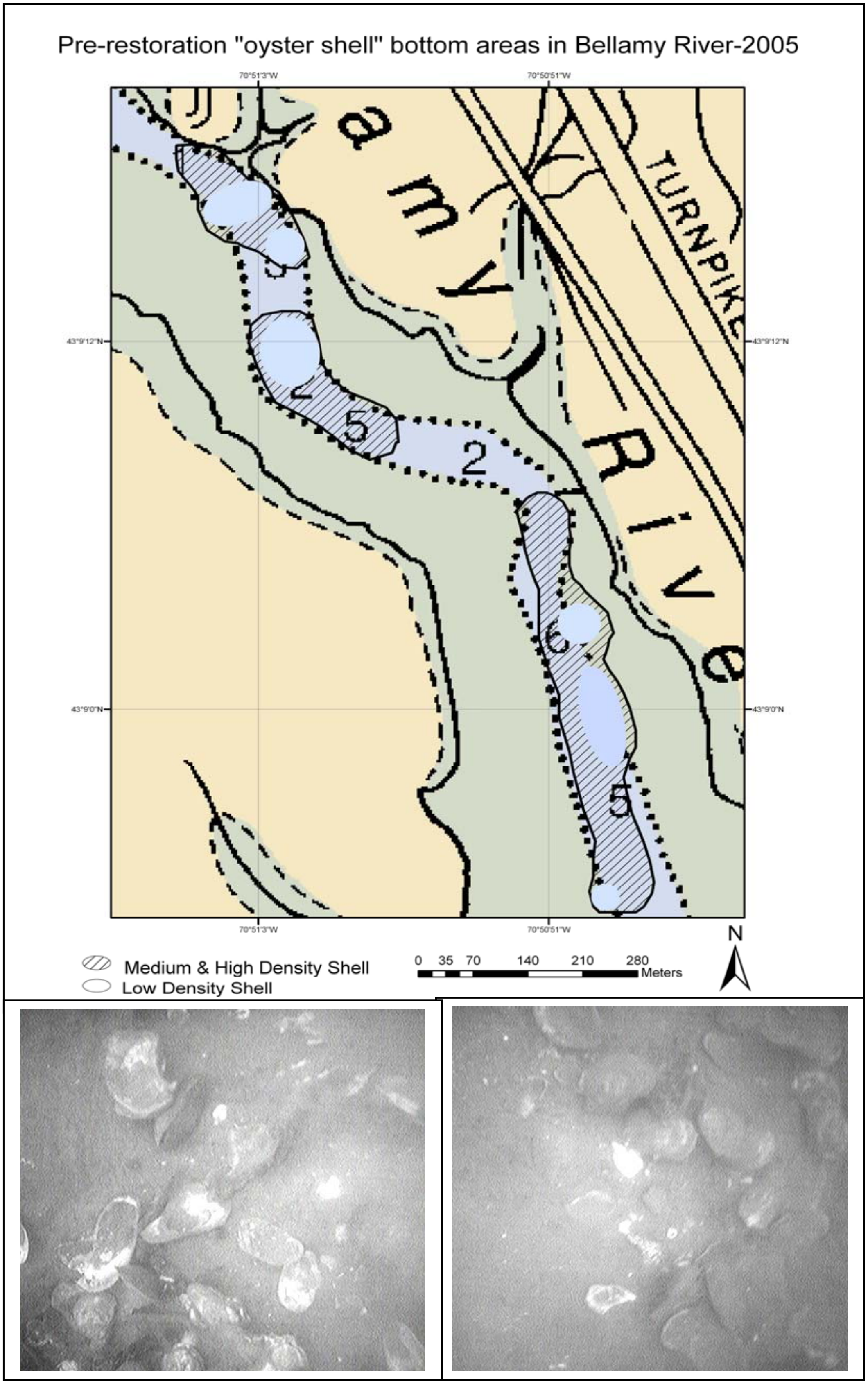

Fig. 1. Location of "oyster shell" bottom (indicating the recent historical extent of the reef) in lower Bellamy River based on video surveys in 2004 and 2005. Photos from video stills show shell densities ("medium") typical of restoration area (Fig. 2).

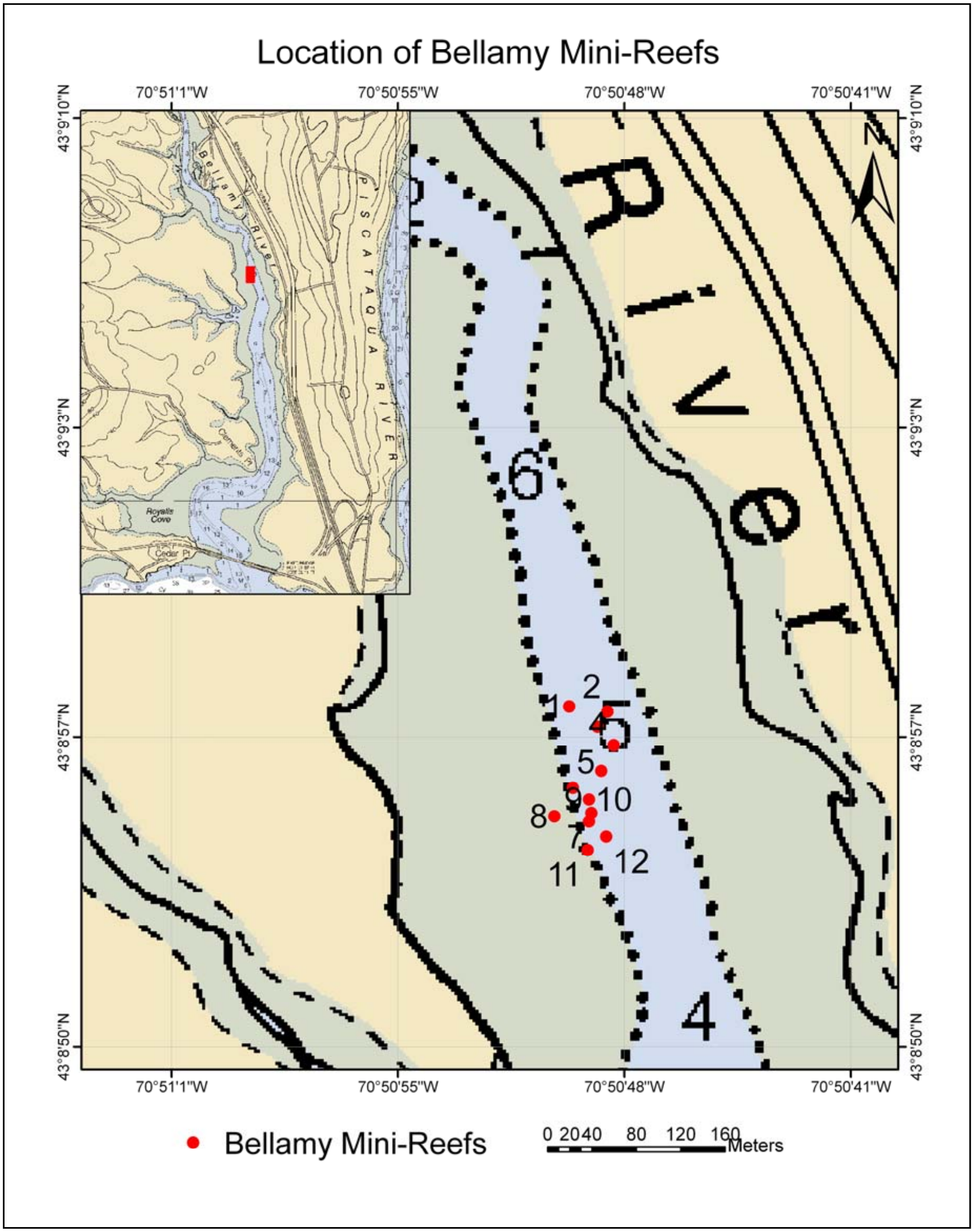

Fig. 2. Locations of twelve "mini-reefs" constructed using spat seeding techniques to initiate restoration of the natural reef. Total bottom area of the twelve "mini-reefs" was about 0.11 acre; total area of overall "restoration area" was 1.5 acres.

Remote setting and "spat seeding" (reef construction)

Approximately 20 million larvae were received at JEL on 15 July 2005 for remote setting, which resulted in approximately 11million spat-on-shell. Survival and growth on the nursery raft were excellent, especially considering the excessive number of spat produced (Fig. 3). When first moved to the raft, there were several times more spat per shell than could be expected to survive in the long-term due to space limitations alone. Hence, substantial mortality rates were expected as the spat grew. After 15 weeks on the raft, there were about 300,000 spat-on-shell ready for reef construction.

Reef construction was accomplished on 3 - 4 November 2005 when about 300,000 spat-on-shell were deposited onto the bottom in twelve separate "mini-reefs" in the southern end of the overall historic reef area (Fig. 2).

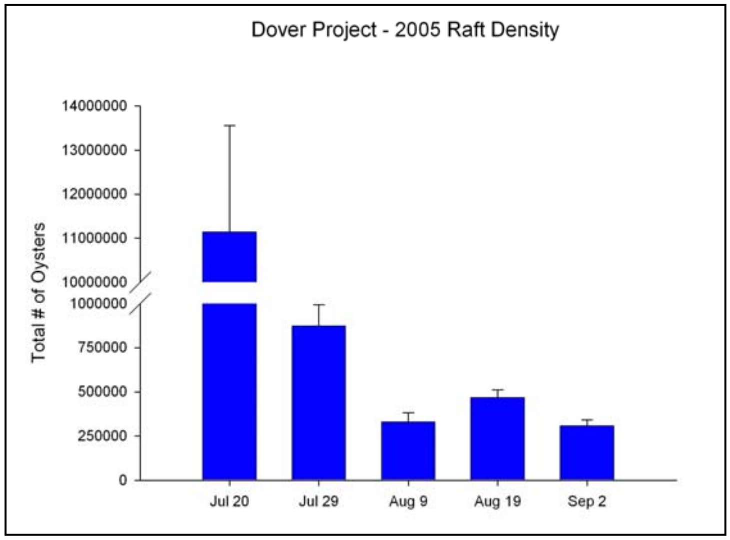

Fig. 3. Total spat abundances over time on nursery raft. (bars show 1 SE)

Restoration success

Sampling on 26 July 2006 (9 months post-construction) indicated a mean density of 64 oysters/m^2 (~6 oysters/ft^2) on the mini-reefs, and no oysters on the immediately adjacent natural reef bottom areas. Therefore, of the approximately 300,000 spat originally used to construct twelve mini-reefs (with total surface area ~ 0.1 acre) in the overall 1.5-acre restoration area, about 32,000 remained after the first winter (Table 1). This represents only ~10% survival, which is low for first year survival compared to most of our previous restoration efforts.

Table 1. Chronological summary of oyster mortality (changes in abundance) and growth during all stages of the restoration process from remote setting to 9 months post-construction

	Setting tanks (JEL)		Nursery raft (JEL)			Reef const.	Reef sampling	
	07/15/05	07/20/05	07/29/05	08/19/05	09/02/05	11/03/05	07/26/06	Fall 2006
Shell height (mm):	<0.5	0.5	(no data)	4.4	13.6	(no data)	34.8	?
Total abundance:	20 million	11 million	800,000	500,000	310,000	(<310,000?)[1]	32,000	?

[1] Reefs were not sampled immediately after construction.

Restoration success in the context of the NHEP goal of restoring 20 acres of oyster bottom by 2010 calls for the project manager to determine the total restored area, with no particular criteria for "success" defined (Trowbridge 2003). The present project resulted in a net gain of 32,000 oysters (no live oysters present before restoration) after the first year (July 2006) to the Bellamy River restoration area, defined overall as a 1.5-acre area at the south end of the historic reef. The 32,000 oysters were concentrated on twelve "mini-reefs" (at a mean density of 64 oysters/m^2) scattered throughout the restoration area (Fig. 1).

The long-term intent is that natural recruitment to the entire 1.5-acre restoration area will be enhanced because of the presence of the new live oysters from the present restoration project. However, inspection of the area by divers in July 2006 indicated that most of the shells originally observed and mapped in 2005 (Fig. 1) were no longer present, perhaps due to the extreme flood conditions that occurred in May 2006. This represents a loss of hard substrate that is needed for natural recruitment to be successful. Hence, longer-term success of the overall area may be compromised unless additional shell material is added to the site. In any case, longer-term success will be assessed based on subsequent sampling. At this time, the entire 1.5-acre area (at a mean density of ~4 oysters/m^2) is considered "restored" in the short-term.

<u>Education</u>

Both education components were addressed but only one, independent studies by UNH undergraduate students, was accomplished as planned. Krystin Ward completed an independent study entitled "Oyster reef restoration techniques" (4 cr.) during Summer 2005 semester, and another entitled "Oyster reef mapping methods" (2 cr.) during Fall 2005. Both studies involved field trips to the Bellamy restoration area; Krystin also participated in all phases of the remote setting process, reef construction and sampling, data processing, and map preparation.

One of us (JKG) exchanged email communications during summer 2005 concerning course content, student participation, and other details of the proposed course involving high school students. A meeting was held with two teachers (Lisa Santy and Terianne McKeon) on 1 September 2005 at Dover High School to further develop plans. No further developments occurred.

Conclusions and Recommendations

The present project has resulted in short-term restoration of 1.5 acres of historically productive oyster reef in the lower Bellamy River, in the City of Dover, New Hampshire based on the survival (as of 26 July 2006) of 32,000 young oysters 9 months after placement onto the bottom. Longer-term restoration success will be assessed by sampling in fall 2006, and at later dates as funding allows.

The present project (as well as previous projects conducted by our laboratory) has demonstrated that spat seeding can be effective in initial restoration success. Each restoration project, however, must be designed in the context of the particular factors contributing to historic declines on that reef if longer-term success is to be achieved. The Bellamy reef was essentially dead before the present project, with the following potential causal factors (Langan 2000): siltation, lack of clean shell (hard substrate), disease, and predation. The present project mainly addressed the issue of disease; many of the broodstock used for spawning were older animals with presumably some amount of disease resistance. It also provided additional shell to the area, but mainly as substrate for the spat used in reef construction. Longer-term success of the present initial effort will likely require addressing at least the lack of clean shell for future spat set, and perhaps other factors.

References

Castagna, M., M.C. Gibbons, and K. Kurkowski. 1996. Culture: application. pp. 675-690 In: Kennedy, V.S., R.I.E. Newell, and A.F. Eble (eds.) The Eastern Oyster, *Crassostrea virginica*. Maryland Sea Grant, College Park, MD.

Grizzle, R.E. and M. Brodeur. 2004. Oyster (*Crassostrea virginica*) reef mapping in the Great Bay Estuary, New Hampshire - 2003. Final Report toThe New Hampshire Estuaries Project, Concord, NH

Grizzle, R.E., M. Brodeur, H. Abeels, and J. Greene. 2006. Seafloor mapping using towed underwater videography: subtidal oyster reefs as an example application. *Journal of Coastal Research* (in review)

Langan, R. 2000. Shellfish habitat restoration strategies for New Hampshire's estuaries. Final Report. Office of State Planning, New Hampshire Estuaries Project, USEPA.

Supan, J.E., C.A. Wilson and K.J. Roberts. 1999. Economics of augmentation of natural production using remote setting techniques. pp. 359-366 in: : Luckenbach, M.W., R. Mann, and J. Wesson (eds.) Oyster Reef Habitat Restoration: A Synopsis and Synthesis of Approaches. Virginia Institute of Marine Science, Gloucester Point, VA.

Trowbridge, P. 2003. Environmental indicator report, species and habitats. New Hampshire Estuaries Project. Concord, NH.

Appendices

Appendix A - QAPP

The procedures outlined in the QAPP for this project were generally followed, with only minor departures. A total of 20 quadrats (10 from the constructed reef areas and 10 from adjacent natural reef bottom) were called for during field sampling, and the reefs were to be sampled immediately after construction. Only one post-construction sampling event occurred in July 2006 (9 months post-construction). On this sampling event, only four (4) quadrats were taken from the natural bottom, but eleven (11) were taken from the restored areas. Field data sheets and other procedures as described in the QAPP were followed; raw data are in Appendix B.

Appendix B - Raw Data

Bellamy River 7/26/06 - 1/8 m^2 quadrats

On/Off Reef[1]	Quadrat #	# of Oysters	#/m^2	Mean #/m^2	Standard Error
On	1	2	16		
On	2	6	48		
On	3	7	56		
On	4	26	208		
On	5	3	24		
On	6	29	232		
On	7	2	16		
On	8	14	112		
On	9	2	16		
On	10	0	0		
On	11	7	56		
On	12	0	0		
On	13	6	48		
	Total #	104		**64**	**20.97128684**
Off	1	0	0		
Off	2	0	0		
Off	3	0	0		
Off	4	0	0		
	Total #	0		**0**	**0**

Footnotes

On/Off Reef[1] = "On" quadrats taken from areas where spat were placed ("spat-seeded"; 12 total mini-reefs); "Off" quadrats taken from natural reef bottom

Field Notes

oyster drills common, some eggs
abundant dead razor clams along bottom of channel in most areas, still partially buried
some of "spat-seeded" oysters buried by several cm of mud -- May flood effects?
majority of 11 "On" reef quadrats taken in southwest corner of overall restoration area

Bellamy River Reef Sampling 7/26/06

shell height (mm)

	Quad #1	Quad #2	Quad #3	Quad #4	Quad #5	Quad #6	Quad #7	Quad #8	Quad #9	Quad #11	Quad #13
	35.6	28.1	43.0	30.0	44.2	38.0	36.5	36.2	30.8	36.1	29.9
	49.7	45.2	43.2	31.4	48.5	43.0	32.8	35.1	30.0	17.8	17.0
		25.5	43.8	24.7	51.0	21.1		33.5		27.0	34.8
		41.5	38.5	35.8		29.2		37.3		23.0	36.9
		35.2	43.2	27.5		27.8		29.7		22.5	13.6
		34.6	40.3	54.8		50.5		20.6		19.2	13.2
			42.2	49.0		44.0		14.3		16.0	
				55.0		31.4		25.1			
				51.2		48.8		13.0			
				44.5		34.6		24.1			
				42.5		38.4		23.8			
				42.1		41.3		25.1			
				44.7		51.0		26.5			
				57.2		42.6		32.5			
				53.0		43.6					
				42.1		39.4					
				59.0		22.4					
				48.5		29.7					
				51.5		28.5					
				30.2		26.0					
				38.6		16.0					
				31.0		24.0					
				21.0		10.0					
				35.3		43.4					
				22.7		42.3					
				62.0		39.7					
						16.4					
						48.2					
						18.4					
Mean	42.7	35.0	42.0	41.7	47.9	34.1	34.7	26.9	30.4	23.1	24.2
SE	7.0	3.1	0.7	2.3	2.0	2.1	1.9	2.0	0.4	2.6	4.4

Total Mean	34.8
Total SE	1.1