Paynter Lab Annual Monitoring and Research Summary 2012

Submitted to the Oyster Recovery Partnership

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Executive Summary

The Paynter Laboratory at the University of Maryland conducted monitoring activities on many restored oyster populations in Maryland in 2012. These activities included pre-planting sonar analysis and ground-truthing (GT), post-planting monitoring (PPM), patent tong surveying, disease diagnostics, and research. GT was used to assess bottom quality prior to planting spat-on-shell by the Oyster Recovery Partnership (ORP). PPM consisted of sampling newly planted spat within four to eight weeks after planting to determine survivorship and growth rates. Patent tong surveys were conducted to estimate the number and density of oysters on various bars as well as to sample the oysters for size and disease. Disease monitoring involved sampling oysters through both patent tong and diver surveys and diagnosing tissues for *Perkinsus marinus* prevalence. Research conducted this year was in collaboration with scientists from the Oyster Hatchery at the Horn Point Laboratory, University of Maryland Center for Environmental Science (UMCES). With the help of the hatchery staff we continued our comprehensive spat survival study, and plan to sample a final time in 2013 to conclude this phase of the project. A full report of the spat survival study will be provided after the final sampling and separate from this report.

Disease monitoring data (Section I) revealed elevated mean *P. marinus* prevalence (53%) and intensity (0.88) relative to other years, however levels were still low overall. In addition, oysters sampled included both ORP-planted oysters as well as native oysters at some locations. This may account for higher disease levels than previous years, particularly when paired higher average salinity observed throughout 2012.

As in 2010 and 2011, side scan sonar data (SSS) were used for guidance when selecting sites to GT (Section II). In 2012, SSS was available for every site surveyed, greatly improving the efficiency of site selection and GT efforts. Also contributing to effective site selection and GT, the NOAA Chesapeake Bay Office (NCBO) generated Chesapeake Bay Marine Ecological Classification Standard (CMECS) provided an extra level of detail with regard to expected bottom for all sites surveyed in Harris Creek. Because the Harris Creek tributary was a focus of 2012 restoration efforts, CMECS data was available for 16 of the 18 bars surveyed. Most surveyed bars were recommended for planting.

PPM (Section III) showed that the **mean survivorship of spat planted was approximately 37%,** which was much higher than the average survivorship of spat in previous years (see Table 1). Fourteen sites were sampled and survival ranged from 18-61%. As in 2011, we believe this success is strongly related to the effort made by our team (Paynter Lab members and Steve Allen of ORP) to direct plantings to areas of more shelled bottom targets than in years past. This was accomplished through the use of acoustic data, diver GT, and in the case of some plots in Harris Creek, artificial substrate (clam shell) planted by the Army Corps of Engineers. Higher salinities may have contributed to better survival as well.

Table 1. Plantings and survival. Values show the total sites and spat planted for each year (2008-2012) as well as the mean spat per shell and percent survival based on post-planting surveys. Note that survivorship in 2011 was nearly twice that of the three previous years and that in 2012 is was 10% higher than in 2011.

					Means per Year			
Sample Year	**Sample Locations**	**Sites Planted**	**Total Acreage Planted**	**Total Spat Planted (Millions)**	**Initial Spat per Shell**	**Survey Spat per Shell**	**Shell Height (mm)**	**% Survival ±SEM**
2008	20	27	215.64	370	30.2	3.9	14.9	17.0±2.8
2009	19	56	408.82	762	17.9	3.4	11.5	12.0±1.9
2010	13	16	99.56	374	14.9	2.0	20.1	12.8±2.4
2011	12	13	93.53	515	16.5	4.4	20.1	27.0±7.7
2012	**10**	**15**	**124.8**	**577**	**16.8**	**6.7**	**19.5**	**36.8±12.1**

Patent tong surveys (Section IV) were conducted to estimate population abundances, assess shell base, estimate oyster size and biomass, and collect oysters to test for *P. marinus*, the parasite that causes Dermo disease. Twelve plots were surveyed at six oyster bars during the 2012 survey, with oyster densities ranging from 0.0 to 23.3 oysters/m^2 (see Table 2). As shown in Table 2, restored bars between three and six years of age show a range of sizes compared to a calculated expected population size (Expected = (planted – 90%) – (remaining*0.15) for each year). Four bars show fairly high levels of expected abundances, while four show low levels (15% or less), suggesting a large degree of variation in factors affecting success across sites. According to the standards set forth by the Oyster Metrics Workgroup (OMW), only two of these sites possess oyster densities and biomass defined as a successfully restored bar (15 oysters/m2 or 15 g/m2 biomass): Shoal Creek 2009B and Thunder and Lightning. Incidentally, Thunder and Lightning is a bar open to hand tonging during the oyster season and thus the oyster population on that bar has likely suffered an unknown amount of fishing mortality.

Table 2. Oyster populations, density and biomass on restored bars surveyed using patent tongs in 2012. Density and biomass values denoted by an asterisk (*) indicate sites meeting OMW metrics of success. SEM values represent standard error of the mean.

Region/River	Bar Name	Planting Year	Spat Planted (Millions)	Expected 2012 Population (Oysters)	Population Estimate from Survey (Oysters)	Mean Live Oyster Density (#/m^2 ±SEM)	Mean Biomass Density (g/m^2 ±SEM)
Anne Arundel Shore	Tolly Point	2006	7,800,000	346,090	446,250	5.1±0.6	9.0±1.0
		2009	28,340,000	2,047,565	139,375	1.8±0.3	2.6±0.5
Chester River	East Neck Bay	2006/2009	61,730,000	3,952,586	377,500	2.9±0.4	2.6±0.5
	Strong Bay	2009A	23,510,000	1,698,598	723,750	10.2±2.2	19.6±4.0*
		2009B	12,120,000	875,670	55,625	0.7±0.2	1.1±0.4
		2009C	9,320,000	673,370	94,375	1.2±0.3	1.7±0.6
Choptank River	Sandy Hill	2009	49,650,000	3,587,213	395,625	1.5±0.2	2.1±0.3
	Shoal Creek	2006 A	4,000,000	177,482	177,500	3.2±0.8	5.8±1.5
		2006 B	N/A	N/A	3,125	0.0±0.0	0.1±0.1
		2009 A	35,480,000	2,563,430	382,500	3.0±0.5	4.5±2.6
		2009 B	29,270,000	2,114,758	1,474,375	18.3±2.2*	23.2±0.8*
South River	Thunder and Lightning	2009	47,500,000	1,447,593	580,625	23.3±8.3*	28.4±10.6*

Long-term PT monitoring (Section V) involved initial surveys at four new sites. Bars selected for long-term surveys include: Little Neck, Lodges, and Mill Point in Harris Creek and Cason in the Little Choptank River. All three of these sites are within sanctuaries, and thus should not be open to harvest during the course of this long-term study. As this was the first survey year at these bars, data collected provide baseline data from which to compare the next three or more years. Each site possessed oyster size frequency, density, and biomass typical of recent plantings. Over time, these data will provide estimates of growth rates, natural mortality (assuming they are not affected by illegal harvest) and disease acquisition. Additionally, changes in observed substrate and buried shell will be tracked over time at these bars, and substrate data is reported as the observed combination of primary and secondary substrate.

Though early spat survival values and the population observed at a number of patent tong sites suggest positive trends in oyster survival at restored sites, there is still much to be investigated with regard to oyster population dynamics in the northern portion of the Chesapeake Bay. In an attempt to further understanding of the influence of bottom type on spat survival, a second season of the collaborative spat survival experiment with researchers at the UMCES Horn Point Laboratory Oyster Hatchery was conducted. Trends in survival suggest that bottom type plays an important role, but full analysis will be completed upon a final one-year sampling to be conducted in the summer of 2013. Results from this study may shed light on differences in survival on each substrate between the standard four to eight weeks post-planting and one year post-planting.

In addition to the spat survival collaboration with the Horn Point Laboratory Oyster Hatchery, staff and students of the Paynter Lab have been conducting and presenting ongoing research (Section I). A joint study with researchers at John Hopkins Center for a Livable Future evaluating the geographic pattern of oyster poaching violations was published in the Journal of Shellfish Research (Volume 31, Number 3, Pages 591-598). Other research was presented at the National Shellfisheries Association annual meeting in Seattle, WA, totaling three papers. Undergraduates in the laboratory continued separate projects investigating 1) mud crab predation on oyster spat and 2) the effect of environmental variables such as temperature and dissolved oxygen on oyster heart rate. In addition, a high school intern from Eleanor Roosevelt High School (Greenbelt, MD) joined the laboratory to carry out another component to the oyster heart rate study, looking at the influence of salinity on oyster heart rate.

In summary, this report describes our findings in detail and presents data and analyses that provide a pathway to adaptive management in oyster restoration by the Oyster Recovery Partnership. Each aspect of our efforts is presented below in sections, as well as a summary of our time in the field and laboratory work related to/funded by the ORP.

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Section I: Annual Summary

Field Summary

- Experimental Work:
  - Predator exclusion experiment
    - Purpose: to determine which predators most affect spat survival (and improve upon previous year's methods).
    - Treatments: Open cage, ¼" mesh cage, fine mesh cage.
    - Three replicates of each treatment were deployed with a consistent amount of spat on shell in each.
    - After two weeks replicates were removed and remaining spat on shell were counted.
    - Two deployments in 2012:
      - June: Cages deployed in the South River for test run.
      - September: Cages deployed in the West River (CBF Oyster Facility).
    - June deployment findings inconclusive due to lack of predators in cages.
    - September deployment findings inconclusive due to 1) the presence of all sizes of predators in each cage type and 2) no pattern in the number of spat eaten by cage type.
    - Predator exclusion experiment underscores the complications associated with monitoring the impact of predation on spat survival.
    - A more complete experiment should be conducted on a more comprehensive level by a student or researcher solely dedicated to this question in the future.
  - Spat size and bottom type study
    - Conducted 7/25, 8/2, 9/11
    - Purpose: To investigate the effect of substrate type on spat survival through time.
    - This was an extension of the experiment conducted in 2011; substrate was identified as being a priority for the second year rather than spat size (which was targeted with substrate in the 2011 experiment).
    - 12 PVC quads were deployed in LaTrappe Creek and divided into thirds.
    - Four quads were deployed in each substrate type (sand, mud, shell) and each quad contained 150 shells (50 in each third of the quad)
    - Spat-on-shell were sampled eight and 48 days post planting.
    - Preliminary data indicate that spat may survive better on shell than on sand and better on sand than on mud.
    - A final sampling will take place 1 year post planting (July 2013) and trends will be evaluated at that time.

- Pre-Planting Ground Truthing Survey
  - See Section II.
  - Similar to 2010 and 2011, 2912 data show that diver surveys of different bottom types confirm bottom typing suggested by the side-scan sonar data.
  - Many target sites in 2012 were in Harris Creek, allowing for further analysis of diver observation compared to CMECS bottom type prediction.

    - Nine of the 16 bars surveyed in Harris Creek matched the CMECS bottom type prediction.

- Post-Planting Monitoring Survey
    - See Section III.
    - Average 2012 spat survival was 36.8%, the highest recorded survival since systematic monitoring began in 2008.
    - A possible reason for the high survival observed could be the ability to select planting sites appropriate for spat survival, due to Harris Creek being a primary target for restoration in 2012.
    - 2012 data do not suggest a trend with initial number of spat on shell or shell density and survival of spat 4-8 weeks post-planting.
    - These results indicate that other factors are affecting spat survival among sites.
    - The impact of bottom type on spat survival was tested in 2012, with the experiment expected to be completed in summer of 2013.

- Patent Tong Survey
    - See Sections VI and V.
    - 12 different survey plots at six oyster bars were surveyed in 2012.
    - Generally, disease prevalence and intensity were low.
    - Population estimates were generated from the patent tong survey data for each bar surveyed, as well as density and shell score plots.
    - New long term bars were selected and surveyed for the first time. Three bars were targeted in Harris Creek (Little Neck (2012), Lodges (2012) and Mill Point (2011)) and one bar was surveyed in the Little Choptank (Cason (2011)). Two more bars in the Little Choptank will be surveyed in 2013 once they are planted.
    - An additional tributary-wide survey was completed in October 2012 of the Nanticoke River for the Nature Conservancy. This survey adds to the growing body of fine-scale knowledge on oyster habitat and density at the tributary level. A similar survey of Broad Creek is scheduled for March of 2013.

- *Perkinsus marinus* (Dermo) monitoring
    - Table 1 compares dermo prevalence and intensity from 2008-2012.
        - Although sites were not consistent between years, these data show that 2012 had the highest prevalence and intensity of any year surveyed.
        - Record low salinities were observed in 2011 but as shown in Table 1, salinities were back within the normal range in 2012.
        - The increase in salinity from 2011 to 2012 may have impacted the increase in infection levels in 2012.
    - Figure 1 shows the sites where dermo was sampled in 2012 by infection prevalence. Larger, darker circles indicate increasing dermo prevalence.
    - Figure 2 shows the sites where dermo was sampled in 2012 by weighted intensity (0-5 scale, 0=no infection, 5=very heavy infection).

- See Table 2 below for a summary of the 2012 data.
- Mean prevalence was 52.77% and mean intensity was 0.88 out of a possible 5.
- Non-hatchery oysters were collected at some sites in 2012 to compare to hatchery oysters (see Table 2). Disease prevalence and intensity at these sites was higher than hatchery-produced oysters and therefore may have increased mean disease levels for 2012.
- These data suggest that while dermo levels in 2012 were the highest since 2008, intensity was still low and therefore dermo was probably not a large factor in oyster survival in 2012.

Table 1. Mean *Perkinsus marinus* prevalence and intensity from 2008-2012, with mean salinity per year.

Year	Mean Prevalence (%)	SEM	Range	Mean Intensity	SEM	Range	Mean Salinity (‰)
2008	29.98	5.28	0 - 93	0.28	0.09	0 - 2.07	N/A
2009	26.07	4.23	0 - 90	0.32	0.09	0 - 1.77	12.3
2010	35.86	4.72	0 - 100	0.41	0.09	0 - 2.53	11.3
2011	40.80	6.03	0 – 100	0.43	0.10	0 – 1.67	6.6
2012	52.77	5.74	0 – 100	0.88	0.14	0 – 2.54	12.5

Figure 1. *Perkinsus marinus* prevalence by site sampled in 2012. Darker, larger circles indicate increasing dermo prevalence. Sites of relatively high prevalence were spread evenly throughout the Bay in 2012.

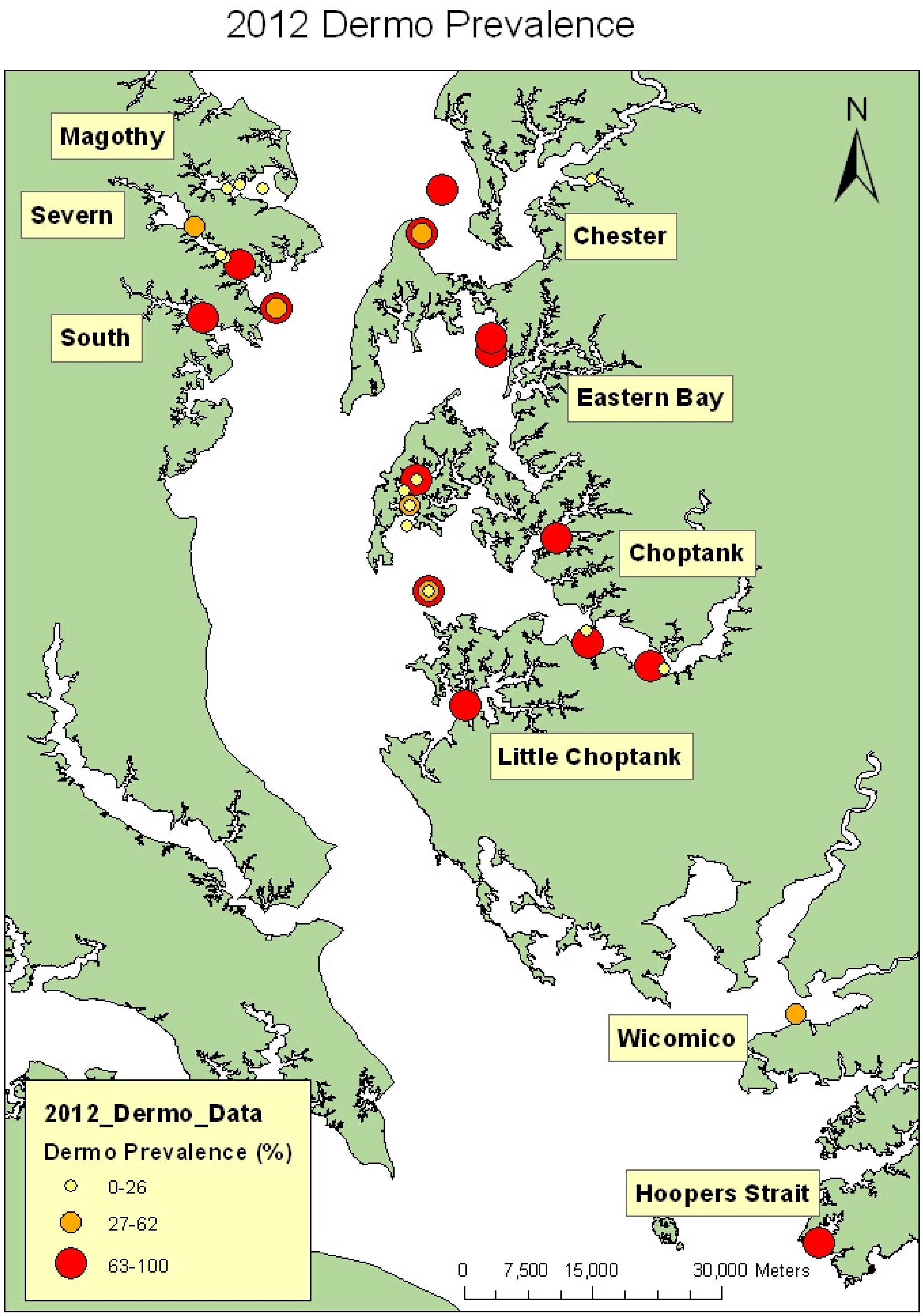


Figure 2. *Perkinsus marinus* weighted infection intensity by site sampled in 2012. Darker, larger circles indicate increasing dermo weighted infection intensity. Samples were measured on a 0-5 scale with 0 indicating no dermo infection and 5 indicating very heavy infection. Similar to the prevalence data, relatively high infection levels were spread evenly throughout the Bay in 2012.

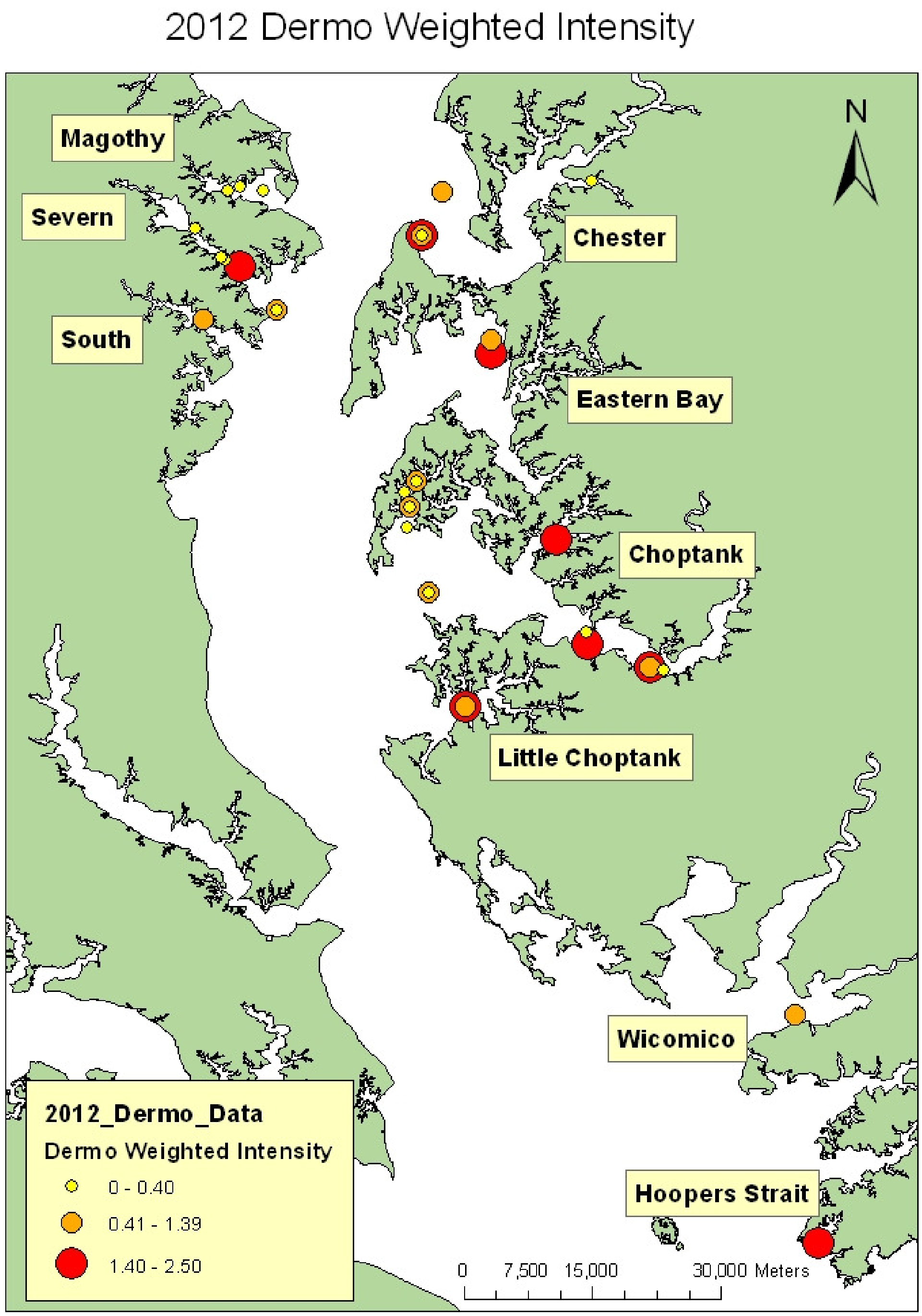


Table 2. 2012 *Perkinsus marinus* prevalence and intensity by site within each tributary.

River	Bar Name	Plant Year	Date Collected	How Collected	# Oysters Tested	Average Shell Height (mm)	Average Total Weight (g)	Average Shell Weight (g)	Dermo Prevalence (%)	Dermo Weighted Intensity
Chester	East Neck Bay	2006	10/1/2012	Tong	28	95.3	102.1	78.5	92.86	1.36
	Strong Bay	2009A	9/27/2012	Tong	30	101.6	112.4	84.7	100.00	2.27
	Strong Bay	2009C	9/21/2012	Tong	30	87.8	62.6	46.2	36.67	0.21
	Strong Bay	2009C	9/21/2012	Tong	28	118.7	180.9	138.2	57.14	1.08
	Possum Point	2006	9/27/2012	Dive	29	130.4	181.8	134.3	13.79	0.04
Choptank	Cook Point	2010	12/4/2012	Dive	30	83.4	83.8	67.5	90.00	1.23
	Cook Point	2011 Alternate	12/4/2012	Dive	28	76.3	45.5	34.3	14.29	0.04
	Cook Point	2011 Sand	12/4/2012	Dive	16	77.9	62.8	48.9	31.25	0.38
	Howell Point	2009	10/4/2012	Dive	30	94.3	146.2	115.9	6.67	0.10
	Sandy Hill	2009	11/6/2012	Tong	26	90.4	130.9	110.0	100.00	2.39
	Shoal Creek	2006	11/1/2012	Tong	30	106.6	200.8	218.7	96.67	2.37
	Shoal Creek	2009	11/1/2012	Tong	30	100.9	103.8	82.4	70.00	0.97
	States Bank	2009	10/4/2012	Dive	30	95.9	108.1	87.5	20.00	0.21
Eastern Bay	Mill Hill	2009	9/27/2012	Dive	28	91.6	117.8	92.8	96.43	2.50
	Saw Mill Creek	2009	9/27/2012	Dive	30	85.2	162.3	136.9	80.00	1.40
Harris Creek	Change	NATIVE	10/23/2012	Dive	30	79.3	108.3	93.2	6.67	0.00
	Lodges	2012	10/23/2012	Dive	29	41.2	12.8	10.2	6.90	0.04
	Mill Point	2011	10/23/2012	Dive	30	66.6	40.1	32.9	26.67	0.31
	Mill Point	NATIVE	10/23/2012	Dive	8	92.3	155.6	133.2	62.50	1.01
	Little Neck	2012	10/23/2012	Dive	30	50.1	13.1	9.8	6.67	0.00
	Little Neck	NATIVE	10/23/2012	Dive	30	91.7	151.1	130.3	73.33	1.07
Hooper Strait	Light House	2009	10/25/2012	Dive	28	88.5	157.4	129.2	92.86	2.50
Little Choptank	Cason	2011	10/17/2012	Tong	30	42.2	-	-	70.00	0.94
	Cason	NATIVE	10/17/2012	Tong	29	93.0	149.0	125.8	96.55	2.04

River	Bar Name	Plant Year	Date Collected	How Collected	# Oysters Tested	Average Shell Height (mm)	Average Total Weight (g)	Average Shell Weight (g)	Dermo Prevalence (%)	Dermo Weighted Intensity
Lower Anne Arundel	Tolly Point	2006	10/23/2012	Tong	30	99.9	168.8	140.2	100.00	1.37
	Tolly Point	2009	10/22/2012	Tong	30	81.1	105.0	87.4	30.00	0.41
Magothy	Chest Neck Point	2006	9/21/2012	Dive	29	117.3	113.7	89.5	0.00	0.00
	Chest Neck Point	2009	9/21/2012	Dive	27	121.9	154.8	128.0	22.22	0.01
	Dobbins	2009	9/21/2012	Dive	25	86.1	67.8	51.3	24.00	0.01
	Park	Duer 2006	9/21/2012	Dive	30	122.6	131.0	105.7	10.00	0.01
Severn	Aisquith Creek	2006	9/17/2012	Dive	30	78.7	55.9	41.5	43.33	0.21
	Wade	2-3, 2010	11/6/2012	Dive	29	70.3	33.0	24.3	13.79	0.04
	Wade	2-4, 2010	11/6/2012	Dive	31	70.4	36.1	26.7	12.90	0.01
	Wade	2-5, 2010	11/6/2012	Dive	30	75.7	48.6	36.6	3.33	0.00
	Weems Upper	2010	11/6/2012	Dive	29	75.0	48.0	34.6	20.69	0.01
South	Thunder and Lightning	2009	10/22/2012	Tong	30	94.6	111.9	88.1	80.00	1.24
	Ferry Point	2006	9/17/2012	Dive	28	91.0	115.7	90.8	92.86	1.72
Tred Avon	Mares Point	2009	10/4/2012	Dive	30	95.3	100.5	79.7	100.00	2.20
Wicomico	Evans	2011	10/25/2012	Dive	29	60.4	34.2	27.3	41.38	0.66

- Salinity, temperature and dissolved oxygen were measured at each site using a Yellow Springs Instruments probe (Model 660).

    - Variables collected include surface and bottom temperature (°C), salinity (‰), and dissolved oxygen (mg/L).
    - Figure 3 indicates sites where water quality was measured in 2012.
    - Table 3 shows water quality at sites, arranged by river/region and data collected while Table 4 gives the average salinity for each region.
    - With salinity values ranging from 1.91**‰** to 13.5 **‰** and an average bottom salinity of 7.9 **‰** with a standard deviation of 2.7, overall 2011 salinity values were unusually low due to freshwater input from several large storms (including Hurricane Irene that traveled up the Bay in August).
    - Table 4 also shows salinity values relative to areas sampled for Dermo.

Figure 3. Sites sampled for water quality in 2012. Point colors indicate sampling month and rivers are labeled in yellow boxes. Many locations were returned to for multiple sampling methods (GT, PPM, etc.) and therefore multiple water quality measurements were taken. Individual sites are listed by river in Table 3 below.

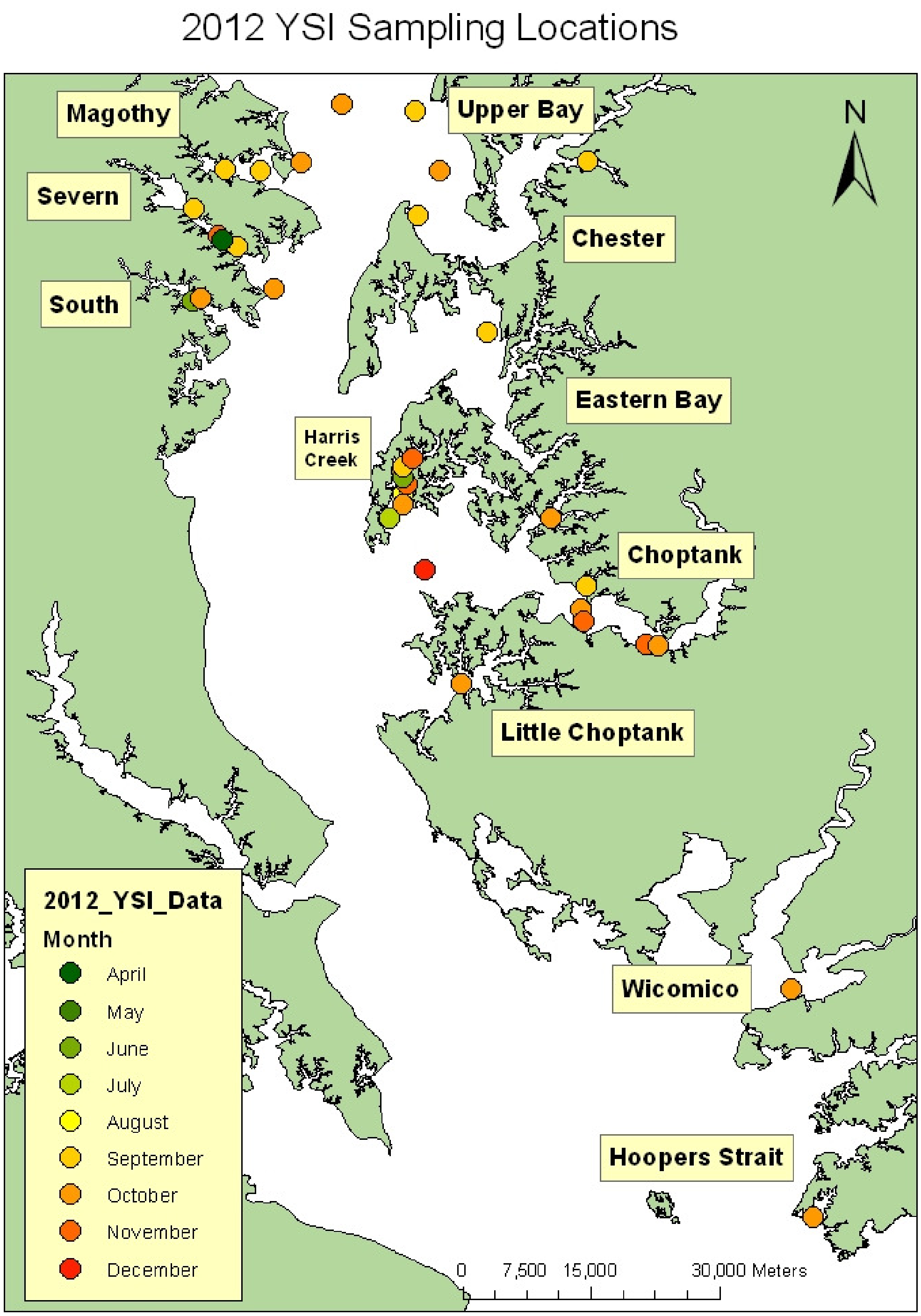


Table 3. Water quality at each site in 2012. Data are further designated by section of river/region, with the following abbreviations: L= lower, M= middle, U= upper.

River/Region	Section	Site	Date Sampled	Location	Temp (°C)	Salinity	DO (mg/L)
Chester River	L	East Neck Bay	10/1/2012	B	21.2	13.4	7.3
	L	East Neck Bay	10/1/2012	S	21.8	13.0	8.2
	L	Strong Bay	9/27/2012	B	21.6	13.6	7.8
	L	Strong Bay	9/27/2012	S	22.1	13.3	8.8
	U	Possum Point	9/27/2012	B	21.9	10.7	6.9
	U	Possum Point	9/27/2012	S	22.3	10.6	8.0
Choptank River	L	Cook Point	12/4/2012	B	8.2	14.7	11.4
	L	Cook Point	12/4/2012	S	8.2	13.6	11.3
	M	Howell Point S	10/4/2012	B	22.3	13.9	7.5
	M	Howell Point S	10/4/2012	S	24.0	13.2	8.1
	M	Sandy Hill	11/6/2012	B	10.0	11.7	11.0
	M	Sandy Hill	11/6/2012	S	9.4	8.9	11.8
	M	Sandy Hill	11/7/2012	B	8.8	10.5	10.3
	M	Sandy Hill	11/7/2012	S	8.8	10.5	11.4
	U	LaTrappe	7/3/2012	B	29.3	11.6	7.5
	U	LaTrappe	7/3/2012	S	30.6	11.5	7.8
	U	LaTrappe	7/6/2012	B	30.3	11.6	6.7
	U	LaTrappe	7/6/2012	S	31.1	11.6	7
	U	LaTrappe	7/25/2012	B	29	12.3	8
	U	LaTrappe	7/25/2012	S	29.4	12.2	8.5
	U	LaTrappe	8/2/2012	B	28.5	12.6	6.5
	U	LaTrappe	8/2/2012	S	28.9	12.5	7.0
	U	LaTrappe	9/11/2012	B	25.0	12.4	7.8
	U	LaTrappe	9/11/2012	S	25.0	12.3	8.1
	U	Shoal Creek	10/26/2012	B	17.7	13.3	8.5
	U	Shoal Creek	10/26/2012	S	17.7	13.3	8.6
	U	Shoal Creek	11/1/2012	B	11.2	11.1	8.8
	U	Shoal Creek	11/1/2012	S	10.2	8.3	9.6
	U	Shoal Creek	11/5/2012	B	10.6	8.9	9.9
	U	Shoal Creek	11/5/2012	S	9.9	11.6	10.2
	U	States Bank	10/4/2012	B	22.8	21.9	7.8
	U	States Bank	10/4/2012	S	22.1	12.7	7.9
Eastern Bay	M	Mill Hill	9/27/2012	B	21.9	14.7	8.7
	M	Mill Hill	9/27/2012	S	23.2	14.7	9.4
Harris Creek	L	ACoE Alt Sites	9/11/2012	B	23.6	13.7	6.8
	L	ACoE Alt Sites	9/11/2012	S	24.5	13.4	8.5
	L	Change	5/9/2012	B	17.8	11.0	8.0
	L	Change	5/9/2012	S	17.9	11.0	8.1
	L	Change	6/15/2012	B	23.8	11.2	7.7

River/Region	Section	Site	Date Sampled	Location	Temp (°C)	Salinity	DO (mg/L)
Harris Creek	L	Change	6/15/2012	S	24.0	11.2	8.0
	L	Change Alt Sub	11/15/2012	B	7.0	13.7	11.1
	L	Change Alt Sub	11/15/2012	S	7.1	13.6	10.8
	L	Change West	7/6/2012	B	28.2	12.3	4.1
	L	Change West	7/6/2012	S	30.5	11.0	7.1
	L	North Change	9/6/2012	B	27.6	13.1	7.1
	L	North Change	9/6/2012	S	27.7	13.1	7.5
	L	South Change	10/23/2012	B	17.1	15.4	9.2
	L	South Change	10/23/2012	S	18.1	15.4	9.1
	L	Tilghman Wharf	4/19/2012	B	14.3	10.8	8.4
	L	Tilghman Wharf	4/19/2012	S	14.5	10.7	8.0
	L	Tilghman Wharf	7/3/2012	B	27.9	12.0	6.0
	L	Tilghman Wharf	7/3/2012	S	29.3	11.9	7.2
	M	Eagle Point	8/8/2012	B	28.7	13.5	6.2
	M	Eagle Point	8/8/2012	S	29.3	13.4	-
	M	Lodges	8/8/2012	B	29.1	13.0	6.7
	M	Lodges	8/8/2012	S	29.5	13.0	7.7
	M	Lodges	11/26/2012	B	7.0	14.0	10.6
	M	Lodges	11/26/2012	S	7.3	14.0	10.4
	M	Mill Point	7/3/2012	B	28.6	11.8	6.0
	M	Mill Point	7/3/2012	S	29.7	11.8	7.5
	M	Mill Point	10/23/2012	B	16.9	15.2	9.1
	M	Mill Point	10/23/2012	S	16.8	15.2	9.1
	M	Mill Point	11/28/2012	B	6.6	14.0	10.9
	M	Mill Point	11/28/2012	S	6.6	14.0	10.8
	M	Seths Point	4/19/2012	B	15.0	10.8	8.2
	M	Seths Point	4/19/2012	S	15.8	10.7	8.5
	M	Seths Point	6/15/2012	B	23.8	11.1	7.3
	M	Seths Point	6/15/2012	S	24.1	11.1	7.9
	M	Walnut	6/8/2012	B	23.6	11.2	7.9
	M	Walnut	6/8/2012	S	24.1	11.1	8.2
	M	Walnut	9/6/2012	B	27.7	12.5	6.3
	M	Walnut	9/6/2012	S	27.7	12.4	7.1
	U	Little Neck	6/6/2012	S	23.5	11.4	8.0
	U	Little Neck	8/8/2012	B	28.9	12.8	5.6
	U	Little Neck	8/8/2012	S	29.6	12.9	7.3
	U	Little Neck	10/23/2012	B	16.6	14.9	9.2
	U	Little Neck	10/23/2012	S	16.8	14.7	9.3
	U	Little Neck	11/15/2012	B	9.3	14.1	10.5
	U	Little Neck	11/15/2012	S	9.3	14.1	10.4

River/Region	Section	Site	Date Sampled	Location	Temp (°C)	Salinity	DO (mg/L)
Hooper Strait	L	Lighthouse	10/25/2012	B	17.8	18.2	8.4
	L	Lighthouse	10/25/2012	S	18.0	18.3	8.5
Little Choptank River	M	Cason	10/17/2012	B	15.9	15.9	9.1
	M	Cason	10/17/2012	S	16.0	15.7	9.1
Lower Anne Arundel Shore	L	Tolly Point	10/22/2012	B	17.0	15.0	9.7
	L	Tolly Point	10/22/2012	S	17.9	14.4	10.0
Magothy River	M	Chest Neck Point	9/21/2012	B	23.1	11.8	7.1
	M	Chest Neck Point	9/21/2012	S	23.1	11.1	9.2
	M	Dobbins	9/21/2012	B	23.2	12.6	6.9
	M	Dobbins	9/21/2012	S	22.9	11.9	9.6
Severn	M	Asquith Creek	9/17/2012	B	24.3	11.9	7.3
	M	Asquith Creek	9/17/2012	S	24.7	11.8	7.5
	M	Wade	4/25/2012	B	13.6	9.5	10.5
	M	Wade	4/25/2012	S	13.8	9.5	11.2
	M	Wade	7/12/2012	B	28.3	10.3	5.1
	M	Wade	7/12/2012	S	28.4	10.2	6.6
	M	Wade	11/6/2012	B	9.8	12.8	9.7
	M	Wade	11/6/2012	S	8.6	9.6	10.5
	M	Weems Upper	4/25/2012	B	13.2	9.9	10.5
	M	Weems Upper	4/25/2012	S	13.8	9.4	11.3
South	L	Ferry Point (Duvall)	9/17/2012	B	24.0	12.5	7.4
	L	Ferry Point (Duvall)	9/17/2012	S	24.1	12.3	8.0
	M	Oak Grove	6/13/2012	B	25.3	7.8	5.0
	M	Oak Grove	6/27/2012	B	25.1	8.3	5.7
	M	Oak Grove	6/27/2012	S	25.3	8.3	6.1
	M	Thunder and Lightning	10/22/2012	B	16.7	14.1	8.3
	M	Thunder and Lightning	10/22/2012	S	16.8	14.0	8.6
Tred Avon River	M	Mares Point	10/4/2012	B	22.7	13.5	7.2
	M	Mares Point	10/4/2012	S	23.4	13.2	8.0
Upper Bay	NA	Mountain Point	8/7/2012	B	28.7	11.2	7.0
	NA	Mountain Point	8/7/2012	S	28.7	11.0	7.4
	NA	Mountain Point	10/17/2012	B	14.8	12.6	8.0
	NA	Mountain Point	10/17/2012	S	14.9	12.0	8.9
	NA	Six Foot Knoll	8/7/2012	B	28.4	11.0	5.1
	NA	Six Foot Knoll	8/7/2012	S	28.7	10.4	7.0
	NA	Six Foot Knoll	10/17/2012	B	14.8	12.5	7.8
	NA	Six Foot Knoll	10/17/2012	S	14.8	11.8	8.6
	NA	Swan Point	9/7/2012	B	27.0	13.1	3.4
	NA	Swan Point	9/7/2012	S	27.0	12.4	6.8
Wicomico River	L	Evans	10/25/2012	B	17.4	17.0	8.2
	L	Evans	10/25/2012	S	17.6	16.9	8.6

Table 4. Mean salinity and *Perkinsus marinus* prevalence and intensity in each river/region surveyed. Data are further designated by section of river/region, with the following abbreviations: L= lower, M= middle, U= upper.

River/ Region	Section	Mean Dermo Prevalence (%)	SEM	Range	Mean Weighted Intensity	SEM	Range	Mean Bottom Salinity (‰)	SEM
Chester River	L	71.67	14.97	0-100	1.23	0.42	0-2.27	13.3	0.13
	M	-	-	-	-	-	-	-	-
	U	13.79	-	0-14	0.04	-	0-0.04	10.7	0.05
	ALL	**60.09**	**16.38**	**0-100**	**1**	**0.41**	**0-2.27**	**12.4**	**0.57**
Choptank River	L	45.18	22.94	0-90	0.55	0.35	0-1.23	14.2	0.55
	M	53.33	46.67	0-100	1.25	1.15	0-2.39	11.5	0.76
	U	62.22	22.47	0-97	1.18	0.63	0-2.37	12.3	0.64
	ALL	**53.61**	**14**	**0-100**	**0.96**	**0.34**	**0-2.39**	**12.3**	**0.49**
Eastern Bay	L	-	-	-	-	-	-	-	-
	M	88.22	8.22	0-97	1.95	0.55	0-2.5	14.7	0
	U	-	-	-	-	-	-	-	-
	ALL	**88.22**	**8.22**	**0-97**	**1.95**	**0.55**	**0-2.5**	**14.7**	**0**
Harris Creek	L	6.67	-	0-7	0	-	0	12.5	0.36
	M	32.02	16.27	0-63	0.45	0.29	0-1.01	12.7	0.32
	U	40	33.33	0-73	0.54	0.54	0-1.07	13.6	0.47
	ALL	**30.46**	**12.34**	**0-73**	**0.41**	**0.21**	**0-1.07**	**12.7**	**0.22**
Hooper Strait	L	92.86	-	0-93	2.5	-	0-2.5	18.3	0.05
	M	-	-	-	-	-	-	-	-
	U	-	-	-	-	-	-	-	-
	ALL	**92.86**	**-**	**0-93**	**2.5**	**-**	**0-2.5**	**18.3**	**0.05**
Little Choptank	L	-	-	-	-	-	-	-	-
	M	83.28	13.28	0-97	1.49	0.55	0-2.04	15.8	0.1
	U	-	-	-	-	-	-	-	-
	ALL	**83.28**	**13.28**	**0-97**	**1.49**	**0.55**	**0-2.04**	**15.8**	**0.1**
Magothy River	L	-	-	-	-	-	-	-	-
	M	14.06	5.62	0-24	0.01	<0.01	0-0.01	11.9	0.31
	U	-	-	-	-	-	-	-	-
	ALL	**14.06**	**5.62**	**0-24**	**0.01**	**<0.01**	**0-0.01**		**0.31**
Severn River	L	92.86	-	0-93	1.72	-	0-1.72	-	-
	M	18.81	6.73	0-43	0.05	0.04	0-0.21	10.5	0.39
	U	-	-	-	-	-	-	-	-
	ALL	**31.15**	**13.51**	**0-93**	**0.33**	**0.28**	**0-1.72**	**10.5**	**0.39**
South River	L	-	-	-	-	-	-	12.4	0.1
	M	80	-	0-80	1.24	-	0-1.24	10.5	1.45
	U	-	-	-	-	-	-	-	-
	ALL	**80**	**-**	**0-80**	**1.24**	**-**	**0-1.24**	**11**	**1.06**

River/ Region	Section	Mean Dermo Prevalence (%)	SEM	Range	Mean Weighted Intensity	SEM	Range	Mean Bottom Salinity (‰)	SEM
Tred Avon River	L	-	-	-	-	-	-	-	-
	M	100	-	0-100	2.2	-	0-2.2	13.4	0.15
	U		-	-	-	-	-	-	-
	ALL	**100**	**-**	**0-100**	**2.2**	**-**	**0-2.2**	**13.4**	**0.15**
Wicomico River	L	41.38	-	0-42	0.66	-	0-0.66	17	0.05
	M	-	-	-	-	-	-	-	-
	U	-	-	-	-	-	-	-	-
	ALL	**41.38**	**-**	**0-42**	**0.66**	**-**	**0-0.66**	**17**	**0.05**

Publications and Presentations

- Publications:
  - Bayshore CJ, Lane HA, Paynter KT, Harding JR and Love DC. (2012) Analysis of marine police citations and judicial dispositions for illegal harvesting of oysters (*Crassostrea virginica*) in the Chesapeake Bay, United States from 1959 to 2010. J Shell Res. 31(3): 591-598.
- Presentations:
  - National Shellfisheries Association Meeting, March 2012, Seattle Washington
    - Patent tong surveys of two oyster sanctuaries in Maryland.
      - Ken Paynter (presenter), Hillary Lane and Adriane Michaelis
    - Reponses of the benthic community to the physical and biotic components of the Eastern oyster, *Crassostrea virginica.*
      - Karen Kesler (presenter), Vince Politano, Hillary Lane and Ken Paynter
    - An ontogenetic comparison of egg quality of female *Crassostrea virginica* from the northern Chesapeake Bay.
      - Hillary Lane (presenter), Adriane Michaelis, Emily Vlahovich, Stephanie Alexander, Heather Koopman, Don Meritt and Ken Paynter

Conclusions/Lessons Learned

- Final conclusions regarding each activity can be found in Section V.
- Spat survival was highest since 2008, when systematic monitoring began.
- Factors influencing the variation in spat survival and bar restoration success are still not well identified.
  - Continued controlled experiments exploring the factors influencing spat survival are a priority for 2013.
  - Tributary-level habitat and population characterizations will also provide more insight into factors influencing adult oyster bar success.

Section II: Ground Truthing 2012

In the Spring of 2012, eighteen individual oyster bars were selected by the Oyster Recovery Partnership (ORP) for ground truthing (GT) surveys by the Paynter Lab in order to determine the suitability of sites for new spat-on-shell plantings. These bars were mostly located in Harris Creek (16 bars), with two bars near the upper Anne Arundel shore in the mainstem of the Chesapeake Bay. In most cases, multiple plots were surveyed within a bar. Figure 1 shows the sites sampled in the 2012 season. Sites are indicated by red dots and rivers are labeled in yellow rectangles.

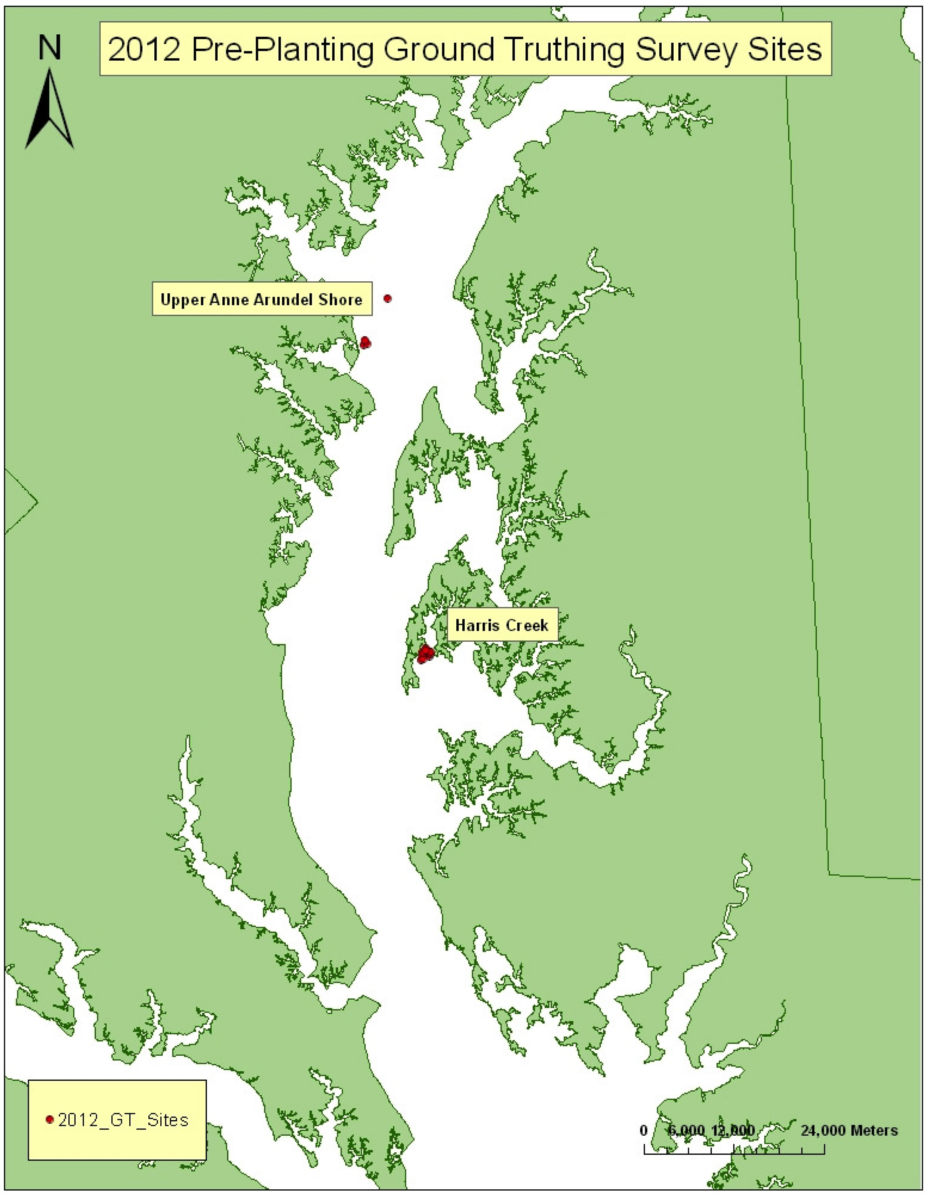


Figure 1. 2012 pre-planting ground-truthing sites. Sites are indicated in red and tributaries are in yellow boxes. Site summaries are presented below, with specfic maps of each site along with the survey data summary.

GT transect paths within a bar were chosen based on side-scan data from The Maryland Geological Survey (MGS) and NOAA Chesapeake Bay Office (NCBO) when available. In general, darker return on a side-scan image means harder bottom. An additional level of detail in Harris Creek was provided using the bottom classification scheme generated by NCBO's Chesapeake Bay Coastal and Marine Ecological Classification Standard (CMECS). CMECS data depicted areas of expected shell and sand, and transect surveys aimed to confirm/refute such expectations as well as target areas suitable for planting. Given the available side scan data, the Paynter Lab determined an area of approximately 10 acres to GT at each site. Transect lines of 100 or 200 m were deployed through the target area and the amount of exposed shell, substrate type, penetration and oyster density were recorded by divers every 2 meters along the transect. The table below outlines the score for each category, with increasing metric values indicating bottom type improvement.

Exposed Shell	**Value**	**Substrate Type**	**Value**	**Penetration (cm)**	**Value**
Zero	0	Silt	0	70	0
Very Little / Patch	1	Mud	1	40	1
Some	2	Sandy Mud	2	20	2
Exposed	3	Sand	3	10	3
Oyster Bar	4	Rock / Bar Fill / Debris	4	5	4
		Shell Hash	5	0	5
		Loose Shell	6		
		Oyster	7		

* Increasing metric values correspond to more favorable bottom type (harder and more shell)

GT transect data was used to create target planting polygons in ArcGIS at sites deemed suitable for planting. Planting targets were sent to the ORP as recommended sites for spat-on-shell plantings. Of the 18 sites surveyed during the ground truthing effort in 2012, ten were seeded with spat-on-shell by the ORP during the summer of 2012. Much of this success was due to the robust data available on the expected bottom type in Harris Creek. Sites in Harris Creek were targeted to be over bottom where sedimentation and shell volume were expected to be appropriate for oyster survival and/or had an exisiting oyster population of at least 1 oyster/m^2. The section below (Site-Specific Data) presents the mode data collected at each site (exposed shell, substrate and penetration) as well as a map of each transect conducted. The expected sedimentation and shell volume are displayed on the map in shades of green, blue and red, with expected bottom type improving as the colors change from red (worst bottom) to blue to green (best bottom). If a site was planted in the summer of 2012, the planting area(s) are indicated on the map as pink polygons.

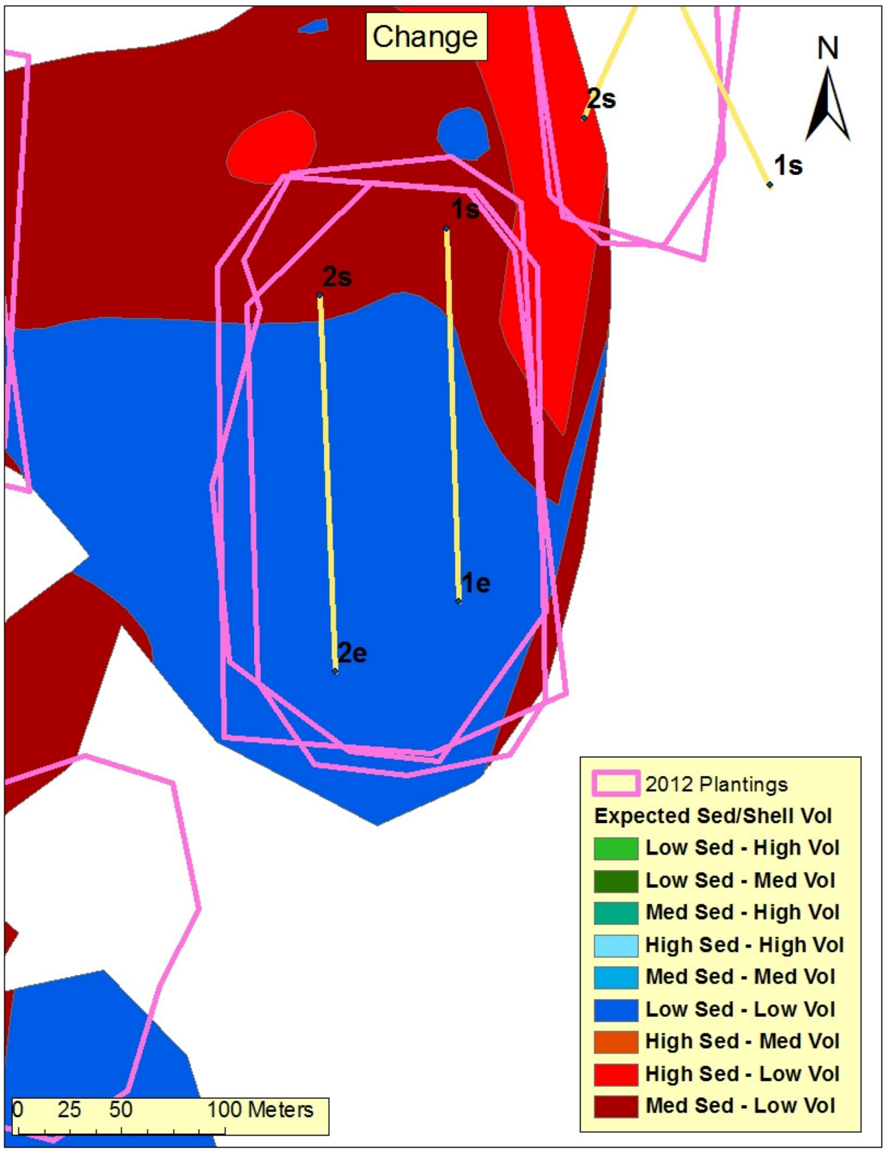
This report contains a detailed map of each site that was surveyed, the associated mode data, as well as a summary of the conclusions gleaned from the collected data. Additionally, target sites that were planted with spat-on-shell in 2012 are shown on relevant maps (as pink polygons).

Site-Specific Data

Change

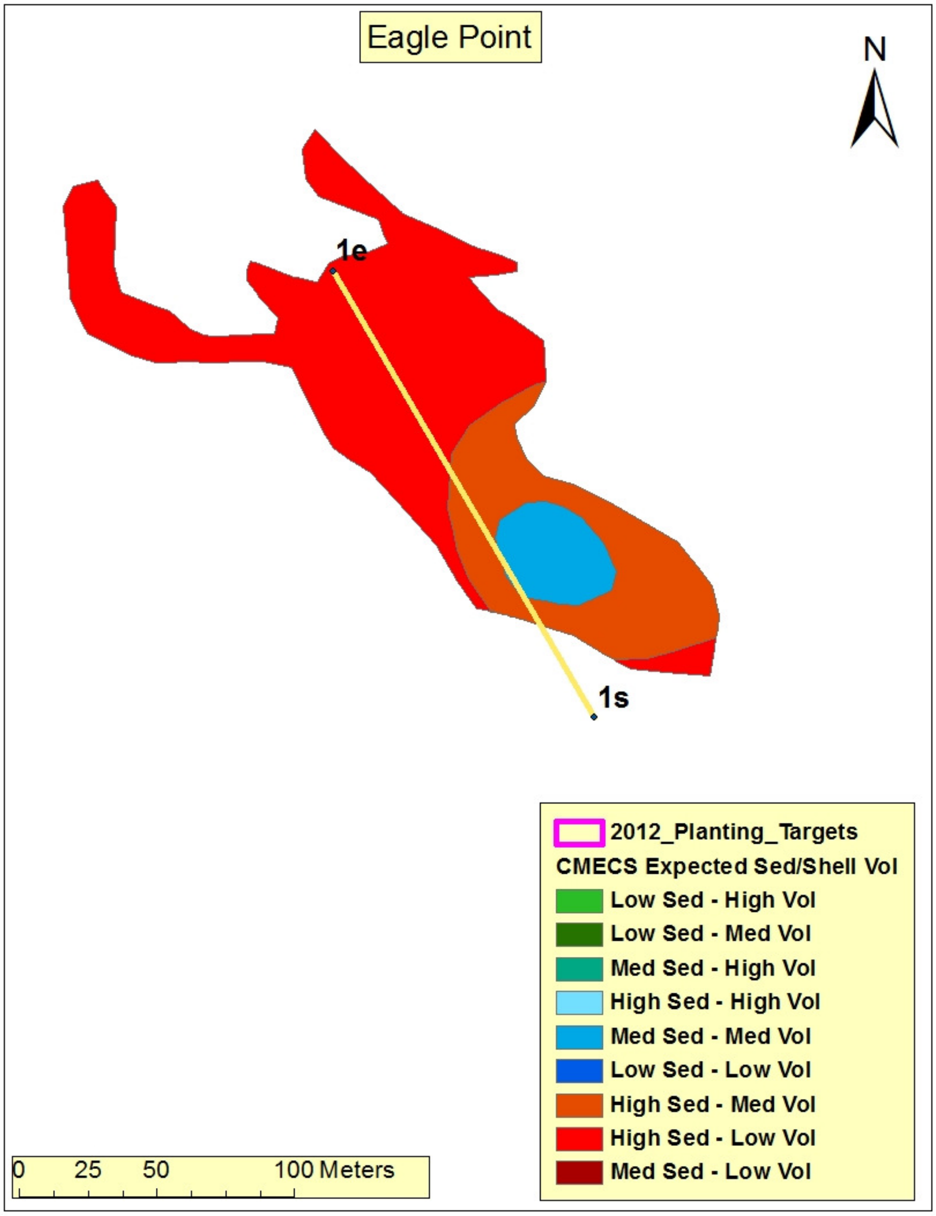
Change was one of the first bars targeted for ground truthing due to the good quality of bottom expected to be found at the site. Transects at Change confirmed the expected bottom type and revealed the presence of bottom suitable for planting. This site was planted three times by the ORP in the summer of 2012. Although some penetration was observed, this was due to a deep layer of shell present, not sedimentation over the shell.

Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
3/19/12	1	Some	5	Loose Shell	1.78
3/19/12	2	Exposed	5	Loose Shell	1.61



Eagle Point
Eagle Point was targeted for ground truthing due to the high amount of oysters expected to be found at the site (not shown on the map below), despite the relatively high sedimentation and low shell volume expected. While oysters were observed at the site at an average density of 1 oyster/m^2, data collected confirmed the expected poor bottom type and therefore the site was not deemed suitable for planting due to the low presence of shell and relatively high penetration. Eagle Point was not planted in the summer of 2012.

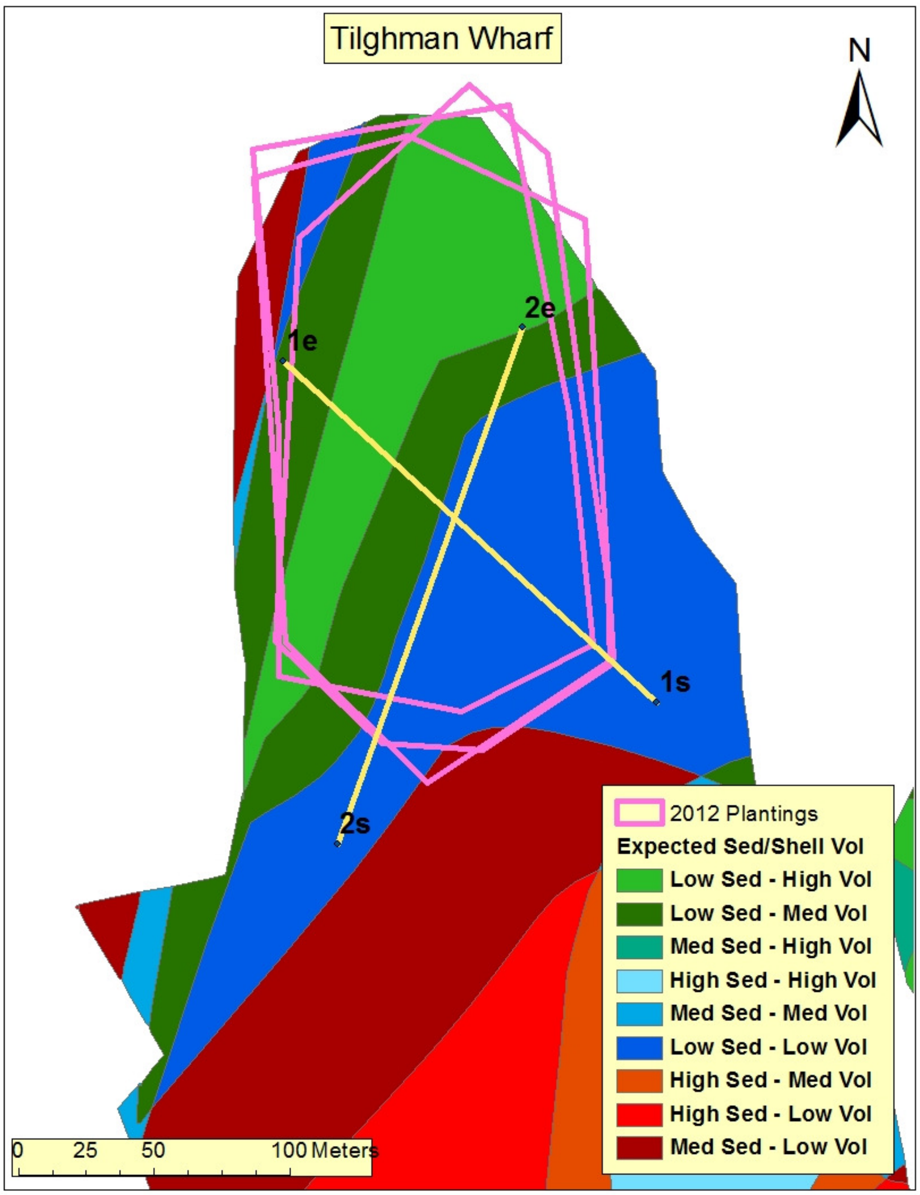
Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
3/19/12	1	Very Little	10	Sand	1.00



Tilghman Wharf

This plot at Tilghman Wharf was chosen due to the high quality of expected bottom at the site. Sedimentation was expected to be low or medium and shell volume was expected to be high. However, the observed data did not match with the expected sedimentation and shell volume. On average, no exposed shell was observed and the substrate was either sand or exposed shell. Despite this relatively poor bottom, oyster density was high – 2 or 5 oysters/m^2. Therefore, this area at Tilghman Wharf was targeted for three plantings in the summer of 2012.

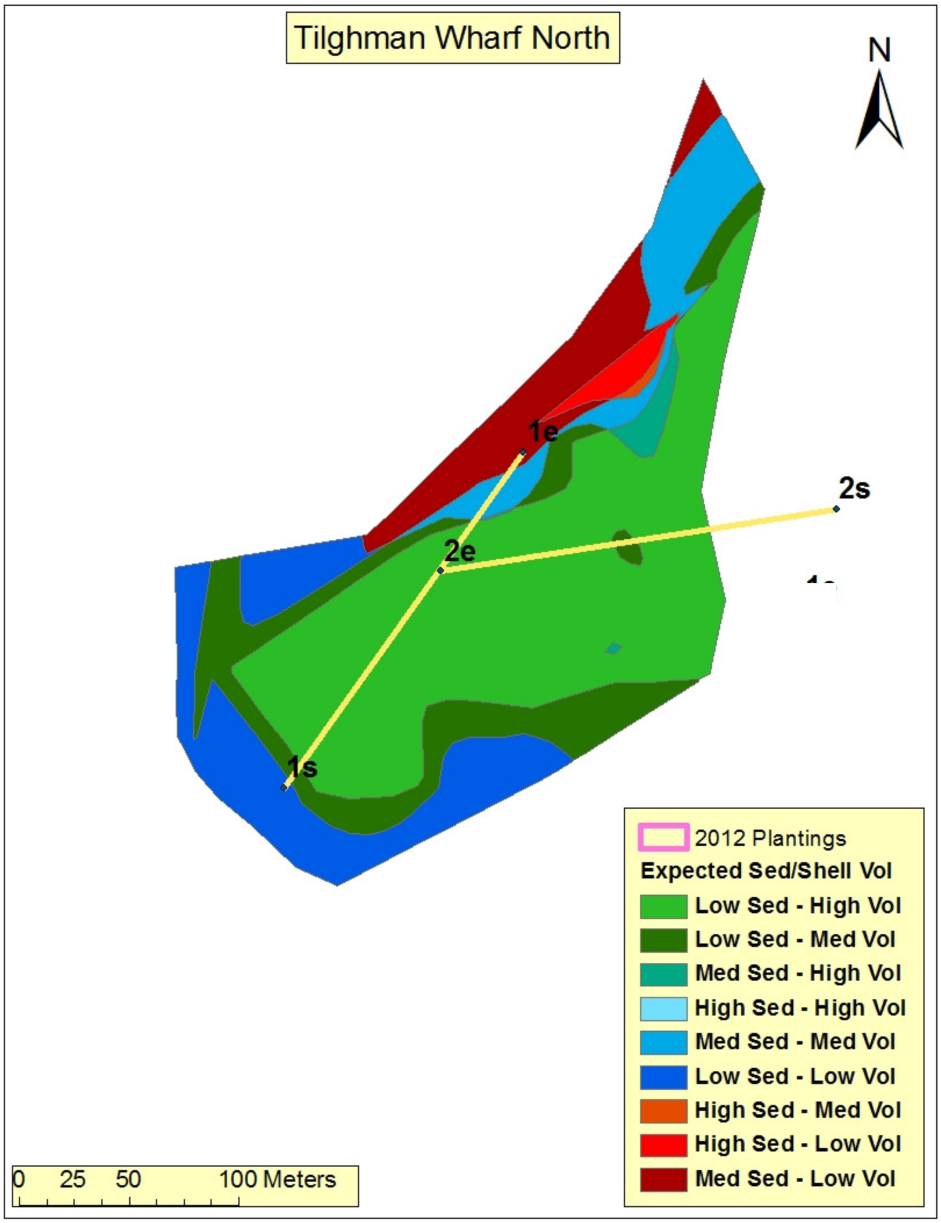
Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
3/19/12	1	Zero	5	Loose Shell	2.00
3/19/12	2	Zero	5	Sand	5.00



Tilghman Wharf North

The area at Tilghman Wharf north was chosen due to the expected good bottom at the site based on the CMECS data. Sedimentation was expected to be low while shell volume was expected to be high. While the ground truthing data at this site confirmed the CMECS predictions, this site was not planted in the summer of 2012, due to budget constraints. This site would be a good candidate for planting in the summer of 2013.

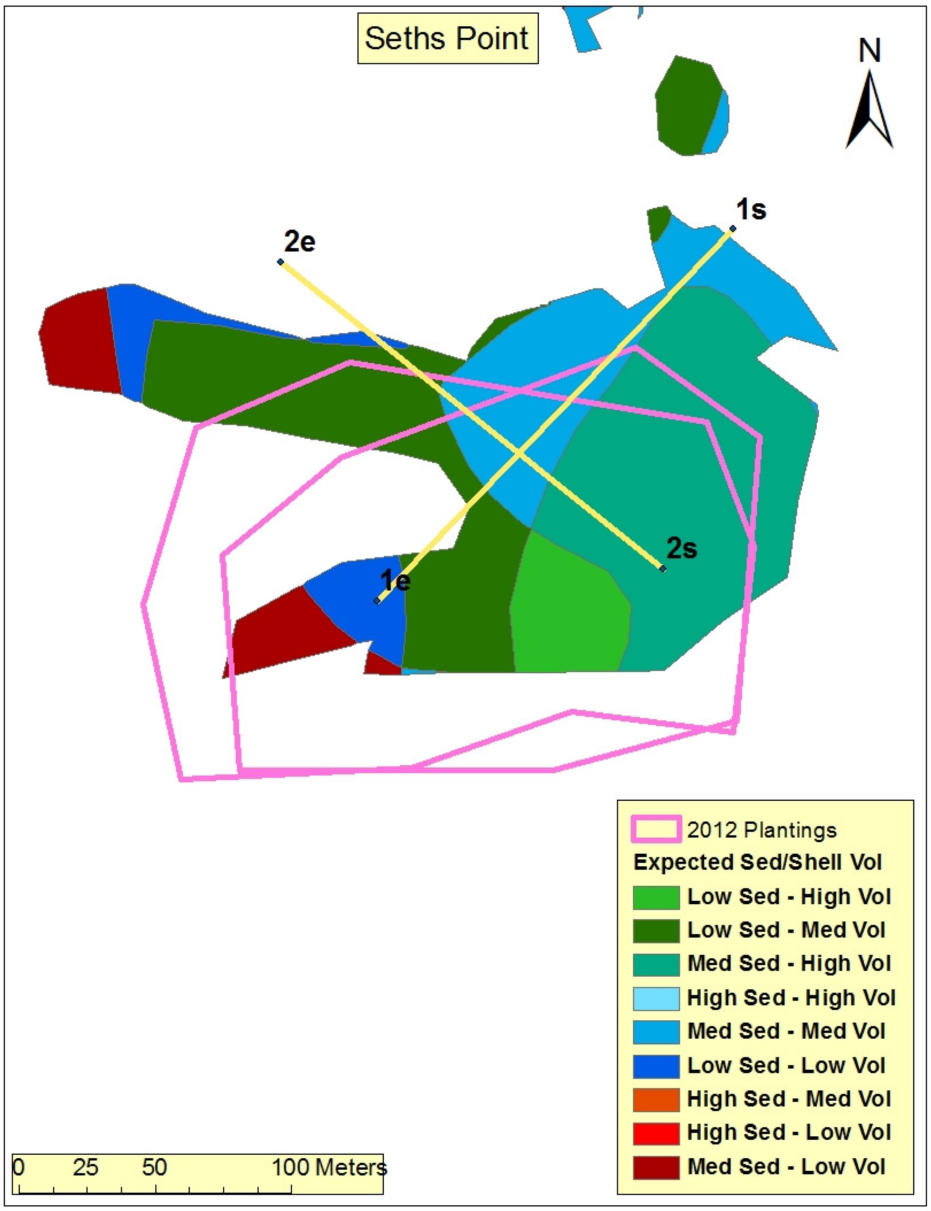
Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
3/19/12	1	Exposed	0	Loose Shell	3.00
3/19/12	2	Some	5	Sand	3.00



Seths Point

The site at Seths Point was targeted because of a combination of good expected bottom (low sedimentation and high shell volume) as well as a relatively large expected oyster population (not shown on map below). Ground truthing data confirmed the presence of oysters, but bottom was marginal – very little to no oyster shell was found, but the bottom was hard (penetration = 0 for both transects). Therefore, this site was the target for two plantings in the summer of 2012.

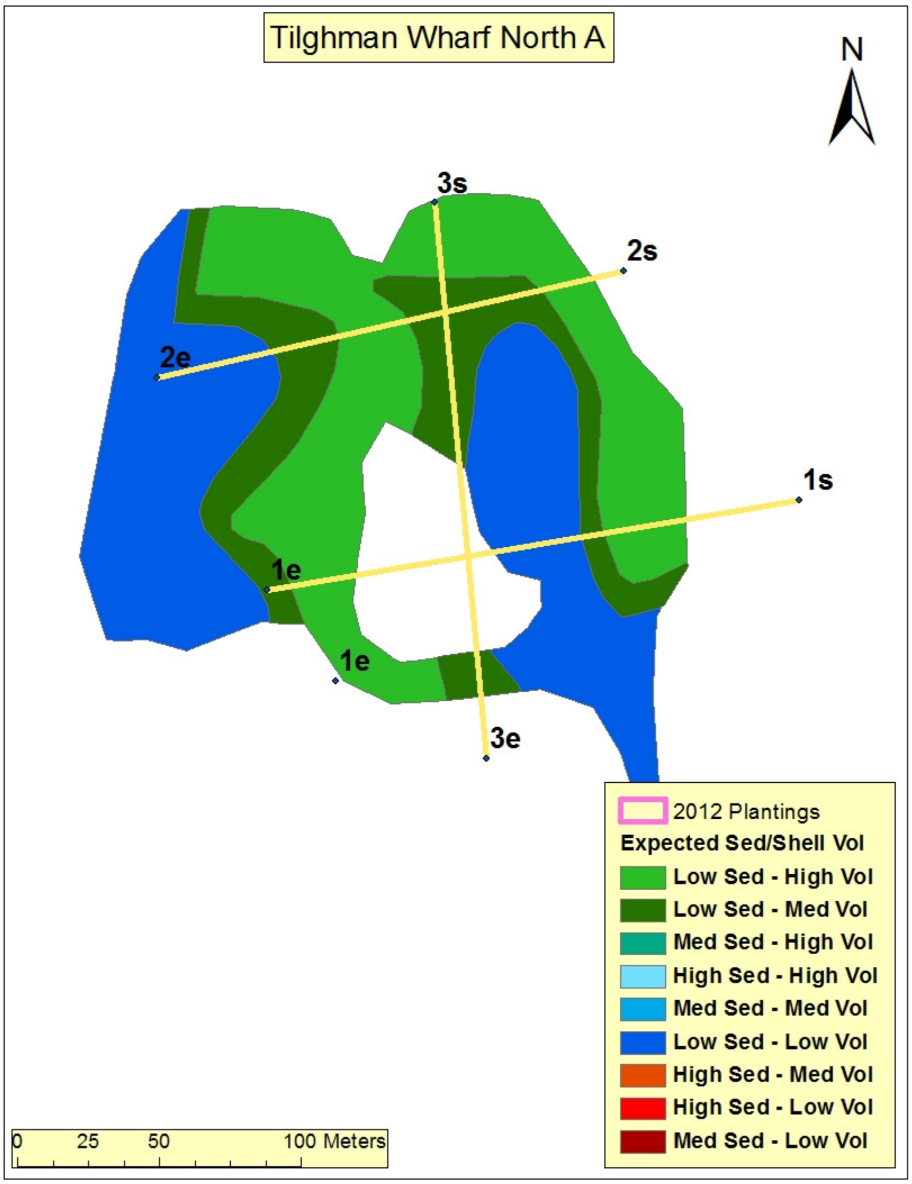
Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
4/19/12	1	Very Little	0	Loose Shell	8.23
4/19/12	2	Zero	0	Sand	7.11



Tilghman Wharf North A

This plot at Tilghman Wharf North was chosen for ground truthing due to the good expected bottom at the site, despite a potential area of poor bottom in the middle of the site (white area at center). While relatively high oyster densities were found at the site, the diver-collected data did not reveal bottom suitable for planting (no exposed shell, sand as a common substrate). Tilghman Wharf North A was not planted by the ORP in the summer of 2012.

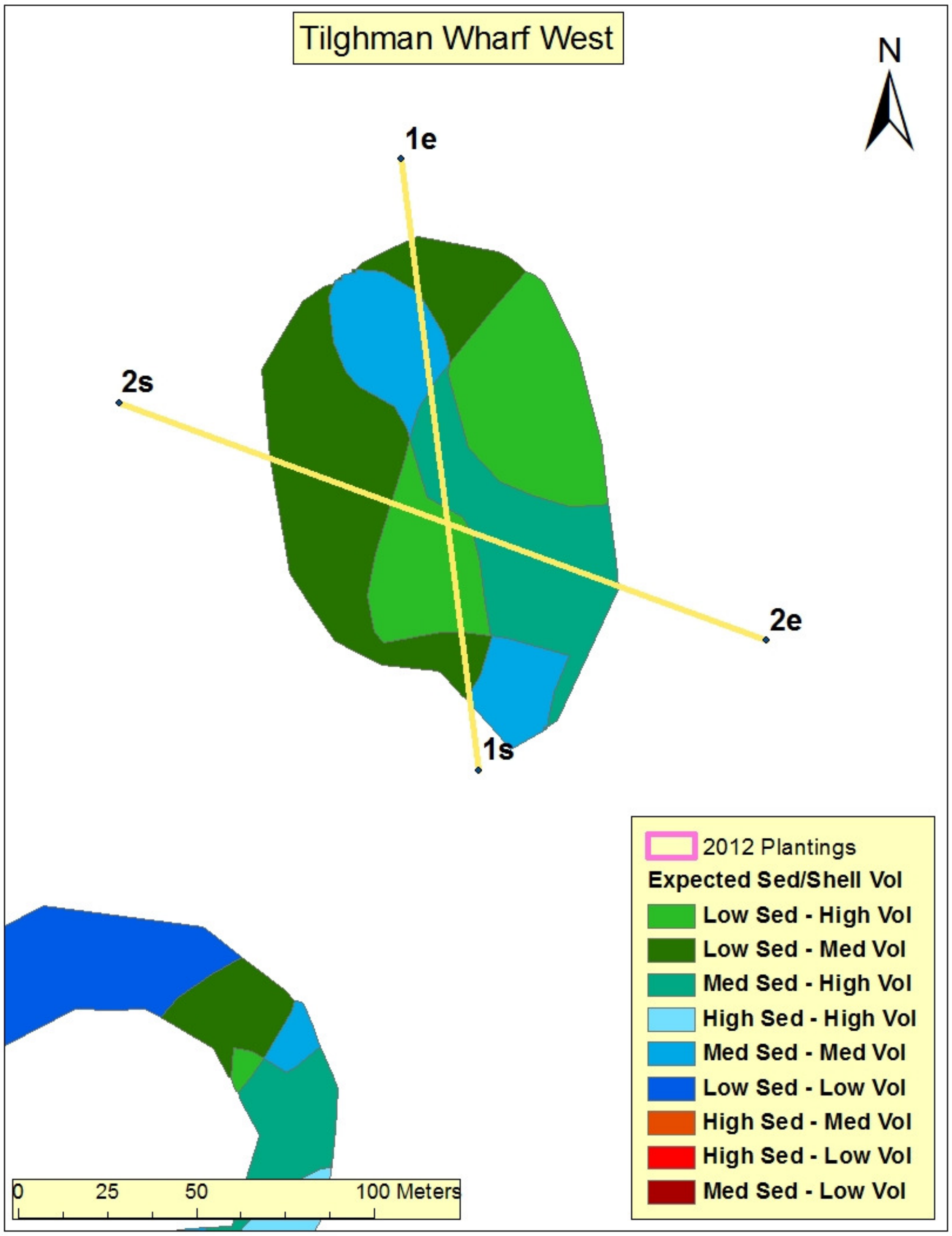
Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
4/19/12	1	Zero	5	Sand	2.00
4/19/12	2	Zero	5	Loose Shell	2.73
4/19/12	3	Zero	5	Sand	2.00



Tilghman Wharf West

This area at Tilghman Wharf West was targeted based on the expected good bottom at the site, despite the relatively small size of the area of expected good bottom. However, ground truthing transect data did not confirm the CMECS expected bottom type and revealed bottom unsuitable for planting. The area at Tilghman Wharf west was not planted in the summer of 2012.

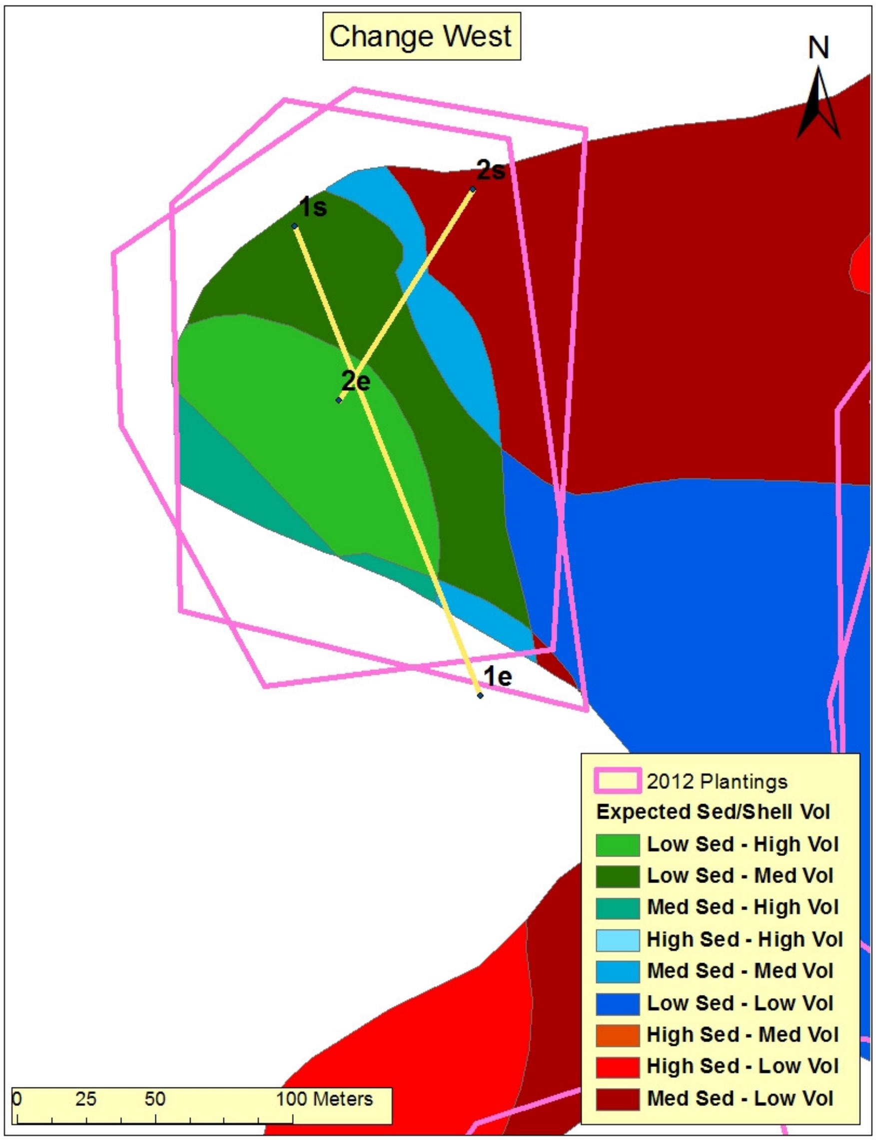
Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
4/19/12	1	Exposed	5	Sand	1.00
4/19/12	2	Zero	5	Sand	0.00



Change West

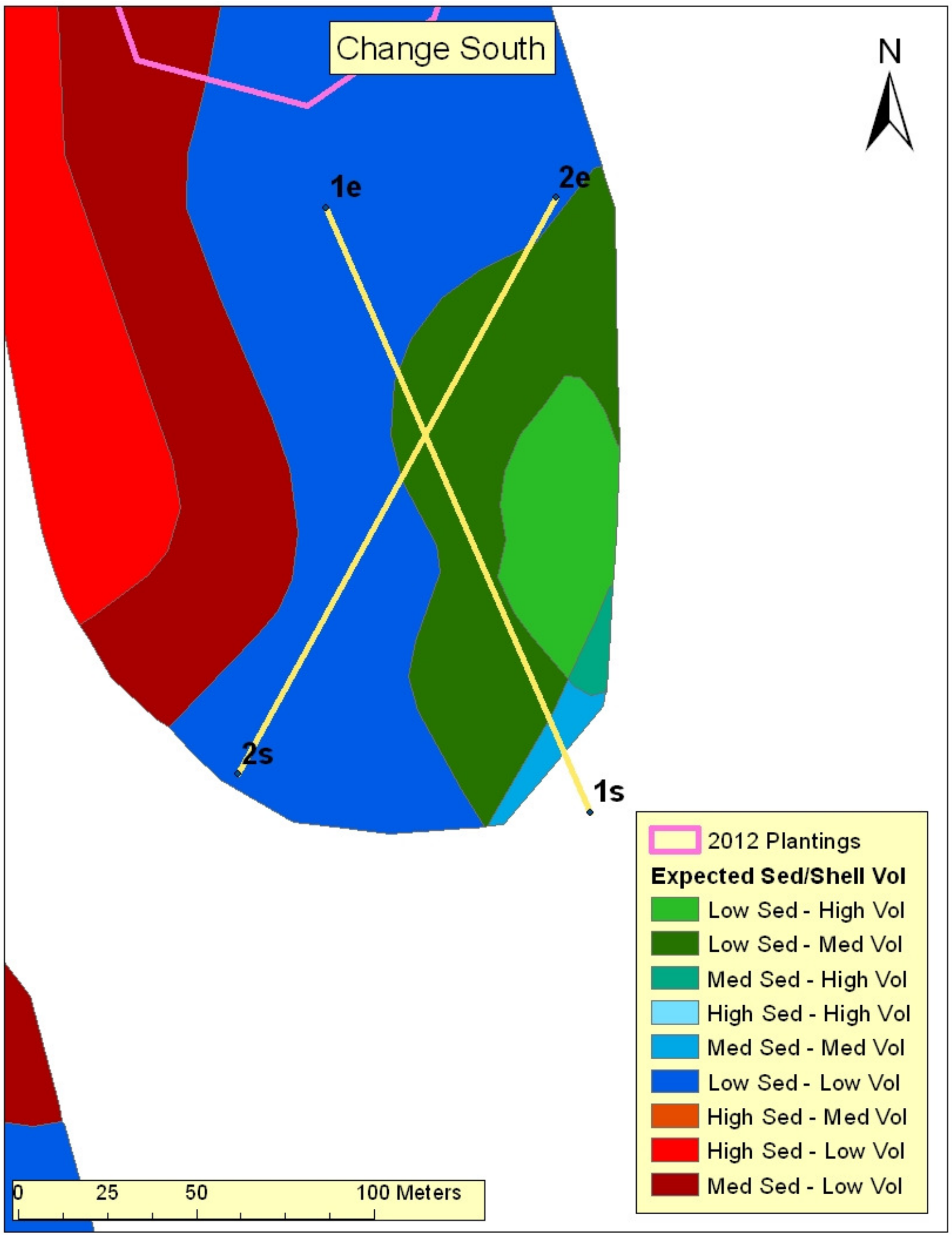
The site at Change West was chosen due to the good expected bottom (low sedimentation and high shell volume). While oysters were found at a density of 1 oyster/m^2 during both transects, only transect two confirmed the predicted CMECS bottom type and revealed bottom appropriate for planting. However, the area around transect two was too small for the ORP planting boat to practically plant, so a larger area (indicated in pink in the map below) was planted twice in the summer of 2012.

Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
5/9/12	1	Zero	0	Sand	1.00
5/9/12	2	Exposed	0	Loose Shell	1.00



Change South
The area at Change South was chosen based on the expected good bottom at the site. However, only transect two confirmed the presence of good bottom (exposed shell, low penetration and presence of oysters). Since transects occupied effectively the same area in terms of planting and transect one revealed poor bottom, the site was not chosen for planting in the summer of 2012.

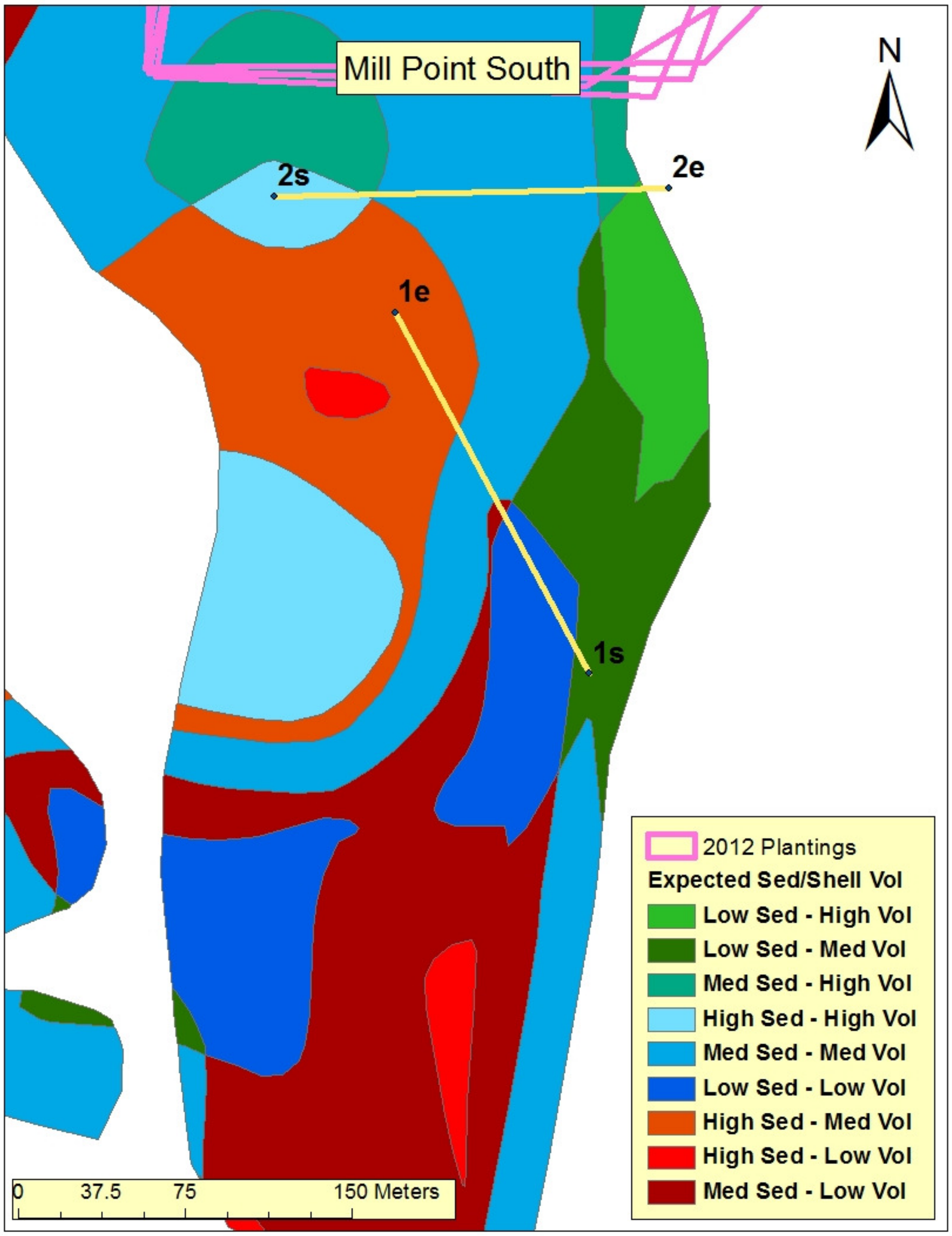
Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
5/9/12	1	Zero	5	Sand	0.00
5/9/12	2	Exposed	0	Loose Shell	2.47



Mill Point South

The area at Mill Point South was chosen based on the expected good bottom at the site. However, the ground truthing data indicated that sand was the primary substrate at the site and penetration was higher than ideal for planting purposes. Although the northern area (around transect two) was better than the area around transect one, none of the Mill Point South site was planted in the summer of 2012.

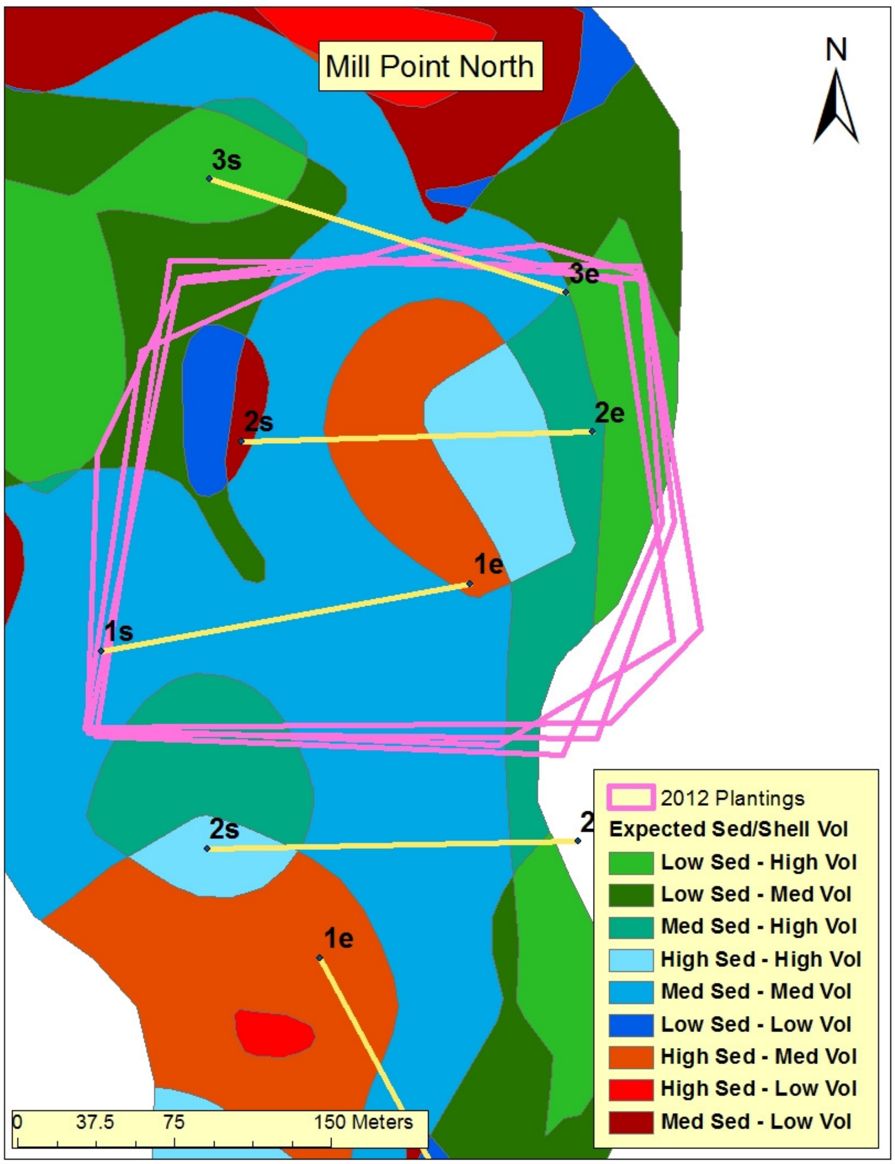
Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
5/9/12	1	Some	5	Sand	0.00
5/9/12	2	Exposed	10	Sand	1.37



Mill Point North

The area targeted near Mill Point North is represented by the three northernmost transects in the map below. This area was chosen both because of good expected bottom and high expected oyster density (not shown on map below). The ground truthing data around transects one and two confirmed the expected CMECS bottom type while the area around transect three did not confirm the CMECS prediction and was not characterized as suitable for planting. The area around transects one and two was planted four times in the summer of 2012.

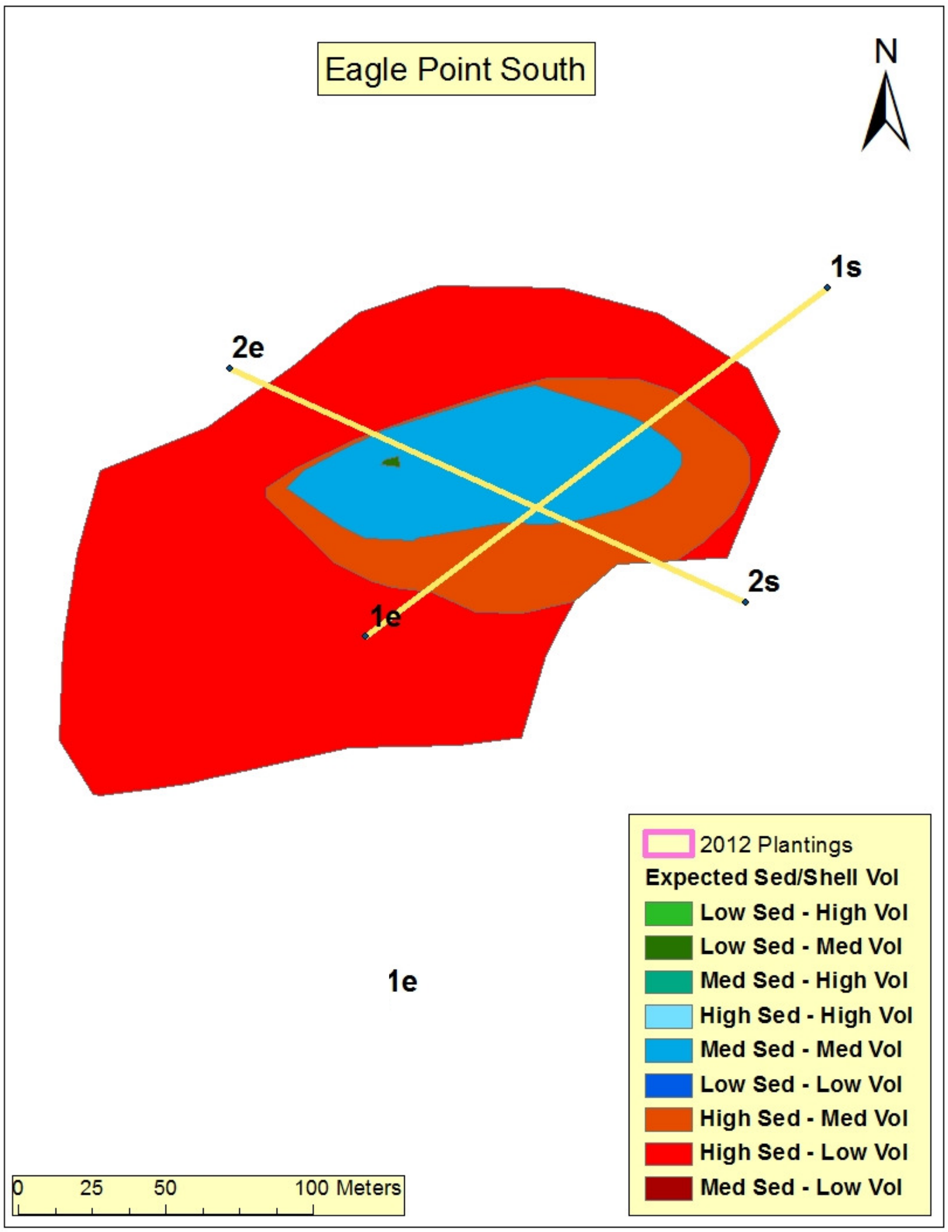
Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
5/9/12	1	Exposed	0	Loose Shell	7.62
5/9/12	2	Exposed	0	Loose Shell	5.00
5/9/12	3	Some	10	Sand	2.27



Eagle Point South

The area at Eagle Point South was targeted due to high expected oyster density, rather than good expected bottom. However, the ground truthing data revealed good bottom (presence of exposed shell, low penetration) as well as relatively high oyster densities at both transects. Despite these promising results, the area at Eagle Point south was not planted in the summer of 2012 due to budget constraints. This site would be a good candidate for planting in future years.

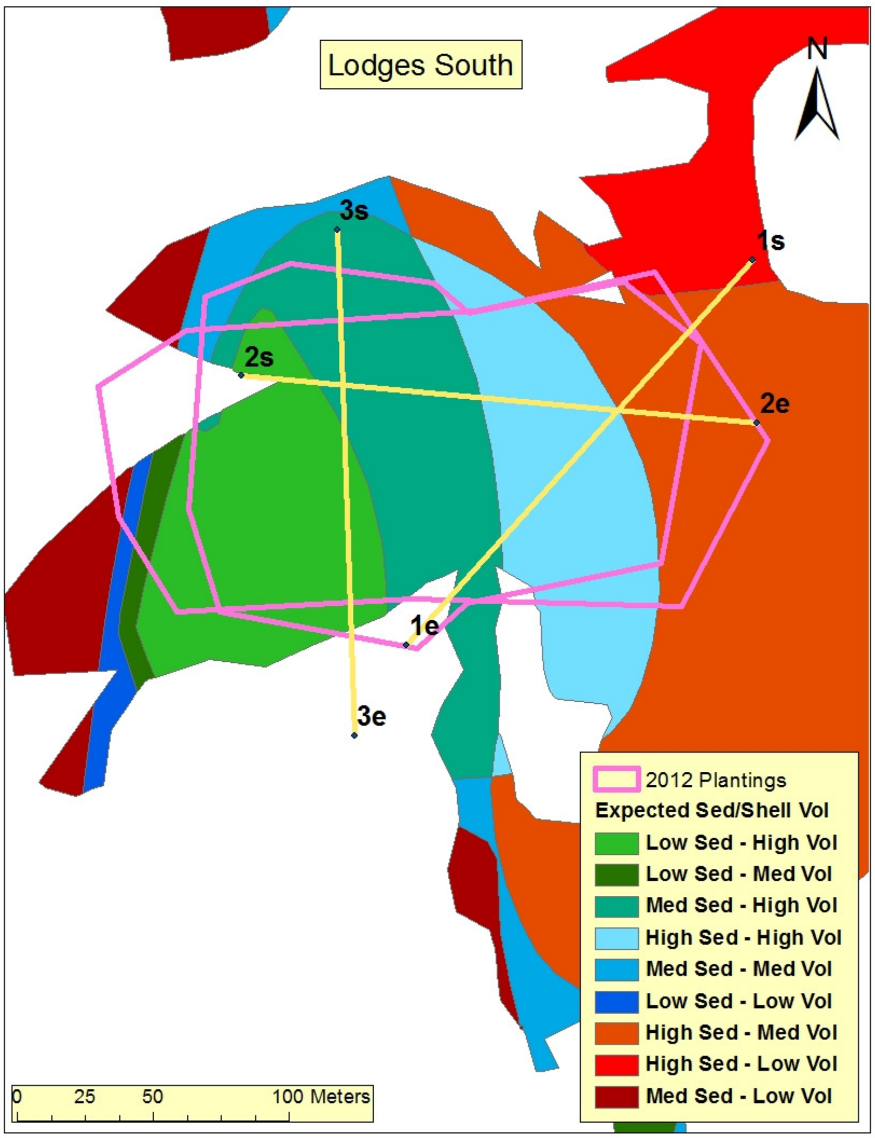
Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
6/6/12	1	Exposed	5	Loose Shell	2.41
6/6/12	2	Exposed	0	Loose Shell	2.42



Lodges South

The area at Lodges South was chosen based on the expected good bottom at the site. The ground truthing data confirmed the presence of good bottom and also found higher oyster densities at transects two and three at Lodges South. The area around transect one was not as suitable for planting as the area around transects two and three, but it still contained appropriate amounts of shell despite relatively high penetration. Therefore, the area around transects one, two and three was planted twice in the summer of 2012.

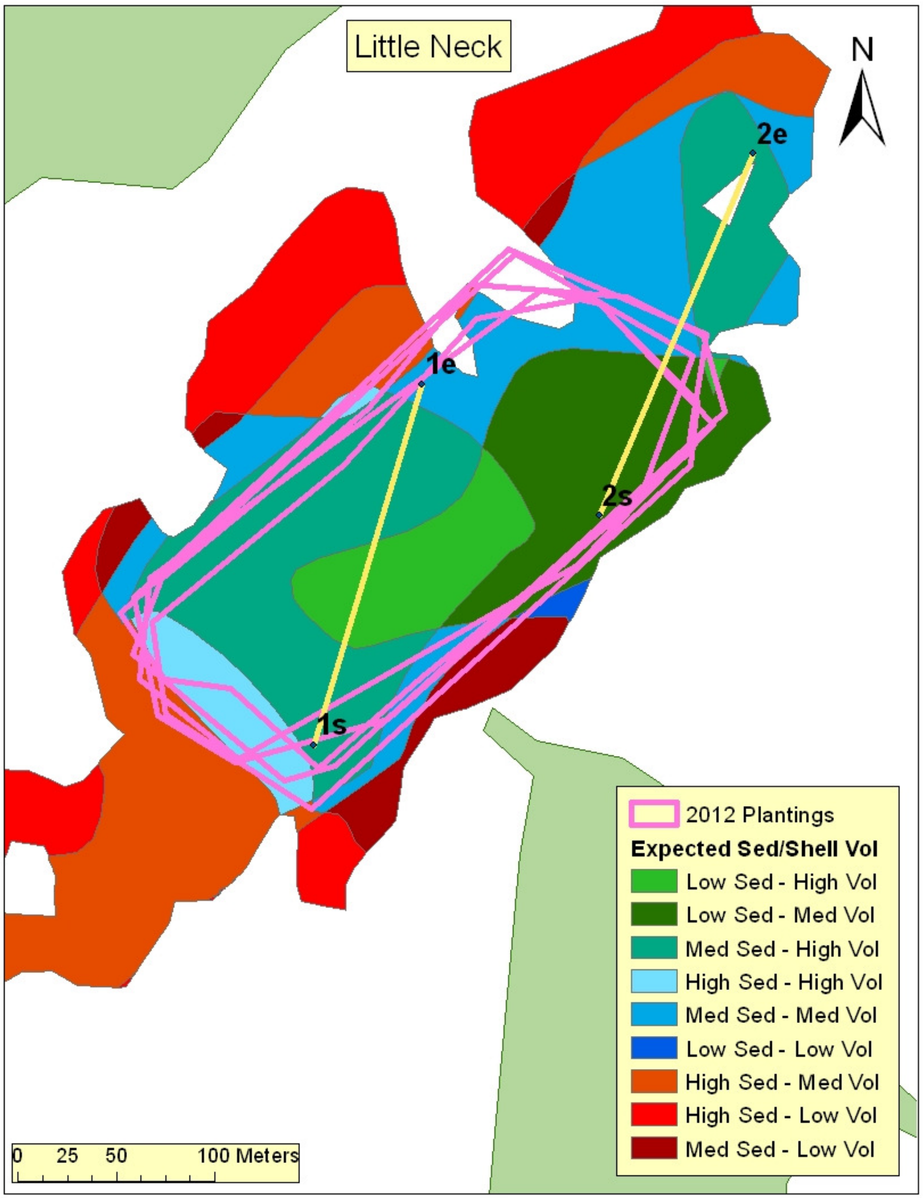
Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
6/6/12	1	Some/Exposed	10	Loose Shell	0.59
6/6/12	2	Exposed	5	Loose Shell	3.59
6/6/12	3	Exposed	5	Loose Shell	2.96



Little Neck

The area at Little Neck was chosen based on the expected good bottom at the site as well as the expected high oyster density. The ground truthing data revealed good bottom at the site (exposed shell and low penetration) as well as oyster presence at a density of about two oysters/m^2. The area around all of transect one and most of transect two was planted five times in the summer of 2012. The area planted was smaller than the total area around the transects due to the total area being too large for one planting event.

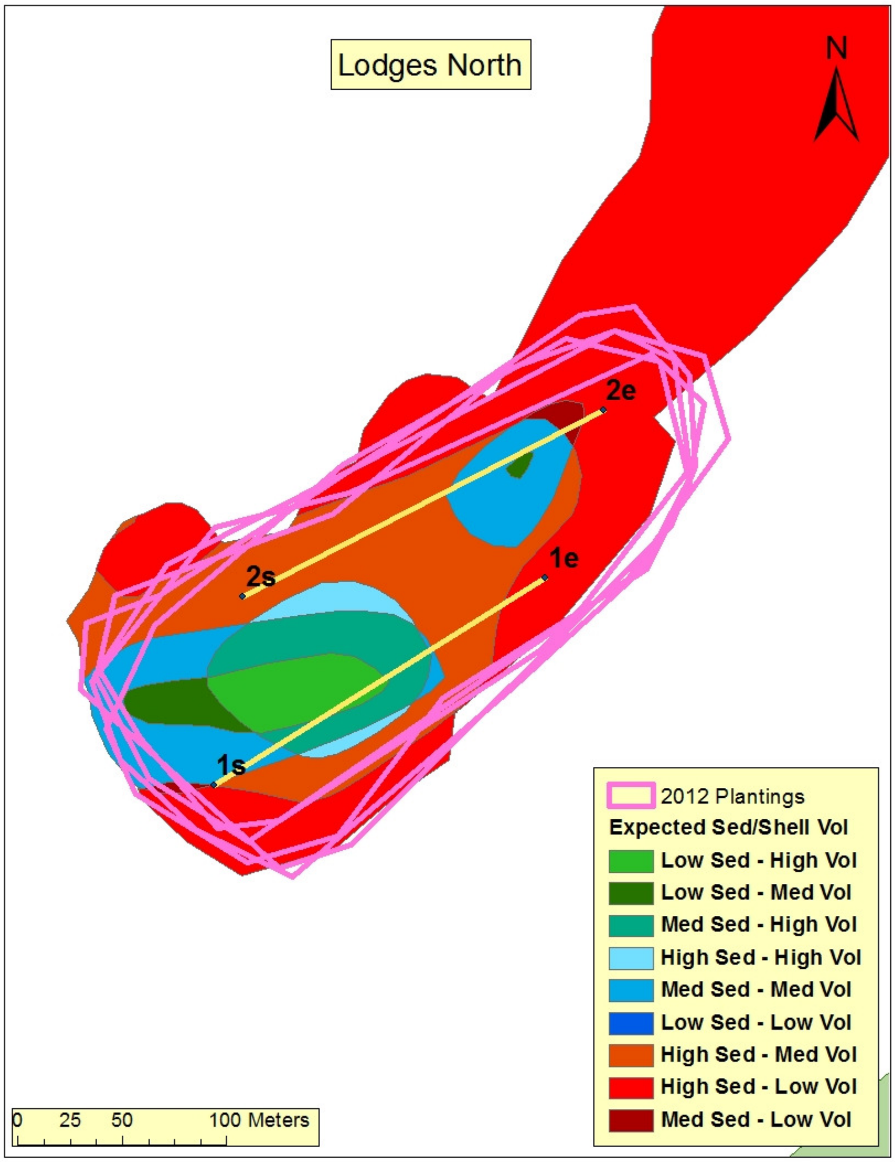
Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
6/6/12	1	Exposed	5	Loose Shell	2.38
6/6/12	2	Exposed	5	Loose Shell	1.93



Lodges North

The area at Lodges North was chosen based on the expected good bottom at the site as well as high expected oyster densities. The ground truthing data confirmed the expected bottom type and revealed exposed shell and relatively low penetration as well oysters at a density of at least 1.3 oysters/m^2. The penetration at transect two was moderate, but since the exposed shell and substrate values were within the range of being appropriate for planting, the area around both transects was planted five times in the summer of 2012.

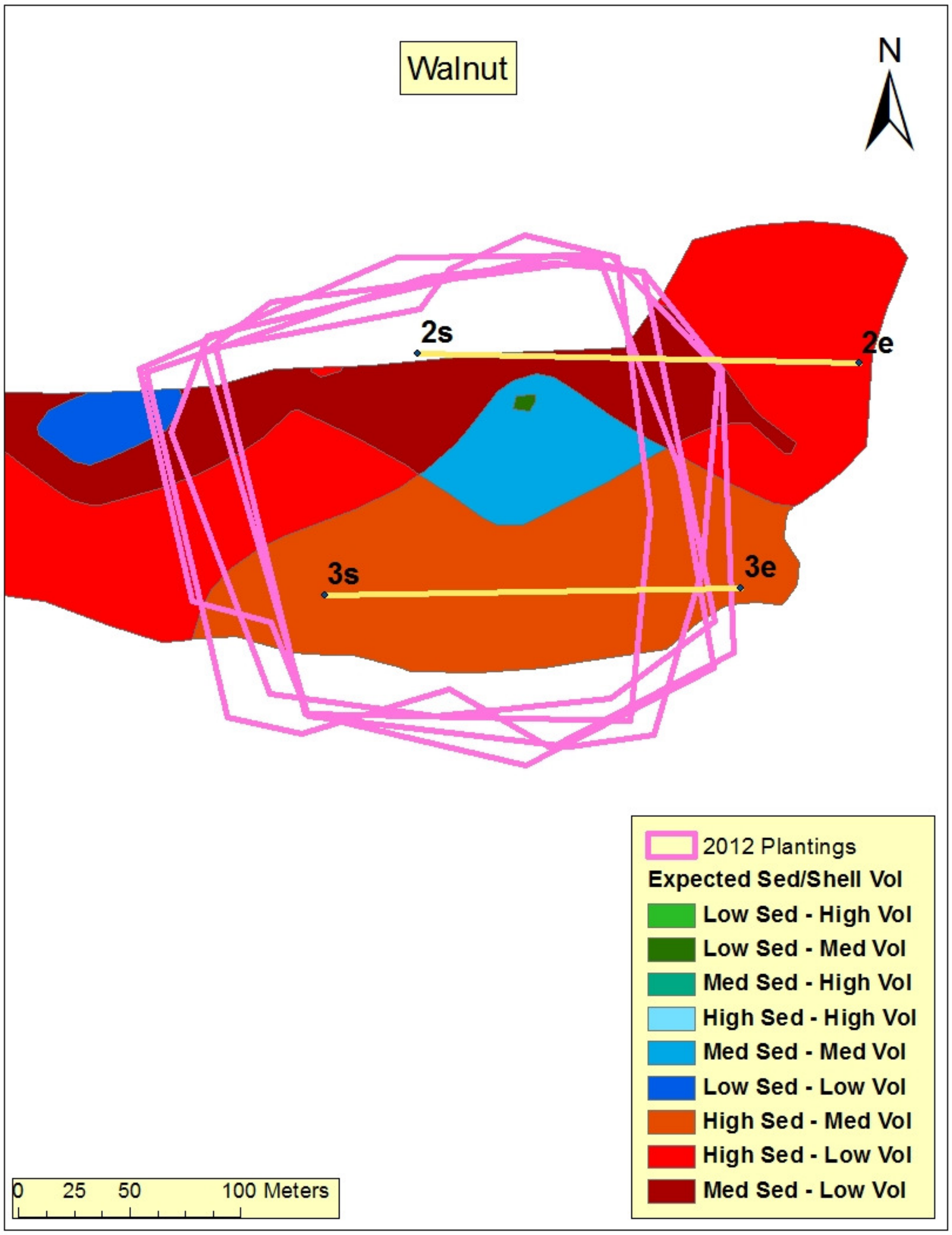
Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
6/8/12	1	Exposed	0	Loose Shell	3.93
6/8/12	2	Exposed	10	Loose Shell	1.28



Walnut

The area at Walnut was chosen based on the high expected oyster density at the site (not shown in the map below) rather than good expected bottom. However, the ground truthing data indicated the presence of good bottom as well as oysters at densities of at least two oysters/m^2 at the site. Therefore, site at Walnut was planted 5 times in the summer of 2012.

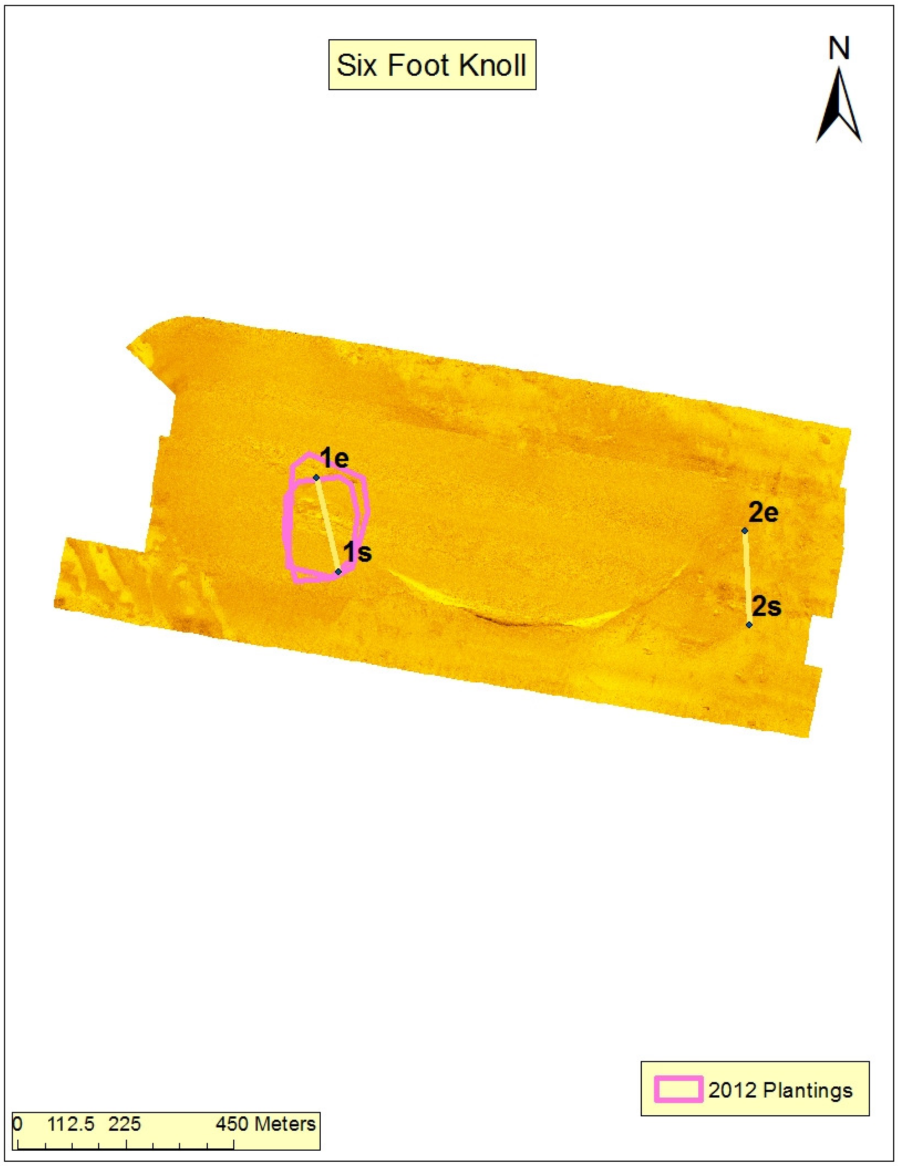
Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Substrate Type	Average Oyster Density (#/m2)
6/8/12	2	Exposed	5	Loose Shell	4.57
6/8/12	3	Exposed	10	Loose Shell	2.10



Six Foot Knoll

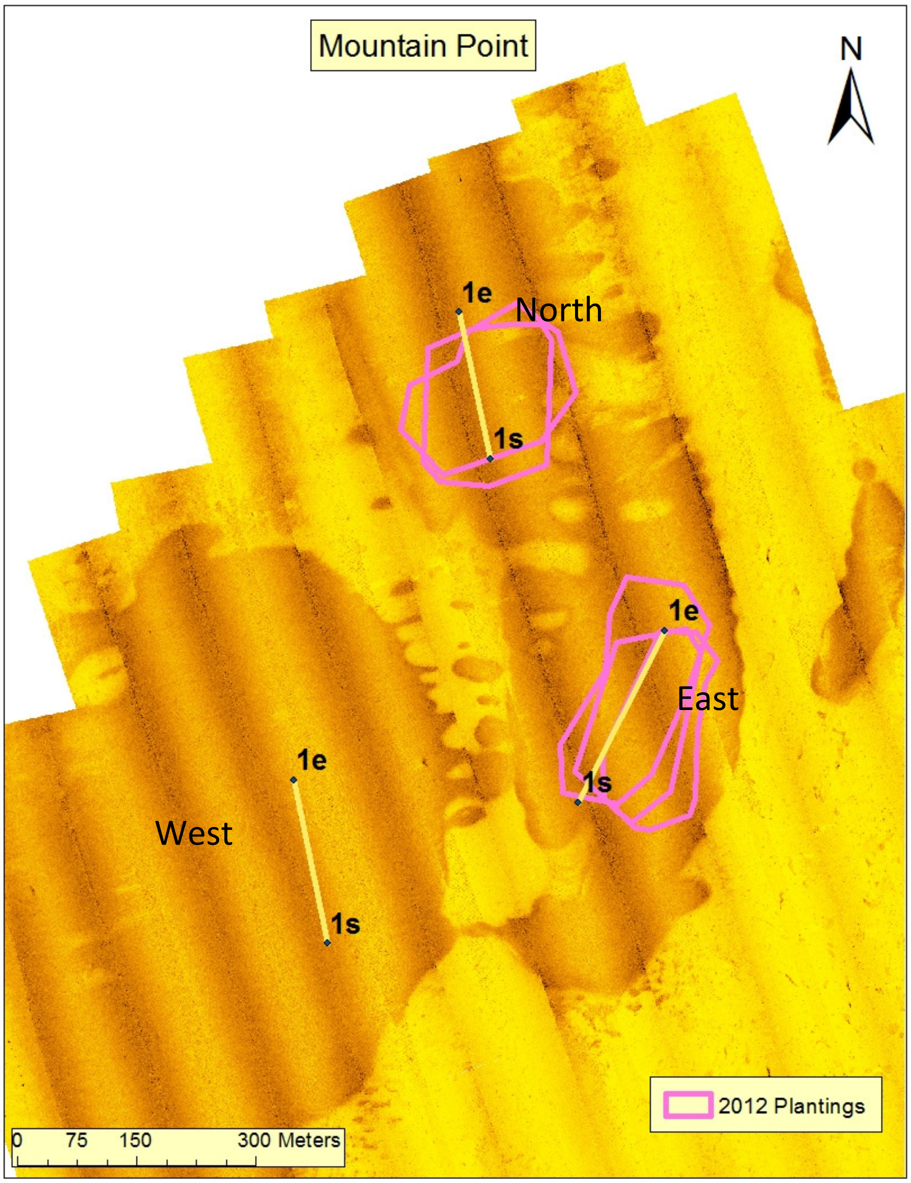
The area at Six Foot Knoll was chosen in order to seed an area known to have shell already present. The survey area was chosen based on the known presence of shell as well as side scan sonar data (shown in the map below). Transect one identified bottom suitable for planting while the bottom around transect two did not contain shell at high enough densities to be suitable for planting. Therefore, the area around transect one was planted twice in the summer of 2012.

Date	Transect #	Mode Exposed Shell	Mode Penetration (cm)	Mode Primary Substrate	Average Oyster Density (#/m2)
8-Jun-12	1	Some	0	Loose Shell	0
8-Jun-12	2	Very Little	10	Sand	1.00



Mountain Point
The area at Mountain Point was chosen in order to seed an area known to have shell already present. The survey area was chosen based on the known presence of shell as well as good bottom identified by side scan sonar data (shown as dark areas in the map below). The transects at the north and east plot indicated bottom suitable for planting and were each planted twice in the summer of 2012.

Site	Date	Mode Exposed Shell	Mode Penetration (cm)	Mode Primary Substrate	Average Oyster Density (#/m2)
North	7-Aug-12	Exposed	0	Loose Shell	0.20
West	7-Aug-12	Some	0	Loose Shell	0
East	7-Aug-12	Exposed	0	Loose Shell	0.46



Conclusions

In the spring of 2012, eighteen bars were ground truthed by divers from the Paynter Lab to determine 1) bottom suitability for spat on shell planting and 2) confirm the bottom type prediction based on the Chesapeake Bay Marine Ecological Classification Standard (CMECS). Sites were chosen for ground truthing based on available side scan sonar and CMECS data and therefore the bottom at sites was generally very good. Of the 18 bars surveyed, 13 were identified as having bottom appropriate for planting and 11 were planted in the summer of 2012, indicating that pre-survey site selection identified many sites that were appropriate for planting. Sixteen of the 18 bars surveyed were located in Harris Creek, where recent CMECS data are available for comparision to diver collected bottom type data. Nine of the 16 bars surveyed matched the CMECS prediction of bottom appropriate for planting and the survey of two additional bars revealed bottom better than expected based on the CMECS data. A more detailed comparison of the diver collected data with the CMECS data will be conducted during the winter of 2013 in preparation for the 2013 ground truthing season. We believe this detailed analysis will allow for refinement of the CMECS classification scheme and improve the predictive ability of bottom type data in general. Extensive ground truthing may have also contributed to the exceptionally high survival (36%) in 2012.

Section III: Post-Planting Monitoring 2012

Data Summary

In 2012, divers surveyed 14 sites planted with spat-on-shell from the Horn Point Laboratory Oyster Hatchery in Cambridge, Maryland 4-8 weeks after the planting occurred. The purpose of these surveys was to determine the density and short term survivorship of spat-on-shell plantings. The diver survey date, number of acres planted and amount of spat planted at each of the 14 locations is presented in Table 1. As suggested by the planting dates, many of the plantings involved multiple plantings over the same areas in an attempt to increase the density of spat planted at a single location. This method follows the planting method from 2010 and 2011, where many sites were overplanted, in contrast to years prior to 2010, where more sites were planted with fewer spat deployed at each site. Figure 1 shows the location of 2012 spat-on-shell post-planting monitoring sites. As part of the 2012 tributary-focused restoration plan, Harris Creek was the primary restoration site where spat-on-shell was planted. This marks a new approach, as recommended and implemented by the NOAA, Maryland Department of Natural Resources, United States Army Corps of Engineers, and Oyster Recovery Partnership.

Table 1. 2012 post-planting monitoring hatchery summary.

River/Region	Site	2012 Planting Dates	2012 PPM Sample Date	Acres Planted	Amount of Spat Planted (millions)
Harris Creek	Change	4/30, 5/2,7	6/15	10.6	44
	Change- artificial and natural	9/10, 19	10/23	4.9	38
	Change North	8/7	9/6	6.3	10
	Change West	5/22, 23	7/6	6.4	31
	Little Neck	6/13, 18-19, 25-26	8/8	10.3	52
	Lodges	6/11, 12	8/8	6.4	28
	Lodges North	7/16-18, 24-25	9/6	10.2	50
	Mill Point	5/14-16, 21	7/3	14.7	62
	Seth's Point	5/8, 9	6/15	7.4	49
	Tilghman Wharf	5/29-30, 6/4	7/3	6.4	29
	Walnut	7/2-3, 9, 10, 16	9/6	11.8	47
Severn River	Wade	6/5, 6	7/12	1.4	17
Upper Bay	Mountain Point South	8/13-14, 20	10/17	10.3	41
	Mountain Point North	8/28, 9/4	10/17	8.6	48
	Six Foot Knoll	8/21, 27	10/17	9.1	31

2012 Post-Planting Monitoring Sites

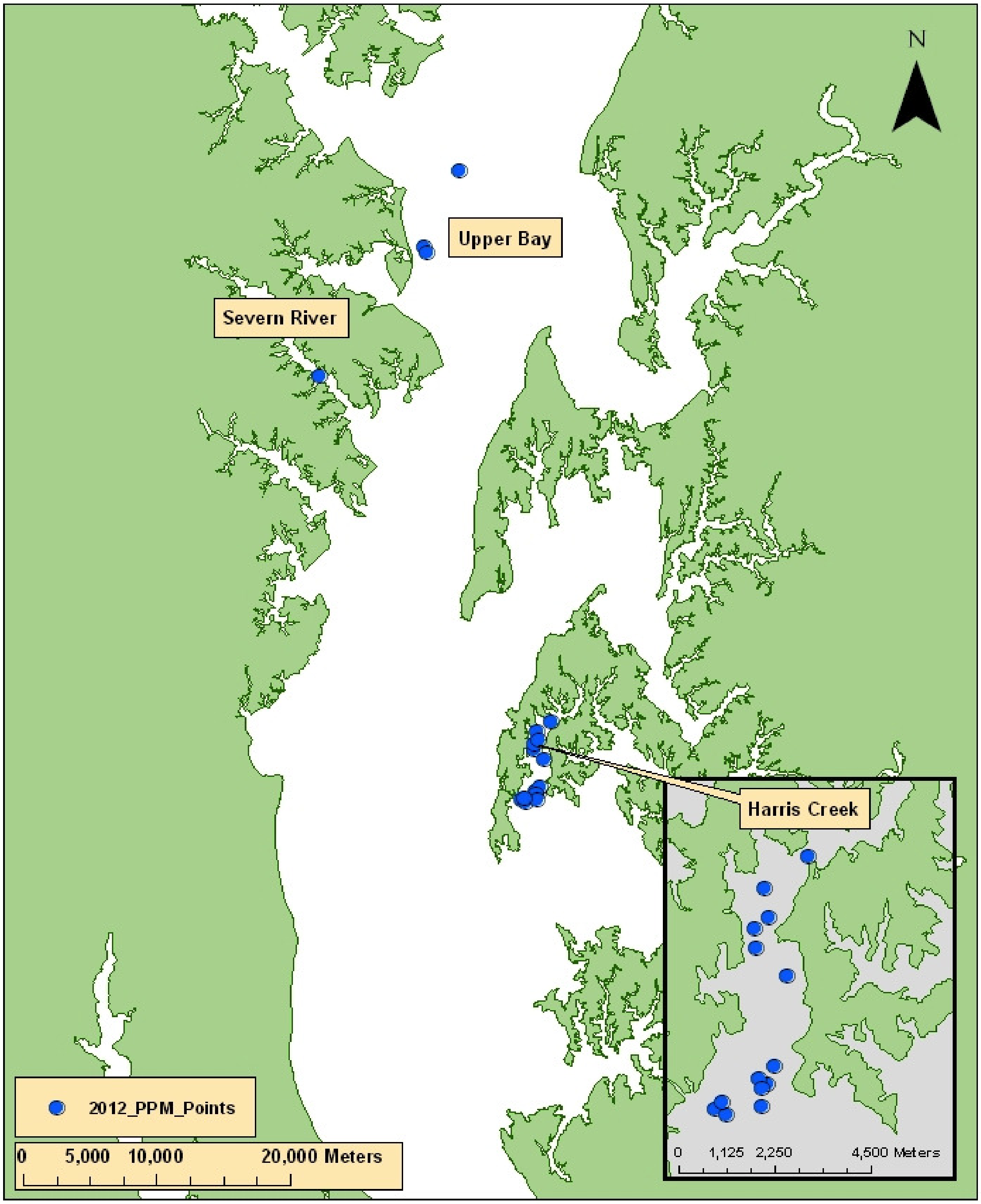


Figure 1. 2012 Post-planting monitoring sites. All sites surveyed post-planting in 2012 are represented by blue circles. The majority of spat-on-shell planting efforts were focused in Harris Creek, and the inset shows Harris Creek survey locations in closer detail.

Using the planting boat's track lines as a target, a diver collected hatchery shells from each survey location. Divers placed a 0.3 m x 0.3 m quadrat on the bottom and collected all shells contained within the quadrat. Attempts were made to collect at least three quadrat samples at each site. When shell densities were too low for quadrat sampling, such that divers could not find at least 50 shells over multiple quads, divers would instead haphazardly collect 50 to 100 shells from throughout the bar. In 2012, quads were used at all sites except for Wade, in the Severn River. Each shell was examined for live spat, boxes, scars, and gapers. Additionally, the first 50 live spat observed in each sample were measured for shell height in order to estimate the size and growth of spat at each planting. The means of those shell metrics are summarized in Table 2 for all sample locations in 2012. The metrics for the Change (Artificial and Natural) planting are separated in Table 2 because samples were taken on each substrate type separately in order to examine for differences in metrics by substrate. No significant differences were found in any metrics recorded in the 2012 PPM survey between artificial and natural substrate at Change.

Table 2**.** 2012 post-planting monitoring survey summary. Change (Artificial and Natural) are separated because samples were taken on each substrate type separately in order to examine for differences in metrics by substrate. No such differences were found at Change.

			Mean Count per Shell				
River/Region	**Bar Name**	**# Shells Sampled**	**#Live**	**#Gapers**	**#Scars**	**#Boxes**	**Shell Height (mm)**
Harris Creek	Change	77	5.8	0	1.7	0	10.4
	Change (Artificial)	56	15.3	0.1	1.4	0.2	13.0
	Change (Natural)	63	14.5	0	1.8	0.1	11.7
	Change North	64	4.9	0	1.4	0.1	20.5
	Change West	70	3.2	0	3.2	0.1	17.1
	Little Neck	61	4.6	0	1.5	0	28.1
	Lodges	37	7.6	0	0.4	0	18.2
	Lodges North	140	4.2	0	1.3	0.1	23.5
	Mill Point	51	6.2	0	2	0	15.1
	Seth's Point	80	13.7	0	2.8	0	10.7
	Tilghman Wharf	62	3.4	0	1.7	0.1	15.8
	Walnut	59	2	0	1.1	0.1	30.8
Severn River	Wade	50	2.7	0.1	2.4	0.1	19.8
Upper Bay	Mountain Point South	53	9.7	0	4.1	0.6	20.9
	Mountain Point North	62	9.8	0.2	2	0.4	28.8
	Six Foot Knoll	61	7	0	3.8	0.2	20.7

In addition to the metrics listed above, each shell was inspected for the presence of the flatworm predator *Stylochus ellipticus*. Values are not included in the table, as *Stylochus* was observed infrequently during the 2012 PPM survey. A single *Stylochus* was observed in samples at Six Foot Knoll, and three were found in samples from Mountain Point North.

Survival was calculated as the mean live spat per shell detected by the survey divided by the initial spat per shell counted prior to planting, multiplied by 100%. The mean spat survival for 2012 plantings was 36.8 % (±12.1). However, it is important to note the range of the data was 17.9% survival (Walnut) to 61.1% survival (Mountain Point North). Although this range is large, it is much smaller than the range of survival observed in 2011 (0.4% to 89.4%). The percent survival of spat planted by bar is presented in Table 3. Change (Artificial and Natural) are not separated in Table 3 because both substrates occurred in the same area and were therefore planted together. Therefore, it was not possible to determine the amount of spat planted on each site separately and the data for both substrates are presented together in Table 3. The quad data (see below) present data separately by substrate type for Change (Artificial and Natural).

Table 3**.** 2012 spat survival by bar. Change (Artificial and Natural) are presented together because one planting occurred over both substrate types and therefore the amount of spat planted on each substrate could not be determined. Separate metrics by substrate at Change are presented in the quad data (see below).

Bar Name	Acres Planted	Mean # Live Spat/Shell	Amount of Shell Planted	Amount of Spat Planted (Millions)	Live Spat Calculated from Survey (Millions)	2012 % Survival
Change	10.6	5.8	2,533,680	44.3	14.7	33.3
Change- artificial and natural	4.9	14.9	1,689,120	38	25.1	55.8
Change North	6.3	4.9	844,560	10	4.1	39.5
Change West	6.4	3.2	1,689,120	31.1	5.5	20.8
Little Neck	10.3	4.6	4,222,800	52.1	19.2	34.7
Lodges	6.4	7.6	1,689,120	28.2	12.9	53.9
Lodges North	10.2	4.2	4,222,800	50	17.7	35
Mill Point	14.7	6.2	3,378,240	62.2	20.8	33.4
Seth's Point	7.4	13.7	1,689,120	48.7	23.2	47.7
Tilghman Wharf	6.4	3.4	2,533,680	29.4	8.6	34.6
Walnut	11.8	2	4,222,800	47	8.4	17.9
Wade	1.4	2.7	1,689,120	16.9	4.6	32.3
Mountain Point South	8.6	9.7	1,689,120	48	16.4	31.6
Mountain Point North	10.3	9.8	2,533,680	41	24.8	61.1
Six Foot Knoll	9.1	7	1,689,120	31	11.9	39.1
			Total	539.9	192.8	-
			Mean	-	-	36.8

Identical metrics were collected in 2008-2011 from sites comparable to those sampled in 2012 (see Table 4). In 2010-2012, the total acreage planted was less than both 2008 and 2009, due to the fact that an over-planting approach was used where plantings were often repeated over previous plantings. Survival was highest in 2012 of all five years. Similar to 2011, spat-on-shell survival percentages increased dramatically relative to earlier years. As in previous years, data were inspected looking for possible trends relating spat survival to factors including initial spat per shell density, planted spat per acre, and initial shell height/spat growth rate. Within 2012 data, no trends were observed relating early spat survival to initial spat per shell (Figure 2), initial spat shell height, or spat density per acre (Figure 4).

Survival variability was also examined annually, and again no trends were observed connecting spat survival to initial spat per shell or amount of spat planted. Additionally, no trend was observed in survival relative to spat growth rate, indicating that the environmental variation known to impact spat growth (oxygen concentration, food availability) does not seem to be correlated with survival of spat in the northern Chesapeake Bay. Location within and among tributaries was also inspected, revealing no trends in spat survival.

Table 4**.** Comparison of 2008 – 2012 post-planting monitoring survey summary metrics.

					Means per Year			
Sample Year	**Sample Locations**	**Sites Planted**	**Total Acreage Planted**	**Total Spat Planted (Millions)**	**Initial Spat per Shell**	**Survey Spat per Shell**	**Shell Height (mm)**	**% Survival ±SEM**
2008	20	27	215.64	370	30.2	3.9	14.9	17.0±2.8
2009	19	56	408.82	762	17.9	3.4	11.5	12.0±1.9
2010	13	16	99.56	374	14.9	2.0	20.1	12.8±2.4
2011	12	13	93.53	515	16.5	4.4	20.1	27.0±7.7
2012	10	15	124.8	577	16.8	6.7	19.5	36.8±12.1

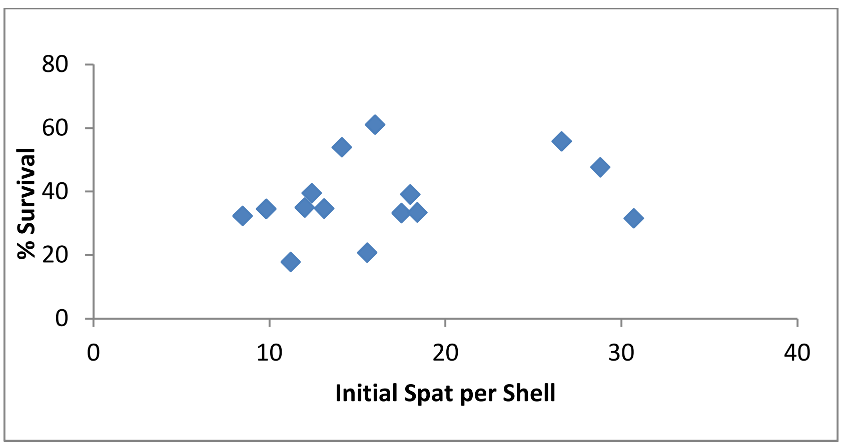


Figure 2. Survival by initial spat per shell for the 2012 post-planting monitoring survey. The data show no trend in survival with initial spat per shell.

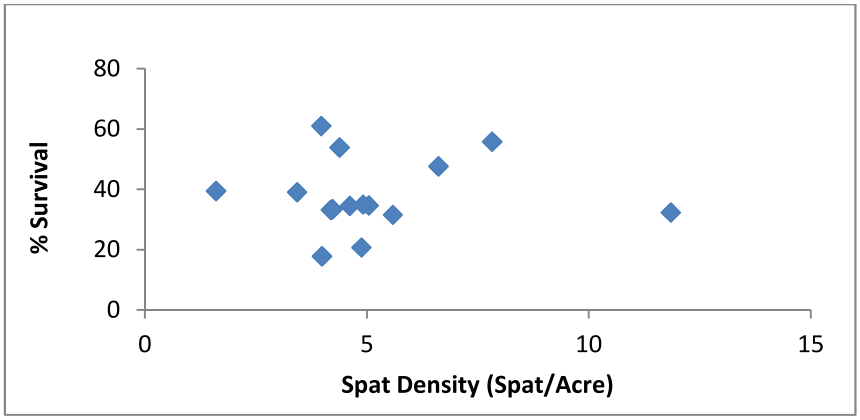


Figure 3. Percent survival by spat per acre (millions) for the 2012 post-planting monitoring survey. The data show no trend in survival based on planning density.

Quadrat-based sampling was employed for the first time during the 2010 survey in order to better understand the relationship of spat and shell density and spat survival; we have continued this method through 2012. At certain sites the presence of alternate substrate or very low shell densities prevented quadrats from being used effectively to collect hatchery shells. By using a quadrat to collect shells within a standard area, density comparisons could be made. At each bar, divers attempted to collect at least three quads. Below, Table 5 shows the bars sampled using quadrats, as well the metrics per quad. Because only the first 50 spat were measured per site, spat in some quads were only counted, thus no shell height is listed. (Data presented above in Table 2 for 2012 includes sums and averages of these quadrat data for comparison across all bars.)

Table 5. Summary of metrics collected per quad for post planting monitoring sites sampled using the quadrat method in 2012. Each line represents a separate quad.

		Mean per Shell (per quad)				
Bar Name (Region)	**# of Shells Sampled**	**#Live**	**#Gapers**	**#Scars**	**#Boxes**	**Spat Shell Height (mm)**
Change (Harris Creek)	6	7.7	0	1.8	0	12.7
	19	5.8	0	1.9	0.1	8.2
	2	8.5	0	2.5	0	-
	10	7.1	0	2.2	0	-
	10	5.7	0	1.5	0	-
	11	0.6	0	0.8	0	-
	12	6	0	1.8	0	-
	7	5.1	0.3	0.7	0	-
Change North (Harris Creek)	1	1	0	0	0	25
	3	6	0	1	0	19.2
	28	5.3	0	1.2	0	17.2
	9	5.4	0.1	0.8	0.1	-
	4	2	0	4	0.3	-
	19	9.5	0	1.7	0	-
Change- Artificial (Harris Creek)	16	14	0	1	0	13
	24	20	0	2	0.2	-
	4	17	0	2	0.5	-
	5	17	0	2	0.2	-
	0	-	-	-	-	-
	7	8.1	0	1	0	-

		Mean per Shell (per quad)				
Bar Name (Region)	# of Shells Sampled	#Live	#Gapers	#Scars	#Boxes	Spat Shell Height (mm)
Change- Natural (Harris Creek)	1	15	0	4	0	13
	14	18	0	2	0.2	10
	12	18	0	3	0.2	-
	8	12	0	1	0.1	-
	19	14	0	1	0.2	-
	9	11	0	1	0	-
Change West (Harris Creek)	0	-	-	-	-	-
	4	2.5	0	6	0.3	-
	23	3.3	0	3.7	0.3	-
	9	2.2	0	2.7	0.1	-
	3	0	0	0	0	-
	0	-	-	-	-	-
	3	7.7	0	0	0	15.5
	5	5.6	0	6.4	0.2	17.4
	4	3.3	0	3.5	0.3	11.2
	7	3.7	0	4.1	0.3	15.3
	8	2.3	0	1.3	0	26
Change West (Harris Creek)	4	1.8	0	4.8	0	-
Little Neck (Harris Creek)	8	3	0	0	0	32.2
	7	6.1	0	3	0	27.1
	6	4.8	0	0.5	0	25
	4	4	0	3	0	-
	12	4.8	0	0.8	0	-
Lodges (Harris Creek)	20	10	0.1	0.8	0.1	19.4
	2	7.5	0	0	0	-
	6	4.5	0	0.2	0	-
	10	7.5	0	0.2	0	-
	1	8	0	0	0	-
	22	7.8	0	1	0.1	17
Lodges North (Harris Creek)	22	6.1	0	2.2	0	23.5
	39	4.5	0.03	1.3	0.1	-
	36	4.2	0	1.4	0.1	-
	14	2.8	0	1.1	0	-
	15	4.9	0	0.4	0	-
	14	3	0	1.1	0.2	-
Mill Point (Harris Creek)	16	6.4	0	1.8	0.2	15.1
	0	-	-	-	-	-
	6	2	0	0.8	0	-
	7	5.6	0	2.1	0	-
	7	5	0	1.7	0	-
	9	7.2	0	1.8	0.1	-
	1	3	0	0	0	-
	5	14	0	5.8	0	-
Seths Point (Harris Creek)	14	7	0	3.4	0.1	12.3
	5	15	0	1.6	0	9.1
	28	10	0	2.5	0	-
	16	15	0	2.7	0	-
	8	18	0	2	0	-
	9	17	0	4.8	0.1	-
Tilghman Wharf (Harris Creek)	6	4.2	0	2.8	0	13
	5	1	0	0.2	0	14.5

		Mean per Shell (per quad)				
Bar Name (Region)	# of Shells Sampled	#Live	#Gapers	#Scars	#Boxes	Spat Shell Height (mm)
Tilghman Wharf (Harris Creek)	7	2.6	0	0.6	0	15.9
	18	4.2	0	2.3	0.2	16.4
	16	6.1	0.1	2.1	0.2	19.2
	3	2.3	0	1.7	0	-
	7	3.4	0	2.1	0	-
Walnut (Harris Creek)	30	2.2	0	1.4	0.1	30.8
	4	3.5	0	1.25	0.25	-
	19	1.9	0	0.9	0	-
	6	0.5	0	0.8	0	-
	50	2.7	0.1	2.4	0.1	19.8
	30	2.2	0	1.4	0.1	13
Mountain Point North (Upper Bay)	19	11	0	5	0.8	-
	3	10	0	3	0	-
	7	8	0	6	0.4	15.8
	4	14	0	9	0.8	-
	8	6.8	0	2	0.5	26
	4	8.5	0	1	0	-
	8	10	0	3	1.4	-
Mountain Point South (Upper Bay)	19	13	0	1	0.8	27.3
	13	5.5	1	3	0.2	-
	10	6.8	0	1	0.3	30.4
	10	8.9	0	2	0.3	-
	5	15	0	1	0.6	-
	5	10	0	3	0.4	-
Sixfoot Knoll (Upper Bay)	9	7	0	4	0	-
	8	5.9	0	3	0.1	-
	4	7	0	4	0.3	19.8
	14	13	0	3	0.7	-
	10	4.1	0	4	0	21.7
	10	9.1	0	9	0.3	-
	6	3	0	1	0	-

The amount of live spat per shell in each quad was multiplied by the total amount of shell found in each quad to calculate the amount of spat per quad detected by the post-planting monitoring survey. Spat survival was then calculated as the percentage of spat planted (per quad as the initial spat per shell multiplied by the total shells per quad) that was detected by the survey. The mean per quad spat survival for 2012 plantings was 38.8%, not far from the overall percent survival of 36.8%. This small difference is due to the absence of quadrat data from the planting on Wade in the Severn River. Because of the alternate substrate at Wade, quadrat sampling was not feasible. The percent survival of spat sampled by quad in 2012 is presented in Table 6.

Table 6. Summary of 2012 survival by site, per quad.

Bar Name	# of Shells in Quad	Initial Spat/Quad	Mean Live/Shell	Total Live/Quad	Quad % Survival	Site % Survival ± SEM
Change (Harris Creek)	6	105	7.7	46	43.8	33.2 ± 4.8
	19	333	5.8	110	33.1	
	2	35	8.5	17	48.6	
	10	175	7.1	71	40.6	
	10	175	5.7	57	32.6	
	11	193	0.6	7	3.6	
	12	210	6.0	72	34.3	
	7	123	5.1	36	29.4	
Change Artificial (Harris Creek)	16	426	13.6	218	51.2	57.6 ± 7.8
	24	638	20.1	483	75.7	
	4	106	17.3	69	64.8	
	5	133	17.4	87	65.4	
	7	186	8.1	57	30.6	
Change Natural (Harris Creek)	1	27	15.0	15	56.4	54.4 ± 4.4
	14	372	17.9	250	67.1	
	12	319	17.5	210	65.8	
	8	213	12.1	97	45.6	
	19	505	13.5	257	50.9	
	9	239	10.8	97	40.5	
Change North (Harris Creek)	1	12	1.0	1	8.1	39.2 ± 10.0
	3	37	6.0	18	48.4	
	28	347	5.3	147	42.3	
	9	112	5.4	49	43.9	
	4	50	2.0	8	16.1	
	19	236	9.5	180	76.4	
Change West (Harris Creek)	3	47	0.0	0	0.0	20.7 ± 4.3
	3	47	7.7	23	49.1	
	5	78	5.6	28	35.9	
	4	62	3.3	13	20.8	
	7	109	3.7	26	23.8	
	8	125	2.3	18	14.4	
	4	62	1.8	7	11.2	
	4	62	2.5	10	16.0	
	23	359	3.3	77	21.5	
	9	140	2.2	20	14.2	
Little Neck (Harris Creek)	8	105	3.0	24	22.9	34.7 ± 4.0
	7	92	6.1	43	46.9	
	6	79	4.8	29	36.9	
	4	52	4.0	16	30.5	
	12	157	4.8	57	36.3	

Bar Name	# of Shells in Quad	Initial Spat/Quad	Mean Live/Shell	Total Live/Quad	Quad % Survival	Site % Survival ± SEM
Lodges (Harris Creek)	20	282	10.4	207	73.4	53.9 ± 5.4
	2	28	7.5	15	53.2	
	6	85	4.5	27	31.9	
	10	141	7.5	75	53.2	
	1	14	8.0	8	56.7	
	22	310	7.8	172	55.4	
Lodges North (Harris Creek)	22	264	6.1	134	50.8	35.4 ± 4.2
	39	468	4.5	174	37.2	
	36	432	4.2	152	35.2	
	14	168	2.8	39	23.2	
	15	180	4.9	74	41.1	
	14	168	3.0	42	25.0	
Mill Point (Harris Creek)	16	294	6.4	103	35.0	33.4 ± 7.9
	6	110	2.0	12	10.9	
	7	129	5.6	39	30.3	
	7	129	5.0	35	27.2	
	9	166	7.2	65	39.3	
	1	18	3.0	3	16.3	
	5	92	13.8	69	75.0	
Seths Point (Harris Creek)	14	403	7.0	98	24.3	47.7 ± 6.2
	5	144	15.4	77	53.5	
	28	806	10.0	281	34.8	
	16	461	14.5	232	50.3	
	8	230	18.0	144	62.5	
	9	259	17.4	157	60.6	
Tilghman Wharf (Harris Creek)	6	59	4.2	25	42.5	34.6 ± 6.3
	5	49	1.0	5	10.2	
	7	69	2.6	18	26.2	
	18	176	4.2	75	42.5	
	16	157	6.1	97	61.9	
	3	29	2.3	7	23.8	
	7	69	3.4	24	35.0	
Walnut (Harris Creek)	30	336	2.2	65	19.3	18.1 ± 5.5
	4	45	3.5	14	31.3	
	19	213	1.9	37	17.4	
	6	67	0.5	3	4.5	
Mountain Point North (Upper Bay)	3	92	10.0	30	32.6	31.6 ± 2.8
	7	215	8.0	56	26.1	
	4	123	13.8	55	44.8	
	8	246	6.8	54	22.0	
	4	123	8.5	34	27.7	
	8	246	10.3	82	33.4	
	19	583	10.7	203	34.8	

Bar Name	# of Shells in Quad	Initial Spat/Quad	Mean Live/Shell	Total Live/Quad	Quad % Survival	Site % Survival ± SEM
Mountain Point South (Upper Bay)	13	208	5.5	71	34.1	61.1 ± 9.0
	10	160	6.8	68	42.5	
	10	160	8.9	89	55.6	
	5	80	15.0	75	93.8	
	19	304	12.5	237	78.0	
	5	80	10.0	50	62.5	
Six Foot Knoll (Upper Bay)	8	144	5.9	47	32.6	39.1 ± 7.1
	4	72	7.0	28	38.9	
	14	252	13.2	185	73.4	
	10	180	4.1	41	22.8	
	10	180	9.1	91	50.6	
	6	108	3.0	18	16.7	
	9	162	7.0	63	38.9	
	Mean:	**184**	**7.3**	**77**	**38.8**	**39.6** ± 1.9

In order to examine the source of the variability seen in post-planting spat per shell and percent survival at the quadrat level, 2012 quadrat data were examined for a relationship between spat survival and initial spat density. These data were also compared to quadrat data collected during the 2010 and 2011 post-planting monitoring survey. As in the comparisons without quadrat-sampling, and also similar to 2010 and 2011 quadrat samples, no clear trend was observed. Figure 8 shows that there was no direct relationship between the initial spat per quad and spat survival in 2010 through 2012.

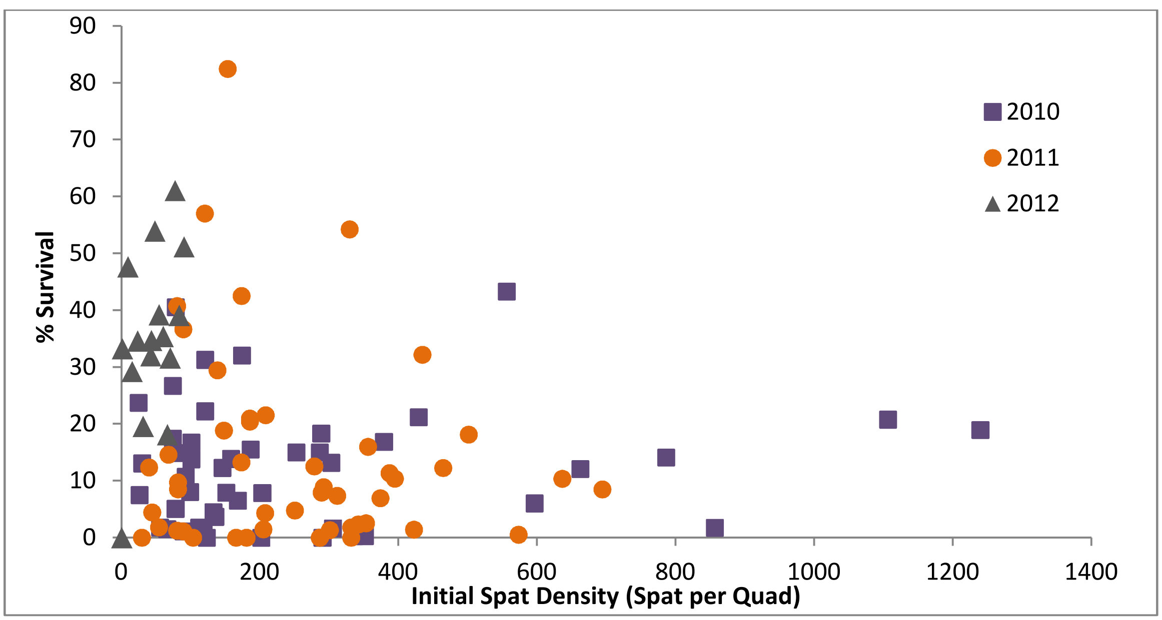


Figure 4. Percent survival relative to initial spat per quad, 2010 through 2012. Data show no obvious relationship between early spat survival and initial spat per quad.

The intent behind quadrat-based sampling was to collect data across a range of shell densities, in order to identify any patterns related to spat-planting density. However, achieving a wide range of initial spat on shell densities proved difficult in 2010, as most of the quad collected had less than 500 spat initially in the area sampled by the quad (see Figure 4). An attempt was made to address this issue in 2011, and some high density quads were collected, but still a majority of the quads contained less than 500 spat initially in the area sampled by the quad (see Figure 4). In 2012, divers sampled with quads, and targeted areas with high numbers of planting tracklines, however initial spat per quad estimates remained below 200 spat per quad. Therefore, although it is difficult to make conclusive statements about the effect of initial spat density on spat survival, these data do not suggest that initial spat density (at least in densities less than 600 spat/quad) impacts spat survival 4 – 8 weeks post planting.

Conclusions:

The overall spat survival observed during the 2012 post-planting monitoring survey was the highest of the past five years. As in 2011, we believe that survival success was due in large part to planting site selection as it relates to bottom type. The task of site selection received further refinement this year in Harris Creek, also the location of the majority of spat-on-shell plantings. In addition to side-scan sonar data typically available prior to planting, the Harris Creek sanctuary had another form of bottom mapping that helped to guide both ground truthing and thus spat-on-shell plantings in Harris Creek. This additional level of detail was provided using the bottom classification scheme generated by NCBO's Chesapeake Bay Coastal and Marine Ecological Classification Standard (CMECS). CMECS data depicted areas of expected shell and sand, and transect surveys confirmed or refuted such expectations as well as targeted areas suitable for planting. Finer scale identification using bottom type mapping helped to better identify the best locations for spat-on-shell and alternate substrate plantings in Harris Creek and likely played a large role in the increased spat survival observed in 2012.

The quadrat method of sample collection remains a valuable tool for starting to understand the effect of density on spat survival. Unfortunately, the range of densities at which we are currently able to collect spat is not large enough to observe a trend. However, due to the valuable nature of data collected at the same scale (quadrat) and the ease of which the diver can collect using quads, we recommend continued use of the quadrat sampling method whenever possible. In addition, quadrat sampling provides important density data at year zero for restored oyster bars that can be compared in subsequent surveys.

The data collected during the post-planting monitoring survey from 2008 – 2012 speaks to the variation present in the survival of hatchery spat on shell 4 – 8 weeks post planting. Spat survival at the bar level consistently ranges from 0% to over 60% in each year sampled and does not seem to be related to any of the variables that we have measured in our survey (total amount of spat and shell, density of spat and shell, growth rate, region/river, environment). Considering the complex process involved in executing a successful hatchery spat-on-shell planting, from the spawning of spat at the hatchery, to their transport to the site, to the conditions they grow in and the sampling method used to estimate survival, it is not surprising that pinpointing factors that consistently influence survival is extremely difficult.

As mentioned following the 2011 sampling season, the large scale of the planting survey further exacerbates the difficulties mentioned above and therefore during the 2011 planting season, the Paynter lab partnered with the Horn Point Lab hatchery to design and execute a small-scale experiment to examine the effect of spat size and bottom type on spat survival. Data from the 2011 trial suggested that spat survived better on shell and sand than mud, however questions remained unanswered relating to longer term survival. This experiment was improved and repeated in 2012, with a final sampling to be carried out in 2013. Detailed analyses of the data collected in this experiment will be presented to the ORP in a separate report, upon completion of the second season in 2013.

Another factor that may influence short term spat survival is predation. An experiment was conducted in the summer of 2011 attempting to examine the impacts of predation on spat survival but methodological issues prevented the data from being examined. The experiment was revised and repeated in 2012 but experience similar problems as the 2011 experiment. These experiment attempts underscore the complications associated with examining the impact of predation on spat survival. We believe that the relationship between spat survival and predation is important to explore but should be done on a more comprehensive level in a controlled setting by a student or researcher dedicated to that problem alone.

Overall, the 2012 planting season possessed higher spat survival than previous seasons, and this was likely due in large part to enhanced planting site selection. Additionally, the 2012 season also saw widespread natural spat sets, most notably observed in Harris Creek alongside ORP-planted spat. As the Harris Creek sanctuary restoration blueprint continues to be fulfilled, we will hopefully gain a greater understanding of both early and late spat survival as we monitor spat-on-shell plantings both within and outside of Harris Creek.

Section IV: Patent Tong Survey 2012

Survey Summary

Patent tong surveys were conducted in the fall of 2012 on oyster bars in the Chester, Choptank, and South Rivers and near the lower Anne Arundel Shore. Below is the list of all sites sampled. According to the ORP monitoring plan, restoration sites are targeted for patent tong surveys 3- and 6-years post-planting. Therefore, bars restored in 2006 and 2009 were the targets of the 2012 patent tong survey.

Table 1. Oyster bars surveyed during the 2012 field season by river and site.

Region/River	Yates Bar Name	Planting Year	Date Surveyed (2012)
Anne Arundel Shore	Tolly Point	2006, 2009	10/22, 10/23
Chester River	East Neck Bay	2006, 2009	10/1
	Strong Bay	2009	9/21, 9/24, 9/27
Choptank River	Sandy Hill	2009	11/9, 11/12
	Shoal Creek	2006, 2009	10/26, 11/1, 11/2, 11/5
South River	Thunder and Lightning	2009	10/22

Using ArcGIS, a grid of 25 m x 25 m cells was overlaid on the planted area and each grid cell was sampled with hydraulic patent tongs. Figure 1 shows an example of the grid with sampling points from the Tolly Point 2012 patent tong survey. Figure 2 indicates the sampling sites for the 2012 patent tong survey. Red dots represent individual bars sampled with rivers are labeled in gray. Number and size (mm) of live and dead (box) oysters were recorded at each grab. In addition, shell score (the amount of shell substrate collected in each tong grab) was quantified on a scale of zero to five and the percent of buried (black, anoxic) shell in each grab was also recorded. A shell score of zero represented tongs with no shell, while a score of five indicates tongs full of shell. The density of oysters at each point was calculated using the area of the tongs and a population estimate was generated using this density data. The total biomass of oysters at each bar was estimated according to Lidell (2007). The density of oysters and shell score at each patent tong survey point was recorded using GIS. These spatial data allowed for a shell score and density plots to be generated to illustrate the spatial distribution of shell and oysters at each site. The oyster density and shell score plots are presented in the “site specific data” section below.

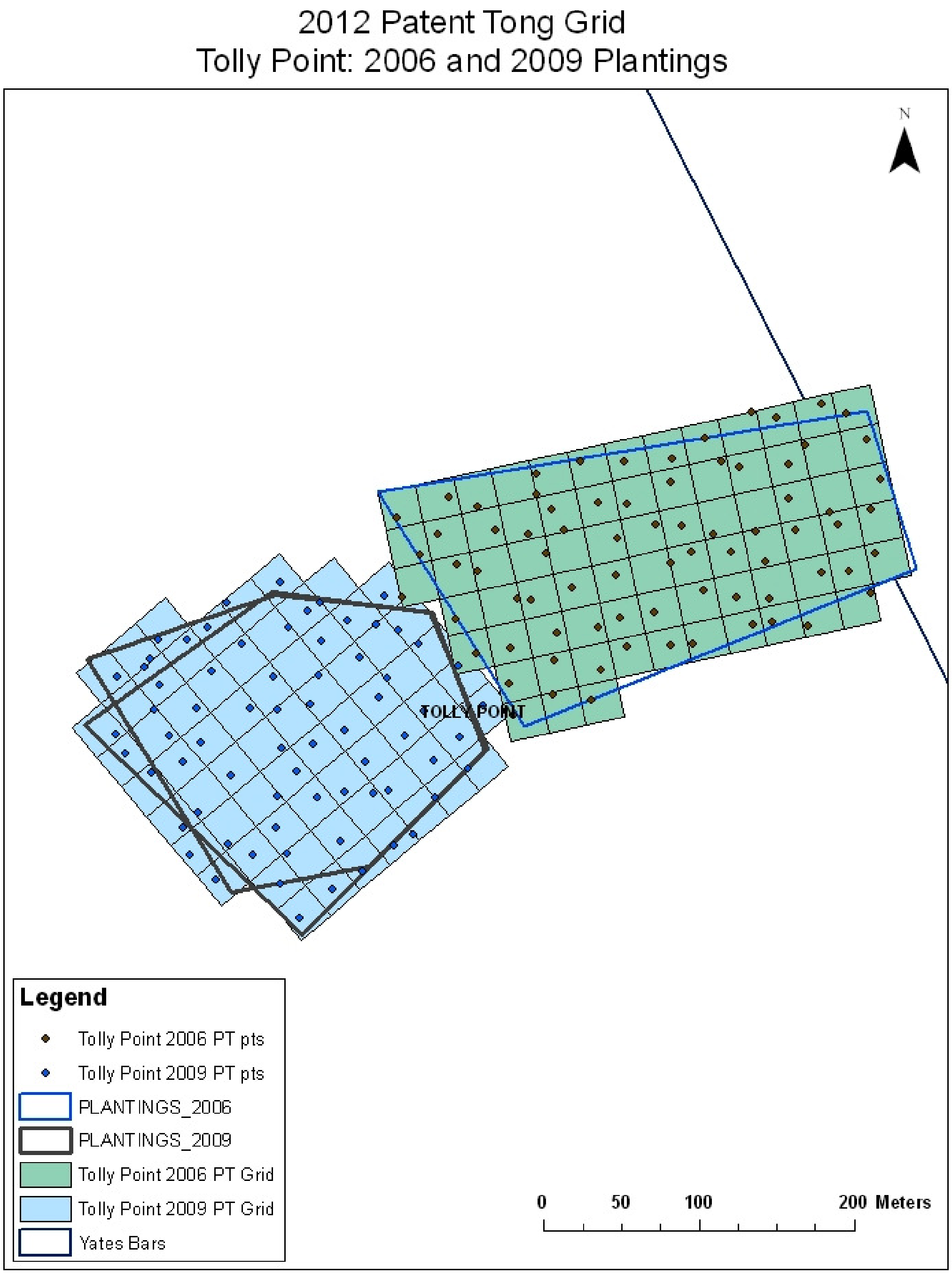


Figure 1. Example of a patent tong grid used in the 2012 patent tong season. Each grid cell is 25 m x 25 m in size and each black point represents one patent tong grab. Two separate year class plantings are shown at Tolly Point, an oyster bar located along the lower Anne Arundel Shore.

2012 Patent Tong Sampling Sites

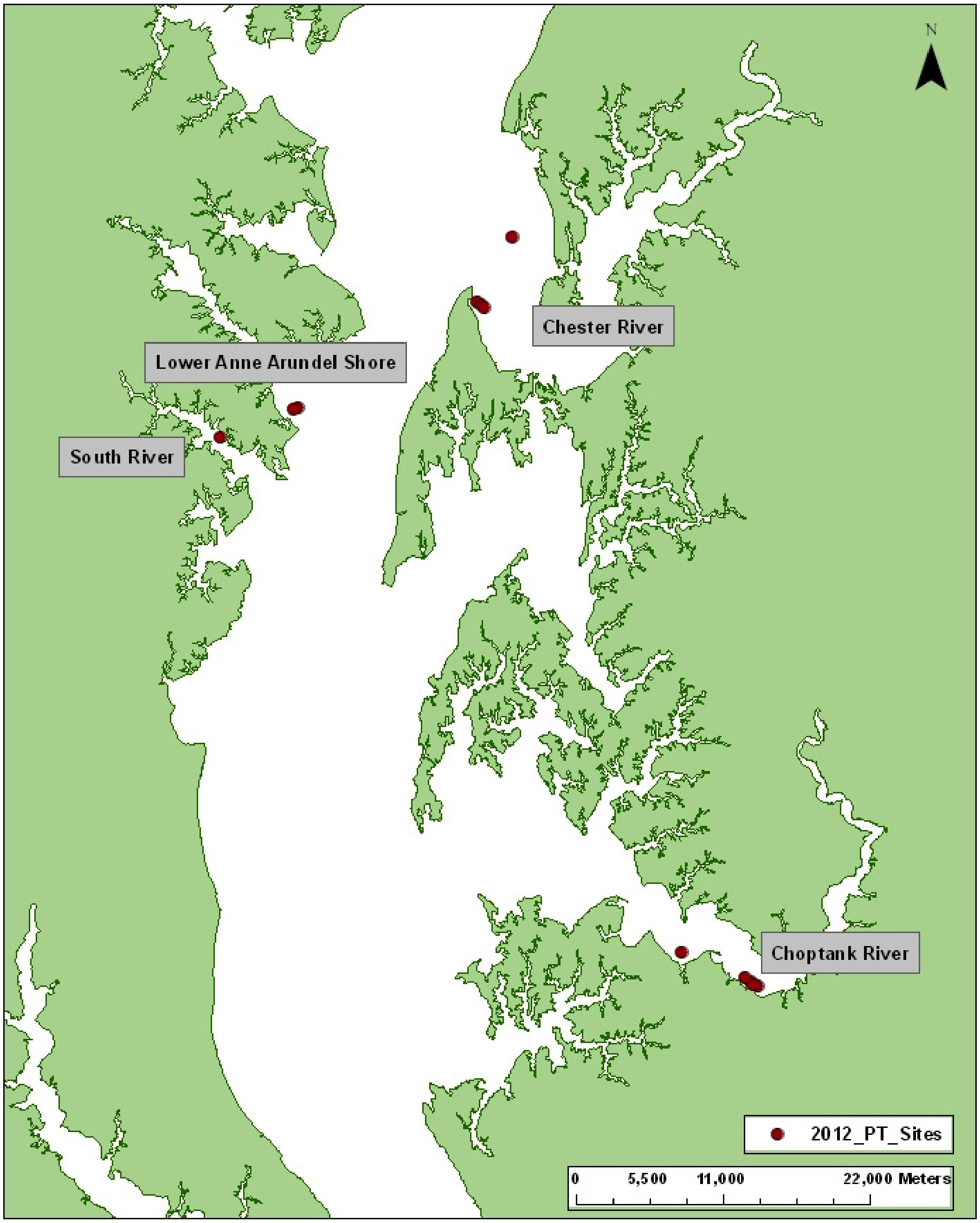


Figure 2. 2012 patent tong survey sampling sites. Red dots represent individual bars sampled. Rivers are labeled in gray. Bar names can be found in Table 1, above.

Table 2 summarizes the metrics collected for each site sampled in 2012; amount of live and dead oysters, percentage of oysters found that were dead, live oyster size and density, biomass density, percent of area sampled with greater than 5oy/m^2, percent of area sampled with shell coverage (scores of 3 or greater), and the average percent of buried shell in each grab. When relevant, means of 2012 metrics are listed in the table as well.

In 2011 the Oyster Metrics Workgroup (OMW) outlined certain criteria that a restored site should meet in order to view as successful. Among these criteria are that the bar should have both an oyster density of 15 or more oysters/m^2 and a biomass density of 15 or more g/m^2. Both of these metrics are shown in Table 2. Of the bars surveyed in 2012, two of them meet these criteria (Shoal Creek 2009B and Thunder and Lightning 2009). Three bars, however, met the criteria for biomass density for a successful bar but did not possess high enough oyster densities (Strong Bay 2009A, Shoal Creek 2009B, Thunder and Lightning 2009). Strong Bay 2009A had a high oyster density (10.2 oysters/m^2) but it was not high enough for the OMW metric.

Table 2. Data collected on 2012 patent tong surveys. "% total area with shell coverage" refers to the percentage of grabs at each bar with shell scores of 3 or greater. Asterisks (*) indicate values that meet the Oyster Metrics Workgroup benchmarks for either oyster density (15oy/m^2) or biomass density (15g/m^2).

Region/ River	Bar Name	Planting Year	# Live Oysters Collected	# Dead Oysters Collected	Dead Oysters (% of Total)	Average Live Oyster Length (mm)	SEM	Average Live Oyster Density (#/m^2)	SEM	Average Biomass Density (g/m^2)	SEM	% Total Area >5 oy/m^2	% Total Area with Shell Coverage	Average Percent of Buried Shell
Anne Arundel Shore	Tolly Point	2006	714	43	6	101.0	1.1	5.1	0.6	8.0	0.9	43	52	13.2
		2009	223	7	3	92.4	1.6	1.8	0.3	2.3	0.4	12	7	30.4
Chester River	East Neck Bay	2006/ 2009	604	874	59	75.8	1.6	2.9	0.4	2.3	0.4	16	3	45.0
	Strong Bay	2009 A	1158	35	3	105.0	1.7	10.2	2.2	17.3*	3.5	46	10	33.6
		2009 B	89	12	12	84.4	6.4	0.7	0.2	1.0	0.4	4	0	18.9
		2009 C	151	16	10	82.9	2.4	1.2	0.3	1.5	0.5	6	0	44.3
Choptank River	Sandy Hill	2009	633	64	9	97.3	1.1	1.5	0.2	2.0	0.3	8	2	38.1
	Shoal Creek	2006 A	284	51	15	106.7	3.1	3.2	0.8	5.8	1.5	18	24	41.2
		2006 B	5	1	17	91.4	16.1	0.0	0.0	0.1	0.1	0	3	2.7
		2009 A	612	35	5	97.8	1.5	3.0	0.5	4.5	0.8	23	24	18.8
		2009 B	2359	133	5	95.4	1.5	18.3*	2.2	23.0*	2.6	65	55	29.7
South River	Thunder and Lightning	2009	929	28	3	82.0	2.3	23.3*	8.3	25.1*	9.4	50	23	15.5
	2012 Mean	-	618	108	12	92.7	-	5.9	-	5.6	-	24	17	-

Table 3 below compares the population estimate at each bar surveyed in 2012 to the expected population based on the following mortality calculation: it is assumed that approximately 90% of spat are lost within one year after planting and 15% of the remaining population each subsequent year. The estimated population of nine of the twelve bars falls below the expected calculated population. Five bars, however, contained populations at or about 40% of the expected, and two of those five bars contained populations at or about 100% of the expected population. These five bars were found in three different regions and were planted in both 2006 and 2009. These data indicate that the variability in survival (see post planting monitoring report) can impact oyster population levels for years into the future.

Table 3 also outlines disease (*Perkinsus marinus,* which causes dermo disease) prevalence and weighted intensity for each site surveyed. Prevalence refers to the percentage of animals infected at each site and weighted intensity refers to the intensity of infection at each site on a scale of zero to five, zero indicating no infection and five indicating very high intensity. When possible, different year classes were sampled for disease separately. At Shoal Creek older animals had higher disease prevalence and weighted prevalence than their younger counterparts. The Strong Bay 2009 dermo prevalence and intensity were divided in half; 15 large and 15 small animals. The large animals had an average shell height of 118.7 mm while the small animals had an average shell height 87.8 mm. The prevalence and intensity for the larger animals are denoted with an (*) in Table 2. Similar to the pattern at Shoal Creek, larger animals at Strong Bay had higher dermo prevalence and intensity than their smaller counterparts. At Tolly Point and East Neck Bay, it was not possible to separate oysters based on age class, therefore one disease sample was collected for both years combined. Populations with weighted prevalences above 2 can be expected to suffer significant mortalities unless the salinities fall substantially before summer 2013.

Table 3. A comparison of expected oyster population to estimated oyster population. Population estimate calculated as sum of all cell oyster densities multiplied by cell area (625 m^2). Dermo prevalence (percentage of animals infected) and weighted intensity (average infection level on a zero to five scale) by site are also shown here. The Strong Bay 2009 dermo prevalence and intensity were divided in half; 15 large and 15 small animals. The prevalence and intensity for the larger animals are denoted with an (*). The survey area at Thunder and Lightning was planted in both 2009 and 2010 and it was not possible to differentiate between year classes during the 2012 survey. The amount of spat planted and the expected population at Thunder and Lightning reflect both the 2009 and 2010 plantings.

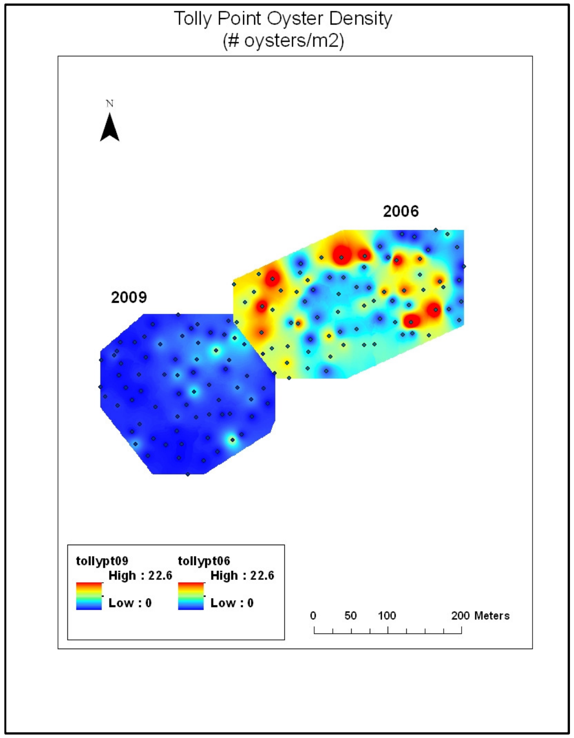
Region/River	Bar Name	Planting Year	Spat Planted (Millions)	Expected 2012 Population (Oysters)	Population Estimate from Survey (Oysters)	% of Expected	Dermo Prevalence (%)	Dermo Weighted Intensity
Anne Arundel Shore	Tolly Point	2006	7,800,000	346,090	446,250	129	30.0	0.41
		2009	28,340,000	2,047,565	139,375	7	-	-
Chester River	East Neck Bay	2006/2009	61,730,000	3,952,586	377,500	10	92.9	1.36
	Strong Bay	2009A	23,510,000	1,698,598	723,750	43	36.7/57*	0.21/1.08*
		2009B	12,120,000	875,670	55,625	6	-	-
		2009C	9,320,000	673,370	94,375	14	-	-
Choptank River	Sandy Hill	2009	49,650,000	3,587,213	395,625	11	100.0	2.39
	Shoal Creek	2006 A	4,000,000	177,482	177,500	100	96.7	2.37
		2006 B	N/A	N/A	3,125	N/A	-	-
		2009 A	35,480,000	2,563,430	382,500	15	70.0	0.97
		2009 B	29,270,000	2,114,758	1,474,375	70	-	-
South River	Thunder and Lightning	2009	47,500,000	1,447,593	580,625	40	80.0	1.24

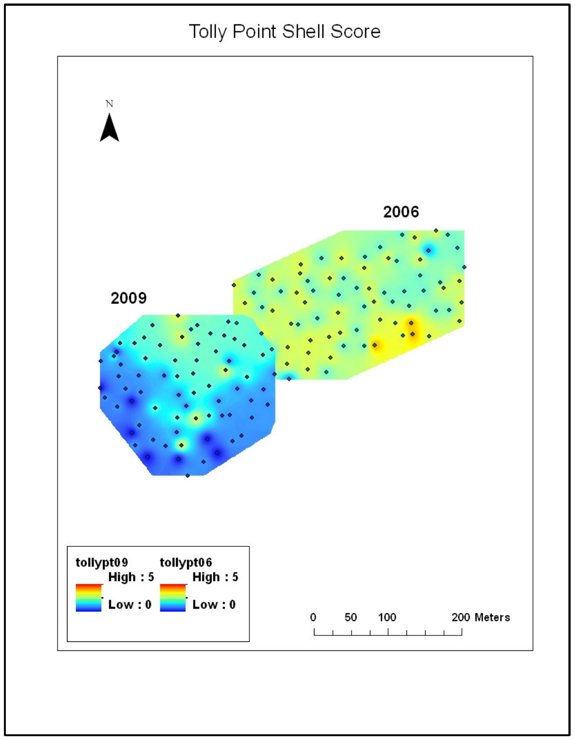
Site Specific Data

The number of oysters and shell score at each patent tong survey point was recorded using GIS. These spatial data allowed for shell score and density plots to be generated to illustrate the spatial distribution of shell and oysters at each site. Both oyster density and shell score data are presented on a color ramp with red representing high scores/densities and blue representing low scores/densities. Oyster density scales are different for each bar, as the number (and therefore densities) of oysters present at each bar was different. Shell score data are presented on a scale of 0 to 5, with 0 indicating no shell (blue on maps) and five indicating tongs full of shell (red on maps). The spatial data presented below allow for a spatial comparison of oysters and shell coverage at each site surveyed in 2012. In addition to a spatial analysis of the distribution of oysters and shell on each bar, the overall success of each bar is discussed below. Factors influencing restoration success that are measured in the patent tong survey are: percent of the expected population remaining on the bar, average oyster density, average oyster biomass density, disease prevalence/intensity, amount of area with good shell coverage, and the average percent of buried shell in each grab. These factors are all taken into account when discussing the success of each bar. While most bars in the 2012 patent tong survey did not meet the benchmark metrics outlined by the Oyster Metrics Workgroup (15 oysters/m^2, 15g/m^2), those that did are noted in the text.

Tolly Point 2006/2009

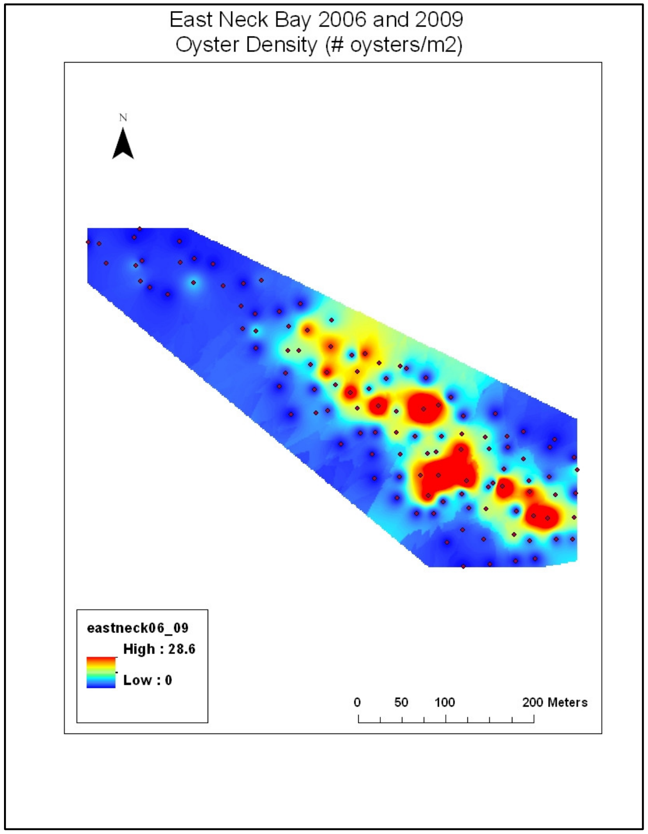
The restoration sites at Tolly Point were very close in proximity to one another and therefore oyster density and shell score maps are presented for both years together. In general, more oysters and more shell were found in the 2006 planting (on the right in both figures) than in the 2009 planting. Areas of high oyster density were correlated with areas of relatively high shell scores. However, most "high" shell scores observed were shell scores of three, as no shell scores of five and only three shell scores of four were observed at both sites combined. At the 2006 site, over 50% of the area had good shell coverage (shell scores of 3 or greater) and the average percent of buried shell in each grab was only 13% while at the 2009 site only 7% of the bar had good shell coverage and the average percent of buried shell in each grab was 30%. The population of the 2006 planting was above what would be expected given natural mortality, the biomass of oysters at the site was at 9.0g/m^2, and the average oyster density at this site was 5.1 oysters/m^2, both less than the benchmarks outlined by the OMW. However, the population of the 2009 planting was only 7% of expected, oyster biomass was at 2.6g/m^2, and average oyster density at this planting was only 1.8 oysters/m^2, also less than the OMW benchmarks. The reason for the discrepancy in success between planting years not known; disease prevalence and intensity are low at the site despite not separating out disease samples by year and short term spat survival for these sites is not known.

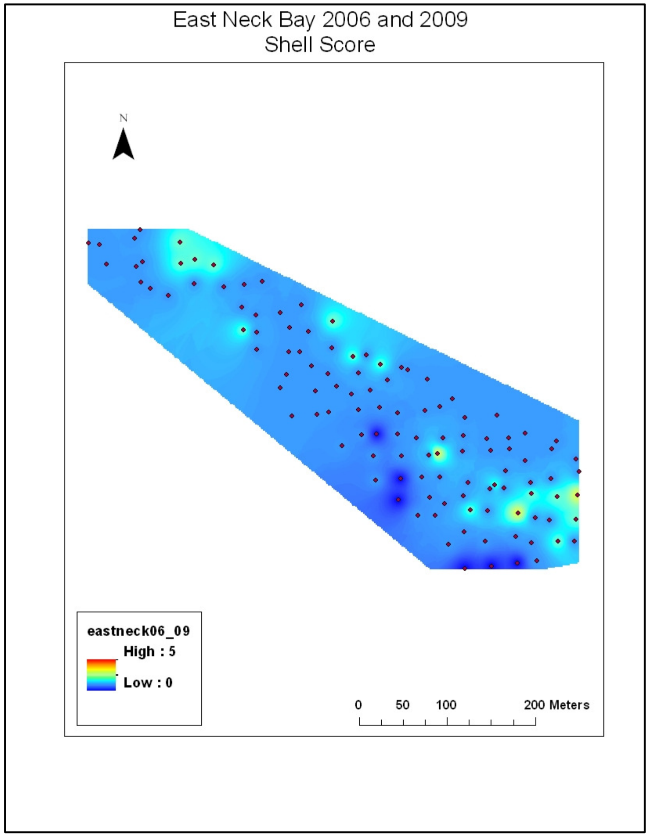




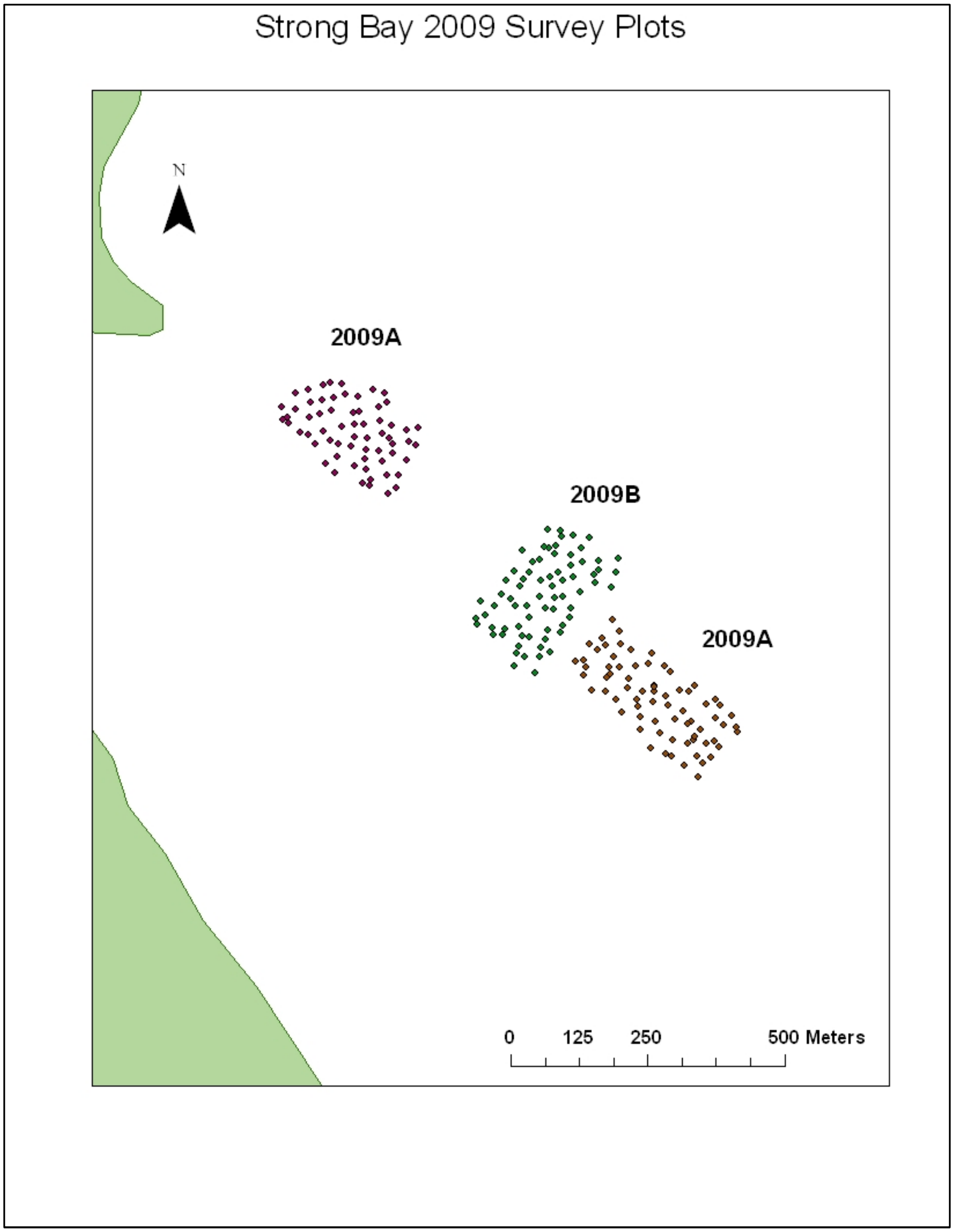
East Neck Bay 2006/2009

The 2006 and 2009 plantings at East Neck Bay were on top of each other and therefore both years were surveyed together. The oyster population at this site is concentrated in the southeastern portion of the bar, with clusters of high oyster density towards the middle of the bar. Sixteen percent of the bar contains oysters at a density of 5 oysters/m^2 or greater. Shell score was generally low throughout the bar, with mostly shell scores of 1 or 2 and a few instances of shell scores of three. Similarly, only 3% of the bar had good shell coverage (shell scores of 3 or greater) and each grab contained 45% buried shell. In general, areas of high oyster densities were not correlated with high shell scores at this bar. This bar has not been very successful since planting, as disease prevalence was above 90%, the oyster population was only 10% of expected, average oyster biomass was at 2.6g/m^2, and average oyster density was only 2.9 oysters/m^2, both less than the OMW benchmarks.



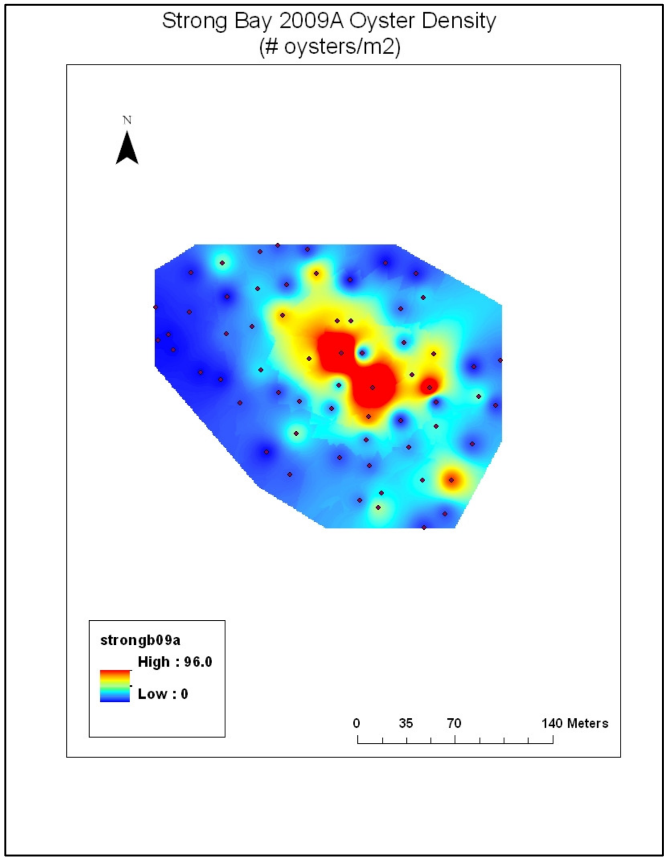


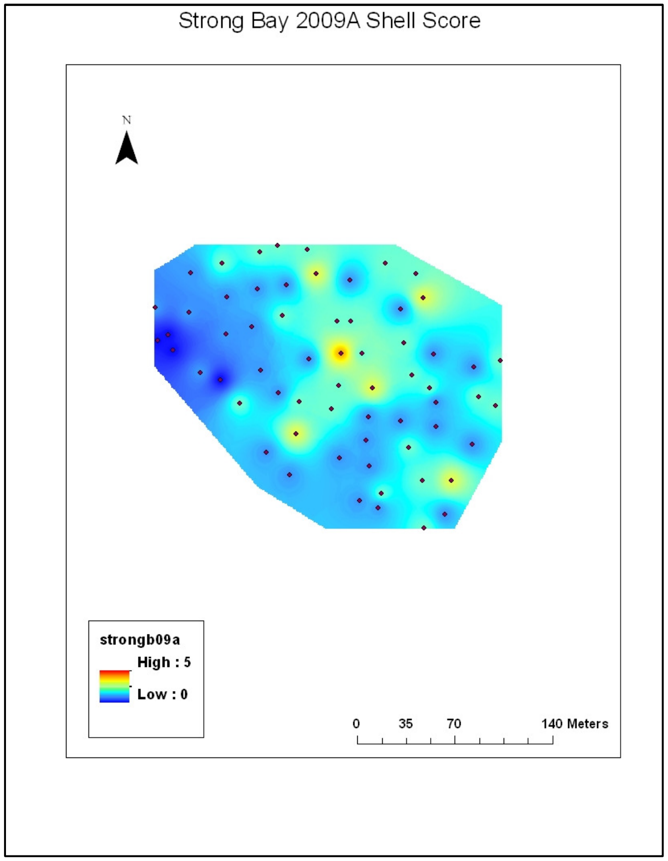
Strong Bay 2009
Three separate non-overlapping plantings occurred in 2009 at Strong Bay and survey areas are shown in the figure below.



Strong Bay 2009A

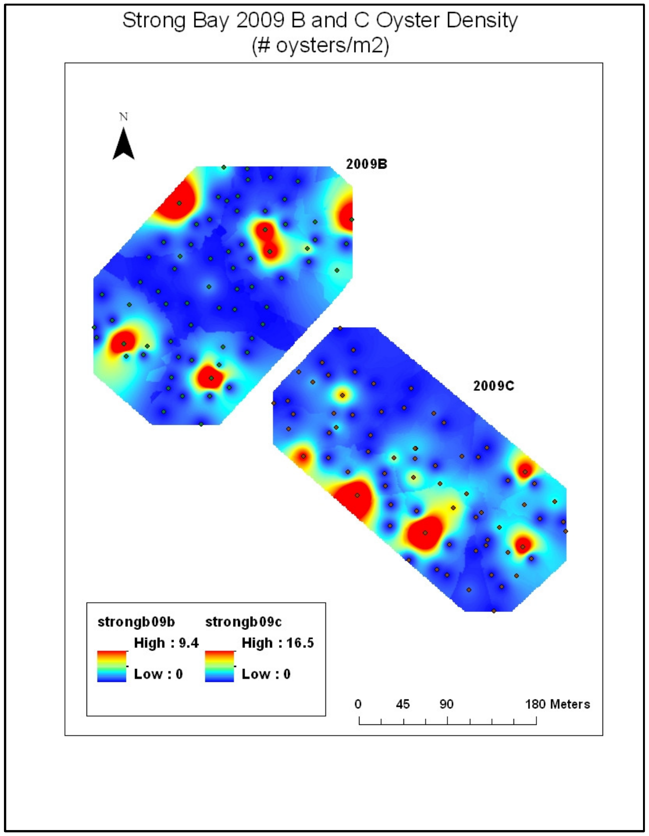
The planting at Strong Bay 2009A has been the most successful of the three plantings at Strong Bay in 2009. Areas of high oyster densities are concentrated at the center of the bar and oysters were observed at this bar at maximum densities of over 90 oysters/m^2. While oyster densities are high in the center of the bar, shell scores were moderate across the bar. Few scores of zero were observed, but few high shell scores were observed at this bar as well. While 46% of the bar had oyster densities greater than 5 oysters/m^2, only 10% of the bar had good shell coverage (shell scores of 3 or greater) and 34% of the shell in each grab was buried. The population at Strong Bay 2009A was 43% of the expected population, which is in the upper half of bars surveyed in the 2012 survey. Average oyster density at this site was 10.2 oysters/m^2 and average oyster biomass density at the site was 19.6 g/m^2, both high values for the 2012 survey overall. While the biomass density for this site is above the OMW benchmark, the oyster density is not at the benchmark level.

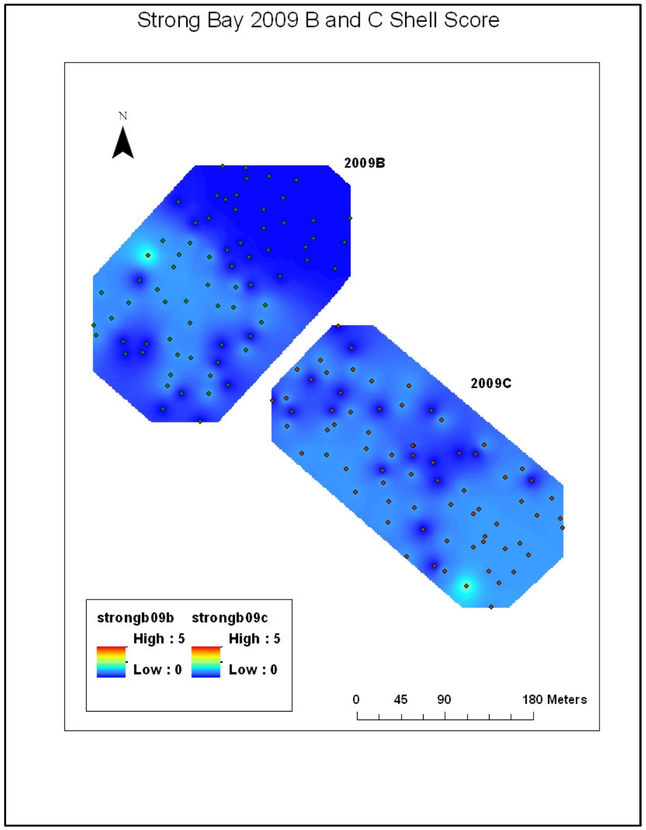




Strong Bay 2009B, C

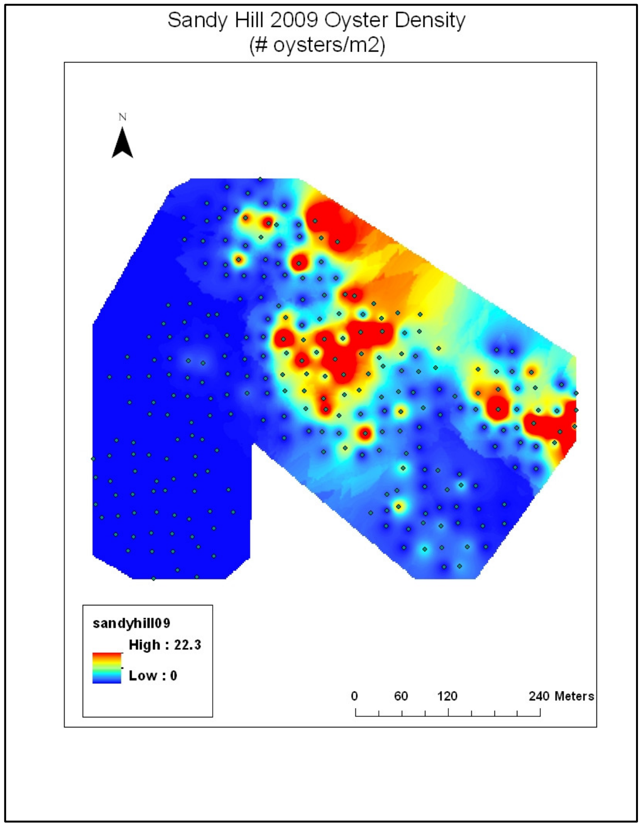
The patent tong surveys of Strong Bay 2009B and C revealed small patches of relatively dense oyster populations with large areas of low oyster densities in between. Shell scores were low across both plots, with no shell scores of 3 or greater observed at either site. However, differences were seen in the amount of buried shell between sites; the average amount of buried shell in each grab at 2009B was 19% while 44% of shell was buried in the 2009C plot. Average oyster densities at 2009B and C were 0.7 and 1.2 oysters/m^2, respectively. The percent of expected oysters remaining and oyster biomass densities were also low at both sites. The oyster population at Strong Bay 2006B was only 6% of expected and average oyster biomass density at the site was 1.1 g/m^2. Similarly, the oyster population at Strong Bay 2006C was only 14% of expected and average oyster biomass density at the site was 1.7 g/m^2. Neither the oyster density nor the biomass density at both Strong Bay 2009B and C were at the OWM benchmark levels. The cause for the low population, oyster densities and biomass observed at this site are most likely due to the lack of suitable bottom rather than disease as dermo prevalence in the largest oysters was 58% but intensity was low, only 1.08/5.

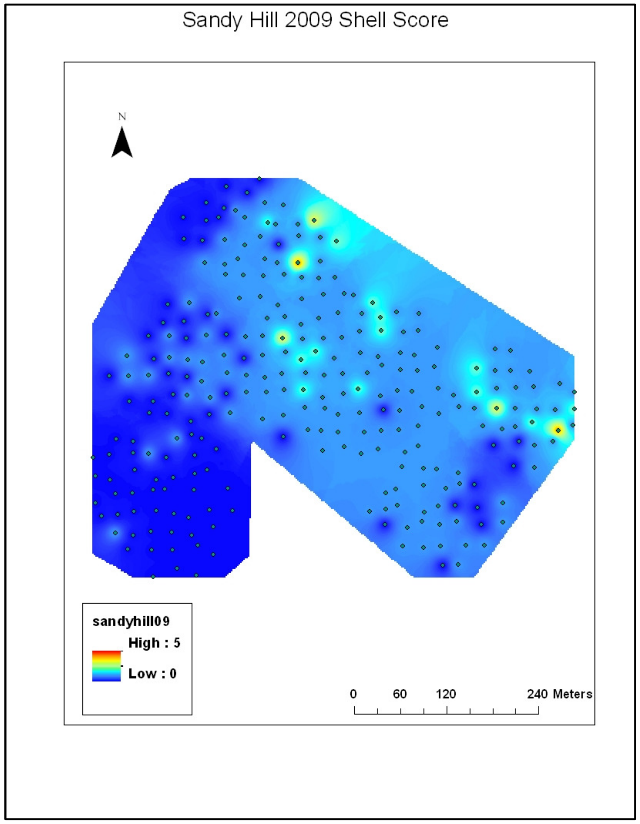




Sandy Hill 2009

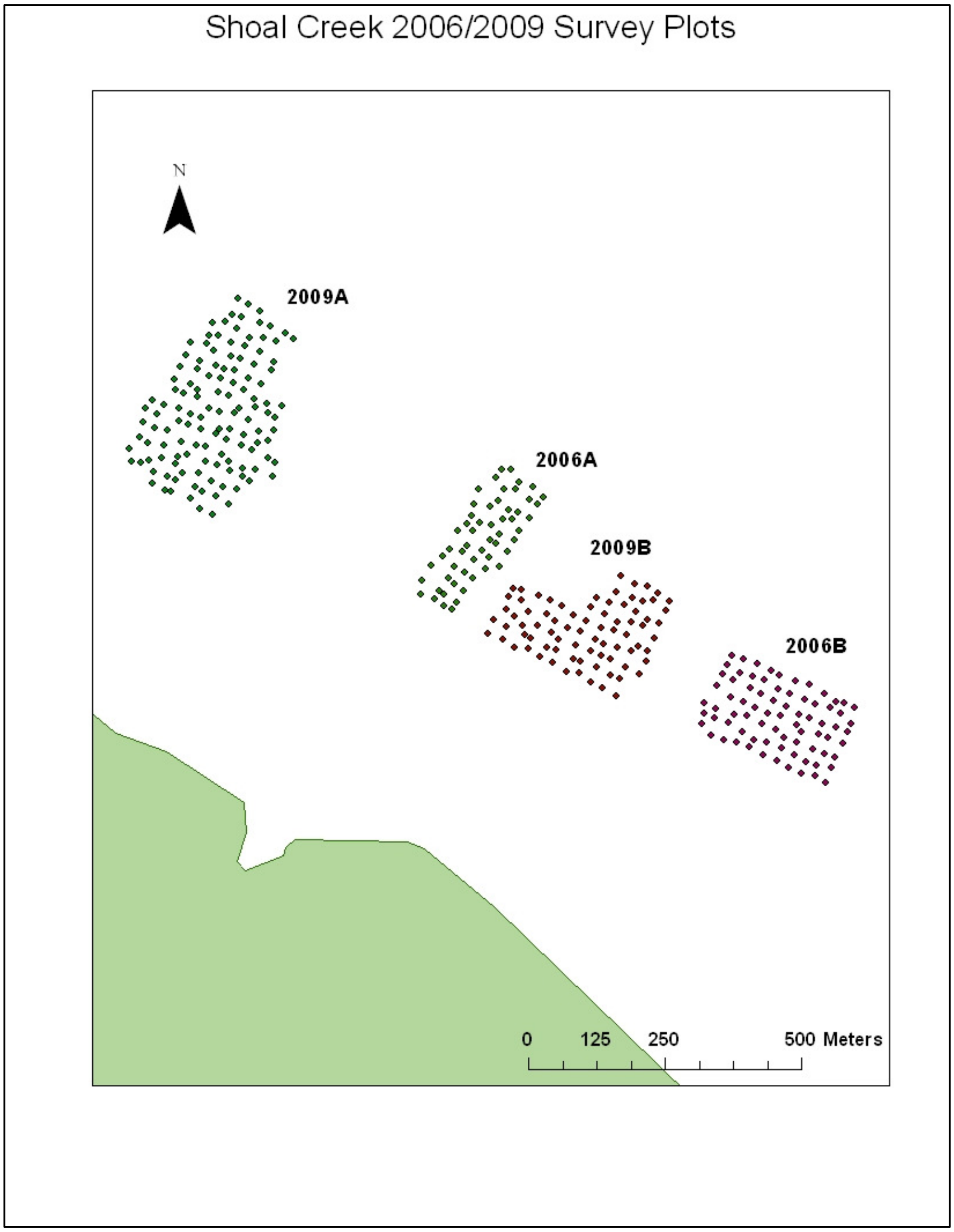
The restoration site at Sandy Hill 2009 was one of the largest in the 2012 patent tong survey. The oysters at this site were concentrated in the eastern portion of the site, as were higher shell densities. However, both oyster density and shell scores were low at this site; only 8% of the bar had oysters at a density of 5 oysters/m^2 or greater and only 2% of the bar had good shell coverage (shell scores of 3 or greater). Similarly, 38% of the shell observed at this site was buried. Along the same vein, the current population at Sandy Hill 2009 was only 11% of what would be expected given natural mortality, average oyster density was only 1.5 oysters/m^2 and average oyster biomass was only 2.1 g/m^2, both well below OMW benchmark levels. One possible explanation for the low population at Sandy Hill 2009 is the high disease prevalence and intensity observed at the site. Dermo prevalence was 100% at this site and intensity was 2.39/5, the highest disease prevalence and intensity observed in the 2012 survey.





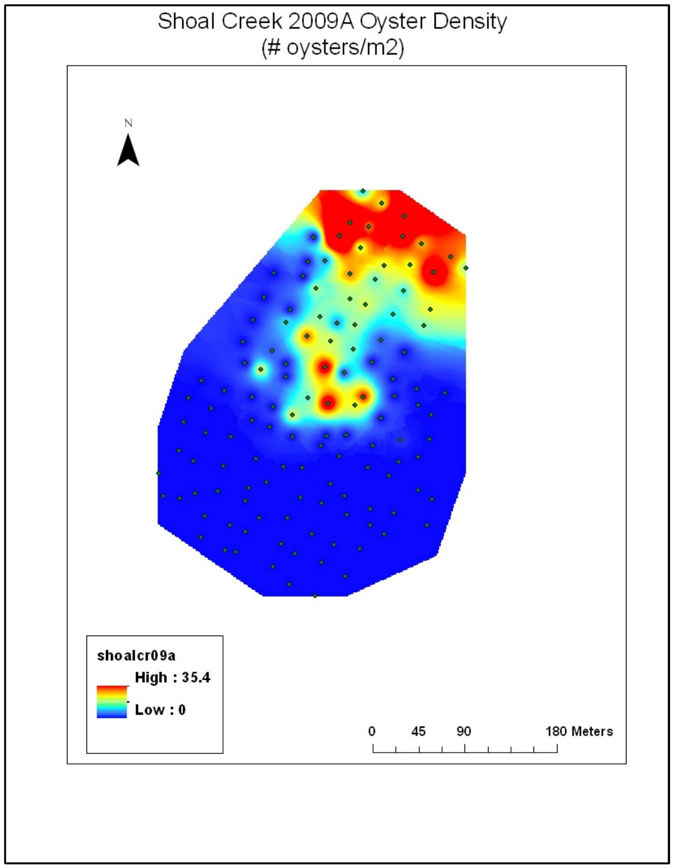
Shoal Creek 2006, 2009

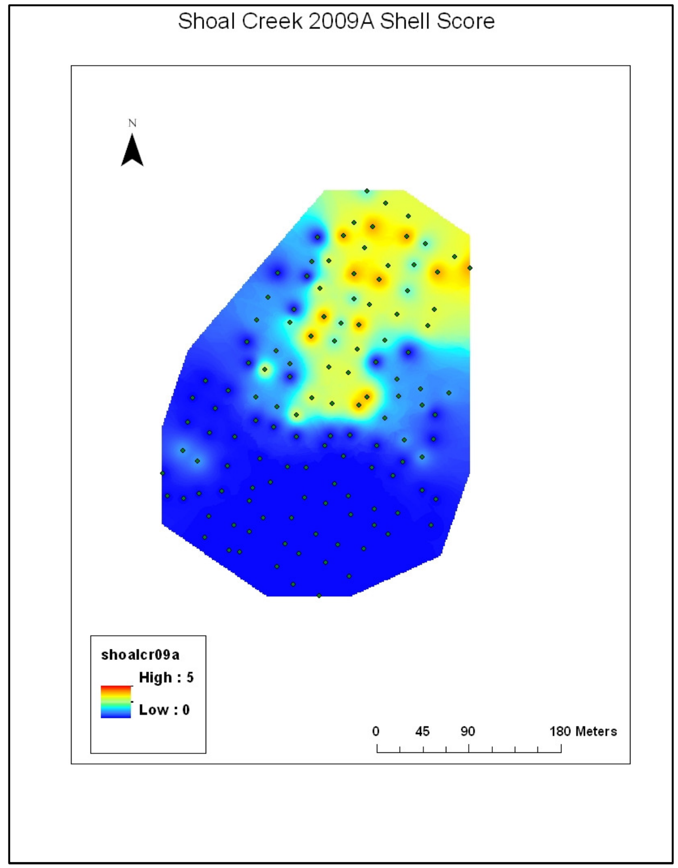
Two separate non-overlapping plantings occurred at Shoal Creek in both 2006 and 2009 and they are shown in the map below.



Shoal Creek 2009A

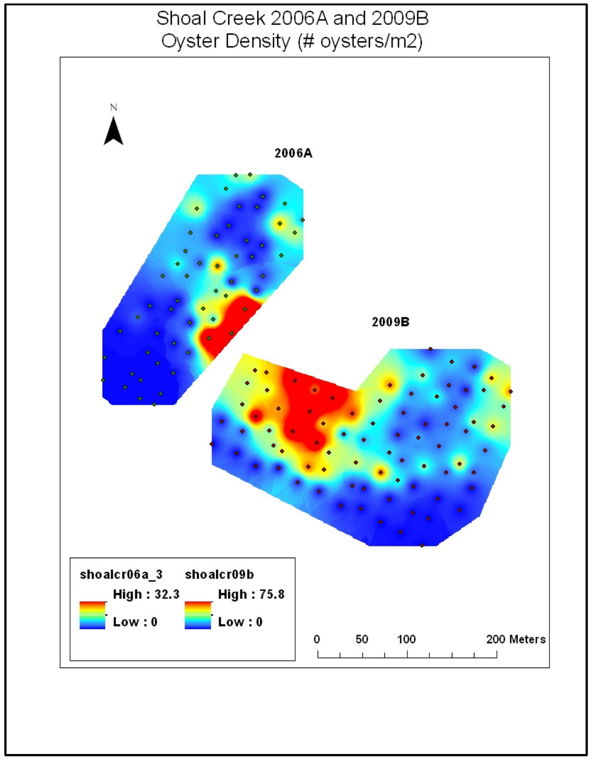
The 2009A site at Shoal Creek was the most successful of the four sites surveyed at Shoal Creek in the 2012 patent tong survey. The oyster population and high densities of shell at Shoal Creek 2009A were both concentrated in the northern half of the restoration site. Despite 70% dermo prevalence, the oyster population at Shoal Creek 2009A was 100% of what would be expected from natural mortality alone. This may be due to the fact that although dermo prevalence was high, intensity was relatively low, at only 0.97%. As is clearly visible in the map below, 24% of the bar area had good shell coverage (shell scores of 3 or greater) and only 19% of the shell at this site was buried. Average oyster density at this site was 3.0 oysters/m^2 and average biomass density at this site was 4.5 g/m^2, indicating that the oysters were relatively large to have achieved a higher biomass density than count density at the site. While both oyster density and biomass were below the OMW benchmarks, the high percent of the expected population observed at this site is promising for the future.

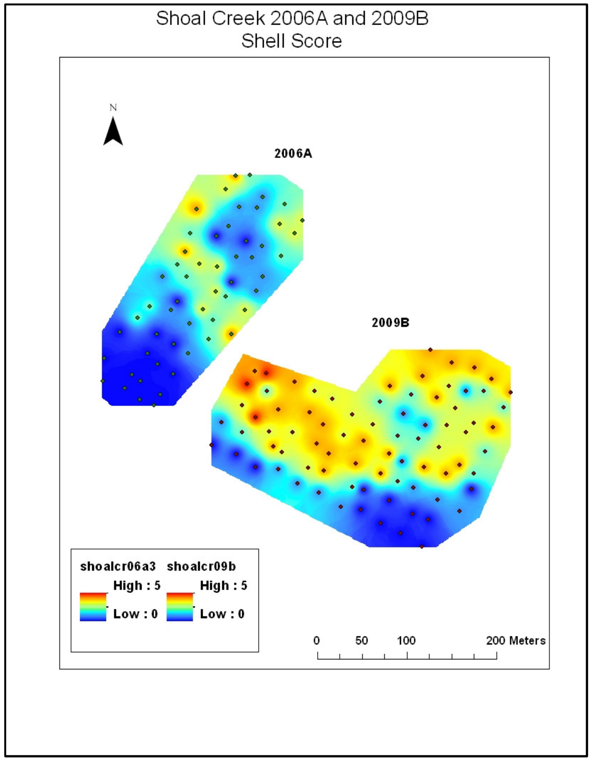




Shoal Creek 2006A, 2009B

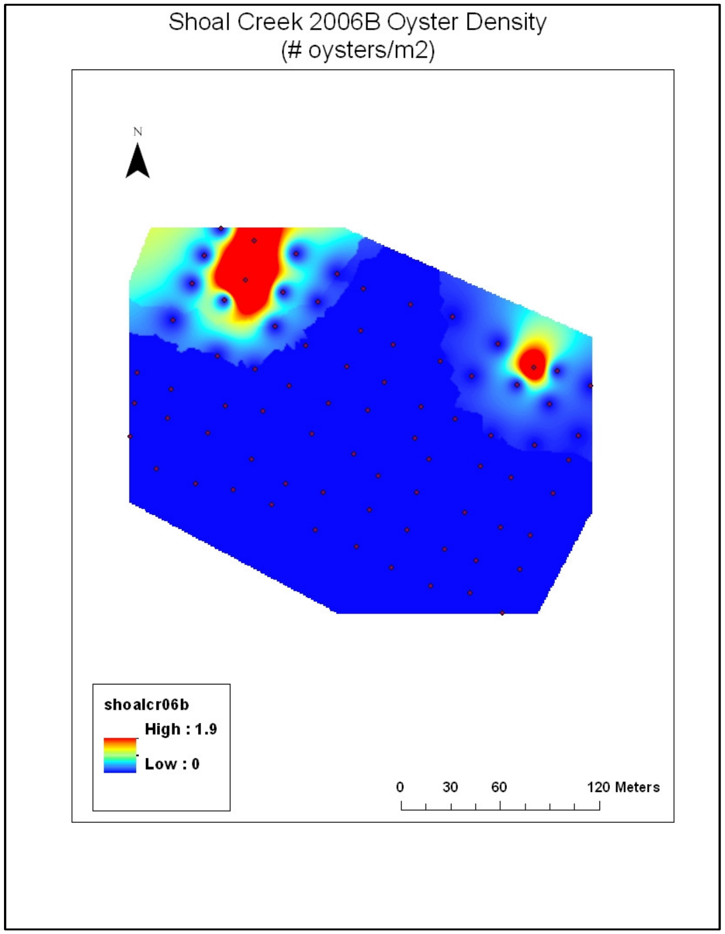
The plantings at Shoal Creek 2006A and 2009B are shown together below because they were located in close proximity to one another. The 2006A site was originally planted with a relatively low number of oysters (4 million) and therefore the expected oyster population at the site was 177 million. Despite high dermo prevalence (97%) and intensity (2.37/5), the population at Shoal Creek 2006A was 100% of expected based on natural mortality alone. This is could be due to the high density of oysters at the edge of the eastern portion of the plot. About one quarter of the 2006A plot has good shell coverage (shell score of 3 or greater), but over 40% of the shell observed at the site was buried. As shown in the figure below, areas of high shell scores in the 2006A plot were not always associated with high oyster densities while areas with high oyster densities always had high shell scores. Seventy percent of the expected population at the 2009B plot was observed on the bar, accompanied by an average oyster density of 18.3 oysters/m^2 and an average biomass of 23.2 g/m^2. While Shoal Creek 2009B was one of two bars in the 2010 survey that met both the biomass and density benchmarks set by the OMW, only 24% of the bar had good shell coverage and 30% of the shell observed was buried. Most of the oysters and shell were concentrated in the western portion of the bar, in close proximity to areas of high oyster density found on the 2006A plot, indicating some continuity between sites.

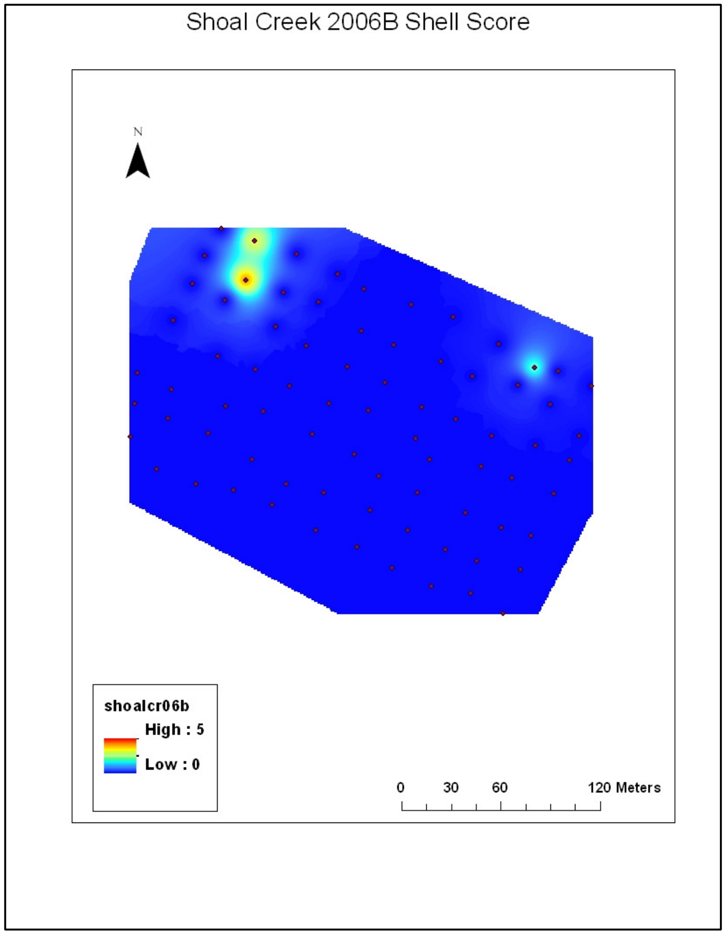




Shoal Creek 2006B

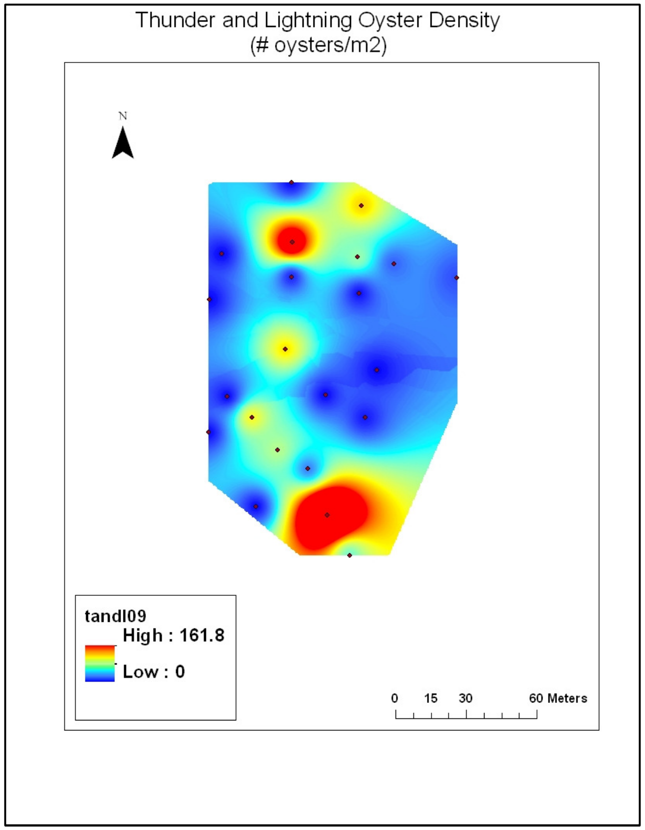
The site at Shoal Creek 2006B was not a successful restoration event. Only one small section of the survey area contained any oysters or shell (northwestern corner), and the oysters that were present were found in very low densities. In fact, only five individual oysters were found during the entire survey of Shoal Creek 2006B. While only 3% of the shell observed at the site was buried, only two grabs contained any shell at all. Original planting numbers for this site were not available, which underscores the suspicion that this site may have not been planted in 2006 which would explain the lack of shell and oysters observed at this site during the 2012 patent tong survey.

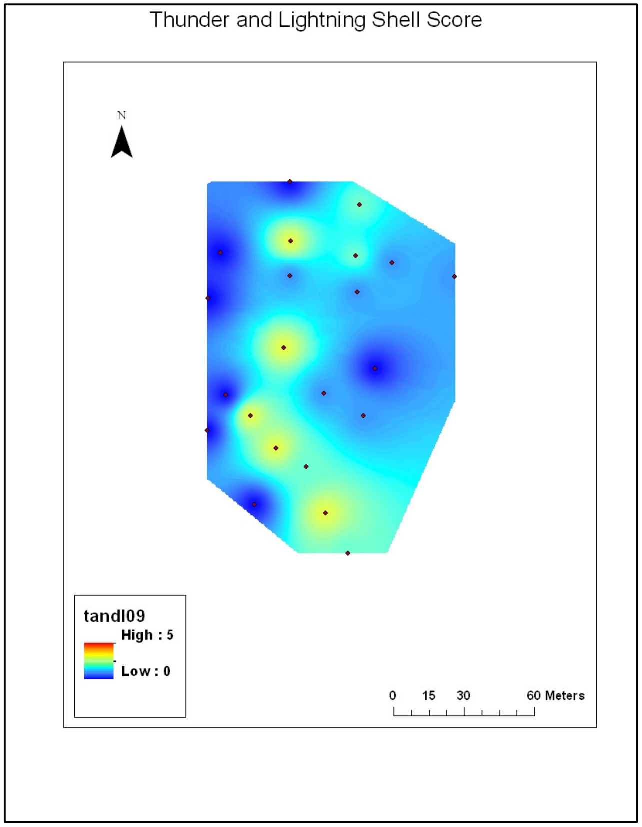




Thunder and Lightning

The restoration site at Thunder and Lightning was a non-sanctuary site, and was open to hand-tonging. Staff from the Paynter Lab observed hand-tongers harvesting oysters at the site during the patent tong survey of Thunder and Lightning. The 2009 planting area at Thunder and Lightning was also planted in 2010 and it was not possible to differentiate between year classes during the 2012 patent tong survey. Therefore, expected population was determined using both the 2009 and 2010 planting information. Despite active harvest at the bar as well as high dermo prevalence (80%), the population observed was 40% of the expected population from natural mortality alone. Both oyster density and biomass density were well above the guidelines set by the OMW, as average oyster density was 23.3 oysters/m^2 and average oyster biomass was 28.4 g/m^2. Thunder and Lightning was the second bar in the 2012 survey that met both the density and biomass benchmarks set by the OMW. While only 24% of the bar had good shell coverage only 14% of the observed shell was buried. The success of this harvest bar may be due to its small size as well as the low intensity of disease (1.24/5) present at the site.





Conclusions

The 2012 patent tong survey was comprised of twelve different survey plots at six different oyster bars in three rivers of the northern Chesapeake Bay. The survey revealed a heterogeneous distribution of oysters at most sites, as was expected based on natural oyster distributions as well as past patent tong surveys. While at most sites the presence of shell was coupled with the presence of high densities of oysters, a few plots did not follow this general pattern (East Neck Bay 06/09, Strong Bay 09B and C, Sandy Hill 09). While it is accepted that the presence of shell is ideal for oyster growth and survival, the patent tong survey this year indicated that is not always the case.

The metrics collected in the 2012 patent tong survey provide valuable information about the health, growth and density of oysters at each site surveyed, especially regarding the inherent variation present in the populations at these restoration sites. Average oyster density ranged from 0-23.3 oysters/m^2, average biomass density ranged from 0-28.4 g/m^2, the percent of a bar with good shell coverage ranged from 0-55%, and disease prevalence ranged from 30-100%. Similarly, the percent of the expected population present at a bar ranged from less than 10% to over 100% during the survey. The variation in these data highlights the natural variability present in the restored oyster network in the Chesapeake Bay. While many metrics are monitored, it is difficult to highlight a single factor that influences the success of a restored bar.

In 2011, the Oyster Metrics Workgroup (OMW) attempted to streamline multi-agency monitoring and outlined criteria that a restored site should meet in order to view as successful. Among these criteria are that the bar should have both an oyster density of 15 or more oysters/m^2 and a biomass density of 15 or more g/m^2. We also believe that the percent of the expected population that survives as well as disease levels should be included in these criteria. The expected population at each bar was determined based on the following mortality calculation: it is assumed that approximately 90% of spat are lost within one year after planting and 15% of the remaining population each subsequent year.

The results of percent of expected population, average oyster density and average biomass density were grouped into low, medium, or high levels according to natural breaks in the data and are presented in Table 4 below. Sites that fell into different categories for different metrics are highlighted as one color. All sites except for Strong Bay 2006B, for which no estimate of expected population could be calculated, are included in the table. The only sites that fell into the same category for both expected population and average oyster density were sites that had low oyster densities and low percent of the expected population. No site that had high oyster density also had a high percent of the expected population. Similarly, no site that had high percent of the expected population had high oyster density.

Table 4. Percent of expected population and average oyster density/biomass for sites sampled in the 2012 patent tong survey. Sites were grouped into low, medium, or high for both categories based on natural breaks in the data. The only sites with consistent categorization between metrics were sites with percent of expected population and low oyster density/biomass.

% of Expected Population			**Average Oyster Density (# oysters/m^2) and Biomass (g/m^2)**		
Low Below 15%	**Medium 40%-70%**	**High 100% +**	**Low 0-2**	**Medium 3-10**	**High 10+**
Tolly Point 09	Strong Bay 09A	Tolly Point 06	Tolly Point 09	Tolly Point 06	Strong Bay 09A
East Neck 06/09	Shoal Creek 09B	Shoal Creek 06A	East Neck 06/09	Shoal Creek 06A	Shoal Creek 09B
Strong Bay 09B	Thunder and L 09/10		Strong Bay 09B	Shoal Creek 09A	Thunder and L 09/10
Strong Bay 09C			Strong Bay 09C		
Sandy Hill 09			Sandy Hill 09		
Shoal Creek 09A					

There are many potential reasons why the expected population and oyster densities/biomass were not in the same category for many sites, including the post-planting spat survival at sites as well as disease prevalence/intensity. Low spat survival immediately post-planting at sites may explain why the percent of the population at Strong Bay 09A, Shoal Creek 09B and Thunder and Lightning 09/10 were at the medium level while the average oyster density/biomass at those sites was high. The oysters that survived the potentially high mortality post-planting grew well and therefore had high surviving densities and biomass. Similarly, high disease prevalence/intensity at Shoal Creek 06A may be why the population level at this site was 100% of expected but the density/biomass at the site was lower than expected. The high disease levels in this population may not have been lethal, but could have been high enough to negatively impact oyster growth. In addition, as a managed harvest bar, the expected population formula does not account for legal take at Thunder and Lightning, which would also lead to a decreased observed population.

While the above mentioned factors are possible explanations for the variation observed in the surviving population and oyster density/biomass at restoration sites, there are many other potential causes of the variation in the success of restoration sites. Other factors are likely available substrate type, water movement, reproductive success and larval dispersal. The patent tong survey data provide information on the available substrate at each site and in general sites with more shell have higher populations and oyster densities. The 2012 survey was also the first time that the amount of buried shell at each site was recorded. The amount of buried shell at each site was relatively low, no site had more than 50% of buried shell. However, in order to understand the impacts of multiple factors on restoration success, long term monitoring of individual restored sites is necessary. The Paynter Lab has started the second round of long-term patent tong monitoring this year by targeting three bars recently targeted for restoration in Harris Creek and one bar in the Little Choptank River. We believe that the data from the long term bars will provide more information on the factors influencing restoration success. The results from the first year of long term monitoring are presented in a separate report.

Section V: Long-Term Patent Tong Monitoring 2012

Survey Summary

In order to obtain a sound representation of oyster population dynamics through time following a spat-on-shell planting, four individual oyster bars will be monitored for five consecutive years from 2007 – 2011. The data from these bars proved valuable in understanding how population levels and substrate at restored bars changes through time. However, the bars chosen for the first round of long term monitoring were small in area and not all bars were in sanctuary areas. Therefore, four new bars were chosen in 2012 to be the target of a second round of long term monitoring. These bars are all in tributaries that are targeted for tributary-level restoration by NOAA, DNR and ACOE. Three bars are in Harris Creek and one bar is in the Little Choptank River. In 2013, two more bars will be added for long term monitoring which are located in the Little Choptank River, creating a final site list of six bars, three in each tributary. Figure 1 shows the four current long-term monitoring sites. Site locations are indicated by red dots, river names in bold black and site names in yellow boxes. These bars, their location, and plant year are outlined in Table 1 below.

Table 1. Oyster bars targeted for long-term monitoring.

Tributary	Bar Name	Plant Year
	Little Neck	2012
Harris Creek	Lodges	2012
	Mill Point	2011
Little Choptank	Cason	2011

A grid of 25 m x 25 m cells was overlaid on the planted area and each grid cell was sampled with hydraulic patent tongs. Number and shell height (mm) of live and dead (box or gaper) oysters were recorded at each grab in addition to substrate type, amount of shell and percentage of shell that was buried. Due to the recent planting of these sites, a large number of oysters were collected in each patent tong grab and in many cases not all oysters were measured. At least 50 live oysters of each size class (less than 80 mm and greater than 80 mm) were measured, while others were counted. In grabs with shell scores of 4 or 5 (with tongs nearly or completely full of oyster/substrate), material was subsampled; a 2.5 gallon bucket was used to quantify the total amount of material in the grab and a representative 2.5 gallons was measured and counted.

The density of oysters at each point was calculated using the area of the tongs and a population estimate was generated using this density data. The biomass of oysters found at each site was calculated using the following equation: Biomass (g) =0.00003*(Shell Height (mm) ^2.3512) (Liddel 2007). This equation was used to calculate the total biomass in each surveyed cell; cell data was then totaled to determine each bar's biomass. The location of each patent tong survey point was recorded using GIS. These spatial data allowed for spatial analysis of the data collected at each patent tong survey point (see above). As this is the first survey year for these bars, data presented below included only that for the 2012 survey. Subsequent data will be added as annual surveys are completed, and oyster population and bottom type characterization will be tracked through time. Results for individual sites are presented below.

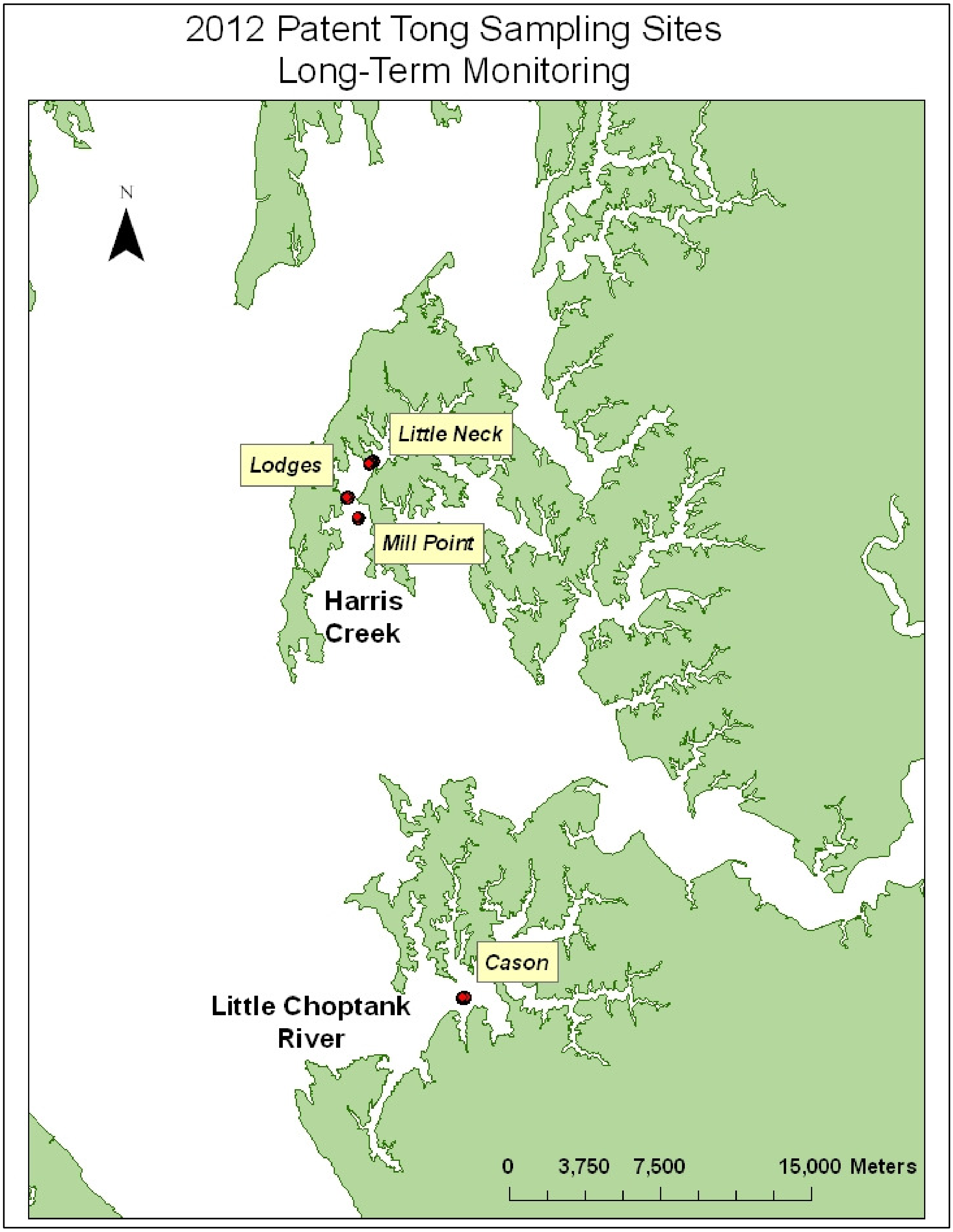


Figure 1. Map of long-term monitoring oyster bars. Bar locations are indicated by red dots with bar names in yellow.

Little Neck

Little Neck is an oyster bar located upriver in the Harris Creek sanctuary. It was planted during the summer of 2012 and surveyed with hydraulic patent tongs in the fall of 2012. In addition, divers collected oysters to sample for disease (*Perkinsus marinus*, Dermo) for both native oysters and those planted in 2012.

As seen in Figure 2, the 2012 survey revealed oyster lengths reflective of the 2012 planting. The majority of oysters measured at Little Neck were between 30 and 70 mm in length, while a smaller group of oysters were centered around 90 mm in length. Still, some oysters were even larger, suggesting the presence of natural spat sets on this bar in the past. These larger oysters (70 mm or greater) were categorized as native, and were used to sample the natural population for dermo.

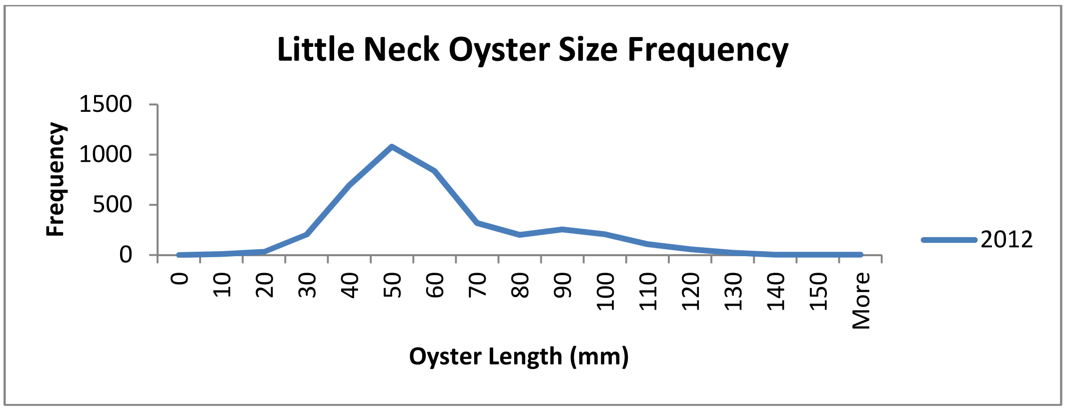


Figure 2. Little Neck oyster size frequency (2012). Size frequency data reflects the 2012 planting, as the majority of oysters measured were less than 70 mm in length, though larger, naturally occurring oysters were also observed.

Table 2 below summarizes oyster population metrics observed at Little Neck in 2012. A high number of live oysters were counted relative to dead oysters, resulting in very low relative death across the bar (3%). The mean oyster density was high, approximately 118 oysters per m^2, reflective of the many small spat planted in 2012. Similarly, overall bar biomass (2,328 kg) and thus biomass density were relatively high, also characteristic of the many small 2012 oysters at Little Neck. Oyster density across the bar can be seen in Figure 3, which illustrates the heterogeneous distribution of oysters on Little Neck. The majority of oysters in 2012 were found in the southern central portion of the bar, and at some points reached densities of 650 oysters/m^2. Figure 4 shows mean biomass density at Little Neck for 2012.

Table 2. Little Neck oyster metrics (2012). Oyster population and sampling metrics are shown for Little Neck.

Sampling Year	Mean Oyster Length (mm)	Live Oyster Count	Box/Gaper Count	% Dead	Mean Oyster Density (#/m2) ±SEM	Population Estimate	Biomass Sum (kg)
2012	61	17,793	407	3	118 ± 14	6,977,096	2,328

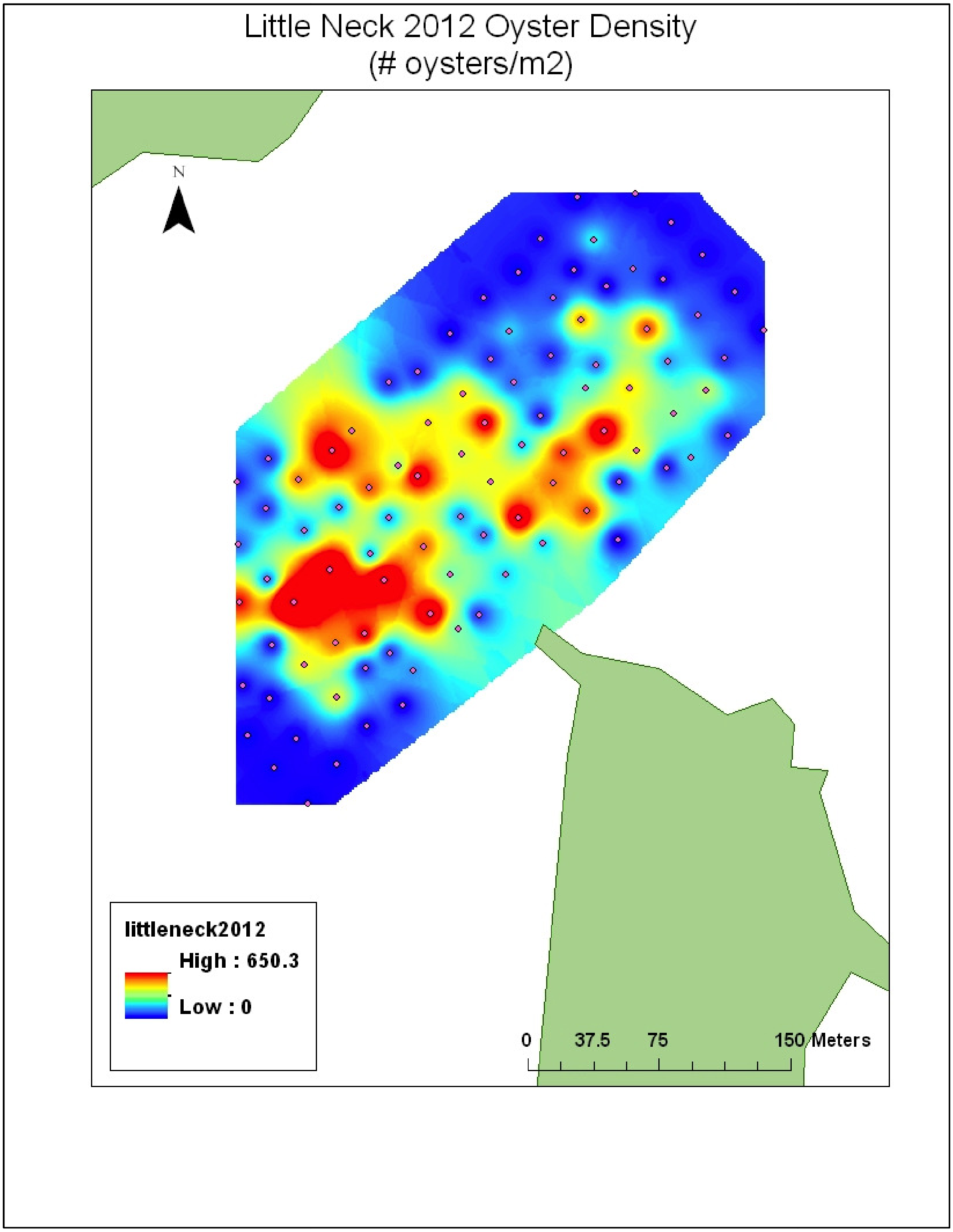


Figure 3. Little Neck oyster density distribution (2012). Oyster density (oyster/m^2) is displayed across the bar. Areas shown in red represent highest oyster densities (650 oysters/m^2), while cooler colors show lower oysters densities, with zero oysters represented by dark blue.

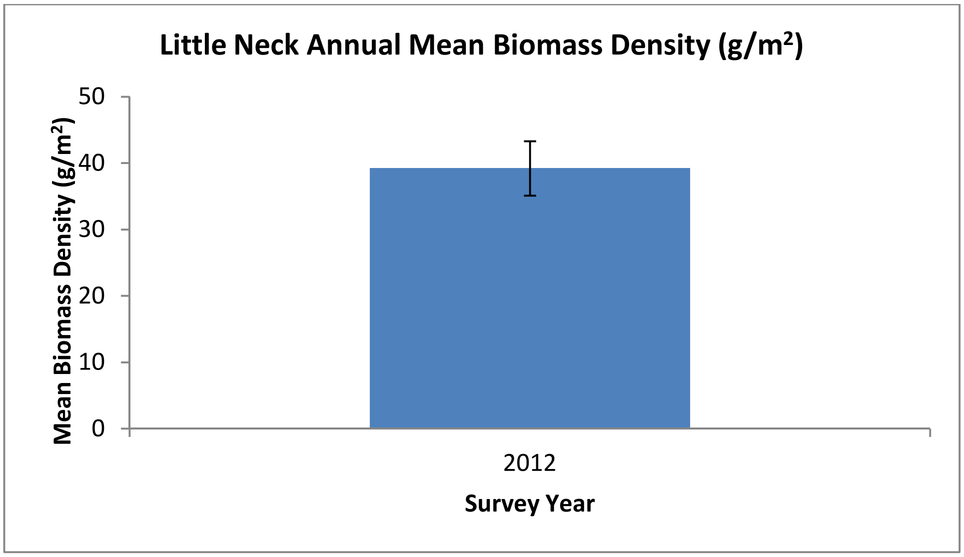


Figure 4. Little Neck annual mean biomass density (2012). The mean bar biomass density is shown for 2012. Error bars represent standard error of the mean. Biomass density was relatively high, corresponding to the high oyster density due to recently planted spat.

Oysters were sampled for dermo disease and were classified as either 2012 or native oysters, as described above. In 2012, dermo prevalence was much greater in the larger, native oysters, as seen in Table 3. Similarly, dermo weighted intensity was greater in native oysters relative to spat planted in 2012 at Little Neck. As expected, dermo prevalence and intensity were low in recently planted spat (close to zero). Native oysters showed rather high prevalence, but low weighted intensity. This suggests that while dermo is not currently present at lethal levels in the adult population, it could be impacting the population through reduced growth or fecundity.

Table 3. Little Neck disease data (2012). Data are presented for both recently planted spat as well as native oysters surveyed from the natural population.

Sampling Year	Oyster Class	Mean Oyster Length (mm)	Dermo Prevalence (%)	Dermo Weighted Intensity
2012	2012	50.07	6.67	0
	Native	91.67	73.33	1.07

In addition to tracking changes in oyster population over time, changes in bottom type and shell availability will also be compared annually. Figure 5 shows the presence of shell across the bar, as observed in the 2012 survey. Shell presence was quantified as shell score, a metric based of off the amount of shell in each grab. Shell scores range from zero to five, with zero representing tongs with no shell and five indicating tongs completely full of shell. Shell scores were relatively high at Little Neck in 2012, with the majority of grabs possessing scores of three or greater, shown on figure 5 as areas of yellow, orange, and red. Areas of highest shell scores were also areas with the greatest oyster densities, as seen in Figure 3.

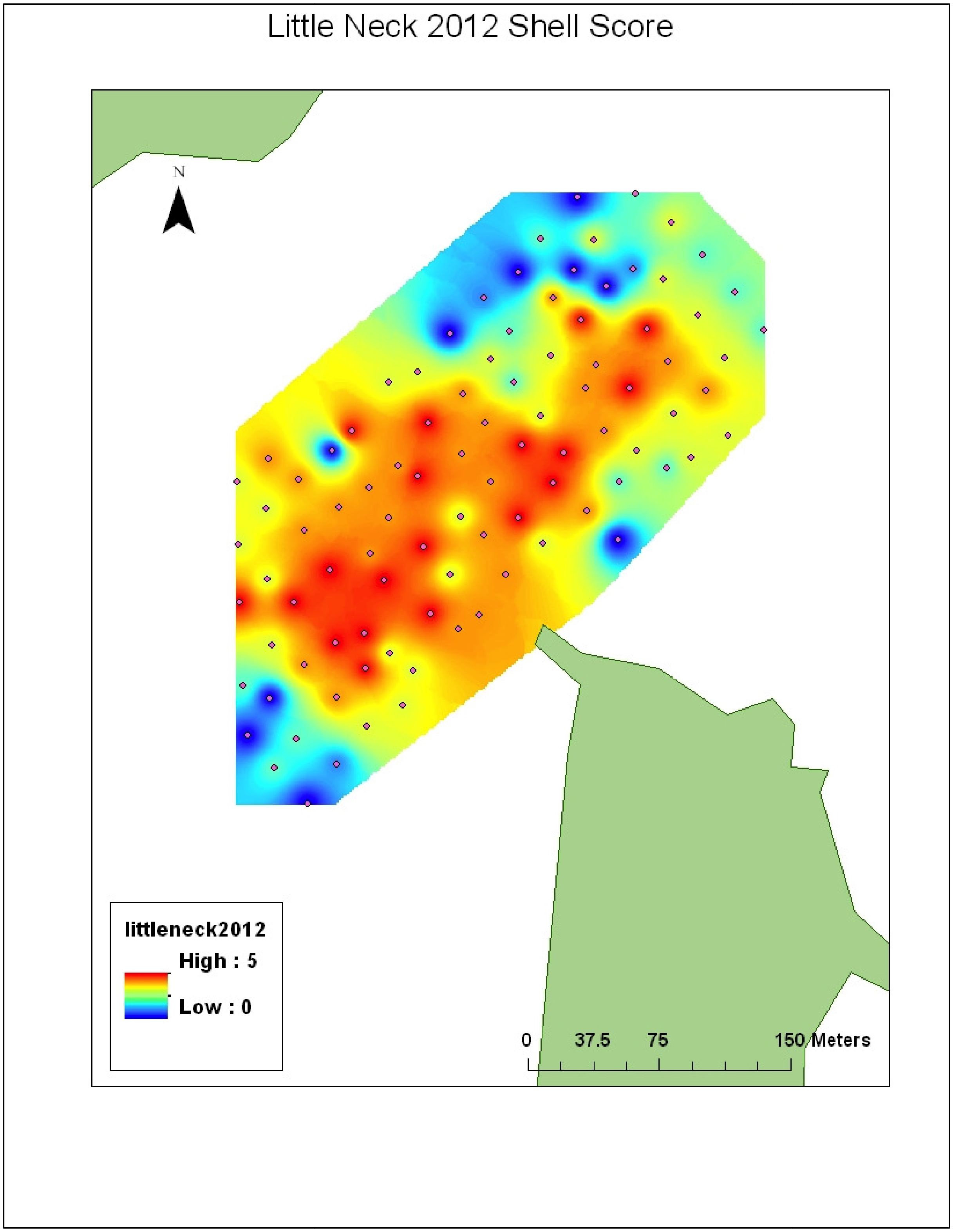
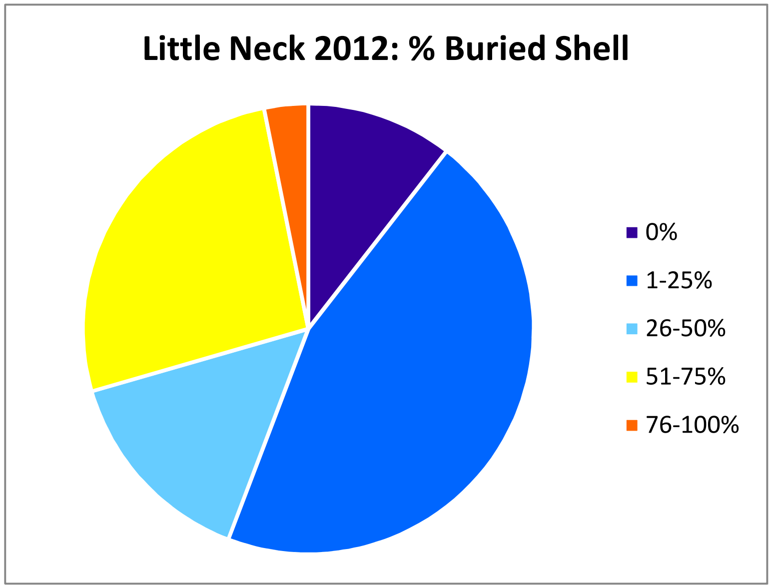


Figure 5. Little Neck shell score distribution (2012). Shell score, ranging from zero to five, is displayed across the bar. A score of zero represents a grab without shell and is depicted by dark blue, while a score of five represents tongs full of shell and is shown in red.

In addition to quantifying the amount of shell in each grab, the percentage of buried shell within each grab was estimated. Buried shell was identified as black or gray shell, which had obviously been covered in mud prior to being brought to the surface. The other shell type was classified as brown shell, or shell that had not been covered in mud before being sampled. The left panel in Figure 6 shows the relative number of grabs with differing amounts of buried shell. Buried shell percentages were grouped as follows: 0%, 1-25%, 26-50%, 51-75%, and 76-100%. They are shown in Figure 6 as the number of grabs at Little Neck possessing that percentage of buried shell. The majority of grabs contained 26-50% buried shell, while very few were completed buried (100%). In the figure, shades of blue represent what may be considered "good" bottom for oysters with bottom type becoming worse as the color changes from blue to gray.

Bottom type was also characterized by the primary and secondary substrates observed in each grab. In addition to shell, all other substrates were documented including: mud, sand, and oyster. The right panel in Figure 6 shows the relative number of grabs with each primary and secondary substrate combination observed at Little Neck in 2012. Shades of blue and purple represent what may be considered "good" bottom for oysters, in that each combination contains some form of shell or oyster and mud is not the primary substrate. Shades of red, orange, and yellow represent less than ideal bottom, with mud as the primary substrate and/or no form of shell or oyster. The majority of grabs at Little Neck in 2012 suggest good bottom with shell and/or oysters. The most common observations were shell with oysters, shell with mud, and mud with shell. As substrate observations in tandem with shell score and percent black shell are monitored annually, changes in bottom quality at Little Neck can be inferred.



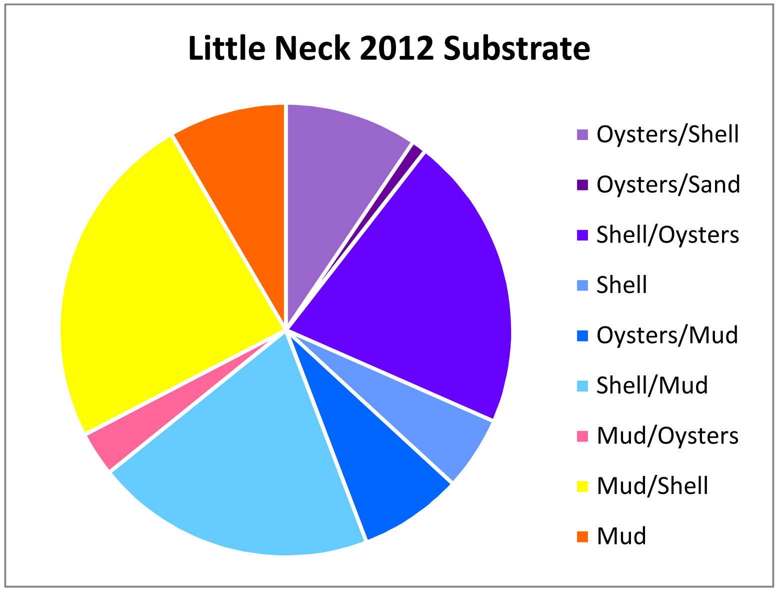


Figure 6. Little Neck percent buried shell and substrate composition (2012). The number of grabs containing buried (black) shell is shown as bracketed into the five percentage categories shown in the figure legend. Most grabs had 26 – 50% buried shell. The relative number of grabs containing each substrate is shown in the figure to the right. In both figures, shades of purple and blue represent what may be considered "good" bottom for oysters with bottom type becoming worse as the color changes from purple to blue or aqua, eventually to shades of yellow, orange, and/or red. In the substrate figure, shades of purple and blue represent grabs that contain some form of shell or oyster and mud is not the primary substrate. Shades of yellow, orange, and red represent less than ideal bottom, with mud as the primary substrate and/or no form of shell or oyster. Over half of the grabs at Little Neck were appropriate for oysters both in the percentage of buried shell as well as the available substrate.

Lodges

Lodges is an oyster bar located midriver in the Harris Creek Sanctuary. It was planted during the summer of 2012, and surveyed with hydraulic patent tongs in the fall of 2012. In addition, divers collected oysters to sample for disease (*Perkinsus marinus*, Dermo) for both native oysters and those planted in 2012.

As seen in Figure 7, the 2012 survey revealed oyster lengths reflective of the 2012 planting. The majority of oysters measured at Lodges were between 30 and 70 mm in length, while a smaller group of oysters were centered around 90 mm in length. Still, some oysters were even larger, suggesting the presence of natural spat sets on this bar in the past. Size frequency at Lodges is very similar to that at Little Neck, showing that both surveys likely accurately reflect the oyster population after 2012 plantings.

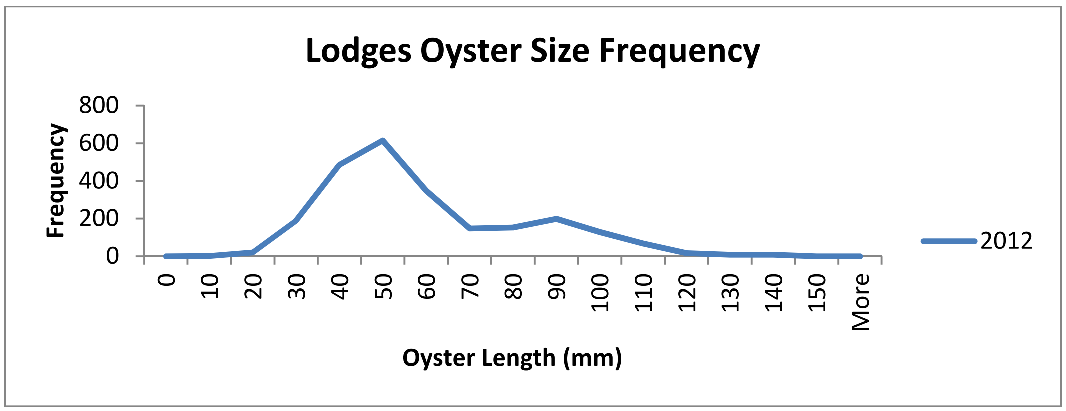


Figure 7. Lodges oyster size frequency (2012). Size frequency data reflects the 2012 planting, as the majority of oysters measured were less than 70 mm in length, though larger, naturally occurring oysters were also observed.

Table 4 below summarizes oyster population metrics observed at Lodges in 2012. A high number of live oysters was counted relative to dead oysters, resulting in very low relative death across the bar (3%). The mean oyster density was high, approximately 86 oysters per m^2, reflective of the many small spat planted in 2012. Similarly, overall bar biomass was high (1,055 kg), also characteristic of the many small 2012 oysters at Lodges. Oyster density across the bar can be seen in Figure 8, which illustrates the heterogeneous distribution of oysters on Lodges. The majority of oysters in 2012 were found in the central portion of the bar, and at some points reached densities of 445 oysters/m^2. Figure 9 shows mean biomass density at Lodges for 2012.

Table 4. Lodges oyster metrics (2012). Oyster population and sampling metrics are shown for Lodges.

Sampling Year	Mean Oyster Length (mm)	Live Oyster Count	Box/Gaper Count	% Dead	Mean Oyster Density (#/m2) ±SEM	Population Estimate	Biomass Sum (kg)
2012	62	8,521	238	3	86 ± 15	3,307,842	1,055

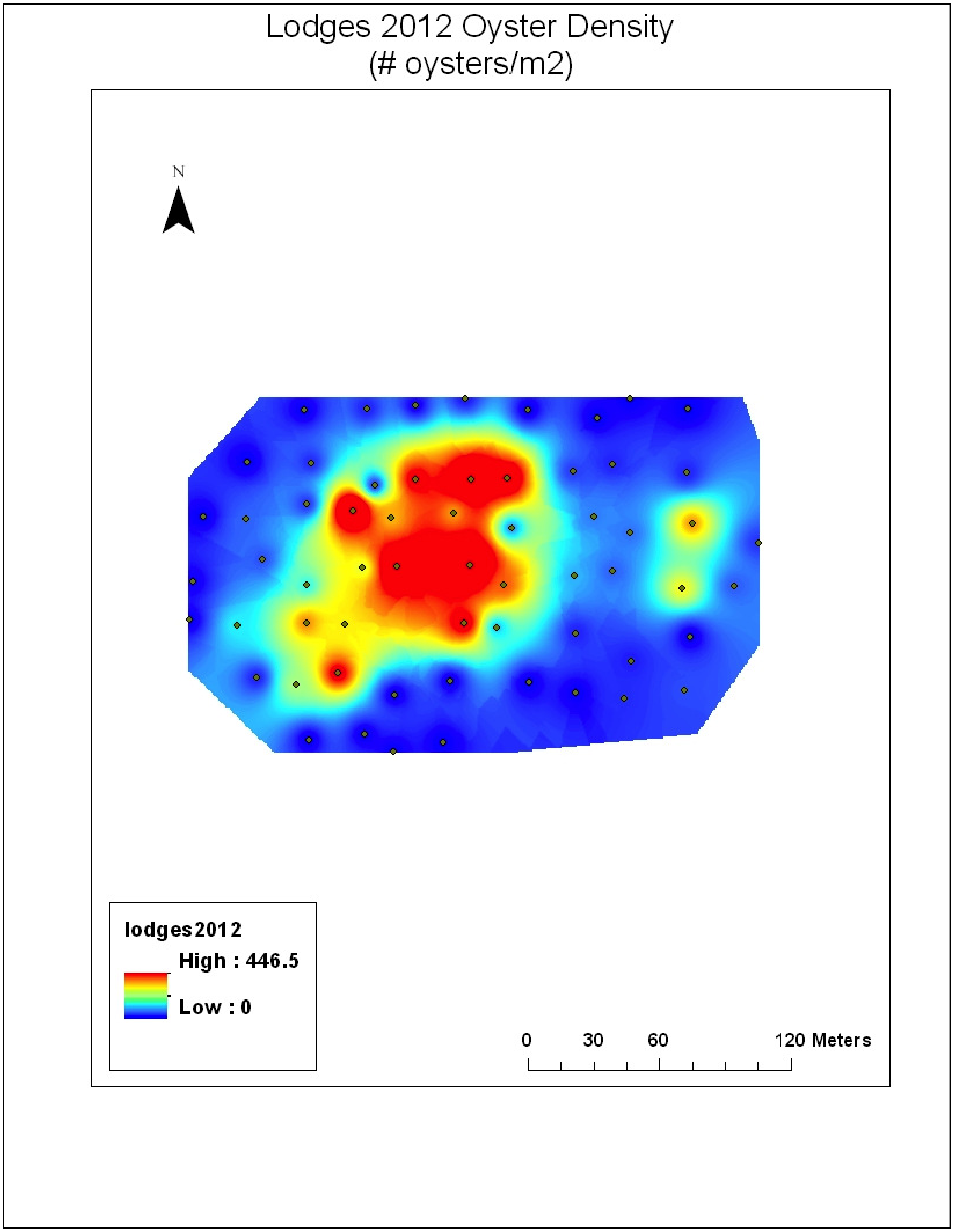


Figure 8. Lodges oyster density distribution (2012). Oyster density (oyster/m^2) is displayed across the bar. Areas shown in red represent highest oyster densities (445 oysters/m^2), while cooler colors show lower oysters densities, with zero oysters represented by dark blue.

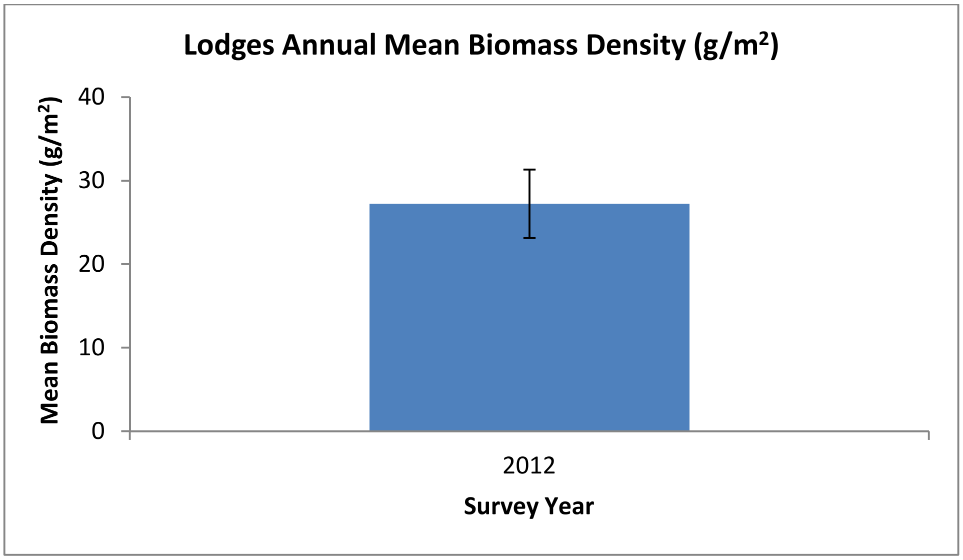


Figure 9. Lodges annual mean biomass density (2012). The mean bar biomass density is shown for 2012. Error bars represent standard error of the mean. Mean biomass was relatively high, corresponding to high oyster density, reflective of a recent spat-on-shell planting.

Oysters at Lodges were sampled for dermo disease in 2012. Overall dermo prevalence and weighted intensity was low, as seen in Table 5. This is as expected in a recently planted, young oyster population. Future surveys will track the possible change in disease presence at Lodges over time.

Table 5. Lodges disease data (2012). Data are presented for recently planted spat.

Sampling Year	Oyster Class	Mean Oyster Length (mm)	Dermo Prevalence (%)	Dermo Weighted Intensity
2012	2012	41.17	6.9	0.04

As described for Little Neck, changes in bottom type and shell availability will also be compared annually. Figure 10 shows the presence of shell across the bar, as observed in the 2012 survey. Shell presence was quantified as shell score, a metric based of off the amount of shell in each grab. Shell scores range from zero to five, with zero representing tongs with no shell and five indicating tongs completely full of shell. Shell scores were low to moderate at Lodges in 2012, with the majority of grabs possessing scores of three or less, shown on Figure 10 as areas of yellow, aqua, and blue. Areas of highest shell scores were also areas with the greatest oyster densities, as seen in Figure 8.

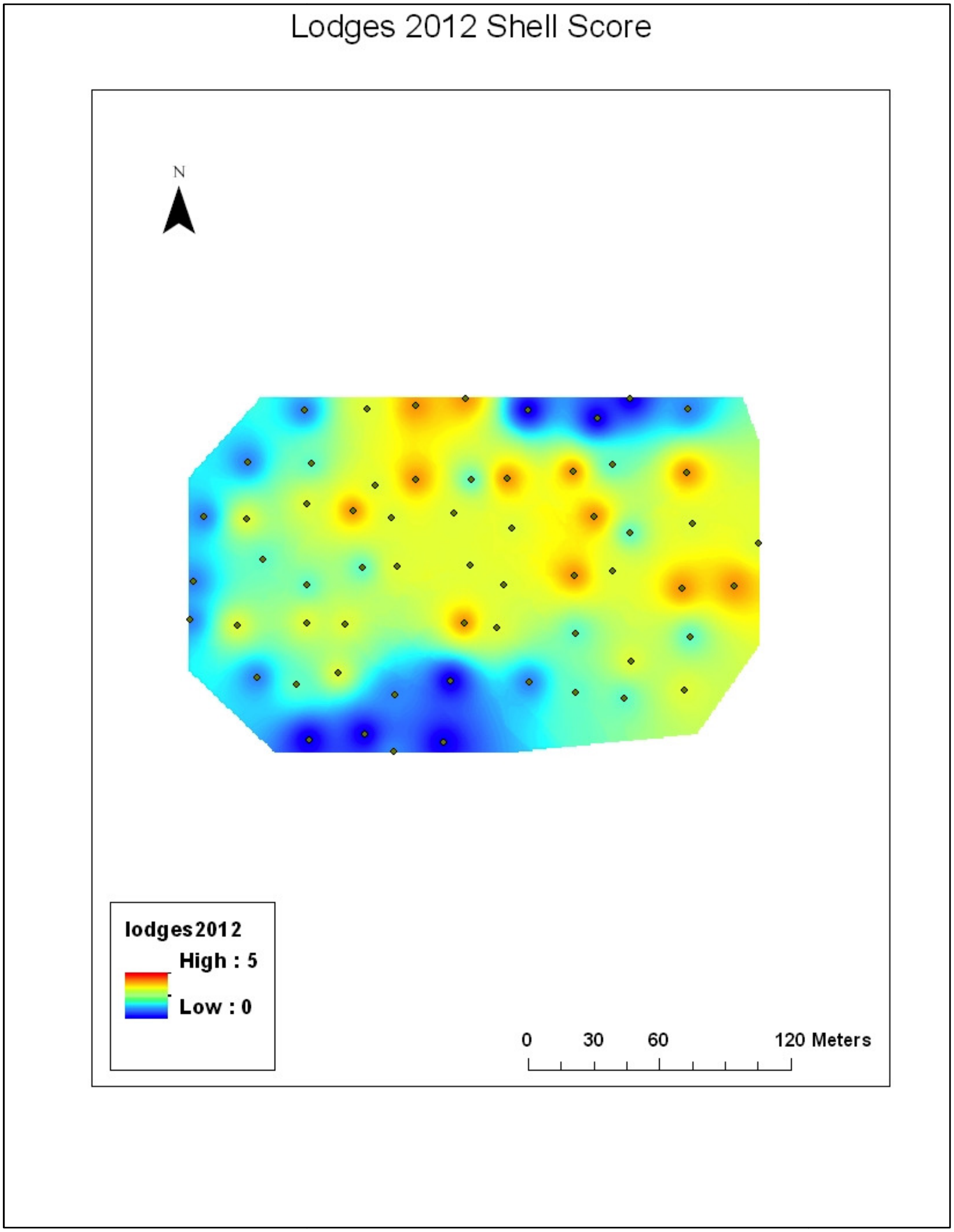
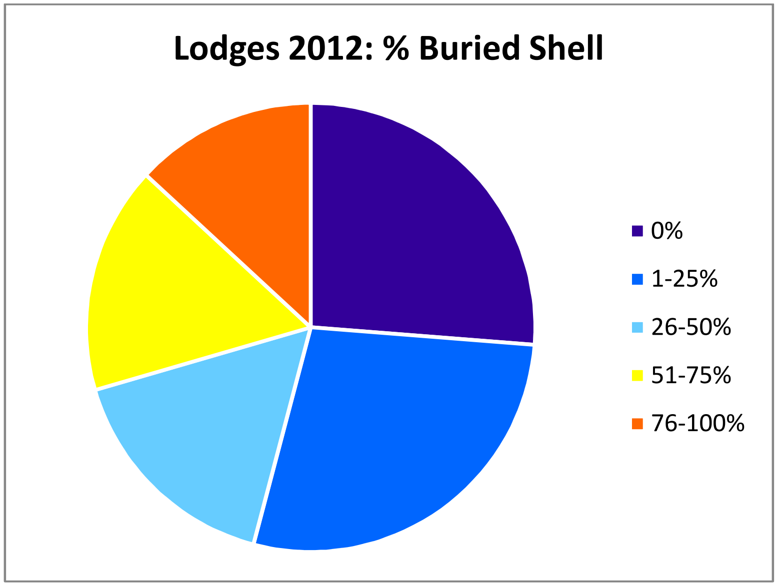


Figure 10. Lodges shell score distribution (2012). Shell score, ranging from zero to five, is displayed across the bar. A score of zero represents a grab without shell and is depicted by dark blue, while a score of five represents tongs full of shell and would be shown in red. No scores of five were observed at Lodges in 2012.

In addition to quantifying the amount of shell in each grab, the percentage of buried shell within each grab was estimated. Buried shell was identified as black or gray shell, which had obviously been covered in mud prior to being brought to the surface. The other shell type was classified as brown shell, or shell that had not been covered in mud before being sampled. The left panel of Figure 11 below shows the relative number of grabs with differing amounts of black shell. Black shell percentages were grouped as follows: 0%, 1-25%, 26-50%, 51-75%, and 76-100%. They are shown in Figure 11 as the number of grabs at Lodges possessing that percentage of black shell. The majority of grabs contained less than 50% buried shell.

Bottom type was also characterized by the primary and secondary substrates observed in each grab. In addition to shell, all other substrates were documented including: mud, sand, and oyster. The right panel of Figure 11 shows the relative number of grabs with each primary and secondary substrate combination observed at Lodges in 2012. Shades of blue and purple represent what may be considered "good" bottom for oysters, in that each combination contains some form of shell or oyster and mud is not the primary substrate. Shades of red, orange, and yellow represent less than ideal bottom, with mud as the primary substrate and/or no form of shell or oyster. The majority of grabs at Lodges in 2012 suggest subpar bottom with mud as the primary substrate, and fewer than 25% of grabs revealed no mud. As substrate observations in tandem with shell score and percent black shell are monitored annually, changes in bottom quality at Lodges can be inferred.



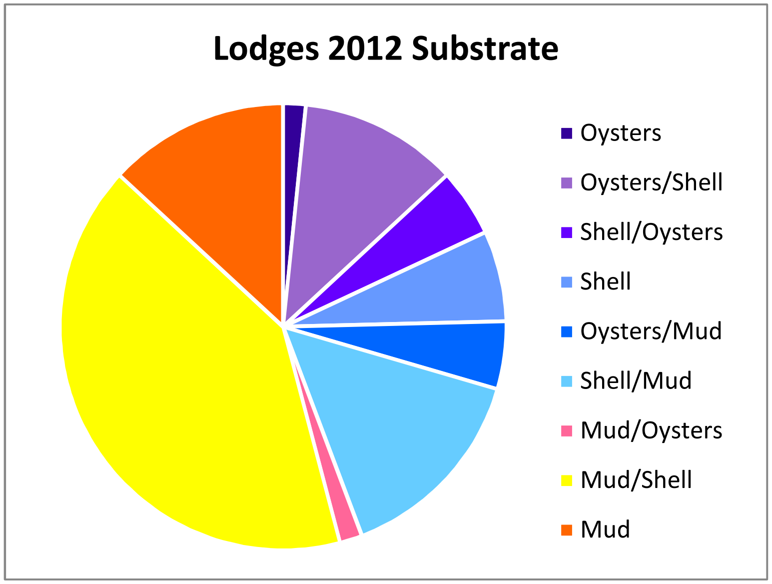


Figure 11. Lodges percent buried shell and substrate composition (2012). The number of grabs containing buried shell is shown as bracketed into the five percentage categories shown in the figure legend. Most grabs had 26 – 50% buried shell. The relative number of grabs containing each substrate is shown in the figure to the right. In both figures, shades of purple and blue represent what may be considered "good" bottom for oysters with bottom type becoming worse as the color changes from purple to blue or aqua, eventually to shades of yellow, orange, and/or red. In the substrate figure, shades of purple and blue represent grabs that contain some form of shell or oyster and mud is not the primary substrate. Shades of yellow, orange, and red represent less than ideal bottom, with mud as the primary substrate and/or no form of shell or oyster. About half of the grabs at Lodges were appropriate for oysters both in the percentage of buried shell as well as the available substrate.

Mill Point

Mill Point is an oyster bar located midriver in the Harris Creek sanctuary. It was planted during the summer of 2011, and surveyed with hydraulic patent tongs in the fall of 2012. In addition, divers collected oysters to sample for disease (*Perkinsus marinus*, Dermo) for both native oysters and those planted in 2012.

As seen in Figure 12, the 2012 survey revealed oyster lengths reflective of the 2011 planting. The majority of oysters measured at Mill Point were between 40 and 90 mm in length. Some oysters were larger, suggesting the presence of natural spat sets on this bar in the past. These larger oysters (approximately 80 mm or greater) were categorized as native, and were used to sample the natural population for dermo.

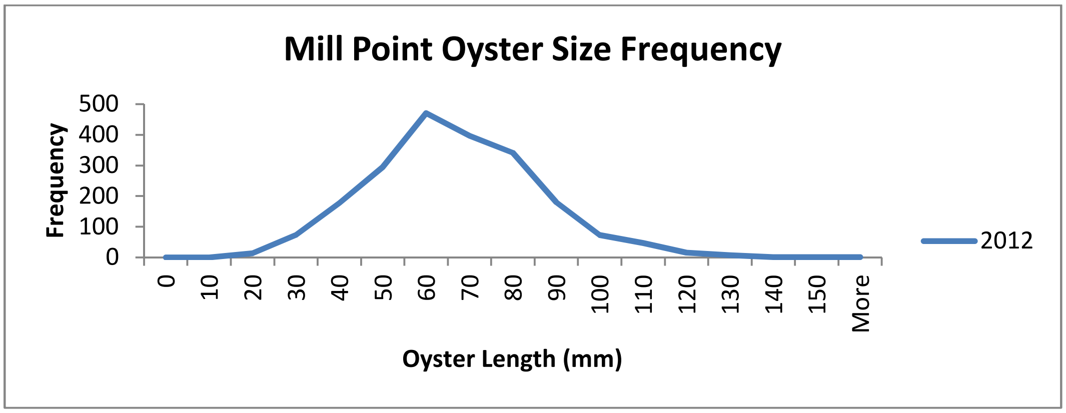


Figure 12. Mill Point oyster size frequency (2012). Size frequency data reflects the 2011 planting, as the majority of oysters measured were less than 90 mm in length, though larger, naturally occurring oysters were also observed.

Table 6 below summarizes oyster population metrics observed at Mill Point in 2012. A high number of live oysters was counted relative to dead oysters, resulting in very low relative death across the bar (l8%). The mean oyster density was fairly high, approximately 31 oysters per m^2, reflective of the many small spat planted in 2011. Though this density is lower than the other long-term survey bars in Harris Creek, this density decline is as expected one-year post-planting. Similarly, overall bar biomass was lower than other sites, but still high (631 kg), also characteristic of the many small 2011 oysters at Mill Point. Oyster density across the bar can be seen in Figure 13, which illustrates the heterogeneous distribution of oysters on Mill Point. The majority of oysters in 2012 were found in the northern central portion of the bar, and at some points reached densities of 191 oysters/m^2. Figure 14 shows mean biomass density at Mill Point for 2012.

Table 6. Mill Point oyster metrics (2012). Oyster population and sampling metrics are shown for Mill Point.

Sampling Year	Mean Oyster Length (mm)	Live Oyster Count	Box/Gaper Count	% Dead	Mean Oyster Density (#/m2) ±SEM	Population Estimate	Biomass Sum (kg)
2012	65	3,257	266	8	31± 4	1,264,363	631

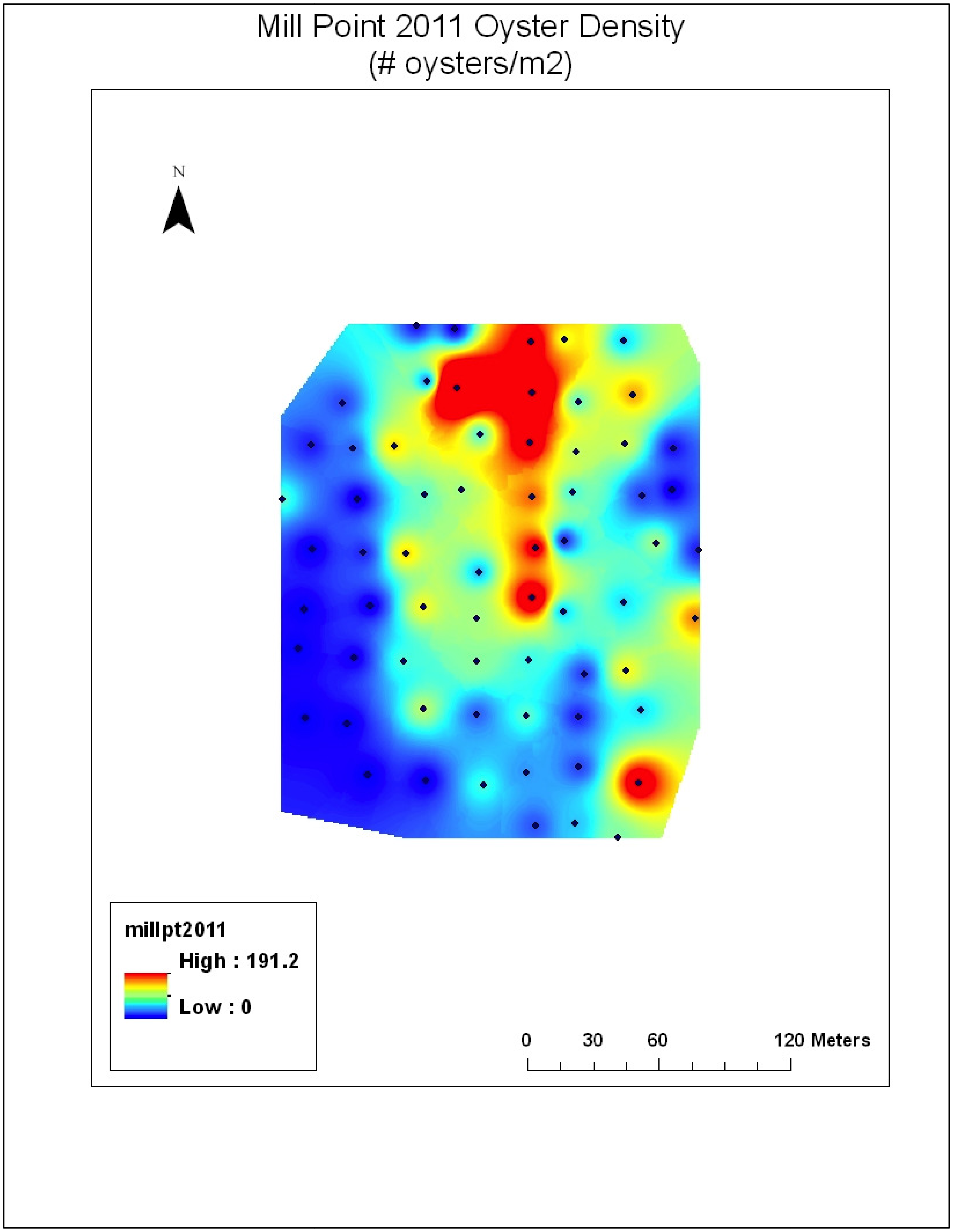


Figure 13. Mill Point oyster density distribution (2012). Oyster density (oyster/m^2) is displayed across the bar. Areas shown in red represent highest oyster densities (191 oysters/m^2), while cooler colors show lower oysters densities, with zero oysters represented by dark blue.

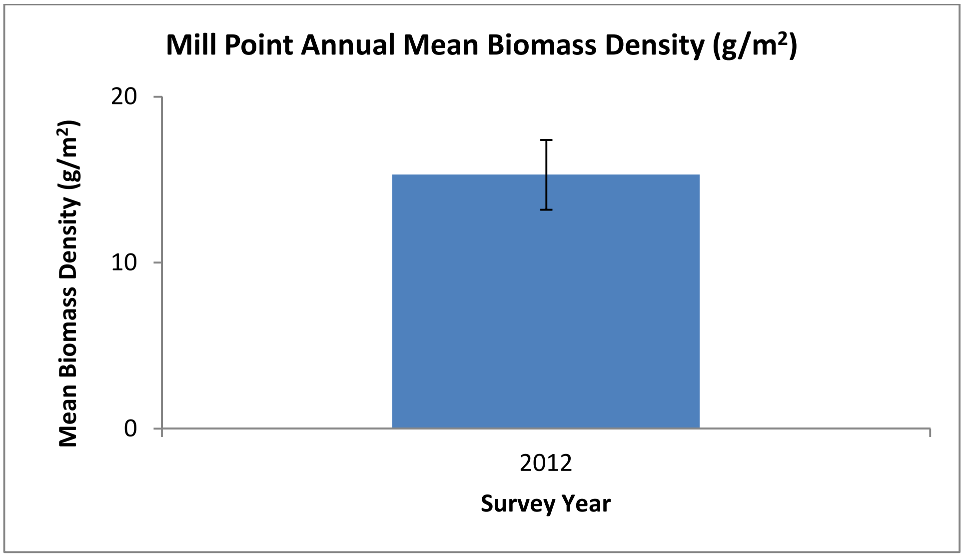


Figure 14. Mill Point annual mean biomass density (2012). The mean bar biomass density is shown for 2012. Error bars represent standard error of the mean. Biomass density was lower than at Little Neck and Lodges, however this is as expected as Mill Point was planted one year earlier and spat mortality is anticipated during the first year post-planting.

Oysters were sampled for dermo disease and were classified as either 2012 or native oysters, as described above. In 2012, dermo prevalence was greater in the larger, native oysters, as seen in Table 7. Similarly, dermo weighted intensity was greater in native oysters relative to spat planted in 2011 at Mill Point. As expected, dermo prevalence and intensity were low in recently planted spat. Native oysters showed rather high prevalence, but low weighted intensity. This suggests that while dermo is not currently present at lethal levels in the adult population, it could be impacting the population through reduced growth or fecundity.

Table 7. Mill Point disease data (2012). Data are presented for both recently planted spat as well as native oysters surveyed from the natural population.

Sampling Year	Oyster Class	Mean Oyster Length (mm)	Dermo Prevalence (%)	Dermo Weighted Intensity
2012	2011	66.6	26.67	0.31
	Native	92.25	62.5	1.01

As described for Little Neck and Lodges, changes in bottom type and shell availability will also be compared annually. Figure 15 shows the presence of shell across the bar, as observed in the 2012 survey. Shell presence was quantified as shell score, a metric based of off the amount of shell in each grab. Shell scores range from zero to five, with zero representing tongs with no shell and five indicating tongs completely full of shell. Shell scores were low to moderate at Mill Point in 2012, with the majority of grabs possessing scores of three or less, shown on Figure 15 as areas of yellow, aqua, and blue. Areas of highest shell scores were also areas with the greatest oyster densities, seen in figure 15.

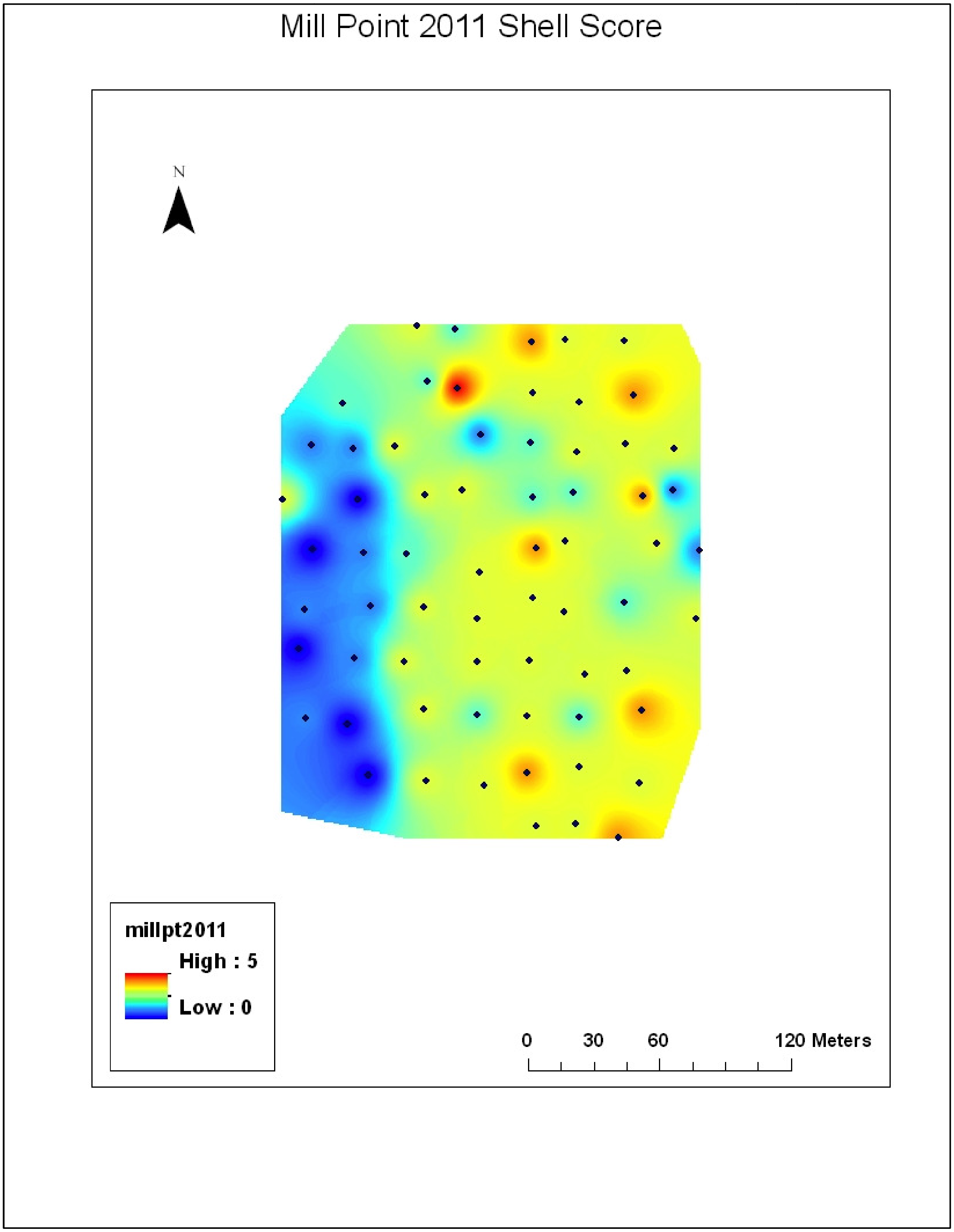
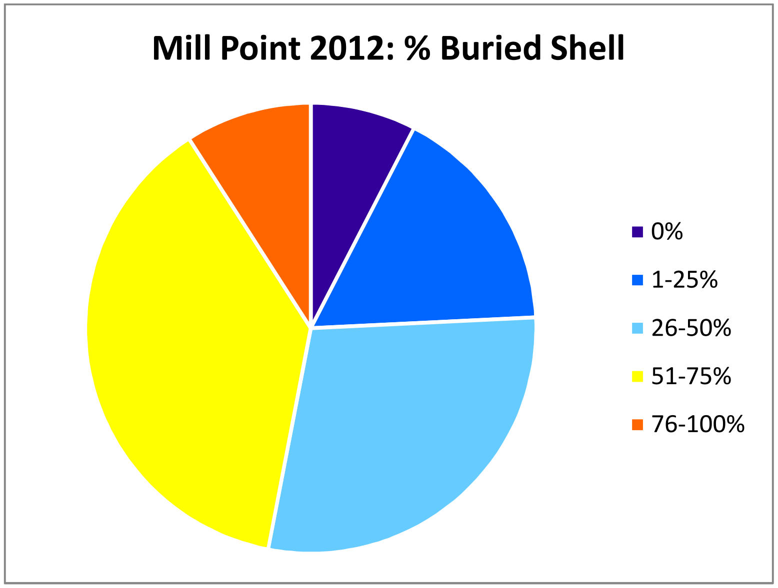


Figure 15. Mill Point shell score distribution (2012). Shell score, ranging from zero to five, is displayed across the bar. A score of zero represents a grab without shell and is depicted by dark blue, while a score of five represents tongs full of shell and are shown in red.

In addition to quantifying the amount of shell in each grab, the percentage of buried shell within each grab was estimated. Buried shell was identified as black or gray shell, which had obviously been covered in mud prior to being brought to the surface. The other shell type was classified as brown shell, or shell that had not been covered in mud before being sampled. The left panel in Figure 16 below shows the relative number of grabs with differing amounts of black shell. Black shell percentages were grouped as follows: 0%, 1-25%, 26-50%, 51-75%, and 76-100%. They are shown in Figure 16 as the number of grabs at Mill Point possessing that percentage of black shell. Just over half of grabs contained less than 50% buried shell.

Bottom type was also characterized by the primary and secondary substrates observed in each grab. In addition to shell, all other substrates were documented including: mud, sand, and oyster. The right panel Figure 16 shows the relative number of grabs with each primary and secondary substrate combination observed at Mill Point in 2012. Shades of blue and purple represent what may be considered “good” bottom for oysters, in that each combination contains some form of shell or oyster and mud is not the primary substrate. Shades of red, orange, and yellow represent less than ideal bottom, with mud as the primary substrate and/or no form of shell or oyster. The majority of grabs at Mill Point in 2012 suggest subpar bottom; mud was the primary substrate and fewer than 25% of grabs revealed no mud. As substrate observations in tandem with shell score and percent black shell are monitored annually, changes in bottom quality at Mill Point can be inferred.



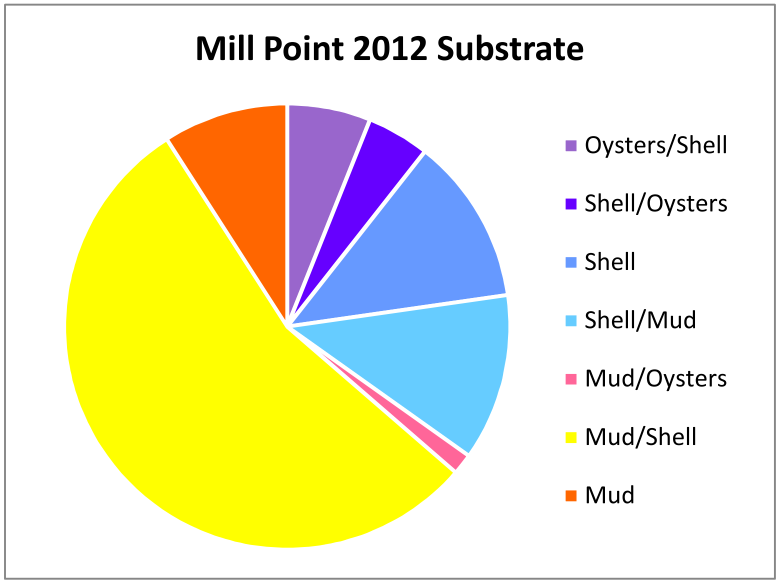


Figure 16. Mill Point percent buried shell and substrate composition (2012). The number of grabs containing buried shell is shown as bracketed into the five percentage categories shown in the figure legend. Most grabs had 26 – 50% buried shell. The relative number of grabs containing each substrate is shown in the figure to the right. In both figures, shades of purple and blue represent what may be considered “good” bottom for oysters with bottom type becoming worse as the color changes from purple to blue or aqua, eventually to shades of yellow, orange, and/or red. In the substrate figure, shades of purple and blue represent grabs that contain some form of shell or oyster and mud is not the primary substrate. Shades of yellow, orange, and red represent less than ideal bottom, with mud as the primary substrate and/or no form of shell or oyster. Less than half of the grabs at Mill Point were appropriate for oysters both in the percentage of buried shell as well as the available substrate.

Cason

Cason is an oyster bar located midriver in the Little Choptank RIver. It is a sanctuary bar that was planted during the summer of 2011, and surveyed with hydraulic patent tongs in the fall of 2012. Oysters were collected to sample for disease (*Perkinsus marinus*, Dermo) for both native oysters and those planted in 2012.

As seen in Figure 17, the 2012 survey revealed oyster lengths reflective of the 2011 planting as well as a possible 2012 natural spat set. The majority of oysters measured at Cason were between 20 and 110 mm in length. Size frequency data suggests that 2011-planted spat were observed (as the large amount of oysters ranging from 70-100 mm in length) as well as a natural spat set in 2012, ranging from 20-70 mm in length. Still, some oysters were even larger (well over 100 mm), suggesting the presence of older native oysters.

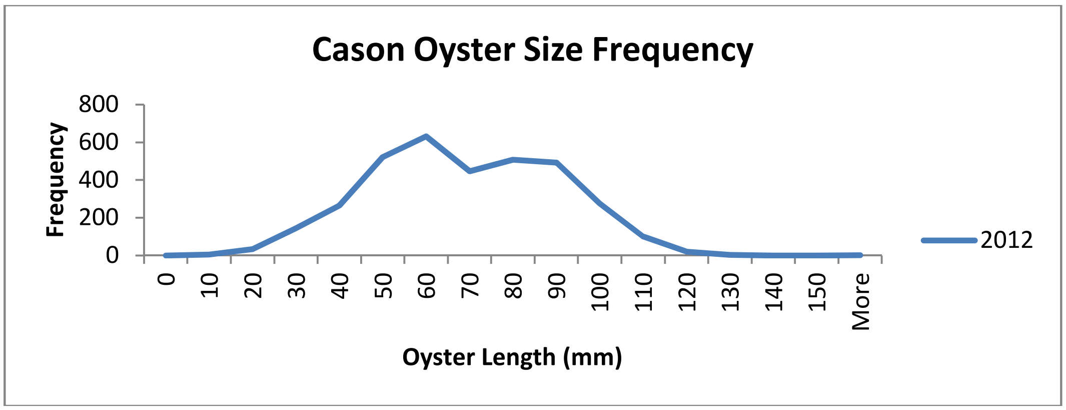


Figure 17. Cason oyster size frequency (2012). Size frequency data reflects the 2011 planting in addition to a natural spat set in 2012, as well as older natural oysters.

Table 8 below summarizes oyster population metrics observed at Cason in 2012. A high number of live oysters was counted relative to dead oysters, resulting in very low relative death across the bar (6%). The mean oyster density was fairly high, approximately 54 oysters per m^2, reflective of the many small spat planted in 2011. This is as expected one-year post-planting, and possibly higher than predicted due to a natural set in 2012. Similarly, overall bar biomass was high (1,542 kg), also characteristic of the many small 2011 and 2012 oysters at Cason. Oyster density across the bar can be seen in Figure 18, which illustrates the heterogeneous distribution of oysters on Cason. The majority of oysters in 2012 were found in the northern central portion of the bar, and at some points reached densities of 407 oysters/m^2. Figure 19 shows mean biomass density at Cason for 2012.

Table 8. Cason oyster metrics (2012). Oyster population and sampling metrics are shown for Cason.

Sampling Year	Mean Oyster Length (mm)	Live Oyster Count	Box/Gaper Count	% Dead	Mean Oyster Density (#/m2) ±SEM	Population Estimate	Biomass Sum (kg)
2012	66	7,862	461	6	54 ± 7	3,052,019	1,542

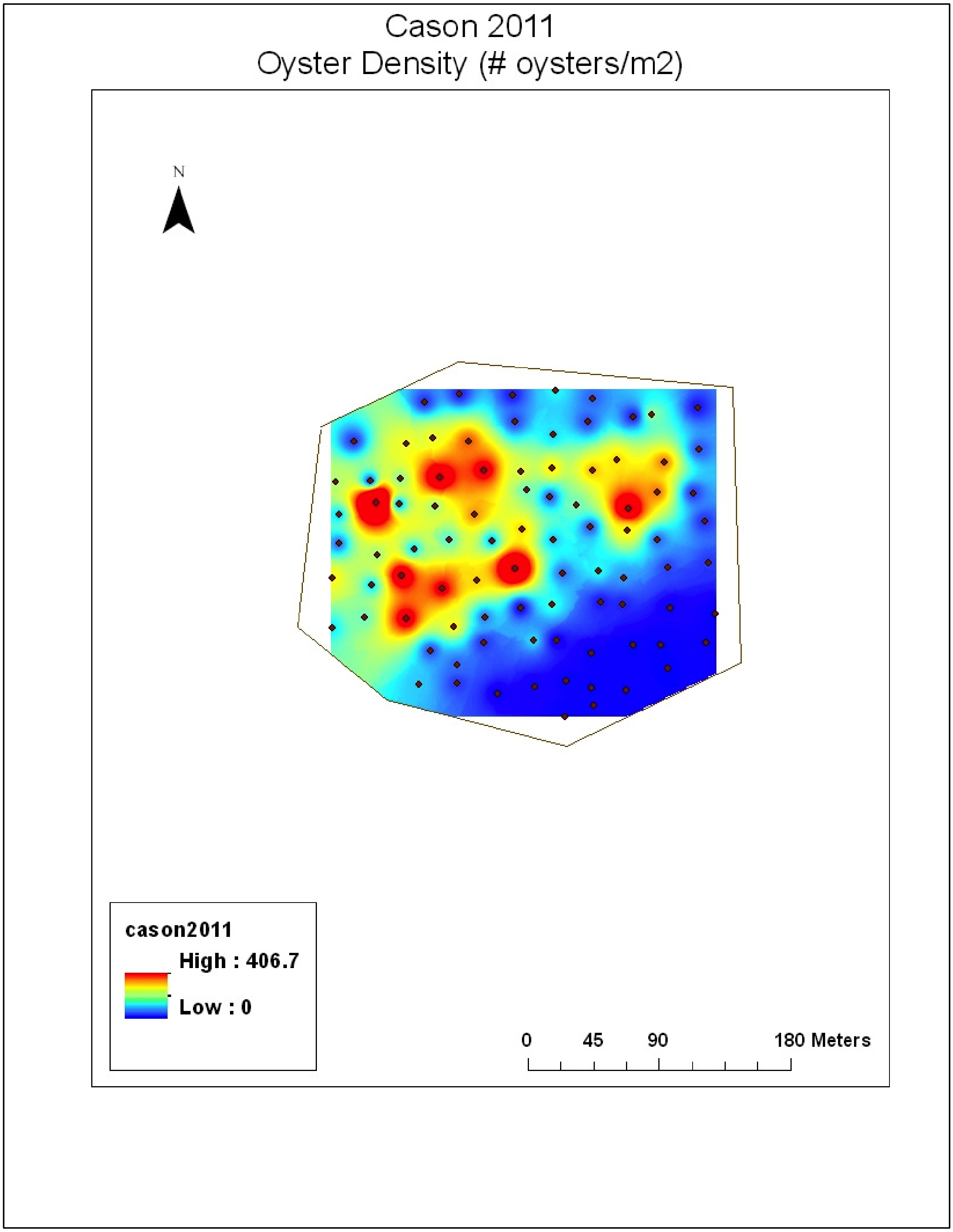


Figure 18. Cason Point oyster density distribution (2012). Oyster density (oyster/m^2) is displayed across the bar. Areas shown in red represent highest oyster densities (407 oysters/m^2), while cooler colors show lower oysters densities, with zero oysters represented by dark blue.

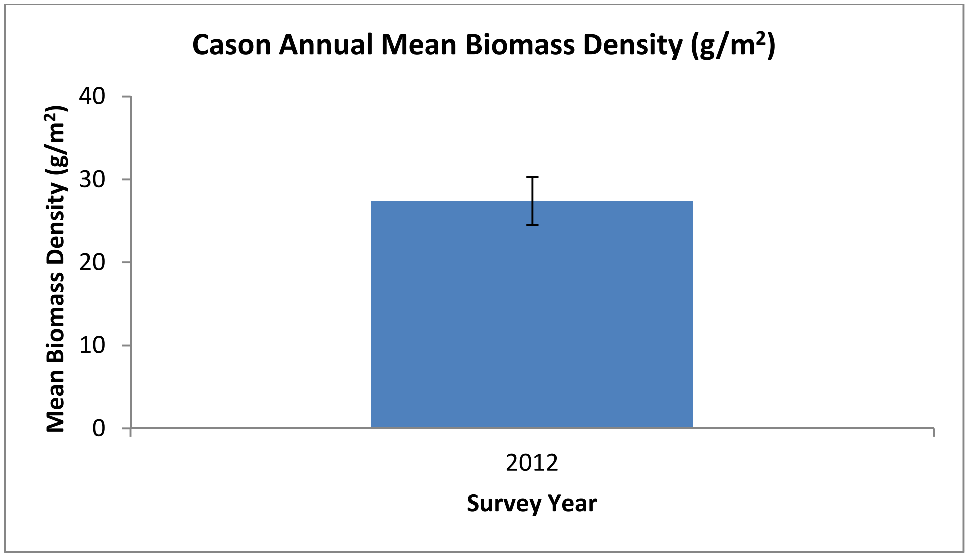


Figure 19. Cason annual mean biomass density (2012). The mean bar biomass is shown for 2012. Error bars represent standard error of the mean. Biomass density was relatively high due to the 2011 spat-on-shell planting and a 2012 natural spat set.

Oysters were sampled for dermo disease and were initially classified as either 2012 or native oysters, as described above. Size frequency data suggest however, that natural spat from 2012 are likely included in the "2011" spat sample. Therefore, dermo data are shown for 2011 planted spat and 2012 natural spat combined, as well as a separate larger native adult sample (Table 9). In 2012, dermo prevalence was greater in the larger native oysters, however, prevalence was still fairly high in 2011/2012 spat. Similarly, dermo weighted intensity was greater in native oysters relative to spat at Cason, though 2011/2012 spat did possess a weighted intensity close to 1. Prevalence and intensity values suggest that dermo may prove detrimental to oysters as Cason as annual surveys continue.

Table 9. Cason disease data (2012). Data are presented for 2011-planted spat and 2012 natural spat combined, as well as a separate sample of older native oysters.

Sampling Year	Oyster Class	Mean Oyster Length (mm)	Dermo Prevalence (%)	Dermo Weighted Intensity
2012	2011/Native 2012	42.2	70	0.94
	Older Native	93.03	97	2.04

As described for other sites, changes in bottom type and shell availability will also be compared annually. Figure 20 shows the presence of shell across the bar, as observed in the 2012 survey. Shell presence was quantified as shell score, a metric based of off the amount of shell in each grab. Shell scores range from zero to five, with zero representing tongs with no shell and five indicating tongs completely full of shell. Shell scores were low to at Cason in 2012, with the majority of grabs possessing scores of three or less, shown on Figure 20 as areas of yellow, aqua, and blue. Areas of highest shell scores were also areas with the greatest oyster densities, seen in Figure 18.

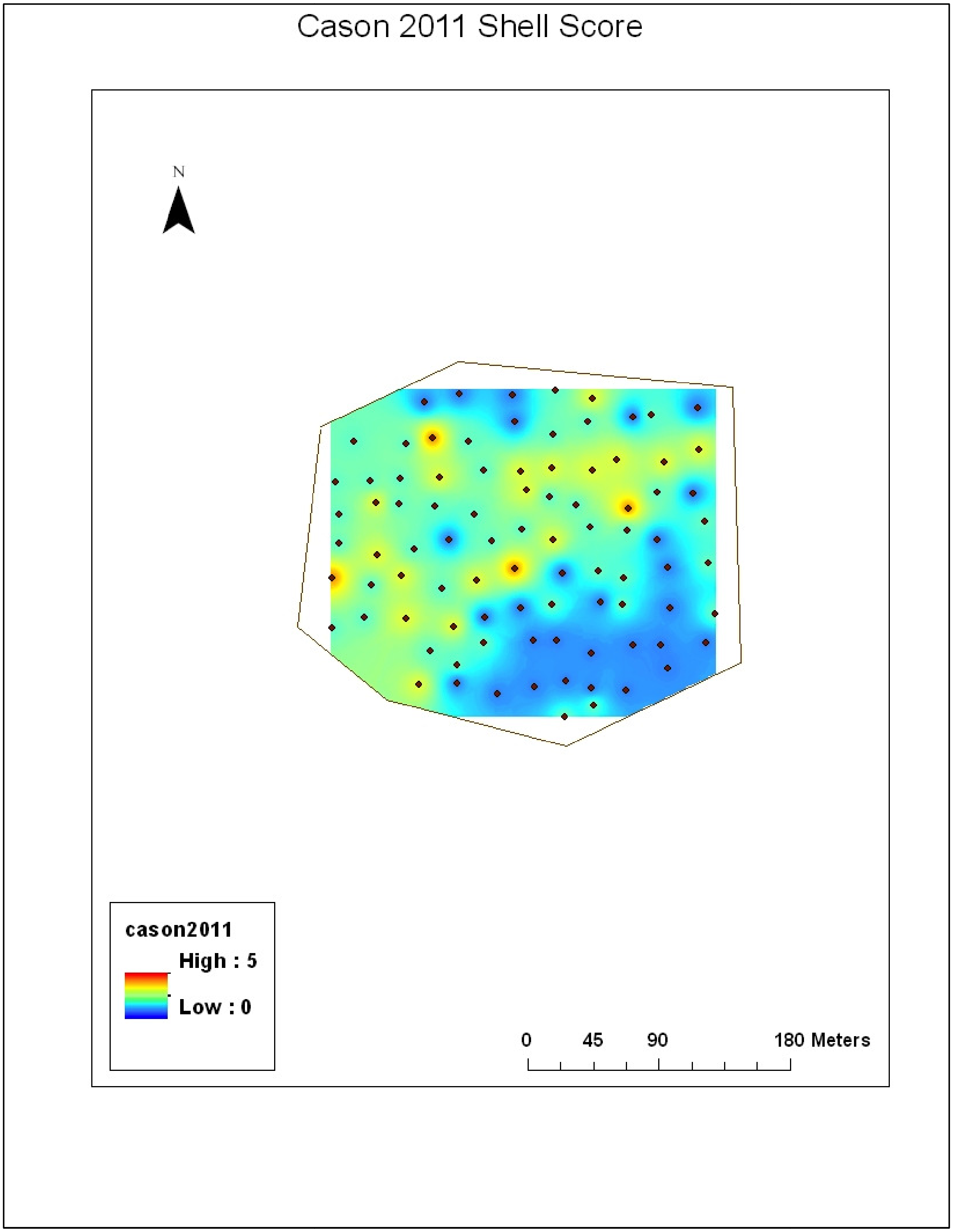
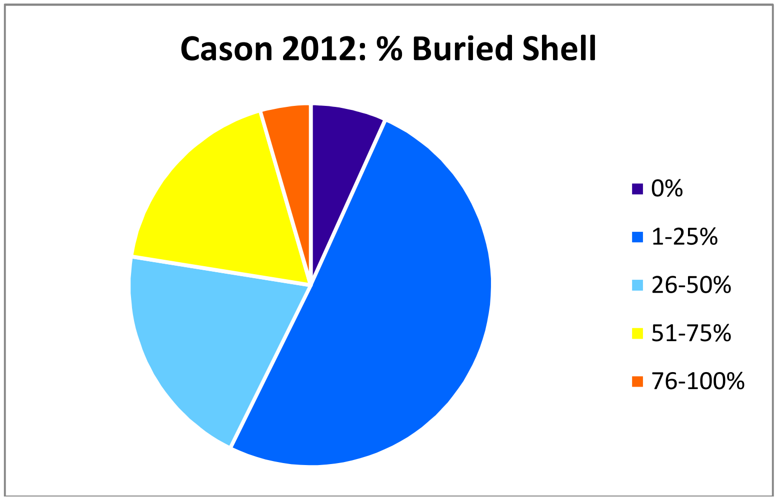


Figure 20. Cason shell score distribution (2012). Shell score, ranging from zero to five, is displayed across the bar. A score of zero represents a grab without shell and is depicted by dark blue, while a score of five represents tongs full of shell and would be shown in red.

In addition to quantifying the amount of shell in each grab, the percentage of buried shell within each grab was estimated. Buried shell was identified as black or gray shell, which had obviously been covered in mud prior to being brought to the surface. The other shell type was classified as brown shell, or shell that had not been covered in mud before being sampled. The right panel on Figure 21 below shows the relative number of grabs with differing amounts of black shell. Black shell percentages were grouped as follows: 0%, 1-25%, 26-50%, 51-75%, and 76-100%. They are shown in Figure 21 as the number of grabs at Cason possessing that percentage of black shell. More than half of all grabs contained less than 50% buried shell.

Bottom type was also characterized by the primary and secondary substrates observed in each grab. In addition to shell, all other substrates were documented including: mud, sand, and oyster. The left panel on Figure 20 shows the relative number of grabs with each primary and secondary substrate combination observed at Cason in 2012. Shades of blue and purple represent what may be considered "good" bottom for oysters, in that each combination contains some form of shell or oyster and mud is not the primary substrate. Shades of red, orange, and yellow represent less than ideal bottom, with mud as the primary substrate and/or no form of shell or oyster. The majority of grabs at Cason in 2012 suggest relatively good bottom, with over 75% of grabs possessing no mud. As substrate observations in tandem with shell score and percent black shell are monitored annually, changes in bottom quality at Cason can be inferred.



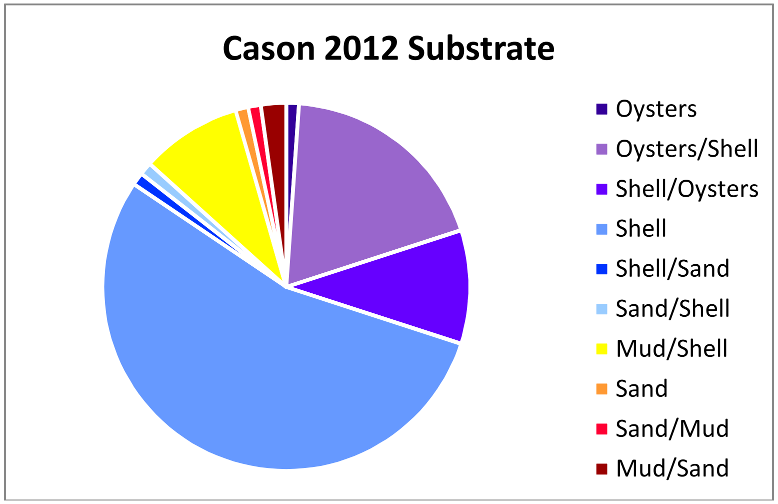


Figure 21. Cason percent buried shell and substrate composition (2012). The number of grabs containing buried shell is shown as bracketed into the five percentage categories shown in the figure legend. Most grabs had 26 – 50% buried shell. The relative number of grabs containing each substrate is shown in the figure to the right. In both figures, shades of purple and blue represent what may be considered "good" bottom for oysters with bottom type becoming worse as the color changes from purple to blue or aqua, eventually to shades of yellow, orange, and/or red. In the substrate figure, shades of purple and blue represent grabs that contain some form of shell or oyster and mud is not the primary substrate. Shades of yellow, orange, and red represent less than ideal bottom, with mud as the primary substrate and/or no form of shell or oyster. Seventy-five percent of the grabs at Cason were appropriate for oysters both in the percentage of buried shell as well as the available substrate.

Conclusions

The 2012 season marked the first survey year of the bars detailed above. The data included provide baseline information to compare oyster population, growth, and survival over time at each of these bars. Additionally, incorporating substrate observations will allow us to relate changes in bottom quality to oyster survival over time. On their own, 2012 data provide baseline information about each of these four bars, but the importance of this study lies in repeated annual surveys.

Of particular note in 2012, estimated biomass was much higher across all four bars than biomass estimates from previous long-term patent tong study sites (Paynter et al. 2011). We believe this is a direct effect of the enhanced planting effort carried out by the ORP at the 2012 long-term sites. Cason, Little Neck, Lodges, and Mill Point were all planted at greater initial densities of spat per m^2 than previous long-term sites (Coppers Hill, Drum Point, Ulmstead Point, and Willow Bottom); long-term observation and data collection may show how an over-planting approach (involving multiple planting days at a single site) affects oyster success over time.

Though all four bars are sanctuaries and three of four are located within the same tributary, the data shows that they are not identical. Substrate and shell data showed that each bar has a unique bottom type and shell budget. Similarly, although each bar was planted in 2011 or 2012, already differences are seen in population estimates and biomass estimates (Figure 22). Some of these differences can be attributed to differing amounts of initial spat planted; Little Neck was planted heaviest of all four sites. Additionally, each bar saw differing degrees of a natural spat set in 2012. Over time we will see how these factors, among many, affect each bar long term, and potentially use observations to guide future restoration projects.

References

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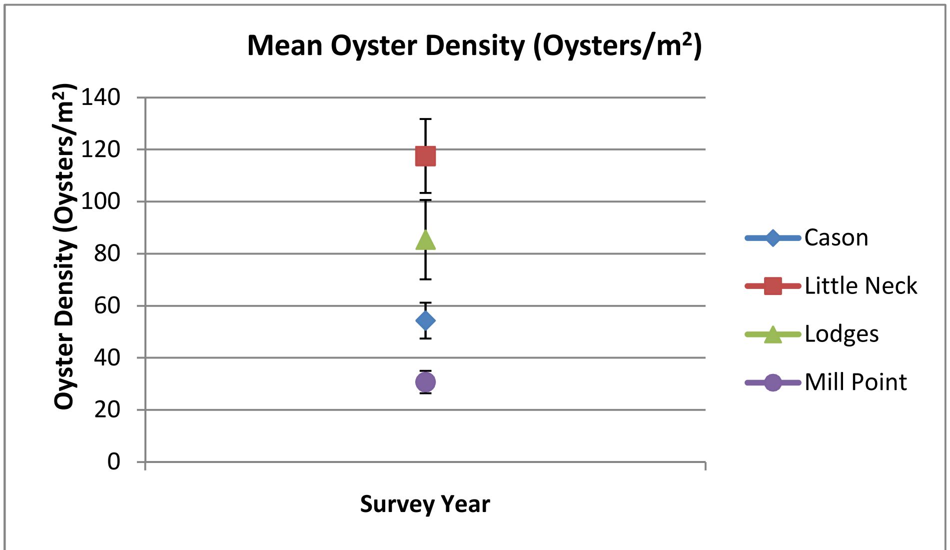

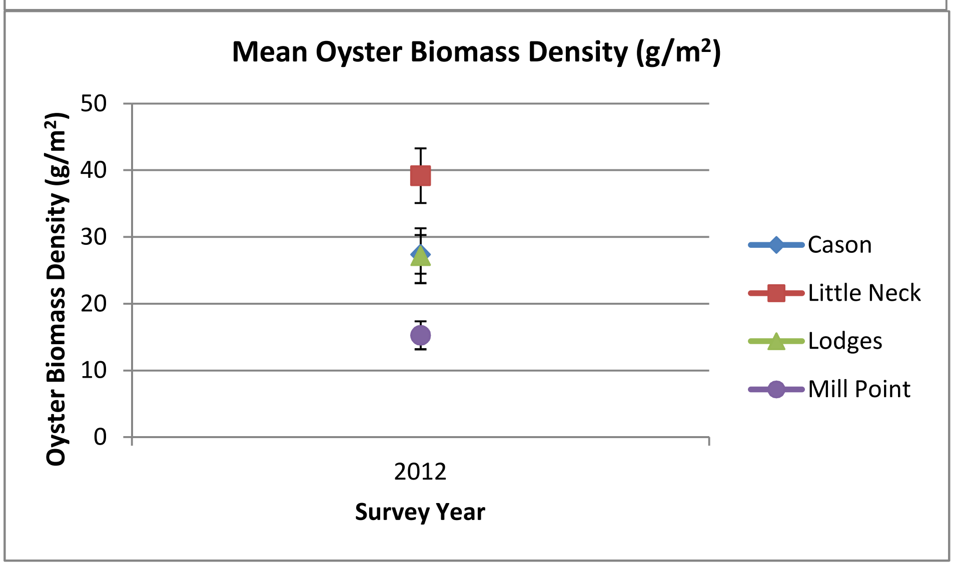

Figure 22. Estimated oyster density and biomass density at all bars. The 2012 estimated oyster density is shown for all four bars that are part of the long-term patent tong survey. Error bars represent standard error of the mean.

Section VI: Lessons Learned

Ground Truthing

Eighteen bars were surveyed Bay-wide during the 2012 season. Most of the 2012 ground truthing effort was concentrated in Harris Creek, due the prioritization of this tributary for restoration by many restoration groups around the Bay. Of the 16 bars surveyed in Harris Creek, nine were planted with spat on shell, indicating that pre-survey site selection accurately identified sites that were appropriate for oyster survival. Due to intensive surveys by the Paynter Lab and Versar, Inc. of Harris Creek in 2011, an up to date and accurate Chesapeake Bay Marine Ecological Classification Standard (CMECS) scheme was available for Harris Creek at the time of the ground truthing survey. The existence of the CMECS data allowed for site selection to be more refined than in previous years and improved the Paynter Lab's ability to accurately pick sites appropriate for planting. A point by point analysis of ground truthing data compared to the CMECS scheme will be presented in a separate report. Continued intensive surveys and further refinement of the CMECS scheme will allow for continued improvement in site selection into the future.

Post Planting Monitoring

Fourteen sites were monitored post-planting by the Paynter Lab in 2012. Overall survival 4 – 8 weeks post-planting was 36.8%, the highest since systematic monitoring began in 2008. However, large variability exists in the survival data by site, with survival ranging from 0 – 60% in 2012. Various factors were examined for their potential impact on spat survival including initial number of spat per shell, spat density per shell, spat density per acre, growth rate, region, environment. Yet, no factors examined trended significantly with spat survival. Considering the complex process involved in executing a successful hatchery spat-on-shell planting, from the spawning of spat at the hatchery, to their transport to the site, to the conditions they grow in and the sampling method used to estimate survival, it is not surprising that pinpointing factors that consistently influence survival is extremely difficult.

Two factors that we believe may have a greater impact than others on spat survival are substrate type and predation. The Paynter lab partnered with the Horn Point Lab hatchery to design and execute a small-scale experiment to examine the effect of spat size and bottom type on spat survival. Data from the 2011 trial suggested that spat survived better on shell and sand than mud, however questions remained unanswered relating to longer term survival. This experiment was improved and repeated in 2012, with a final sampling to be carried out in 2013. Detailed analyses of the data collected in this experiment will be presented to the ORP in a separate report, upon completion of the second season in 2013. Multiple attempts were made to examine the impact of predation on spat survival in both 2011 and 2012, but methodological issues prevented the data from being examined. These experiment attempts underscore the complications associated with examining the impact of predation on spat survival. We believe that the relationship between spat survival and predation is important to explore but should be done on a more comprehensive level in a controlled setting by a student or researcher dedicated to that problem alone.

Overall, the 2012 planting season possessed higher spat survival than previous seasons, and this was likely due in large part to enhanced planting site selection. Additionally, the 2012 season also saw widespread natural spat sets, most notably observed in Harris Creek alongside ORP-planted spat. Finally, higher salinities may have contributed to better survival.

Patent Tong Survey

Twelve different survey plots at six oyster bars were patent tonged during the 2012 season. As with previous year's surveys, at most sites the presence of shell was coupled with the presence of high densities of oysters. Average oyster density ranged from 0-23.3 oysters/m^2, average biomass density ranged from 0-28.4 g/m^2, the percent of a bar with good shell coverage ranged from 0-55%, and disease prevalence ranged from 30-100%. Similarly, the percent of the expected population present at a bar ranged from less than 10% to over 100% during the survey. The variation in these data highlights the natural variability present in the restored oyster network in the Chesapeake Bay. While many metrics are monitored, it is difficult to highlight a single factor that influences the success of a restored bar. Specific benchmarks for restoration success were identified by the Oyster Metrics Workgroup (OMW) in 2011. Among these criteria are that the bar should have both an oyster density of 15 or more oysters/m^2 and a biomass density of 15 or more g/m^2. We also believe that the percent of the expected population that survives as well as disease levels should be included in these criteria. The success of each bar surveyed in 2012 was evaluated against the above mentioned criteria and the results indicate a large variation in restoration success by bar as well as data type examined.

There are many potential causes of the variation in the success of restoration sites described above. Factors include available substrate type, water movement, reproductive success and larval dispersal. The patent tong survey data provide information on the available substrate at each site and in general sites with more shell have higher populations and oyster densities. The 2012 survey was also the first time that the amount of buried shell at each site was recorded. The amount of buried shell at each site was relatively low, no site had more than 50% of buried shell. However, in order to understand the impacts of multiple factors on restoration success, long term monitoring of individual restored sites is necessary. The Paynter Lab has started the second round of long-term patent tong monitoring this year by targeting three bars recently targeted for restoration in Harris Creek and one bar in the Little Choptank River. Two additional bars in the Choptank River (to be planted in 2013) will be added to the long term survey in the 2013 season. We believe that the data from the long term bars will provide more information on the factors influencing restoration success.

Summary

Spat survival in 2012 was the highest since systematic monitoring began in 2008. We believe that the steady increase in spat survival each year since 2009 is largely due to improved site selection each year. Restoration efforts in 2012 were focused in Harris Creek, a tributary that is very well characterized due to extensive population and bottom type surveys conducted in 2011 by the Paynter Lab and Versar, Inc. NCBO took advantage of the plethora of data available on the bottom type and oyster population in Harris Creek and revised the Chesapeake Bay Marine Ecological Classification Standard (CMECS) for the area within Harris Creek to include the recent, improved data. The new CMECS data paired with existing recent side scan sonar data allowed for the identification of planting sites with appropriate bottom characteristics in Harris Creek with unprecedented success. The improved spat survival observed in 2012 was therefore not unexpected, considering the bottom conditions upon which most spat were planted.

Identifying the factors that impact restoration success is a continued challenge. For instance, higher salinities in 2012 could have contributed to higher survival. While many factors are monitored in both the post planting monitoring and patent tong surveys, we have not been able to identify a small set of factors that greatly influence restoration success. The metrics outlined by the Oyster Metrics Workgroup (OMW) in 2011 provide benchmarks for evaluating adult reefs and we are using the OMW criteria to evaluate the success of 3+ year old bars surveyed using patent tongs as well as to evaluate success at the tributary-level when data are available. Controlled experiments to determine the factors impacting spat survival continue to be a priority for the Paynter Lab. We believe that the data from the bottom type/spat survival experimental collaboration with the Horn Point Oyster Hatchery will be important in beginning to understand variation in spat survival. Finally, in 2013 we will continue our tributary-level habitat and population surveys with a survey of Broad Creek. The Broad Creek survey will not only add to the growing body of knowledge on tributary-level population dynamics and habitat, but will also provide a harvest area comparison to the Harris Creek sanctuary survey that was conducted in 2011. We believe that the continued monitoring and experimental plans for the 2013 season will provide greater insight into the factors impacting oyster restoration success and survival in the Chesapeake Bay.