



Analysis of Monitoring Data from Harris Creek Sanctuary Oyster Reefs

Data on the First 102 Acres/12 Reefs Restored

July 2016



Produced in partnership with the Maryland Oyster Restoration Interagency Workgroup under the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team



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Cover photo by Oyster Recovery Partnership

Executive Summary

The National Oceanic and Atmospheric Administration, U.S. Army Corps of Engineers-Baltimore District, Maryland Department of Natural Resources, the Oyster Recovery Partnership, and other partners are working to achieve the oyster outcome of the Chesapeake Bay Watershed Agreement to restore oysters in ten Chesapeake Bay tributaries by 2025. A set of oyster restoration success criteria, the Chesapeake Bay “Oyster Metrics”¹, was developed by scientists and resource managers prior to the start of tributary-scale restoration work. Harris Creek was the first tributary selected for large-scale oyster restoration. Partners developed a Harris Creek Tributary Plan² to guide restoration, and in-water work began there in 2011.

Per the Harris Creek Tributary Plan and the Oyster Metrics success criteria, each restored reef is to be monitored three years and six years after restoration treatment. In Harris Creek, the first 12 reefs (102 acres) were treated in 2012, and were due for their three-year monitoring in fall 2015. These 12 reefs are collectively called the ‘first cohort’ of Harris Creek reefs. (Harris Creek reefs built and/or seeded later—an additional 248 acres—will also be monitored when each is three years old, and again at age six.) This report describes how each reef is faring against the preestablished Oyster Metrics success criteria, as of fall 2015.

Table 1 summarizes the status of the first cohort of restored Harris Creek reefs (reefs #1-12, Figure 1) against each of the six Oyster Metrics success criteria. Additional information about each reef is included in Appendix A. Beyond the first cohort of reefs, an additional six reefs were monitored: four of these are control sites (reefs #14- #17), which were

Reef Information and Restoration Treatment		Biological Success Metrics						Structural Success Metrics	
Reef #	Restoration Treatment	Fall 2015: Did reef meet threshold density?	Fall 2015: Did reef meet target density?	Fall 2015: Did reef meet threshold biomass?	Fall 2015: Did reef meet target biomass?	Fall 2015: Does this reef have multiple year classes present?	Fall 2015: Is this reef's shell budget stable or increasing?	Fall 2015: Is the reef footprint stable or increasing from baseline?	Fall 2015: Is the reef height stable or increasing from baseline?
<i>First cohort of treated reefs</i>	1	Substrate (shell) & Seed	Y	Y	Y	Y	Y	Y	N
	2	Substrate (shell) & Seed	Y	Y	Y	Y	Y	Y	N
	3	Seed Only	Y	N	Y	N	Y	TBD in 2018^b	TBD in 2018^b
	4	Seed Only	Y	N	Y	N	Y		
	5	Seed Only	Y	Y	Y	Y	Y		
	6	Seed Only	Y	Y	Y	Y	Y		
	7	Seed Only	Y	Y	Y	Y	Y		
	8	Seed Only	Y	N	Y	N	Y		
	9	Seed Only	Y	N	Y	N	Y		
	10	Seed Only	Y	Y	Y	Y	Y		
	11	Seed Only	Y	N	Y	N	Y		
	12	Seed Only	Y	N	Y	N	Y		
<i>Additional reefs monitored</i>	13	Seed Only	Y	N	Y	N	Y	TBD in 2018^b	TBD in 2018^b
	14	none (control site)	Y	N	Y	N	Y		
	15	none (control site)	Y	N	Y	N	Y		
	16	none (control site)	N	N	N	N	Y		
	17	none (control site)	N	N	N	N	Y		
18	Substrate (stone) & Seed	Y	Y	Y	Y	Y	Y	Y	

Table 1: Summary table of how each monitored reef fared against each Oyster Metric success criteria. Bold text shows actual success criteria; other columns show relevant reef information beyond the success criteria.

For the oyster density success criterion:

- **minimum threshold = 15 oysters per m² over 30% of the reef area**
- **target = 50 oysters per m² over 30% of the reef area**

For the oyster biomass success criterion:

- **minimum threshold = 15 grams dry weight per m² over 30% of the reef area**
- **target = 50 grams dry weight per m² over 30% of the reef area**

***TBD in 2018 = fall 2015 data will serve as baseline, and will be compared to fall 2018 data to determine success for these criteria. See shell budget and reef structural metrics methods sections for full explanation.**

not treated; one reef (#13) met the Oyster Metrics success density criteria prior to the start of the project due to seeding in 2011; and one reef (#18) was not planted until 2013, so is not due for monitoring until fall 2016. This reef (#18) was constructed of stone, and was monitored in 2015 to gauge how a reef constructed of stone is performing.

Several key findings are evident from the information in this report.

- The analysis in this report shows substantial success against the preestablished Oyster Metrics criteria on the reefs monitored.
- All 12 reefs in the first cohort meet, at least, the minimum threshold success criteria for oyster density (15 oysters per m² over 30% of the reef area) and for oyster biomass (15 grams dry weight per m² over 30% of the reef area).
- Half of the reefs in the first cohort meet the higher, target criteria for oyster density (50 oysters per m² over 30% of the reef area), and for oyster biomass (50 grams dry weight per m² over 30% of the reef area).
- All 12 reefs in the first cohort meet the Oyster Metrics success criterion for presence of multiple year classes of oysters.
- Success in the shell budget, reef footprint, and reef height criteria will be able to be determined once fall 2018 monitoring is complete. (See details in sections 2A and 2B.)
- Beyond the first cohort of reefs, one reef (#18), constructed of stone substrate and planted in 2013 (a year later than the first cohort), was also monitored. Data show oyster density here in fall 2015 was more than three times as high as at any other site monitored in Harris Creek. As this reef was planted a year later than the first cohort, densities between it and the first cohort may not be completely comparable. However, the high density and the complex reef structure evident in the sonar image show promising early results from the use of stone substrate for restoration. This was the only stone reef monitored in 2015, so results are not conclusive.

Although the information in the report looks promising for the eventual success of the Harris Creek project, several factors could affect continued success. These include water quality, oyster disease, funding, and poaching. See the Discussion section for more information about each of these.

Data and analysis in this report will be used by the partners to help determine what adaptive management measures, if any, should be taken on each of the first cohort of reefs. It will also be used to guide restoration in other tributaries, notably the nearby Little Choptank and Tred Avon rivers, also selected for large-scale restoration per the oyster outcome of the Chesapeake Bay Watershed Agreement.

Section I: Introduction and Background

Policy Drivers, Oyster Restoration Success Criteria, and Oyster Restoration Planning

The Chesapeake Bay Watershed Agreement (2014) establishes an outcome to “Restore native oyster habitat and populations in 10 tributaries by 2025 and ensure their protection.” The Chesapeake Bay Program’s Sustainable Fisheries Goal Implementation Team (GIT) is charged with advancing this outcome. The GIT convened the Chesapeake Bay Oyster Metrics Workgroup, which, in its 2011 report, “Restoration Goals, Quantitative Metrics and Assessment Protocols for Evaluating Success on Restored Oyster Reef Sanctuaries”¹ (hereafter, ‘Oyster Metrics report’), established Bay-wide, science-based, consensus success criteria for oyster restoration.

Once the success criteria were adopted, the GIT convened interagency workgroups in Maryland and Virginia to plan restoration work in each state, in consultation with appropriate partners. In Maryland, the Maryland Oyster Restoration Interagency Workgroup (hereafter, ‘the Workgroup’) is chaired by the National Oceanic and Atmospheric Administration (NOAA), and includes members from the U.S. Army Corps of Engineers-Baltimore District (USACE), the Maryland Department of Natural Resources (MD DNR), and the Oyster Recovery Partnership (ORP).

The first three Maryland tributaries selected for large-scale oyster restoration were Harris Creek, Little Choptank River, and Tred Avon River. These were selected primarily because of their status as oyster sanctuaries (nonharvest areas) as established by MD DNR in 2009, historic and current presence of oysters, and existing water-quality and benthic habitat conditions suitable for oysters. The Workgroup has developed oyster restoration tributary plans for each river, in collaboration with a group of consulting scientists for each, and the public. The first plan developed was the Harris Creek Oyster

Restoration Tributary Plan² (hereafter, ‘the Harris Creek Tributary Plan’), and Harris Creek was the first to receive large-scale oyster restoration treatment. The Harris Creek Tributary Plan initially called for restoring 377 acres of reefs. During implementation, some planned locations proved unsuitable for restoration, and in September 2015 the last of 350 acres of reefs was seeded with oysters, completing initial in-water restoration work on the Harris project. (The Harris Creek Tributary Plan calls for a light ‘maintenance seeding’ on each reef four to five years postrestoration, depending on the survival rates of oysters planted initially.)

Metric	Success criterion
Oyster density	Minimum threshold: 15 oysters per m ² over 30% of the reef area Target: 50 oysters per m ² over 30% of the reef area
Oyster biomass	Minimum threshold: 15 grams dry weight over 30% of the reef area Target: 50 grams dry weight over 30% of the reef area
Multiple year classes	Presence of multiple year classes on the reef
Shell budget	Stable or increasing shell budget on the reefs
Reef footprint	Stable or increasing reef footprint compared to baseline
Reef Height	Stable or increasing reef height compared to baseline

Table 2. Chesapeake Bay Oyster Metrics Success Criteria.

Overview of Report Content

Both the Oyster Metrics report and the Harris Creek Tributary Plan call for monitoring three years and six years after restoration treatment, to determine how each reef is faring against the Oyster Metrics success criteria. The year a reef is planted is considered year zero. The first cohort reefs were planted in Harris Creek in 2012, and, therefore were monitored three years post restoration (fall 2015). This report details how that monitoring was done and provides analyses of data collected. The reefs monitored in 2015, collectively referred to as the first cohort of Harris Creek reefs, comprise 12 reefs (reefs #1-12 in Figure 1). Together these represent 102 acres of reefs out of the total of 350 acres of reefs eventually treated in Harris Creek. This first cohort will be monitored again at six years post restoration (in fall 2018), per recommendations in the Oyster Metrics report and the Harris Creek Tributary Plan. Similarly, the remaining 248 acres will be monitored as they mature to three years old, and again when they are six years old. At six years, a determination will be made as to whether each reef can be considered successfully restored, per the Oyster Metrics criteria.

In addition to the first cohort of reefs, six other reefs were monitored in fall 2015 (reefs #13-18 in Figure 1). Four of these reefs (reefs #14-17 in Figure 1) serve as control sites, and did not receive any restoration treatment. One reef (#13) was planted in 2011, prior to the start of the large-scale restoration effort in Harris Creek, and is not considered part of the first cohort of reefs. This reef, however, was monitored as part of the overall Harris Creek restoration effort. Reef #18 was constructed of stone substrate, and planted in 2013 (a year later than the first cohort reefs). Stone is a novel reef building material in the Choptank, and interest is high in understanding its value, so this reef was monitored in 2015, even though it is not part of the first cohort.

Throughout this document, two basic types of restoration treatment are referenced: ‘seed only’ and ‘substrate and seed.’

- **‘Seed only’ reefs** were treated only with hatchery-produced oyster seed (spat-on-shell). No base reef-building substrate was added prior to seeding. This treatment was generally used on reefs where the prerestoration population was five oysters per m² or greater (see Harris Creek Tributary Plan for detailed description of how the Workgroup determined treatment type for each reef).
- **‘Substrate and seed’ reefs** were treated with reef-building substrate (generally 6” to one foot deep; either shell, stone, or a combination), followed by planting with hatchery-produced oyster seed. This treatment type was generally used where oyster populations were below five oysters per m², or where sonar surveys found no evidence of shell.

Data for the biological success metrics (oyster density, oyster biomass, multiple year classes, and shell budget) were collected by the Paynter Labs at the University of Maryland, with NOAA funding via the National Fish and Wildlife Foundation (NFWF) and ORP. Analysis of these data was done by ORP. Data for the reef structural metrics were collected and analyzed by NOAA. This report was drafted by NOAA, with support from the Maryland Interagency Oyster Restoration Workgroup.

Results of this analysis will be used for adaptive management of these reefs, and also to inform future ecological restoration efforts in Maryland and Virginia.

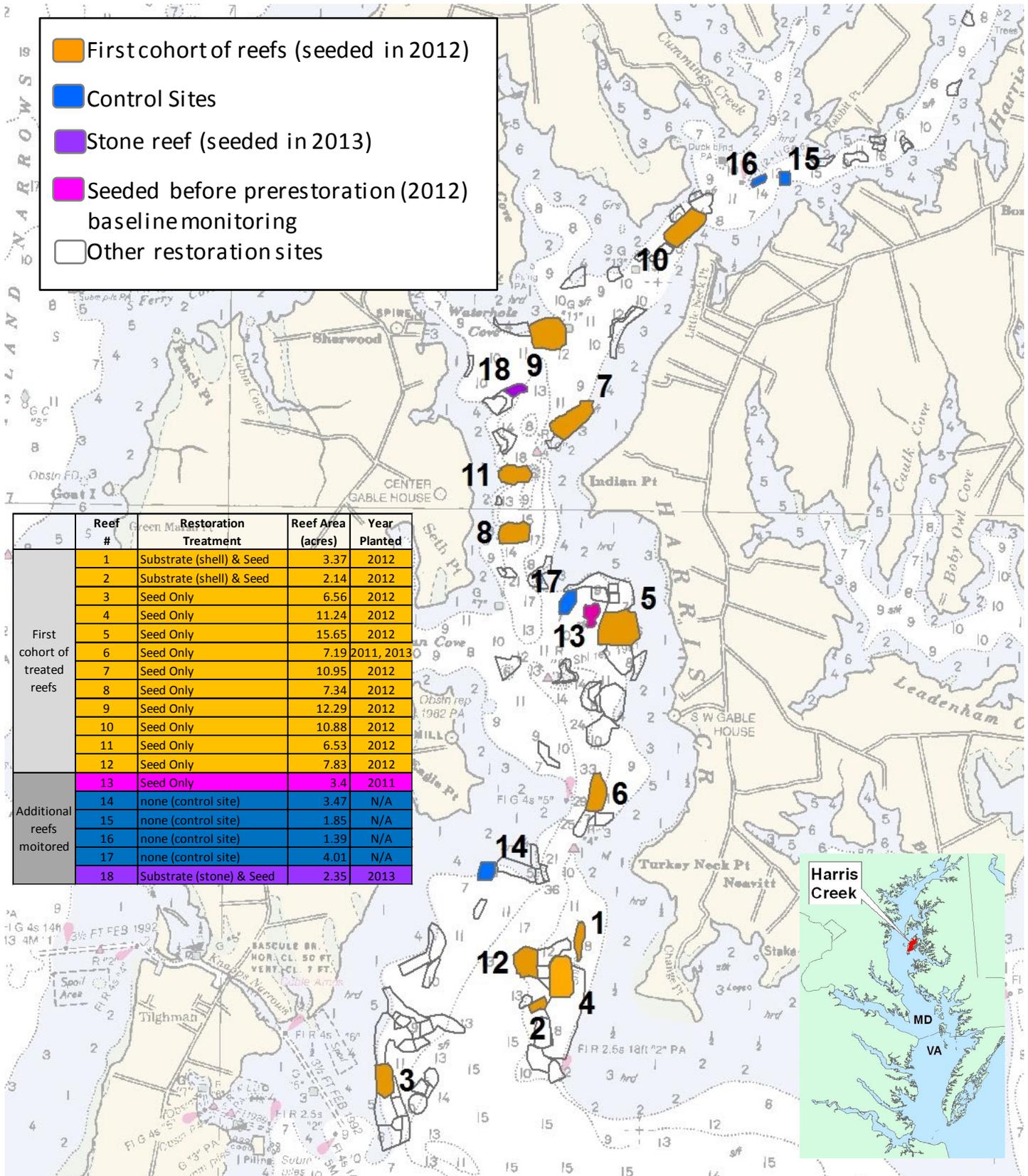


Figure 1. Location of each reef monitored in fall 2015.

Availability of Data Related to this Report

Geographic Information Systems (GIS) data relevant to this report are available in the Harris Creek Geodatabase, http://www.habitat.noaa.gov/chesapeakebay/gis/oyster_restoration_geodatabases/harris_creek/

In some cases, raw data are proprietary, and are not provided in this database, but meta-data or analyses are provided. This database can be accessed using a GIS program, or by downloading the free and open-source QGIS program, <http://www.qgis.org/en/site/>

Reef numbers in this report (#1-18) can be cross-referenced with Site_ID numbers in the geodatabase per Table 3. Site_ID numbers were replaced with simpler reef numbers in this report for reader clarity. Site_ID numbers are consistent throughout the Harris Creek GIS geodatabase.

Reef #	Site_ID in Geodatabase
1	AltSub_104
2	AltSub_106
3	Seed_02
4	Seed_08
5	Seed_46
6	Seed_56
7	Seed_72
8	TREATMENT_1
9	TREATMENT_2
10	TREATMENT_3
11	TREATMENT_4
12	TREATMENT_5
13	EXCEEDS_GOAL_2012
14	CONTROL_1
15	CONTROL_3
16	CONTROL_4
17	CONTROL_2
18	AltSub_20A

Table 3: Reef numbers to GIS geodatabase SiteID cross-reference list.

Section 2: Methods for Data Collection and Analysis for Fall 2015 Monitoring

The methods used to determine whether or not a reef is performing successfully against the Oyster Metrics criteria as of fall 2015 are described in this section. The six Chesapeake Bay Oyster Metrics success criteria can be roughly categorized as biological metrics (oyster density; oyster biomass; shell budget; presence of multiple year classes), and reef structural metrics (reef height; reef footprint). Each success criteria is listed, along with the data collection and analysis methods used for each.

Section 2A. Methods for determining success against biological criteria (oyster density, oyster biomass, multiple year classes, shell budget)

Oyster Metrics Success Criteria and Methodology for Biological Metrics

The Oyster Metrics success criteria for each of the four biological metrics are described below, along with the methodology used to evaluate each criterion.

Oyster Density

Oyster Metrics success criteria:

- Minimum threshold = 15 oysters per m² over 30% of the reef area
- Target = 50 oysters per m² over 30% of the reef area

Method: The proportion of reef area with oyster density that met the minimum threshold or target reef-level restoration goal criteria was determined by standardizing each patent-tong grab or diver quadrat to the area of the sample unit (patent-tong or quadrat). Multiple samples within grid cells were averaged and then multiplied by the area of the grid cell where the sample was collected. This calculated the total number of live oysters for each grid cell sampled in a reef. The percent of reef area having greater than 15 and 50 oysters/m² was calculated by summing the area of grid cells exhibiting those densities and dividing by the total area of the reef.

Oyster Biomass

Oyster Metrics success criteria:

- Minimum threshold = 15 grams dry weight per m² over 30% of the reef area
- Target = 50 grams dry weight per m² over 30% of the reef area

Method: The amount of oyster biomass within a grid was calculated for individual oysters within each grid and then evaluated following the same approach as the density estimates (above).

Multiple Year Classes

Oyster Metrics success criterion: Presence of two or more year classes of live oysters

Methods: Year-class presence was approximated through visual inspection of length frequency plots of all oyster heights measured at each reef. For simplicity, a reef was determined to have multiple year classes when oysters from at least two standard size class categories (market [76 mm], small [40–75 mm], and spat [<40 mm]) were present.

Shell Budget

Oyster Metrics success criterion: Neutral or positive shell budget on the reef

Method:

Changes to the shell budget at individual reefs could not be assessed because baseline information on shell volume did not exist. Fall 2015 shell budget data will be compared to fall 2018 shell budget data, and a determination of success against the established criteria will be made in fall 2018 (six years post restoration treatment).

Survey Design for Biological Metrics

Data to determine success against all four biological metrics were collected at the same time, using one survey design.

A systematic cluster design was developed as the sampling framework to quantify inter-reef scale distributions and densities of oyster and shell resources for fall 2015 sampling. The survey design followed a modified version of the survey outlined and implemented in Harris Creek in previous years^{3,4}. Survey modifications enhanced the design so that additional statistical tests could be performed on sample data. A flexible design was originally employed that used variable-sized grids as the sampling “primary units,” and a single “secondary unit” or sampling location was sampled in the centroid of each grid cell. Systematic sampling often uses one single random starting point to generate the position of the sampling location in each grid cells, and the position of the sampling location remains the same in all grid cells within the sampling extent. Single-point systematic sampling essentially yields a cluster of one sample, and no variance can be calculated from a sample of one cluster⁵. The inability to calculate a variance put constraints on the types of analysis that could be performed on the fall 2015 data. However, if more than one random starting point is chosen, resulting in multiple clusters, then a variance can be calculated. Therefore, two random points were generated that provided two independent starting points within each grid cell, allowing an unbiased variance estimate to be calculated.

Sampling sites were generated from systematic grids developed in a geographic information system (GIS) and superimposed over a GIS layer of constructed oyster reefs. The sampling framework was optimized through the use of variable-sized grids to ensure appropriate sample density on various-sized reefs, and to account for logistical constraints of various sampling methods (see sampling methods below). The application of a specific grid size was based on reef acreage³. All reefs were sampled using a 50 x 50m grid, except for two that used a 25 x 25m grid. These two reefs are part of a separate long-term monitoring project where 25 x 25m grids are used, so that protocol was followed for consistency on those sites. The sampling framework was completed by creating grids for each cell size and extracting the portions of those grids that overlapped the extent of all 2015 three-year check-in reefs (Figure 2). Partial grids cells smaller than 250 m² that resulted from GIS processing were removed from the final sampling grids. The final number of combined grid cells in the Harris Creek sampling framework was 305.

The final set of sampling locations for each grid cell was generated in a GIS. The systematic cluster design requires more than one sample location to be sampled within each grid. Therefore, two independent starting locations (points) were randomly chosen within the extent of the sampling frame. The position of each of the two starting locations was then applied to all grid cells in the sampling extent (Figure 2). In some instances, the shape of a grid cell was irregular and the location where samples were positioned was removed through GIS processing. In these instances, an alternate sampling location was generated as the centroid of the grid cell. A total of 575 sampling locations was generated to sample three-year and control reefs.

Sampling Methods for Biological Metrics

The density and distribution of oysters and shell resources were assessed using hydraulic patent-tong and diver sampling techniques. Patent-tongs were used to sample oyster reefs that either had a natural base of oyster shell or were constructed using other natural shell (e.g., scallop, conch, clam). Divers were required to collect samples at one alternate substrate site that was constructed using granite. Sampling was scheduled and implemented by the University of Maryland Paynter Laboratory. Patent-tong sampling was conducted from the commercial fishing vessel *Captain's Lady*. Diver sampling was conducted from the Paynter Lab R/V *Callinectes*. Sampling was conducted during daylight hours and

generally required four to six hours to complete. Navigation to sampling locations and sample coordinate documentation was done using a differential global positioning system (DGPS) attached to a laptop with ArcView 10.2 running as a navigational program.

Hydraulic patent-tongs are a specialized commercial fishing gear used to harvest oysters in Chesapeake Bay. The patent-tong design functions much like a benthic grab, collecting oysters and underlying substrate from a known fixed area of the bottom. The patent-tongs were suspended from a boom over one side of the vessel and deployed to the bottom at each sampling location. One or two samples were collected within most sampling grids; in some instances no samples were collected due to logistic or other survey constraints. A DGPS antenna was positioned adjacent to where the patent-tongs were deployed and the geographic coordinates of each sample location was documented when the patent-tongs were brought to the surface. The patent-tong dimensions were 1.52m by 1.22m sampling a 1.67m² area of the bottom.

Diver survey techniques were used to collect samples on reefs constructed with granite. Diver sampling was conducted by navigating the R/V to each sampling location and deploying diver flag-labeled buoys with anchors to mark each sample location. Divers descended to the bottom of each diver buoy and collected samples in the general proximity of the diver buoy anchor. Samples were collected at each location using a 1m x 1m square quadrat comprised of four 0.5m x 0.5m sections. All oysters and substrate within each section were removed and transported to the surface by divers using sampling bags and lift bags.

The contents of patent-tong and diver samples were documented in the field by entering data directly into a database using a laptop computer. Samples were processed on a sorting table at the stern or midpoint of the vessel. Several habitat specific variables were documented from each sample including total volume of shell, amount of shell hash, percent buried shell (gray or black shell), and the primary, secondary, and tertiary substrate type (sand, mud, or rock) when present. The total volume of shell was measured by placing the entire sample in five-gallon buckets with liter volume increments marked on the outside. Only substrate type was documented when samples were collected without exposed or buried shells. When shell was present but buried, an estimate of the amount buried shell was made or all of the overlying substrate was washed out and the total volume of buried shell was ascertained. The presence of granite was also documented when it occurred in diver samples.

Total counts and shell height measurements of at least 30 live oysters were documented for each sample. Live oysters were categorized as market (76 mm), small (40–75 mm), and spat (<40 mm) size classes. Oyster clumps, the number of oysters associated with a clump, and the substrate type that oysters were attached to was also documented. The shell height and total count of dead (old box) and recently dead (gapers) oysters in each of size class was also documented from each sample. The percent of the sample covered by tunicates or mussels was also documented for each sample. Surface and bottom water temperature, dissolved oxygen, pH, turbidity, conductivity, and salinity were collected daily at representative locations over each oyster reef using a 6600 multi-parameter water quality sonde (YSI Corporation, Yellow Springs, Ohio). Other environmental and station specific variables collected at each site included sample number, date and time, weather information, depth of water, Yates reef name, vessel name, and scientific staff.

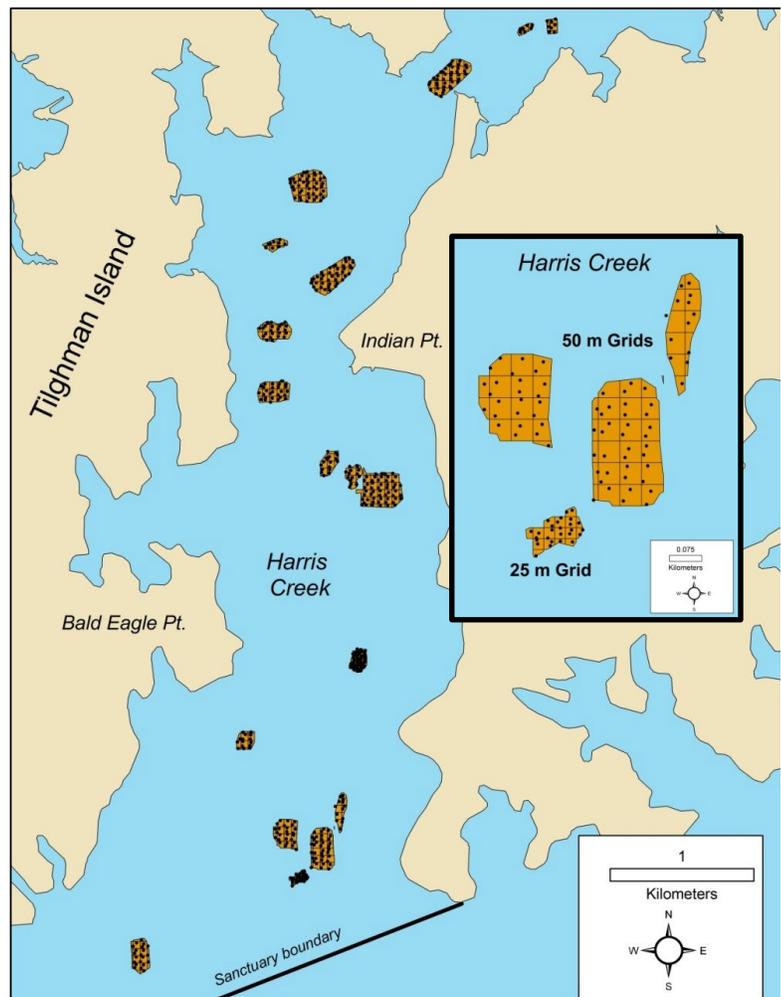


Figure 2. Map of systematic sampling grid used to sample oysters in Harris Creek. The insets show examples of 25m and 50m grid cells and the location of samples within each of the representative grids. Reef delineations and the sampling extent was derived from the Harris Creek Tributary Plan.

Statistical Analysis for Biological Metrics

Oyster density estimates were standardized to the area sampled by patent-tong or by diver quadrat. Total counts of live oysters or other variables (e.g., oyster size class, shell volume) were averaged over all samples collected at the individual reef.

Oyster biomass estimates were calculated for individual oysters using the equation⁶ $W = 0.000423 * L^{1.7475}$, where W=dry tissue weight in g and L= shell height in mm. Biomass was then averaged over all samples collected at an individual reef. The standard error of the mean is estimated for all density and biomass estimates.

Total sampled shell and surface shell volumes were estimated for each individual oyster reef. Field measurements of shell resources included total shell volume and the percent of black (buried) shell estimated in a sample. Average shell volumes were standardized by the area sampled by patent-tong or by diver quadrat. Total sampled shell volume was estimated using average sampled shell volume multiplied by the sampled area. Surface shell estimates were calculated as the percent of the total sampled shell volume that was not considered black shell. Total surface shell was estimated using the average percent surface shell multiplied by the total sampled reef shell volume.

Section 2B: Methods for determining success against reef structural criteria (reef footprint; reef height)

Staff from the NOAA Chesapeake Bay Office conducted multibeam bathymetric (depth) surveys following the construction of substrate and seed reefs and again three years post restoration (fall 2015). For the planting years 2012-2015, surveys were not conducted on seed-only reefs, because bathymetric updates to nautical charts were not required. Future seed-only plantings, 2016 and on, will be surveyed with multibeam to evaluate the structural metrics for all restoration sites. These survey data are acquired and processed to the standards set forth in “NOS Hydrographic Surveys Specifications and Deliverables, 2016”⁷. Surfaces derived from the processed data are exported in CARIS HIPS software at a 0.25m grid resolution using the BASE Cube Mean Depth, a repeatable method.

Reef Footprint (Spatial Extent)

Oyster Metrics success criterion: Neutral or positive change in reef spatial extent (footprint) as compared to baseline measurements.

Methods: Substrate and Seed Reefs: Perimeter change was evaluated between the postconstruction bathymetric surface and the three-years-postconstruction bathymetric surface. A visual comparison was conducted to identify significant differences between the two perimeters in the event that a portion of the reef was lost due to subsidence or removal. If an observable loss was not detected, the reef spatial extent was reported as meeting the metric.

Seed-Only Reefs: Bathymetric surface data was not collected on seed-only reef sites immediately following seed planting. Therefore, it is not possible at this time to determine whether or not the seed-only reefs meet the reef footprint success criteria. The bathymetric surface data collected at the three-year post restoration mark (fall 2015) will be compared against bathymetric surface data collected at the six-year post-restoration mark (fall 2018). At that time, evaluation of the two data sets will follow the methods above for the substrate and seed restoration sites. The success or failure of this metric on seed-only reefs is therefore noted as ‘TBD in 2018.’

Reef Height

Oyster Metrics success criterion: Neutral or positive change in reef height as compared to baseline measurements.

Methods: Substrate and Seed Reefs: To evaluate reef height, the difference between the postconstruction surface and the three-years-postconstruction surface is calculated by subtracting the former from the latter. To establish a common baseline elevation between multiple surfaces, the depth values for the two sources were compared at a minimum of ten points outside of the restored site. The mean difference from the ten points was calculated and used to adjust one of the surfaces. The calculated differences between all of the cells within the restoration site polygon were then assumed to have occurred from the construction of reef, including artifacts of moving equipment, deposition of seed, scouring or deposition of sediments, growth of oyster clumps, loss from poaching, loss from subsidence of the site base, or artifacts within the sonar data. If the mean calculated difference for the surface within the site boundary was neutral or positive, then the reef height was reported as meeting the metric.

Seed-Only reefs: Surface data was not collected on seed-only reef sites immediately following seed planting. Therefore, it is not possible at this time to determine whether or not the seed-only reefs meet the reef height success criteria. Surface data collected at the three-year post-restoration mark (fall 2015) will be compared against surface data collected at the

six-year postrestoration mark (fall 2018). At that time, evaluation of the two data sets will follow the methods above for the substrate and seed restoration sites to determine whether or not the reef height success criteria was met. The success or failure of this metric on seed-only reefs is therefore noted as ‘TBD in 2018.’

Bathymetric Features and Observations

Postrestoration images created from multibeam bathymetric (depth) surveys on each reef are available in Section 3C. Figure 3 shows interpretation of the various bathymetric features visible in these images.

Having two surveys repeated within a short period of time (2-3 years) provides an opportunity to identify and evaluate specific forms of seabed change at restoration sites. Features present in the three-year assessment sonar imagery (Section 3C) that are not present in the postconstruction imagery are attributed to the reef construction process or caused by other events that occurred between monitoring surveys. These features include the acoustic signature of different restoration materials, artifacts from tug and barge equipment that include drag marks and spud holes, scouring or deposition of sediments, growth of oyster clumps, and mechanical scarring from keel drag or commercial harvest. Each feature form has a somewhat unique signature on the seabed and can usually be attributed to a specific action. Based on observations of the various methods of harvesting oysters, one such unique signature is the oyster dredge drag scar, a furrowed feature that has been observed with video within harvest areas.

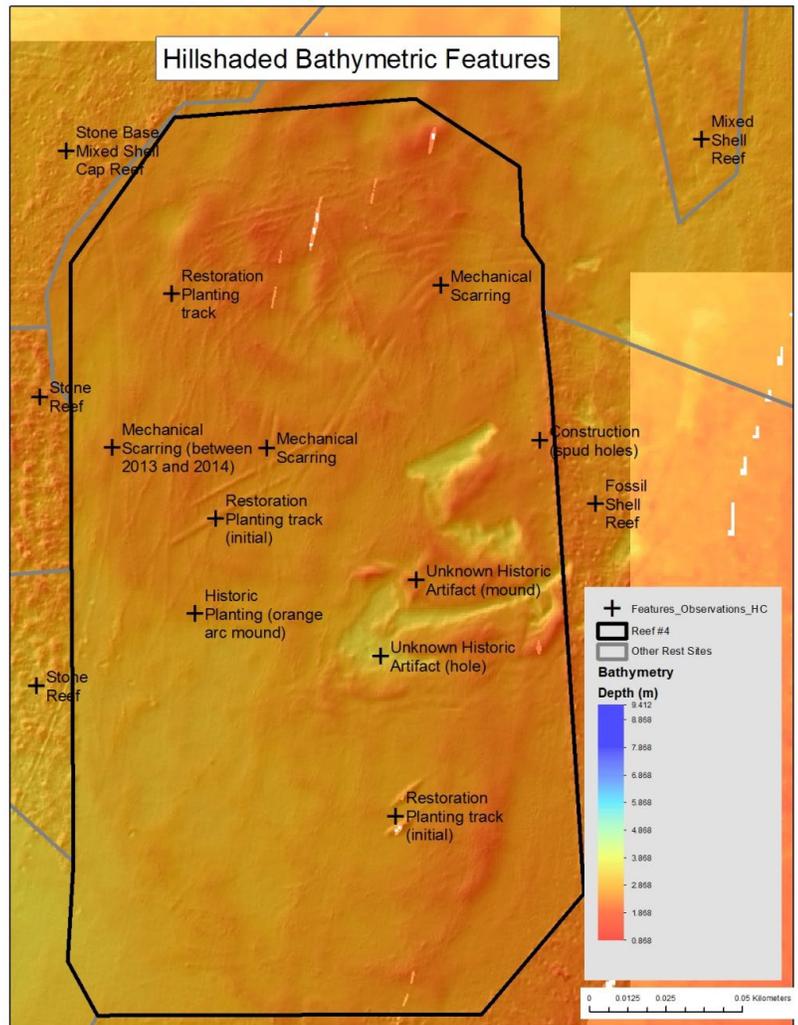


Figure 3: Interpretation of bathymetric features visible in sonar images of treated oyster reefs.

Section 2C: Diagnostic Monitoring

In addition to monitoring to determine if reefs met the Oyster Metrics success criteria, information was also collected to aid in diagnosing why reefs may have succeeded or failed. These are primarily water-quality data and oyster disease data.

- With funding from The Nature Conservancy, MD DNR monitored three water-quality stations on Harris Creek (mddnr.chesapeakebay.net/eyesonthebay). Water conditions were favorable for oysters throughout 2015 except for brief periods of hypoxia in late summer.
- Oyster disease is a factor that may influence the success of this project. Partners continue to evaluate available disease data and adapt project management as needed.

Section 3: Results

Section 3A: Success against Oyster Metrics criteria, by reef

Table 4 (next page) shows each reef’s prerestoration population density status, restoration treatment, and success against the Oyster Metrics criteria.

Section 3B: Detailed information and sonar images for each reef monitored

‘Reef pages’ that show general information about each reef, details on how each fared against each of the six Oyster Metrics success criteria, degree to which the planted spat survived on the reef, and a fall 2015 sonar image of the reef, are available in Appendix A.

Reef Information and Restoration Treatment				Biological Success Criteria							Structural Success Criteria		
Reef Area (acres)	Restoration Treatment	Year Planned	Actual Start Date (Yr/Mo)	Actual End Date (Yr/Mo)	Fall 2015: Average oyster density (ysters per m ²)	Fall 2015: Old reef made identifiable?	Fall 2015: Old reef made deeper?	RM12 OLS: Old reef made identifiable?	RM11 OLS: Old reef made deeper?	RM12 OLS: Does the reef have multiple year classes present?	Fall 2015: Is the reef's shell budget stable or increasing?	Fall 2015: Is the reef's structure stable or increasing from?	Fall 2015: Is the reef's height stable or increasing from?
2A17	Substrate (Fall 11)	2012	21.27	2.28	5.6	Y	Y	Y	Y	Y		Y	N
2A4	Substrate (Fall 11)	2012	17.06	7.67	4.8	Y	Y	Y	Y	Y		Y	N
656	Seed Only	2012	28.5	4.5	2.8	Y	N	Y	N	Y			
1124	Seed Only	2012	44.2	2.94	2.8	Y	N	Y	N	Y			
1263	Seed Only	2012	61.24	2.66	4.7	Y	Y	Y	Y	Y			
712	Seed Only	2011, 2012	60.16	2.27	4.7	Y	Y	Y	Y	Y			
1093	Seed Only	2012	20.06	4.67	2.0	Y	Y	Y	Y	Y			
724	Seed Only	2012	46.63	6.63	2.4	Y	N	Y	N	Y			
1228	Seed Only	2012	47.23	2.24	2.2	Y	N	Y	N	Y			
1028	Seed Only	2012	51.09	4.78	5.8	Y	Y	Y	Y	Y			
652	Seed Only	2012	24.16	4.21	2.0	Y	N	Y	N	Y			
722	Seed Only	2012	21.1	2.67	1.7	Y	N	Y	N	Y			
2A	Seed Only	2011	21.76	15.22	2.2	Y	N	Y	N	Y			
2A7	None (2010)	N/A	0	0	1.7	Y	N	Y	N	Y			
1A5	None (2010)	N/A	0	0	1.6	Y	N	Y	N	Y			
1A9	None (2010)	N/A	0	0	6	N	N	N	N	Y			
4D1	None (2010)	N/A	0	0	4	N	N	N	N	Y			
2A5	Substrate (2011)	2012	14.44	7	1.72	Y	Y	Y	Y	Y		Y	Y

Table 4: Summary of Each Reef's Prerestoration Status, Restoration Treatment, and Success against Oyster Metrics Criteria.

For the oyster density success criterion:

- Minimum threshold = 15 oysters per m² over 30% of the reef area
- Target = 50 oysters per m² over 30% of the reef area

For the oyster biomass success criterion:

- Minimum threshold = 15 grams dry weight per m² over 30% of the reef area
- Target = 50 grams dry weight per m² over 30% of the reef area

*TBD in 2018 = fall 2015 data will serve as baseline, and will be compared to fall 2018 data to determine success for these criteria. See shell budget and reef structural metrics methods sections for full explanation.

Section 4: Discussion and Conclusions

All 12 reefs in the first cohort show healthy oyster populations.

- All 12 reefs in the first cohort meet, at least, the minimum threshold success criteria for oyster density (15 oysters per m² over 30% of the reef area) and for oyster biomass (15 grams dry weight per m² over 30% of the reef area).
- Half of the reefs (reefs #1, 2, 5, 6, 7, 10) in the first cohort meet the higher, target criteria for oyster density (50 oysters per m² per over 30% of the reef area) and for oyster biomass (50 grams dry weight per m² over 30% of the reef area).
- Prior to restoration treatment, none of the 12 first cohort reefs met the target oyster density (50 oysters per m² per over 30% of the reef area), and only two reefs (#6 and #10) met the minimum threshold density (15 oysters per m² over 30% of the reef area) prior to restoration.
- All 12 reefs in the first cohort met the Oyster Metrics success criterion for presence of multiple year classes of oysters. On reefs where all of the hatchery-produced seed was planted onto the site in a single year (i.e., where a single year class was planted), this means that there were either remnant oysters that pre-date restoration efforts, or that there was a natural oyster set (natural reproduction resulting in wild juvenile oysters), or both. On reefs where hatchery-produced oysters were planted in two or more different years (i.e., two or more year classes of oysters were planted), the multiple year classes may be due to hatchery plantings, the presence of remnant oysters that pre-date restoration efforts, a natural oyster set (natural reproduction resulting in wild juvenile oysters), or a combination.

Success in some Oyster Metrics criteria will not be able to be determined until fall 2018.

- It is not yet possible to determine whether the first cohort of reefs meet the success criterion for shell budget. (See shell budget methods section for full explanation.) The shell budget data collected in fall 2015 will be compared to data collected in fall 2018 to determine success against this metric.
- For reefs (#3-12) that received seed only (no reef-building substrate) treatment, baseline reef footprint and reef height data were not collected. Therefore, it is not possible at this time to determine success against these criteria. Fall 2015 data will be compared to fall 2018 data to determine success against these metrics. (See reef structural metrics methods section for full explanation.)

Tracking data at control and other reefs highlights interesting findings.

- In addition to the first cohort of reefs, four control reefs were monitored (#14-17). These reefs received no restoration treatment, but may have received natural spat set. As of fall 2015, two of these reefs (#14 and #15) met the minimum threshold for oyster density (oysters per m² over 30% of the reef area) and biomass (15 grams dry weight per m² over 30% of the reef area). None of the four control reefs met the target for oyster density (50 oysters per m² over 30% of the reef area) or biomass (50 grams dry weight per m² over 30% of the reef area).
- Beyond the first cohort of reefs, one reef (#18), constructed of stone substrate and planted in 2013 (a year later than the first cohort reefs) was monitored. Data show oyster density here in fall 2015 was more than three times as high as at any other site monitored in Harris Creek. As this reef was planted a year later than the first cohort reefs, though, spat survival rates between it and the first cohort reefs may not be comparable. However, the high spat survival rate, and the complex reef structure evident in the sonar image, show promising early results from the use of stone substrate for restoration. This was the only stone reef monitored in 2015.
- One reef (#13) was planted in 2011, prior to the start of the large-scale restoration effort in Harris Creek, and is not considered part of the first cohort of reefs. This reef is, however, being monitored as part of the overall Harris Creek restoration effort. The planting density here was over 15 million oysters per m², more than three times the Harris Creek Tributary Plan target of 5 million per m², and considerably higher than on any other site in Harris Creek to date. As of fall 2015, this reef met the minimum threshold for oyster density (15 oysters per m² over 30% of the reef area) and oyster biomass (15 grams dry weight per m² over 30% of the reef area), but did not meet the higher, target level for oyster density (50 oysters per m² over 30% of the reef area) or biomass (50 grams dry weight per m² over 30% of the reef area).

- A variety of features on the seabed can be observed with multibeam bathymetric sonar, including construction artifacts such as spud holes and drag marks, historic plantings of shell and/ or oysters, recent mechanical scarring, scour and deposition, and the growth of oyster clumps. Features and observations within the bathymetric data suggest some reefs have been disturbed since the start of restoration (see Figure 3 and images in Appendix A).

Taken together, this information is promising, and, as of fall 2015, shows substantial success against the preestablished Oyster Metrics criteria. However, there are factors that may negatively influence the continued success of the Harris Creek project. These include:

- **Water quality:** Although water quality in Harris Creek since the project's start in 2012 has generally been conducive to oyster growth and survival, it is possible that extreme low dissolved oxygen, freshets, weather events, or other water-quality issues could result in significant oyster mortality. Upstream and upland activity, or watershed-wide decreases in water quality, could also affect Harris Creek oysters.
- **Oyster disease:** Dermo disease has generally been highly prevalent in Harris Creek oysters, but at a very low (sublethal) intensity. A dry weather spell, resulting in high salinity, could cause an increase in Dermo intensity, and could lead to significant oyster mortality. Some scientists believe such outbreaks may actually benefit oyster populations in the long run, as the surviving oysters may pass along disease-resistant genes. This theory has both supporters and detractors in the scientific community. If oysters die due to disease, the shell substrate left behind may still be available for a period of time for future larval settlement.
- **Poaching:** Poaching (illegal harvest of oysters) has been documented in the Harris Creek oyster sanctuary. It is not possible at this time to quantify the extent of the damage to restoration sites. Unchecked poaching has the potential to do substantial damage by lowering oyster densities and flattening reef structure.
- **Organizational support from partners, including funding:** Progress made to date on large-scale oyster restoration in Harris Creek has been achieved through partner support in the form of shared science, planning, monitoring, and funding. Funding for the Harris Creek project has come primarily from MD DNR, NOAA, and USACE. Other funding partners include the Chesapeake Bay Foundation, National Fish and Wildlife Federation, The Nature Conservancy, and CSX. Although initial in-water restoration work is complete in Harris Creek, funds are still needed for monitoring, and potentially for smaller maintenance plantings if needed. (The Harris Creek Tributary Plan calls for small maintenance plantings on each reef between four and five years after the initial reefs are seeded.) Poor cooperation among partners, or lack of funding, could result in slowed or stopped progress toward achieving the Chesapeake Bay Watershed Agreement oyster goal.

Data and analysis in this report will be used by the Maryland Interagency Oyster Restoration Workgroup, consulting scientists, and oyster resource managers to help determine what, if any, adaptive management measures should be taken on each of the first cohort reefs. It will also be used to guide restoration in other tributaries, notably the nearby Little Choptank and Tred Avon rivers, also selected for large-scale restoration under the Chesapeake Bay Watershed Agreement. Monitoring and evaluation protocols will similarly be examined, and adapted as needed.

Appendix A: “Reef Pages”

‘Reef pages’ that show general information about each reef, details on how each fared against each of the six Oyster Metrics success criteria, degree to which the planted spat survived on the reef, and a fall 2015 sonar image of the reef, are available in Appendix A on the following pages.

Reef #1 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	AltSub_104
Reef area (acres)	3.37
Restoration treatment	Substrate (shell) & Seed
Substrate type added	Shell
Year planted with spat	2012
Number of spat planted (millions)	31.27
Number of spat planted per acre (millions)	9.28
Spat produced by	University of Maryland
Spat planted by	Oyster Recovery Partnership

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	Y
Fall 2015: Did reef meet <i>target*</i> density?	Y
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	Y
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	Y
Avg. live oyster density across the entire reef (oysters per m2)	55.81
Standard error of live oyster density (oysters per m2)	10.24
Avg. live oyster biomass across the entire reef (g dry weight per m2)	66.09
Standard error of live oyster biomass (g dry weight per m2)	14.04
Most recent monitoring sample date	05-Dec-15
Number of samples taken	13
Number of live oysters measured	370
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	N
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

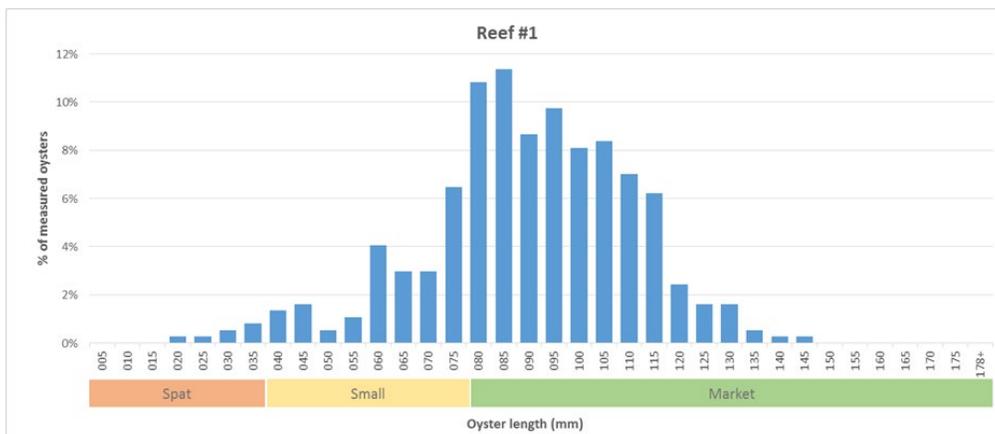
*Oyster density success criteria, per Oyster Metrics:
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.
Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.
Target: 30% of the reef area is covered with 50 oysters or more per square meter.

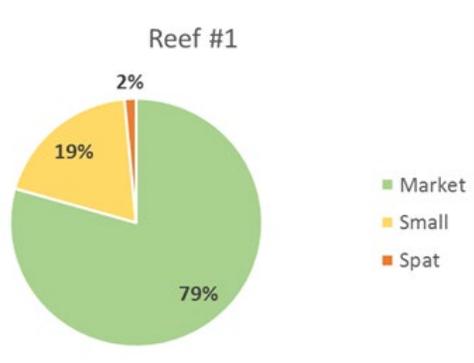
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	1.24
Max shell volume on the reef (liters)	27.33
Avg shell volume on the reef (liters)	13.76
Standard error of the shell Volume on the reef (liters)	2.51
Number of samples taken	13
% of samples containing shell	85.72
Total shell volume (liters)	185,769.58
Avg surface shell across all samples (%)	78.46
Total surface shell volume (liters)	40,011.91

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

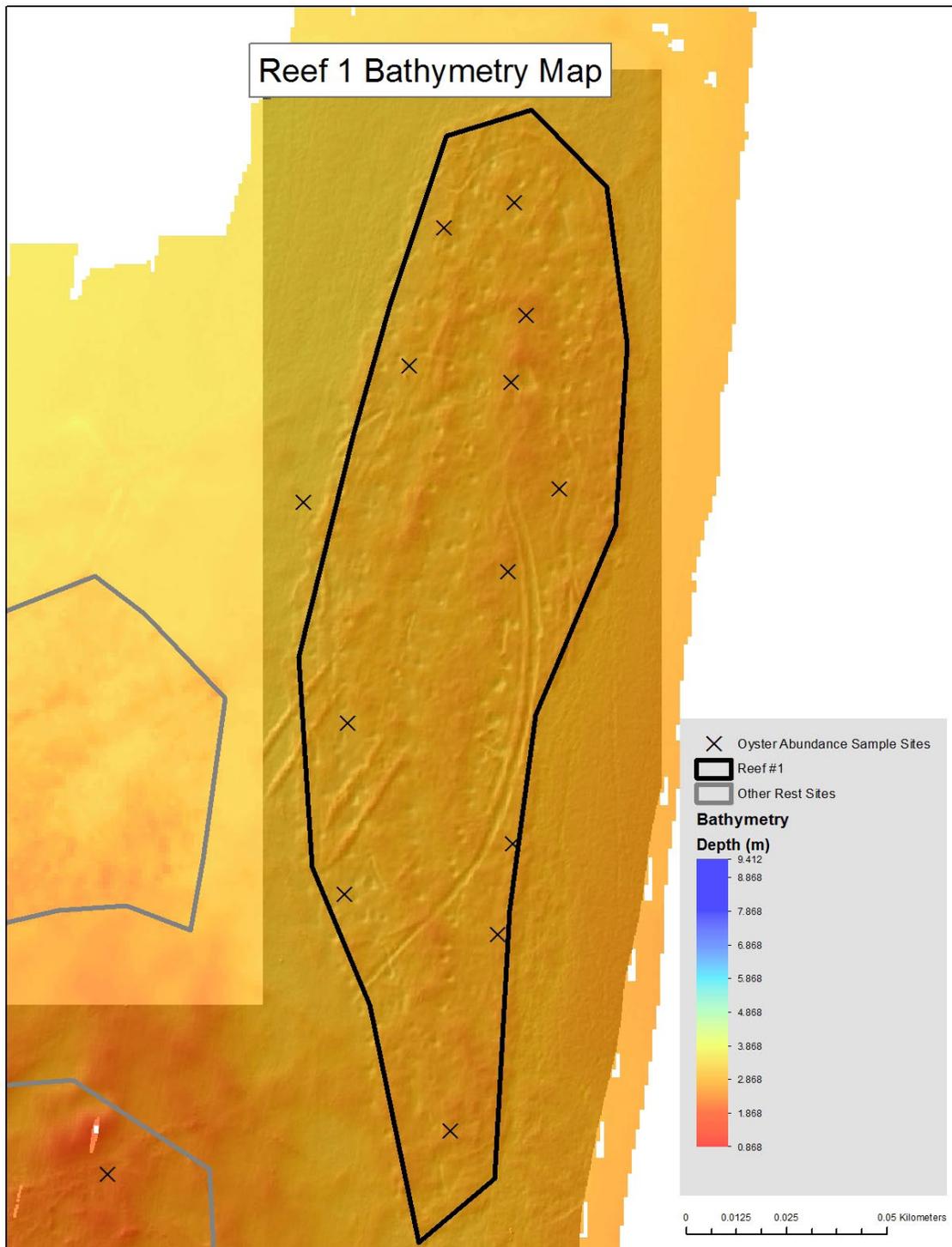
Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	Y
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	N
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Fall 2015 Sonar Image of the Reef (See Figure 3 for interpretation of bathymetric features.)



Reef #2 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	AltSub_106
Reef area (acres)	2.14
Restoration treatment	Substrate (shell) & Seed
Substrate type added	Shell
Year planted with spat	2012
Number of spat planted (millions)	17.06
Number of spat planted per acre (millions)	7.97
Spat produced by	University of Maryland
Spat planted by	Oyster Recovery Partnership

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	Y
Fall 2015: Did reef meet <i>target*</i> density?	Y
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	Y
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	Y
Avg. live oyster density across the entire reef (oysters per m2)	47.76
Standard error of live oyster density (oysters per m2)	5.48
Avg. live oyster biomass across the entire reef (g dry weight per m2)	41.82
Standard error of live oyster biomass (g dry weight per m2)	6.08
Most recent monitoring sample date	04-Nov-15
Number of samples taken	27
Number of live oysters measured	954
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	N
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

*Oyster density success criteria, per Oyster Metrics:

Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:

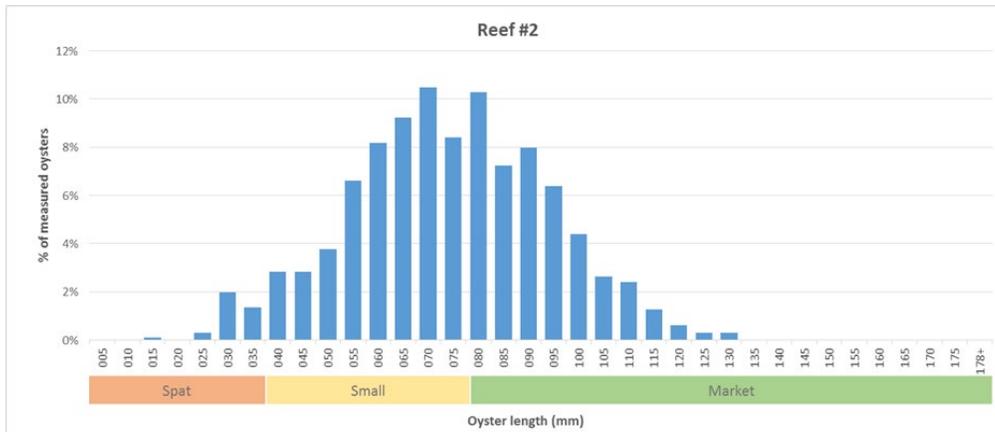
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

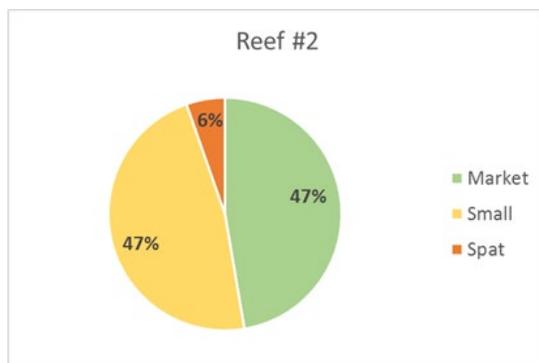
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	4.97
Max shell volume on the reef (liters)	15.53
Avg shell volume on the reef (liters)	10.05
Standard error of the shell Volume on the reef (liters)	0.94
Number of samples taken	27
% of samples containing shell	100.00
Total shell volume (liters)	78,297.69
Avg surface shell across all samples (%)	70.00
Total surface shell volume (liters)	23,489.31

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

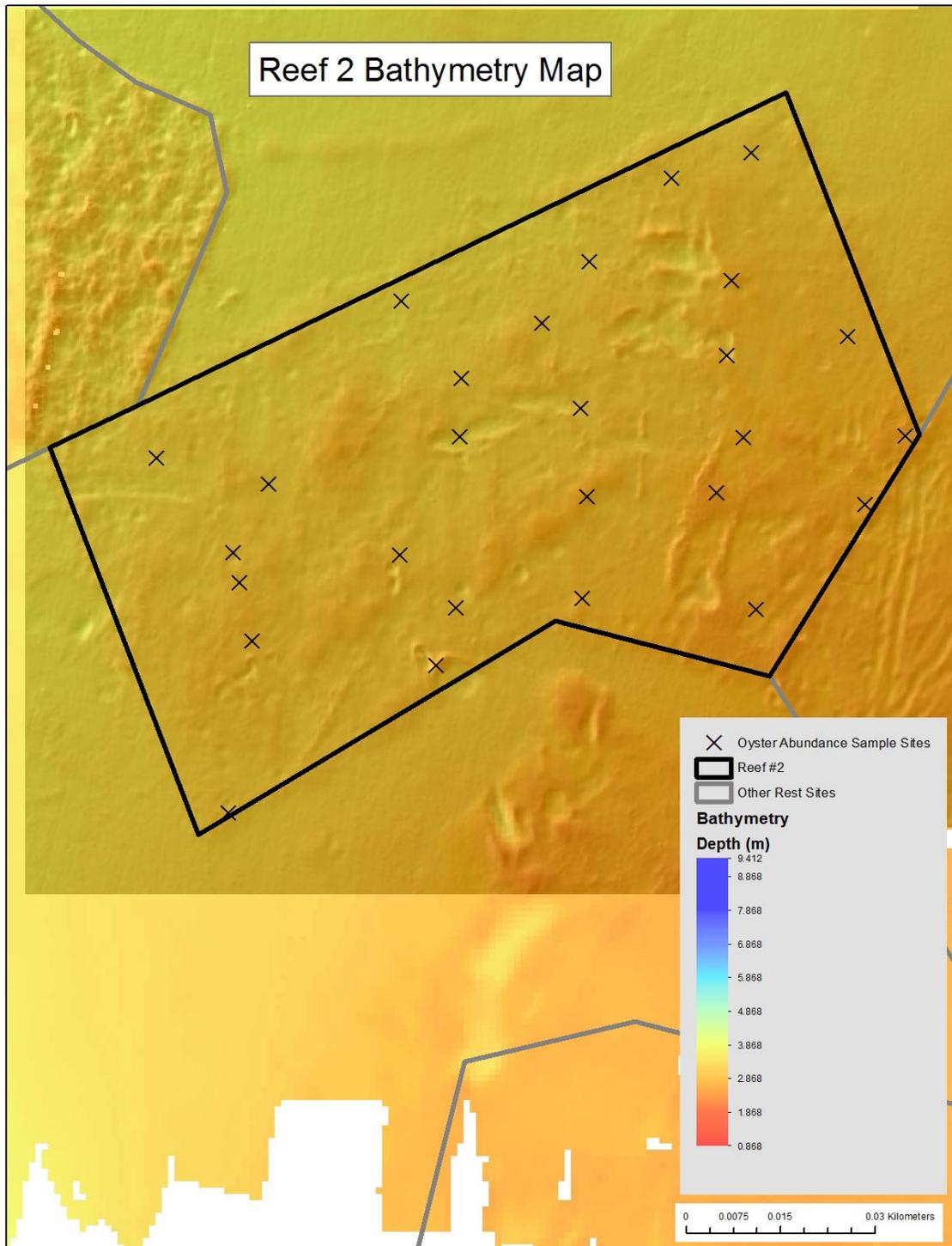
Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	Y
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	N
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Fall 2015 Sonar Image of the Reef (See Figure 3 for interpretation of bathymetric features.)



Reef #3 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	Seed_02
Reef area (acres)	6.56
Restoration treatment	Seed Only
Substrate type added	None
Year planted with spat	2012
Number of spat planted (millions)	29.5
Number of spat planted per acre (millions)	4.5
Spat produced by	University of Maryland
Spat planted by	Oyster Recovery Partnership

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	Y
Fall 2015: Did reef meet <i>target*</i> density?	N
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	Y
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	N
Avg. live oyster density across the entire reef (oysters per m2)	32.86
Standard error of live oyster density (oysters per m2)	7.40
Avg. live oyster biomass across the entire reef (g dry weight per m2)	33.42
Standard error of live oyster biomass (g dry weight per m2)	7.00
Most recent monitoring sample date	03-Nov-15
Number of samples taken	21
Number of live oysters measured	681
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	N
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

*Oyster density success criteria, per Oyster Metrics:

Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:

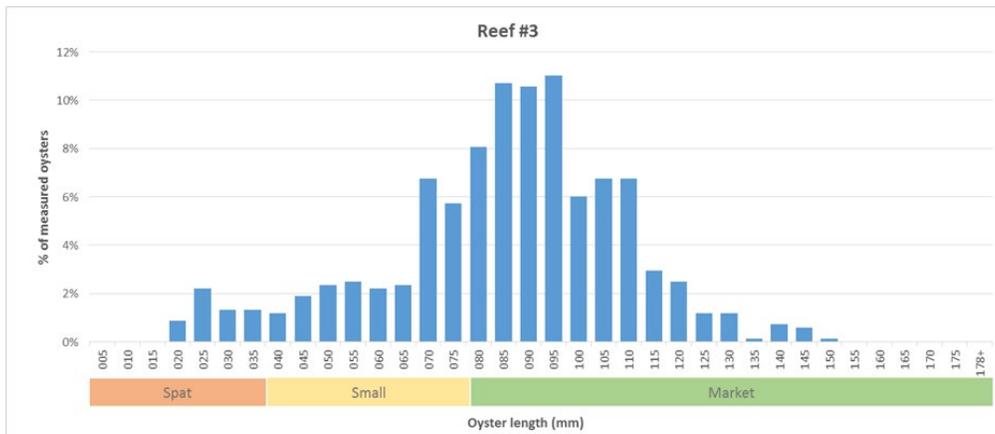
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

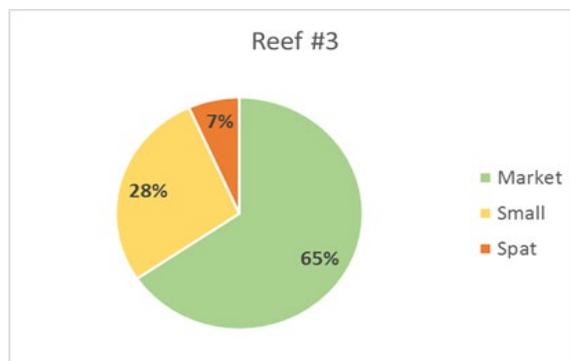
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	1.55
Max shell volume on the reef (liters)	21.12
Avg shell volume on the reef (liters)	8.49
Standard error of the shell Volume on the reef (liters)	1.51
Number of samples taken	21
% of samples containing shell	100.00
Total shell volume (liters)	192,225.86
Avg surface shell across all samples (%)	71.67
Total surface shell volume (liters)	54,463.99

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

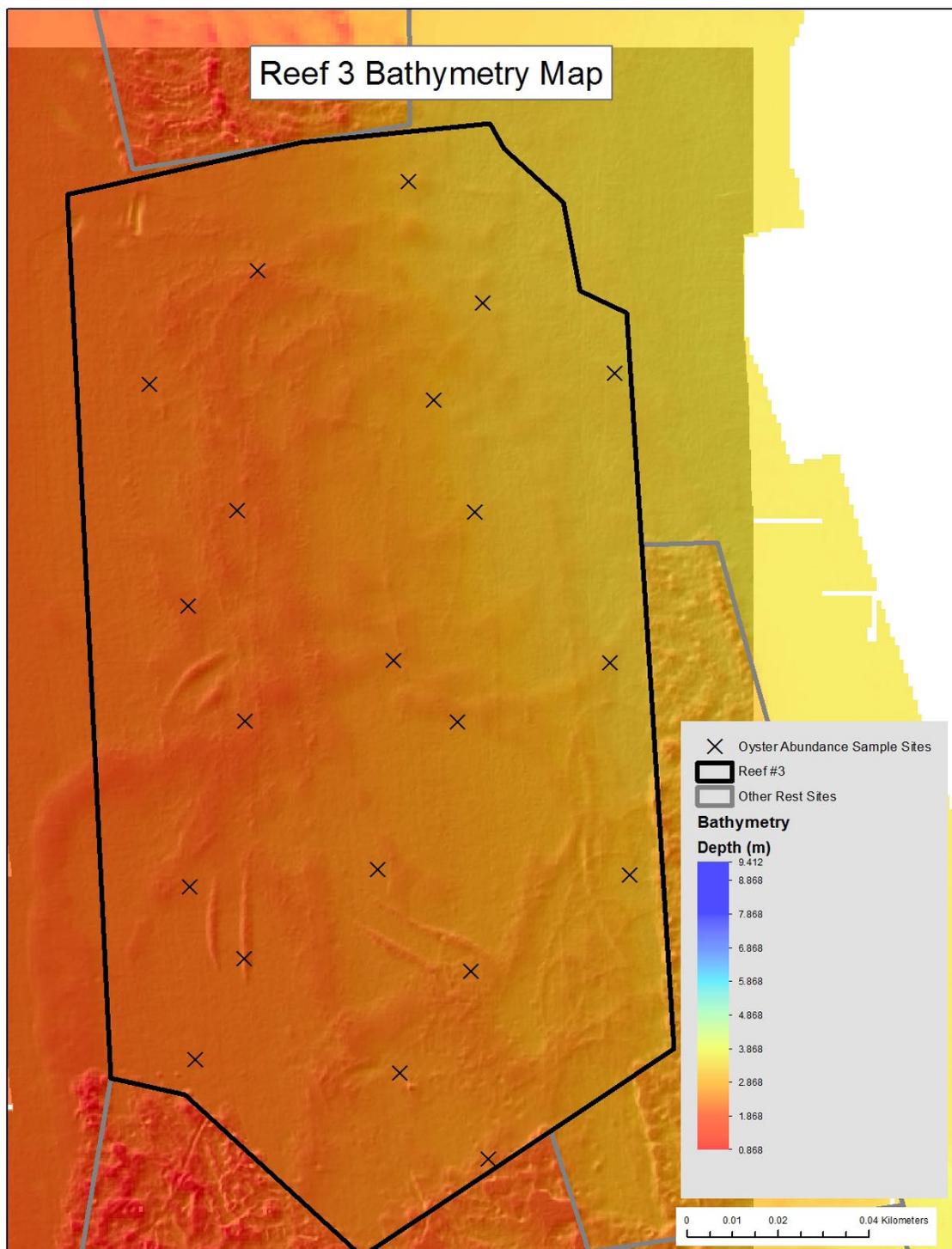
Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Fall 2015 Sonar Image of the Reef (See Figure 3 for interpretation of bathymetric features.)



Reef #4 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	Seed_08
Reef area (acres)	11.24
Restoration treatment	Seed only
Substrate type added	None
Year planted with spat	2012
Number of spat planted (millions)	44.3
Number of spat planted per acre (millions)	3.94
Spat produced by	University of Maryland
Spat planted by	Oyster Recovery Partnership

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	Y
Fall 2015: Did reef meet <i>target*</i> density?	N
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	Y
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	N
Avg. live oyster density across the entire reef (oysters per m2)	38.96
Standard error of live oyster density (oysters per m2)	4.44
Avg. live oyster biomass across the entire reef (g dry weight per m2)	37.97
Standard error of live oyster biomass (g dry weight per m2)	4.19
Most recent monitoring sample date	5-Nov-15
Number of samples taken	37
Number of live oysters measured	1,167
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	N
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

*Oyster density success criteria, per Oyster Metrics:

Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:

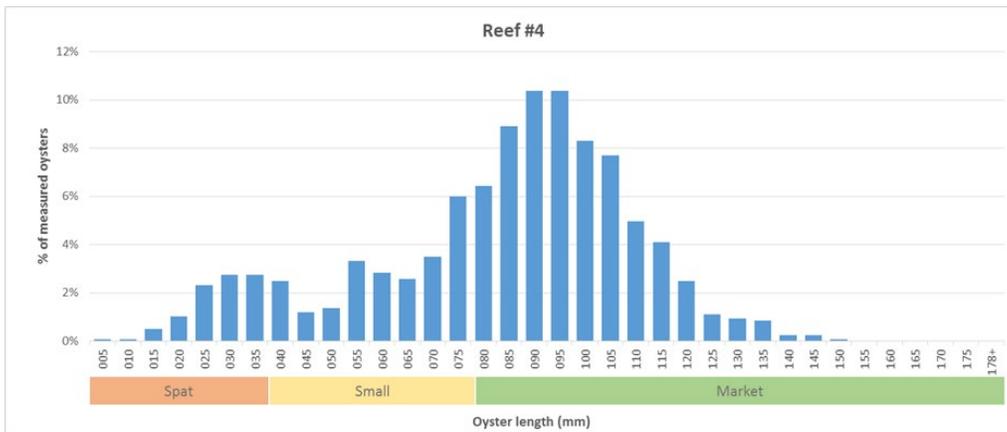
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

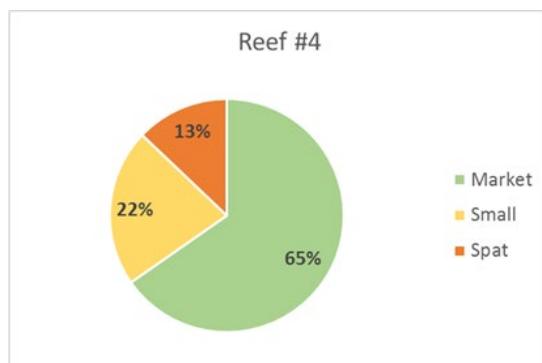
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	1.86
Max shell volume on the reef (liters)	19.88
Avg shell volume on the reef (liters)	9.37
Standard error of the shell Volume on the reef (liters)	0.85
Number of samples taken	37
% of samples containing shell	100
Total shell volume (liters)	404,855.95
Avg surface shell across all samples (%)	68.51
Total surface shell volume (liters)	127,474.91

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

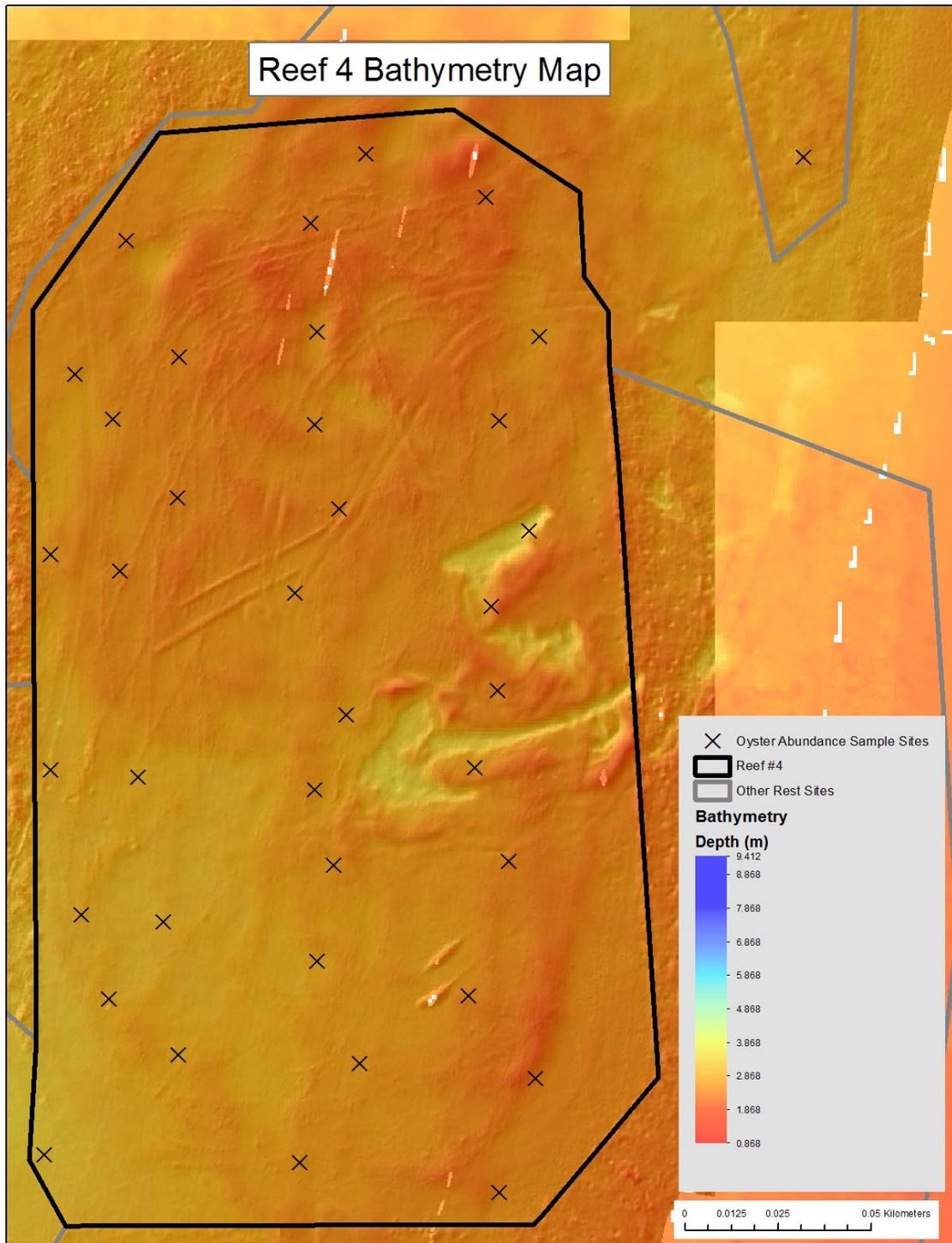
Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Fall 2015 Sonar Image of the Reef (See Figure 3 for interpretation of bathymetric features.)



Reef #5 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	Seed_46
Reef area (acres)	15.65
Restoration treatment	Seed Only
Substrate type added	None
Year planted with spat	2012
Number of spat planted (millions)	62.24
Number of spat planted per acre (millions)	3.98
Spat produced by	University of Maryland
Spat planted by	Oyster Recovery Partnership

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	Y
Fall 2015: Did reef meet <i>target*</i> density?	Y
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	Y
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	Y
Avg. live oyster density across the entire reef (oysters per m2)	47.15
Standard error of live oyster density (oysters per m2)	4.24
Avg. live oyster biomass across the entire reef (g dry weight per m2)	45.75
Standard error of live oyster biomass (g dry weight per m2)	4.24
Most recent monitoring sample date	10-Dec-15
Number of samples taken	54
Number of live oysters measured	1,489
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	N
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

*Oyster density success criteria, per Oyster Metrics:

Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:

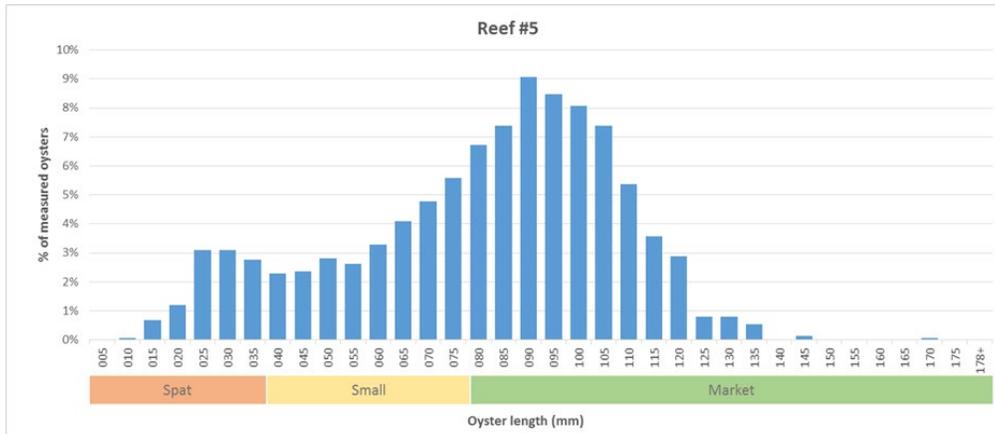
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

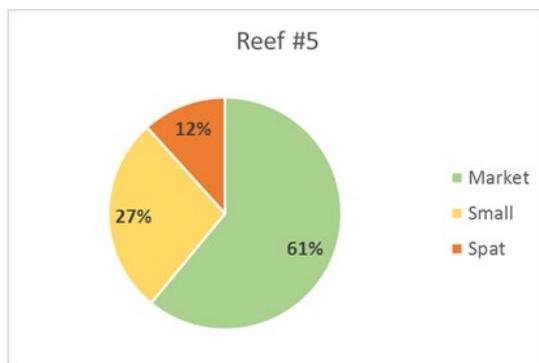
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	3.11
Max shell volume on the reef (liters)	27.95
Avg shell volume on the reef (liters)	12.81
Standard error of the shell Volume on the reef (liters)	0.98
Number of samples taken	54
% of samples containing shell	97.79
Total shell volume (liters)	780,838.50
Avg surface shell across all samples (%)	58.70
Total surface shell volume (liters)	322,457.38

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

Reef Footprint

Is the reef footprint stable or increasing?
(from post-treatment survey to fall 2015 monitoring)

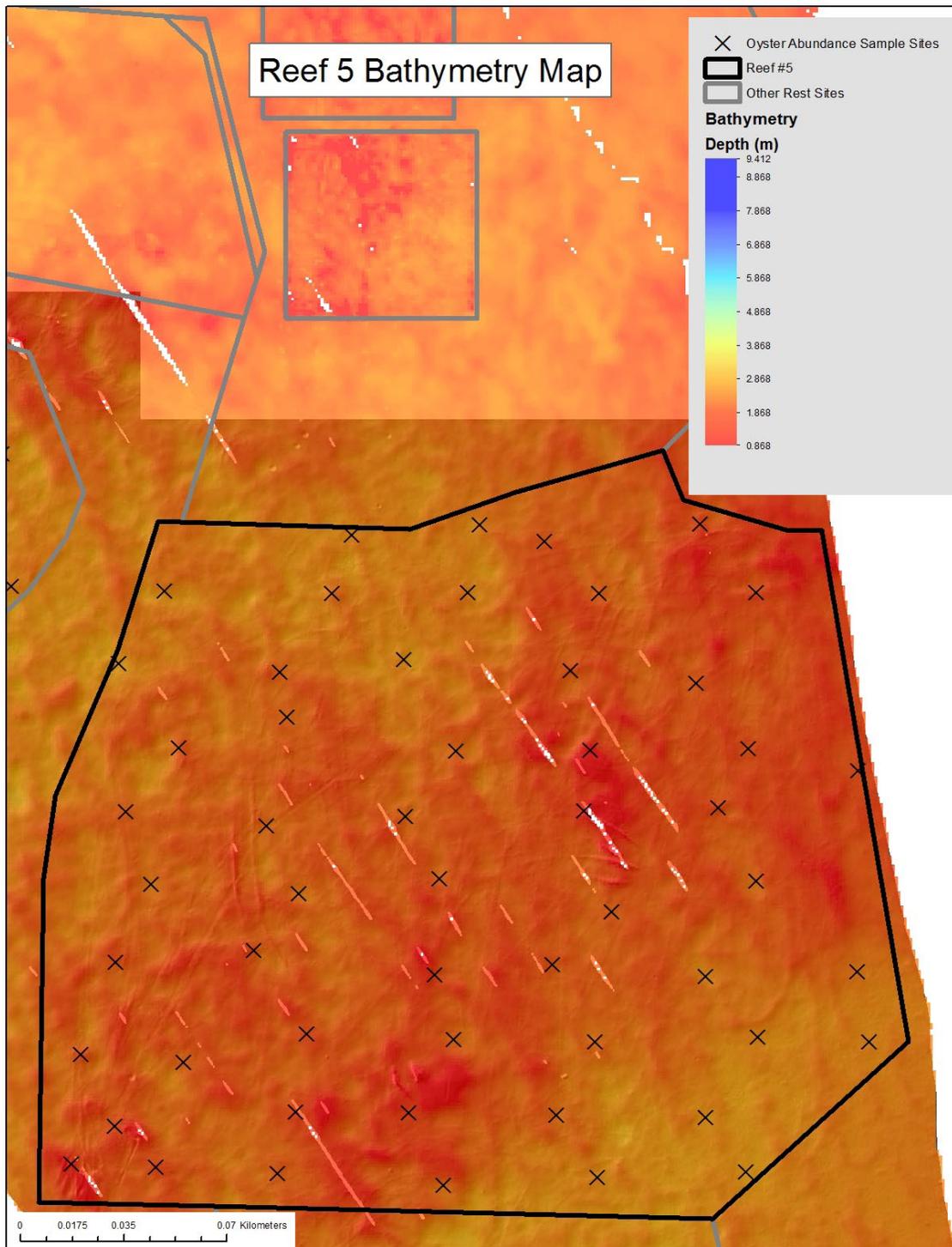
TBD in 2018+

Reef Height

Is the reef height stable or increasing?
(from post-treatment survey to fall 2015 monitoring)

TBD in 2018+

Fall 2015 Sonar Image of the Reef (See Figure 3 for interpretation of bathymetric features.)



Reef #6 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	Seed_56
Reef area (acres)	7.19
Restoration treatment	Seed Only
Substrate type added	None
Year planted with spat	2011, 2013
Number of spat planted (millions)	60.16
Number of spat planted per acre (millions)	8.37
Spat produced by	University of Maryland
Spat planted by	Oyster Recovery Partnership

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet minimum threshold* density?	Y
Fall 2015: Did reef meet target* density?	Y
Fall 2015: Did reef meet minimum threshold** oyster biomass?	Y
Fall 2015: Did reef meet target** oyster biomass?	Y
Avg. live oyster density across the entire reef (oysters per m2)	47.11
Standard error of live oyster density (oysters per m2)	3.70
Avg. live oyster biomass across the entire reef (g dry weight per m2)	41.72
Standard error of live oyster biomass (g dry weight per m2)	3.05
Most recent monitoring sample date	16-Dec-15
Number of samples taken	51
Number of live oysters measured	1,553
Pre-restoration (2012): Did reef meet threshold oyster density?	Y
Pre-restoration (2012): Did reef meet target oyster density?	N

*Oyster density success criteria, per Oyster Metrics:

Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:

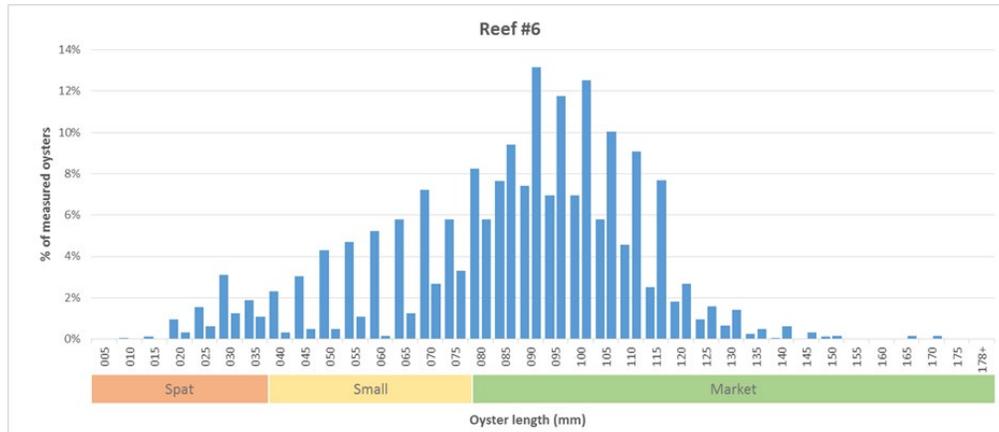
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

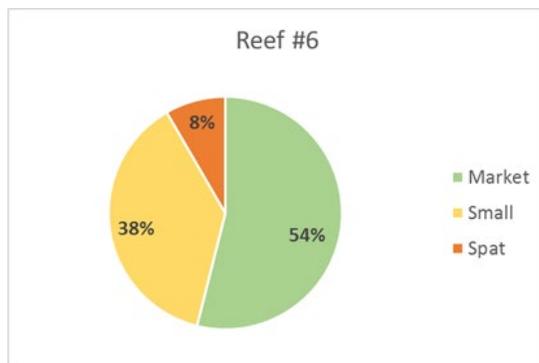
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	5.75
Max shell volume on the reef (liters)	23.91
Avg shell volume on the reef (liters)	14.97
Standard error of the shell Volume on the reef (liters)	0.93
Number of samples taken	51
% of samples containing shell	100.00
Total shell volume (liters)	222,616.19
Avg surface shell across all samples (%)	72.10
Total surface shell volume (liters)	62,109.92

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

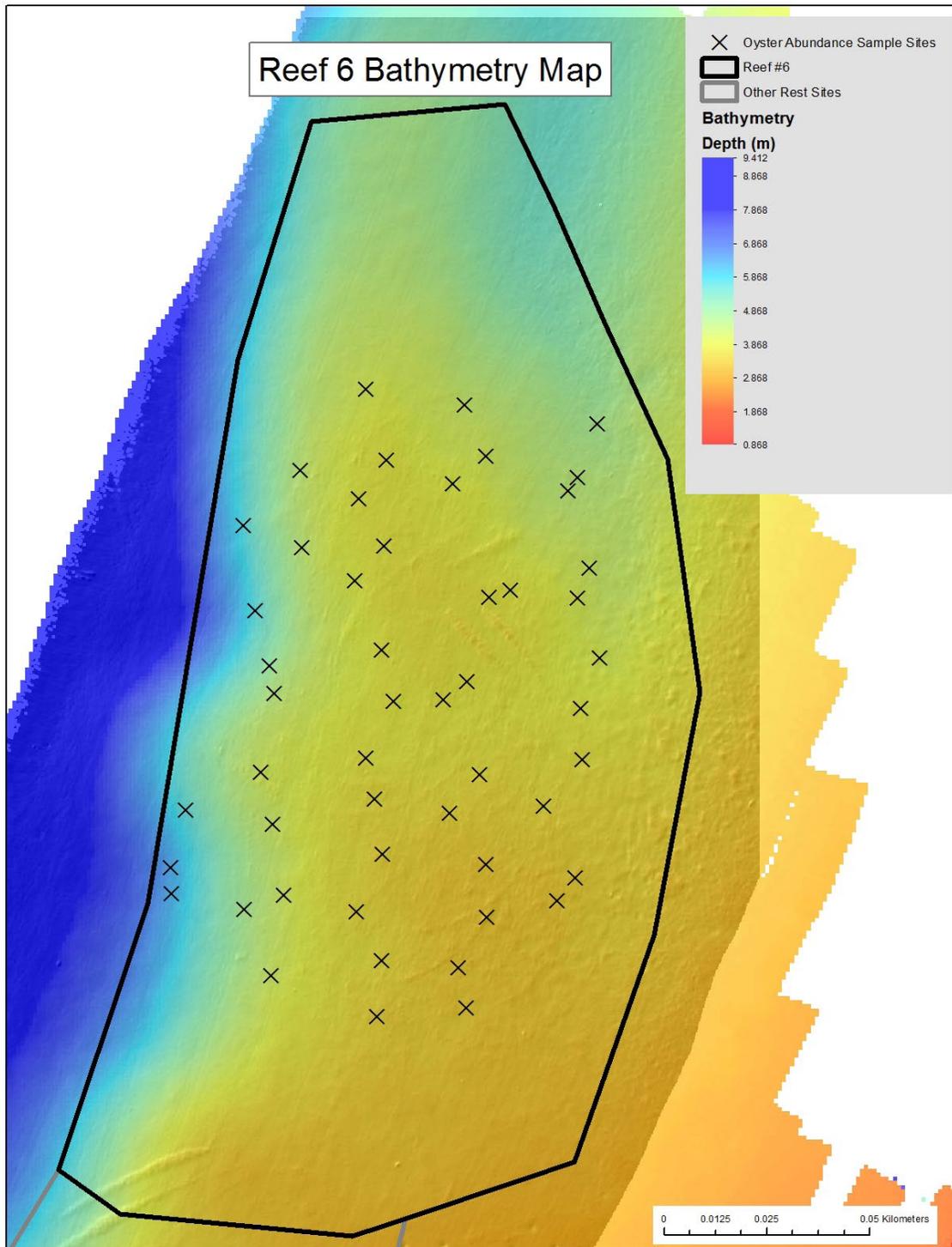
Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Fall 2015 Sonar Image of the Reef (See Figure 3 for interpretation of bathymetric features.)



Reef #7 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	Seed_72
Reef area (acres)	10.95
Restoration treatment	Seed Only
Substrate type added	None
Year planted with spat	2012
Number of spat planted (millions)	50.06
Number of spat planted per acre (millions)	4.57
Spat produced by	University of Maryland
Spat planted by	Oyster Recovery Partnership

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	Y
Fall 2015: Did reef meet <i>target*</i> density?	Y
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	Y
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	Y
Avg. live oyster density across the entire reef (oysters per m2)	29.95
Standard error of live oyster density (oysters per m2)	4.08
Avg. live oyster biomass across the entire reef (g dry weight per m2)	31.72
Standard error of live oyster biomass (g dry weight per m2)	4.38
Most recent monitoring sample date	17-Nov-15
Number of samples taken	40
Number of live oysters measured	972
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	N
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

*Oyster density success criteria, per Oyster Metrics:

Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:

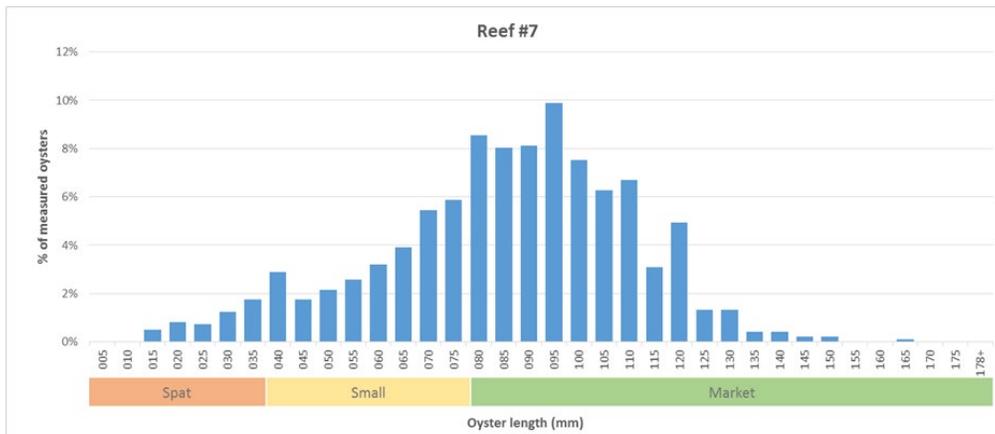
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

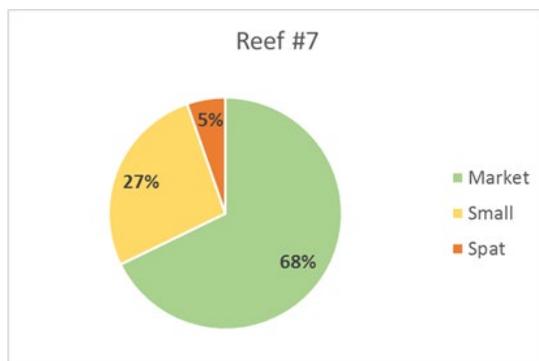
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	0.62
Max shell volume on the reef (liters)	21.43
Avg shell volume on the reef (liters)	9.49
Standard error of the shell Volume on the reef (liters)	1.20
Number of samples taken	40
% of samples containing shell	95.38
Total shell volume (liters)	399,119.54
Avg surface shell across all samples (%)	52.25
Total surface shell volume (liters)	190,579.58

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

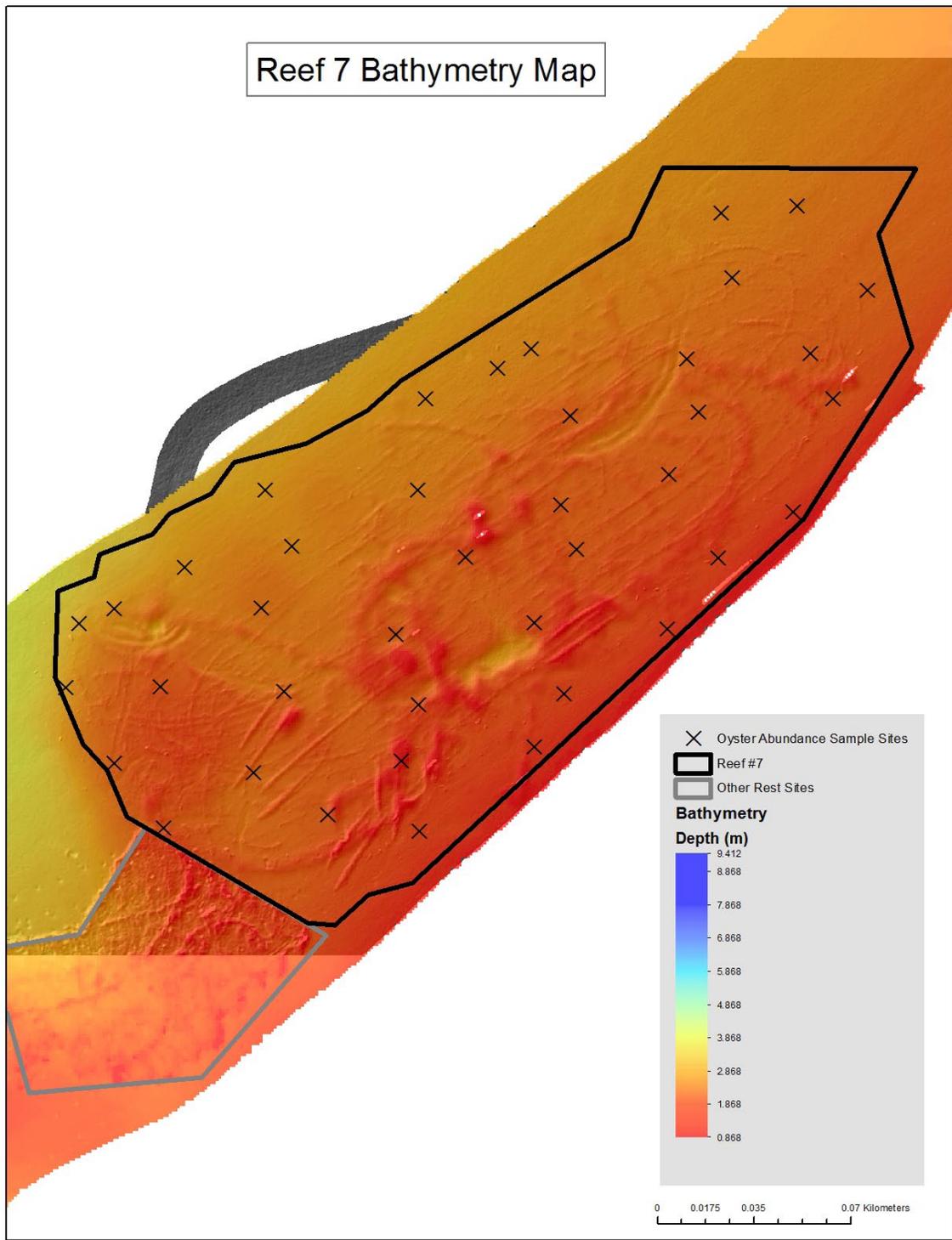
Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Fall 2015 Sonar Image of the Reef (See Figure 3 for interpretation of bathymetric features.)



Reef #8 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	TREATMENT_1
Reef area (acres)	7.34
Restoration treatment	Seed Only
Substrate type added	None
Year planted with spat	2012
Number of spat planted (millions)	48.65
Number of spat planted per acre (millions)	6.63
Spat produced by	University of Maryland
Spat planted by	Oyster Recovery Partnership

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	Y
Fall 2015: Did reef meet <i>target*</i> density?	N
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	Y
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	N
Avg. live oyster density across the entire reef (oysters per m ²)	24.11
Standard error of live oyster density (oysters per m ²)	4.08
Avg. live oyster biomass across the entire reef (g dry weight per m ²)	26.60
Standard error of live oyster biomass (g dry weight per m ²)	4.26
Most recent monitoring sample date	16-Dec-15
Number of samples taken	27
Number of live oysters measured	567
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	N
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

*Oyster density success criteria, per Oyster Metrics:

Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:

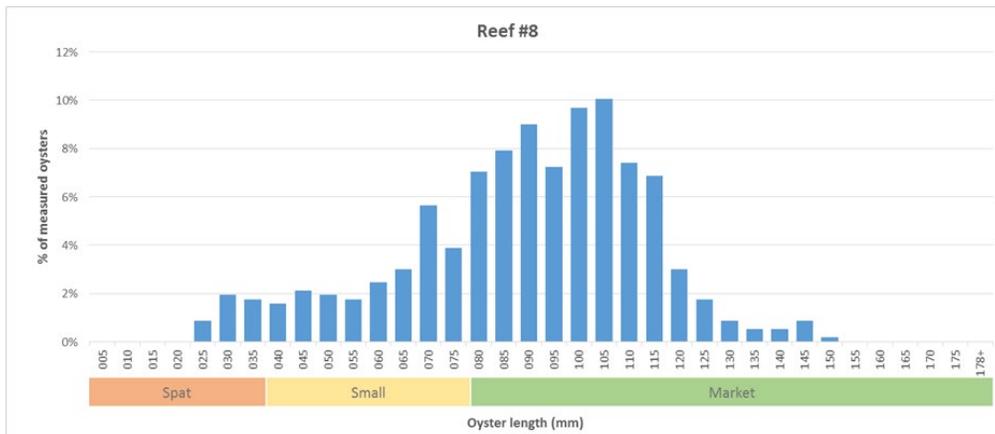
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

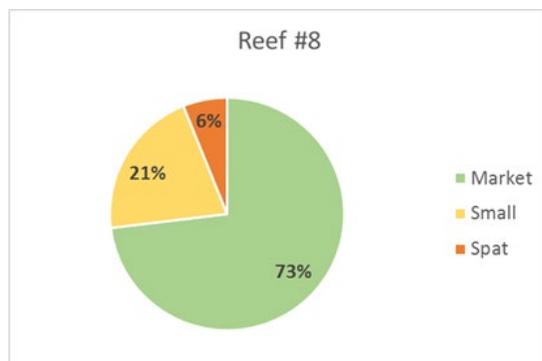
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	5.59
Max shell volume on the reef (liters)	22.36
Avg shell volume on the reef (liters)	7.89
Standard error of the shell Volume on the reef (liters)	1.32
Number of samples taken	27
% of samples containing shell	73.12
Total shell volume (liters)	229,327.95
Avg surface shell across all samples (%)	81.30
Total surface shell volume (liters)	42,892.82

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

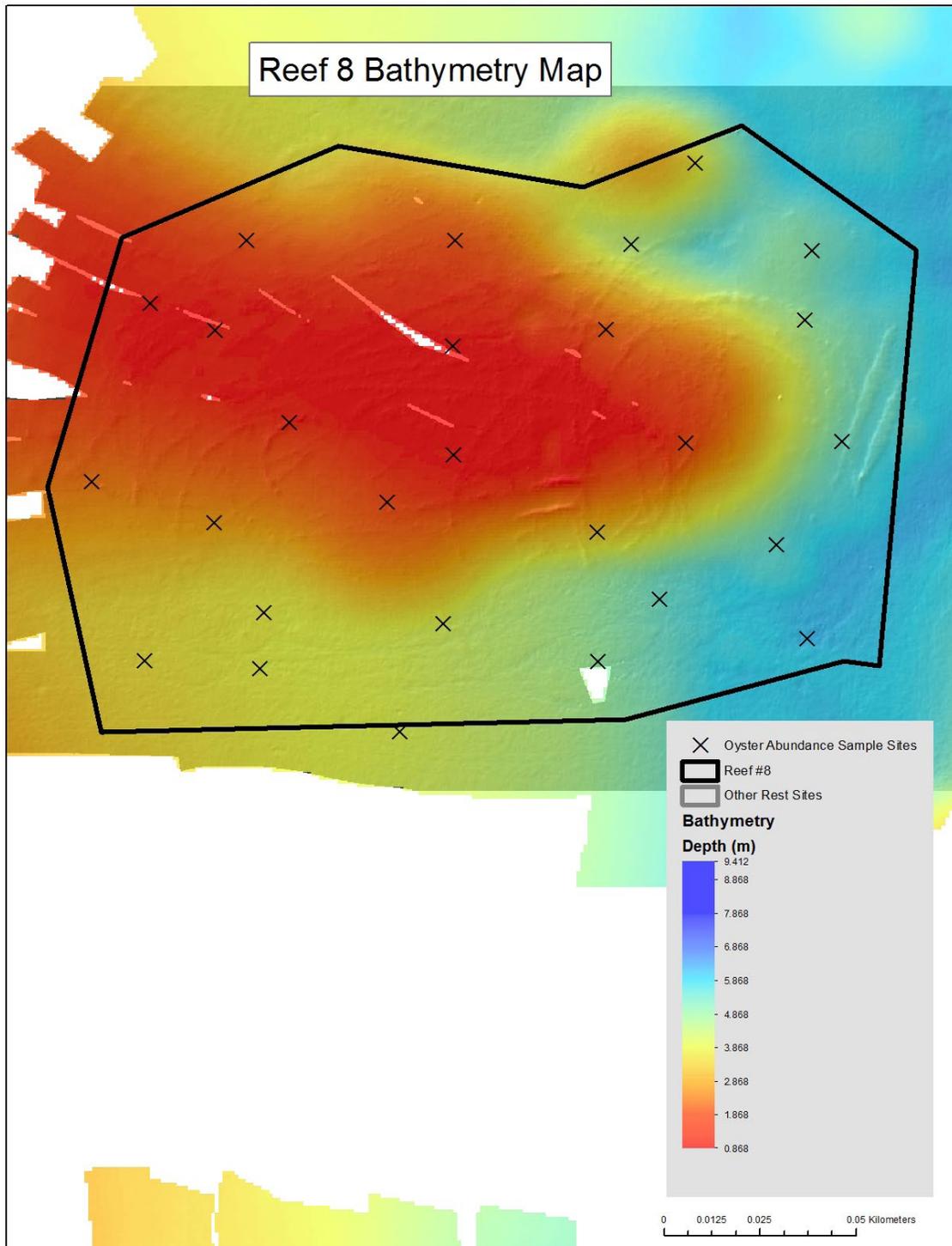
Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Fall 2015 Sonar Image of the Reef (See Figure 3 for interpretation of bathymetric features.)



Reef #9 Data and Analysis (See Figure 1 for reef location.)

Reef Monitoring Analysis

Harris Creek geodatabase Site_ID	TREATMENT_2
Reef area (acres)	12.29
Restoration treatment	Seed Only
Substrate type added	None
Year planted with spat	2012
Number of spat planted (millions)	47.23
Number of spat planted per acre (millions)	3.84
Spat produced by	University of Maryland
Spat planted by	Oyster Recovery Partnership

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	Y
Fall 2015: Did reef meet <i>target*</i> density?	N
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	Y
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	N
Avg. live oyster density across the entire reef (oysters per m2)	32.18
Standard error of live oyster density (oysters per m2)	4.65
Avg. live oyster biomass across the entire reef (g dry weight per m2)	30.01
Standard error of live oyster biomass (g dry weight per m2)	4.35
Most recent monitoring sample date	08-Dec-15
Number of samples taken	43
Number of live oysters measured	966
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	N
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

*Oyster density success criteria, per Oyster Metrics:

Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:

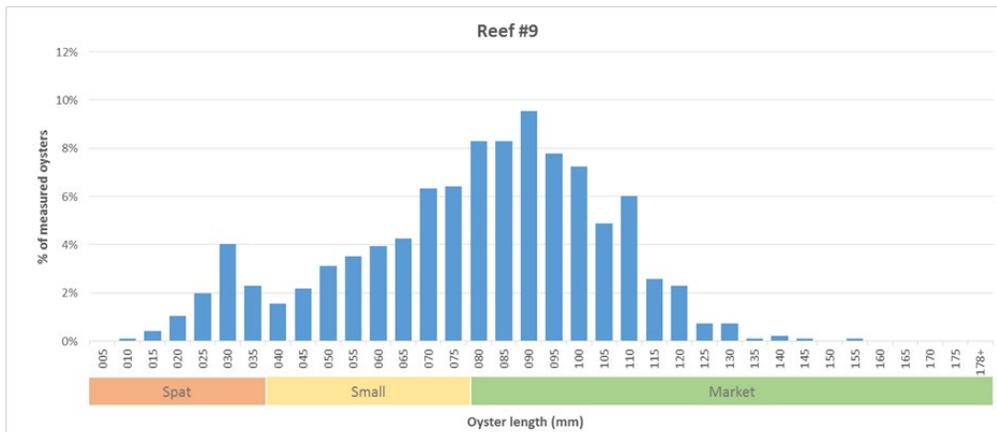
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

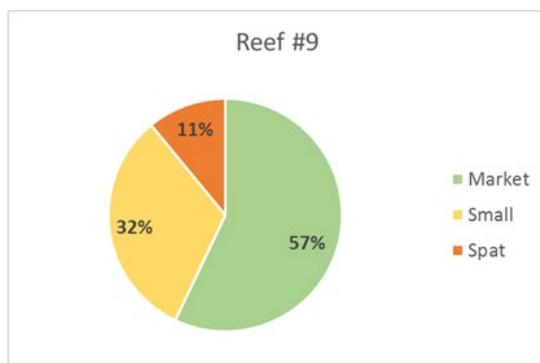
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	0.31
Max shell volume on the reef (liters)	18.63
Avg shell volume on the reef (liters)	7.82
Standard error of the shell Volume on the reef (liters)	1.06
Number of samples taken	43
% of samples containing shell	85.24
Total shell volume (liters)	384,564.43
Avg surface shell across all samples (%)	60.00
Total surface shell volume (liters)	153,825.77

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

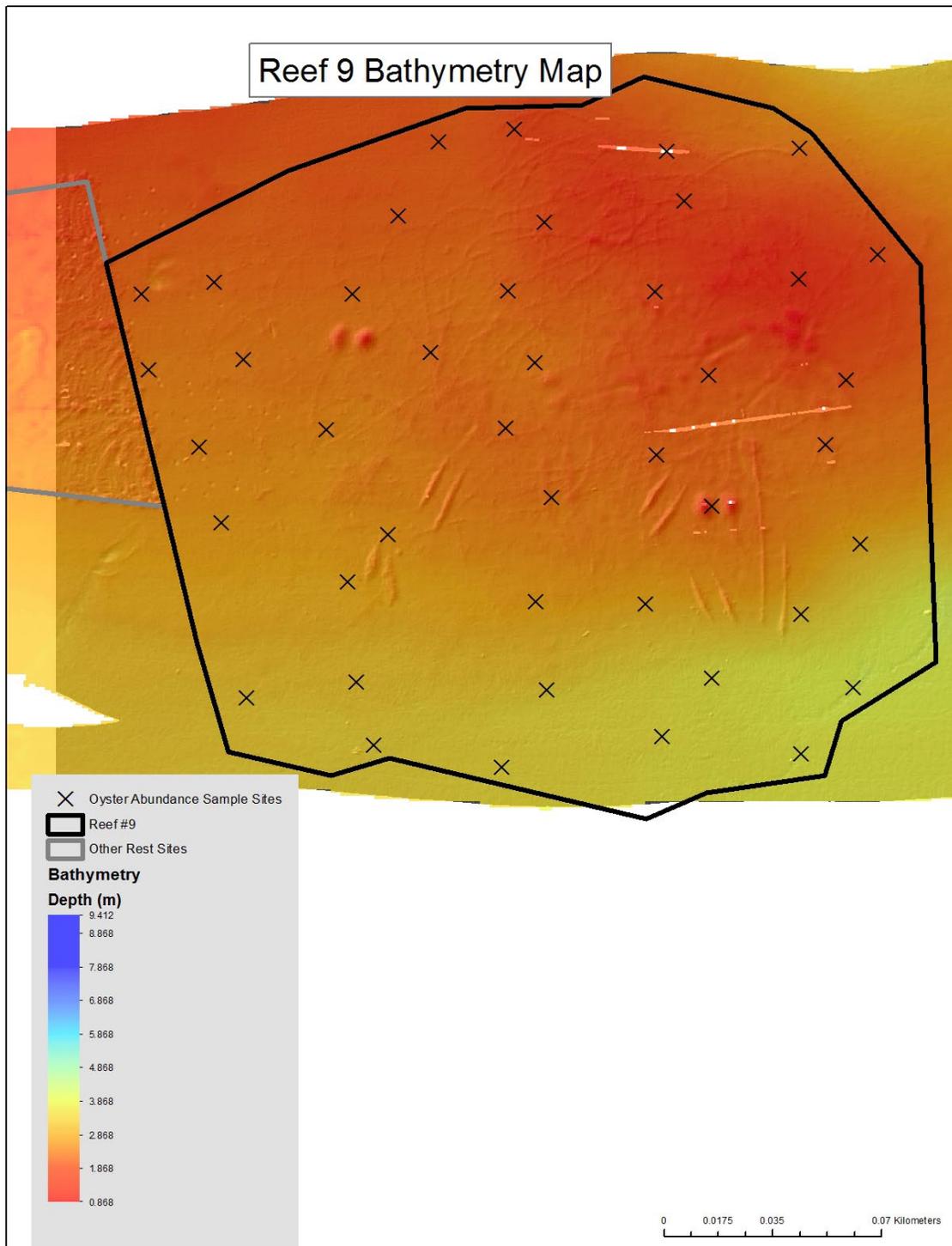
Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Fall 2015 Sonar Image of the Reef (See Figure 3 for interpretation of bathymetric features.)



Reef #10 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	TREATMENT_3
Reef area (acres)	10.88
Restoration treatment	Seed Only
Substrate type added	None
Year planted with spat	2012
Number of spat planted (millions)	52.09
Number of spat planted per acre (millions)	4.78
Spat produced by	University of Maryland
Spat planted by	Oyster Recovery Partnership

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	Y
Fall 2015: Did reef meet <i>target*</i> density?	Y
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	Y
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	Y
Avg. live oyster density across the entire reef (oysters per m2)	58.10
Standard error of live oyster density (oysters per m2)	4.56
Avg. live oyster biomass across the entire reef (g dry weight per m2)	62.72
Standard error of live oyster biomass (g dry weight per m2)	4.79
Most recent monitoring sample date	06-Dec-15
Number of samples taken	41
Number of live oysters measured	1,338
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	Y
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

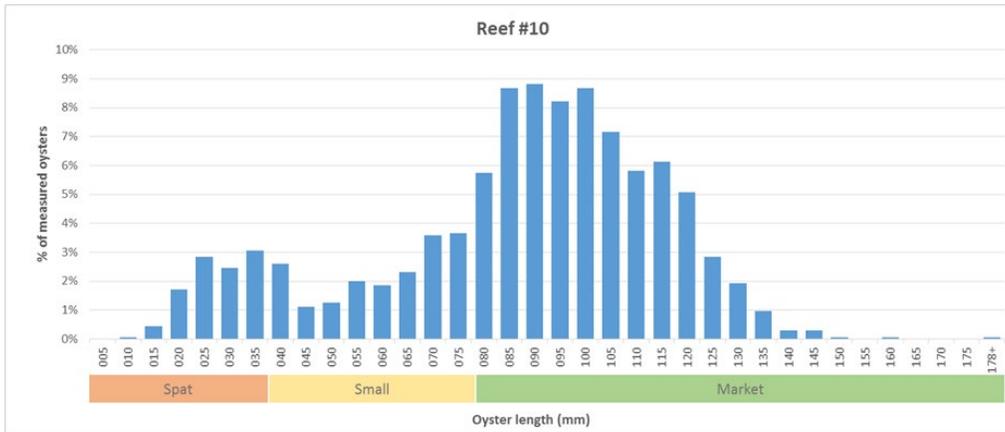
*Oyster density success criteria, per Oyster Metrics:
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.
Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.
Target: 30% of the reef area is covered with 50 oysters or more per square meter.

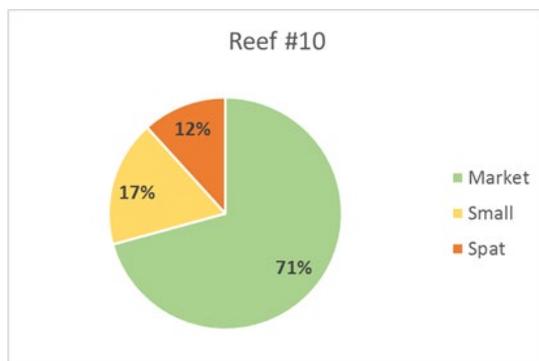
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	7.76
Max shell volume on the reef (liters)	26.40
Avg shell volume on the reef (liters)	18.42
Standard error of the shell Volume on the reef (liters)	1.23
Number of samples taken	41
% of samples containing shell	100.00
Total shell volume (liters)	800,963.10
Avg surface shell across all samples (%)	51.50
Total surface shell volume (liters)	388,467.10

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

Reef Footprint

Is the reef footprint stable or increasing?

(from post-treatment survey to fall 2015 monitoring)

TBD in 2018†

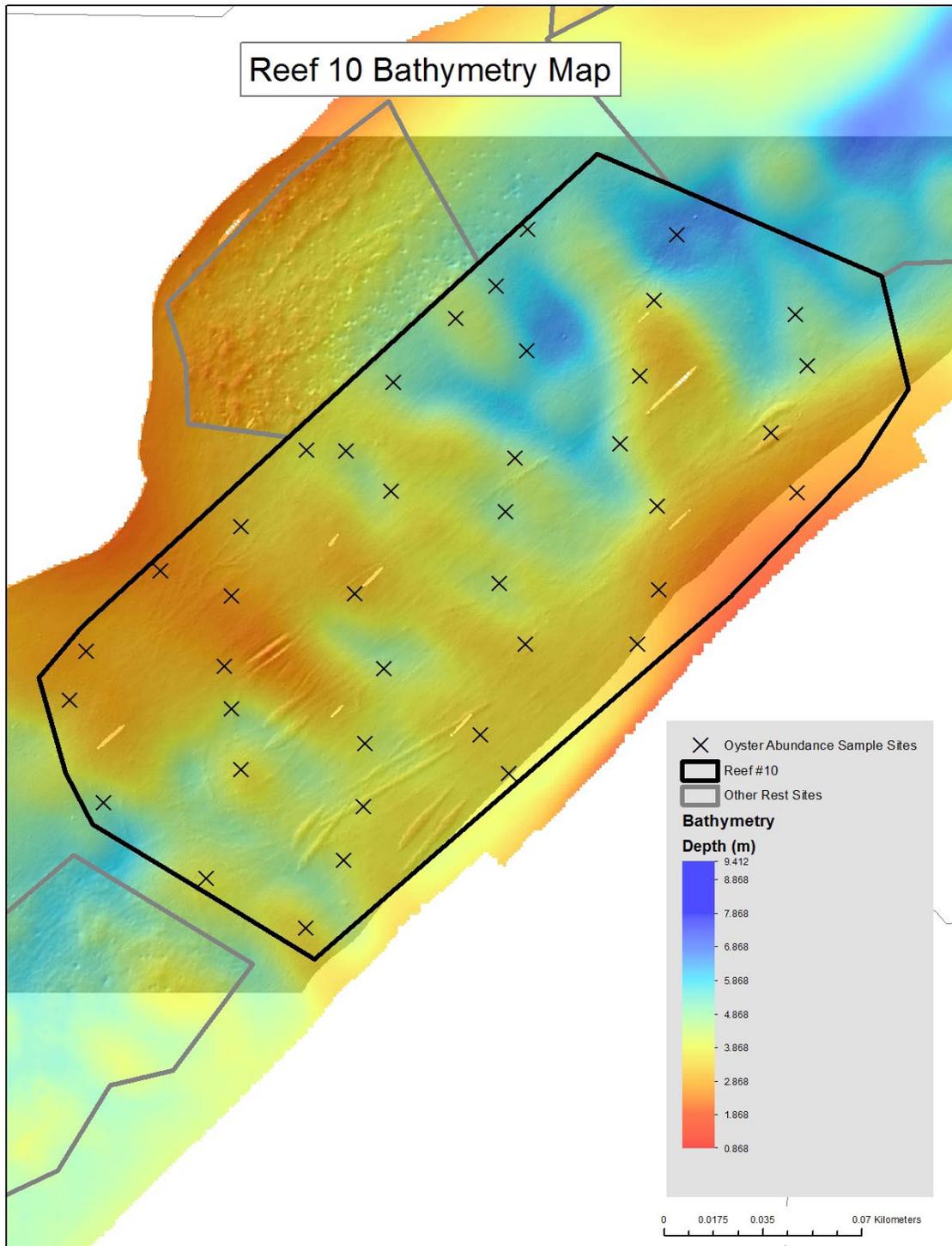
Reef Height

Is the reef height stable or increasing?

(from post-treatment survey to fall 2015 monitoring)

TBD in 2018†

Fall 2015 Sonar Image of the Reef (See Figure 3 for interpretation of bathymetric features.)



Reef #11 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	TREATMENT_4
Reef area (acres)	6.53
Restoration treatment	Seed Only
Substrate type added	None
Year planted with spat	2012
Number of spat planted (millions)	28.19
Number of spat planted per acre (millions)	4.32
Spat produced by	University of Maryland
Spat planted by	Oyster Recovery Partnership

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	Y
Fall 2015: Did reef meet <i>target*</i> density?	N
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	Y
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	N
Avg. live oyster density across the entire reef (oysters per m2)	20.39
Standard error of live oyster density (oysters per m2)	3.51
Avg. live oyster biomass across the entire reef (g dry weight per m2)	22.96
Standard error of live oyster biomass (g dry weight per m2)	3.75
Most recent monitoring sample date	24-Nov-15
Number of samples taken	23
Number of live oysters measured	511
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	N
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

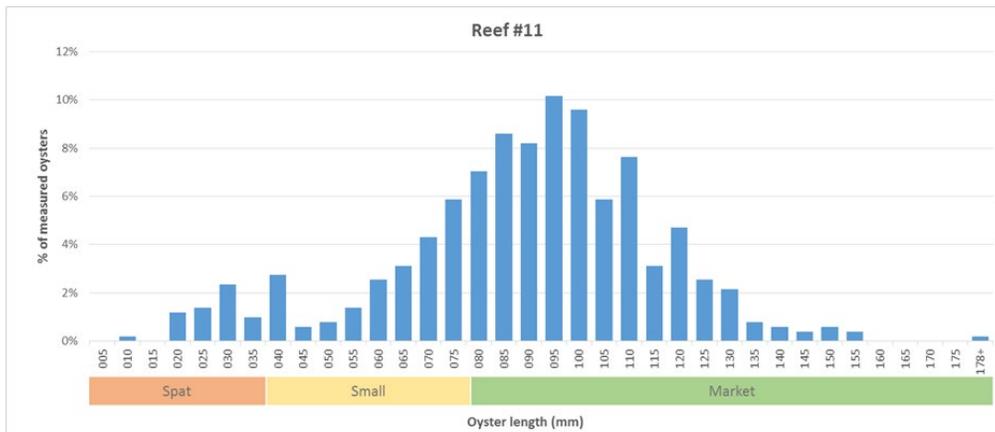
*Oyster density success criteria, per Oyster Metrics:
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.
Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.
Target: 30% of the reef area is covered with 50 oysters or more per square meter.

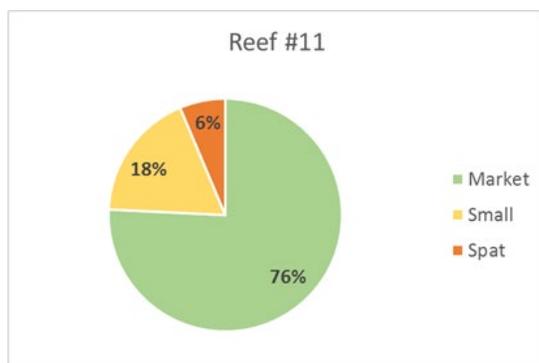
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	3.11
Max shell volume on the reef (liters)	24.84
Avg shell volume on the reef (liters)	7.72
Standard error of the shell Volume on the reef (liters)	1.21
Number of samples taken	23
% of samples containing shell	94.16
Total shell volume (liters)	189,133.95
Avg surface shell across all samples (%)	61.96
Total surface shell volume (liters)	71,953.13

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

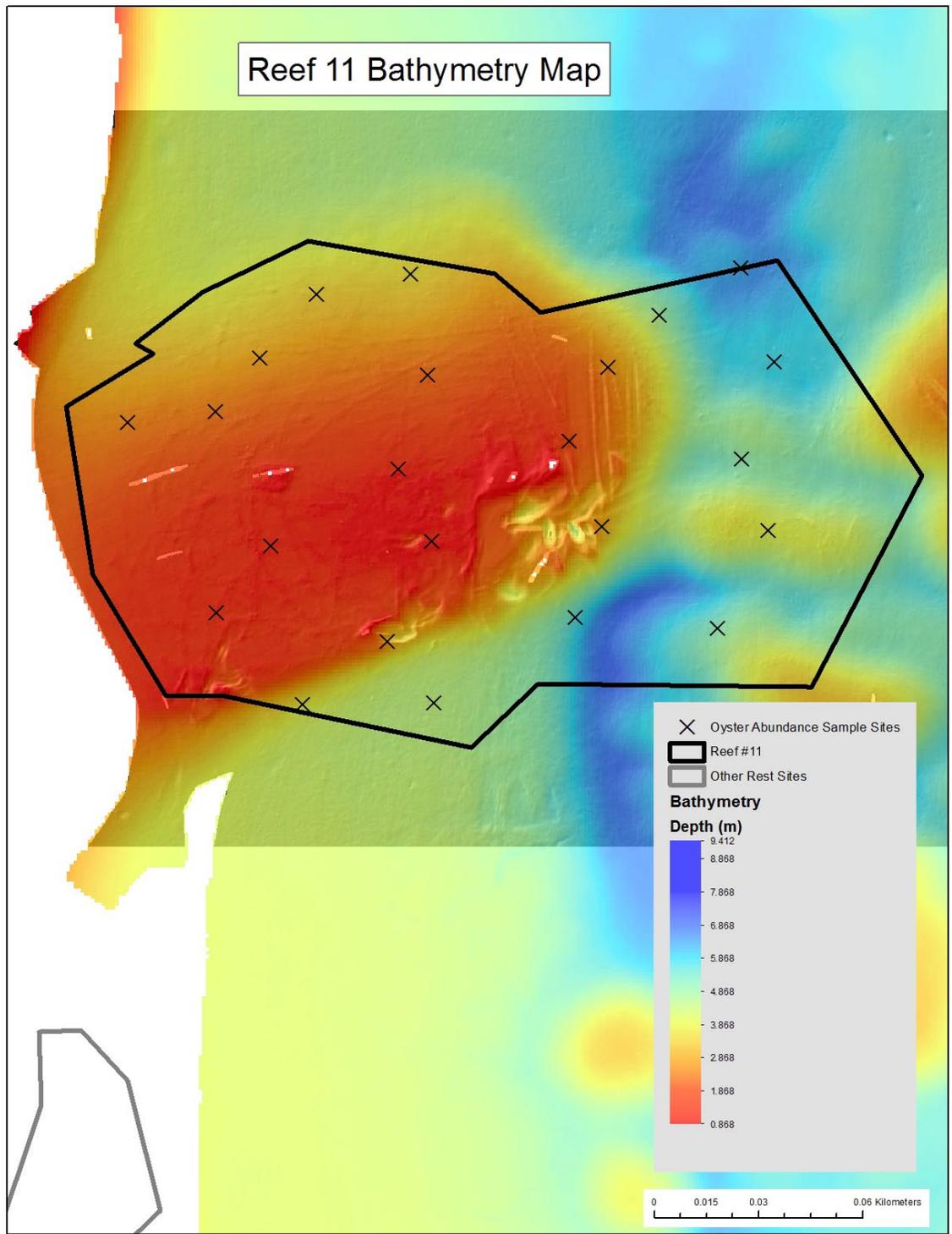
Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018+
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018+
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Fall 2015 Sonar Image of the Reef (See Figure 3 for interpretation of bathymetric features.)



Reef #12 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	TREATMENT_5
Reef area (acres)	7.83
Restoration treatment	Seed Only
Substrate type added	None
Year planted with spat	2012
Number of spat planted (millions)	31.1
Number of spat planted per acre (millions)	3.97
Spat produced by	University of Maryland
Spat planted by	Oyster Recovery Partnership

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	Y
Fall 2015: Did reef meet <i>target*</i> density?	N
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	Y
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	N
Avg. live oyster density across the entire reef (oysters per m2)	16.53
Standard error of live oyster density (oysters per m2)	3.41
Avg. live oyster biomass across the entire reef (g dry weight per m2)	20.53
Standard error of live oyster biomass (g dry weight per m2)	4.20
Most recent monitoring sample date	04-Nov-15
Number of samples taken	26
Number of live oysters measured	638
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	N
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

*Oyster density success criteria, per Oyster Metrics:

Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:

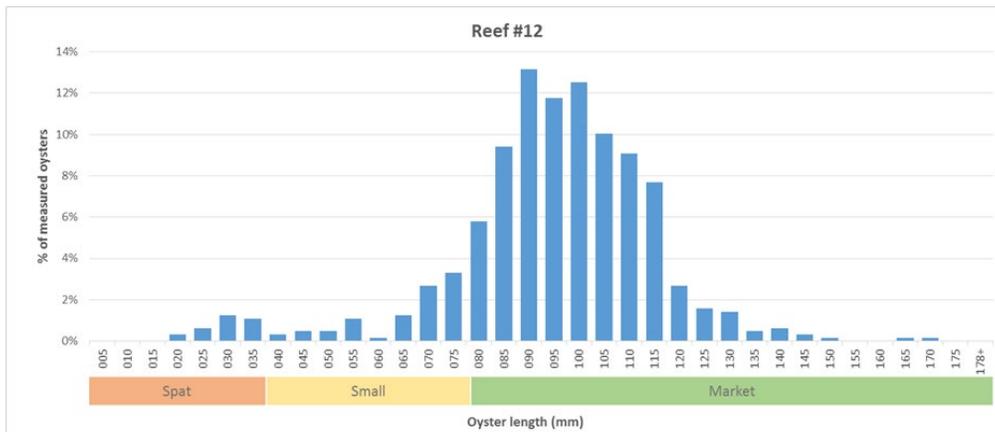
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

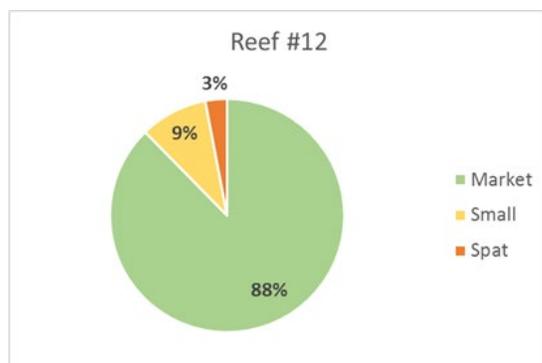
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	0
Max shell volume on the reef (liters)	17.39
Avg shell volume on the reef (liters)	6.04
Standard error of the shell Volume on the reef (liters)	1.14
Number of samples taken	26
% of samples containing shell	61.41
Total shell volume (liters)	177,721.84
Avg surface shell across all samples (%)	50.67
Total surface shell volume (liters)	87,676.11

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

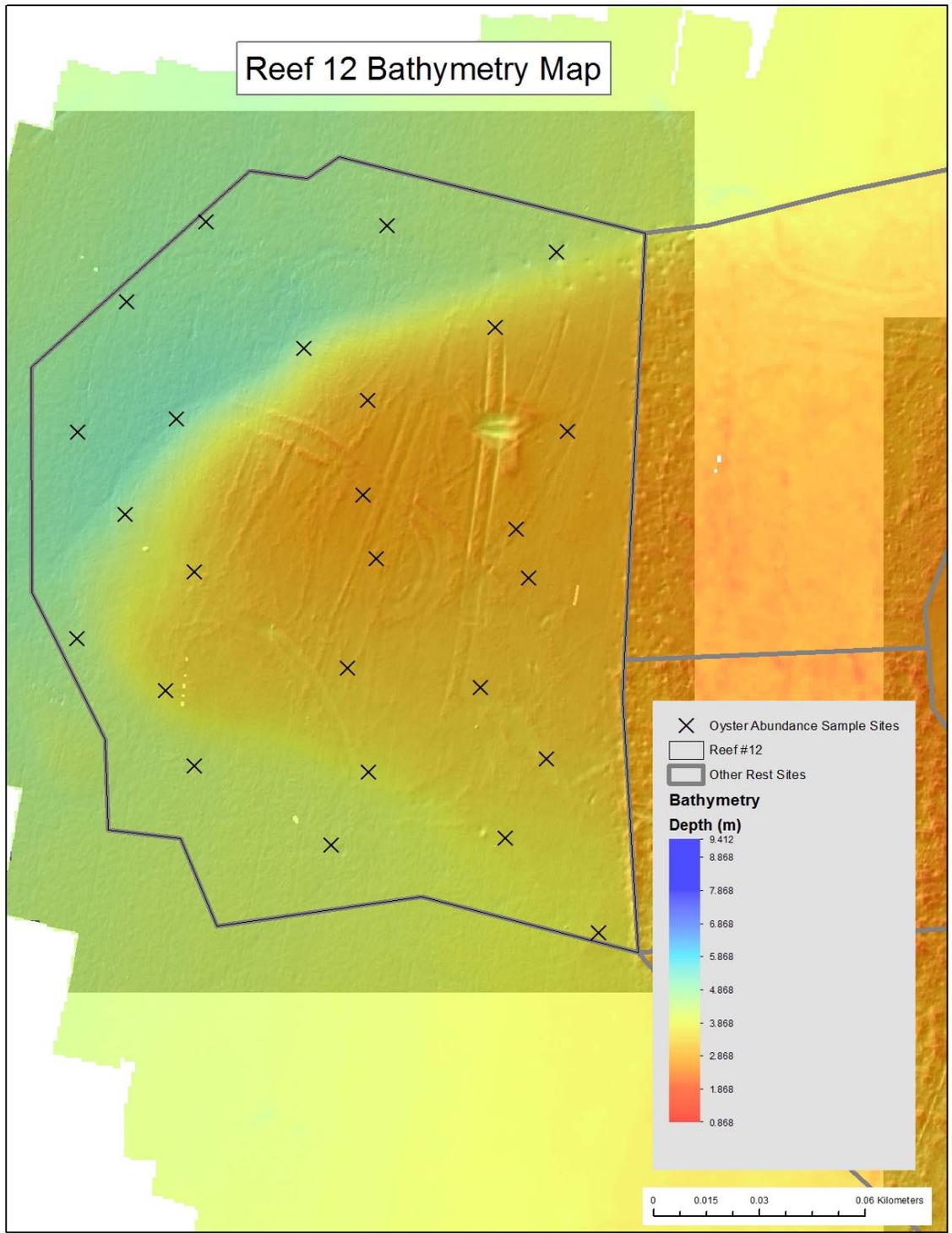
Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Fall 2015 Sonar Image of the Reef (See Figure 3 for interpretation of bathymetric features.)



Reef #13 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	EXCEEDS_GOAL_2012
Reef area (acres)	3.4
Restoration treatment	Seed Only
Substrate type added	None
Year planted with spat	2011
Number of spat planted (millions)	51.76
Number of spat planted per acre (millions)	15.22
Spat produced by	University of Maryland
Spat planted by	Oyster Recovery Partnership

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	Y
Fall 2015: Did reef meet <i>target*</i> density?	N
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	Y
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	N
Avg. live oyster density across the entire reef (oysters per m2)	33.10
Standard error of live oyster density (oysters per m2)	4.13
Avg. live oyster biomass across the entire reef (g dry weight per m2)	36.57
Standard error of live oyster biomass (g dry weight per m2)	6.02
Most recent monitoring sample date	10-Dec-15
Number of samples taken	14
Number of live oysters measured	427
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	Y
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	Y

*Oyster density success criteria, per Oyster Metrics:

Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:

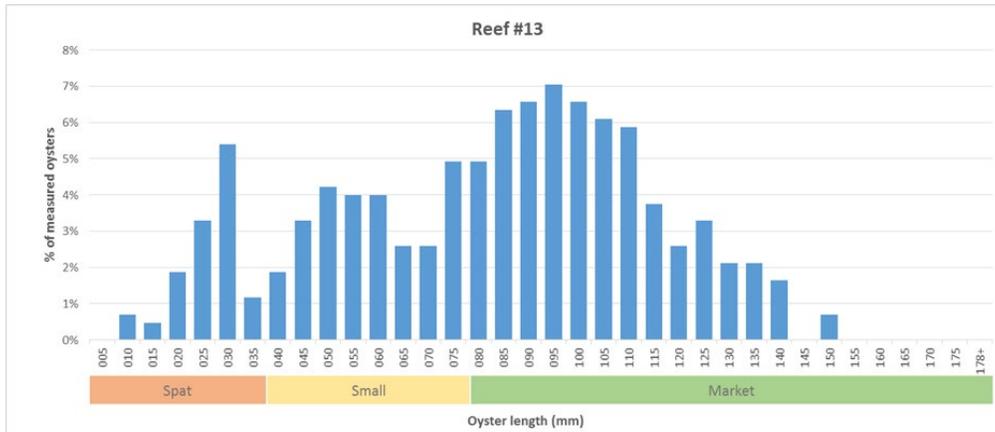
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

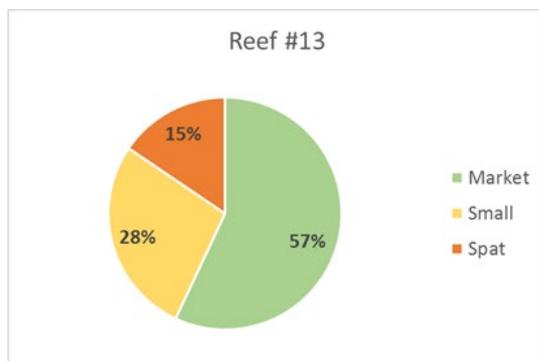
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	6.83
Max shell volume on the reef (liters)	18.01
Avg shell volume on the reef (liters)	11.45
Standard error of the shell Volume on the reef (liters)	1.28
Number of samples taken	14
% of samples containing shell	100.00
Total shell volume (liters)	154,489.87
Avg surface shell across all samples (%)	59.29
Total surface shell volume (liters)	62,899.45

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

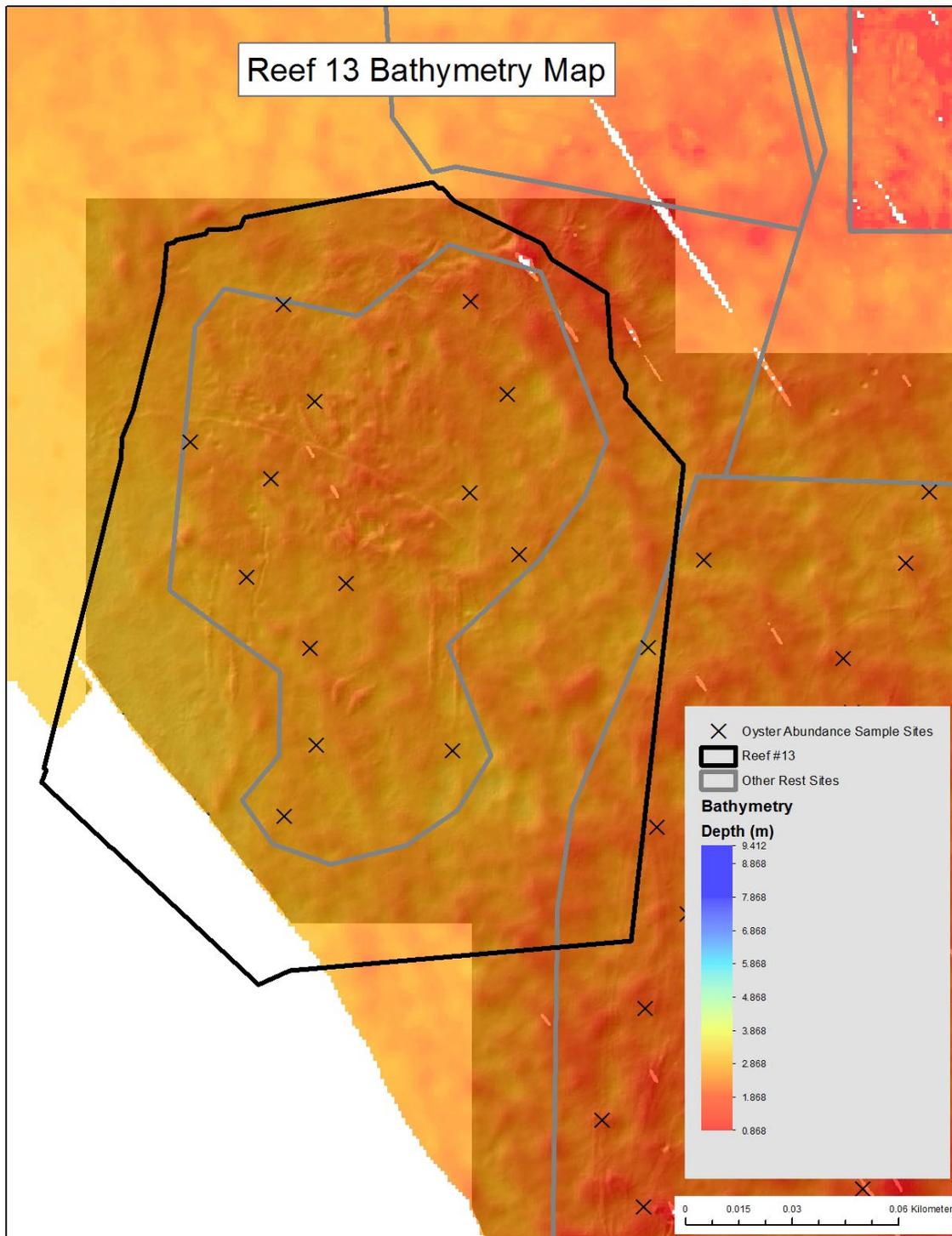
Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Fall 2015 Sonar Image of the Reef (See Figure 3 for interpretation of bathymetric features.)



Reef #14 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	CONTROL_1
Reef area (acres)	3.47
Restoration treatment	none (control site)
Substrate type added	None
Year planted with spat	N/A
Number of spat planted (millions)	0
Number of spat planted per acre (millions)	0
Spat produced by	N/A
Spat planted by	N/A

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	Y
Fall 2015: Did reef meet <i>target*</i> density?	N
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	Y
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	N
Avg. live oyster density across the entire reef (oysters per m2)	17.31
Standard error of live oyster density (oysters per m2)	3.06
Avg. live oyster biomass across the entire reef (g dry weight per m2)	20.11
Standard error of live oyster biomass (g dry weight per m2)	3.56
Most recent monitoring sample date	09-Jan-16
Number of samples taken	15
Number of live oysters measured	342
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	Y
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

*Oyster density success criteria, per Oyster Metrics:

Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:

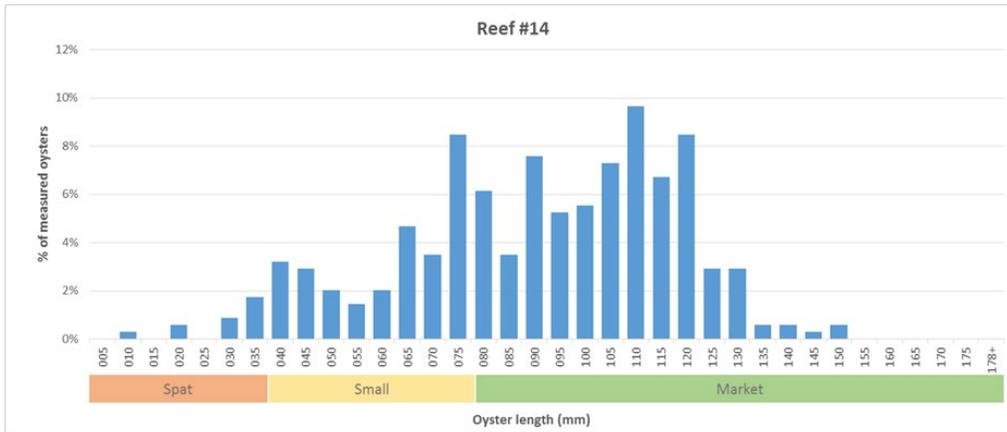
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

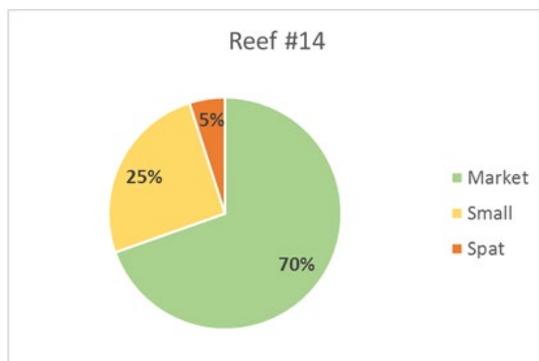
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	1.86
Max shell volume on the reef (liters)	9.94
Avg shell volume on the reef (liters)	5.67
Standard error of the shell Volume on the reef (liters)	0.87
Number of samples taken	15
% of samples containing shell	95.84
Total shell volume (liters)	79,130.76
Avg surface shell across all samples (%)	37.67
Total surface shell volume (liters)	49,324.84

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Fall 2015 Sonar Image of the Reef

(no images were taken of control sites)

Reef #15 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	CONTROL_3
Reef area (acres)	1.85
Restoration treatment	none (control site)
Substrate type added	None
Year planted with spat	N/A
Number of spat planted (millions)	0
Number of spat planted per acre (millions)	0
Spat produced by	N/A
Spat planted by	N/A

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	Y
Fall 2015: Did reef meet <i>target*</i> density?	N
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	Y
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	N
Avg. live oyster density across the entire reef (oysters per m2)	15.61
Standard error of live oyster density (oysters per m2)	5.98
Avg. live oyster biomass across the entire reef (g dry weight per m2)	9.14
Standard error of live oyster biomass (g dry weight per m2)	2.40
Most recent monitoring sample date	16-Dec-15
Number of samples taken	8
Number of live oysters measured	141
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	N
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

*Oyster density success criteria, per Oyster Metrics:

Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:

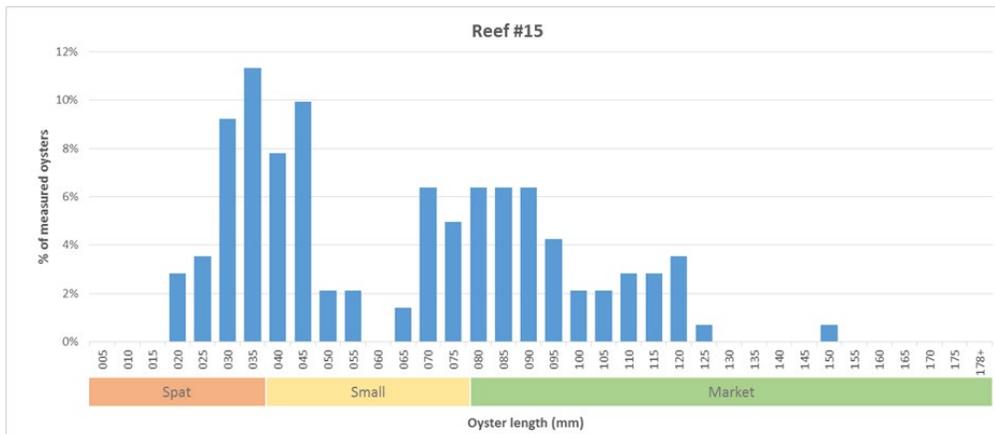
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

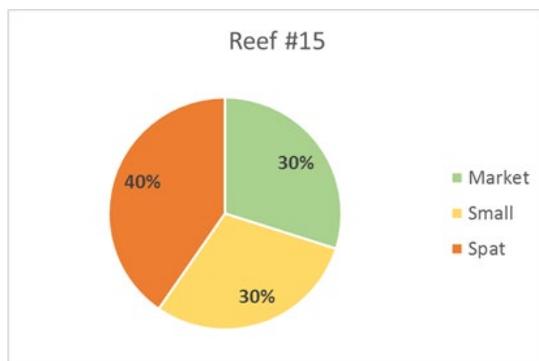
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	3.42
Max shell volume on the reef (liters)	9.32
Avg shell volume on the reef (liters)	4.66
Standard error of the shell Volume on the reef (liters)	1.00
Number of samples taken	8
% of samples containing shell	90.46
Total shell volume (liters)	33,629.92
Avg surface shell across all samples (%)	38.75
Total surface shell volume (liters)	20,598.33

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Fall 2015 Sonar Image of the Reef

(no images were taken of control sites)

Reef #16 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	CONTROL_4
Reef area (acres)	1.39
Restoration treatment	none (control site)
Substrate type added	None
Year planted with spat	N/A
Number of spat planted (millions)	0
Number of spat planted per acre (millions)	0
Spat produced by	N/A
Spat planted by	N/A

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	N
Fall 2015: Did reef meet <i>target*</i> density?	N
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	N
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	N
Avg. live oyster density across the entire reef (oysters per m2)	5.68
Standard error of live oyster density (oysters per m2)	2.50
Avg. live oyster biomass across the entire reef (g dry weight per m2)	6.45
Standard error of live oyster biomass (g dry weight per m2)	2.64
Most recent monitoring sample date	16-Dec-15
Number of samples taken	7
Number of live oysters measured	70
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	N
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

*Oyster density success criteria, per Oyster Metrics:

Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:

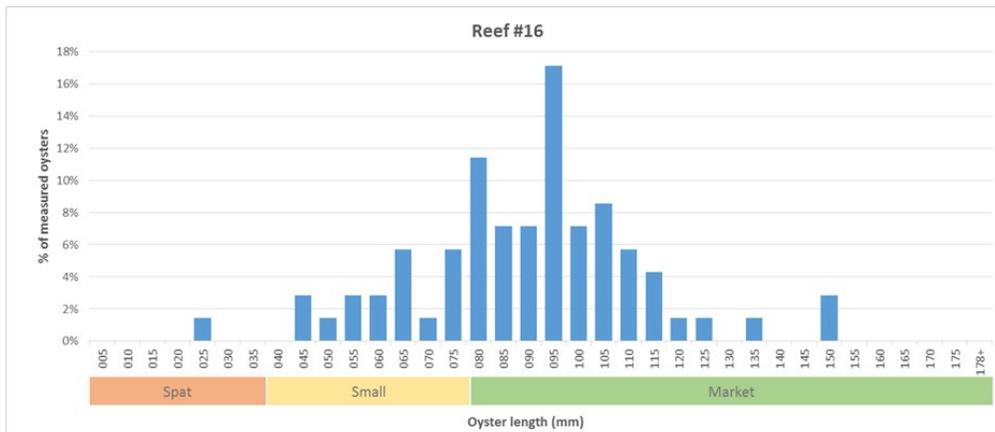
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

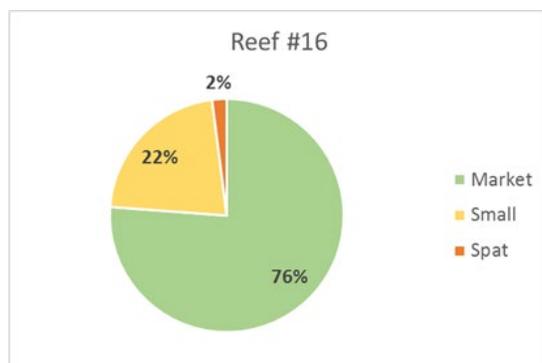
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	0.55
Max shell volume on the reef (liters)	8.01
Avg shell volume on the reef (liters)	3.24
Standard error of the shell Volume on the reef (liters)	1.45
Number of samples taken	7
% of samples containing shell	100.00
Total shell volume (liters)	17,567.70
Avg surface shell across all samples (%)	25.71
Total surface shell volume (liters)	13,050.29

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Fall 2015 Sonar Image of the Reef

(no images were taken of control sites)

Reef #17 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	CONTROL_2
Reef area (acres)	4.01
Restoration treatment	none (control site)
Substrate type added	None
Year planted with spat	N/A
Number of spat planted (millions)	0
Number of spat planted per acre (millions)	0
Spat produced by	N/A
Spat planted by	N/A

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	N
Fall 2015: Did reef meet <i>target*</i> density?	N
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	N
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	N
Avg. live oyster density across the entire reef (oysters per m2)	4.42
Standard error of live oyster density (oysters per m2)	2.20
Avg. live oyster biomass across the entire reef (g dry weight per m2)	4.76
Standard error of live oyster biomass (g dry weight per m2)	2.10
Most recent monitoring sample date	10-Dec-15
Number of samples taken	17
Number of live oysters measured	92
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	N
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

*Oyster density success criteria, per Oyster Metrics:

Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:

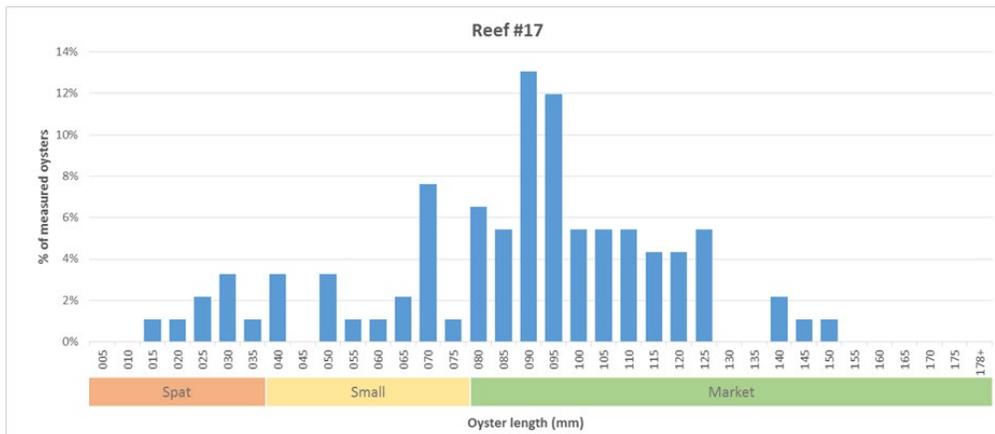
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

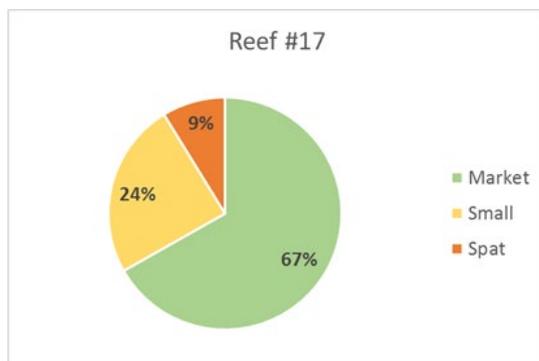
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	1.24
Max shell volume on the reef (liters)	12.42
Avg shell volume on the reef (liters)	3.62
Standard error of the shell Volume on the reef (liters)	0.94
Number of samples taken	17
% of samples containing shell	85.33
Total shell volume (liters)	58,401.35
Avg surface shell across all samples (%)	25.29
Total surface shell volume (liters)	43,629.24

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	TBD in 2018†
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Fall 2015 Sonar Image of the Reef

(no images were taken of control sites)

Reef #18 Data and Analysis (See Figure 1 for reef location.)

Reef Information and Restoration Treatment

Harris Creek geodatabase Site_ID	AltSub_20A
Reef area (acres)	2.35
Restoration treatment	Substrate (stone) & Seed
Substrate type added	Stone
Year planted with spat	2013
Number of spat planted (millions)	16.46
Number of spat planted per acre (millions)	7
Spat produced by	University of Maryland
Spat planted by	Oyster Recovery Partnership

Reef Monitoring Analysis

Each Oyster Metric is noted below, along with data acquired as part of the fall 2015 monitoring. See Methods section for full explanation of how information was collected and analyzed. Parameters in **bold** are Chesapeake Bay Oyster Metrics success criteria.

Oyster Density and Oyster Biomass

Fall 2015: Did reef meet <i>minimum threshold*</i> density?	Y
Fall 2015: Did reef meet <i>target*</i> density?	Y
Fall 2015: Did reef meet <i>minimum threshold**</i> oyster biomass?	Y
Fall 2015: Did reef meet <i>target**</i> oyster biomass?	Y
Avg. live oyster density across the entire reef (oysters per m2)	172.22
Standard error of live oyster density (oysters per m2)	35.39
Avg. live oyster biomass across the entire reef (g dry weight per m2)	147.65
Standard error of live oyster biomass (g dry weight per m2)	42.69
Most recent monitoring sample date	02-Nov-15
Number of samples taken	9
Number of live oysters measured	891
Pre-restoration (2012): Did reef meet <i>threshold</i> oyster density?	N
Pre-restoration (2012): Did reef meet <i>target</i> oyster density?	N

*Oyster density success criteria, per Oyster Metrics:

Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

**Oyster biomass success criteria, per Oyster Metrics:

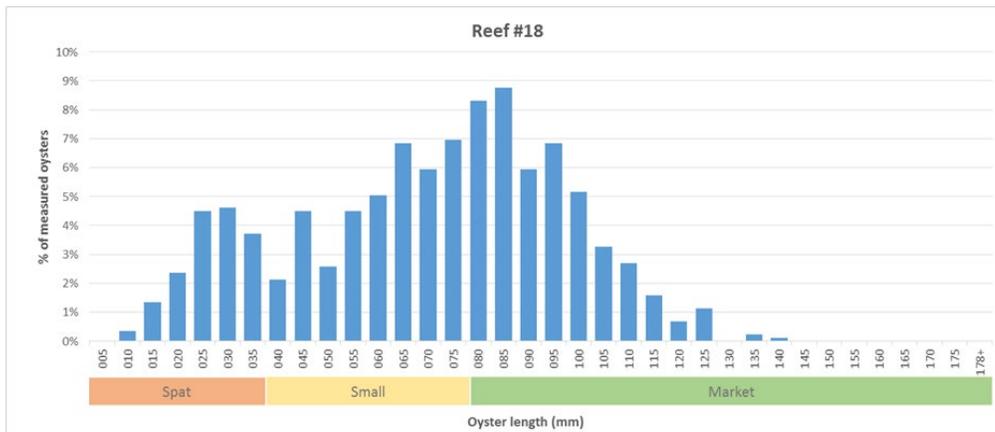
Minimum threshold: 30% of the reef area is covered with at least 15 oysters per square meter.

Target: 30% of the reef area is covered with 50 oysters or more per square meter.

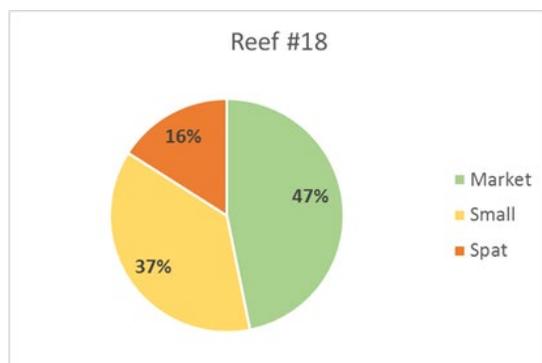
Presence of Multiple Year Classes of Oysters

Does this reef have multiple year classes of oysters as of fall 2015?	Y
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Length of Oysters Measured on Reef



Percent of Measured Oysters in the Market, Small, and Spat Categories



Shell Budget

Is this reef's shell budget stable or increasing?	TBD in 2018†
Min shell volume on the reef (liters)	20.00
Max shell volume on the reef (liters)	55.00
Avg shell volume on the reef (liters)	17.22
Standard error of the shell Volume on the reef (liters)	7.46
Number of samples taken	9
% of samples containing shell	52.74
Total shell volume (liters)	162,128.63
Avg surface shell across all samples (%)	81.67
Total surface shell volume (liters)	29,723.58

†Data collected in fall 2015 will serve as baseline for this metric. This will be compared to data collected in fall 2018 to determine if this metric was successfully met. See Methods section for full explanation.

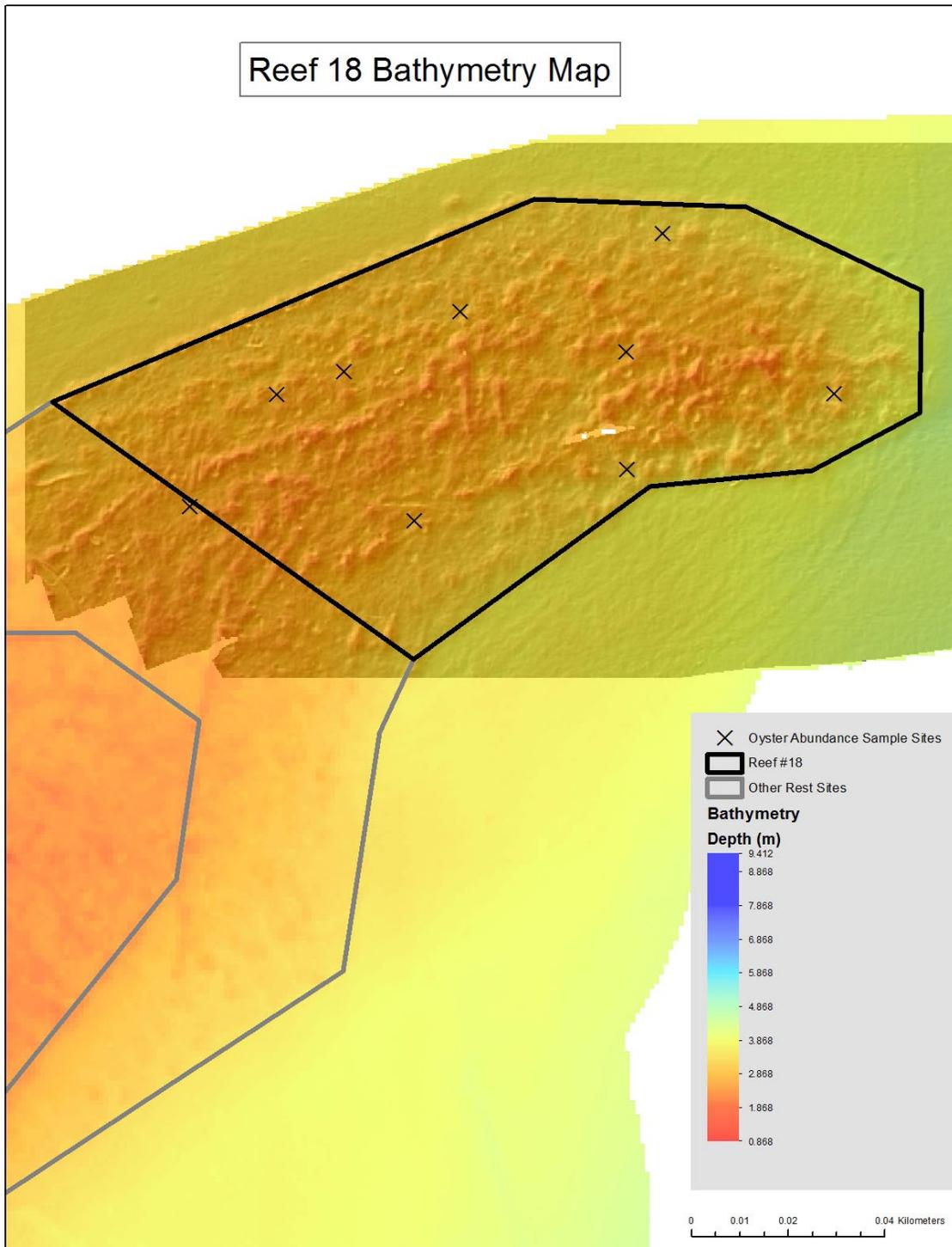
Reef Footprint

Is the reef footprint stable or increasing? (from post-treatment survey to fall 2015 monitoring)	Y
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Reef Height

Is the reef height stable or increasing? (from post-treatment survey to fall 2015 monitoring)	Y
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Fall 2015 Sonar Image of the Reef (See Figure 3 for interpretation of bathymetric features.)



References

1. Oyster Metrics Workgroup. Restoration Goals, Quantitative Metrics and Assessment Protocols for Evaluating Success on Restored Oyster Reef Sanctuaries. Report to the Sustainable Fisheries Goal Implementation Team of the Chesapeake Bay Program. 2011. Available from www.chesapeakebay.net/channel_files/17932/oyster_restoration_success_metrics_final.pdf.
2. Maryland Interagency Oyster Restoration Workgroup of the Sustainable Fisheries Goal Implementation Team. Harris Creek Oyster Restoration Tributary Plan: A blueprint to restore the oyster population in Harris Creek, a tributary of the Choptank River on Maryland's Eastern Shore. 2013. Available from www.chesapeakebay.noaa.gov/images/stories/habitats/harrisreekbblueprint1.13.pdf.
3. Slacum H.W., Jr., L. Methratta, and J. Dew. A Sampling Plan to Provide Spatially-Explicit Oyster Demographic Data to Guide Restoration Planning and Assess Restoration Success. Prepared for NOAA Chesapeake Bay Office, Annapolis, Maryland, by Versar, Inc., Applied Ecosystem Assessment Group, Columbia, Maryland; 2012. 18 pp.
4. Slacum H.W., Jr., J. Dew, and D. Wong. An Assessment of Oyster Resources in Harris Creek and Little Choptank River, Chesapeake Bay. Prepared for NOAA Chesapeake Bay Office, Annapolis, Maryland, by Versar, Inc., Applied Ecosystem Assessment Group, Columbia, Maryland; 2012. 81 pp.
5. Cochran, W.G. Sampling Techniques, 3rd edition. John Wiley & Sons, Inc., New York; 1977. 428 pp.
6. Mann, R. and D.A. Evans. 1998. Estimation of oyster, *Crassostrea virginica*, standing stock, larval production, and advective loss in relation to observed recruitment in the James River, Virginia. *Journal of Shellfish Research* 17(1): 239-253.
7. Office of Coast Survey, National Ocean Service, National Oceanic and Atmospheric Administration. Hydrographic Surveys Specifications and Deliverables. 2016. Available from www.nauticalcharts.noaa.gov/hsd/specs/specs.htm

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