

## Severn River 2021 Oyster Dive Report

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February 25, 2022

### Background

Starting in the summer of 2010, the Severn River has received plantings of oyster spat-on-shell by the Severn River Association (SRA) and the Oyster Recovery Partnership (ORP) three established Yates bars known locally as Peach Orchard, Wade and Weems Upper (Table 1 and Figure 1.) Additionally, SRA leads the Marylanders Grow Oysters (MGO) program in the Severn River to plant oysters over one established Yates bar at the reef area known as Traces Hollow. This team was tasked with assessing the spat survival and analyze any growth patterns and mortality for all of these sites in the Severn River. Multiple dives were conducted on each of the oyster bars (see dots in the chart below).

Table 1. Site characteristics for each monitored reef in the Severn River during the 2021 diver efforts.

River	Bar Name	Site Name	Site Acreage	Substrate
Severn River	Peach Orchard	PO_01	1.28	Granite
Severn River	Traces Hollow (MGO)	TH_1A	2.26	Granite
Severn River	Wade	WA_02	3.76	Granite
Severn River	Weems Upper	WU_01	2.71	Granite w/shell

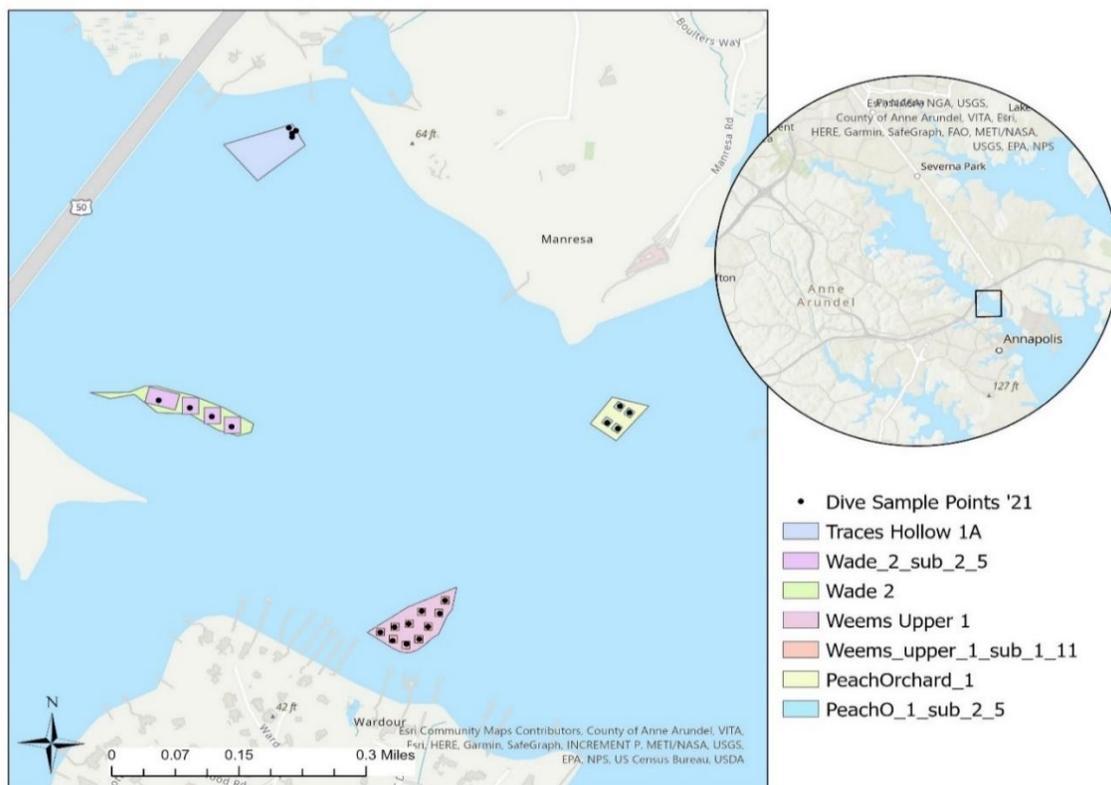


Figure 1. Map of all Yates Bars and sites sampled by divers in 2021 in the Severn River.

## Methods

For the 2021 Severn River oyster population analysis, sampling efforts were selected based on Bar, site, and in some cases, sub-site. Using ArcGIS, random sampling points were selected within each of the restoration sites studied (Figure 1). The reefs on Peach Orchard, Wade, and Traces Hollow were sampled 4 times each while the SRA dive team sampled 10 areas within the Weems Upper site.

Samples of oysters and substrate were collected using SCUBA techniques. Diver operations were conducted from the SRA's scientific research vessel, *Sea Girl*. Coordinates of the sampling points were programmed onto the vessel's Lowrance positioning unit. Sampling locations on each reef were marked in the field by deploying dive flag-labeled buoys with anchors. Divers descended to the bottom at each buoy with a 0.71m x 0.71m (0.5041m<sup>2</sup>) quadrat and sample collection bags. Upon descent, the area around the dive anchor was inspected for oyster presence. If no oysters were visible, the diver conducted a circle-search pattern around the dive anchor until the divers located enough oysters to guarantee survival metrics could be determined. The quadrat was placed up-current of the dive anchor, with one corner touching the anchor. A combination of measurements were collected from in-situ observations by divers and from samples of oysters and substrate collected and processed in the field and in the laboratory (Table 2).

Table 2. Three-year check in survey metrics. Data collected with each sample are described.

Data Collection Location	Data Type	Description
In Field	Planting accuracy	Note if there are clear planting mounds or some straggling shells outside of planting delineations.
	Sediment Depth	Depth of sediment buildup over top layer of oysters.
	Substrate Types	Primary and secondary substrate seen within quad.
	Bottom Oyster	Number of live, box, and gaper oysters left on the bottom.
	% Alternate Substrate	Percent of quad filled with granite/rock/concrete.
In Lab	Oyster number	Count of each live or dead (box or gaper) oyster in each sample.
	Oyster size (mm)	Measurement of each live and dead oyster. At minimum, fifty oysters of each live, box, and gaper in each sample were measured.
	Oyster Volume (L)	Liters of oysters per sample
	% Black Shell	Percent of total oyster sample stained black.
	Predation Markers	Note any clear shell shearing from crab predation or clearing scars from harvest equipment
% Fouling	Percent of total oyster surface area covered by fouling organisms (barnacles, tunicates, mussels, etc.)	

## Data Analysis Methods

Paper copies of all raw data were maintained and entered into Excel worksheets. Quality control and assurance was performed on all survey data. All observed and measured variables were averaged at the reef level and compared against a set of biological performance metrics (Table 3) set by the Maryland Oyster Advisory Commission.

Table 3. Three biological metrics used to evaluate the performance of reefs constructed with granite and granite with shell veneer located in the Severn River.

Metric	Tolerance Level	Value	Criteria
Oyster Density	Target	50 Oysters/m <sup>2</sup>	30% of Reef Area
	Minimum threshold	15 Oysters/m <sup>2</sup>	
Oyster Biomass	Target	50g dry weight/m <sup>2</sup>	
	Minimum threshold	15g dry weight/m <sup>2</sup>	
Multiple Year Class		Present	Entire Reef

Data analysis methods follow those established by the Oyster Advisory Commission to guarantee comparable statistics across agencies.

Oyster density estimates were standardized to number of individual oysters collected in diver quadrats standardized to m<sup>2</sup>. 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 according to Liddel (2007). Biomass was then summed for the entire sample and standardized using the same method as density estimates. Biomass values were averaged over all samples collected at an individual reef. The standard error of the mean is estimated for all density and biomass estimates.

The presence of two, or more, year classes of live oysters was approximated by examining height frequency data 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; spat <40 mm) were present.

It is typically estimated that 20% of oysters survive after the first 6-8 weeks after planting. Optimally, oysters prefer an environment with 10-15 ppt salinity and above 5 mg/L of oxygen for proper growth and reproduction. In optimal conditions, oysters can grow an average of 50-60 mm in their first year, followed by 25-30mm each year after.

## Results

The diver operations performed in 2021 assessed several plantings occurring from 2010 – 2020. All recorded plantings are for reefs on Peach Orchard, Wade, Weems Upper (Table 4). Additionally, the Marylanders Grow Oysters (MGO) reef on Traces Hollow was planted annually by citizens starting in 2011, except for the year 2020, totaling 9 years of plantings. The MGO reefs average about 460,000 spat-on-shell per year. All spat is supplied by the Horn Point Hatchery in Cambridge, MD and distributed by the Oyster Recovery Program for the Severn River Association.

Table 4. Planting metrics for all Yates Bar plantings in the Severn River from 2010 – 2020, excluding the MGO site on Traces Hollow.

<b>Planting Date</b>	<b>River</b>	<b>Bar Name</b>	<b>Site Name</b>	<b>Amt. Planted (million)</b>	<b>Substrate</b>
8/23/2010	Severn River	Peach Orchard	PO_01	5.66	Granite
8/14/2018	Severn River	Peach Orchard	PO_01	6.06	Granite
8/7/2018	Severn River	Peach Orchard	PO_02	10.78	Granite
5/21/2013	Severn River	Peach Orchard	PO_02, PO_03	18.49	Granite
8/23/2010	Severn River	Wade	WA_01, WA_02	5.33	Granite
9/27/2010	Severn River	Wade	WA_01, WA_02	11.38	Granite
6/5/2012	Severn River	Wade	WA_02	5.74	Granite
6/6/2012	Severn River	Wade	WA_02	11.2	Granite
7/23/2020	Severn River	Wade	WA_02	16.9	Granite
8/3/2010	Severn River	Weems Upper	WU_01	10.06	Granite w/shell
8/9/2010	Severn River	Weems Upper	WU_01	11.29	Granite w/shell
8/11/2010	Severn River	Weems Upper	WU_01	16.81	Granite w/shell
5/20/2013	Severn River	Weems Upper	WU_01	25.94	Granite w/shell
7/23/2018	Severn River	Weems Upper	WU_01	11.06	Granite w/shell
7/26/2018	Severn River	Weems Upper	WU_01	9.96	Granite w/shell
8/8/2018	Severn River	Weems Upper	WU_01	7.28	Granite w/shell

During the first day of sampling, 1 bag was lost from the Wade\_02 site and another bag was lost from the Peach Orchard\_01 site. Samples had been split between two bags during collection, so the oyster count sampled was doubled to compensate for the lost bag.

The Peach Orchard\_01 site was planted twice in 2010 and 2018 with a total of 11.72 million spat over the granite bottom. Wade\_02 was planted in 2010, 2012, and a third time in 2020 with a total of 48.32 million spat over a granite bottom. Weems Upper\_01 was planted in 2010, 2013, and 2018 with a total of 92.40 million spat over a granite with shell veneer bottom (Table 4). The Traces Hollow\_1A site was

estimated to have a total of 4.14 million spat based on the annual citizen plantings of 460,000 spat per year.

Table 5. Observed and measured variables collected by divers and average metrics from data collected at the four constructed reefs sampled in the Severn River in 2021.

Site Name	Site Acreage	Sample Date	# of Samples	# Live Measured	# Live Counted	# Dead Counted	% Dead Population	Avg. Live Density (#/m <sup>2</sup> )	Avg. Live Biomass (g dry weight/m <sup>2</sup> )
PO_01	1.28	6/21/2021, 6/29/2021	4	32	32	36	53%	19.5	36.1
TH_1A	2.26	6/16/2021, 6/28/2021	5	173	267	169	39%	104.0	201.6
WA_02	3.76	6/16/2021, 6/29/2021	4	182	877	113	11%	463.5	405.5
WU_01	2.71	6/29/2021, 7/12/2021	10	428	587	417	42%	127.4	284.5

Based on the collected samples (Table 5), the Wade\_02 site had the highest sampled live density at 463 oysters per square meter and the lowest dead population with only 11% of the population consisting of boxes or gapers. The site with the lowest live density and the highest percent of dead oysters was the Peach Orchard\_01 site. The Peach Orchard\_1 site was the only site to not meet the target live density or target biomass density (Table 6).

Table 6. Identifying reefs that have met the minimum restoration threshold of 15 oysters/m<sup>2</sup> and 15 g/m<sup>2</sup> of dried biomass and the restoration target threshold of 50 oysters/m<sup>2</sup> and 50 g/m<sup>2</sup> of dried biomass.

Site ID	Ave. live density (#/ m2)	Did reef meet minimum threshold* density?	Did reef meet target* density?	Ave. live biomass (g/ m2)	Did reef meet minimum threshold* biomass?	Did reef meet target* oyster biomass?
Peach Orchard_1	19.5	YES	NO	36.1	YES	NO
Traces Hollow_1A	104.0	YES	YES	201.6	YES	YES
Wade_2	463.5	YES	YES	405.5	YES	YES
Weems Upper_1	127.4	YES	YES	284.5	YES	YES

## Peach Orchard 1 site

The Peach Orchard\_1 site was built with granite and planted in 2010 and 2018 with a total of 11.72 million spat over 1.28 acres. It is important to note that there was one lost sample bag at this site, so the height distribution and size class graphs are only representing half of the sampled stock. Additionally, despite divers' best efforts, it was difficult to locate accurate planting locations, so sample sizes were smaller than expected.

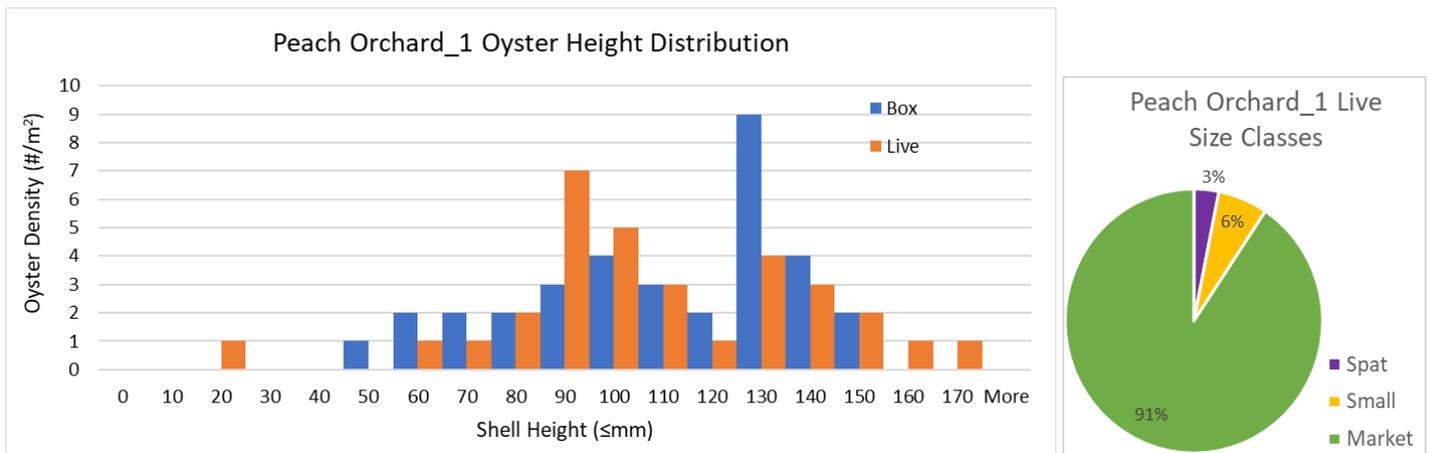


Figure 2. Peach Orchard\_1 relative height frequencies for live and dead oysters (left) and size class distribution for live oysters (right).

Peach Orchard\_1 had an average live oyster density of 19.5 oysters/m<sup>2</sup> and average live oyster biomass of 36.1 g dry weight/m<sup>2</sup> (Table 5). The population structure (Figure 2) of oysters observed at Peach Orchard\_1 was mostly comprised of market size (91%) with some small oysters (6%) and spat (3%). The smallest live oyster was measured at 15 mm with the next smallest at 54mm.

At the time of sampling, the last planting was 3 years old, providing an estimated average height for this planting of 100mm. Given that we measured oysters smaller than that, we can infer that natural reproduction is occurring at this site. There were 3 live oysters measured at less than 75 mm with the smallest live oyster measured at 15mm. During the previous sampling in 2018, the smallest oyster measured was 56 mm, so new reproduction appears to be present. Additionally, during the 2021 sampling, oysters were found attached to non-hatchery material, like granite, which would be proof of natural reproduction.

The last time this site was sampled, in 2018, the average density was 28 oysters/m<sup>2</sup> and 63.8 g/m<sup>2</sup>, suggesting a possible loss in biomass. In 2021, 53% of the sampled population was comprised of dead oysters with a large spike in dead oysters found in the 120-130mm range. In 2018, there had been a large spike in live oysters in the 110-130mm range suggesting a mortality event in 2019-2020. The percent of the total population that were dead increased from 17% in 2018 to 52% in 2021.

## Wade\_2 site

The Wade\_2 site was built with granite and planted in 2010, 2012, and 2020 with a total of 48.32 million spat over 3.76 acres. This site was only one of two Severn River reefs planted in 2020 with a new saltwater tolerant brood stock to test spat growth improvements.

It is important to note that there was one lost sample bag at this site, so the height distribution and size class graphs are only representing half of the sampled stock.

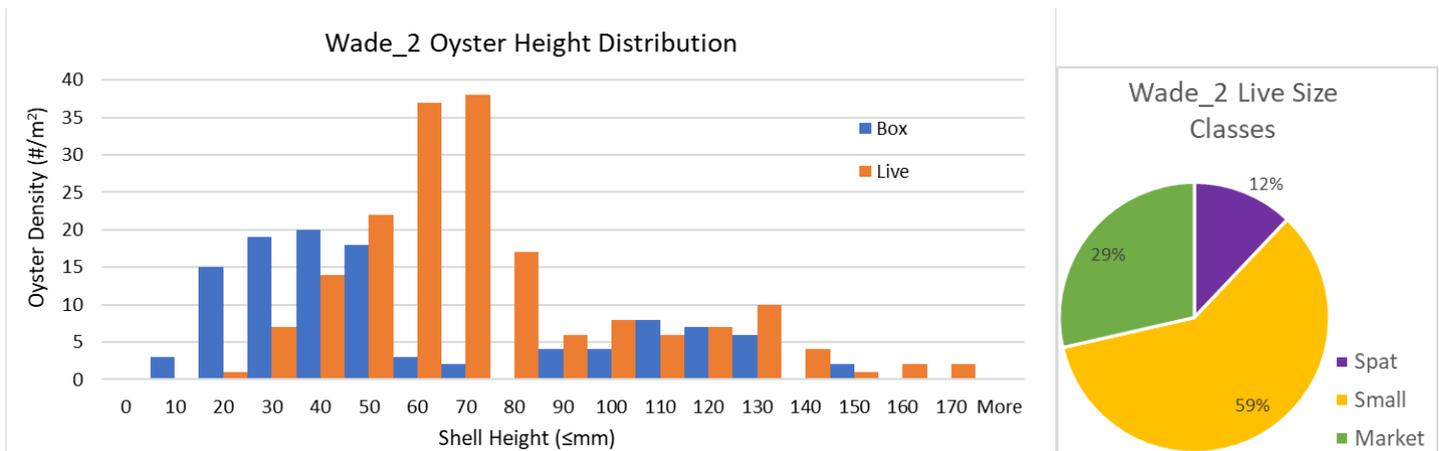


Figure 3. Wade\_2 relative height frequencies for live and dead oysters (left) and size class distribution for live oysters (right).

Wade\_2 had an average live oyster density of 463.5 oysters/m<sup>2</sup> and average live oyster biomass of 405.5 g dry weight/m<sup>2</sup> (Table 5). The population structure (Figure 3) of oysters observed at Wade\_2 was mostly comprised of small size (59%) oysters, followed by market size (29%), then spat (12%). With the new planting in 2020, having most of the population be small oysters is a good sign of planting survival.

The newest planted oysters had a surprisingly wide range of sizes, measuring from 20mm to 80mm. Following optimal growth assumptions, we would assume an average height of about 60mm after one year. This brood surpassed that rate assumption, reaching up to 80mm after the first year of planting. Many of the 1-year old hatchery oysters had notably thin shells. While growth was evident, there seemed to be a priority for vertical growth into the water column as compared to building shell thickness and integrity.

There was evidence of natural reproduction given the presence of live oysters growing off non-hatchery shell, such as granite or fossil shell, with heights ranging from 91 – 125mm, suggesting a reproduction event in 2017. The recent planting appears to take up the largest portion of live and dead oysters with the largest portion of dead oysters in the <50mm height range.

The previous study on Wade\_2 in 2018 showed an average density of 27.7 oysters/m<sup>2</sup>, suggesting a very large increase in live oyster density since that time, including another round plantings. In 2018, the largest portion of live oysters were in the 110 – 140mm age range with densities of 6-10 oysters/m<sup>2</sup>. The percent of dead oysters dropped from 22% in 2018 to 11% in 2021.

## Weems Upper\_1 Site

The Weems Upper\_1 site was built with granite and shell and planted in 2010, 2013, and 2018 with a total of 92.40 million spat across 2.71 acres. The Weems Upper\_1 site is divided up into 10 sub sections and were sampled individually, making this the most sampled site.

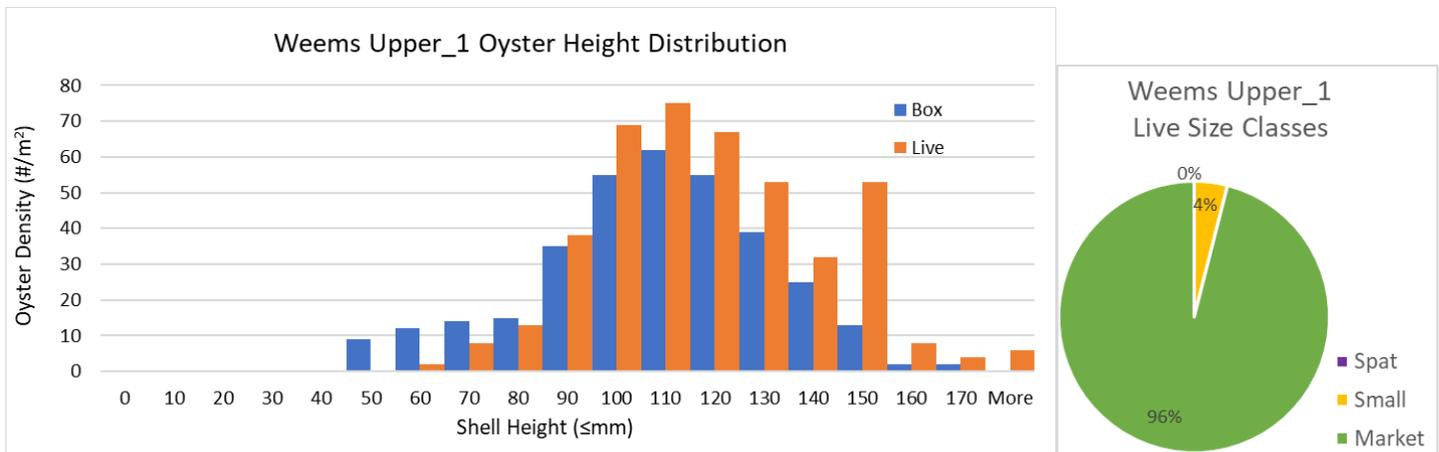


Figure 4. Weems Upper\_1 relative height frequencies for live and dead oysters (left) and size class distribution for live oysters (right).

Weems Upper\_1 had an average live oyster density of 127.4 oysters/m<sup>2</sup> and average live oyster biomass of 284.5 g dry weight/m<sup>2</sup> (Table 5). The population structure (Figure 4) of oysters observed at Wade\_2 was mostly comprised of market size (96%) oysters, followed by small size (4%), with no spat. The most recent planting in 2018 would be estimated to be around 100mm. The largest portion of live oysters was in the 90-130mm range, coinciding with the planting in 2018.

The smallest live oyster was measured at 54mm and was growing off an oyster on a hatchery clump estimated to be from the 2018 planting, suggesting a reproduction event in late 2018 or 2019 (which had been suggested during the 2019 sampling event). There were additional oysters growing off non-hatchery material, such as granite or non-hatchery oyster shell, further supporting natural reproduction events.

The previous sampling event in 2018 found a large portion of live oysters in the 110 – 140mm range. During the 2021 sample, there was a large portion of dead oysters in the 100 – 130mm range, with an increase from 19% of the total population being dead in 2018 to 40% in 2021.

## Traces Hollow 1A

The Traces Hollow\_1A site was constructed with granite and is the communal planting site for the Marylanders Grow Oysters (MGO) program. The planting coordinates move annually within the Traces Hollow\_1A site which is 2.26 acres. It is estimated that about 460,000 spat are planted each year within a designated marked area. Since 2011, the site has been planted 9 times with an estimated total of 4.14 million spat.

During the 2021 sampling, individual samples were taken near the planting coordinates for the 2016, 2017, 2018, and 2019 plantings (no planting took place in 2020), plus an additional random sample near the center of the site, for a total of 5 samples. The samples were averaged across the site to estimate the survival of the Traces Hollow\_1A site, as a whole.

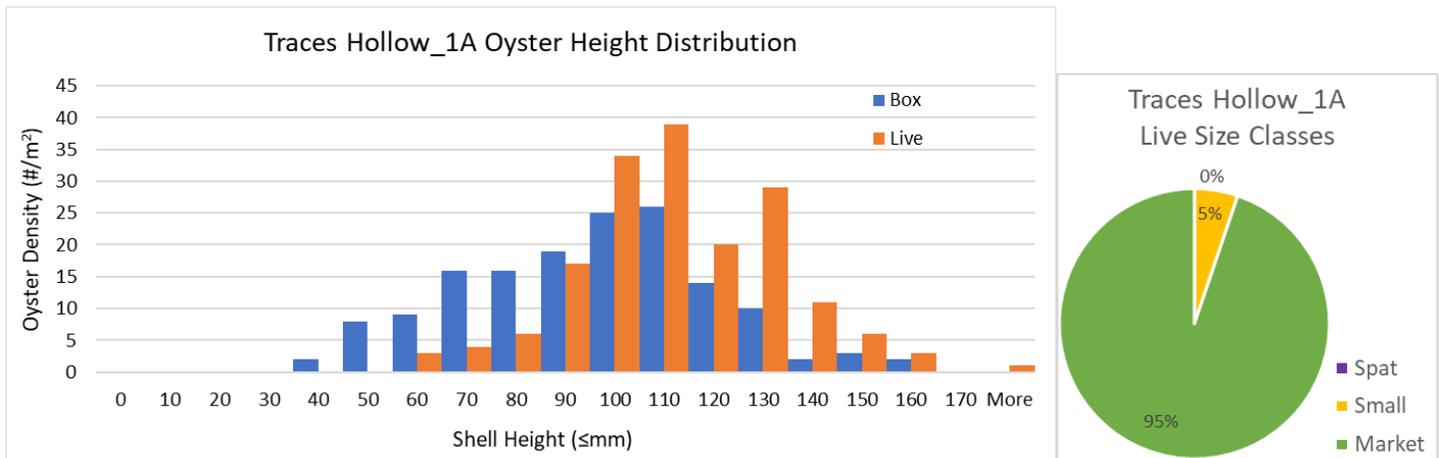


Figure 5. Traces Hollow\_1A relative height frequencies for live and dead oysters (left) and size class distribution for live oysters (right).

Traces Hollow\_1A had an average live density of 104 oysters/m<sup>2</sup> and average live biomass density of 201.6 g/m<sup>2</sup> (Table 5). The population structure (Figure 5) of oysters observed at Traces Hollow\_1A was mostly comprised of market-sized oysters (95%) and then small oysters (5%), with no spat. With annual plantings and the most recent planting being in 2019, we would expect an even distribution of live oysters from 75mm – 170mm. However, we saw a spike in live oysters from 100mm – 130mm.

The average live length for each year's planting was 132mm (2016), 100mm (2017), 106mm (2018), and 116mm (2019). While these do not decrease sequentially as would be expected, this could be due to a combination of natural reproduction, death of older oysters, and planting inaccuracies.

In the 2019 sample, live oysters measuring in the 140-170 mm range were found. These oysters are more likely to be either naturals prior to the time of planting, or oysters planted from a previous year that had settled into the 2019 planting location. The percentage of the total population that were dead oysters increased from 23% in 2018 to 39% in 2021.

## Conclusions

During the 2021 dive sampling efforts in the Severn River, 23 sub-sites were sampled across 4 reefs on Peach Orchard\_01, Traces Hollow\_1A, Wade\_02, and Weems Upper\_01. All monitored sites had been constructed with granite to increase bottom rigidity to support oyster settling and growth.

The only site that did not meet the restoration benchmarks was the Peach Orchard\_01 site. The other three reefs (Traces Hollow, Wade and Weems Upper) surpassed all minimum and target restoration thresholds.

Each site exhibited evidence of natural reproduction, with oysters growing off non-hatchery material, such as granite or shell fragments. Additionally, there was evidence of predation on oysters from blue crabs due to large puncture holes present in oyster shells. This blue crab predation is more common with market-sized oysters compared to the mud crab predation on spat and small-sized oysters.

Table 7. Site characteristics measured at each sample and averaged to create site-wide metrics.

Site Name	Avg. Sediment Depth (mm)	Primary Observed Substrate	Secondary Observed Substrate	Avg. % Granite Coverage	Avg. % Black Shell	Avg. % Fouling
PO_01	2	Granite	Loose Shell	93%	20%	40%
TH_1A	2	Oyster	Loose Shell	33%	11%	50%
WA_02	2.25	Oyster	Loose Shell	73%	15%	33%
WU_01	8.1	Oyster	Granite	65%	47%	45%

Additional factors that were measured at each site (Table 7) include the sediment depth accumulating on the oysters, primary and secondary substrates visible, percent of quad filled with granite, percent of black staining on oyster shells caused by anoxic sediment exposure, and percent of oyster coverage by fouling organisms.

For most sites, the sedimentation depth was minimal with only 0-5mm of sediment accumulation. However, there were two sites on Weems Upper\_01 with deep accumulation, reaching up to 25mm of sediment buildup.

Additionally, the Weems Upper\_01 sites had the highest average coverage of black shell staining from historic sediment buildup. On Traces Hollow\_1A, there was very little granite found, possibly due to the high live and dead oyster buildup covering up any granite. The percent fouling coverage was fairly uniform through all Severn River sites with 30-50% of all oysters monitored covered by algae, mussels, and barnacles.

Overall, the reefs in the Severn River appear to be surviving well, excluding the Peach Orchard site. The live oyster density far surpassed the required threshold requirements to be deemed "restored". With the evidence of natural reproduction and less than overwhelming sedimentation over the oyster plantings, survival and growth appears to be continuing at the sites sampled.