Follow-Up Monitoring of the S.O.A.R. Oyster Cohort

Supporting Oyster Aquaculture and Restoration (S.O.A.R.):

A program by The Nature Conservancy (TNC)

Contract with the Oyster Recovery Partnership (ORP)

Submitted to:

The Nature Conservancy (TNC)
Chesapeake Bay Program
Maryland/DC Office
425 Barlow Pl #100,
Bethesda, MD 20814

Prepared by:

The Oyster Recovery Partnership (ORP)
1805A Virginia Street
Annapolis, MD 21401

August 2022

Table of Contents

List of Figures

List of Tables

1.0 Introduction

The Nature Conservancy (TNC) partnered with The Pew Charitable Trusts (Pew) in coordination with the National Oceanic and Atmospheric Administration (NOAA), the oyster aquaculture industry, and state regulators to initiate a program called Supporting Oyster Aquaculture and Restoration (SOAR). The SOAR program aims to provide financial support to oyster farmers who were impacted by the market crash during the COVID-19 pandemic. TNC provided funding to purchase surplus oysters from oyster farms for use in oyster restoration.

In 2021, TNC worked with the Oyster Recovery Partnership (ORP) to purchase oysters from farmers and deploy oysters onto sanctuary reefs in Maryland. Planting locations were designated by the Department of Natural Resources (DNR). Between January and June of 2021, approximately 1.3 million oysters were purchased from a total of 22 oyster farms and planted within sanctuary reefs in three separate tributaries (Eastern Bay, St. Mary's River, and Nanticoke River).

In April through July 2022, ORP monitored the Maryland SOAR reefs to quantify growth, recruitment, and mortality of SOAR oysters relative to pre-existing oysters found in adjacent oyster habitat.

2.0 Methods

2.1 Survey Design

A monitoring survey was designed to assess the status of oysters planted under the SOAR program. Oysters were sampled from planted areas to quantify growth, recruitment, and mortality of SOAR oysters. In addition, non-planted, reference areas on the same reef were sampled to evaluate whether the SOAR program enhanced oyster densities. The adjacent reef habitat was assumed to represent oyster densities prior to SOAR plantings and served as reference data for the comparison.

Monitoring was conducted on all 6 reefs planted within each tributary. This included three reefs in the Nanticoke River (Upper Newfoundland, Cherry Tree, and Hickory Nut), one reef in Eastern Bay (Mill Hill), and two reefs in the St. Mary's River (EXG04 and EXG06).

Using ArcMap 10.7, a 3-meter buffer was placed around vessel tracklines collected during planting to account for oysters settling outside of the planting vessel's immediate path. Random sample points were generated within the planted area and on adjacent reef areas where planting did not occur (Figures 1-5).

The number of samples collected on the planted area of each reef was based on acreage. A minimum of 6 samples were collected from the smallest reef (St. Mary's, EXG06) and 10 samples were collected from the largest reef (Nanticoke, Upper Newfoundland). A minimum of 5 samples were collected from reference areas on each reef; however, when time allowed or samples contained no oysters, additional samples were collected (Table 1).

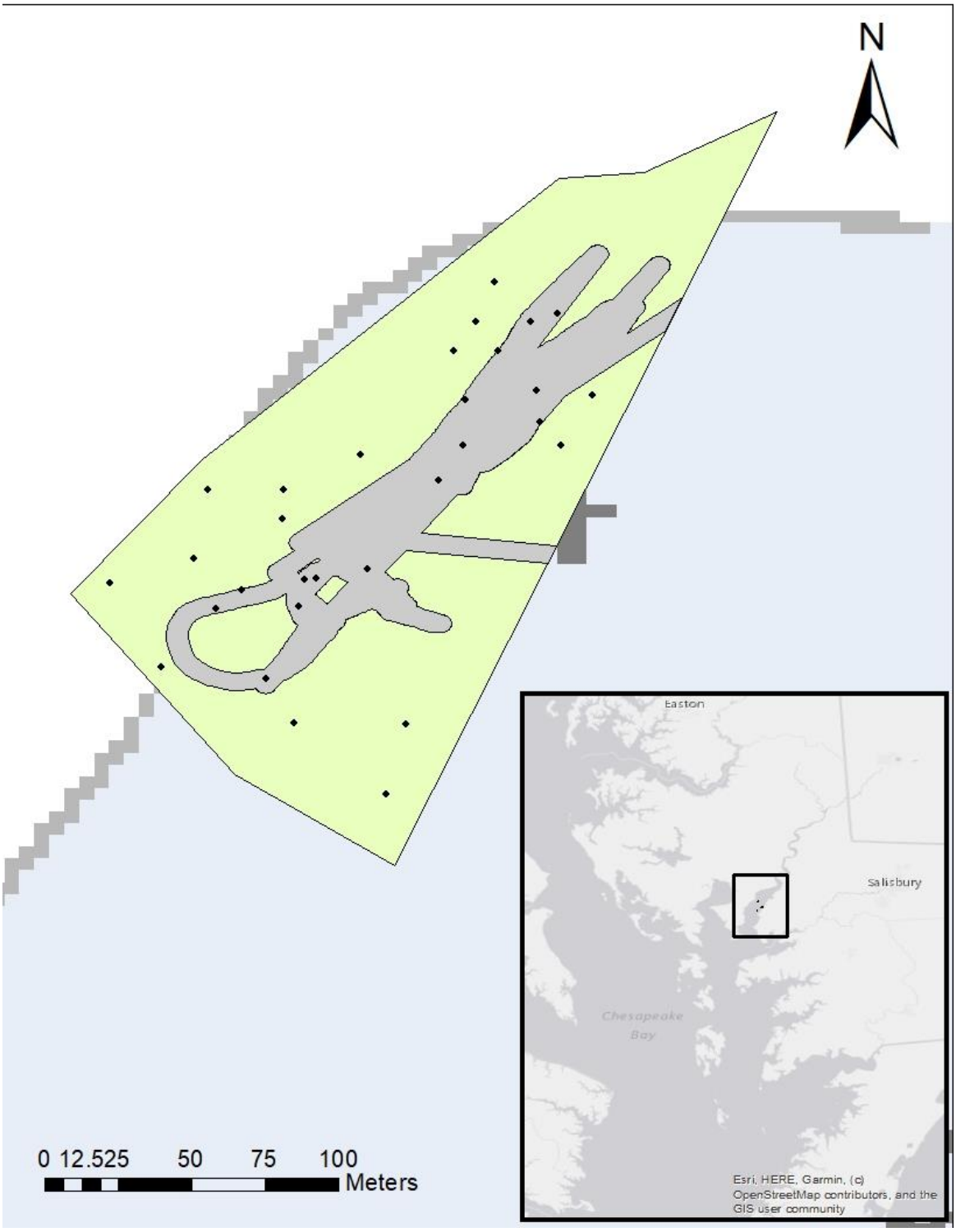

Figure 1. Planting area for sanctuary site 'Cherry Tree', located within the Nanticoke River sanctuary (light green) with 3-m buffer around the SOAR planting trackline (gray). Black dots are randomly assigned target sampling points.

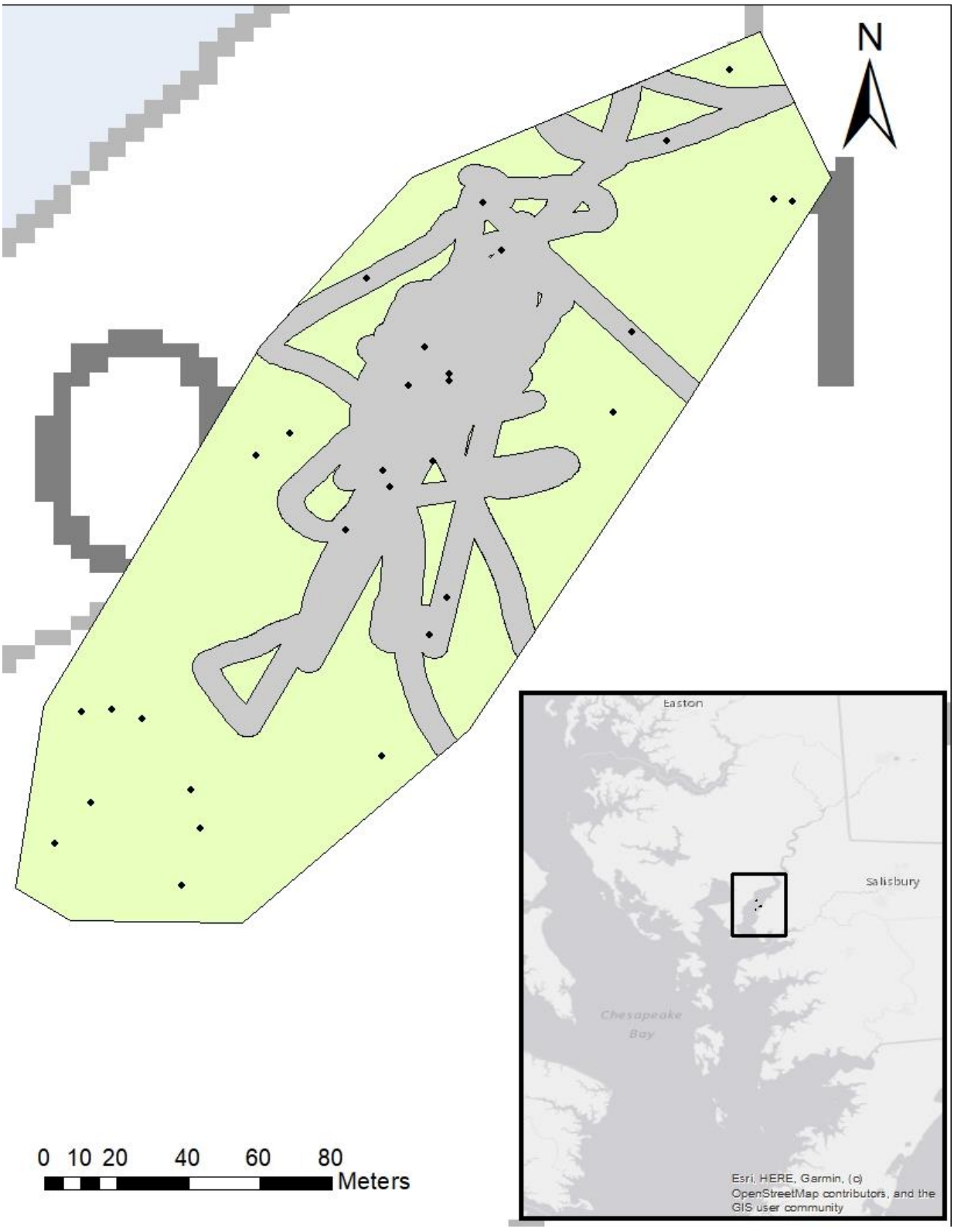

Figure 2. Planting area for sanctuary site 'Upper Newfoundland', located within the Nanticoke River sanctuary (light green) with 3-m buffer around the SOAR planting trackline (gray). Black dots are randomly assigned target sampling points.

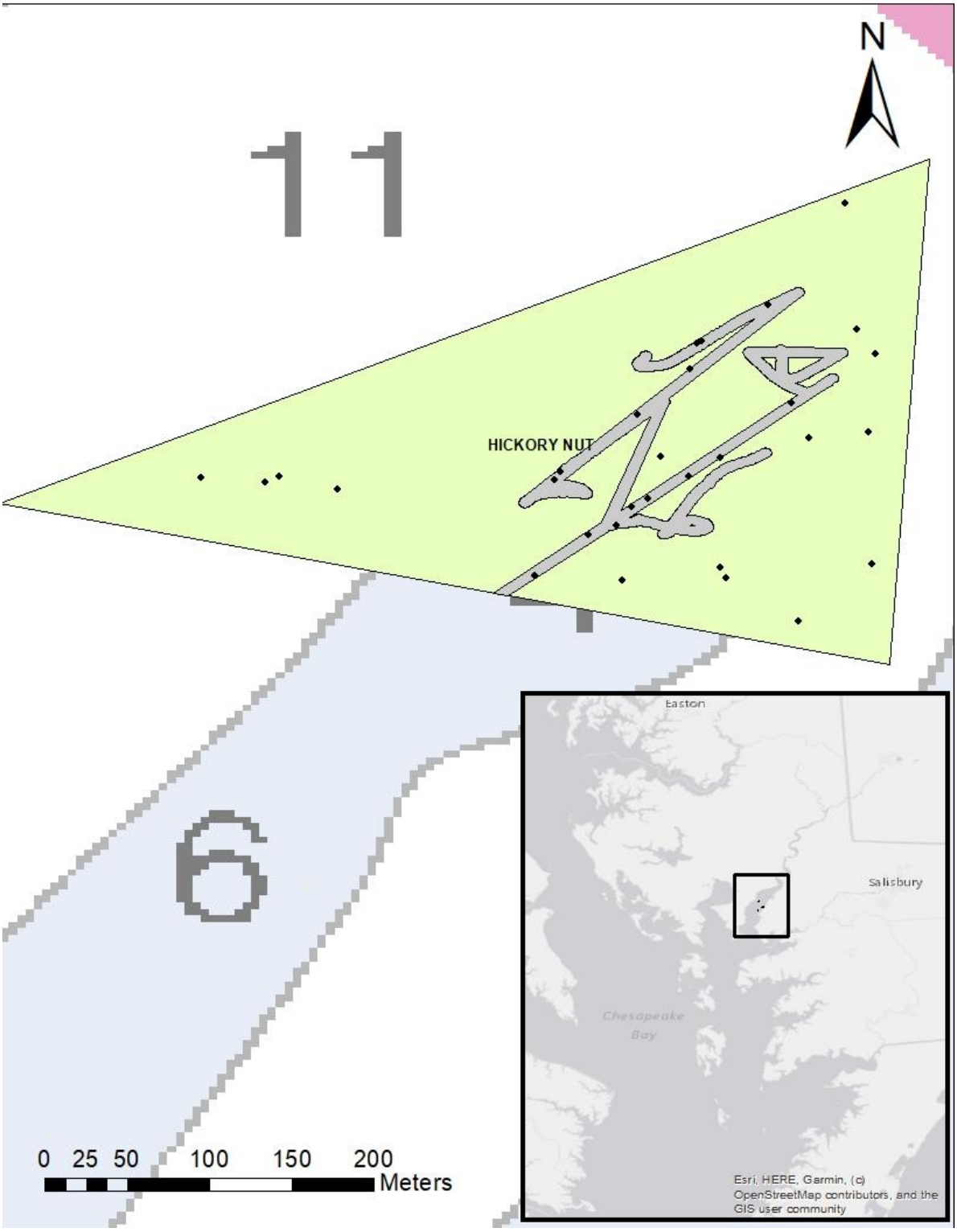

Figure 3. Planting area for sanctuary site 'Hickory Nut', located within the Nanticoke River sanctuary (light green) with 3-m buffer around the SOAR planting trackline (gray). Black dots are randomly assigned target sampling points.

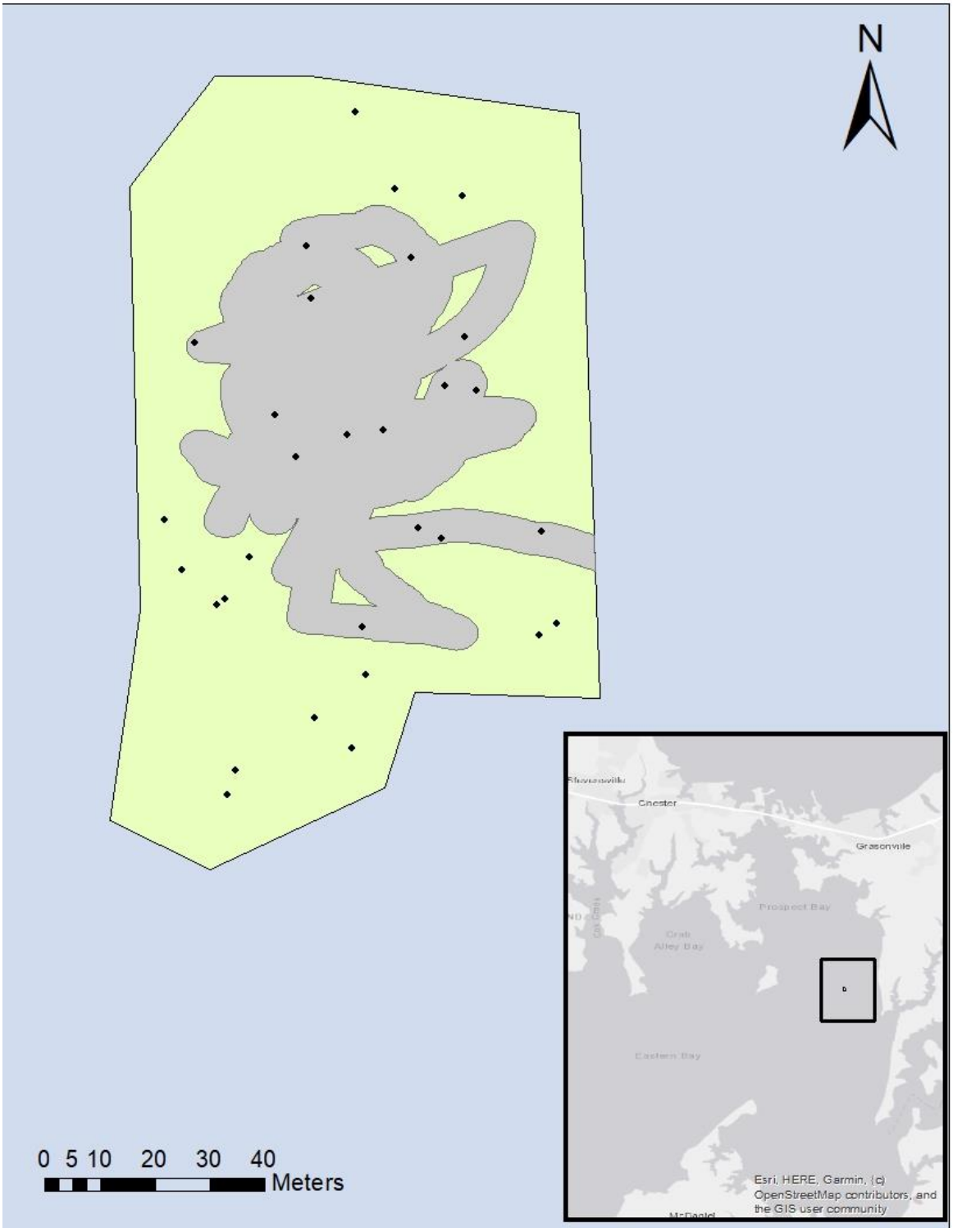

Figure 4. Planting area for sanctuary site 'Mill Hill', located within the Eastern Bay sanctuary (light green) with 3-m buffer around the SOAR planting trackline (gray). Black dots are randomly assigned target sampling points.

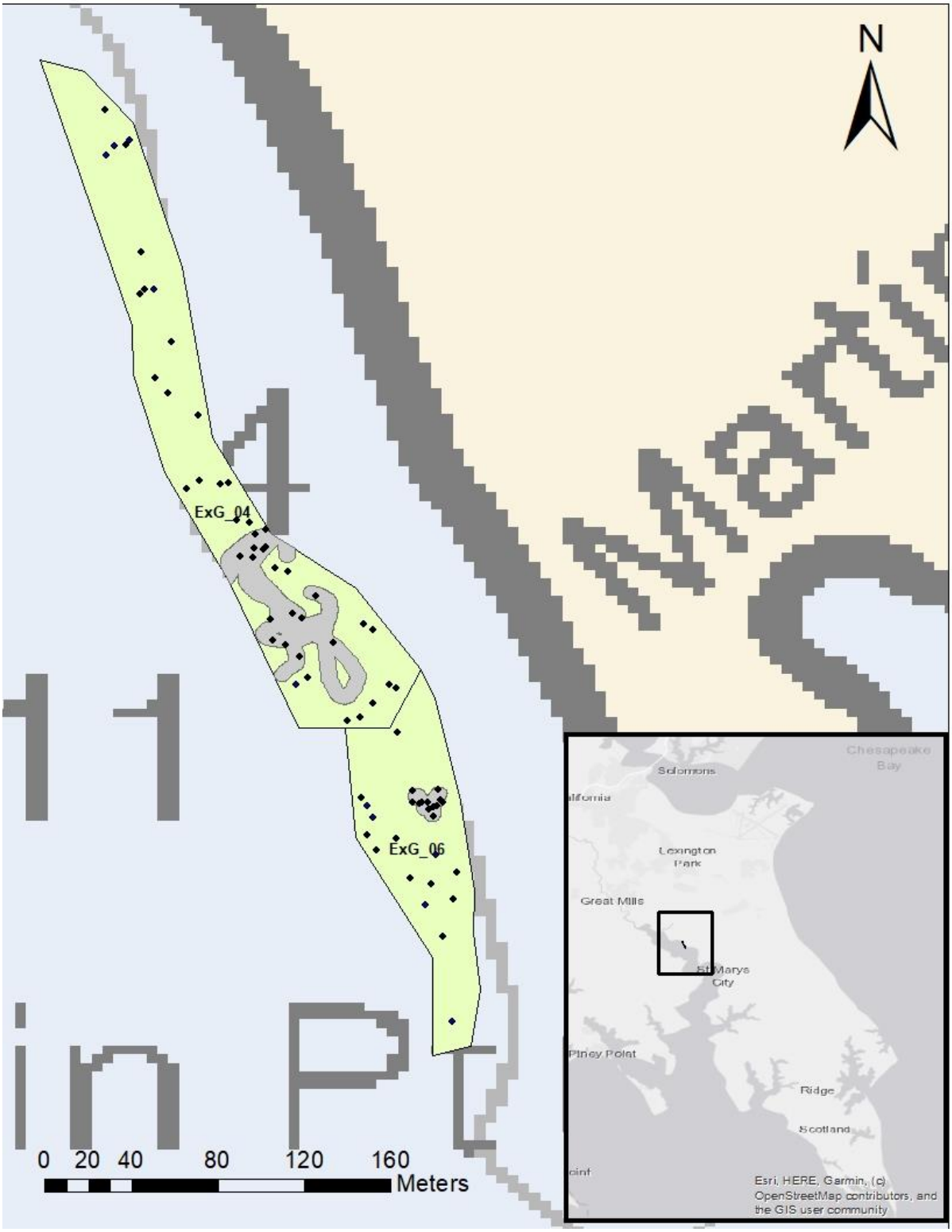

Figure 5. Planting area for sanctuary sites 'EXG04' and 'EXG06', located within the St. Mary's River sanctuary (light green) with 3-m buffer around the SOAR planting tracklines (gray). Black dots are randomly assigned target sampling points.

Table 1. Reef size, proportion of reef that was planted, and number of samples collected in planted and reference areas on each SOAR reef.

Trib	Reef	Area Planted (acres)	Site Size (acres)	% of Site planted	# Planted Samples Collected	# Reference Samples Collected
Nan	Cherry Tree	1.11	4.79	23.17	9	5
Nan	Upper Newfoundland	1.69	5.16	32.75	10	7
Nan	Hickory Nut	1.25	16.46	7.59	9	5
EB	Mill Hill	0.66	1.98	33.33	9	10
StM	ExG_04	0.37	2.25	16.44	7	6
StM	ExG_06	0.036	1.11	3.24	6	5

2.2 Data Collection

Monitoring was conducted over four days from April through July 2022. The Mill Hill site in the Eastern Bay sanctuary was monitored on April 18, 2022. Sites EXG04 and EXG06 in the St. Mary's River sanctuary were sampled on June 27, 2022. The Cherry Tree, Upper Newfoundland, and Hickory Nut reefs in the Nanticoke River sanctuary were sampled on July 11 and July 19, 2022.

Oysters were sampled from within a 0.5 m^2 quadrat using SCUBA. The diver visually estimated the percent coverage of oyster shell, live oysters, and other bottom types (e.g., sand, mud) in situ. All material in the quadrat was then excavated and brought to the surface for processing. The depth of excavation was recorded (in inches). Dominant bottom type (oysters, loose shell, shell hash, mud, sand) and a description of shell quality (percent black shell, shell hash, fouling) were visually assessed once the sample was brought to the surface. Subsampling occurred if at least ~60 live oysters were present in the sample.

A minimum of 30 live oysters were measured to the nearest millimeter, shell height. The remaining oysters in a sample (or subsample) were counted and binned into the following size classes (following Tarnowski et al., 2022):

Spat: ≤ 40mm

Small: 41mm to 75mm

Market: ≥ 76mm

These size classifications were assigned to determine whether oysters on a given reef were part of the SOAR cohort. We attempted to differentiate between oysters that were part of the SOAR cohort and natural oysters. Observations of differences in fouling, oyster condition and size, and whether an oyster was cultchless were used to identify potential SOAR oysters. Potential SOAR oysters were given a unique identifier on the field data sheet and within the database that could be used for further analysis.

Each oyster was classified as live, box (dead – empty hinged shells), or gaper (recently dead – meat present inside shell), and the configuration of the oyster (present as an individual or part of a clump of oysters) was recorded. Up to 30 box oysters were measured from each sample, if present.

The total volume (L) of oysters and shell substrate were collected to estimate a shell budget.

An example field datasheet is included in Appendix A.

2.3 Data Entry & Analysis

Data was entered into a Microsoft Access © database. Quality Assurance and Quality Control checks were conducted on raw data files and using GIS to assess data accuracy and identify data entry errors or other data abnormalities. An explanation of the QAQC is explained in detail in Appendix B.

Oyster density, mortality, average shell and substrate volume, and oyster length-frequency histograms were calculated for samples collected from SOAR planted areas and adjacent non-planted reference areas. Oyster mortality was calculated as the proportion of boxes out of the total number of oysters measured at a site. Oyster metrics were compared between reference areas and planted areas to determine the impact of the 2021 SOAR plantings on reef composition and density.

3.0 Results

Attempts were made to differentiate between SOAR oysters and pre-existing oysters on areas where plantings occurred. Our ability to distinguish SOAR oysters was inconsistent among reefs and samples. Therefore, we provide qualitative comparisons between planted and reference sites in this report. In many figures, the term "control" refers to data from the reference sites. The observed impact of SOAR plantings on the sanctuary reefs varied in magnitude across tributaries and sites.

3.1. Nanticoke River

In the Nanticoke River, monitored oyster density was greater on planted areas than reference areas on all reefs except Cherry Tree, where oyster density was similar between planted and reference areas (Figure 6). Shell volume followed a similar pattern, where shell volume was greater on planted areas than reference areas except at Cherry Tree (Figure 7). There were no oysters or shell collected at Upper Newfoundland outside of the planted area.

On the Cherry Tree and Upper Newfoundland reefs, the average length of planted oysters was 97.5mm (Figures 8 & 9). On the Hickory Nut reef, the average length of planted oysters was 96.5mm (Figure 10). The SOAR cohort was observed in the length-frequency histograms at the planted areas as the presence of market-sized oysters (Figures 8-10, 14). Market-sized oysters and spat were present on all three reefs in both the planted and reference areas, except for Upper Newfoundland, where no oysters were measured in reference areas (Figures 8-10, 14, 15).

Mortality, as indicated by the frequency of dead oysters, occurred across all size classes in both planted and reference areas (Figures 8-10). Oyster mortality in planted areas was 9% at Cherry Tree, 27% at Upper Newfoundland, and 5% at the Hickory Nut reef (Figure 16). The oysters at Upper Newfoundland were planted on mud.

3.2 Eastern Bay

In Eastern Bay, monitored oyster density was 6 times greater on the planted reef area compared to the reference area (Figure 6). Shell volume on the planted area was double that on the reference area at this site (Figure 7).

The average length of planted oysters was 95.5mm at Mill Hill (Figure 11). The SOAR cohort was observed in the length-frequency histograms at the planted area as the presence of market-sized oysters (Figures 11 & 14). Recruitment occurred, and market-sized oysters were present in both planted and reference areas (Figures 11, 14-15). The length-frequency histograms were similar between planted

and reference areas, however, there were a higher density of larger market-sized oysters in the planted area (Figures 11 & 14).

Mortality in the planted area at Mill Hill was 10% (Figure 16). Mortality, as indicated by the frequency of dead oysters, was consistent across all size classes (Figure 11).

3.3 St. Mary's River

We observed mixed results in the St. Mary's River. Oyster density was greater on the planted area relative to the reference area at site EXG04 (Figure 6). EXG06 was the only site on which the density of the planted area was lower than that of the reference (Figure 6). Shell volume was greater on the planted areas than reference areas at both sites (Figure 7).

The average length of planted oysters was 92.8mm and 82.6mm at sites EXG04 (Figure 12) and EXG06 (Figure 13), respectively. Mortality in planted areas was 53% and 32% at sites EXG04 and EXG06, respectively (Figure 16). Mortality, as indicated by the frequency of dead oysters, occurred predominantly in larger size classes across both planted and reference areas (Figures 12-13), which resulted in a lower proportion of market-sized oysters in this tributary compared to Nanticoke River and Eastern Bay (Figure 14).

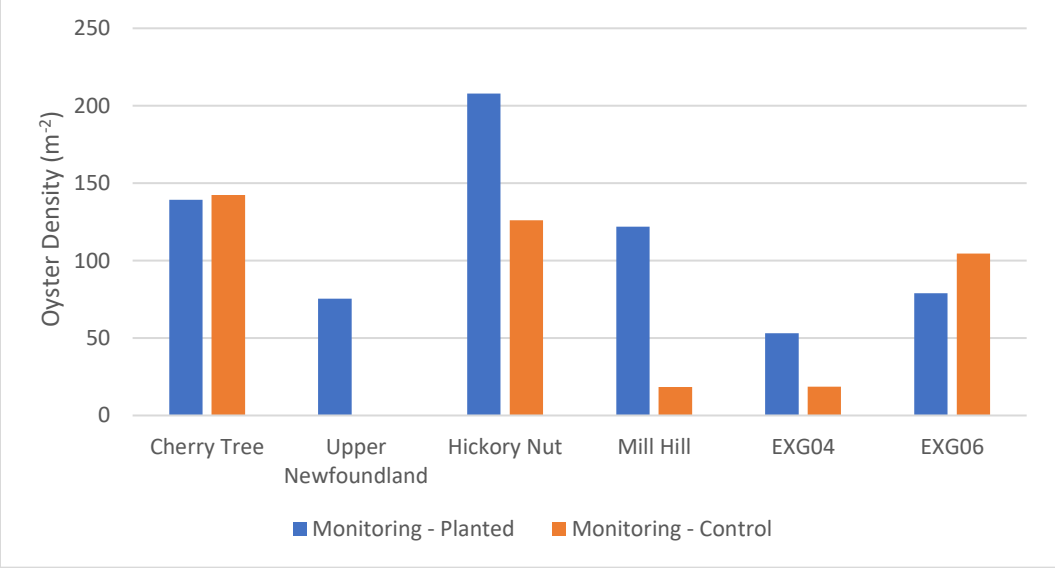

Figure 6. Oyster density (m^{-2}) on planted and reference areas at each reef. No oysters were observed on the reference areas at Upper Newfoundland. Control = reference area.

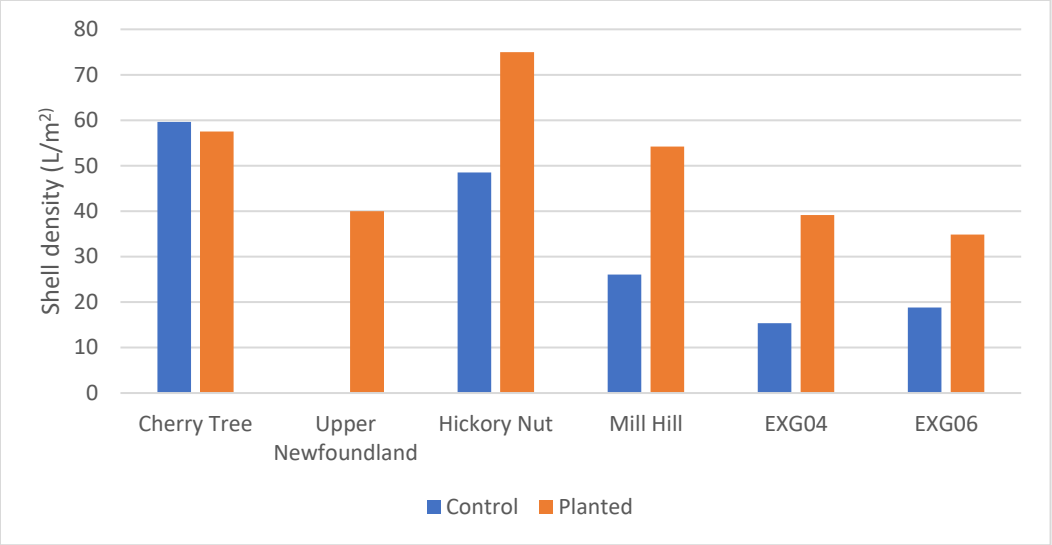

Figure 7. Shell density (L/m²) on planted and reference areas at each reef. No oysters were observed on the reference areas at Upper Newfoundland. Control = reference area.

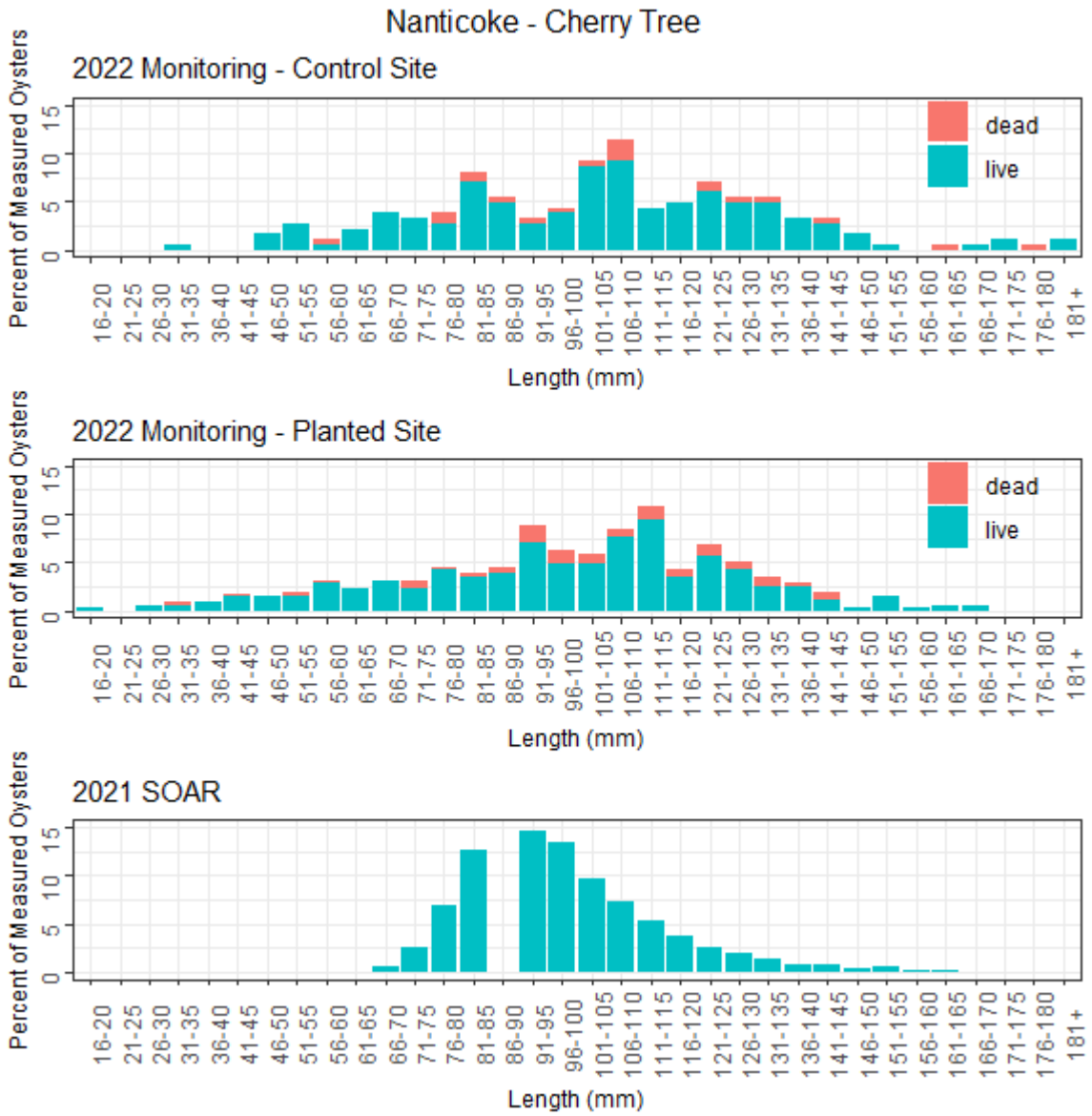

Figure 8. Oyster length-frequency histogram of live and dead oysters on planted and reference areas at Cherry Tree reef. Bottom panel is oysters that were planted in 2021 as part of the SOAR cohort. Control = reference area.

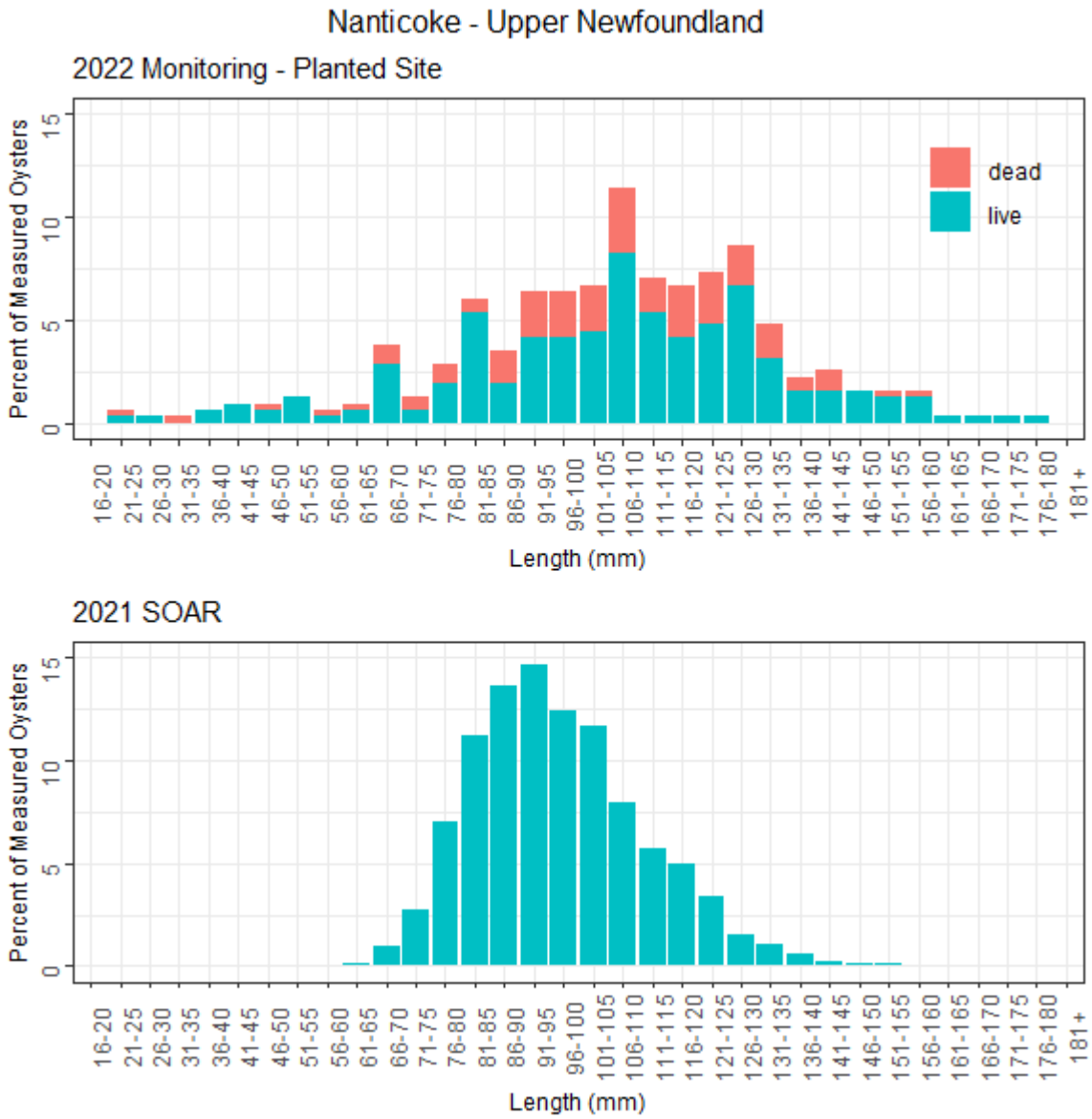

Figure 9. Oyster length-frequency histogram of live and dead oysters on planted areas at Upper Newfoundland reef. Bottom panel is oysters that were planted in 2021 as part of the SOAR cohort. No oysters were collected from reference areas.

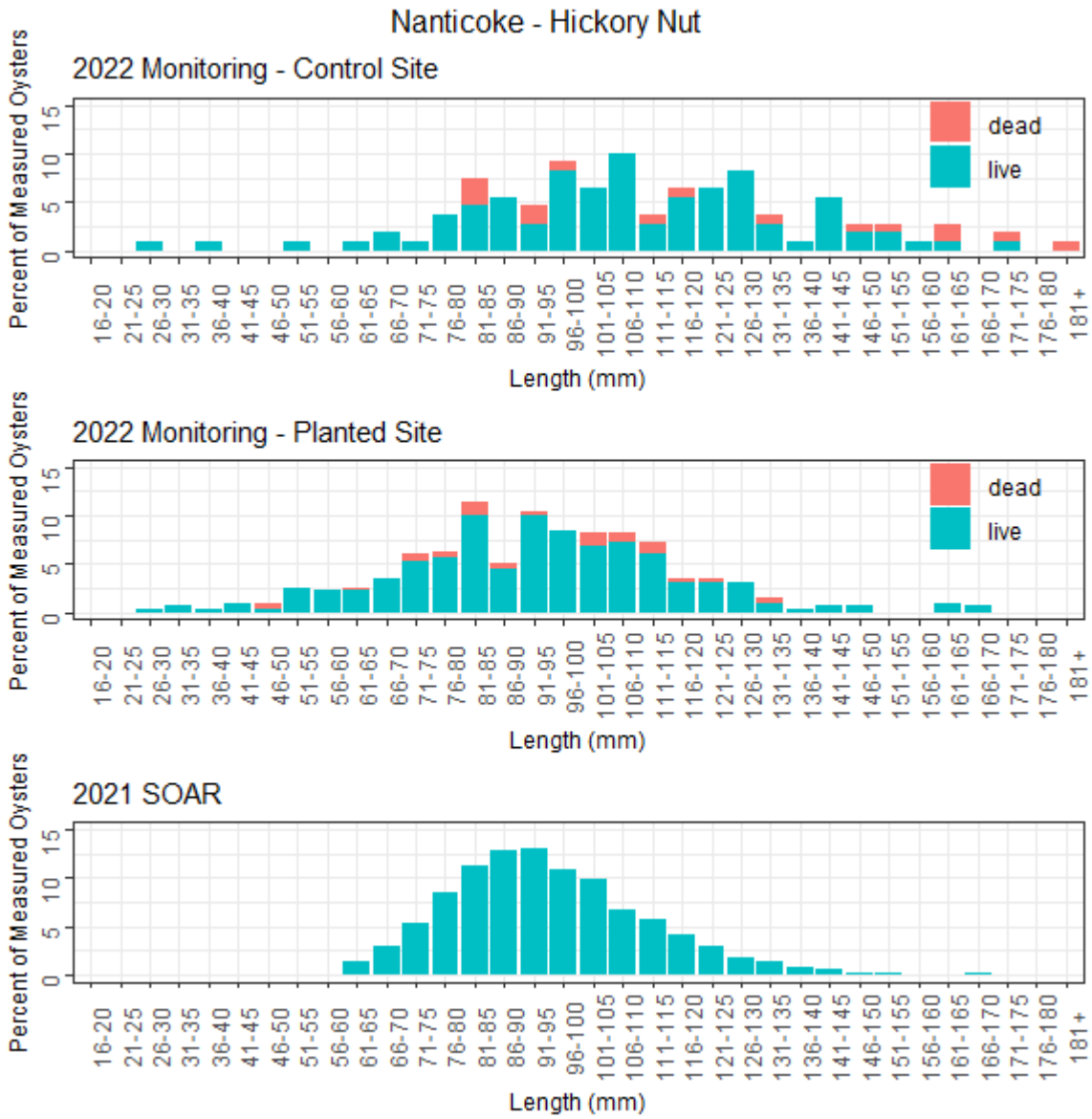

Figure 10. Oyster length-frequency histogram of live and dead oysters on planted and reference areas at Hickory Nut reef. Bottom panel is oysters that were planted in 2021 as part of the SOAR cohort. Control = reference area.

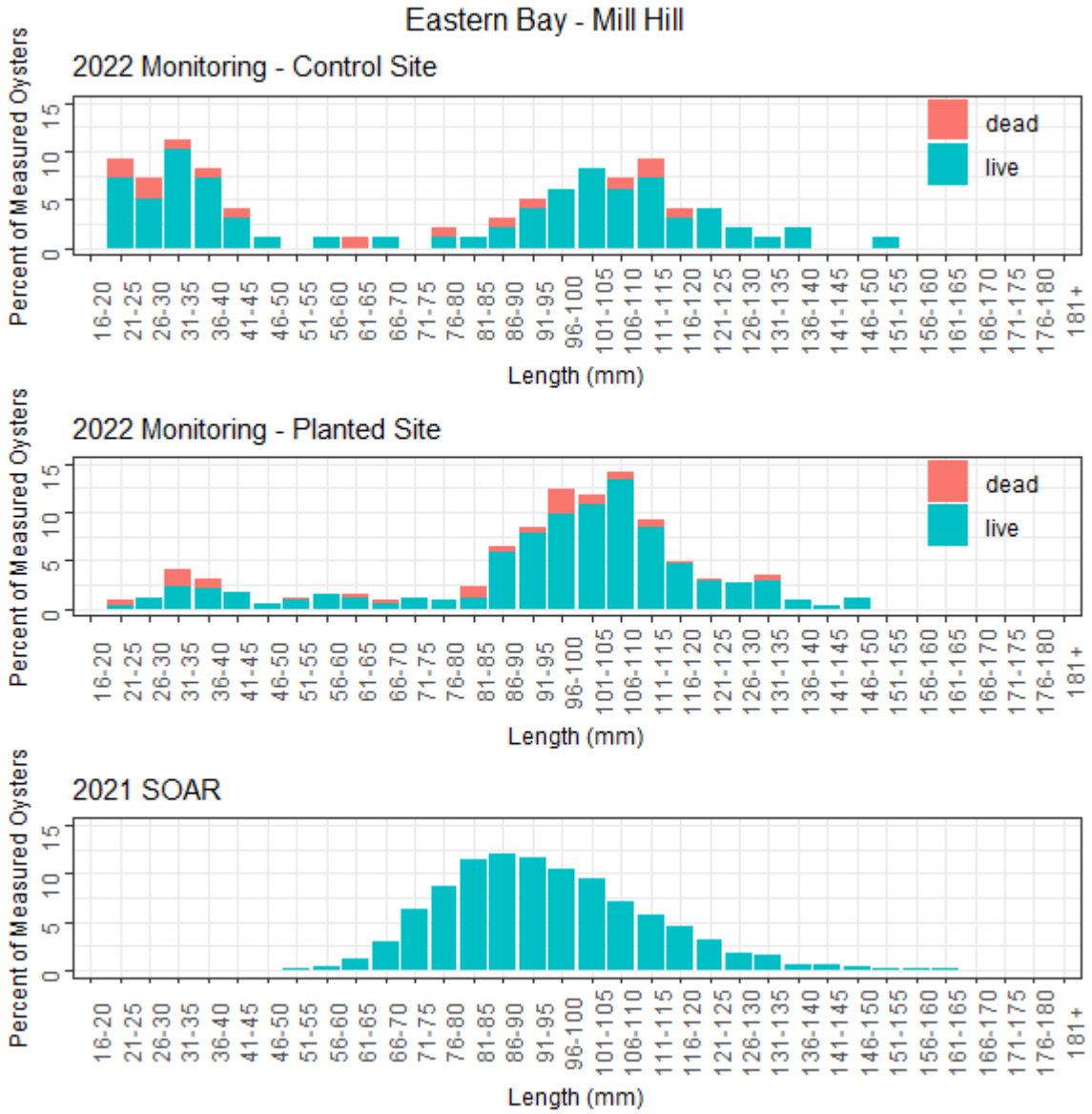

Figure 11. Oyster length-frequency histogram of live and dead oysters on planted and reference areas at Mill Hill reef. Bottom panel is oysters that were planted in 2021 as part of the SOAR cohort. Control = reference area.

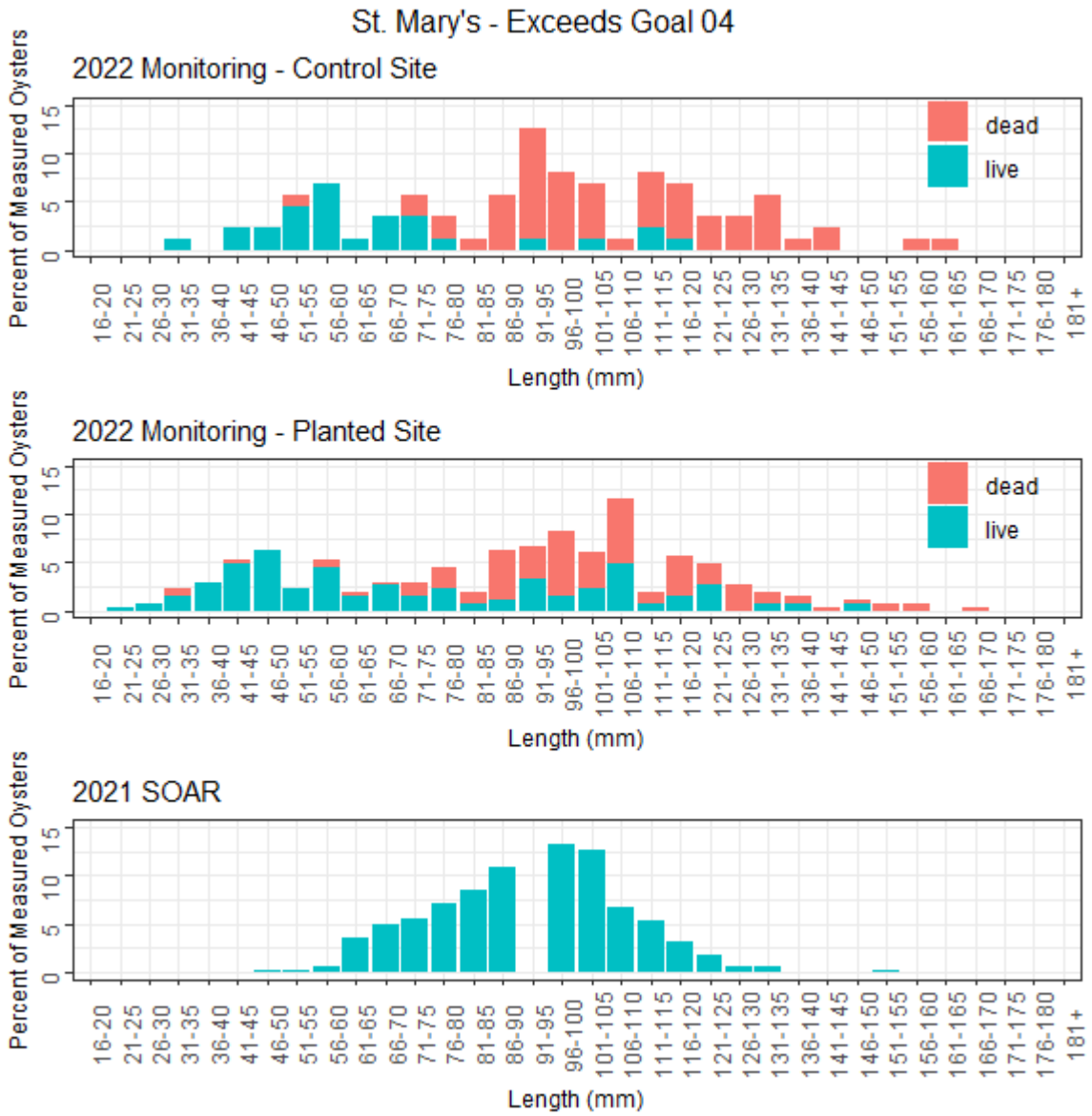

Figure 12. Oyster length-frequency histogram of live and dead oysters on planted and reference areas at EXG04 reef. Bottom panel is oysters that were planted in 2021 as part of the SOAR cohort. Control = reference area.

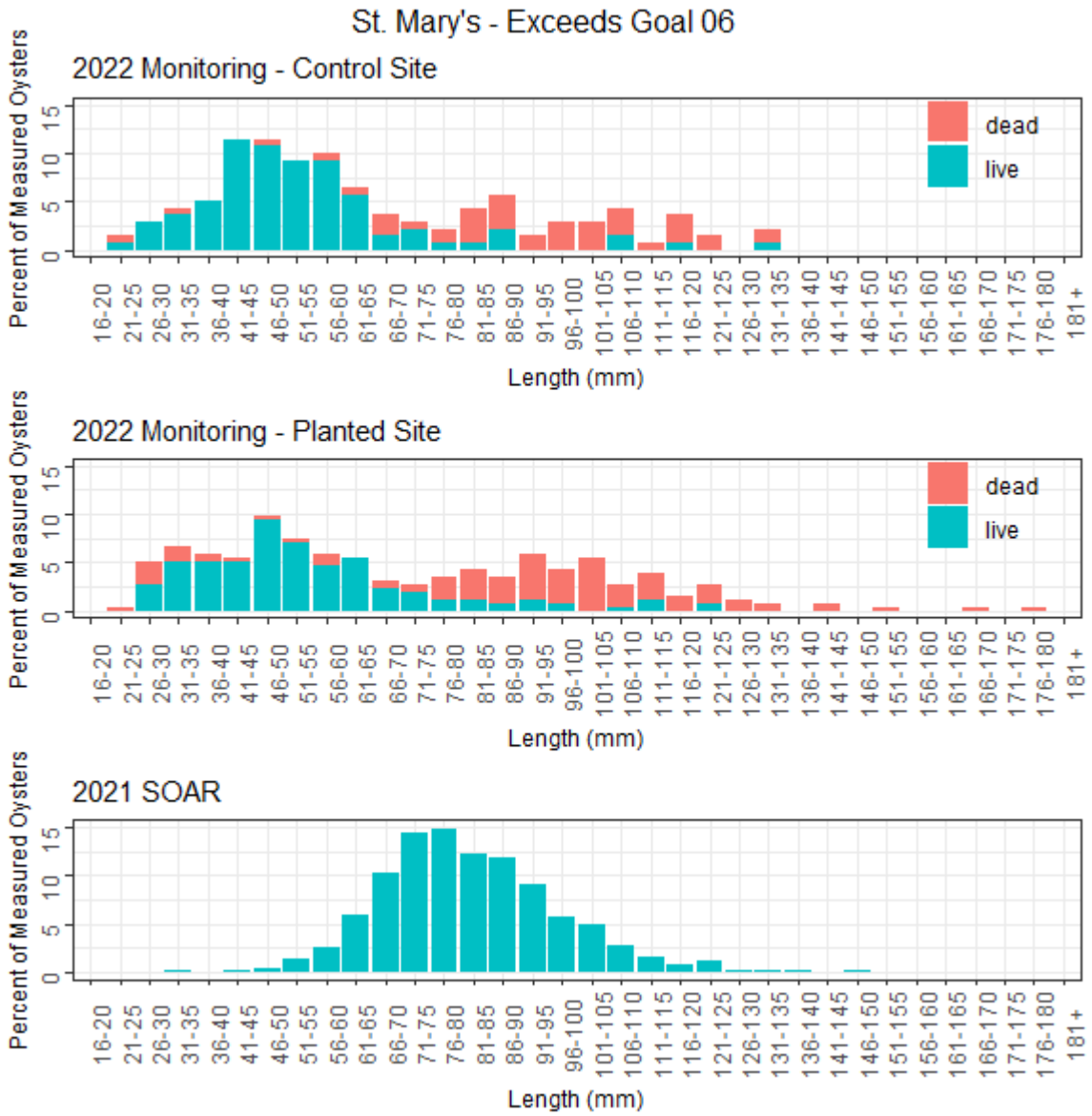

Figure 13. Oyster length-frequency histogram of live and dead oysters on planted and reference areas at EXG06 reef. Bottom panel is oysters that were planted in 2021 as part of the SOAR cohort. Control = reference area.

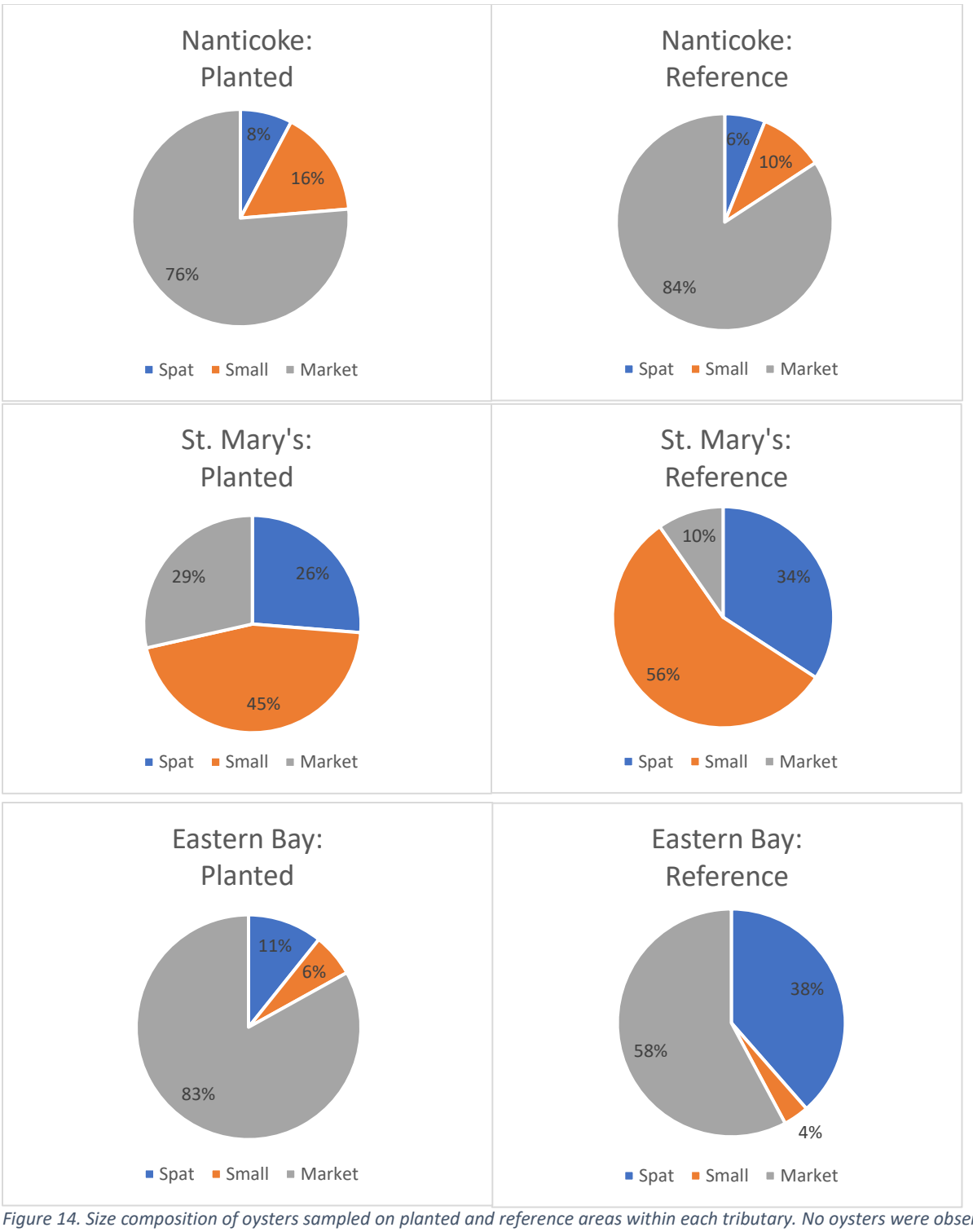

Figure 14. Size composition of oysters sampled on planted and reference areas within each tributary. No oysters were observed on the reference areas at Upper Newfoundland. Spat: ≤ 40 mm, Small: 41 – 75 mm, Market: ≥ 76 mm.

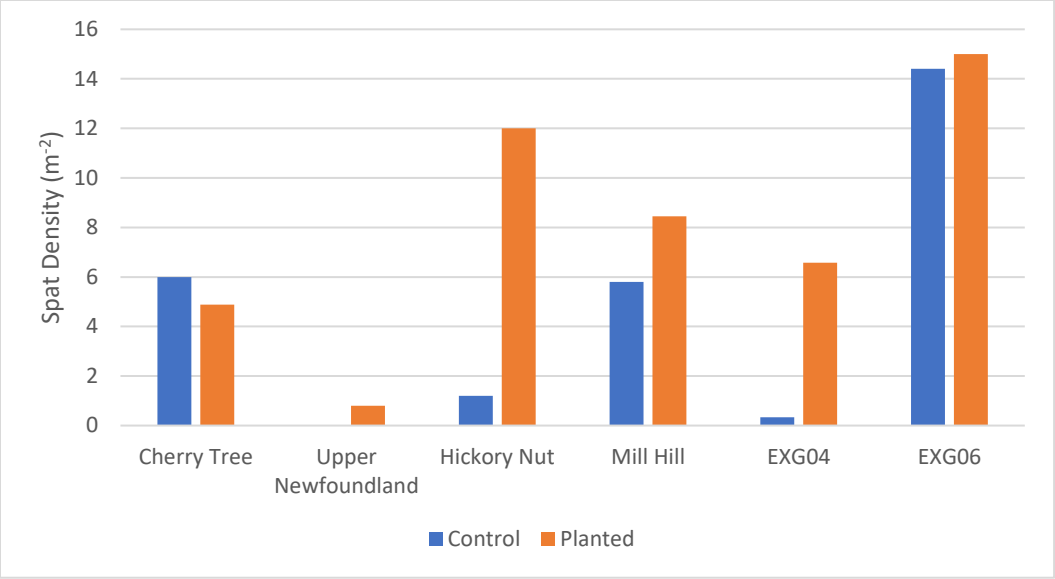

Figure 15. Spat density (m^{-2}) on planted and reference areas at each reef. No oysters were observed on the reference areas at Upper Newfoundland. Control = reference area.

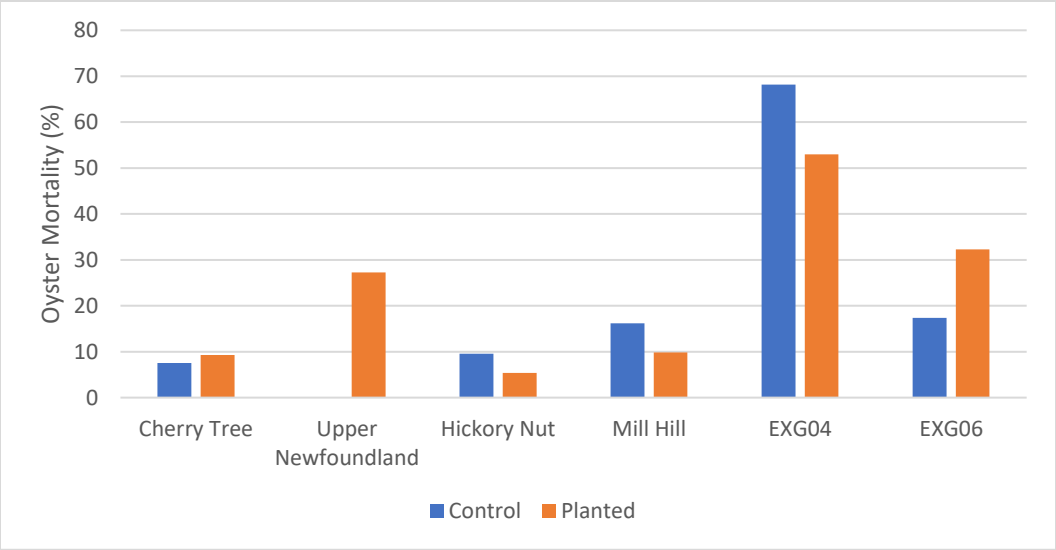

Figure 16. Oyster mortality (proportion (%) of boxes out of total number of oysters sampled) on planted and reference areas at each site. No oysters were observed on the reference areas at Upper Newfoundland. Control = reference area.

4.0 Discussion

A set of planted and non-planted reference areas within each SOAR reef were sampled to determine whether the SOAR program enhanced oyster densities relative to a pre-planting reference estimate. SOAR plantings enhanced oyster density relative to non-planted areas on all reefs except for those in the St. Mary's River. This suggests that the SOAR program successfully contributed to restoration progress on reefs in the Nanticoke River and Eastern Bay. The mechanism driving mortality in the St. Mary's River

is unknown, but mortality was likely related to some environmental stressor(s). A local captain hired to assist with monitoring in this tributary informed us that there was a large-scale "die off" event in 2021.

SOAR plantings enhanced shell volume on planted areas relative to reference portions of all reefs except for Cherry Tree in the Nanticoke River. The deployment of live oysters or shell provides more habitat suitable for the recruitment of naturally occurring larvae, which can have additional restoration benefits long after oysters were planted. This may have been observed, in part, at Hickory Nut in the Nanticoke River, which had the greatest shell volume and one of the highest densities of spat relative to all other reefs. The type of oyster planted (diploid or triploid) did not have an effect on recruitment. In fact, reefs that were planted with mostly triploid oysters had the highest density of spat (ORP, 2021).

In the Nanticoke River and Eastern Bay, the SOAR oyster cohort was observed as a greater density of market-sized oysters at the planted areas relative to reference areas. In Maryland, oysters grow, on average, 29 mm yr^{-1}, but can range from <1 mm yr^{-1} to 53 mm yr^{-1} (Coakley 2004). Growth rate decreases with oyster age (Coakley 2004). It is possible that oysters planted as part of the SOAR cohort did grow; however, since SOAR oysters were not always distinguishable from natural oysters, we could not calculate a growth rate for each reef.

Overall, plantings from the SOAR project enhanced oyster populations in a subset of Maryland sanctuary reefs. Future SOAR programs should consider additional habitat characteristics, such as substrate type, to ensure that the planted oysters survive. For example, no oysters and only muddy bottom was observed on the reference areas at the Upper Newfoundland reef in Nanticoke River. Oyster mortality was highest at this reef compared to other reefs in the Nanticoke River. Placing oysters in areas where they may be buried can increase mortality, reduce the substrate available for naturally settling larvae, and reduce additional benefits of restoration. Conducting baseline, ground truthing surveys prior to planting can identify the most suitable areas for restoration and generate baseline data to evaluate the impact of the SOAR planting effort more effectively.

5.0 References

Coakley, Jessica. 2004. GROWTH OF EASTERN OYSTER, CRASSOSTREA VIRGINICA, IN CHESAPEAKE BAY. Thesis submitted to the Faculty of the Graduate School of the University of Maryland, College Park in partial fulfillment of the requirements for the degree of Master of Science. August 2022. <https://drum.lib.umd.edu/bitstream/handle/1903/1471/umi-umd1590.pdf?sequence=1&isAllowed=y>

NOAA Fisheries. 2020 Maryland Oyster Monitoring Report. Analysis of Data from the '10 Tributaries' Sanctuary Oyster Restoration Initiative in Maryland. Chesapeake Bay Program. August 2022. <https://www.chesapeakebay.net/documents/2020_Maryland_Oyster_Monitoring_Report_%282%29.pdf>

Oyster Recovery Partnership (ORP). 2021. Supporting Oyster Aquaculture and Restoration (SOAR): A program by The Nature Conservancy (TNC) – Contract with the Oyster Recovery Partnership (ORP) to Expand Program to Maryland. Technical report submitted to The Nature Conservancy. August 2022.

Tarnowski, M et al. 2022. Maryland Oyster Population Status Report 2020 Fall Survey. Maryland Department of Natural Resources. DNR 17-062521-282. August 2022. <https://dnr.maryland.gov/fisheries/Documents/oysters/2020RptFinal.pdf>