MITIGATION MONITORING REPORT PROJECT OVERVIEW FORM

Project No.: Polpis Harbor Oyster Restoration and Salt Marsh Stabilization Project

Site Name: Medouie Creek
Location of Site: *41.306102, -70.013314*
Start and Completion Dates for Mitigation: *[August 2021 – August 2026*
Name and Contact Information for Project Sponsor:

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Project Summary:

The goal of this project is to restore the degraded structure of the Medouie Creek ecosystem and provide future shorelines resilience by establishing 0.17 acres of intertidal oyster reef designed to retain marsh sediment near shore and mitigate shoreline erosion in an adjacent 1.1-acre salt marsh. Concurrently, this project will mitigate salt marsh soil loss through crab trapping and native cordgrass planting in the 1.1-acre salt marsh as well as the adjacent, contiguous 14.6-acre salt marsh for a total of 15.7-acres of salt marsh enhancement. The Medouie Creek salt marsh, located in Polpis Harbor on Nantucket, MA, has experienced extensive dieback due to purple marsh crab population explosion, leaving the salt marsh sediments susceptible to erosion. While NCF is concurrently conducting active crab management stabilize the marsh, that reclamation process can be slow, and valuable salt marsh area could be lost. Although marshes on the mainland have begun recovering from salt marsh dieback, regrowth of smooth cordgrass was observed 15 years after initial dieback. As sea level rise increases and extreme storms become more frequent, waiting 15 years for natural recovery could potentially lead to catastrophic loss of salt marsh sediments due to erosion.

The first objective of this project will examine the potential of an intertidal oyster reef to provide structural buffering of unstable marsh sediments from wind and tide events, potentially helping to reduce erosion as we mitigate dieback within the marsh. The second objective is to continue restoration management mitigating salt marsh dieback in Medouie Creek. The third objective of this project is to examine the potential of the oyster reef to facilitate salt marsh growth in response to buffering. The fourth objective of this project is to actively improve intertidal oyster habitat and ecology within an impacted harbor on Nantucket.

Party Conducting the Monitoring, if not Sponsor:

Monitoring Report: 2 of 5

Performance Standards **are**/**are not** being met: ARE

Four Performance Standards have been established for this project and we are meeting these standards in the directly enhanced area of the project as outlined in this report. The only portion of the performance standards not met is documenting an increase in salt marsh dieback in the indirectly enhanced portion of the marsh where only minimal purple marsh crab control had been in place. Purple marsh crab management was enhanced in 2023 and will continue in 2024.

Dates of Corrective or Maintenance Activities Conducted Since Last Report:

N/A

Recommendations for Adaptive Management, If Any:

Due to the increase in salt marsh dieback in the indirectly enhanced portion of the salt marsh, we will be continuing to expand control of the purple marsh crab and expect to see results from this in 2024. This method has proved successful and met performance standards for the directly enhanced marsh on this property.

Annual Monitoring Report Format

1) Project Overview (1 page)

This report documents monitoring for the second full year post installation of the intertidal oyster reef as well as continued purple marsh crab removal during the growing season to facilitate marsh recovery and restoration from salt marsh dieback. Baseline conditions at the project site were documented in the December 2021 report. A comparison between baseline monitoring conditions and years one and two post-restoration will be used to document the achievement of performance standards for this restoration project. In partnership with Town of Nantucket Natural Resource Department biologists, monitoring protocols were established covering a suite of site characteristics and were based on protocols established by the Town of Nantucket's Oyster Restoration Project, the "Oyster Habitat Restoration Monitoring and Assessment Handbook" (The Nature Conservancy, 2014) and the Massachusetts Division of Marine Fisheries Subtidal Shellfish Surveys (2013).

In 2020, we established four sampling transects within the proposed oyster reef site (Figure 1 within the yellow area). In 2021, additional transects were established within the reference area (Figure 1, red area) and adjacent to the oyster reef (Figure 1, blue lines). All transects originate within the adjacent salt marsh and extend through the intertidal zone seaward of the proposed oyster reef location (Figure 1). Transects serve as a base to measure salt marsh stability and salt marsh dieback.

Data collected to determine the performance standards of this project fall into four categories: Oyster Reef Structure, Oyster Populations, Salt marsh and habitat health and Salt marsh dieback.

Oyster Reef Structure: Visual assessments of the reef samples occur at the beginning and end of each field season through snorkel surveys at low tide. If greater than 10% of the oyster reef castles are damaged, replacement will occur as soon as possible, as long as replacement does not impact the stability and structure of the reef.

Oyster Populations: The oyster population was monitored using randomly placed quadrats (0.25m) across the reef to monitor oyster density (Count inside quadrat) and oyster size-frequency (average size of oysters in each quadrat). Sampling occurred at the end of the oyster growing season. Oyster density is expected to increase over time.

Salt Marsh and Habitat Health: Along all transects, salt marsh vegetation composition and density was documented in $1m^2$ quadrats, as correlates of salt marsh health. The performance standard for salt marsh health is the percent cover of salt marsh vegetation within the plots. Elevation of the salt marsh and intertidal area will be monitored along the transects annually to document erosion and accretion.

Salt marsh dieback: Vegetation monitoring within the 1.1-acre revegetated dieback area will document the increase in salt marsh vegetation percent coverage over time with crab management. Additionally, each fall, NCF will GPS the extent of exposed soil within the project site, both in the front and back salt marsh to document the effects of salt marsh dieback management. Purple marsh crab populations (which drive the vegetation dieback) will be documented each year as well as the number of crabs removed from the marsh.

2) Requirements (1 page)

The 2023 field season represents monitoring Year 2 for this project with 4 Performance Standards documented within Table 1. Performance Standards refer to the four monitoring protocols outlined above and compared to the baseline monitoring report.

Table 1: Established Performance Standards, Metrics and 2023 Status on the Medouie Creek Oyster Reef Project.

Performance Standard	Metrics	2023 Status
1) Successful survival of the oyster reef castles for one year and/or adaptive management completed (replacement of reef components)	1) Documentation through snorkel or dive surveys of reef castle condition that 90% of the reef structure is in excellent condition and/or 2) replacement of any reef components to bring the reef to 90% excellent condition.	Visual observation of the reef at extreme low tides in April, July and October indicated very little change to the structure of the reef since installation. A few castles on the top had shifted and were easily moved back in place. No castles were chipped or broken. This represents a successful Metric for survival of the reef structure.
2) Successful establishment of oysters on the oyster castles and/or adaptive management through addition of spat on shell	Increase in oyster density by 5% collectively over the reefs.	Oyster density increased from 8-27 (average 19.7) oysters per quadrat in 2022 to 12-49 (average of 28) oysters per quadrat in 2023. This represents a 42% increase in density, which exceeds the Year 2 Performance Standard. Spat on shell was observed for the first time in 2023 with the oyster

		reef reproducing. Oyster length in 2022 averaged 61mm. Oyster length in 2023 averaged 73.99mm.
3) Salt marsh health maintained or improved in the salt marsh	1) Maintenance = No decrease of salt marsh vegetation % coverage measured in $1m^2$ plots in the directly enhanced marsh. 2) Improvement = increase of 10% coverage of salt marsh vegetation compared to previous year.	1) In 2023, in sampled plots in the directly enhanced marsh, only salt marsh plants were found. 80% of the plots had 50% or higher coverage of salt marsh vegetation. This was a slight increase compared to previous documenting an improvement in salt marsh vegetation. 2) Bare soil in the Directly enhanced marsh decreased slightly from 0.0631 acres to 0.546 acres. Represents an improvement. 3) Bare soil decreased very slightly in the indirectly enhanced salt marsh (0.2135 acres) due to adding purple marsh crab management in 2023.
4) Maintain or increase salt marsh stability	Documented as no change in salt marsh shoreline location and elevation compared to 2021.	The salt marsh maintained stability with minor advancement in the shoreline, defined as the extent of salt marsh vegetation into the intertidal zone. A small area of advancement was again documented behind the reef. Elevation was recorded along each of the sampling transects and established a baseline with 4 transects in the reef, 4 adjacent to the reef and 4 in the reference area. Transects within the reef showed increased elevations compared to adjacent and reference and also showed elevation peaks corresponding with areas immediately landward of the reef.

3) Summary Data (maximum of 4 pages)

Oyster Reef Structure: Visual assessments of the reef samples occur at the beginning and end of each field season through snorkel surveys at low tide. If greater than 10% of the oyster reef castles are damaged, replacement will occur as soon as possible, as long as replacement does not impact the stability and structure of the reef.

The reef castles were visually inspected at extremely low tides in April, July and November 2023. Tides were low enough that the entire reef could be observed without needing to snorkel. Castles were checked for significant movement, total loss and any chipping or other damage.

The castles and the reef structure were remarkably intact following the winter season. In April 2023, a few castles on the top row had shifted and leaned but were easily pulled back into place. No castles were lost, and no chipping or other damage was observed along the reef. Surveys in July and October showed no impact or change to the oyster reef through the growing season.

Surveys did show that the entire reef has sunk into the soft sediment. This was expected and the reason that oysters were only settled on the top two rows of the reef. The bottom row appears to have sunk ~3-5inches into the soft sediments. Additionally, more sediment has been accumulating landward of the marsh, further burying the reef structure.

The reef will be revisited throughout 2024 starting in April for additional surveys. No other maintenance is needed at this time to meet the Performance Standards.

Oyster Populations: The oyster population was monitored using randomly placed quadrats (0.25m^2) across the reef to monitor oyster density (Count inside quadrat) and oyster size-frequency (average size of oysters in each quadrat). Sampling occurred towards the early part of the growing season. Oyster density and oyster size are expected to increase over time as the reef reaches carrying capacity.

June 7th 2023, we visited the reef at an extreme low tide and monitored 18 quadrats (0.25m^2) to document oyster density and size. Quadrats were randomly placed along the top and sides of the reef at a spacing of at least 3 meters between quadrats. We saw significant growth compared to oysters sampled in 2022.

In 2021, oyster spat was newly set on the reef castles. Oyster spat density was approximately 6-15 oysters per 0.25m^2 with spat length averaging 3-6mm. In 2022, oysters grew significantly in size with oyster density ranging from 8-27 oysters per 0.25m^2 quadrat. Average oyster length ranged from 52 – 80.5mm, averaged from 5 oysters per quadrat.

In 2023, oyster density ranged from 12-49 total oysters per 0.25m^2 quadrat with an average density of 28 oysters per quadrat. In 2023, we surveyed dead and alive oysters on the reef for the first time; in 2022 we only encountered 1 dead oyster. Living oysters averaged 20 oysters per quadrat with an average of 8 dead oysters per quadrat. This is a normal trend in oyster population growth both as oysters age and as they compete for resources. Oyster density in 2023 was similar to 2022, but we are seeing the maturation and death of oysters as the reef grows. In 2023, we also encountered oyster spat recruiting on the reef for the first time.

Oyster size (measured as oyster shell height) increased in 2023 compared to previous years from an average of 61.04mm to an average of 73.99mm (Figure 1).

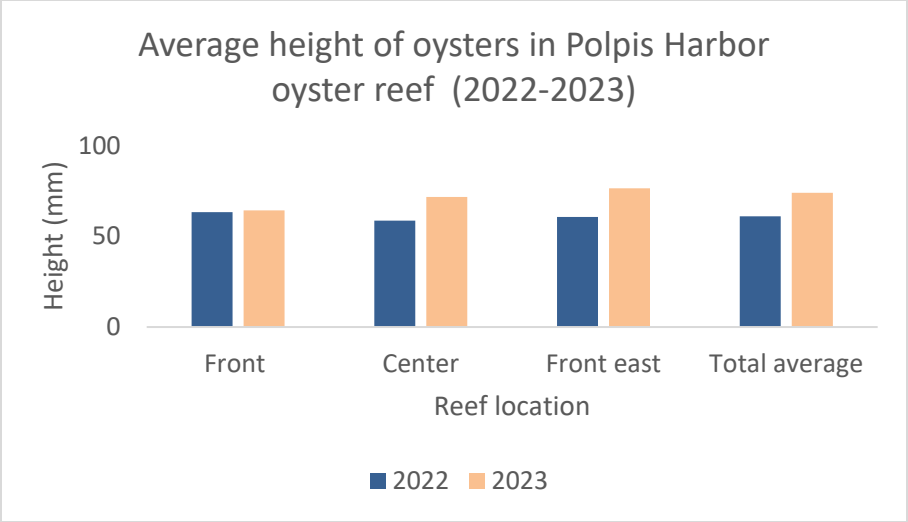


Figure 1: average height of oysters on the reef in 2022 compared to 2023.

Salt Marsh and Habitat Health: Along all transects, salt marsh vegetation composition and density was documented in 1m^2 quadrats, as correlates of salt marsh health. The performance standard for salt marsh health is the percent cover of salt marsh vegetation within the plots. We also GPSed the area of salt marsh dieback within the reef area, reference area and entire salt marsh area. Elevation of the salt marsh and intertidal area were monitored along the transects annually to document erosion and accretion.

July 2023, we surveyed 37 1m^2 vegetation sampling plots along the transects indicated on the Monitoring Map. Transects were monitored within the restoration area as well as within the reference area. All plants were identified to species, where possible, and the coverage of each species estimated. Additionally, the coverage of exposed (unvegetated) peat and/or sand was estimated. Sampled plots originated at the transect start within the salt marsh (farthest from the shoreline) and plots were sampled every 2m until the plot was officially intertidal with no salt marsh vegetation encountered.

All identified plants along the transects in 2023 were salt marsh obligate plants, plants that are only typically found in salt marshes (Table 2) except for *Fucus distichus* (rockweed) which is an alga predominant in the intertidal area. This plant was washed up and deposited on shore as a living wrack. The most abundant plant encountered was *Spartina alterniflora* (saltmarsh cordgrass), indicative of primarily low marsh vegetation communities. The Restoration site (H=1.678) had significantly higher species diversity compared to the Reference (H=0.874 site with 5 more species present in the Restoration site.

Table 2: Plant Species Identified in Restoration and Reference Area Sampled Transects in 2023

2023 Plant Species sampled
Spartina alterniflora (tall and short form)
Spartina patens
Limonium carolinianum
Salicornia sp.
Distichlis spicata
*Fucus distichus**
Sueda maritima

While the species encountered within the sampling plots were 100% salt marsh vegetation, the coverage of plots by vegetation was slightly different between the Restoration and the Reference transects (Table 3). In the Restoration area, 80% of all plots were over 50% vegetated. The Reference area had 83% of all plots over 50% vegetation. This is only a small difference between the sites, and the Restoration site did show an increase in coverage in 2023 (80%) compared to 2022 (73%). This increase in vegetation coverage along the transects is related to recovery of salt marsh dieback due to purple crab management. This indicates an increase in salt marsh health within the 1.1-acre direct restoration area.

The shoreline of the Reference area was originally GPSed at an extreme low tide in 2020. These areas were re-GPSed in 2022 and in October 2023 to document the location of the shoreline. Documentation took place at low tide and followed the most intertidal-ward extent of salt marsh vegetation along the shoreline. Essentially the shoreline location is documented as the edge of salt marsh vegetation extending into the harbor area. We did see an advancement of salt marsh vegetation in the Restoration area from 2020 to 2022 and from 2022 to 2023 as vegetation is colonizing into the sediments accumulating in the intertidal area.

On 2-23, we were finally able to purchase and set up our RTK GPS unit and measured elevation every meter along all 10 transect lines. While we don't have a comparison to pre-restoration, the transects within the reef show increased elevation in the intertidal area compared to adjacent and reference transects. Additionally, two elevation spikes occur on all transects within the physical reef area (Transects 1,2,3,4) that corresponds with increased sediment immediately landward of each reef structure. This corroborates physical observation of increased sediment landward of the reef. This sediment is currently soft and unconsolidated but will hopefully be colonized by vegetation in the future.

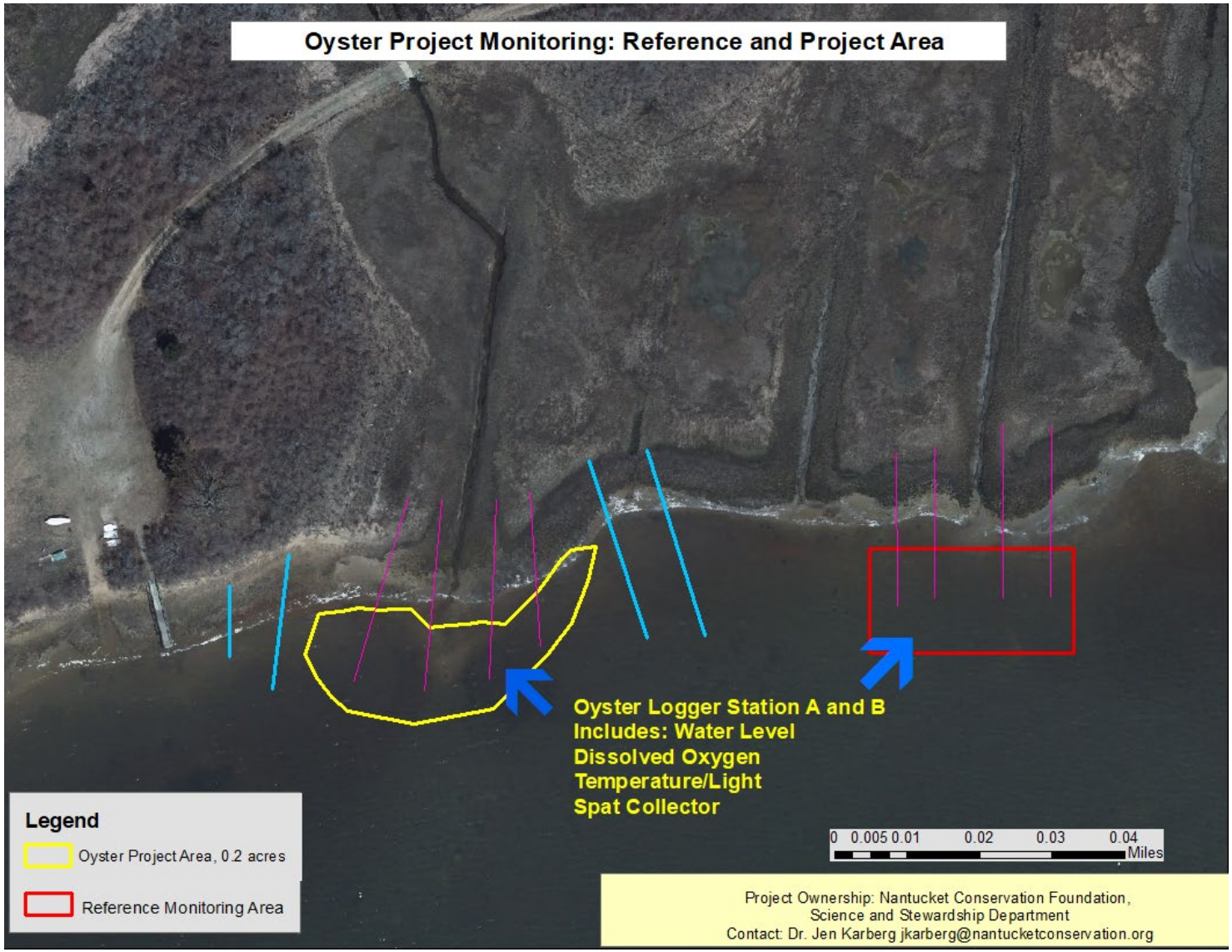
Salt marsh dieback: Vegetation monitoring within the 1.1-acre directly enhanced marsh area will document the increase in salt marsh vegetation percent coverage over time with crab management. Visual surveys will be made in the indirectly enhanced marsh area to be able to adapt management if dieback is detected. Additionally, each fall, NCF will GPS the extent of exposed soil within the project site, both in the front and back salt marsh to document the effects of salt marsh dieback management. Purple marsh crab populations (which drive the vegetation dieback) will be documented each year as well as the number of crabs removed from the marsh.

Salt marsh dieback areas were GPSed in October 2023 in the Restoration area (directly enhanced area 1.1 acres) and within the indirectly enhanced area (14.6 acres) and compared to areas documented in 2022. Dieback, measured as exposed soil with no rooted vegetation, decreased marginally in the directly enhanced marsh from 0.631 acres in 2022 to 0.0546 acres in 2023. The decrease was due to recolonization of dieback areas by *Spartina alterniflora*. *S. alterniflora* regrew due to a reduction in grazing pressure caused by the regular removal of purple marsh crabs during the growing season.

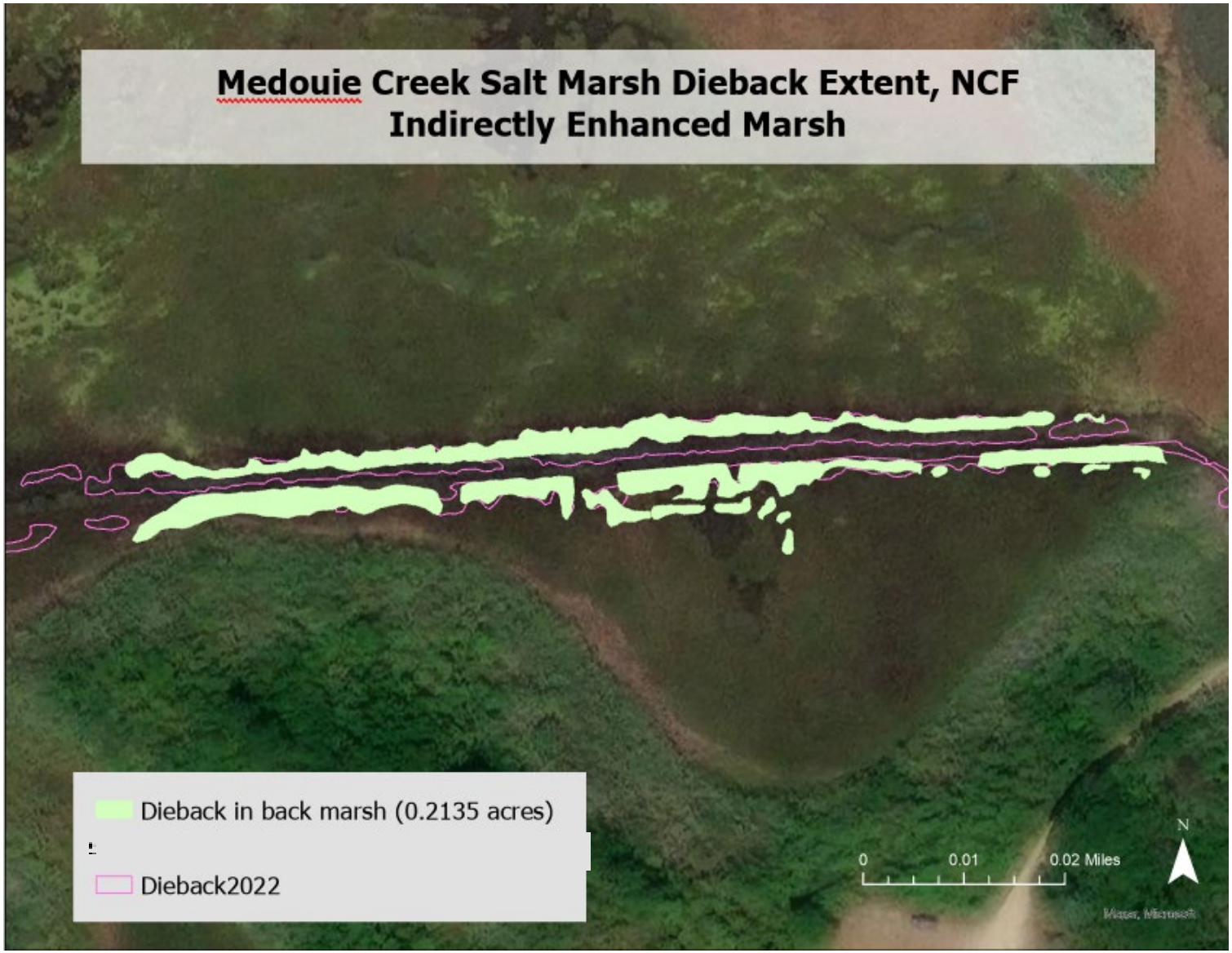
2022 saw a dramatic increase in dieback in the indirectly enhanced marsh area with 0.281 acres. Strategic trapping of the purple marsh crab showed a small decrease in dieback area in 2023 (0.2135 acres) This was the first year of management of the crab populations, and we expect the dieback to decrease in the future with continued and enhanced crab removal.

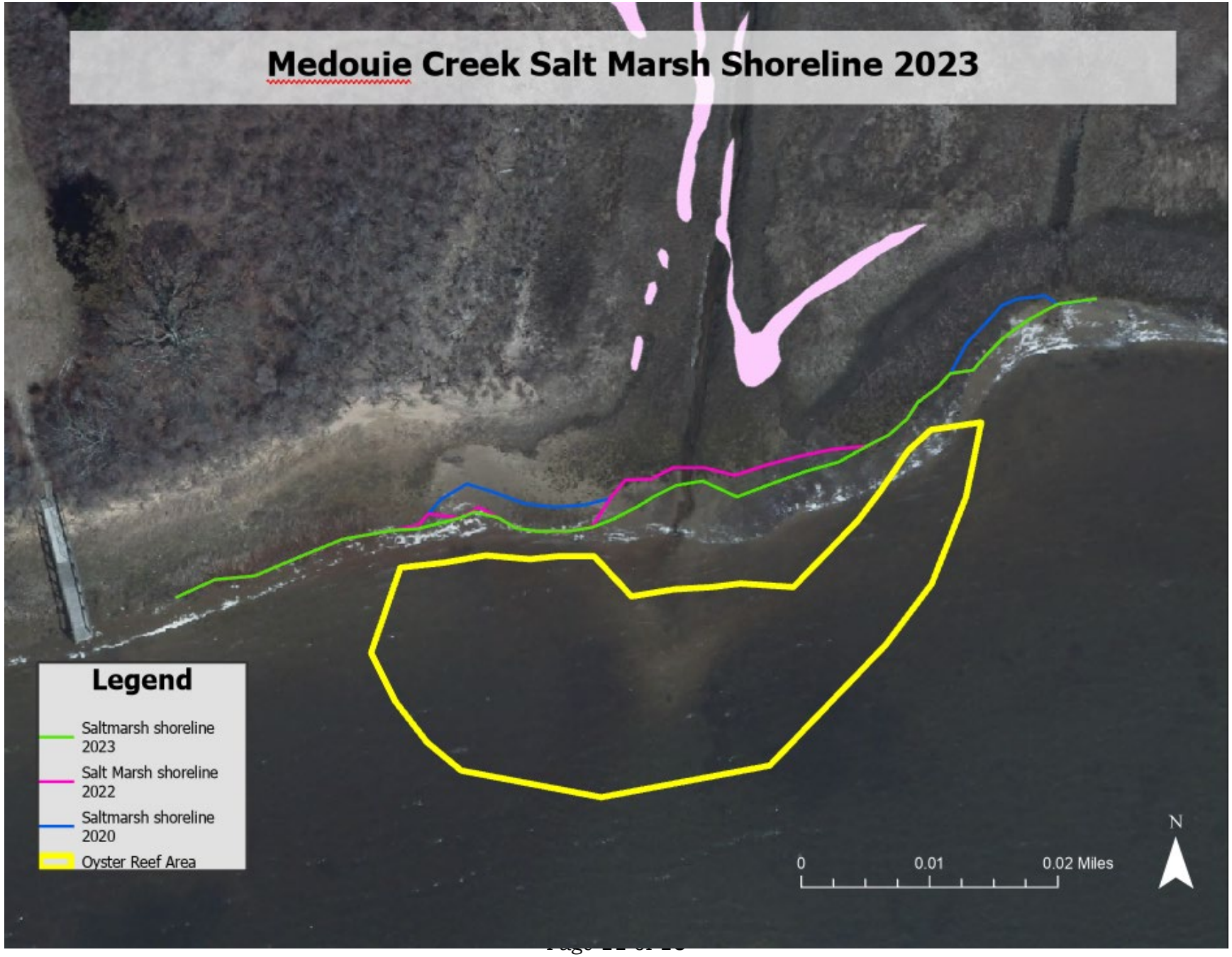
Overall, the project is meeting stated Monitoring Year 2 performance standards. The only adaptive management suggested is increased control of the purple marsh crab in 2024 within the indirectly enhanced marsh areas to reduce dieback. Supporting Maps and Photographs to this data are presented in the following sections.

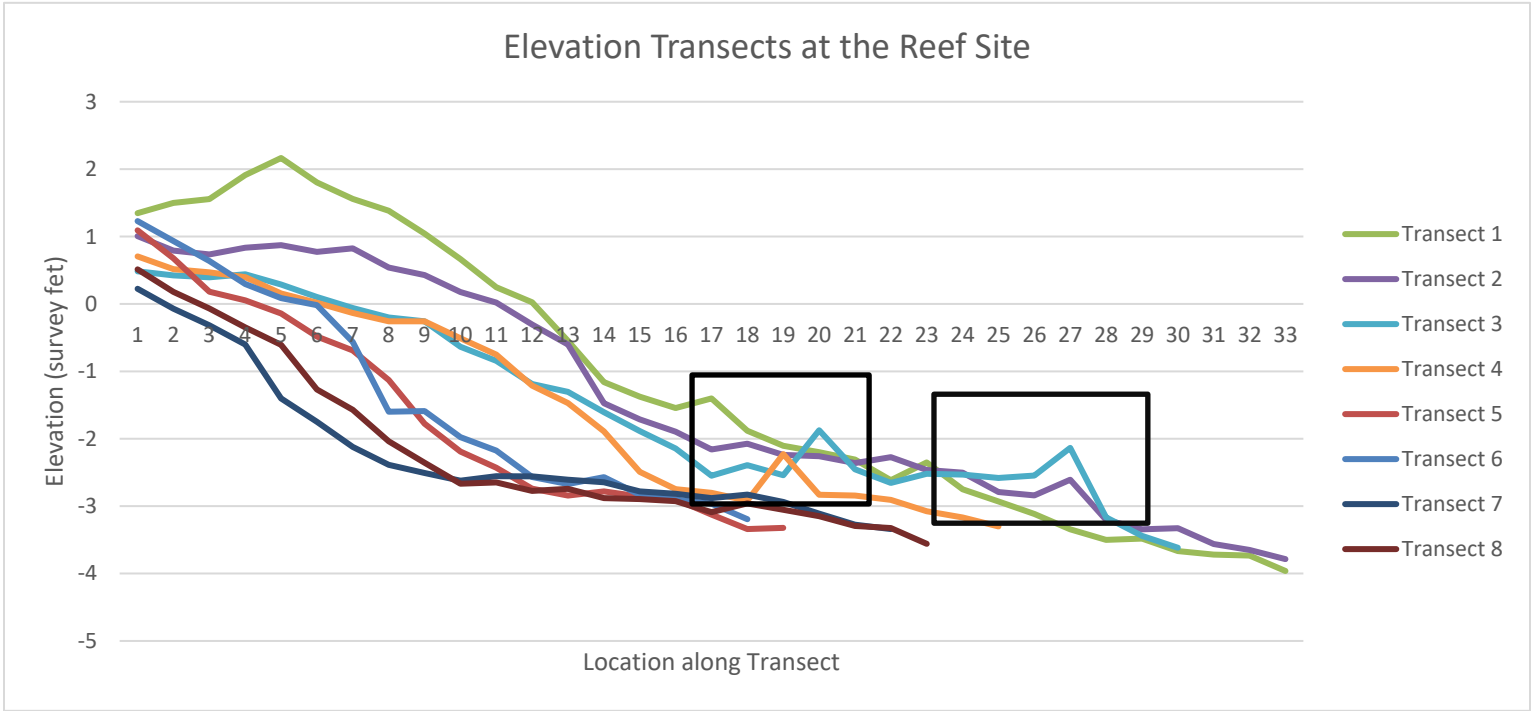
4) Maps/Plans (maximum of 3 pages)

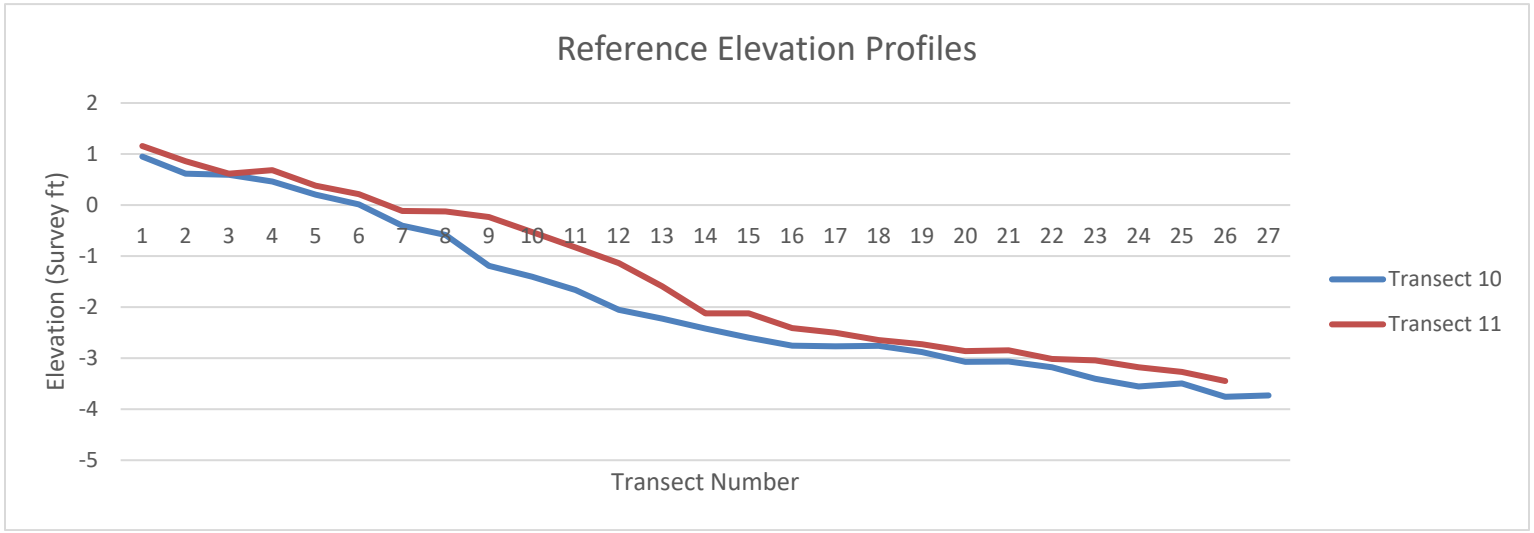



Medouie Creek Salt Marsh Dieback Extent, NCF
Directly Enhanced Marsh
Dieback in front marsh (0.0546 acres)
Dieback2022
0
0.01
0.02 Miles
N


Medouie Creek Salt Marsh Dieback Extent, NCF
Indirectly Enhanced Marsh
Dieback in back marsh (0.2135 acres)
Dieback2022
0
0.01
0.02 Miles
N


Medouie Creek Salt Marsh Shoreline 2023
Legend
Saltmarsh shoreline 2023
Salt Marsh shoreline 2022
Saltmarsh shoreline 2020
Oyster Reef Area
0
0.01
0.02 Miles
N


Elevation Transects at the Reef Site
Elevation (survey fet)
3
2
1
0
-1
-2
-3
-4
-5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
Location along Transect
Transect 1
Transect 2
Transect 3
Transect 4
Transect 5
Transect 6
Transect 7
Transect 8


Reference Elevation Profiles
Elevation (Survey ft)
2
1
0
-1
-2
-3
-4
-5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
Transect Number
Transect 10
Transect 11

5) Conclusions (1 page)

After two years of installation, the oyster reef at Medouie Creek appears to be stabilized and meeting anticipated performance standards. The reef has remained stable over two years and has not needed any physical maintenance. The oysters themselves are healthy and growing on the reef and expanding on the reef. We actually encountered oyster spat in 2023, indicating oysters are reaching maturity and reproducing. Salt marsh health is increasing with both the reef providing stabilization and trapping sediment and with removal of the purple marsh crab allowing vegetation to recolonize dieback areas. The only adaptive management warranted in 2024 is to increase purple crab management in the back part of the salt marsh (the indirectly enhanced area) to mitigate observed salt marsh salt marsh dieback and maintain gains in the directly enhanced marsh.

Overall, we are pleased with the progress of the project and look forward to realizing increased benefit in the next few years as the reef stabilizing and the salt marsh grows in elevation.

Monitoring Report Appendices

Appendix A Photographic Log

Salt Marsh Dieback Area:

2020 Dieback Area

2021 Dieback Area

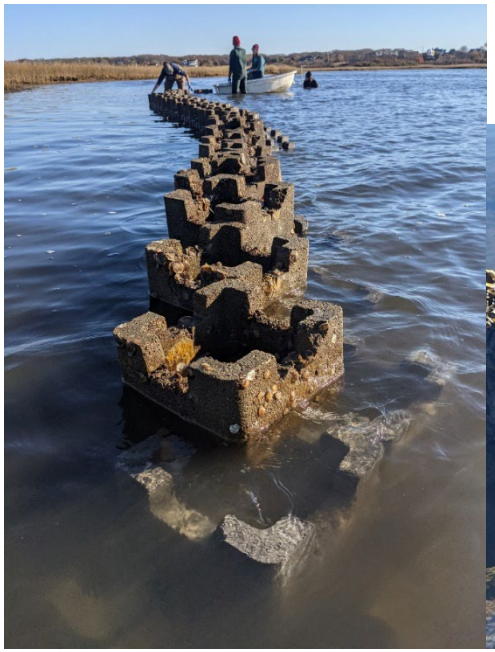
2022 Dieback Area

Oyster Reef Project Area:

Looking from salt marsh towards reef area: 2020

Looking from salt marsh towards reef area: 2022

Oyster Reef Structure:



Oyster spat on castles during Installation: 2021

One year oyster growth on castles: 2022

Two years of growth on castles: 2023