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YEAR 3 EELGRASS BIOMASS AND DELINEATION REPORT
CUSTOM PLYWOOD MILL SITE
CLEANUP SITE IDENTIFICATION NO. 4533
PHASE III SUBTIDAL SEDIMENT CLEANUP
FIDALGO BAY
ANACORTES, WASHINGTON

by
Haley & Aldrich, Inc.
Seattle, Washington

for
Washington State Department of Ecology
Olympia, Washington

File No. 0202972-000
June 5, 2026

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SIGNATURE PAGE FOR

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PREPARED FOR
WASHINGTON STATE DEPARTMENT OF ECOLOGY
OLYMPIA, WASHINGTON

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Table of Contents

List of Tables

List of Figures

List of Appendices

1. Purpose

The purpose of this report is to present the biomass results of the eelgrass (*Zostera marina*) and macroalgae survey conducted in July 2024 as part of the Phase III Subtidal Sediment Cleanup at the Custom Plywood Mill site, located in Anacortes, Washington. Full results for the delineation, including area surveyed, density counts, and other observations, can be found in a separate report authored by Marine Services and Assessments (MSA; 2025), included here as Appendix A.

2. Introduction

The Washington State Department of Ecology (Ecology) Toxics Cleanup Program completed Phase II of the sediment cleanup at the Custom Plywood Mill site, located on Fidalgo Bay, in 2013 (Figure 1). The Phase II cleanup addressed dioxin contamination and included in-water remedial activities such as dredging and excavation, as well as habitat enhancements. Specific enhancements included transplanting eelgrass and establishing a 2,000-square-foot eelgrass bed (transplant area) within the Phase II excavation and backfill area following construction.

Phase III focused on the remediation of intermediate levels of dioxin contamination through the application of a thin-layer sand cap over roughly 6 acres of subtidal habitat along with a minor dredging effort. These cleanup activities occurred over one construction season. This report summarizes eelgrass biomass analysis while the Year 3 Eelgrass Delineation Report (MSA, 2025; Appendix A), details the delineation and density evaluation.

Figure 1. Vicinity Map (Hart Crowser, Inc., 2020)

3. Survey Location

The project site is located in Anacortes, Washington, in Section 30 of Township 35 North, Range 2 East (Figure 1). MSA biologists in conjunction with Haley & Aldrich, Inc. (Haley & Aldrich) conducted the survey on July 21 to 22, 2024, and included areas from approximately +1 feet mean lower low water (MLLW) to –5 feet MLLW. The 2024 survey area was conducted in the area of Phase III sediment cleanup to determine the extent of eelgrass and macroalgae within this area. For consistency with previous surveys, the survey also extended outside the Phase III sediment cleanup boundary to capture the main portion of the eelgrass bed and included the transplant area established in Phase II, as well as areas north of the project site to include contractor access and staging areas.

4. Survey Methodology

Previous eelgrass and macroalgae surveys (completed in 2011, 2015, 2019, and 2021) were conducted in accordance with the Washington Department of Fish and Wildlife (WDFW) Eelgrass/Macroalgae Habitat Interim Survey Guidelines dated June 16, 2008 (WDFW, 2008). The 2022 survey followed the 2008 WDFW guidelines for consistency where possible, but the survey also satisfies the detection and precision requirements dictated by the United States Army Corps of Engineers (USACE) guidelines (USACE, 2016).

On July 20, 2024, MSA staff used georeferenced maps containing the GPS positions of the sampling locations to locate each area of interest shown in Table 1. MSA staff used their zodiac boat to drop labeled weighted marker buoys at each sampling location. They then utilized several different methodologies on July 21 and 22, 2024 to conduct the delineation and density survey based on the scope of work summarized in the July 2024 Eelgrass and Macroalgae Delineation Work Plan (MSA, 2024), in response to the relatively large size and shallow depths of the project site (see Appendix A for details). Biomass samples were collected by MSA and biomass analysis was conducted by Haley & Aldrich. Shoot biomass is potentially an important metric to examine since it is essentially a proxy for shoot morphology, integrating number of leaves and leaf surface area into one metric after drying (measured as grams Dry Weight (gDW) per shoot). Aboveground biomass is an areal estimate derived from shoot biomass and shoot density (gDW per square meter (gDW/m^2)).

4.1 BIOMASS SAMPLING METHODOLOGY

In accordance with the 2019 Custom Plywood Phase III – Thin-Layer Capping Eelgrass Monitoring and Adaptive Management Plan (Ecology Toxics Cleanup Program, 2019), both eelgrass shoot biomass and belowground biomass were to be evaluated prior to thin-layer capping placement.

At each of the eelgrass density locations, MSA divers collected five aboveground eelgrass shoots. In addition to these locations, two more monitoring points were identified for biomass collection without density counts; these locations are designated “TLC-1” and “TLC-2” to represent the eastern and western portions of eelgrass that received a thin-layer cap in 2021. Monitoring location M-7 is located at the approximate center of the 0.5-acre area that received a thin-layer cap in 2021.

The shoots were gently shaken to dislodge any residual sediment, and then placed into collection bags. After returning to the surface, the eelgrass shoots were inspected for clinging sediment or macroalgae;

any sediment/macroalgae on the shoots was gently removed. The shoots were then placed into labeled bags and placed into a cooler for transport to shore.

Divers then collected two 4-inch core samples from each density location for belowground eelgrass biomass analysis, collocating the belowground sample location to align with where the five aboveground shoots were collected. Divers utilized a stainless steel four-inch hand core for collecting the sediment samples (Figure 2). The belowground biomass samples were also placed into labeled bags and placed into the cooler for transport to shore. Upon returning to shore, the cooler containing the shoot biomass and belowground biomass samples was transferred to Haley & Aldrich staff for transport to the analytical laboratory.

Figure 2. Four-Inch Stainless Steel Hand Corer

4.2 BIOMASS LABORATORY METHODOLOGY

Processing of aboveground eelgrass samples began by thawing the frozen sample and then placing the eelgrass shoots in a large bowl or bucket of water. The blade of each shoot was individually cleaned and any epifauna or algae was removed. The shoot was then cut 2 millimeters (mm) above the last belowground root node to remove any belowground material. The length and width of the blades for each shoot were then measured and recorded. If any blades were broken or damaged, they were measured to the point at which the blade was still intact. The width of each blade was measured at the midpoint between the tip and the leaf base. After measuring, the samples were patted dry, weighed using a tared beaker, and the weight was recorded. The shoots were then placed in a labeled paper bag and dried at 65 degrees Celsius for at least 48 hours. Once dry, the dried shoots were removed from the bag and reweighed in a tared beaker and the weight was recorded.

Belowground eelgrass samples were defrosted using a warm-water bath and once thawed, the sample was emptied into a mixing bowl to stir and loosen the sediment. Afterwards, the sediment sample was sieved using a 0.5-mm screen. The sample was rinsed until only roots and rhizomes, infauna, and larger wood debris was left. All roots and rhizomes were removed from the sieve with forceps and kept in a second tray filled with water. The roots and rhizomes that were removed from the sieve were then cleaned of any additional debris. Any decayed root matter was rejected from further processing and discarded. Cleaned and clipped belowground material was then patted dry and transferred and wrapped in a pre-labeled and pre-weighed coffee filter. After taring the scale, the weight was recorded in grams and then placed in an empty glass beaker for containment during the drying process in the oven. The filter-wrapped samples were then dried at 65 degrees Celsius for at least 48 hours. The dried samples were then reweighed and the weight was recorded.

5. Results

Project biologists conducted the eelgrass delineation from July 21 to 22, 2024. Weather conditions were mostly to partly sunny with calm to breezy winds. The water column was moderately turbid for most of the survey with an average visibility of 3 to 6 feet. The delineation surveys covered approximately 30 acres to include the sediment cleanup area, transplant area, and areas of potential use by the contractor for access and staging (Figure 3). See the Appendix A report for details regarding delineation and density analysis.

5.1 EELGRASS

Photographs within Appendix A of the delineation report show the eelgrass habitat within the survey area (MSA, 2025). Density data was collected from four locations throughout the project site and in one reference area; biomass was collected from five locations and the reference area (Table 1, Figure 3).

Table 1. Locations of Density and Biomass Data Collection

Location Name	Parameter	Latitude	Longitude	Treatment
M-2	Density + Biomass	48.49334819	-122.598257	Uncapped
M-4	Density + Biomass	48.4927123	-122.5978556	Uncapped
M-6	Density Only	48.49378896	-122.5979421	Uncapped
M-7	Density + Biomass	48.49216163	-122.5987248	Capped
TLC-1	Biomass Only	48.49221674	-122.5992057	Capped
TLC-2	Biomass Only	48.49223624	-122.5983639	Capped
REF-2	Density + Biomass	48.4901805	-122.5932989	Reference
2014 Transplant *	Density Only	48.49461581 48.49472403 48.49476947	-122.59940214 -122.59951899 -122.59949303	Uncapped
2021 Transplant**	Density Only	Plot 11: 48.49421716 Plot 12: 48.49424344	Plot 11: -122.59910456 Plot 12: -122.59900086	Uncapped

Notes:
**Location collected at the perimeter corners of the target area.*
*** Location collected at the center of each plot.*

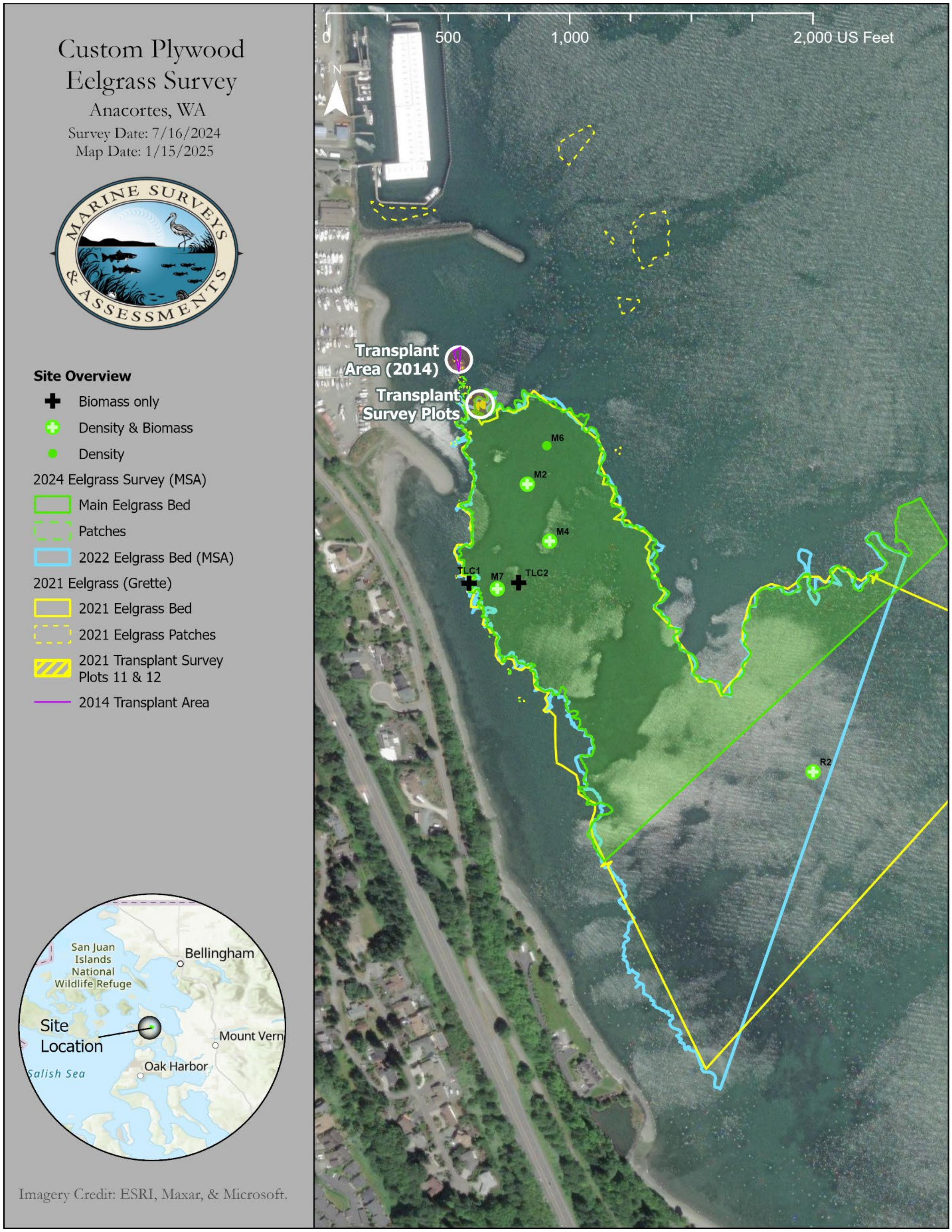

Figure 3. 2024 Eelgrass Density and Biomass Sample Locations and Delineation Results (MSA, 2025)

The delineated eelgrass bed was approximately 30.89 acres in size (Figure 3). Of those 30.89 acres, 30.08 acres (1,342,125.3 ft^2) accounted for the main eelgrass bed and 0.08 acres (3,584.6 ft^2) accounted for the eelgrass patches on the outer boundaries of the main bed. Since there is variability from year to year on the total eelgrass that is delineated, the eelgrass bed comparison between years is evaluated by creating a common boundary of the overlapping survey areas and calculating the eelgrass within that common area. Overall, the results show that the total eelgrass area has continued to increase each year since 2019 after the initial decline from 2011 to 2016 (see attached report for details; MSA, 2025).

5.1.1 Eelgrass Biomass Results

5.1.1.1 Belowground Biomass

During the pre-construction survey (Year 0, "Pre-Con"), overall material in all samples was limited to bare roots without rhizomes, leading to very low initial material to be analyzed. During sampling, positioning of the two 4-inch cores may have been placed beyond the extent of rhizomal growth or may have failed to reach the depth at which rhizomes were present. When processing, it was also difficult to distinguish live from dead material, which appeared to be nearly identical to wood waste particulates. This leads to high data variability in a set with low sample size. Thus, conclusions based on this data set should be interpreted cautiously.

When examining change in belowground biomass between Years 1 and 3, there is a mix of results. Belowground biomass is consistent between Years 1 and 3 for the reference site, M-7, and TLC-1 but has lowered at TLC-2 (25-percent drop) and risen at locations M-42 and M-4 (Table 3). The data do not yet demonstrate a clear pattern.

5.1.1.2 Shoot and Aboveground Biomass

Shoot biomass and aboveground biomass data was collected for all six sites. Shoot biomass was calculated by taking the biomass (dry weight) of the complete sample and dividing it across the number of shoots per sample (five per sample). This results in an average biomass per shoot across samples. Aboveground biomass is an areal estimate derived from shoot density and shoot biomass. Therefore, sites with higher densities saw an increased aboveground biomass due to the proportionately higher quantity of shoots per area.

Overall, using a single factor analysis of variance analysis (ANOVA) test, there were statistically significant differences in blade length across the sample sites both by site and when all sites within the project boundary were combined and compared to the reference site (Reference vs Project) (p-values of $5.6\ e^{-10}$ and 0.004, respectively, using an alpha of 0.05). Blades were generally longer within the reference site than those within project boundaries. In Year 1, there was no statistically significant difference was determined when groups were combined by whether or not they had received a thin-layer cap in 2021 (Reference vs Capped vs Uncapped) (p-value of 0.1, alpha of 0.05). However, in Year 3, there is a statistically significant difference in blade length, with blades in reference areas being the longest, those in the uncapped areas being next longest, and those in the capped areas being the shortest (p-value of 5.4e-7, alpha of 0.05). A similar pattern emerges when looking at blade width, indicating a statistically significant difference in blade width across sites, between the project area and reference, as well as between capped and uncapped areas.

Aboveground biomass decreased from Year 0 at all sites save for site M-2 and the reference site (Figure 3, Table 2 [attached]). Shoot biomass is inconsistent across monitoring locations when compared to Year 0, with no clear pattern emerging – while the reference site and M-7 have roughly stayed the same compared to Year 0, some minor decreases are seen in TLC-1, TLC-2, and M-4, while shoot biomass at location M-2 increased. Since there are fluctuations across sites in shoot biomass, it is unclear whether the changes in shoot biomass can be directly correlated to thin-layer capping. As previously mentioned, aboveground biomass is also directly proportional to eelgrass density. Since aboveground biomass is a product of shoot biomass and density, and we have seen an increase in overall density the change in density may significantly contribute to the variability and differences between sites. Locations M-7, TLC-1, and TLC-2, however, did not see an increase in eelgrass density and thus decreased in both aboveground biomass and density (Table 2).

Table 2. Density Change Summary

Sample Site	2021- Pre-Con	2022- Year 1	2024-Year 3
REF-2	25.6	19.7	28.9
M-2	10.3	8.0	18.8
M-4	12.9	14.9	23.3
M-6	18.5	11.2	23.3
M-7*	35.5	22.9	19.3

Notes:

For details, see Appendix A (MSA, 2025). A smaller quadrat was used in the 2022 Year 1 survey as compared to the 2021 Pre-Con and 2024 Year 3 surveys; this may lead to an underrepresentation of eelgrass density in the 2022 Year 1 survey.

**M-7 density is used as a proxy for locations TLC-1 and TLC-2*

Samples M-7, TLC-1, and TLC-2 are representative of the 0.5 acres of eelgrass that received 2 inches of thin-layer capping with sand material. These areas will be examined for indications of eelgrass health while monitoring continues.

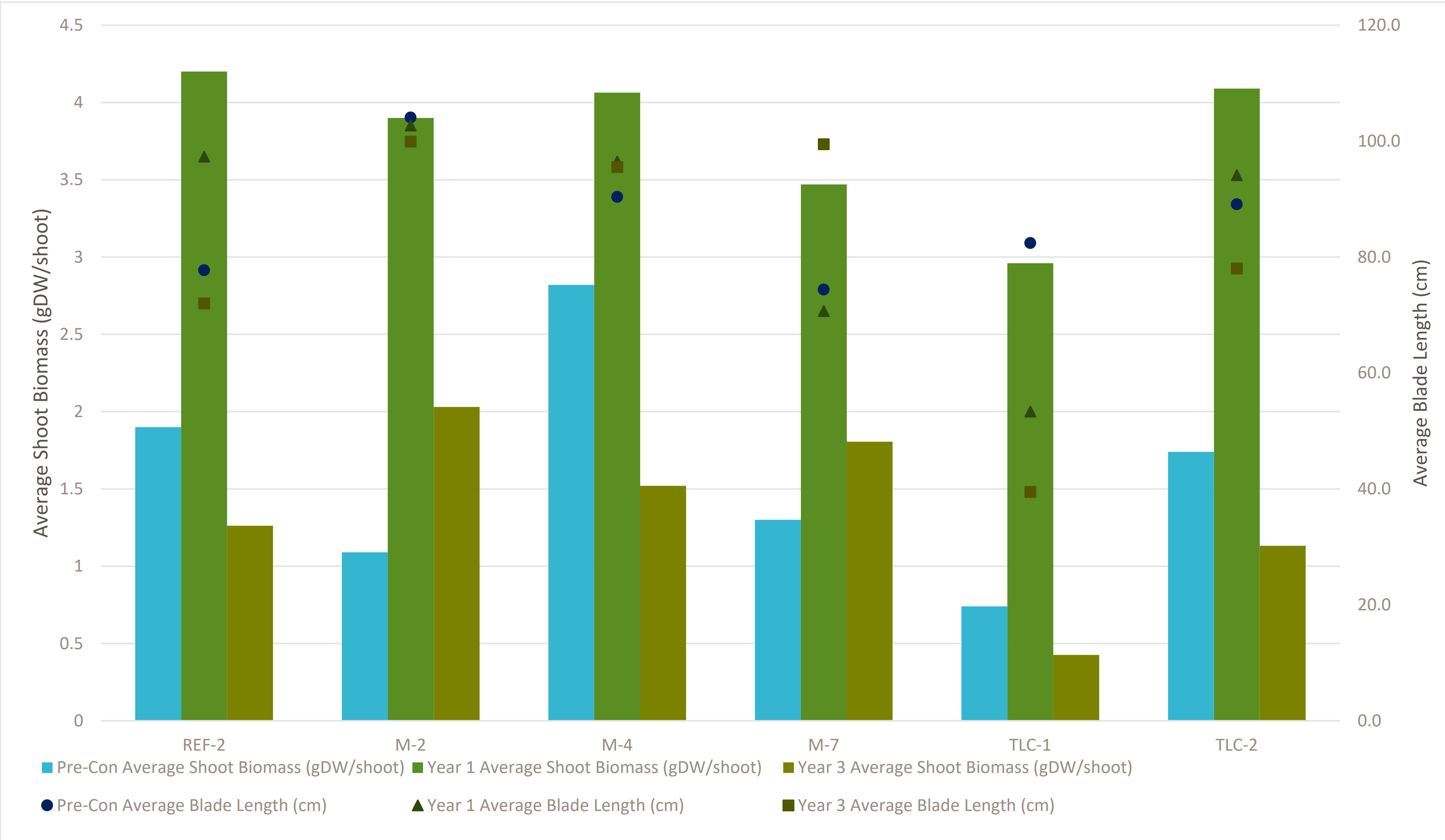

Figure 3. Average Blade Length and Shoot Biomass by Site for Pre-Construction, Year 1, and Year 3

Table 3. Biomass Results Summary

Sample Site	Sample Site Condition	Average Blade Length (cm)			Average Blade Width (cm)			Average # of Blades per Shoot			Belowground Biomass (gDW)[a]			Shoot Biomass (gDW/shoot)			Aboveground Biomass (gDW/m^2)			Change in Biomass Since Pre-Con (gDW/m^2)	
		Pre-Con	Year 1	Year 3	Pre-Con	Year 1	Year 3	Pre-Con	Year 1	Year 3	Pre-Con	Year 1	Year 3	Pre-Con	Year 1	Year 3	Pre-Con	Year 1	Year 3	Aboveground	Belowground
REF-2	Reference	104.1	102.7	99.9	1.2	1.1	1.3	5.4	5.6	6.1	-0.1[b]	0.4	0.4	1.9	3.9	2.0	49.4	77.0	58.7	9.3	0.4
M-2	Uncapped	74.4	70.7	99.5	0.9	1.0	1.1	5.1	6.6	6.2	-0.1[b]	0.0	0.4	1.1	3.5	1.8	10.9	27.8	34.0	23.1	0.5
M-4		90.4	96.5	95.5	1.1	1.1	1.2	7.0	5.9	4.8	-0.1[b]	0.5	0.8	2.8	4.1	1.5	36.7	60.7	35.5	-1.3	0.8
M-7	Capped	77.7	97.3	72.0	0.9	1.2	1.1	5.6	5.6	7.4	0.2	0.4	0.4	1.3	4.2	1.3	45.4	96.3	24.4	-21.0	0.2
TLC-1[c]		82.4	53.3	39.5	0.8	0.7	0.7	5.1	6.4	8.7	--	0.1	0.1	0.7	3.0	0.4	25.8	67.9	8.2	-17.5	0.1
TLC-2[c]		89.1	94.1	78.0	1.1	1.1	1.1	5.2	6.3	6.1	--	0.4	0.3	1.7	4.1	1.1	61.0	93.8	21.9	-39.1	0.3

Notes:

[a] *See Section 5.1.1.1 regarding belowground biomass.*

[b] *Negative values observed are likely attributable to the lack of substantive rhizomes observed, representing negligible root material and ambient moisture loss in the coffee filter media.*

[c] *Extrapolated using the density of M-7 due to proximity; density counts were not conducted at TLC-1 or TLC-2.*

6. Conclusions

Shoot and aboveground biomass for this monitoring event demonstrates varied results across the project site with decreases in aboveground biomass at all sites except for M-2 and at the reference site. However, when examining biomass per shoot, there is no clear pattern. Considering the direct relationship between density and aboveground biomass as stated in Section 5.1.1.2, it can be concluded that the decrease in density is likely a significant contributor to the decrease in aboveground biomass. Though belowground biomass will continue to be monitored, alterations in protocol may result in increased recovery of material relative to the findings in this report; as such, the pre-construction baseline should be considered carefully when analyzing belowground biomass.

The size of the eelgrass bed has decreased since monitoring began in 2011, though after 2019 the bed has increased in area in years 2021, 2022, and 2024. This total increase in surface area combined with a spike in biomass during Year 1, as depicted in Figure 3, indicates the bed may be experiencing rhizomal spread across the monitoring years. The interannually variability observed here indicates further monitoring is warranted prior to the completion of capping throughout the bed. Since the bed is demonstrating statistically significant differences between the reference area, capped areas, and uncapped areas, future monitoring should consider analysis between these areas.

Eelgrass is dynamic in morphology and mobile using horizontal rhizome growth to spread bed boundaries while also being highly variable in reproductive effort between years, becoming a moving target to determine stability (Marba et al., 2004). There were no observations of significant wasting within the bed. The natural variability in eelgrass growth in tandem with changes in Fidalgo Bay should be considered when determining health of the existing bed. Understanding eelgrass bed stability will be necessary to assess effects of the project on the existing bed and should be collaboratively determined with the Samish Tribe and other local partners investigating current eelgrass health in Fidalgo Bay.

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APPENDIX A
Custom Plywood Mill Phase III- A Subtidal Sediment Cleanup Project - Year 3 Eelgrass Delineation Report (MSA, 2025)

Custom Plywood Mill Phase III-A Subtidal Sediment Cleanup Project

Year 3 Eelgrass Delineation Report

Anacortes, WA

CSID No.: 4533

March 10th, 2025

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1 Contents

List of Figures and Tables

2 Project Overview

The Washington Department of Ecology (Ecology) Toxics Cleanup Program (TCP) completed Phase II of the sediment cleanup at the Custom Plywood Mill site located on Fidalgo Bay, in 2013 (Figure 1). The Phase II cleanup addressed dioxin contamination and included in-water remedial activities such as dredging and excavation, as well as habitat enhancements. Specific enhancements included transplanting eelgrass and establishing a 2,000 square-foot eelgrass bed (transplant area) within the Phase II excavation and backfill area following construction.

Phase III focused on the remediation of intermediate levels of dioxin contamination through the application of a thin-layer sand cap over roughly 6 acres of subtidal habitat along with a minor dredging effort. These cleanup construction activities were authorized under U.S. Army Corps of Engineers (USACE) permit NWS-2012-868.

The original objective of the eelgrass and macroalgae delineations and biomass evaluations described herein were twofold: to document the extent and density of eelgrass and macroalgae within the project footprint and immediate vicinity to inform the contractor conducting the Phase III-A dredging, and to collect data that would allow for the comparison of pre- and post-project conditions as a means to evaluate the potential for project-related impacts and understand how the habitat has changed through time. A pre-construction survey was conducted prior to the Phase III-A dredging that occurred in 2021 and a post-construction survey was conducted in 2022 (Year 1). Therefore, the purpose of this report is to provide the Year 3 results of the eelgrass (*Zostera marina*) and macroalgae survey conducted in July 2024 to compare the pre- and post-project conditions as well as compare the conditions through time.

All protocols and methods for the eelgrass and macroalgae delineations are in compliance with the current guidance from the USACE (*Components of an Eelgrass Delineation Report*, January 2018) and the Washington Department of Fish and Wildlife (WDFW) (*Eelgrass/Macroalgae Habitat Interim Survey Guidelines*, June 2008).

3 Project Location

The project site is in Anacortes, Washington in Section 30 of Township 35 North, Range 2 East. Latitude: 48.494862, Longitude: -122.599750

The 2024 survey area was conducted within the Phase III sediment cleanup area to determine the extent of eelgrass and macroalgae within this area. For consistency with previous surveys, the survey also extended outside of the Phase III sediment cleanup boundary to capture the main portion of the eelgrass bed and included the transplant area established in Phase II, as well as areas north of the project site to include the access and staging areas used by the contractors. The total survey area covers 30.89 acres. A vicinity map of the project site can be seen in Figure 1 below.

Figure 1. Project Site Vicinity Map

4 Survey Methodology

Previous eelgrass and macroalgae surveys (completed in 2011, 2015, 2019, and 2021) were conducted in accordance with the Washington Department of Fish and Wildlife (WDFW) Eelgrass/Macroalgae Habitat Interim Survey Guidelines dated June 16, 2008 (WDFW 2008). The 2022 and 2024 survey followed the 2008 WDFW guidelines for consistency where possible, but the survey also satisfies the detection and precision requirements dictated by the United States Army Corps of Engineers (USACE) guidelines (USACE 2016).

On July 20th, 2024, MSA staff used georeferenced maps containing the GPS positions of the sampling locations to locate each area of interest shown in Table 1. In 2021, rebar stakes were initially put into the substrate at the transplant site to aid in (1) finding the exact plot locations and (2) to allow for consistent counts between years (2021 Transplant Area – Plot 11 and Plot 12); however, these stakes were no longer present during the 2024 survey. Therefore, only the georeferenced maps could be utilized across all sampling locations. MSA staff used their zodiac boat to drop labeled weighted marker buoys at each sampling location. They then utilized several different methodologies (*see each section below*) on July 21st and 22nd, 2024 to conduct the delineation and density survey based on the scope of work, in response to the relatively large size and shallow depths of the project site.

Table 1. Sampling locations with the associated scope for each sample.

Location	Scope	Lat	Long
M-2	Density & Biomass	48.49334819	-122.598257
M-4	Density & Biomass	48.4927123	-122.5978556
M-6	Density only	48.49378896	-122.5979421
M-7	Density & Biomass; general notes on health since this is in the thin layer cap area and will inform further placement.	48.49216163	-122.5987248
TLC-1	Biomass only; general notes on health since this is in the thin layer cap area and will inform further placement.	48.49221674	-122.5992057
TLC-2	Biomass only; general notes on health since this is in the thin layer cap area and will inform further placement.	48.49223624	-122.5983639
REF-2	Density & Biomass	48.4901805	-122.5932989
Corners of the 2014 Transplant area	Density count & GPS of perimeter	48.49487567	-122.5994416
Corners of the 2014 Transplant area	Density count & GPS of perimeter	48.49483311	-122.5995527
Corners of the 2014 Transplant area	Density count & GPS of perimeter	48.4946023	-122.599458
2021 Transplant area – Plot 11	Density count & GPS of perimeter to represent the combination of both plots, the Lat/Long included are the center points of each plot but together they make the 2021 transplant area. Plantings were mostly to the west in each plot. These points should align with the semicircles on the map.	48.49420701	-122.5991085
2021 Transplant area – Plot 12	Density count & GPS of perimeter to represent the combination of both plots, the Lat/Long included are the center points of each plot but together they make the 2021 transplant area. Plantings were mostly to the west in each plot. These points should align with the semicircles on the map.	48.49423026	-122.5990029
Area of historical EG loss	generally reconned each year in case of new recruitment after some was lost in	48.4953882	-122.5984741

	earlier phases. Likely limited by visibility, lower in priority.		

4.1 Eelgrass and Macroalgae Delineation

The entire eelgrass bed boundary as well as the boundaries of the transplant areas were defined using the Eelgrass Delineation Method A, from the USACE guidelines (USACE 2016). On July 21st and 22nd, 2024, MSA utilized a Bad Elf Flex Unit (Model: BE-GPS-5500) in real time kinematics (RTK) mode, using Global Navigation Satellite System (GNSS) corrections (GEOID99) to log delineation datapoints along the eelgrass boundaries and on average, the horizontal accuracy of the unit was 0.32 meters. The shoreward perimeter of the Survey Area was located at elevations that were exposed during daylight low tides on July 21st and 22nd (Table 2). Therefore, MSA staff walked the main bed boundaries and nearby isolated patches. For the seaward boundaries, MSA utilized an 8 ft zodiac to delineate the boundaries with the GPS. Two staff were aboard the zodiac, one to log the datapoints using the GPS and the other to visually spot the boundaries of the eelgrass. The third staff member was in the water walking the boundary at low tide in a drysuit aiding the research vessel. Datapoints were logged no more than 40 feet apart, dependent on the complexity of the eelgrass boundary. Additionally, photographs were taken of the eelgrass boundary delineations, as well as of the portions of the Survey Area devoid of eelgrass.

Table 2. Tides from July 21 & 22, 2024 using NOAA Tides & Currents: Anacortes, Fidalgo Island, WA- Station ID: 9448794

Day	Predicted Tide (MLLW)	Time (24-hr)
July 21, 2024	Low: -2.9 ft	11:30
	High: +8.4 ft	19:00
July 22, 2024	Low: -2.9 ft	12:00
	High: +8.5 ft	20:00

4.2 Eelgrass Density

4.2.1 Main Eelgrass Bed and Reference Site

MSA SCUBA divers used the weighted marker buoys as the center point for each sampling location in the main bed (M-2, M-4, M-6, M-7) and the reference site (REF-2). MSA biologists navigated along three cardinal directions (0°, 90°, and 180°) outbound from the center point using a 200 ft survey tape with an attached compass. A random number (1 through 10) was selected prior to the start of the dives for each day to indicate at what distance along the transect tape to start density counts. Start and end points of eelgrass were not noted since all sampling occurred within the main eelgrass bed and did not extend beyond the outer boundaries of the bed. Eelgrass densities were taken every 5 ft by counting the number of shoots present within a 0.25-m^2 quadrat and recorded onto waterproof datasheets. Counts were completed every 5 ft to ensure that sufficient data was collected to meet the WDFW minimum requirements of 30 density counts. These densities were then multiplied by 4 to provide shoots per 1-m^2.

Statistical tests (one-way ANOVA) were performed to compare the average eelgrass shoot densities between different years and the results are discussed below. However, due to a protocol discrepancy that occurred in 2022 (year 1 post construction), the 2022 data was excluded from the statistical analysis. In the 2021 survey, a 0.25-m^2 quadrat was utilized for the density counts, however, in the 2022 survey, a 0.0625-m^2 quadrat was used to count the number of eelgrass shoots in three areas along the sampling location and those three counts were used to create an average. This average was then multiplied by 16 to provide shoots per 1-m^2. A smaller quadrat increases the likelihood for the density counts to be zero and as a result can underrepresent the eelgrass present. Therefore, for future accuracy and comparability, the 0.25-m^2 quadrat was utilized for the 2024 survey and will continue to be used for future monitoring to allow for statistical comparisons.

4.2.2 Transplant Areas

The corners of the 2014 transplant area were marked with weighted marker buoys and at low tide MSA staff counted every shoot within the marked boundaries, took GPS points, and documented the substrate and any other submerged aquatic vegetation. Quadrats were not utilized to count the shoots due to the minimal eelgrass presence within the boundaries.

For the 2021 transplant area (plot 11 and 12), MSA staff used the 0.25-m^2 quadrats to count the number of eelgrass shoots within the entire semicircle (Figure 8). The weighted marker buoy was used as the center point of the diameter of the semicircle. A transect tape was then laid out to delineate the diameter of the semicircle. The 0.25-m^2 quadrat was then placed at the edge of the semicircle, and counts were recorded along the whole area. The substrate and additional notes about the presence of other submerged aquatic vegetation and wood chips were recorded. Due to the lack of eelgrass presence in plot 12 (see results below), MSA also counted eelgrass shoots surrounding the outer boundary of the semi-circle to provide quantitative information surrounding the void. Eelgrass shoots within 6-ft of the outer boundary were recorded.

4.3 Biomass Field Sampling Methodology

In accordance with the *2019 Custom Plywood Phase III – Thin-Layer Capping Eelgrass Monitoring and Adaptive Management Plan* (Ecology 2019), both eelgrass shoot biomass and belowground biomass was evaluated prior to thin layer capping placement. The resulting data collected in following years will be used in comparisons with post-project biomass monitoring to evaluate eelgrass health after thin-layer capping.

At each of the eelgrass density locations specified in the 2019 Eelgrass and Macroalgae Survey (Haley & Aldrich 2020, Table 1), MSA divers collected five aboveground eelgrass shoots. Each eelgrass shoot was individually collected by cutting them at the mudline with decontaminated scissors. The shoots were gently shaken to dislodge any residual sediment and then placed into labeled collection bags. MSA divers also collected two four-inch core samples from each density location for belowground eelgrass biomass analysis using a hand core (Figure 2). After returning to the surface, the eelgrass shoots were inspected for clinging sediment or macroalgae; any sediment/macroalgae on the shoots were gently removed. Once sampling was complete, the shoots and the 4-inch cores were placed into a cooler for transport to a laboratory for analysis. Samples were given to Haley & Aldrich, Inc. (Haley & Aldrich), who stored the samples in a freezer until analysis was conducted by Haley & Aldrich. Photos taken during sample collection can be seen in Attachment A.

Figure 2. Four-inch stainless steel hand corer

4.4 Drone Imagery

Prior to conducting field work, MSA staff ensured they were in compliance with the Federal Aviation Administration (FAA) regulations by checking the airspace and weather conditions. For commercial drone pilots, the maximum altitude allowed is 400 ft above ground level (AGL) and upon examining the survey area, there were no restrictions or authorizations required to fly a commercial drone. Once on site, orange cones were laid out along the shoreline as reference control points. At each of the five cones, GPS points were collected using the Bad Elf RTK GPS unit. From shore, one FAA certified remote pilot flew the drone over the project site collecting a series of images to cover the entire project site while a second person was the visual observer that had eyes on the drone at all times and was in direct contact with the remote pilot via handheld satellite radios. The drone did not exceed 108 m (or 354 ft) AGL. Due to windy weather conditions and the large survey area, the images could not be collected with the use of a single battery nor were they collected within the same day. Variability in images is bound to occur when taking photos across multiple days due to weather and tidal conditions that affect the lighting and positioning. Therefore, to reduce the variability as much as possible, images were taken at a low tide (between -1 ft MLLW and -2.9 ft MLLW). The initial drone images were taken on July 21st and 22nd, 2024 and finished on July 31st, 2024. Images were then stitched together using Auto Stitch software.

5 Results

MSA biologists collected all samples and data between July 21st & 22nd, 2024. Weather conditions were mostly to partly sunny with light to breezy winds and scattered rain. The water column was moderately turbid for most of the survey with an average visibility of 3 to 6 feet. The delineation surveys covered approximately 28 acres to include the sediment cleanup area, transplant area, and areas used by the contractor for access and staging (Figure 6).

5.1 Substrate and Macroalgae

The substrate was predominantly mud/silt throughout the survey area with some shell hash and wood waste, which was similar to previous years. Macroalgae was opportunistically documented throughout the survey area, which was primarily *Saccharina latissimia* (sugar kelp) and *Ulva* sp. (*prolifera and lactuca*). There was drift *Ulva lactuca* along the shoreline at low tide and *Ulva prolifera* was documented at TLC-1. *Saccharina latissimia* was the dominant macroalgae species that was present at M-2, M-4, M-7, TLC-2, 2021 transplant plot 11, and the 2014 transplant area. Additionally, during the dive survey, epiphytic algae was noted on the surface of the eelgrass blades.

5.2 Fish and Invertebrate Fauna

Observations of benthic invertebrates were opportunistic, collected incidental to eelgrass surveys and delineations. Within the survey location, Dungeness crabs (*Metacarcinus magister*), kelp crabs (*Pugettia productus*), gunnels (*Pholidae sp*.), brooding anemones (*Epiactis prolifera*), eelgrass isopods (*Pentidotea resecata*), Pacific oysters (*Crassostrea gigas*), barnacles (*Cirripedia sp*.), and horse clams (*Tresus capax*) were noted.

5.3 Anthropogenic Elements

Anthropogenic materials were noted throughout the survey but were not the focus of this survey. In 2022, wood waste was observed in sites M-2, M-6 and REF-2; however, in the 2024 survey, wood waste was present at TLC-1, M-4, 2021 transplant plot 11 and on the southern side of the spit (Figure 3).

Figure 3. Close up image of the wood waste on the south side of the spit

5.4 Eelgrass

5.4.1 Survey Area Delineation

The delineated eelgrass bed was approximately 30.89 acres in size (Figure 6). Of those 30.89 acres, 30.08 acres (1,342,125.3 ft^2) accounted for the main eelgrass bed and 0.08 acres (3,584.6 ft^2) accounted for the eelgrass patches on the outer boundaries of the main bed. Since there is variability from year to year on the total eelgrass that is delineated, the eelgrass bed comparison between years is evaluated by creating a common boundary of the overlapping survey areas and calculating the eelgrass within that common area. Therefore, the common area calculated for the 2024 eelgrass survey includes 11.8 acres or 513,125 ft^2. Overall, the results show that the total eelgrass area has continued to increase each year since 2019 after the initial decline from 2011 to 2016 (Table 3).

Table 3. Comparison of Existing Eelgrass Bed Size between Survey Years

Year	Total Eelgrass Area	
	Acres	Square Feet
2011	14.5	633,515
2015	12.4	538,068
2016	12.2	532,060
2019	11.5	502,804
2021	11.7	511,650
2022	11.8	512,517
2024	11.8	513,125

5.4.2 Main Eelgrass Bed and Reference Site

Within the main eelgrass bed, the eelgrass was dense and contained on average 21.20 shoots/m^2 in the 2024 survey (Figure 7). Within each sampling location, M-2, M-4, M-6, and M-7, there were 18.80, 23.33, 23.33, and 19.33 shoots/m^2, respectively (Table 4). The reference site (REF-2) had an average of 28.93 shoots/ m^2 (Table 5). No wasting disease was observed at any of the sampling locations.

Table 4. Summary of the 2024 Eelgrass Density Counts within the Main Bed

Site	Number of Quadrats	Total Number of Shoots	Average Number of Shoot Per m^2	Per Quadrat (0.25 m^2)				
				Average Count	Min/Max Count	25th/75th Quartile Count	Coefficient of Variance	Variance
M-2	30	564	18.80	4.70	0/12	3/6	61.25	8.29
M-4	30	700	23.33	5.83	0/11	3.25/8.75	55.70	10.56
M-6	30	700	23.33	5.83	4/13	4/7	51.15	8.90
M-7	30	580	19.33	4.83	0/11	3/6	56.75	7.52
Total	**120**	**3412**	**21.20**	**5.30**	**0/13**	**3/7**	**56.24**	**8.88**

Table 5. Summary of the 2024 Density Counts within the Reference Site

Site	Number of Quadrats	Total Number of Shoots	Average Number of Shoot Per m^2	Per Quadrat (0.25 m^2)				
				Average Count	Min/Max Count	25th/75th Quartile Count	Coefficient of Variance	Variance
REF-2	30	868	28.93	7.23	0/15	5/10	52.70	14.53

In the 2021 pre-construction survey, the main eelgrass bed contained an average of 19 shoots/m^2, while the reference site contained 26 shoots/m^2 (Table 6). In the year 1 monitoring survey in 2022, these densities decreased to 4 shoots/m^2 in the main eelgrass bed and 5 shoots/m^2 in the reference area. Although this decline could have been due to environmental factors, it is also likely due to the change in quadrat size that would have allowed for more counts to be zero. With a quadrat that is four times the size, it is more likely to have some eelgrass within that area to count. Due to the method discrepancies, year 1 is difficult to compare and shall be referenced with caution. Therefore, comparing the 2021 and 2024 survey results, the main eelgrass bed and reference area has increased in density by 11 % (11.3 % increase at the reference site and 11.6 % increase in the main bed). In 2024, the main eelgrass bed contained an average of 21.2 shoots/m^2 and the reference site contained 28.9 shoots/m^2. However, statistically, the bed has not changed and has remained consistent throughout time as there was no significant difference between years (main bed p-value = 0.34 and reference site p-value= 0.46). This means that there has been no significant change in the eelgrass bed between pre-construction and 3-years post construction. Additionally, the main eelgrass bed relative to the reference site has remained consistent throughout the years as (although not significant) the eelgrass has been increasing at a proportional rate (~11% for both the reference and main eelgrass bed).

Table 6. Summary of the eelgrass densities through time within the main bed and reference site

Survey Year	Main Eelgrass Bed	Reference Site
Pre-Construction (2021)	19 shoots/m^2	26 shoots/m^2
1-Year Post-Construction (2022)*	4 shoots/m^2	5 shoots/m^2
3-Years Post Construction (2024)	21.2 shoots/m^2	28.9 shoots/m^2

*Sampling methods in the 2022 survey utilized a 0.0625 m^2 quadrat as opposed to a 0.25 m^2 used in the other years

5.4.3 Transplant Area

In the 2022 survey, the 2014 advanced mitigation area (2014 transplant area) had receded significantly and only contained 51 shoots. During this 2024 survey, the eelgrass boundary further receded and only contained 13 shoots (Figure 8). The substrate was very muddy (i.e. high content of silt/fine material) and rocky and most of the area was smothered in *Saccharina latissima* (sugar kelp), which could be a reason for the significant reduction in eelgrass.

In the 2021 transplant plot 11, the substrate was very muddy with shell hash and contained a lot of wood chips. There was a layer of wood chips present throughout the entire survey plot. Additionally, there was *Saccharina latissima* present. However, the eelgrass bed was very dense and contained 195 shoots within the entire semicircle (Figures 3 & 8). The 2021 plot 12 had a large void of eelgrass and only contained 14 shoots (Figures 4,5, & 8). The substrate was also very muddy without any other submerged aquatic vegetation present. Due to the lack of eelgrass, MSA biologists also counted 6-ft along the outer edge of the semicircle and documented 27 shoots. After further investigation, this site was unfortunately misrepresented due to GPS accuracy issues while on-site that were clarified upon reviewing the GPS data back at the office. The horizontal accuracy was only 3.0 m, meaning the horizontal location used in the field was likely only within 3 meters of the actual position. Therefore, the void of eelgrass was not within the 2021 plot 12 transplant area and should have been at the edge of the main bed. Regardless, the 2021 transplant area has seen an increase in density since the total shoot count between both sites in 2022 was 66 shoots and is >195 shoots in 2024.

Figure 4. MSA team counting the eelgrass within the 2021 Transplant Area, Plot 11

Figure 5. Photo depicting the eelgrass which was thought to be the void within the 2021 Transplant Area, Plot 12

*It is important to note that this void was not representative of the 2021 Transplant Area, Plot 12 due to a GPS error. Surrounding the void, the eelgrass bed was dense, which is likely more representative of the actual sample location.

Figure 6. MSA team counting the eelgrass within the 2021 Transplant Area, Plot 12

Figure 7. The 2024 eelgrass delineation Survey Area

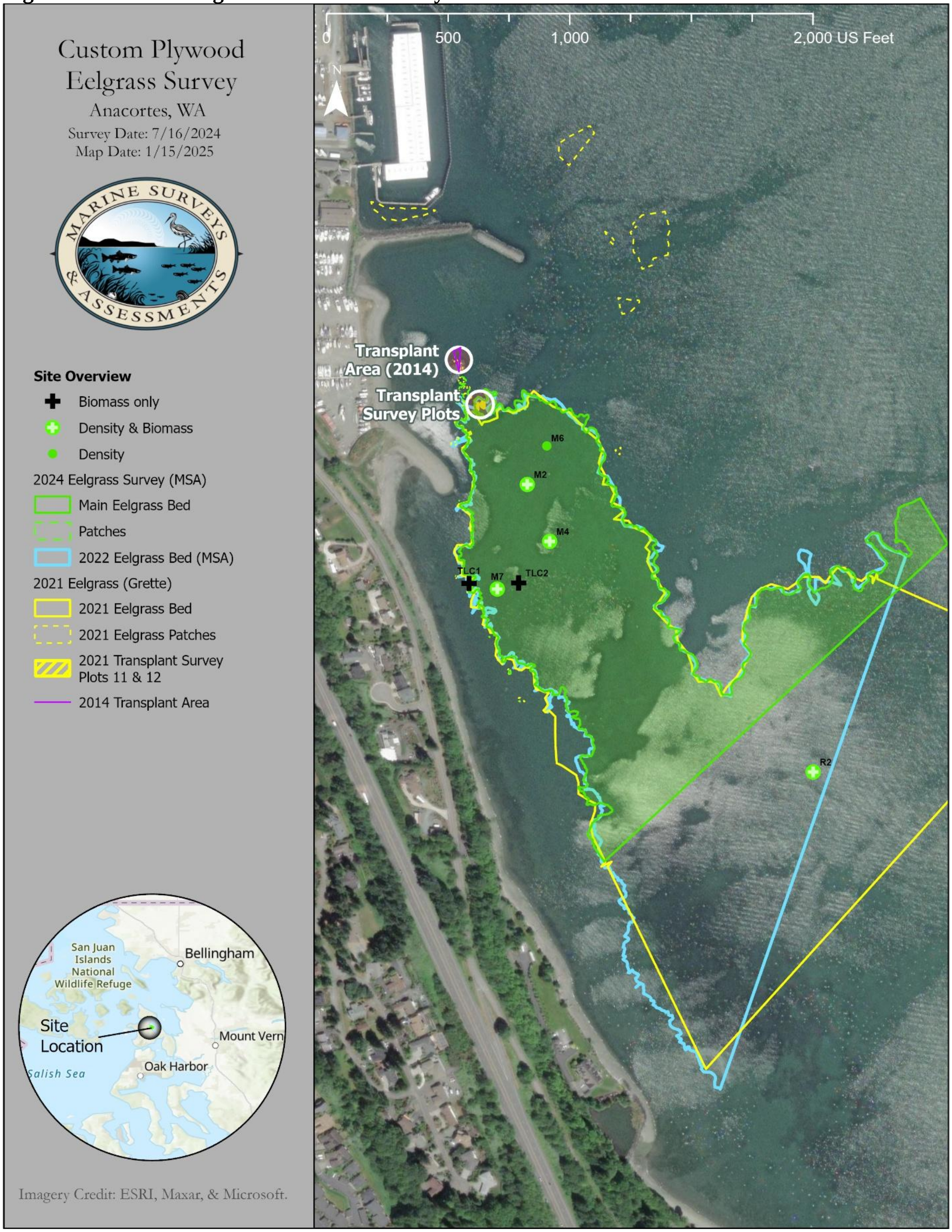


Figure 8. The eelgrass density counts at each sampling location in the main eelgrass bed and reference site

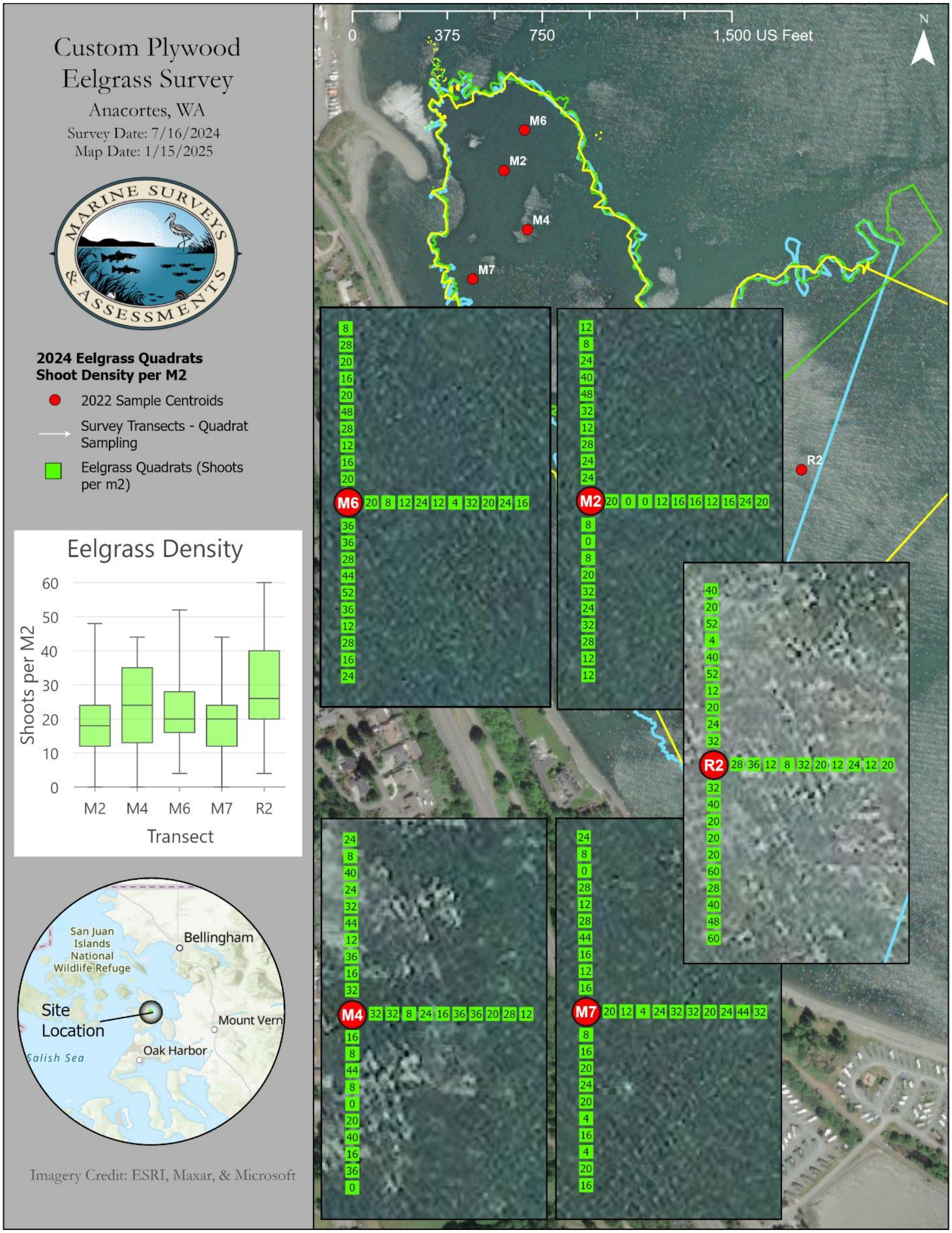
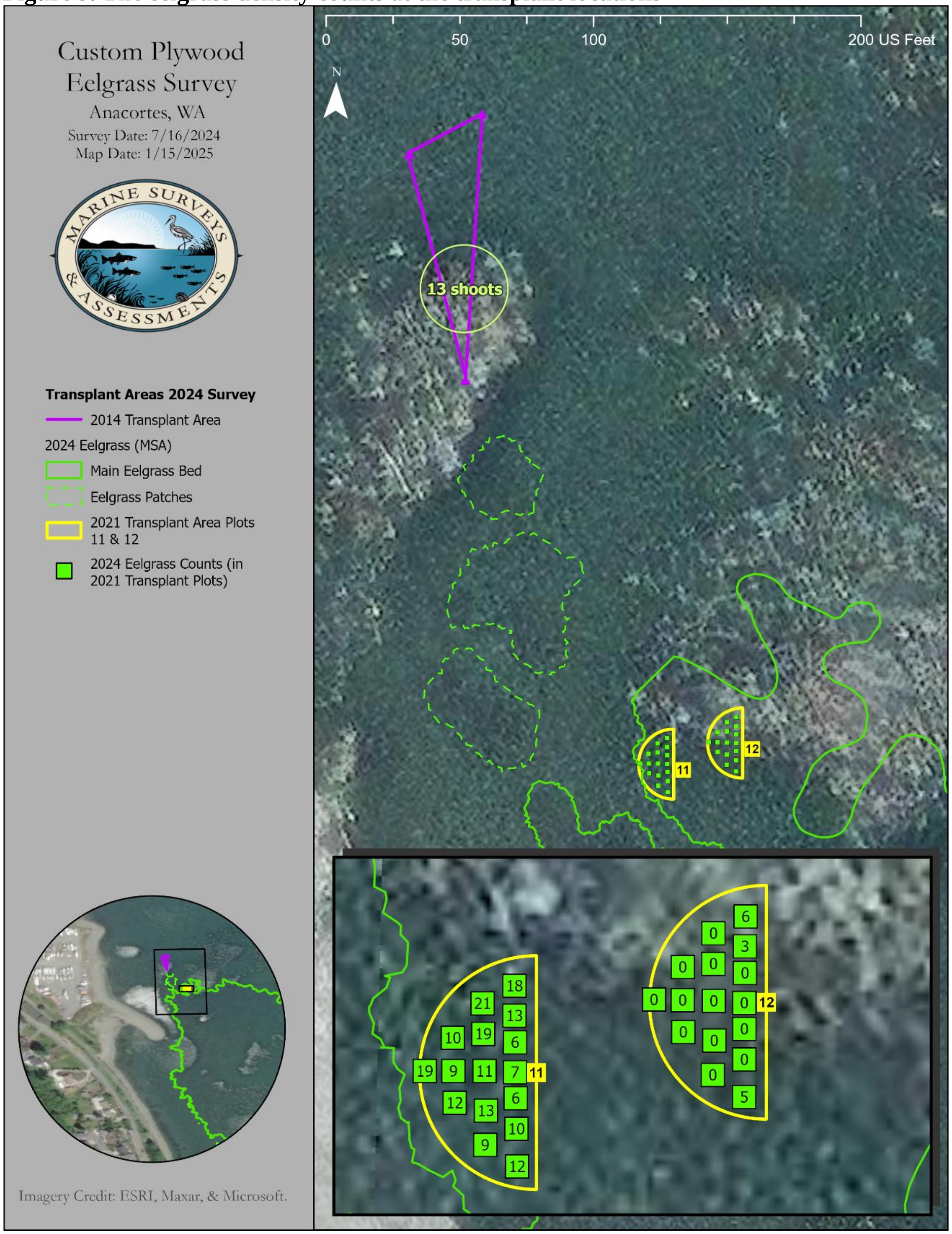


Figure 9. The eelgrass density counts at the transplant locations



5.4.4 Eelgrass Biomass

Overall, the sediment collected within the cores was mostly dark grey or dark brown silty fine sand with some shell hash containing a strong sulfuric odor. At TLC-1, there was approximately 15% *Enteromorpha*, while site M-2, M-4, M-7, and TLC-2 had 20-90% coverage of *Saccharina latissima*. No submerged aquatic vegetation was present at REF-2. The data collected can be seen in Table 3 and photos taken during sample collection can be seen in *Attachment A*.

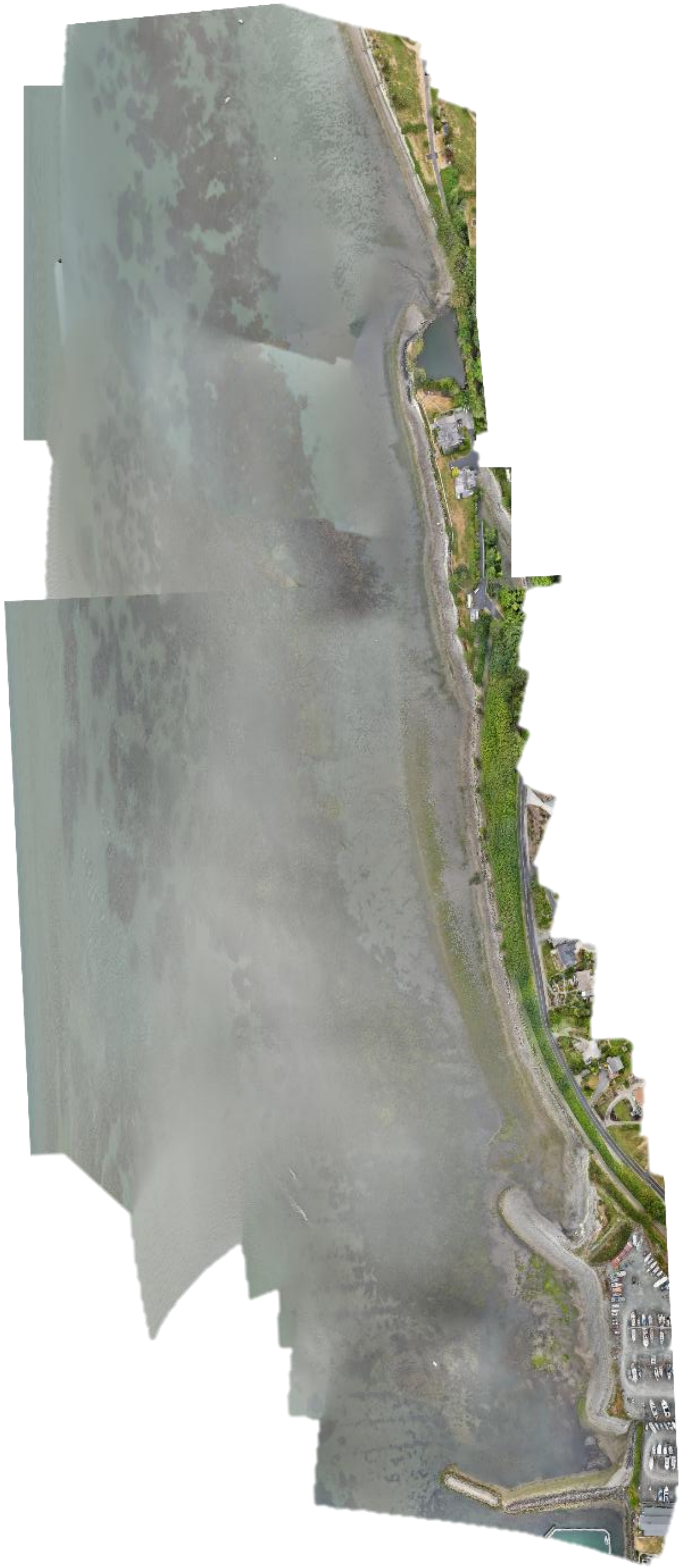
Table 7. Data collected for biomass samples

Sample Location	Sample Type	Date Collected	Time Collected	Sample Collection Notes	General Notes
TLC -1	Core 1 (TLC1-1)	07/21/2024	10:28	Dark, uniform sediment with shells on top layer	Sediment is mostly silt and shell hash, ~15% *Enteromorpha*, noticeable wood waste, depth= approximately 1 ft, Gunnel & Dungeness Crab, no signs of wasting disease on eelgrass
	Core 2 (TLC1-2)	07/21/2024	10:33	Dark, sandy/gritty silt, decaying smell	
	Shoots	07/21/2024	10:36	None	
M-7	Core 1 (M7-1)	07/21/2024	10:42	Dark sediment with some macroalgae	Sediment is mostly silt, site is within the eelgrass bed boundary, 80-90% coverage of S*accharina latissima*, no signs of wasting disease on eelgrass
	Core 2 (M7-2)	07/21/2024	10:47	Dark sediment, sandier, more water captured, some shell hash, strong odor	
	Shoots	07/21/2024	10:49	None	
TLC-2	Core 1 (TLC2-1)	07/21/2024	10:57	Similar dark silt/sand with strong odor	Sediment is mostly silt, site is within the eelgrass bed boundary, ~90% coverage of S*accharina latissima*, depth= approximately 1.5 ft, no signs of wasting disease on eelgrass
	Core 2 (TLC2-2)	07/21/2024	11:00	Dark silt/sand, with macroalgae, strong odor	
	Shoots	07/21/2024	10:55	None	
M-4	Core 1 (M4-1)	07/21/2024	11:08	Dark siltier sediment, stronger odor	Sediment is a finer silt, site is within the eelgrass bed boundary, ~40-50% coverage of S*accharina latissima*, brooding anemone, eelgrass isopod, no signs of wasting disease on eelgrass
	Core 2 (M4-2)	07/21/2024	11:14	Dark siltier sediment, stronger odor	
	Shoots	07/21/2024	11:07	None	
M-2	Core 1 (M2-1)	07/21/2024	11:27	Dark siltier sediment, not as strong of an odor	Sediment is mostly silt with some shell hash, site is within the eelgrass bed boundary, ~20% coverage of S*accharina latissima*, depth= approximately 2 ft, no signs of wasting disease on eelgrass
	Core 2 (M2-2)	07/21/2024	11:32	Dark silty sediment, strong odor	
	Shoots	07/21/2024	11:24	None	
REF-2	Core 1 (REF2-1)	07/21/2024	13:30	Mud/silt, strong odor	Sediment is mostly soft mud/silt with no shell hash, no SAV or kelp present, no inverts, depth= approximately 3 ft, ~3 ft of visibility, no signs of wasting disease on eelgrass
	Core 2 (REF2-2)	07/21/2024	13:34	Mud/silt, strong odor	
	Shoots	07/21/2024	13:28	None	

5.5 Drone Imagery

Due to the large survey area and the flight time limitations with the DJI drone batteries, only a portion of the area could be captured with a single flight. Therefore, multiple flights were required and due to high wind speeds, these flights occurred over the span of multiple days. Unfortunately, with the high volume of open-water photos needed to cover the entire survey area, there is slight distortion that occurs during the image processing which did not allow MSA to use the final stitched drone image for the base mapping. However, the image does provide a general view of the existing eelgrass bed and demonstrates locations with patchy eelgrass distribution as well as areas with dense sugar wrack kelp (Figure 10).

Figure 10. Drone imagery of the 2024 Custom Plywood Survey Area



6 Conclusion

The substrate throughout the survey area was predominantly mud and silt with some shell hash and wood waste, which was similar to previous years. *Saccharina latissima* was still the dominant macroalgae species and was present at M-2, M-4, M-7, TLC-2, 2021 transplant plot 11, and the 2014 transplant area. Additionally, the project area is still utilized by a variety of invertebrate and vertebrate fauna, with Pacific oysters, horse clams and barnacles being the most abundant species in the intertidal regions and various crab species being more abundant in the subtidal regions.

The 2024 survey delineated a total of 30.89 acres of eelgrass, including areas outside of the common delineation areas from previous surveys, which include boundaries from Phase II of construction. Of those 30.89 acres, 11.8 acres were within the comparable boundaries. Overall, annually, there has been an increase in the eelgrass bed coverage since 2019 after the initial decline from 2011 to 2016. When comparing the 2024 boundaries to 2022, there are some boundaries that have expanded whereas others have receded, in no obvious pattern, but overall, there has been an increase in eelgrass surface area. The minor change in boundaries is to be expected since eelgrass beds are not static and can change due to numerous reasons (i.e. temperature, sedimentation, water quality, currents, etc.) (Frederiksen et al. 2004, Marba et al. 2004). Visually, the eelgrass bed appears to be dense and healthy, and there were no signs of wasting disease on the surveyed eelgrass.

The 2014 advanced mitigation area significantly receded in 2022 with only 51 shoots remaining. In 2024, there were only 13 shoots within the 2014 transplant area, meaning the eelgrass has continued to recede through time in that area. However, the 2021 transplant area was very dense and has increased in density through time. In 2022, there were only 66 shoots within both transplant areas (plot 11 and 12) and in 2024, there were over 195 shoots. This means that the transplant was a success when comparing between the two years.

The density of the bed within and directly adjacent to the remedial action boundary has remained comparable between 2021 (pre-construction) and 2024 (3-years post-construction). In the 2021 survey, the main eelgrass bed contained an average of 19 shoots/m^2, while the reference site contained 26 shoots/m^2 compared to the 2024 survey, which contained 21 shoots/m^2 in the main bed and 29 shoots/m^2 in the reference site. This 11% increase between years is not statistically significant, which indicates that the eelgrass has remained consistent throughout the Phase III project.

Eelgrass is plastic in morphology and mobile using horizontal rhizome growth to establish clonal growth while also being highly variable in reproductive effort between years, becoming a moving target to determine stability (Marba et al. 2004). The natural variability in eelgrass growth in tandem with changes in Fidalgo Bay should be considered when determining health of the existing bed. Understanding eelgrass bed stability will be necessary to assess effects of the project on the existing bed and should be collaboratively determined with the Samish Tribe and other local partners investigating current eelgrass health in Fidalgo Bay.

7 References

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Custom Plywood Mill Phase III-A Subtidal Sediment Cleanup Project

Year 3 Eelgrass Delineation Report

Attachment A: Photo Documentation

Figure 1. MSA team using sediment core device to collect samples

Figure 2. Sediment Core Sample TLC1-1

Figure 3. Sediment Core Sample TLC1-2

Figure 4. Five Eelgrass Shoots collected at TLC-1

Figure 5. Sediment Core Sample TLC2-1

Figure 6. Sediment Core Sample TLC2-2

Figure 7. Five Eelgrass Shoots collected at TLC-2

Figure 8. Large percent coverage of *Saccharina* at site TLC-2

Figure 9. Sediment Core Sample M2-1

Figure 10. Sediment Core Sample M2-2

Figure 11. Five Eelgrass Shoots collected at M-2

Figure 12. Sediment Core Sample M4-1

Figure 13. Sediment Core Sample M4-2

Figure 14. Five Eelgrass Shoots collected at M-4

Figure 15. Sediment Core Sample M7-1

Figure 16. Sediment Core Sample M7-2

Figure 17. Five Eelgrass Shoots collected at M-7

Figure 18. Sediment Core Sample REF2-1

Figure 19. Sediment Core Sample REF2-2

Figure 20. Five Eelgrass Shoots collected at REF-2