



Eelgrass (*Zostera marina* L.) Abundance and Depth Distribution at Two Environmental Aquatic Reserves

- I. Maury Island
- II. Fidalgo Bay

Final Report to the DNR Aquatic Reserves Program

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WASHINGTON STATE DEPARTMENT OF
Natural Resources
Peter Goldmark - Commissioner of Public Lands

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by Jeffrey Gaeckle
Nearshore Habitat Program
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All contributors are DNR staff unless otherwise indicated.

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1 Introduction

The Nearshore Habitat Program in the Washington State Department of Natural Resources (DNR) has collected data annually since 2000 on the status of *Zostera marina* L. (eelgrass) throughout Puget Sound as part of the Submerged Vegetation Monitoring Project (SVMP). The SVMP is one component of the Puget Sound Assessment and Monitoring Program (PSAMP), a multi-agency effort to monitor key aspects of the Puget Sound environment to support resource management.

In 2008, the DNR Aquatic Reserves Program contracted the DNR Nearshore Habitat Program to collect baseline eelgrass area and depth distribution data at seven SVMP sites within the Maury Island Environmental Aquatic Reserve (Maury Island AQR) and at one SVMP site within the Fidalgo Bay Environmental Aquatic Reserve (Fidalgo Bay AQR). The Aquatic Reserve (AQR) sites sampled in 2008 were selected to determine a baseline understanding of eelgrass area and depth distribution to satisfy specific Reserve management plans.

This report summarizes the DNR sampling methods and the eelgrass area and depth distribution results at the Maury Island AQR and Fidalgo Bay AQR sites.



2 Methods

In order maintain methodological continuity with the SVMP the sites sampled in the two AQRs were previously established as part of the DNR eelgrass monitoring project (Berry et al. 2003). The DNR SVMP sampling methods are described in detail in Berry et al. (2003), Dowty (2005), Dowty et al. (2005), Gaeckle et al. (2007, 2008). The methods are summarized briefly in the following sections to provide context for the eelgrass monitoring in the Maury Island and Fidalgo Bay AQRs.

2.1 *Study Area Description*

Maury Island Environmental Aquatic Reserve

The Maury Island AQR is a 2,254 ha reserve located on the eastern shore of Maury Island and encompasses Quartermaster Harbor, the body of water between Maury Island and Vashon Island (Figure 2-1). The full extent of the Maury Island AQR includes 33 SVMP sites (Figure 2-2). Seven sites were sampled in 2008 for this project (Figure 2-2, Table 2-1). Six sites within the AQR were previously sampled as part of the annual SVMP or for a contract with King County (Reeves 2005) (Figure 2-2, Table 2-1).

Fidalgo Bay Environmental Aquatic Reserve

The Fidalgo Bay AQR is a 198 ha reserve located in the northern part of Puget Sound between March Point and the city of Anacortes (Figure 2-1, Figure 2-3). One SVMP site, *flats15-Fidalgo Bay*, encompasses the Fidalgo Bay AQR, but it was divided into two sites, *flats15N-Fidalgo Bay North* and *flats15S-Fidalgo Bay South* due to sampling restrictions from a train trestle that crosses the bay. The train trestle prevented the primary research vessel, the *R/V Brendan D II*, to navigate into the southern part of the site (Figure 2-4, Figure 2-5, Table 2-1).



Figure 2-1. Location of the eelgrass (*Zostera marina* L.) monitoring study areas in Puget Sound, WA, USA; Fidalgo Bay AQR (red) and the Maury Island AQR (green).



Figure 2-2. Map of the Maury Island AQR (yellow polygon) with seven sites that were sampled in 2008 for the DNR Aquatic Reserves Program. The six additional sites were sampled in the years indicated for the SVMP annual sound-wide sampling (SVMP) and the 2004 King County (KC) survey (Reeves 2005).

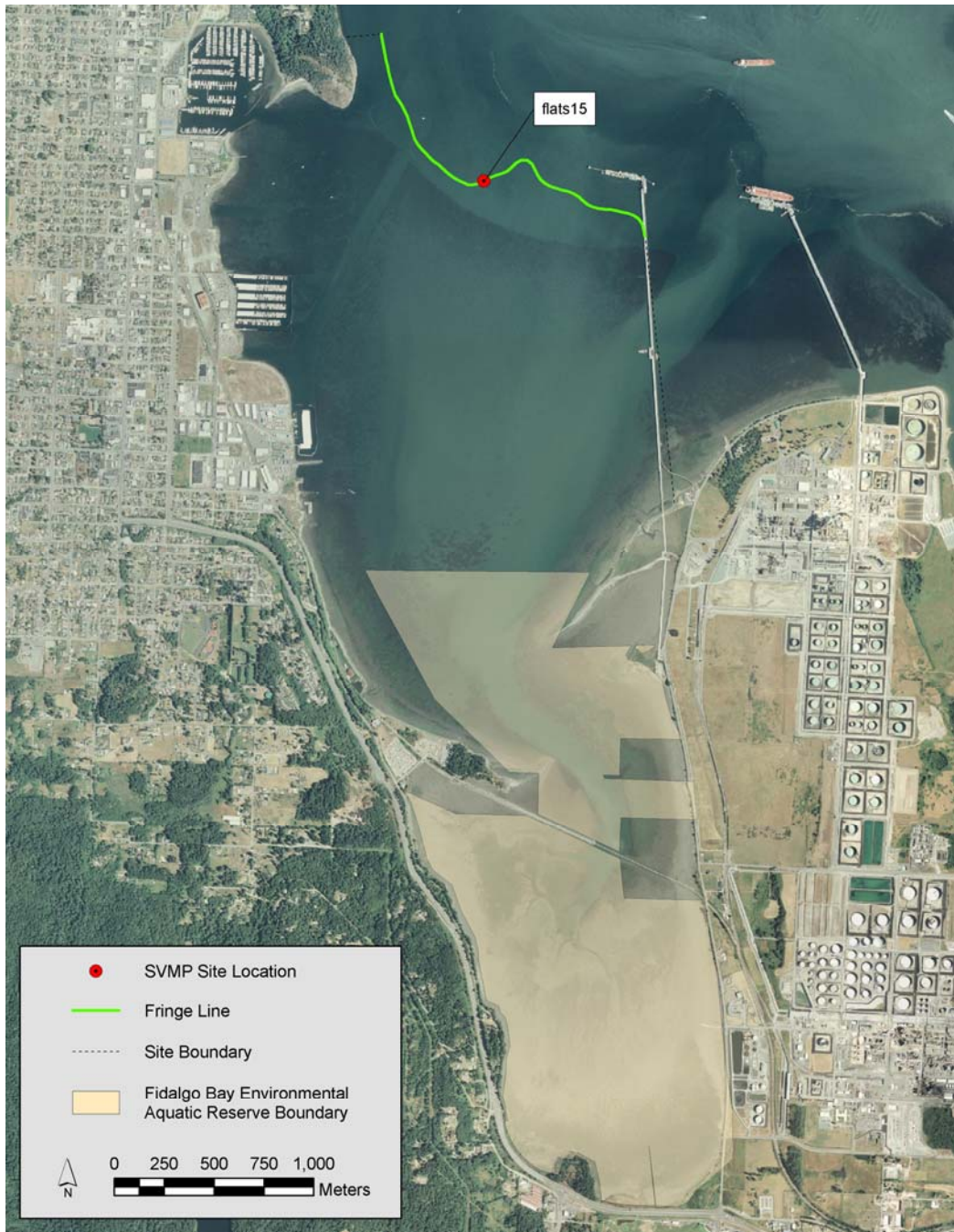


Figure 2-3. Map of the Fidalgo Bay AQR (yellow polygon) located within the SVMP site *flats15-Fidalgo Bay*. *Flats15-Fidalgo Bay* is delineated by the fringe line (-6 m bathymetry contour), the site boundary lines and the ordinary high waterline along the shoreline.

Table 2-1. Sites within the Maury Island and Fidalgo Bay Environmental Aquatic Reserves that were monitored for eelgrass (*Z. marina*) abundance and depth distribution in 2008. SITE CODE indicates the region the site is located (Central Puget Sound, cps) and the site number. SITE NAME refers to an adjacent geographical location. The STRATA column indicates whether the site is a flats (fl), narrow fringe (fr) or wide-fringe (frw) site. A flats site is a large shallow embayment. At a narrow fringe site the -6 m (-20 ft) bathymetry contour is < 305 m (1000 ft) from shore and > 305 m (1000 ft) from shore at wide-fringe sites. The LAT (latitude) and LONG (longitude) columns demarcates the center point of the fringe line at the sample site.

SITE CODE	SITE NAME	STRATA	LAT	LONG
(region site #)	(reference to an adjacent geographical location)	(narrow fringe, fr; wide-fringe, frw)	(dec deg)	(dec deg)
MAURY ISLAND ENVIRONMENTAL AQUATIC RESERVE				
cps1116	South of Viewpoint Park	fr	47.3575	-122.4867
cps1167	Maury Island Marine Park NE	fr	47.3817	-122.3915
cps1168	Maury Island Marine Park Center	fr	47.3783	-122.4039
cps1180	Dockton Point	fr	47.3754	-122.4626
cps1183	Rabb's Lagoon	fr	47.3880	-122.4372
cps2886	Orphan West - Burton	frw	47.3927	-122.4441
cps2887	Orphan East - Mileta	fr	47.3948	-122.4401
FIDALGO BAY ENVIRONMENTAL AQUATIC RESERVE				
flats15	Fidalgo Bay	fl	48.5091	-122.5888



Figure 2-4. Map of the Fidalgo Bay Environmental Aquatic Reserve. *Flats15-Fidalgo Bay* was divided into two sites, *flats15N-Fidalgo Bay North* and *flats15S-Fidalgo Bay South*, because the train trestle restricted sampling in the southern portion of the site with the primary research vessel.

2.2 Field Sampling

Field sampling at *flats15S-Fidalgo Bay South* was conducted on 11 June 2008 from a research skiff that was able to navigate beneath the train trestle. The remaining sites, *flats15N-Fidalgo Bay North* and the seven Maury Island AQR sites were all sampled between 27 June 2008 and 28 August 2008 from the primary 11 m (36 ft) research vessel, *R/V Brendan D II* (Figure 2-5).



Figure 2-5. The *R/V Brendan D II* owned and operated by the Marine Resources Consultants. Eelgrass (*Z. marina*) presence and depth distribution data was collected at the Maury Island AQR sites and the northern portion of the Fidalgo Bay AQR site (*flats15N-Fidalgo Bay North*) from the *R/V Brendan D II* using underwater videography and depth sounding instrumentation. A small research skiff and BioSonics echosounder were used to sample eelgrass at the southern portion of the Fidalgo Bay AQR site (*flats15S-Fidalgo Bay South*).

Equipment

The *R/V Brendan D II* was equipped with an underwater video camera mounted in a “downward-looking” orientation on a weighted towfish (Figure 2-6a). Parallel lasers mounted 10 cm apart created two red dots in the video images for scaling reference. The towfish was deployed directly off the stern of the vessel using an A-frame cargo boom and hydraulic winch. The weight of the towfish positioned the camera directly beneath a DGPS antenna, ensuring that the data accurately reflected the geographic location of the camera (Figure 2-6b). Time, differential global positioning system (DGPS) data, Garmin and BioSonics echosounder depth data were acquired simultaneously during sampling. Differential corrections were received from the United States Coast Guard public DGPS network using the WSG 84 datum. Table 2-2 lists the equipment used to conduct the video sampling and acquisition of eelgrass depth data.



Figure 2-6. The *R/V Brendan D II* is equipped with a weighted towfish that contains an underwater video camera mounted in a ‘downward looking’ orientation, dual lasers for scaling reference, and underwater lights for night work (a). The towfish is deployed directly beneath the DGPS antenna attached to the A-frame cargo boom, ensuring accurate geographic location of the camera (b).

Table 2-2. Equipment and software used to collect underwater video and depth data aboard the primary research vessel at the Maury Island and Fidalgo Bay AQR sites.

Equipment	Manufacturer/Model
Differential GPS	Trimble AgGPS 132 (sub-meter accuracy)
Depth Sounders	BioSonics DE 4000 system (including Dell laptop computer with Submerged Aquatic Vegetation software)
	Garmin FishFinder 250
Underwater Cameras (2)	SplashCam Deep Blue Pro Color (Ocean Systems, Inc.)
Lasers	Deep Sea Power & Light
Underwater Light	Deep Sea Power & Light RiteLite (500 watt)
Navigation Software	Hypack Max
Video Overlay Controller	Intuitive Circuits TimeFrame
DVD Recorder	Sony RDR-GX7
Digital Video Recorder	Sony DVR-TRV310 Digital8 Camcorder

The equipment used to sample eelgrass at *flats15S-Fidalgo Bay South* included the differential global positioning system (DGPS), Hypack navigational software, and a BioSonics echosounder. Eelgrass observed in the real-time echosounder data stream was ground truthed with a drop camera.

Site and Sample Polygons

Prior to field sampling a site polygon is delineated for each site. The site polygon delineates the area of potential eelgrass occurrence, it encompasses the area along 1000 m (3280 ft) of the -6 m (-20 ft) bathymetry contour to the ordinary high water mark (Figure 2-7a). A series of reconnaissance underwater video or echosounder transects were completed throughout the site polygon to delineate the sample polygon (Figure 2-7b). Sample polygons include observed eelgrass and any potential habitat where eelgrass presence could not be ruled out with a high degree of certainty (Berry et al. 2003). Random video and echosounder transects were selected from within the sample polygon for each site using ArcGIS software (Figure 2-7c).

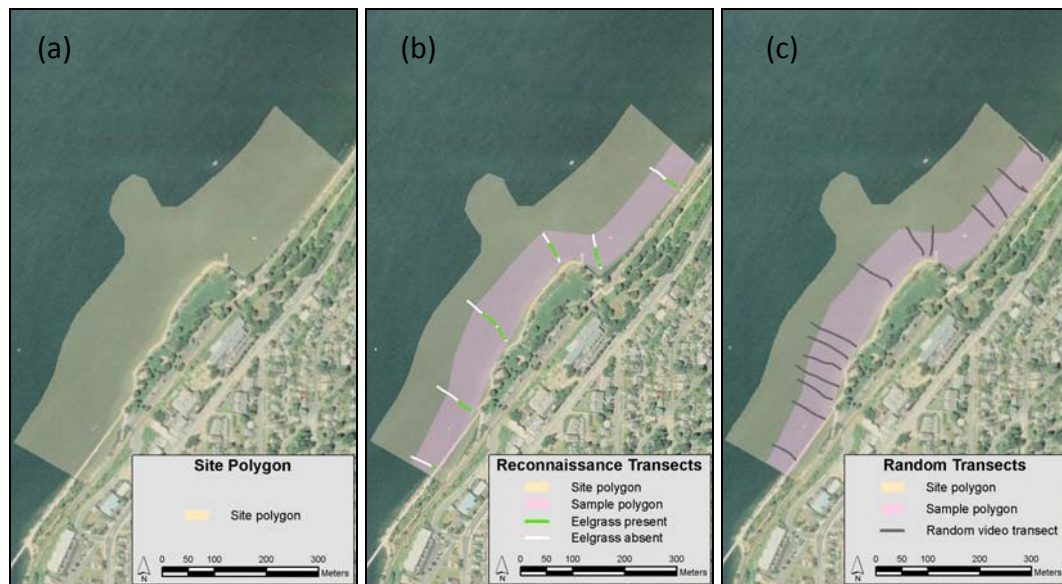


Figure 2-7. Prior to field work a site polygon, delineated as the area between the -6 m (-20 ft) bathymetry contour and the ordinary high water mark, was created using ArcGIS (a). Reconnaissance transects using underwater videography or BioSonics echosounder (*flats15S-Fidalgo Bay South*) throughout the site provided the necessary data to identify a sample polygon (b). The site was then sampled with 10-20 random underwater videography or echosounder transects in the case of *flats15S-Fidalgo Bay South* (c).

Eelgrass video and echosounder data collection

At all but one site, underwater videography was used to sample the presence of eelgrass along random transects in a modified line-intercept technique (Norris et al. 1997). *Flats15S-Fidalgo Bay South* was the only site where underwater videography was not used to sample eelgrass. Instead, a BioSonics echosounder

was used to sample the presence of eelgrass along random transects in a modified line-intercept technique. The random video and echosounder transects are restricted to a sample polygon that represents the general location of eelgrass presence within a site that was delineated from reconnaissance transects. The 10 – 20 random video or echosounder transects, oriented perpendicular to shore, extend beyond the shallow and deep edges of the sample area.

2.3 Video and Echosounder Data Processing and Analysis

The video sampling resolution is nominally one square meter and eelgrass is categorized as present or absent based on the observation of rooted shoots within the video field of view. Each second of BioSonics echosounder data is analyzed and eelgrass is categorized as present or absent based on the signal received (Sabot et al. 2002), field notes, and ground truthing. All classification results were recorded with corresponding spatial and temporal information. The fractional cover of eelgrass along transects is used to calculate site eelgrass area. The depth at which eelgrass grows along each transect is used to estimate mean maximum and minimum depth of eelgrass relative to Mean Lower Low Water (MLLW) within each sample polygon at each site.

All measured depths were corrected to the MLLW datum by adding the transducer offset, subtracting the predicted tidal height for the site and adding the tide prediction error (calculated using measured tide data from the National Oceanic and Atmospheric Administration website http://co-ops.nos.noaa.gov/data_res.html). These final corrected depth data were merged with eelgrass data and spatial information into a site database so the eelgrass observations had associated date/time, position and depth measurements corrected to MLLW datum.

Eelgrass area at each site was calculated using GIS software and the site database file in the following sequential steps:

1. Calculated the area within the Sample Polygon;
2. Calculated the fraction of eelgrass along each random line transect;
3. Calculated the mean fraction and associated variance;
4. Estimated the overall eelgrass area and variance at the site by extrapolating the mean fraction along random transects over the Sample Polygon area.

Every random transect that intersected eelgrass had a minimum and maximum depth observation. Minimum and maximum eelgrass depth characteristics for each site are described using descriptive statistics (i.e. means and ranges).

2.4 *Sidescan Sonar*

Sidescan sonar data was collected at all the Maury Island AQR sites where eelgrass was previously observed using the SVMP methodology. Sidescan sonar was collected by Tony Petrillo of Blue Water Engineering Services, Inc. (BWES) of Port Townsend, WA. Details of the sidescan sonar survey and field notes can be found in Appendix R.

2.5 *Deliverables*

All underwater videography for the Maury Island AQR sites and *flats15N-Fidalgo Bay North* site in the Fidalgo Bay AQR was archived on DVD. The DVDs are labeled by Site Code, sample date, and list the transect numbers recorded on each DVD for each site (Appendix S).

Appendix T contains a CD with all post-processed electronic and ArcGIS data for the sites sampled.

The post-processed electronic data for each site will include:

- 1) Pre-sampling random transect map
- 2) Transect notes
- 3) Site description
- 4) Transect data - provides eelgrass presence/absence, date, time stamp, position stamp, and depth data for each second of video collected at a site.
- 5) Post-sampling site map

The ArcGIS data will include:

- 1) site polygon shapefile
- 2) sample polygon shapefile
- 3) transect data shapefile

All ArcGIS data is projected in
<stateplane_nad83HARN_feet_Washington_south>.

In addition, a separate folder on the data CD will include sidescan sonar data for each site sampled with eelgrass present in the Maury Island AQR (BWES, Appendix T).

3 Results

3.1 Eelgrass Abundance at the Maury Island AQR

The seven Maury Island Aquatic Reserves sites were surveyed on the 27 and 28 August 2008. The average number of random videography transects per site was 12 and ranged from 10 to 13 (Table 3-1). Overall, 3.67 ± 1.40 ha of eelgrass was observed at the Maury Island AQR sites sampled in 2008 (Table 3.1).

Table 3-1. Eelgrass (*Z. marina*) monitoring summary statistics from the sites sampled at seven sites in the Maury Island AQR. Data presented in acres (ac) can be found in Appendix A.

Number of sites sampled	Number of sites with <i>Z. marina</i>	Number of sites without <i>Z. marina</i>	Average Number of Transects	Average Fraction	Total <i>Z. marina</i> Area	Total Variance	Standard Error	95% CI Lower Limit	95% CI Upper Limit
					(ha)			(ha)	(ha)
7	5	2	12	0.18	3.67	0.51	0.72	2.27	5.08

Eelgrass was not evenly distributed throughout the seven sites sample in the Maury Island AQR. The greatest amount of eelgrass was observed at *cps1116-South of Viewpoint Park* with 2.01 ± 1.30 ha (Figure 3-1, Table 3-2). The eelgrass at *cps1116-South of Viewpoint Park* is 55 m (180 ft) from the YTB-395 Navy Tugboat, *Murph*, that was scuttled in 12 m (40 ft) of water during the winter of 2007 (Appendix Q). The least amount of eelgrass was observed at *cps1180-Dockton Point* with 0.10 ± 0.08 ha. Eelgrass was not observed at two sites, *cps2886-Orphan West-Burton* and *cps2887-Orphan East-Mileta* (Figure 3-1, Table 3-2). A few patches of dwarf eelgrass, *Zostera japonica*, were observed at *cps2886-Orphan West-Burton* (Appendix Q).

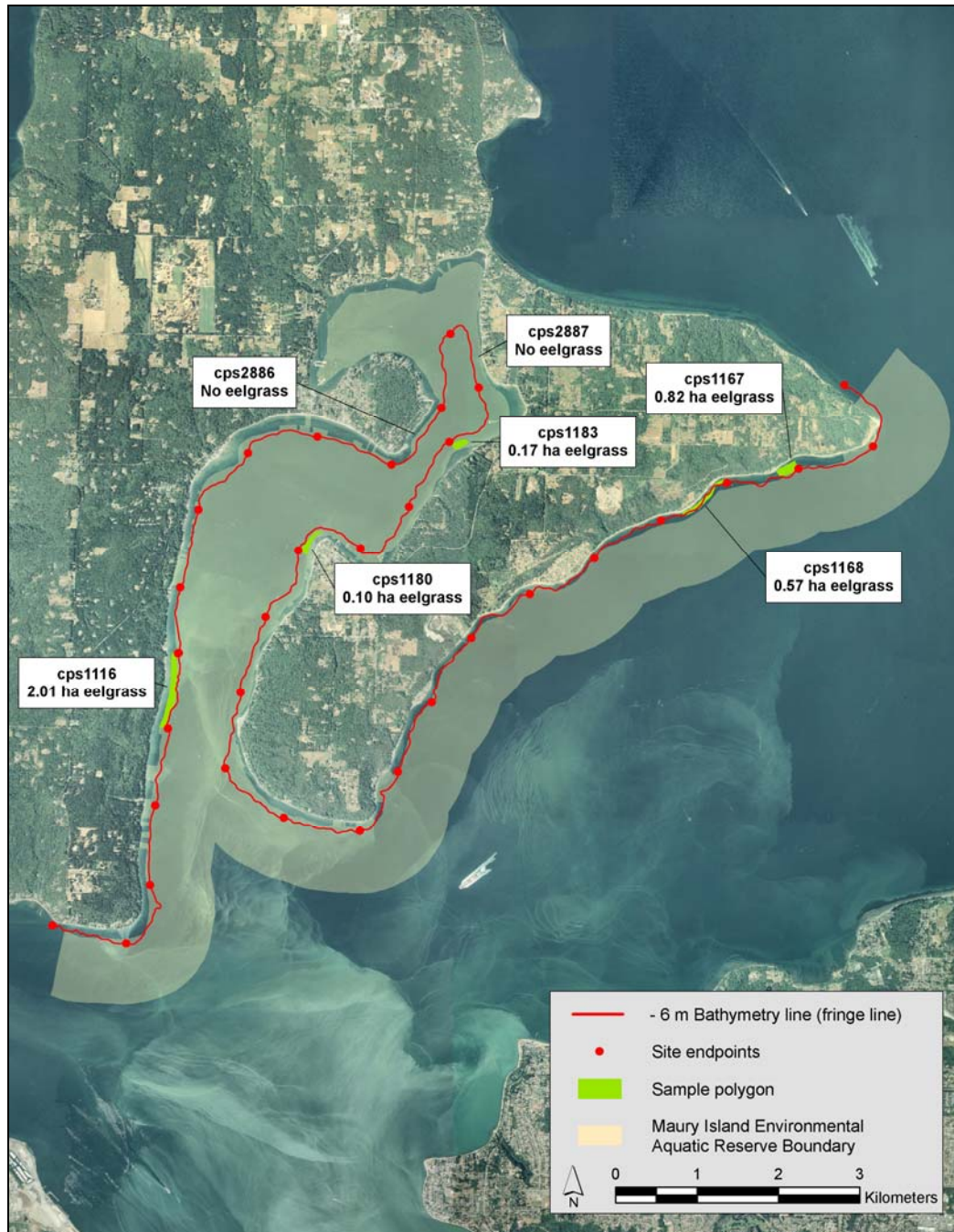


Figure 3-1. Eelgrass (*Z. marina*) area (ha) at the seven Maury Island AQR sites sampled in 2008. Sites are initially delineated by the -6 m bathymetry line (fringe line) and the site endpoints. The green sample polygons represent the general area where eelgrass was observed at each site. There was no eelgrass (*Z. marina*) observed at *cps2886-Orphan West-Burton* and *cps2887-Orphan East-Mileta*, however, a few small patches of dwarf eelgrass, *Zostera japonica*, were observed at *cps2886-Orphan West-Burton*. Data presented in acres (ac) can be found in Appendix B.

Table 3-2. Eelgrass (*Z. marina*) area (ha) at the seven sites sampled in the Maury Island AQR in 2008. Data presented in acres (ac) can be found in Appendix C.

Site	Date Sampled	Number of Transects	Eelgrass Fraction Along Transects	Eelgrass Area at Site	Variance	Coefficient of Variance	Estimated Eelgrass Area Confidence Interval	
							95% Lower Limit	95% Upper Limit
				(ha)			(ha)	(ha)
cps1116	28-Aug-08	11	0.30	2.01	0.44	0.33	0.71	3.32
cps1167	28-Aug-08	13	0.30	0.82	0.05	0.27	0.39	1.26
cps1168	28-Aug-08	12	0.17	0.57	0.01	0.21	0.34	0.81
cps1180	27-Aug-08	12	0.05	0.10	0.00	0.40	0.02	0.18
cps1183	27-Aug-08	10	0.11	0.17	0.00	0.36	0.05	0.29
cps2886	27-Aug-08	0	0	0	0	0	0	0
cps2887	27-Aug-08	0	0	0	0	0	0	0

Sidescan sonar was collected at all the sites where eelgrass (*Z. marina*) area was estimated using the SVMP methodology. Estimates of eelgrass area from the sidescan sonar data were calculated using ArcGIS and were compared to the eelgrass area estimates calculated from the underwater videography (Table 3-3). The resolution of sidescan sonar differs in that it does not capture the fine scale heterogeneity (i.e. patches and gaps) of the eelgrass bed and the area estimates from sidescan sonar do not have associated confidence intervals.

Table 3-3. Comparison of eelgrass (*Z. marina*) area (ha) calculated using sidescan sonar and video transects at the seven Maury Island AQR sites. Data presented in acres (ac) can be found in Appendix D.

Site	Date Sampled	Eelgrass area at Site	Eelgrass area at Site	DIFFERENCE
		(Side Scan)	(Video)	
		(ha)	(ha)	(ha)
cps1116	16-Sep-08	1.85	2.01	0.16
cps1167	16-Sep-08	0.20	0.82	0.62
cps1168	16-Sep-08	0.48	0.57	0.09
cps1180	19-Sep-08	0.06	0.10	0.04
cps1183	03-Jul-08	0.15	0.17	0.02
cps2886	17-Sep-08	0.00	0.00	
cps2887	19-Sep-08	0.00	0.00	
TOTAL		2.74	3.67	0.93

3.2 Eelgrass Depth at the Maury Island AQR

Eelgrass was found from an absolute minimum depth of 0.5 m (1.6 ft, MLLW) to an absolute maximum depth of -6.5 m (-21.3 ft, MLLW) at the Maury Island AQR sites (Table 3-4). The mean minimum eelgrass depth at the seven sites ranged from -0.6 m (-1.9 ft, MLLW) to -1.6 m (-5.2 ft, MLLW). The mean maximum eelgrass depth ranged from -1.8 m (-5.9 ft, MLLW) to -3.2 m (-10.5 ft, MLLW, Table 3-5).

The absolute minimum depth of eelgrass observed at the Maury Island AQR sites was 1.1 m deeper than the absolute minimum depth in the *Central Puget Sound Region* from 2000 to 2007 (Table 3-4, Gaeckle et al. 2008). However, the mean minimum depth falls in the range of mean minimum depths observed in this region. A similar pattern was observed in the absolute maximum and mean maximum depths. The absolute maximum depth at the Maury Island sites was 5.4 m shallower compared to the absolute maximum depth eelgrass was observed in the *Central Puget Sound Region* from 2000 to 2007. Again, the mean maximum depths where eelgrass was observed at the Maury Island sites was within the range observed in the region (Table 3-4, Gaeckle et al. 2008).

Table 3-4. Comparison of absolute and mean minimum and maximum depths (m) of eelgrass (*Z. marina*) observed at the Maury Island AQR sites and sites sampled in the *Central Puget Sound Region* from 2000 – 2007. Data presented in acres (ft) can be found in Appendix E.

Location	Minimum Depth		Maximum Depth	
	Absolute Depth	Range in Mean Depths	Absolute Depth	Range in Mean Depths
	(m)	(m)	(m)	(m)
Maury Island AQR	+0.5	-0.6 to -1.6	-6.5	-1.8 to -3.2
Central Puget Sound Region	+1.6	+1.1 to -3.5	-11.9	-0.5 to -6.9

Table 3-5. Eelgrass (*Z. marina*) depth (m) at the seven Maury Island AQR sites. Data presented in feet (ft) can be found in Appendix F.

Site	Minimum Eelgrass Depth					Maximum Eelgrass Depth				
	n	Absolute Depth	Mean Depth	Standard Error	95% Confidence Interval	n	Absolute Depth	Mean Depth	Standard Error	95% Confidence Interval
		(m)	(m)		(m)		(m)	(m)		(m)
cps1116	8	-0.2	-0.6	0.1	0.2	8	-3.8	-2.2	0.3	0.7
cps1167	9	-0.7	-0.9	0.1	0.1	9	-4.5	-3.2	0.4	0.8
cps1168	10	0.5	-1.3	0.5	1.0	10	-6.5	-2.2	0.6	1.2
cps1180	6	-1.2	-1.6	0.1	0.2	6	-2.2	-1.8	0.2	0.3
cps1183	5	-0.9	-1.2	0.1	0.2	5	-2.4	-2.1	0.1	0.2
cps2886	0	-9999	-9999	-9999	-9999	0	-9999	-9999	-9999	-9999
cps2887	0	-9999	-9999	-9999	-9999	0	-9999	-9999	-9999	-9999

-9999 = no eelgrass found at site. No eelgrass depth data available.

3.3 Eelgrass Abundance at the Fidalgo Bay AQR

The Fidalgo Bay AQR consists of a portion of the *flats15N-Fidalgo Bay North* site that lies within the Fidalgo Bay AQR boundary (Figure 2-1, Figure 2-3) and the entire *flats15S-Fidalgo Bay South* site. The portion of *Flats15N-Fidalgo Bay North* in the Reserve was sampled on 31 July 2008 while *flats15S-Fidalgo Bay South* was sampled on 11 June 2008. The average number of random videography or echosounder transects per site was 9 and ranged from 7 to 11 (Table 3-10). Overall, 72.90 ± 32.04 ha of eelgrass was observed in the Fidalgo Bay AQR in 2008 (Table 3.1).

Table 3-6. Eelgrass (*Z. marina*) monitoring summary statistics from *flats15N-Fidalgo Bay North* and *flats15S-Fidalgo Bay South* that lie within the Fidalgo Bay AQR. Data presented in acres (ac) can be found in Appendix G.

Number of sites sampled	Number of sites with <i>Z. marina</i>	Number of sites without <i>Z. marina</i>	Average Number of Transects	Average Fraction	Total <i>Z. marina</i> Area	Total Variance	Standard Error	95% CI Lower Limit	95% CI Upper Limit
					(ha)			(ha)	(ha)
2	2	0	9	0.29	73.08	161.58	12.71	48.16	97.99

There are 57.76 ± 24.01 ha of eelgrass in the northern portion of the Fidalgo Bay AQR associated with the *flats15N-Fidalgo Bay North* site (Table 3-11). The portion of the Reserve south of the train trestle has 15.32 ± 6.68 ha of eelgrass (Table 3-11).



Figure 3-2. Eelgrass (*Z. marina*) area (ha) at the Fidalgo Bay AQR in 2008. The Fidalgo Bay AQR consists of a portion of *flats15N-Fidalgo Bay North* AQR and all of *flats15S-Fidalgo Bay South* AQR. The Fidalgo Bay Aquatic Reserve Boundary for *flats15N-Fidalgo Bay North* AQR is the same as the 2008 sample polygon. Detailed transect data and results presented in acres (ac) can be found in Appendix H.

Table 3-7. Eelgrass (*Z. marina*) area (ha) at the two sites that make up the Fidalgo Bay AQR in 2008. Data presented in acres (ac) can be found in Appendix I.

Site	Date Sampled	Number of Transects	Eelgrass Fraction Along Transects	Eelgrass Area at Site	Variance	Coefficient of Variance	Estimated Eelgrass Area Confidence Interval	
							95% Lower Limit	95% Upper Limit
				(ha)			(ha)	(ha)
flats15N	27-Jul-08	10	0.39	57.76	149.98	0.21	33.77	81.79
flats15S	11-Jun-08	11	0.19	15.32	11.60	0.22	8.64	22.00

3.4 Eelgrass Depth at the Fidalgo Bay AQR

Eelgrass was found from an absolute minimum depth of 0.2 m (0.7 ft, MLLW) to an absolute maximum depth of -4.1 m (-13.5 ft, MLLW) at the Fidalgo Bay AQR sites (Table 3-8). The absolute minimum eelgrass depth value in the Fidalgo Bay AQR is over a meter deeper than the value observed in the *North Puget Sound Region*. The absolute maximum depth value in the Fidalgo Bay AQR is 4.3 m shallower than the deepest eelgrass depth observed in the *North Puget Sound Region*. The mean minimum eelgrass depth at the Fidalgo Bay AQR ranged from 0.1 m (0.3 ft, MLLW) to -0.8 m (-2.6 ft, MLLW). The mean maximum eelgrass depth ranged from -0.7 m (-2.3 ft, MLLW) to -2.4 m (-7.9 ft, MLLW, Table 3-8). The mean minimum and maximum depths are within the range of mean depths observed in the *North Puget Sound Region* (Table 3-8).

Table 3-8. Eelgrass (*Z. marina*) depth (m) at the Fidalgo Bay AQR. Data presented in feet (ft) can be found in Appendix J.

Location	Minimum Depth		Maximum Depth	
	Absolute Depth	Range in Mean Depths	Absolute Depth	Range in Mean Depths
	(m)	(m)	(m)	(m)
Fidalgo Bay AQR	+0.2	+0.1 to -0.8	-4.1	-0.7 to -2.4
North Puget Sound Region	+1.4	+0.6 to -3.3	-8.4	-0.7 to -6.6

The eelgrass was deeper in the northern portion (*flats15N-Fidalgo Bay North*) of the Fidalgo Bay AQR compared to the southern portion (*flats15S-Fidalgo Bay South*; Table 3-9). In the portion of the Reserve within *flats15N-Fidalgo Bay North* the eelgrass was observed between -0.4 m to -2.0 m with a mean maximum depth

of -1.5 m (Table 3-9). In the southern extent of the Reserve, the eelgrass grew between 0.2 m and -1.2 m with a mean maximum depth of -0.7 m (Table 3-9).

Table 3-9. Eelgrass (*Z. marina*) depth (m) at two SVMP sites within the boundary of the Fidalgo Bay AQR. Data presented in feet (ft) can be found in Appendix K.

Site	Minimum Eelgrass Depth					Maximum Eelgrass Depth				
	n	Absolute Depth	Mean Depth	Standard Error	95% Confidence Interval	n	Absolute Depth	Mean Depth	Standard Error	95% Confidence Interval
		(m)	(m)		(m)		(m)	(m)		(m)
flats15N	9	-0.4	-0.8	0.1	0.3	10	-2.0	-1.4	0.1	0.3
flats15S	11	0.2	0.1	0.1	0.1	11	-1.2	-0.7	0.1	0.2

3.5 Eelgrass Abundance at flats15-Fidalgo Bay North and South

The extent of *flats15N-Fidalgo Bay North* that was not included in the Fidalgo Bay AQR was surveyed on 27 July 2008. The data from the 27 July 2008 effort combine with the data from *flats15S-Fidalgo Bay South* are presented in the following section.

The total number of random videography transects at *flats15N-Fidalgo Bay North* was 21 and there were 11 BioSonics echosounder transects sampled at *flats15S-Fidalgo Bay South* (Table 3-6). Overall, a total of 184.55 ± 39.43 ha of eelgrass was observed at the two sites, *flats15N-Fidalgo Bay North* and *flats15S-Fidalgo Bay South*, in 2008 (Table 3-6).

Table 3-10. Eelgrass (*Z. marina*) monitoring summary statistics from *flats15N-Fidalgo Bay North* and *flats15S-Fidalgo Bay South*. Data presented in acres (ac) can be found in 0.

Number of sites sampled	Number of sites with <i>Z. marina</i>	Number of sites without <i>Z. marina</i>	Average Number of Transects	Average Fraction	Total <i>Z. marina</i> Area	Total Variance	Standard Error	95% CI Lower Limit	95% CI Upper Limit
					(ha)			(ha)	(ha)
2	2	0	16	0.27	184.55	404.80	20.12	145.12	223.99

Flats15N-Fidalgo Bay North had 167.65 ± 38.86 ha of eelgrass while *flats15S-Fidalgo Bay South* had 16.90 ± 6.45 ha of eelgrass (Table 3-11).



Figure 3-3. Eelgrass (*Z. marina*) area (ha) at *flats15N-Fidalgo Bay North* and *flats15S-Fidalgo Bay South* in 2008. Detailed transect data and results presented in acres (ac) can be found in Appendix M.

Table 3-11. Eelgrass (*Z. marina*) area (ha) at flats15N-Fidalgo Bay North and flats15S-Fidalgo Bay South. Data presented in acres (ac) can be found in Appendix N.

Site	Date Sampled	Number of Transects	Eelgrass Fraction Along Transects	Eelgrass Area at Site	Variance	Coefficient of Variance	Estimated Eelgrass Area Confidence Interval	
							95% Lower Limit	95% Upper Limit
				(ha)			(ha)	(ha)
flats15N	27-Jul-08	21	0.35	167.65	393.95	0.12	128.79	206.63
flats15S	11-Jun-08	11	0.20	16.90	10.85	0.19	10.45	23.37

3.6 Eelgrass Depth at flats15-Fidalgo Bay North and South

Eelgrass was found from an absolute minimum depth of 0.2 m (0.76 ft, MLLW) to an absolute maximum depth of -4.1 m (-13.4 ft, MLLW) at the Fidalgo Bay North and South sites (Table 3-4). The mean minimum eelgrass depth at the sites ranged from 0.1 m (0.3 ft, MLLW) to -0.8 m (-2.6 ft, MLLW). The mean maximum eelgrass depth at the two sites ranged from -0.7 m (-2.3 ft, MLLW) to -2.4 m (-7.9 ft, MLLW, Table 3-7, Table 3.8).

The absolute minimum depth of eelgrass observed at the Fidalgo Bay North and South sites was 1.2 m deeper than the absolute minimum depth in the *North Puget Sound Region* from 2000 to 2007 (Table 3-7, Gaeckle et al. 2008). However, the mean minimum depth falls in the range of mean minimum depths observed in this region. A similar pattern was observed in the absolute maximum and mean maximum depths. The absolute maximum depth at the Fidalgo Bay North and South sites was 4.3 m shallower compared to the absolute maximum depth eelgrass was observed in the *North Puget Sound Region* from 2000 to 2007. Again, the mean maximum depths where eelgrass was observed at the Fidalgo Bay sites fall within the range observed in the region (Table 3-4, Gaeckle et al. 2008).

Table 3-12. Comparison of absolute and mean minimum and maximum depths of eelgrass (*Z. marina*) observed at the Fidalgo Bay SVMP site, *flats15-Fidalgo Bay* and sites sampled in the North Puget Sound Region from 2000 – 2007. Data presented in acres (ac) can be found in Appendix O.

Location	Minimum Depth		Maximum Depth	
	Absolute Depth	Range in Mean Depths	Absolute Depth	Range in Mean Depths
	(m)	(m)	(m)	(m)
Fidalgo Bay N & S	+0.2	+0.1 to -0.9	-2.0	-0.7 to -1.5
North Puget Sound Region	+1.4	+0.6 to -3.3	-8.4	-0.7 to -6.6

Table 3-13. Eelgrass (*Z. marina*) depth (m) at the *flats15N-Fidalgo Bay North* and *flats15S-Fidalgo Bay South* sites. Data presented in feet (ft) can be found in Appendix P.

Site	Minimum Eelgrass Depth					Maximum Eelgrass Depth				
	n	Absolute Depth	Mean Depth	Standard Error	95% Confidence Interval	n	Absolute Depth	Mean Depth	Standard Error	95% Confidence Interval
		(m)	(m)		(m)		(m)	(m)		(m)
flats15N	19	-0.3	-0.8	0.1	0.2	20	-4.1	-2.4	0.3	0.5
flats15S	11	0.2	0.1	0.0	0.1	11	-1.2	-0.7	0.1	0.2

A detailed description of each site and notes on the underwater videography transects can be found in each site folder on the data CD (Appendix T).

4 Discussion and Recommendations

4.1 Observations Related to Eelgrass Distribution in Study Area

The SVMP measured eelgrass area and depth at sites in the Maury Island Environmental Aquatic Reserve and the Fidalgo Bay Environmental Aquatic Reserve in 2008. The observed pattern of eelgrass from the 2008 survey generally supports where one would expect to find eelgrass in these two Reserves.

Maury Island Environmental Aquatic Reserve

The eelgrass habitat in the Maury Island AQR consists primarily of narrow, fringe beds based on surveys at four sites in 2004 (Reeves 2005) and the seven sites in 2008. *Flats33-Quartermaster Harbor* is considered a flats site in the SVMP methods; however, the eelgrass at the site is only present in a small band, fringing bed, at the northern end of the site (Figure 4-1; Reeves 2005). The 2004 survey estimated a total of 7.35 ± 0.49 ha (18.16 ± 1.21 ac) of eelgrass at sites within Quartermaster Harbor (Figure 4-1). The 2008 Maury Island AQR survey sampled three additional sites (*cps2886-Orphan West-Burton*, *cps2887-Orphan East-Mileta*, and *cps1183-Rabb's Lagoon*) adjacent to *flats33-Quartermaster Harbor*, and four other sites randomly distributed throughout the Reserve. The sum of the eelgrass area from the 2004 and 2008 Maury Island AQR surveys is 11.03 ± 1.48 ha (27.26 ± 3.66 ac) (Table 4-1, Figure 4-1). In addition to *Z. marina* at the four sites sampled in 2004, there was evidence of *Z. japonica* (dwarf eelgrass) at all the sites (Reeves 2005). It is highly likely that there is more *Z. marina* (native eelgrass) in the Maury Island AQR since only 11 of 33 sites (33%) have been sampled for eelgrass abundance. Future surveys at the Maury Island AQR will improve the eelgrass area estimates and distribution for this area.

Table 4-1. Eelgrass (*Z. marina*) area summary for 2004 Quartermaster Harbor sample sites.

Site	Number of Transects	Mean Fraction Along Transects	Eelgrass Area at Site		Coefficient of Variation	Estimated Eelgrass Coverage Confidence Interval (hectares)	
			(hectares)	Variance		80% Lower Limit	80% Upper Limit
Flats33	11	0.2822	0.95	0.032	0.19	0.72	1.18
cps1181	11	0.6235	1.33	0.012	0.08	1.19	1.47
cps1182	11	0.7393	4.60	0.046	0.05	4.32	4.87
cps1186	11	0.6783	0.47	0.001	0.06	0.43	0.5



Figure 4-1. Map of the eelgrass sample sites from the 2004 King County (KC) survey and the 2008 Maury Island AQR survey.

Fidalgo Bay Environmental Reserve

Eelgrass is distributed throughout the Fidalgo Bay AQR with the exception of the deep sections of the drainage channel that runs through the northern portion of the Reserve. These results are consistent with the results of the Puget Sound Environmental Atlas in the southern area of the Reserve, south of the train trestle (PSEA 1987). However, in the northern area of the Reserve (north of the train trestle), the Puget Sound Environmental Atlas only captures eelgrass along the edges of the bay and Reserve, whereas the 2008 underwater videography surveys observed eelgrass throughout the Reserve boundary.

Eelgrass also extends well beyond the Fidalgo Bay AQR boundary. To the north, eelgrass was found adjacent to Cap Sante and along the northern edge of Fidalgo Bay extending east towards the fuel refinery pier. Eelgrass was also observed south along the pier and adjacent to the western and eastern shorelines of Fidalgo Bay. There was a limited amount of eelgrass observed in the middle of the northern portion of Fidalgo Bay based on the analysis of the underwater videography surveys (Appendix M).

4.2 *Data Uses*

The eelgrass abundance, distribution, and depth data presented in this report provide a baseline or benchmark to which future eelgrass surveys can be compared to assess change over time. These data also identify sensitive habitat areas for consideration in DNR's Environmental Aquatic Reserves management plan. Given the recognized ecological importance of eelgrass, planning should explicitly consider the location of the eelgrass habitat in this area and its environmental requirements.



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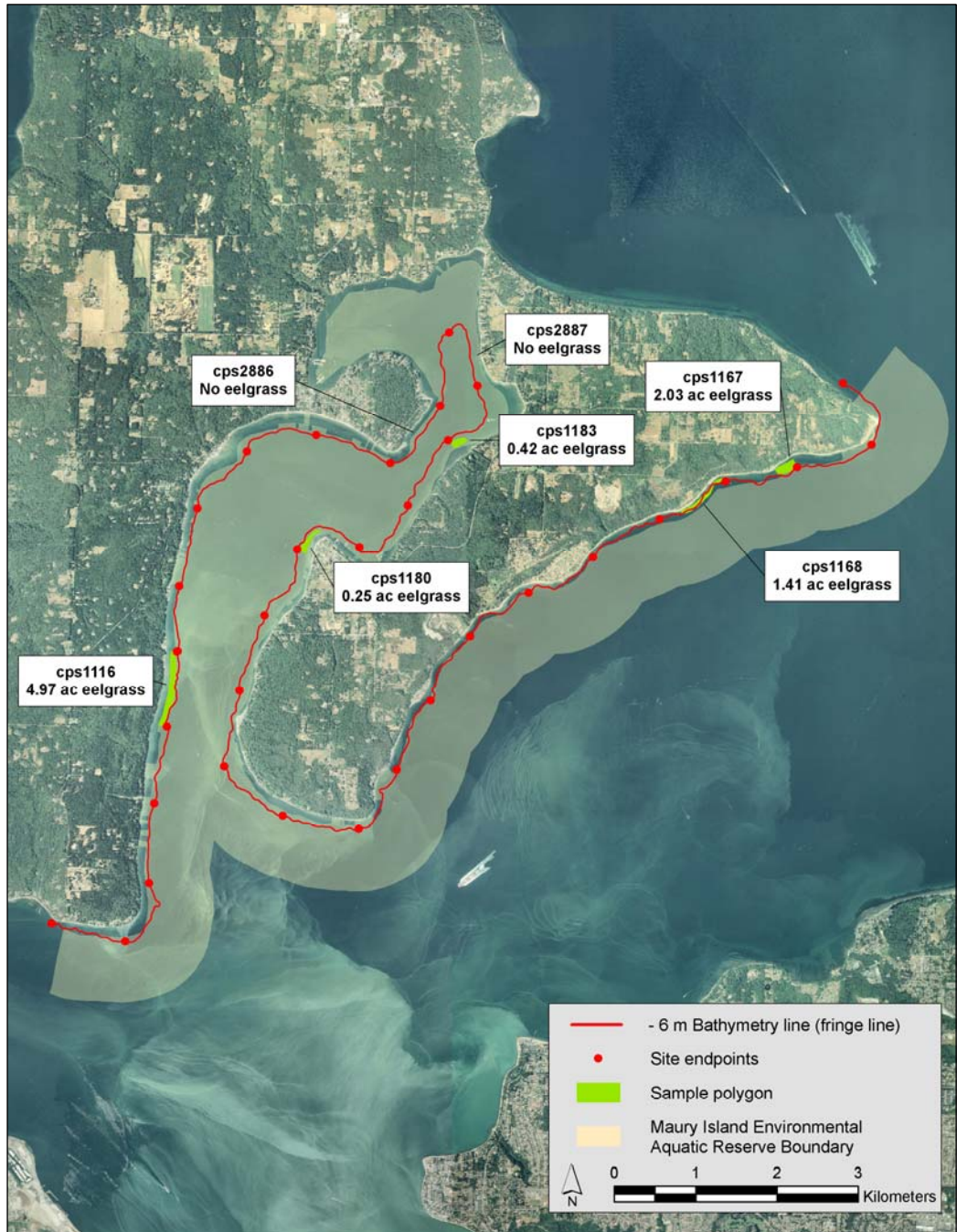
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APPENDICES

Appendix A Eelgrass (*Z. marina*) summary statistics at the Maury Island AQR

Number of sites sampled	Number of Sites with Eelgrass	Number of Sites without Eelgrass	Average Number of Transects	Average Fraction	Total Eelgrass Area	Total Variance	Standard Error	95% CI Lower Limit	95% CI Upper Limit
					(ac)			(ac)	(ac)
7	5	2	12	0.18	9.07	3.11	0.72	5.61	12.55

Appendix B Map of eelgrass area (ac) at the Maury Island AQR



Eelgrass (*Z. marina*) area (ha) at the seven Maury Island AQR sites sampled in 2008. Sites are initially delineated by the -6 m bathymetry line (fringe line) and the site endpoints. The green sample polygons represent the general area where eelgrass was observed at each site. There was no eelgrass (*Z. marina*) observed at *cps2886-Orphan West-Burton* and *cps2887-Orphan East-Mileta*, however, a few small patches of dwarf eelgrass, *Zostera japonica*, were observed at *cps2886-Orphan West-Burton*.

Appendix C Eelgrass (*Z. marina*) area (ac) at the Maury Island AQR

Site	Date Sampled	Number of Transects	Eelgrass Fraction Along Transects	Eelgrass Area at Site	Variance	Coefficient of Variance	Estimated Eelgrass Area Confidence Interval	
							95% Lower Limit	95% Upper Limit
				(acres)			(acres)	(acres)
cps1116	28-Aug-08	11	0.30	4.97	2.69	0.33	1.75	8.20
cps1167	28-Aug-08	13	0.30	2.03	0.31	0.27	0.96	3.11
cps1168	28-Aug-08	12	0.17	1.41	0.06	0.21	0.84	2.00
cps1180	27-Aug-08	12	0.05	0.25	0.00	0.40	0.05	0.44
cps1183	27-Aug-08	10	0.11	0.42	0.00	0.36	0.12	0.72
cps2886	27-Aug-08	0	0	0	0	0	0	0
cps2887	27-Aug-08	0	0	0	0	0	0	0

Appendix D Comparison of eelgrass (*Z. marina*) area (ac) calculated using sidescan sonar and videography at the Maury Island AQR

Site	Date Sampled	Eelgrass Area at Site	Eelgrass Area at Site	DIFFERENCE
		(Sidescan)	(Video)	
		(ac)	(ac)	(ac)
cps1116	16-Sep-08	4.57	4.97	0.40
cps1167	16-Sep-08	0.49	2.03	1.54
cps1168	16-Sep-08	1.19	1.41	0.22
cps1180	19-Sep-08	0.15	0.25	0.10
cps1183	03-Jul-08	0.37	0.42	0.05
cps2886	17-Sep-08	0.00	0.00	
cps2887	19-Sep-08	0.00	0.00	
TOTAL		6.77	9.08	2.31

Appendix E Comparison of eelgrass (*Z. marina*) depth (ft) between the Maury Island AQR and the Central Puget Sound Region

Comparison of absolute and mean minimum and maximum depths of eelgrass (*Z. marina*) observed at the Maury Island AQR sites and sites sampled in the Central Puget Sound Region from 2000 – 2007 (Gaeckle et al. 2008).

Location	Minimum Depth		Maximum Depth	
	Absolute Depth	Range in Mean Depths	Absolute Depth	Range in Mean Depths
	(ft)	(ft)	(ft)	(ft)
Maury Island AQR	+1.6	-2.0 to -5.2	-21.3	-5.9 to -10.5
Central Puget Sound Region	+5.3	+3.6 to 11.5	-39.0	-1.6 to -22.6

Appendix F Eelgrass (*Z. marina*) depth (ft)

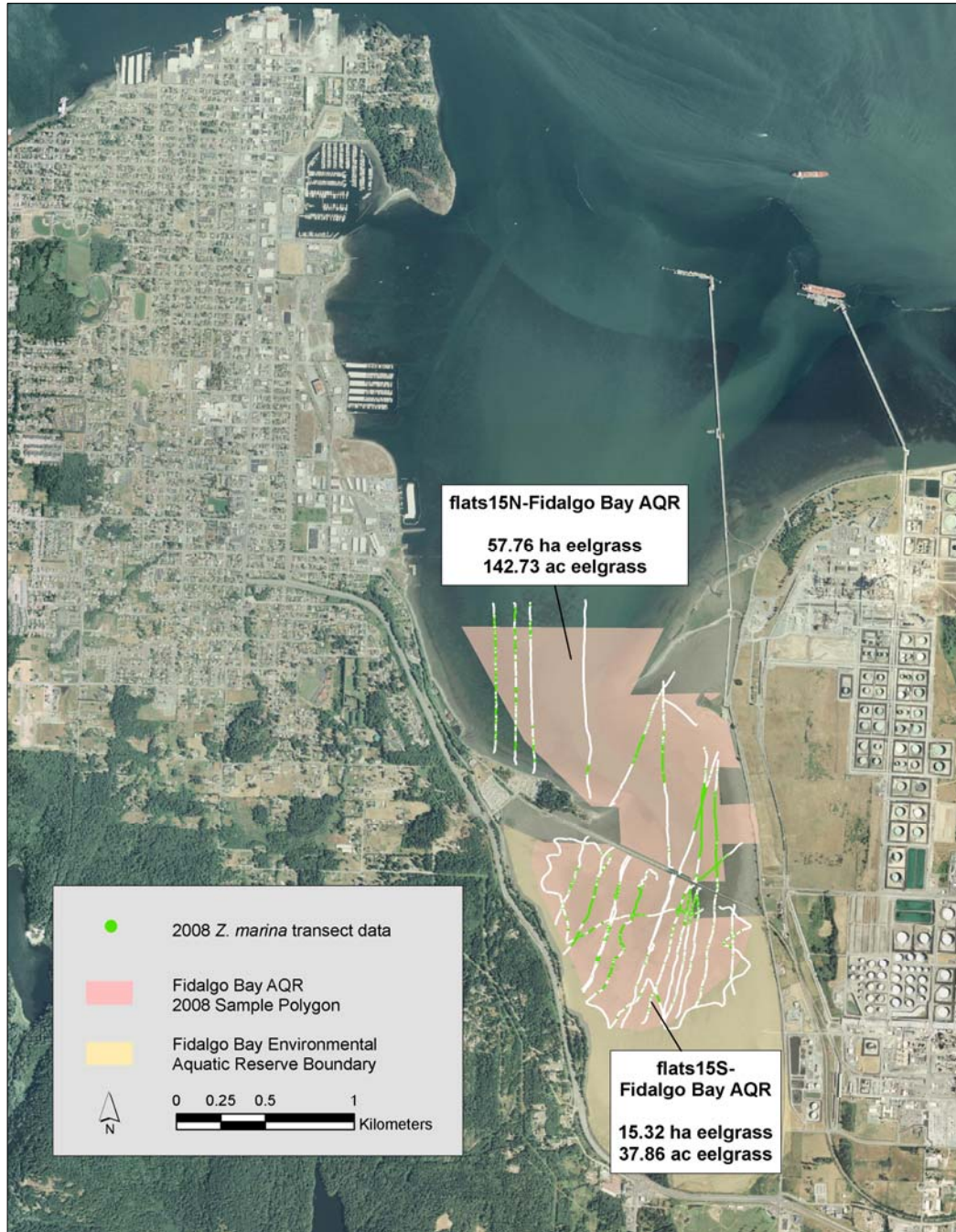
Site	Minimum Eelgrass Depth					Maximum Eelgrass Depth				
	n	Absolute Depth	Mean Depth	Standard Error	95% Confidence Interval	n	Absolute Depth	Mean Depth	Standard Error	95% Confidence Interval
		(ft)	(ft)		(ft)		(ft)	(ft)		(ft)
cps1116	8	-0.1	-0.2	0.1	0.1	8	-1.2	-0.7	0.3	0.2
cps1167	9	-0.2	-0.3	0.1	0.0	9	-1.4	-1.0	0.4	0.2
cps1168	10	0.2	-0.4	0.5	0.3	10	-2.0	-0.7	0.6	0.4
cps1180	6	-0.4	-0.5	0.1	0.1	6	-0.7	-0.5	0.2	0.1
cps1183	5	-0.3	-0.4	0.1	0.1	5	-0.7	-0.6	0.1	0.1
cps2886	0	-9999	-9999	-9999	-9999	0	-9999	-9999	-9999	-9999
cps2887	0	-9999	-9999	-9999	-9999	0	-9999	-9999	-9999	-9999

-9999 = no eelgrass found at site. No eelgrass depth data available.

Appendix G Eelgrass (*Z. marina*) summary statistics at the Fidalgo Bay AQR

Number of sites sampled	Number of sites with <i>Z. marina</i>	Number of sites without <i>Z. marina</i>	Average Number of Transects	Average Fraction	Total <i>Z. marina</i> Area	Total Variance	Standard Error	95% CI Lower Limit	95% CI Upper Limit
					(ac)			(ac)	(ac)
2	2	0	9	0.29	180.14	986.62	16.35	100.97	259.34

Appendix H Map of eelgrass (*Z. marina*) video transect and area (ha & ac) estimates at the Fidalgo Bay AQR



Appendix I Eelgrass (*Z. marina*) area (acres) at the Fidalgo Bay AQR

Site	Date Sampled	Number of Transects	Eelgrass Fraction Along Transects	Eelgrass Area at Site	Variance	Coefficient of Variance	Estimated Eelgrass Area Confidence Interval	
							95% Lower Limit	95% Upper Limit
				(ac)			(ac)	(ac)
flats15N	27-Jul-08	10	0.39	142.73	915.79	0.21	60.86	216.02
flats15S	11-Jun-08	11	0.190	37.86	70.83	0.22	25.82	57.75

Appendix J Comparison of eelgrass (*Z. marina*) depth (ft) at the Fidalgo Bay AQR

Location	Minimum Depth		Maximum Depth	
	Absolute Depth	Range in Mean Depths	Absolute Depth	Range in Mean Depths
	(ft)	(ft)	(ft)	(ft)
Fidalgo Bay AQR	+0.6	+0.3 to -2.5	-6.4	-2.0 to -4.7
North Puget Sound Region	+4.6	+2.0 to -10.8	-27.6	-2.3 to -21.6

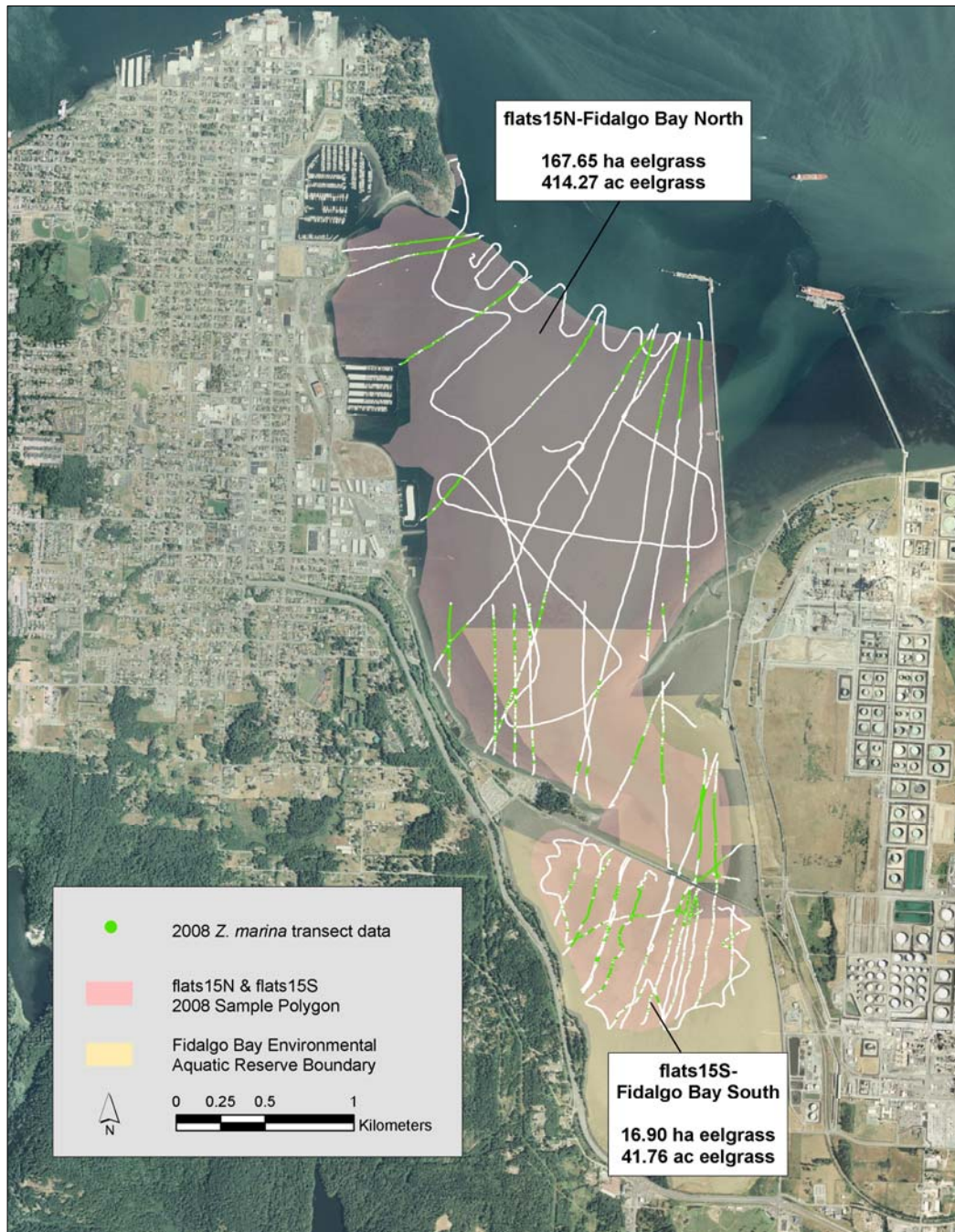
Appendix K Eelgrass (*Z. marina*) depth (ft) at the Fidalgo Bay AQR

Site	Minimum Eelgrass Depth					Maximum Eelgrass Depth				
	n	Absolute Depth	Mean Depth	Standard Error	95% Confidence Interval	n	Absolute Depth	Mean Depth	Standard Error	95% Confidence Interval
		(ft)	(ft)		(ft)		(ft)	(ft)		(ft)
flats15N_AQR	9	-1.2	-2.5	0.5	0.9	10	-6.4	-4.7	0.5	0.9
flats15S_AQR	11	0.6	0.3	0.1	0.2	11	-4.0	-2.0	0.3	0.7

Appendix L Eelgrass (*Z. marina*) monitoring statistics from *flats15N-Fidalgo Bay North* and *flats15S-Fidalgo Bay South*

Number of sites sampled	Number of sites with <i>Z. marina</i>	Number of sites without <i>Z. marina</i>	Average Number of Transects	Average Fraction	Total <i>Z. marina</i> Area	Total Variance	Standard Error	95% CI Lower Limit	95% CI Upper Limit
					(ac)			(ac)	(ac)
2	2	0	16	0.27	456.03	2471.74	20.12	358.60	553.49

Appendix M Map of eelgrass (*Z. marina*) area (ac) at flats15N-Fidalgo Bay North and flats15S-Fidalgo Bay South



Appendix N Eelgrass (*Z. marina*) area (ac) at flats15N-Fidalgo Bay North and flats15S-Fidalgo Bay South

Site	Date Sampled	Number of Transects	Eelgrass Fraction Along Transects	Eelgrass Area at Site	Variance	Coefficient of Variance	Estimated Eelgrass Area Confidence Interval	
							95% Lower Limit	95% Upper Limit
				(ac)			(ac)	(ac)
Fidalgo Bay - N	27-Jul-08	21	0.35	414.27	2405.49	0.12	318.25	510.59
Fidalgo Bay - S	11-Jun-08	11	0.20	41.76	66.25	0.19	25.82	57.75

Appendix O Comparison of eelgrass (*Z. marina*) depth at the Fidalgo Bay SVMP sites

Location	Minimum Depth		Maximum Depth	
	Absolute Depth	Range in Mean Depths	Absolute Depth	Range in Mean Depths
	(ft)	(ft)	(ft)	(ft)
Fidalgo Bay N & S	+0.6	+0.3 to -2.6	-13.4	-2.3 to -7.9
North Puget Sound Region	+4.6	+2.0 to -10.8	-27.6	-2.3 to -21.6

Appendix P Eelgrass Depth (ft) at flats15N-Fidalgo Bay North and flats15S-Fidalgo Bay South

Site	Minimum Eelgrass Depth					Maximum Eelgrass Depth				
	n	Absolute Depth	Mean Depth	Standard Error	95% Confidence Interval	n	Absolute Depth	Mean Depth	Standard Error	95% Confidence Interval
		(ft)	(ft)		(ft)		(ft)	(ft)		(ft)
flats15N	19	-1.1	-2.6	0.4	0.8	20	-13.4	-7.8	0.9	1.8
flats15S	11	0.6	0.2	0.1	0.2	11	-4.0	-2.3	0.3	0.7

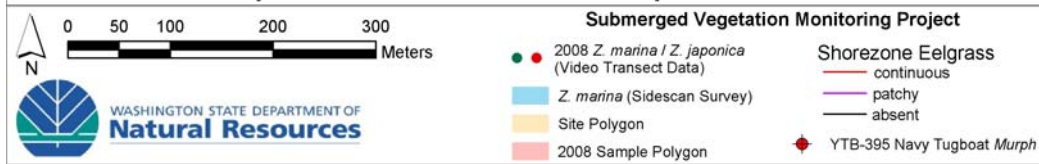
Appendix Q Site maps of eelgrass (*Z. marina*) videography at the Maury Island AQR

Data were collected using two methods at the Maury Island AQR sites: SVMP videography (DNR) and sidescan sonar (Tony Petrillo of Blue Water Engineering Services, Inc. (BWES) of Port Townsend, WA). Maps also include eelgrass data from ShoreZone Inventory (2000).

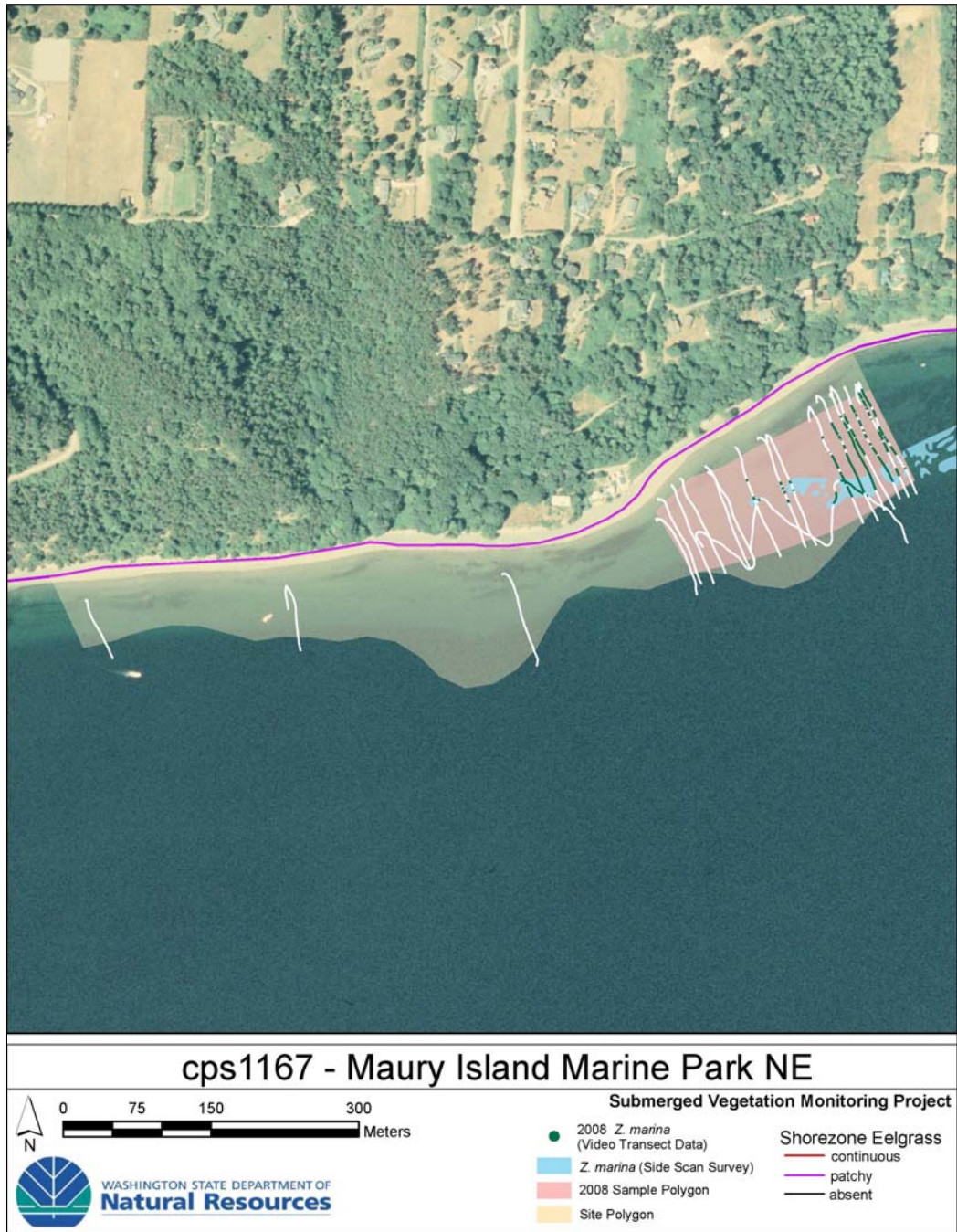
Q.1 cps1116 – South of Viewpoint Park



cps1116 - South of Viewpoint Park



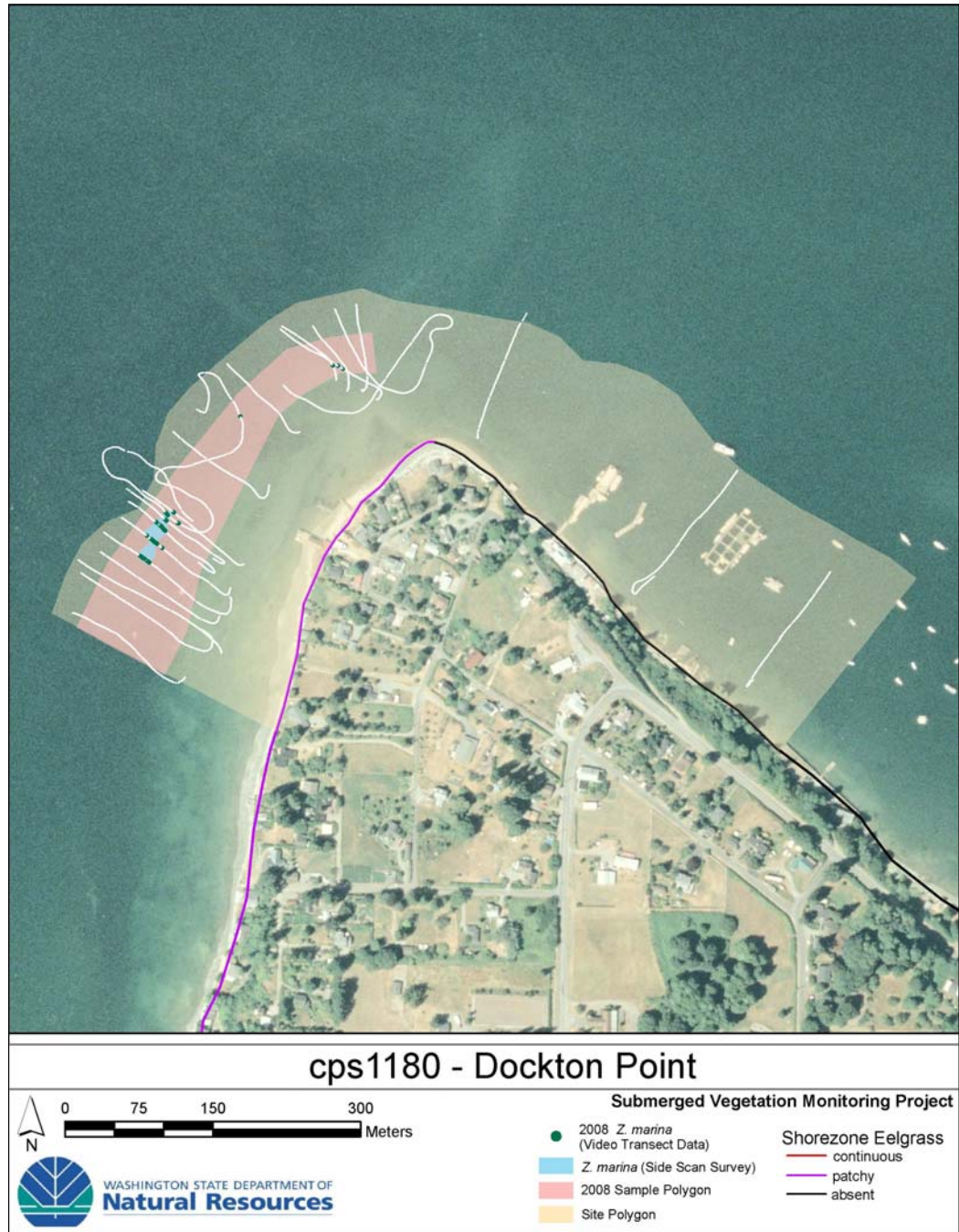
Q.2 cps1167 – Maury Island Marine Park NE



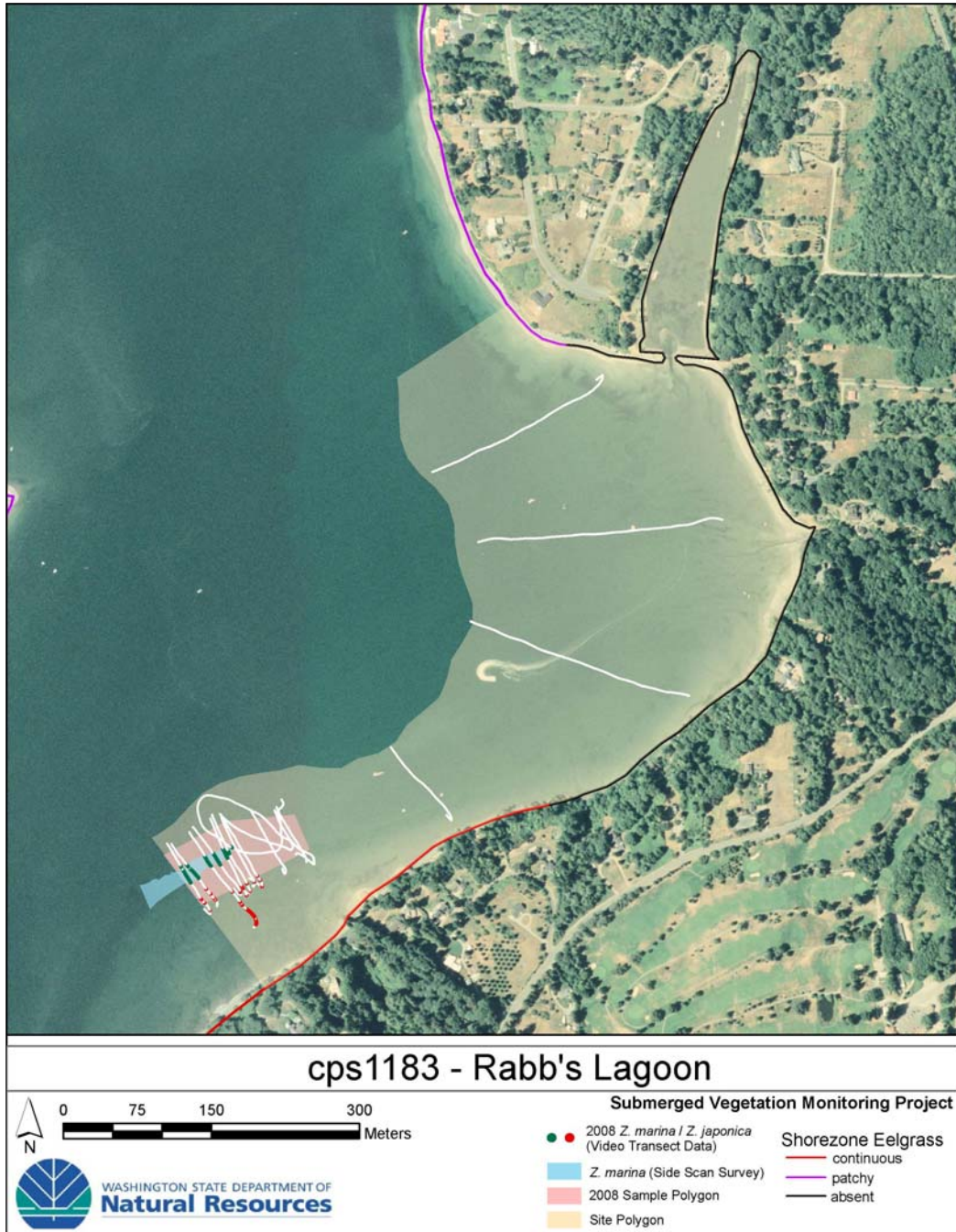
Q.3 cps1168 – Maury Island Marine Park Center



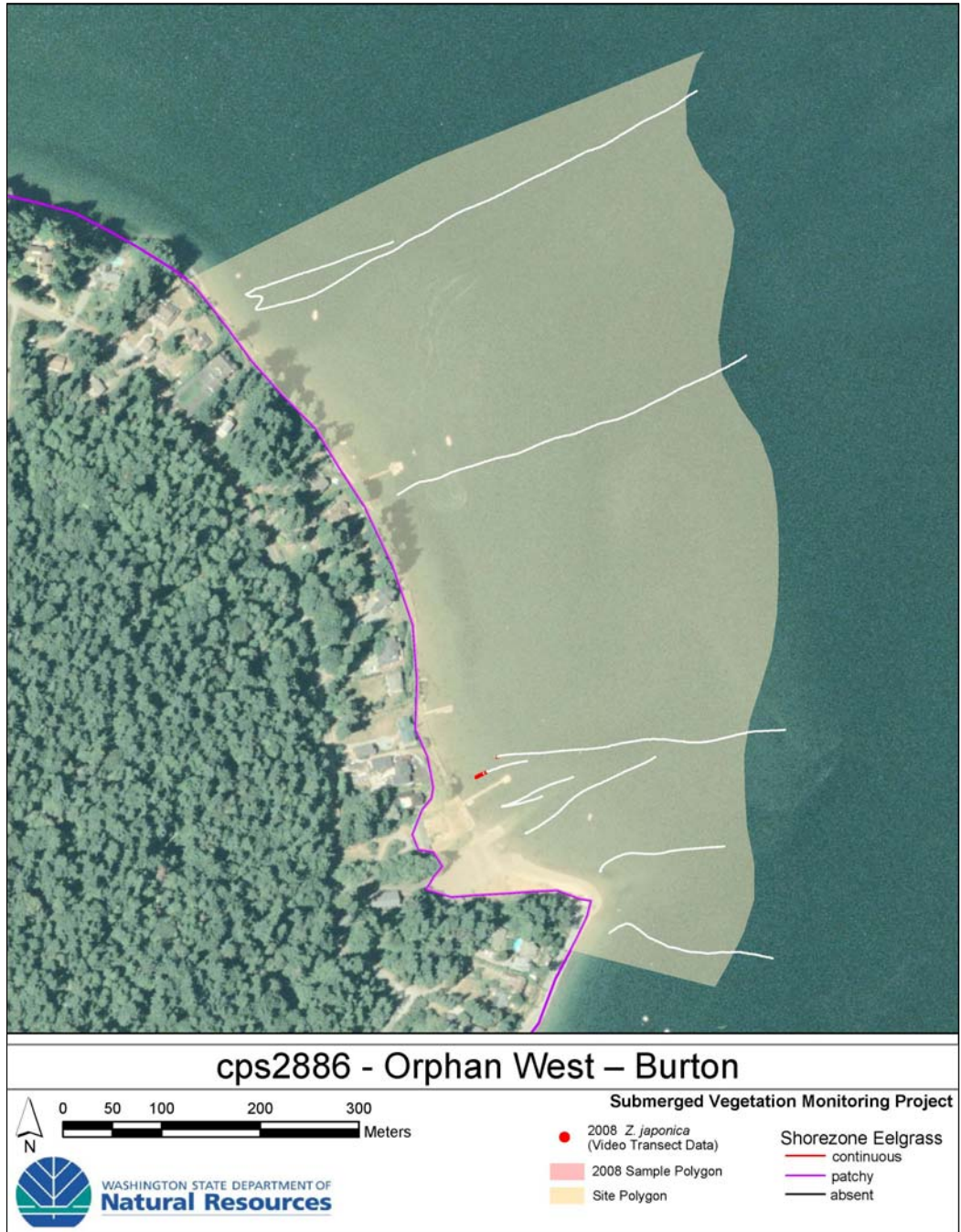
Q.4 cps1180 – Dockton Point



Q.5 cps1183 – Rabb's Lagoon



Q.6 cps2886 – Orphan West – Burton



Q.7 cps2887 – Orphan East - Mileta



Appendix R Sidescan sonar data

Contents of Appendix R were provided by Tony Petrillo of Blue Water Engineering Services, Inc. (BWES) of Port Townsend, WA.

R.1 Sidescan sonar survey

The sidescan sonar data acquisition was conducted by Tony Petrillo of Blue Water Engineering Services, Inc. (BWES) of Port Townsend, WA. The sidescan sonar and navigation systems were mobilized on the Brendan D II. Field operations to acquire data were conducted on Friday, 29 August at the Vashon Island site and Thursday, 18 September at the Bellingham site.

The sidescan sonar survey data was acquired using an analog sidescan sonar system (SSS), a digital sidescan data acquisition and processing (SSSDAS) system, a differential GPS (DGPS), and a navigation and hydrographic software system (HYPACK). The sidescan sonar was a Geoacoustics Dual Frequency system. It consisted of a topside electronics processing unit, a tow cable and a submersible sonar tow fish. The SSSDAS was a Chesapeake Technologies hardware-software package. It consisted of a desktop computer fitted with a dual channel analog-to-digital (A-D) conversion board and ran both data acquisition and post-processing software. Vessel positioning was done using a DGPS and a laptop running HYPACK hydrographic software. The DGPS data was split so that both the HYPACK and the SSSDAS software were receiving the data at the same time. The survey vessel was guided by pre-programmed survey track line data on HYPACK and was displayed on a monitor for the helmsman.

Sidescan sonar detects images using acoustic pulses. The tow fish is fitted with a sonar transducer on the left and right (port and starboard) sides of the unit. Each transducer simultaneously transmits an acoustic pulse at set intervals depending upon the port and starboard channel transmit distance in meters. The SSS could be set to fire at a high or low frequency (nominally, 100 or 500 kHz) depending upon the quality of image displayed in real time. As a starting point, we used 100 meters per channel at 500 kHz. The plan was to make a single pass with the SSS along the shoreline where eelgrass was previously detected by Marine Resources Consultants (NORRIS) surveys. Based upon previous experience, SSS survey is best conducted parallel with the bathymetric contour when possible. Surveying along a bathymetric contour interval means that one channel faced upslope and one channel faced down slope. Due to the physics of the sonar pulse upslope images resolve more detail than down slope images. Thus, the survey track lines were planned based on the sonar “looking” upslope towards known patches of eelgrass.

The track lines for the survey were pre-planned based on the recent video-sonar mapping done by NORRIS.

During survey, the SSS tow fish was deployed over the port side of the vessel directly below the DGPS antenna. Thus, there was no offset or layback. Because the tow fish was deployed over the port side, all track lines were run with the port side of the survey vessel facing shore. Thus, the SSS tow fish was always facing upslope. Track lines were laid out based upon an assumed offset of about 100 ft to the deep side of existing eelgrass beds. All track lines were run at between 2 and 3 knots.

During the survey, the helmsman would align the survey vessel at the start of the track line. Once aligned, the HYPACK data acquisition was started, and then the SSSDAS was started. At the end of each track line, the SSSDAS was terminated and then HYPACK was ended. The acquired HYPACK navigation data was used in post-processing to confirm that there were no shifts in the position of the vessel track between the navigation and the sidescan vessel track. The data from each system were stored separately on each respective computer. At the end of each survey data the raw data were stored on separate media so that there were 2 copies of all data.

The SSS was set at high or low frequency depending upon data quality for local site conditions. It was always set for 100 meters per channel

Post-Processing and Analysis

HYPACK Analysis

To confirm that there were no gross errors in the navigation data, they HYPACK track line data was reviewed line by line using the HYPACK post-processing software. Once completed, that data was forwarded to Sound GIS in the form of northings and eastings in Washington state plane coordinates—south zone (NAD 83/91). The units were US survey feet.

SSS Analysis

The raw digital SSS data acquired and saved by the SSSDAS were stored in a proprietary format with an XTF extension. All the SSS data were imported into the Sonar Wiz processing program (SONARWIZ) for an initial pass through the software. After the first pass, the navigation data were reviewed for errors. This is essentially the same data as the HYPACK data. Next, the bottom tracking data was reviewed and edited. This data shows the raw SSS data including the water column. A detailed discussion of the physics of SSS analysis is beyond the scope of this report. Suffice it to say that this process allows the user to “remove” the water column from the SSS data to make the data look more like a scale-corrected plan view photograph of the sea bed. Once this process was completed, all the SSS data was processed for a second pass and then review for errors. This process was iterative until all errors were corrected.

The final products of this analysis were 2 files for each track line. The primary file was a JPG file of the sidescan image for each track line. An ancillary file was a JGW (world) file which provided positioning information for the JPG file in GIS.

Digitizing

Digitizing of the sidescan images was done in GIS as a collaborative effort between Exa Data and Mapping and BWES personnel. The GIS system had the capability of displaying the SSS images and the NORRIS eelgrass data simultaneously. The SSS data was displayed on the GIS screen and reviewed relative to the NORRIS data. Once SSS eelgrass images were identified on the screen relative to the NORRIS data a polygon was digitized around the eelgrass patches.

R.2 Sidescan field notes.

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Location _____ Date _____
Project / Client _____

1542 ROBINSONS - 1542 STBD SIDE
PORT BEST 21KTS 500KHZ
- BOAT PULL EVIDENT IN RECORDS
- DRIP TOWN FISH 5'
1557 ROBINSONS 4 STBD 500KHZ
1617 ROBINSON SW STBD 100KHZ
N/G 1614 **ABORT**
1631 - ROBINSON SW STBD 500KHZ
- RAISE TOW FISH UP 5 FT
1646 ROBINSON SW STBD 500KHZ
1700 U/W TO GIG HBR.

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Location _____ Date _____
Project / Client _____

0700 U/W FURN PT
0845 ALU @ GIG HBR. MUSHIERE.
1203 U/W FURN GIG HBR
1320 ALU @ VI - 1400
TRAIL RUN 75 m / SIDE
500 KHZ 21KTS
1345 INTER - 1345 NE-SW
PORT SIDE DEPLOYMENT 2KTS
SITE - PORT SIDE
1351 U/W TO DOCK JON
1406 BOUEN - 1406 100KHZ
PORT SIDE 2KTS N-S
1412 DOCKTON - 1412 500KHZ
PORT SIDE 2KTS N-S
1415 U/W TO ENTRANCE
- SWITCH GPS & TOW FISH
TO STBD SIDE
1431 ENTRANCE - 1431 500KHZ
STBD SIDE 2KTS
1455 U/W TO ROBINSON PT.
1539 ALU @ ROBINSON - S
TOW FISH
IAN GUNTER / TOM ORRICK

VISION SSS
F21 29 JUL 2008

Appendix S Underwater videography data (DVD)

Appendix T Site data (CD)

Maury Island folder:

Sidescan_eelgrass_2008 – Interpretations of cumulative Maury Island eelgrass presence using sidescan images and post-processed video data. Sidescan data collection and interpretation was performed by Tony Petrillo of Blue Water Engineering Services, Inc. (BWES) of Port Townsend, WA.

Maury Island_eelgrass_database_2008 – MS Access Database of videography data. Included in the data base are:

1. Two tables
 - a. *2008sites*: table consists of site level results.
 - b. *2008transects*: table consists of transect levels results by site.
2. One query
 - a. *qry_site_samp_convert_to_metric_08*: Converts sites table input units from feet to meters and hectares.
3. Two reports
 - a. *2008 Maury Island Area Estimates*: Site-level area results in hectares.
 - b. *2008 Maury Island Depth Estimates*: Site-level depth results in hectares

Individual site folders (cps1116, cps1167, cps1168, cps1180, cps1183, cps2886, and cps2887):

These folders contain post-processed electronic and ArcGIS site-specific data. Within each site folder are three additional folders:

ArcGIS data:

Included are site-level GIS polygons, sample polygons (when *Z. marina* is present) and video transect data.

Electronic site data:

Contents of this folder are as follows:

1. Pre-sampling random transect map (*random_transects.pdf*)
2. Post-sampling random transect map (*2008_field_transect_map.pdf*)
3. Post-sampling site map (*ortho.pdf*)
4. Transect notes (*2008 Transect Notes.xls*)
5. Site description (*2008 Site Description.xls*)
6. Raw, post-processed transect data (*TD.csv*)
7. Area and depth estimates (*Zm_area_depth.xls*)

Sidescan Sonar Polygon:

All sites have a PDF with sidescan and SVMP transect data overlaid. Sites with *Z. marina* present have a GIS shapefile of sidescan interpretations

(*2008_Sidescan_Polygon.shp*) and site-level area calculations in the attribute table.

Fidalgo Bay folder:

Fidalgo_Bay_eelgrass_database_2008 – MS Access Database of videography data. Included in the data base are:

4. Two tables
 - a. *2008sites*: table consists of site level results.
 - b. *2008transects*: table consists of transect levels results by site.
5. One query
 - a. *qry_site_samp_convert_to_metric_08*: Converts sites table input units from feet to meters and hectares.
6. Two reports
 - a. *2008 Fidalgo Bay Area Estimates*: Site-level area results in hectares.
 - b. *2008 Fidalgo Bay Depth Estimates*: Site-level depth results in hectares

Individual site folders (flats15N & flats15S):

These folders contain post-processed electronic and ArcGIS site-specific data. Within each site folder are three additional folders:

ArcGIS data:

Included are site-level GIS polygons, sample polygons (when *Z. marina* is present) and video transect data.

Electronic site data:

Contents of this folder are as follows:

8. Pre-sampling random transect map (*random_transects.pdf*)
9. Post-sampling random transect map (*2008_field_transect_map.pdf*)
10. Post-sampling site map (*ortho.pdf*)
11. Transect notes (*2008 Transect Notes.xls*)
12. Site description (*2008 Site Description.xls*)
13. Raw, post-processed transect data (*TD.csv*)
14. Area and depth estimates (*Zm_area_depth.xls*)

All ArcGIS information projected in: NAD 1983 HARN State Plane Washington South FIPS 4602 Feet.