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2017 Aerial and Underwater Videography Assessments of Eelgrass in Island County

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Overview

The objective of the eelgrass project is to monitor the health of eelgrass (*Zostera marina*, *Zm*) beds in Island County. The goal of the project is to measure the area of our largest eelgrass beds in regions sensitive to damage from human activity or environmental stress. Our strategies are: (1) to select sites within Island County, as defined by the Washington State Department of Natural Resources (WADNR), that are of interest to Island County Marine Committee (ICMRC) and WADNR and aligned with our project's goal, (2) to collect underwater video using methods developed by WADNR, (3) to collect aerial photographs of vegetation at extreme low tides for entire shoreline in regions of interest, (4) to analyze the data and present the results using GIS mapping techniques and (5) to communicate the results as a oral presentation to the ICMRC and as a written report to the NW Straits Commission. Our measure of success for this project is communication of the current status and biologically significant changes in the area of eelgrass beds in Island County. Delivery of this report and the associated data in GIS format completes the project for 2017.

Over the years we have determined our capacity for underwater videography data collection is about ten sites during the summer months if all goes well. This year we were able to complete only six sites. After consultation with the ICMRC and WADNR we chose the sites of Cornet Bay (flats29 - core), Oak Harbor (swh0884), Monroe Landing (swh0888 - core), Freeland Park (swh0932 -core), South Summerhill Drive (swh0963) and added Possession Park (swh0973) after new information suggested the existence of eelgrass wasting disease on South Whidbey. The rationale for each site will be further described later (see 2017 Sites).

We were fortunate to have the continued opportunity to investigate sonar mapping in 2017. Albert Foster used his capability to perform sonar surveys for our selected eelgrass study sites (and more) using a consumer grade digital fish-finder sonar and GPS chart-plotter made by Navico Lowrance. This provided additional data points to our evaluation of sonar as an alternative/complimentary method to aerial and underwater video transect maps.

Between June 15th and August 11th of 2017 we collected underwater video of all six sites. Aerial photographs were taken for the entire shorelines of Whidbey and Camano Islands by July 22nd. Maps depicting both underwater video assessments and geo-referenced aerial photographs were prepared for all sites and bed area estimates were calculated from the underwater video analysis results. Albert produced sonar maps for all the same sites and bed area measurements were calculated from his maps for comparison.

Of the core sites, Monroe Landing (swh0888) and Freeland Park (swh0932) continue to have stable bed areas. Monroe Landing shows some redistribution of eelgrass within the site as in previous years, but the overall area is basically unchanged.

For Cornet Bay (flats29) we now have a seven-year downward trend in eelgrass bed area measurements that is statistically significant (R^2=0.98) and represents a 19% loss since 2011. By aerial inspection we continue to see local damage to eelgrass beds by boating activity, but do not believe this is a significant factor in the overall eelgrass bed area loss as measured by underwater videography. We have studied potential causes and temperature changes at our core sites.

We established a baseline to be used for comparison after construction at the Oak Harbor near Windjammer Park (swh0884) and now have repeat analyses of South Summerhill Drive (swh0963) and Possession Beach Park (swh0973). A report of eelgrass wasting disease in Island County has been investigated.

Our second year of using sonar shows further good correlation with underwater videography, but with some caveats. Just as with aerial photos, the identity of the vegetation needs to be confirmed with visual methods. We have further understanding for the potential for false positives and negatives using sonar, but remain impressed with the utility of the method. This comparison study will be extended to 2018 but not beyond.

Methods

Underwater Videography

A complete description of our underwater videography method has been defined in the attached document: "Underwater Videography Manual v1_5.doc". Briefly, our method is modeled after techniques developed by WADNR to collect underwater video of shoreline vegetation at depths from approximately 3 feet to about 25 feet below the surface of the water at medium tide levels. Data is collected by recording underwater video and GPS & depth finder information while navigating a small boat slowly (0.5 knots) along transect lines that are perpendicular to the median line of the transect points defined by DNR. Data for ten to fifteen transect lines are collected for each site. Our equipment diagram is shown below:

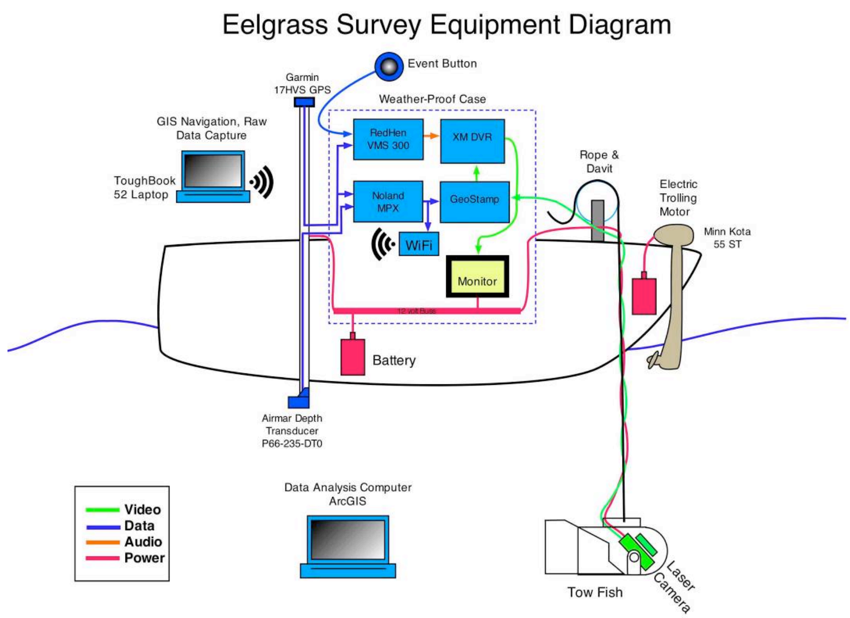

Figure 1. Equipment diagram for Beachwatcher's underwater video data collection.

Figure 2. Boat used for ICMRC team's underwater video data collection.

Once the GPS and depth data have been collected into a tracklog file, the file is processed into spreadsheets (.CSV format) that can be displayed as XY data on GIS maps. To determine the area of eelgrass coverage, volunteers review the video files and record their scores for the presence or absence of eelgrass into the corresponding Video Analysis spreadsheets. An assessment of video quality is also recorded to indicate places where eelgrass identity could not be determined due to poor positioning of the camera above the seabed by the camera operator or poor underwater visibility. The scores of the reviewers are then displayed in GIS maps and the resulting spreadsheets and sampling polygons are used by WADNR (Lisa Ferrier) to estimate eelgrass bed areas. Complete results of DNR calculations are returned to us in spreadsheet form. Alternatively we have developed a method (described in previous years) to calculate the eelgrass bed areas ourselves.

Aerial Photography

A detailed description of the tasks required to complete the aerial photography segment of this project have been defined previously in the attached document: "Aerial Photography Manual v1_1.doc". Briefly, overlapping vertical photographs of the shorelines of interest were taken from a small airplane using a wing-mounted camera controlled remotely from the cabin. The images were geo-tagged with the GPS data from the navigation system of the plane to identify the position of each photograph and markers were placed on a map for each photograph. Since sites require more than one image to cover the entire area, overlapping photographs were stitched together into a collective site image. The images for each site were then geo-referenced to a base map using ArcGIS 10 (usually ESRI Satellite maps) to allow comparison with other GIS data (underwater videography data primarily) and to make accurate measurements of the size of features of interest.

Figure 3. Wing mounted Camera

Figure 4. View from 2500' over Useless Bay

Figure 5. Resolution of single photo over Holmes Harbor

Figure 6. Geo-referenced low-tide site image of Holmes Harbor site swh0932.

The iPad program, "Galileo", was used along with an external GPS (Dual XGPS170) to navigate the airplane along the shoreline. This provided navigation and a tracklog in GPX format to more easily geotag all the photographs after the flights.

Sonar Mapping

As a member of the eelgrass team since 2016, Albert Foster, provided us with a new method for measuring underwater vegetation using consumer grade sonar products from Navico Lowrance (now a CMAP company). Our intention was to investigate the feasibility of this method by comparing sonar maps to maps from aerial and underwater video at the same sites. Albert provided the boat, hardware and $2,500 annual subscription to the BioBase sonar data processing service (https://www.cibiobase.com/) as well as his donated time and expenses to single handedly collect and process the data (see Figure 7). The hardware consisted of the Lowrance HDS-9 GEN 3 chartplotter with transom mounted Lowrance HST-WSBL/HST-WSU 200/83kHz sonar transducer (see Fig. x) and transom mounted Simrad GPS antenna. Hardware settings for sonar data collection in .sl2 file format per BioBase instructions (https://www.cibiobase.com/Home/EcoSoundFeatures)

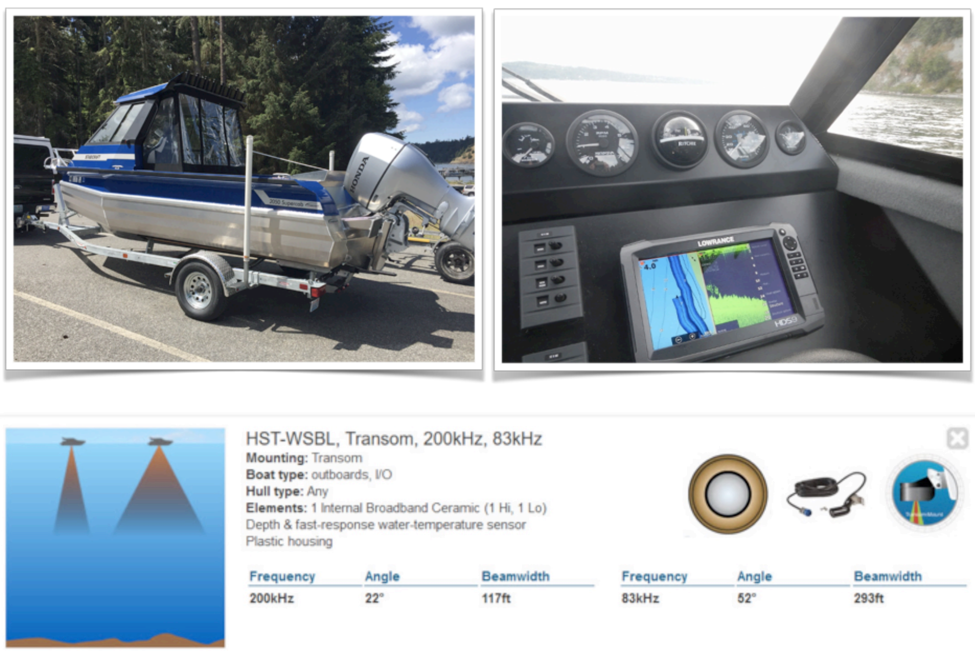

Figure 7. Albert Foster's Boat and Lowrance sonar mapping system.

A brief description of the method is provided. At one second intervals a scanned line of data points were collected containing measurements of latitude, longitude, depth of the seafloor and % of that depth occupied by vegetation. The line of data points were perpendicular to the boat transom and roughly 25 feet either side of the sonar transducer (see left diagram in Figure 8). Albert navigated his boat at approximately 5 knots such that the data lines overlapped, akin to mowing a lawn (see red lines in upper right diagram in Figure 8). From all the overlapping data points, the offline BioBase data service later calculated maps of the seafloor contour (see blue map in upper right diagram in Figure 8) and of the vegetation (see lower right diagram in Figure 8).

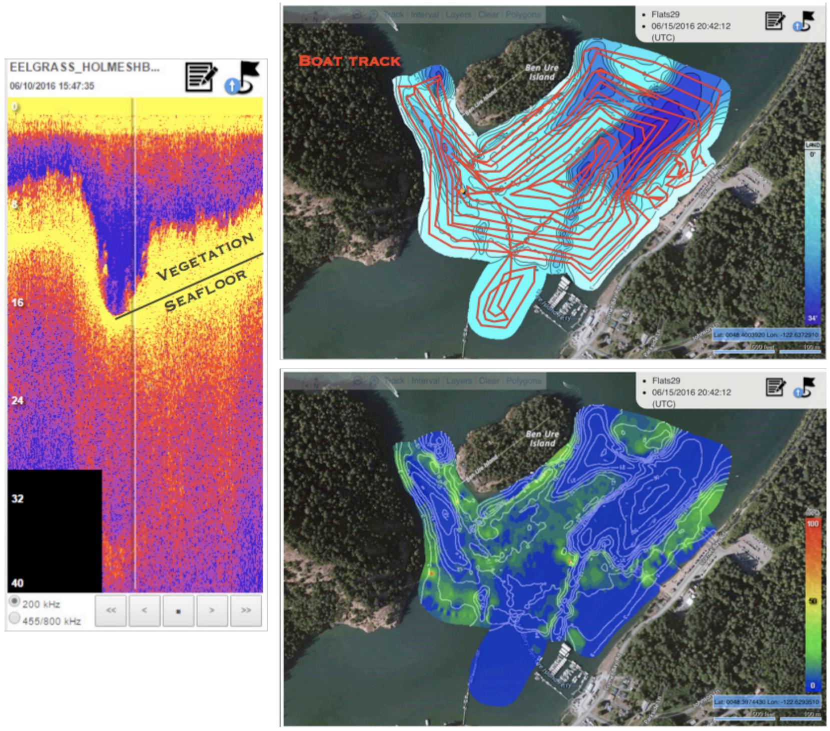

Figure 8. Raw sonar data (left), Boat track and seafloor contour map (upper right) and vegetation map with contour lines (lower right).

Data Presentation

The Video Analysis spreadsheet files were imported into ArcGIS 10 and mapped onto aerial images that were geo-referenced to each site's basemap (Google). The underwater video assessment data are displayed as: (a) white lines represent the absence of all eelgrass, (b) green lines represent the presence of Z*marina*, (c) red line represent the presence of Z*japonica* , (d) orange lines represent the presence of both *Zmarina* and *Zjaponica* and (e) black represent unusable video, and (f) dark green represents areas where *Zmarina* or *Zjaponica* eelgrass was present, but the identity of which was not possible to determine from the video (see Figure 9). A yellow line represents the sampling polygon used to calculate eelgrass bed areas. Only data within the yellow polygon are used for eelgrass bed area calculations. In a few of the older diagrams the data outside the yellow polygon have not been clipped, but those data points did not contribute to the calculations.

The green stars identify the boundaries of the sites as described by WADNR. All maps with underwater video data are oriented with North being toward the top. Photographs without underwater video data are oriented with the long axis along convenient for display purposes. Dates shown with blue background are for aerial flights and dates with green background are for underwater video outings. A small map shows the location of the site with a yellow dot; blue dots represent all the sites (e.g. 2015 in the example shown here). The *Zmarina* Bed Area measurement in hectares is shown at the bottom.

The accompanying graphs show historic values for eelgrass bed areas in hectares (1 hectare = 2.47 acres). The blue data points are values calculated by DNR from their underwater videography data and the red are values calculated by DNR from our data (ICMRC). The error bars represent ±2 standard errors. Only values with no overlap in error bars are statistically different from each other at the 95% confidence level.

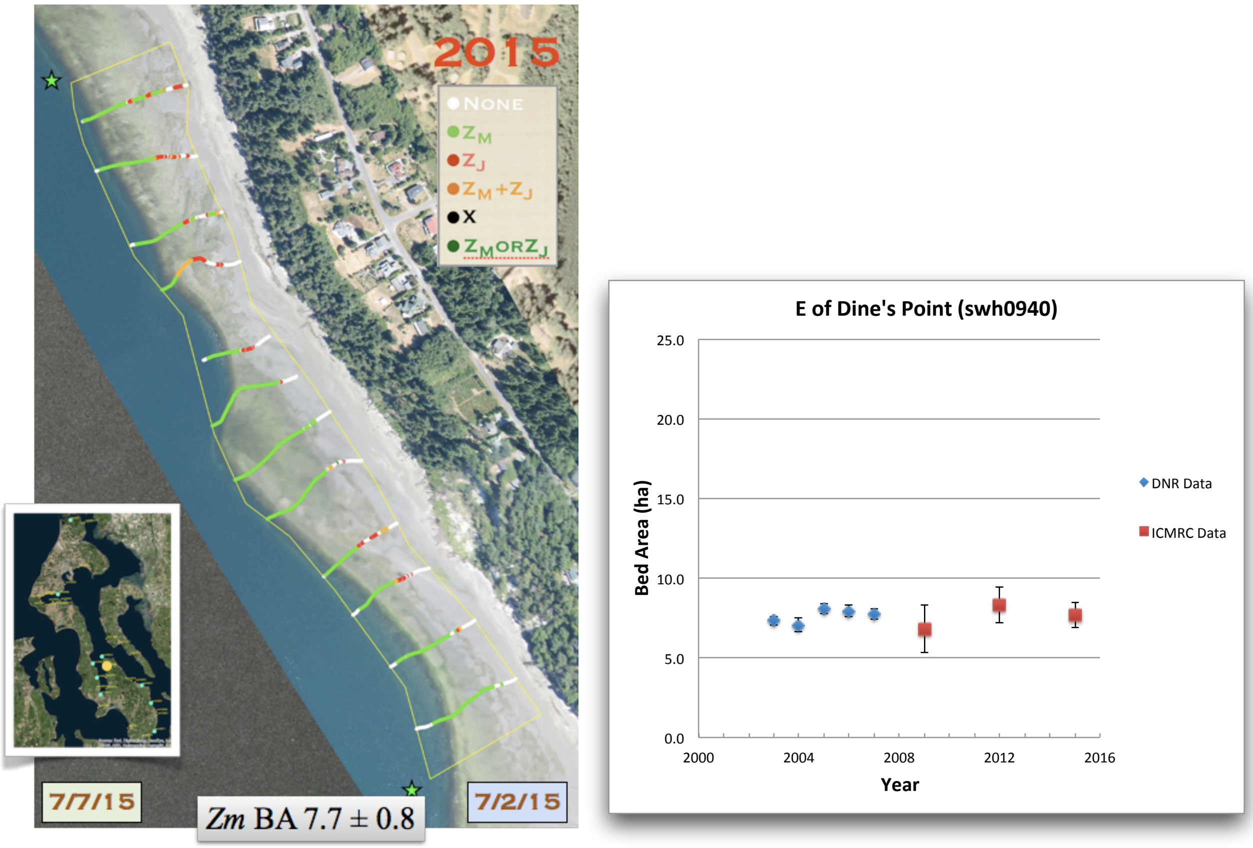

Figure 9. Example of geo-referenced aerial photograph, underwater videography transects and historic results of eelgrass bed areas.

An example of the sonar maps is shown in Figure 10. In order to bed area measurements from the underwater videography with sonar data, the contour of the vegetation map was determined using image analysis techniques and constrained to the sampling polygon (see red boundary in Figure 10) and enumerated in ArcGIS.

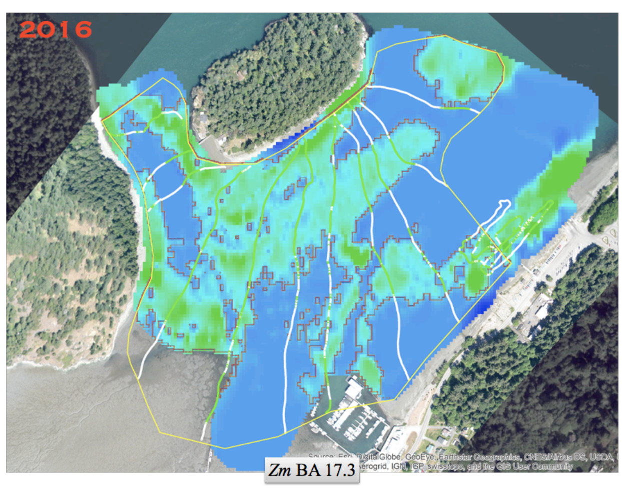

Figure 10. An example of sonar mapping of Cornet Bay overlaid with the underwater video analysis transect data, the sampling polygon (yellow line) and outline of vegetation boundaries (red lines)

2017 Sites

Our goal is ***not*** to randomly sample Whidbey and Camano islands to estimate overall eelgrass bed area for all of Island County. Due to under-sampling, this goal would be difficult to achieve to a precision needed to be meaningful. Our goal instead is to selectively sample sites with known human activity or environmental stress to understand the related changes in eelgrass bed areas over shorter periods of time (3-5 years).

To begin our selection process, each year we consult with the IC MRC and WADNR for their preferences. We also review our aerial photographs and results from previous years to develop the list of sites to study by underwater videography. We always welcome input from other interested parties (Whidbey Camano Land Trust -WCLT, Port Authorities, City Councils, individuals, etc.). In 2017 we identified and were able to complete underwater videography for six sites within Island County. Three of the selected sites were our core sites that have been sampled every year: Cornet Bay (flats29), Monroe Landing in Penn Cove (swh0888) and Freeland Park in Holmes Harbor (swh0932). Two other sites were of interest to the ICMRC and WCLT due to recent construction or restoration: (1) Windjammer Park near the Oak Harbor marina (swh0884) because of significant new construction. We established an area of interest in front of the park within the Oak Harbor site (swh0884) and drew transect lines to survey only this portion. (2) A bulkhead was removed in the last year at the South Summerhill Drive (swh0963) site. We measured the eelgrass bed area in 2015 in anticipation of the removal and now wanted to determine if the eelgrass bed area had changed. (3) At a seminar in late June on Eelgrass Wasting Disease by Friday Harbor Laboratories by Morgan Eisenlord, a study site on South Whidbey was identified that showed significant severity and prevalence of eelgrass wasting disease. Since the site coordinates were not available within the timeframe of our season, we guessed that the site was Possession Park (swh0973) based on previous aerials and available information. On July 28 we collected the underwater video data. We later learned the eelgrass wasting disease study was actually performed within the Glendale site (swh0971). Given that we had studied this site in 2015, we relied on our previous data to get a perspective on wasting disease.

A map of our entire site list with those sampled by underwater videography in 2017 is shown in below.

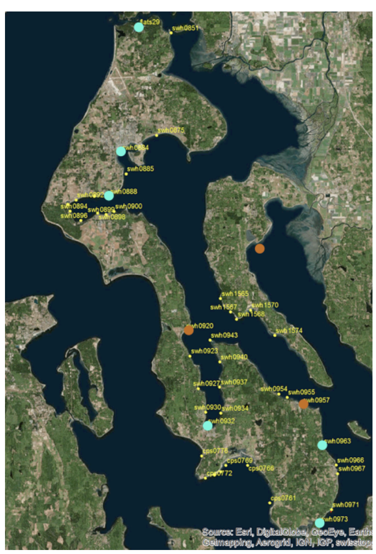

Figure 11. Underwater videography sampling sites studied in 2017 (blue dots) are shown with other sites studied in previous years (small yellow dots). Also included are three sites studied in 2017 by sonar alone (orange dots).

Underwater Video Data Acquisition

A small document was created to record events and issues for each outing and to map the tracklog of the boat's path shortly after each event (see Appendices: "2017 Quick Report.doc"). The list of crew and sites for 2017 are shown in Table 1. All of our underwater video data collection was completed by August 11, 2017.

Crew Schedule for 2017 Eelgrass Monitoring				
Date	**Site**	**Captain**	**Equipment**	**Camera**
6/14/17	swh0932	Ken Urstad	Gregg,Tom,Kes	Training/Testing
6/28/17	flats29	Ken Urstad	Gregg	Mark
7/13/17	swh0884	Ken Urstad	Gregg	Mark
7/27/17	swh0963	Ken Urstad	Gregg	Bob
7/28/17	swh0973	Ken Urstad	Gregg	Neal
8/11/17	swh0888	Ken Urstad	Gregg	Neal

Table 1. Crew Schedule for 2017 Underwater Videography outings (complete names of equipment/camera crew are: Gregg Ridder, Bob Gentz, Neal Clark, Tom Vos, Albert Foster, Kes Tautvidas, and Mark Kennedy).

Sonar Surveys

Albert Foster was able to complete nine surveys in Island County by sonar in 2017. Beyond the six sites listed above for underwater videography, he also surveyed Greenbank (swh0920), Langley Marina (swh0957) and a reconnaissance survey of Barnum Point on Camano Island. All of his data acquisition outings were performed between June 29-30, 2017 and July 20-23, 2017.

Aerial Photography Data Acquisition

Two flights were sufficient to cover the entire coastline of Whidbey and Camano Islands and an additional flight to capture the eelgrass beds in San Juan County. The map below (Figure 12) shows the track of the flight used to gather aerial photographs of shorelines in 2017. An earlier flight on (5/27/17) was flown to capture Whale pits and an early look at eelgrass beds (data not shown). Three additional flights (8/20/17, 8/21/17 and 9/10/17; not shown) were performed to gather images of kelp beds in Island, San Juan, Jefferson and Whatcom Counties. The total number of aerial photos collected in 2017 was approximately 8,900.

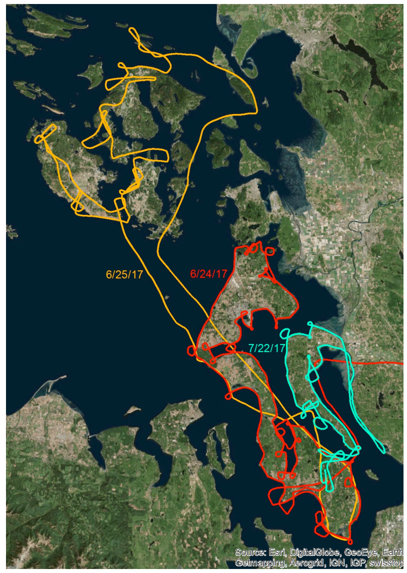

Figure 12. GPX tracks of some of the aerial eelgrass photography flights in 2017.

Data Preparation

By December 2017, all of the underwater video files and accompanying spreadsheets were prepared. Also, by December of 2017 the aerial photographs had been geo-tagged, made into panoramic images for each of the six sampling sites and geo-referenced to a base map. The geo-referenced aerial images and available video-analysis of transects were superimposed on a base map to allow comparison of the two data sets (underwater video and aerial photography) by April.

Video Analysis

The analysis of the underwater video for the presence/absence of eelgrass was completed by Gregg Ridder by March 1, 2018 using the video and spreadsheets produced in December.

Eelgrass Bed Area Estimates

The scored transect tracks for 2017, clipped to include only data within the sampling polygon, were submitted to Lisa Ferrier (WADNR) as ArcGIS shape files for her to calculate the eelgrass beds areas for each site. To date Lisa has now provided the estimates of eelgrass bed areas using our data from 2010 to 2014 with their latest analysis programs. For 2015, 2016 and 2017 we have done our own calculations of eelgrass bed areas by our own method (described and compared to WADNR in the 2012 final report). The results of all the eelgrass bed area estimates over the last nine years are presented in the Table 2. The results are grouped by site (colored by site to make comparisons over the years easier). Future reports will include WADNR calculations when available.

Sonar Results

Albert Foster produced BioBase (www.cibiobase.com) analyses and maps of the sonar data in March, 2017. These maps and results were compared to underwater video analyses by April, 2017.

Results

A summary of *Zm* eelgrass bed area estimations (in hectares) is shown in Table 2.

Site Code	Site Name	Date	N	Zm Area (ha)		95% CI
cps0761	Dave Macke County Park, Maxwelton	23-Jun-11	12	4.0	±	0.8
cps0761	Dave Macke County Park, Maxwelton*	9-Aug-16	12	5.7	±	0.7
cps0766-0772	North Useless Bay	8-Aug-16	2	Recon Only		
cps0776	Mutiny Bay Boat Ramp, SW Whidbey	3-Aug-14	11	7.1	±	1.2
flats29	Cornet Bay, Whidbey*	27-Aug-09	7	20.6	±	5.3
flats29	Cornet Bay, Whidbey	3-Aug-10	10	16.2	±	3.8
flats29	Cornet Bay, Whidbey	9-Jun-11	8	22.5	±	4.4
flats29	Cornet Bay, Whidbey	11-Jul-12	9	21.7	±	3.8
flats29	Cornet Bay, Whidbey	15-Jun-13	8	21.0	±	3.1
flats29	Cornet Bay, Whidbey	18-Jun-14	11	19.3	±	3.6
flats29	Cornet Bay, Whidbey*	22-Jun-15	12	18.2	±	3.2
flats29	Cornet Bay, Whidbey*	27-Jun-16	11	17.1	±	3.4
flats29	Cornet Bay, Whidbey*	28-Jun-17	11	16.7	±	2.8
swh0851	Ala Spit Beach Access, Whidbey	19-Jun-14	1	Recon Only		
swh0875	Midway Blvd, Oak Harbor	29-Jun-13	12	6.0	±	2.4
swh0884	Oak Harbor SW	13-Jul-17	9	5.7	±	4.5
swh0885	Blower's Bluff North, Whidbey	28-Jun-13	10	18.0	±	1.7
swh0885	Blower's Bluff North, Whidbey	15-Aug-14	9	20.9	±	3.9
swh0888	E of Monroe Landing	17-Jul-10	12	8.0	±	1.6
swh0888	E of Monroe Landing	6-Jul-11	10	5.9	±	1.8
swh0888	E of Monroe Landing	21-Aug-12	10	5.4	±	2.2
swh0888	E of Monroe Landing	27-Jul-13	13	5.9	±	1.6
swh0888	E of Monroe Landing	16-Jul-14	10	5.6	±	2.0
swh0888	E of Monroe Landing*	23-Jun-15	13	5.5	±	1.6
swh0888	E of Monroe Landing*	9-Jul-16	12	5.1	±	1.5
swh0888	E of Monroe Landing*	11-Aug-17	12	5.7	±	1.8
swh0890	W of Monroe Landing	16-Jul-10	12	0.0	±	0.0
swh0892	San de Fuca, Whidbey	30-Jul-10	9	0.0	±	0.1
swh0893	Kennedy's Lagoon, Whidbey	29-Jul-13	12	0.0	±	0.0
swh0894	Mueller Park, Whidbey	30-Jul-10	12	0.0	±	0.0
swh0896	Carriage Heights Ln	19-Jul-10	0	0.0	±	0.0
swh0898	W of Lovejoy Point, Coupeville	2-Jul-10	12	1.0	±	0.6
swh0898	W of Lovejoy Point, Coupeville	13-Jul-13	11	1.2	±	0.7
swh0898	W of Lovejoy Point, Coupeville*	25-Jun-16	10	0.8	±	0.4
swh0899	Lovejoy Point, Coupeville	28-Jul-13	10	1.3	±	0.7
swh0900	Mineral Spring, Coupeville*	26-Aug-09	14	1.4	±	1.0
swh0900	Mineral Spring, Coupeville	17-Jun-10	11	1.3	±	1.2
swh0900	Mineral Spring, Coupeville	10-Jun-11	14	0.9	±	0.9
swh0900	Mineral Spring, Coupeville	23-Jul-12	10	1.5	±	1.5
swh0900	Mineral Spring, Coupeville	12-Jul-13	13	1.2	±	1.1
swh0900	Mineral Spring, Coupeville*	24-Jun-16	11	1.0	±	1.2
swh0920	S of Pratt's Bluff South, Whidbey*	25-Jul-16	13	5.4	±	1.1
swh0923	N of Dines Pt North, Whidbey	9-Aug-12	10	3.6	±	0.8
swh0923	N of Dines Pt North, Whidbey*	8-Jul-15	11	2.6	±	0.7

Site Code	Site Name	Date	N	Zm Area (ha)		95% CI
swh0927	Honeymoon Bay, Whidbey*	17-Aug-09	14	10.9	±	1.0
swh0927	Honeymoon Bay, Whidbey	7-Jul-12	12	10.2	±	1.1
swh0927	Honeymoon Bay, Whidbey*	6-Jul-15	12	10.9	±	1.2
swh0930	S Harbor Hills Dr, Whidbey*	17-Jun-09	12	3.8	±	0.9
swh0930	S Harbor Hills Dr, Whidbey	26-Jun-12	11	3.8	±	0.8
swh0932	Freeland Park, Whidbey*	19-Jun-09	10	13.1	±	2.3
swh0932	Freeland Park, Whidbey	31-Jul-10	12	15.0	±	1.3
swh0932	Freeland Park, Whidbey	7-Jun-11	11	15.0	±	1.0
swh0932	Freeland Park, Whidbey	9-Jun-12	10	13.2	±	1.6
swh0932	Freeland Park, Whidbey	31-May-13	13	14.5	±	1.7
swh0932	Freeland Park, Whidbey	3-Jul-14	11	14.9	±	1.5
swh0932	Freeland Park, Whidbey*	10-Jun-15	13	14.6	±	1.7
swh0932	Freeland Park, Whidbey*	28-Jun-16	14	14.9	±	1.6
swh0932	Freeland Park, Whidbey*	14-Jun-17	12	13.9	±	2.0
swh0934	NW of Lone Lake, Whidbey*	18-Jun-09	18	4.9	±	0.5
swh0934	NW of Lone Lake, Whidbey	6-Aug-12	9	5.5	±	1.4
swh0937	East of Honeymoon Bay, Whidbey*	12-Aug-09	10	9.0	±	1.0
swh0937	East of Honeymoon Bay, Whidbey	7-Aug-12	12	9.1	±	0.6
swh0940	East of Dine's Point, Whidbey*	4-Jun-09	10	6.8	±	1.5
swh0940	East of Dine's Point, Whidbey	10-Aug-12	11	8.3	±	1.1
swh0940	East of Dine's Point, Whidbey	7-Jul-15	12	7.7	±	0.8
swh0943	Baby Island, SE Whidbey*	19-Aug-09	13	17.7	±	2.0
swh0943	Baby Island, SE Whidbey	11-Aug-12	13	18.0	±	1.3
swh0943	Baby Island, SE Whidbey*	9-Jul-15	12	18.7	±	1.0
swh0954	N of Brooks Hill Rd, SE Whidbey	31-Jul-14	10	20.6	±	1.8
swh0955	West Langley, SE Whidbey	1-Aug-14	11	14.7	±	1.5
swh0957	Port of South Whidbey	20-Jun-11	10	9.1	±	1.5
swh0957	Port of South Whidbey	2-Aug-14	12	11.0	±	1.4
swh0957	Port of South Whidbey*	20-Jul-15	12	11.2	±	1.2
swh0963	S Summerhill Drive, SE Whidbey*	21-Jul-15	9	14.6	±	0.7
swh0963	S Summerhill Drive, SE Whidbey*	27-Jul-17	11	14.4	±	0.8
swh0966	Clinton Ferry Terminal	21-Jun-11	11	7.5	±	1.2
swh0967	S of Clinton Ferry Terminal	22-Jun-11	13	2.7	±	1.0
swh0971	South Glendale, SE Whidbey*	9-Jun-15	11	6.8	±	2.4
swh0973	Possession, SE Whidbey	19-Jul-11	12	13.7	±	2.4
swh0973	Possession, SE Whidbey*	28-Jul-17	11	14.0	±	2.9
swh1565	Cama Beach, Camano Island	8-Aug-12	12	3.6	±	1.0
swh1567	Camano State Park*	26-Jul-16	10	1.3	±	1.0
swh1568	Lowell Point, Camano Island*	26-Jul-16	7	0.1	±	0.2
swh1570	Elger Bay, South Camano	26-Jul-13	11	18.2	±	2.1
swh1574	Camp Diana West, South Camano	4-Aug-14	10	17.1	±	2.3

Table 2. Eelgrass Bed Areas by Site for the period from 2009 to 2017. The 2009 & 2015 -2017 results were calculated by method developed by G. Ridder and marked (*). The 2010 - 2014 were calculated by DNR from our videography analysis data.

Results and Discussion by Site

The following pages contain the maps and discussion of results for each site sampled by underwater videography in 2017 by the Island County MRC Eelgrass Project.

Cornet Bay (flats29)

Cornet Bay is one of our core sites and is therefore monitored each year. It contains one of the largest eelgrass beds of all the sites in Island County. The high level of interest for Cornet Bay is due to the extensive boating activity in the bay and inclusion of Deception Pass State Park where removal of creosote bulkheads and restructuring of the beach facilities was done in late 2012. In addition, a new proposal was submitted by WADNR and Island County Parks to change Cornet Bay moorage at the park perhaps as early as the summer-fall of 2017. The existing docks will be removed and replaced with new ones in deeper water to have less impact on the eelgrass beds than the existing docks. The project will replace creosote pilings with metal pilings and increase moorage space to reduce the anchorage of boats in the eelgrass beds. As of this writing (October 2018), the project remains delayed.

This site has a very irregular distribution of eelgrass in large intertidal and subtidal areas. It also has dredged channels to allow ingress/egress of boats to marinas and around Ben Ure Island. Every year in the aerial photos we have seen physical disturbances from boating activity in the form of propeller strikes and anchor scour. The propeller strikes are usually aligned with the dredged channels and the anchor scour mostly occurs along their edges. This damage seems to recover within a year or two and doesn't appear to be an increasing area (see Figure 13 bottom left). We have no measure of wave action from boats or naturally occurring.

The result of our 2017 underwater video analysis shows the eelgrass bed area (16.7 ± 2.8 ha) is not statistically different than the average (19.3 ha) for all the years (see Figure 13 top left & center). The error bars in Figure 13 are two standard errors based on the variance among the individual transects. However, these error bars *really* represent the patchiness of the site rather than true variance of repeated eelgrass bed area estimates. The range of the results from all the years has stayed roughly consistent since 2009 and 2010. But, the downward trend in eelgrass bed area since 2011 is significant (R^2 = 0.98) and represents a 19% loss.

While the sampling differences over the years should result in variance, the downward trend from 2011 is too regular to be explained by random sampling. The plot of all transects over the years (Figure 13 right) shows consistent boundaries in the subtidal areas (darker aerial areas) and more variation in the intertidal (lighter aerial areas). This leads us to suspect the loss is occurring in the intertidal areas, however it is not obvious exactly where. In the future we will establish boundaries of the intertidal and subtidal areas, possibly based on the sonar contour map, and reanalyze all of data by tidal area. We will also run simulations to test whether our sampling strategy is a determinant error in this downward trend.

We have not seen any similar downward trend in eelgrass bed area at any other site we have monitored. But, no other site in our list has such a large intertidal area with *Zm* growth. Dave Mackey Park (cps0761) is our other measured site that has a large, intertidal flat, but it contains only Z*japonica*.

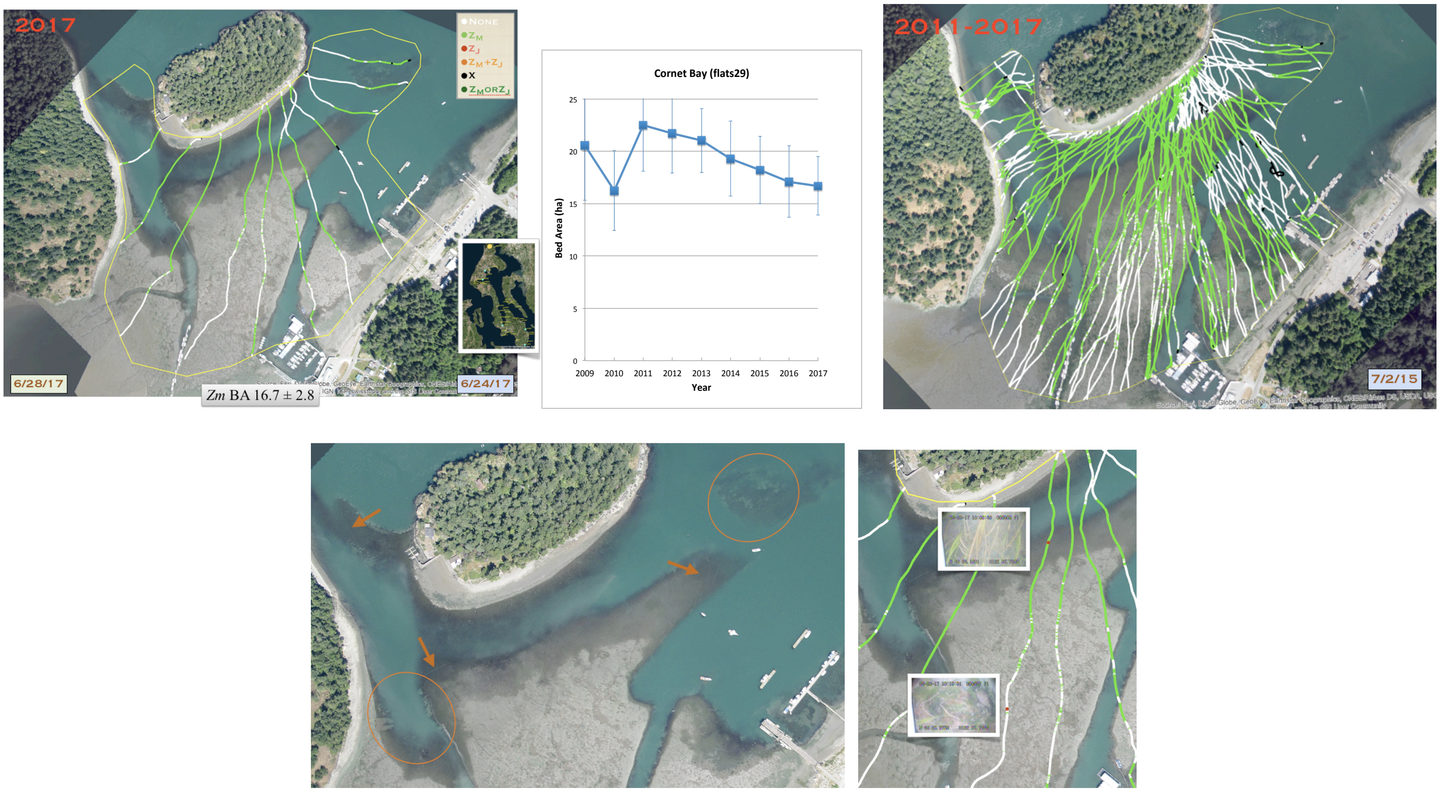

Figure 13. Aerial and Underwater Videography results for Cornet Bay (flats29) in 2017 (left) and historic Bed Area graph from 2009 (center). All underwater videography data from 2009 to 2017 (right). Examples of propeller strikes (orange arrows) and anchor scour (orange circles) in 2017 (bottom left). Density of eelgrass presence in subtidal and intertidal areas (bottom right – red dots indicate position of snapshots). Aerial photographs were taken at extreme low tides; subtidal areas appear darker.

Factors that are known to effect eelgrass growth include algal blooms, eutrophication, physical disturbance, sea level changes, light, salinity, temperature and dessication (Thom 2003). Understanding all the causes of spatial and temporal changes in eelgrass bed area is a multivariate problem that is beyond the scope or our project. However, we do have recorded surface water temperature data to explore.

Our depth finder includes a temperature sensor and we can analyze the surface water temperature data from the transect recordings. We have not investigated this temperature data until now. Even though the sensor has not been calibrated, our results appear to be similar to those reported by others at similar sites (Thom 2014). A plot of our surface temperature data over the years shows mean water temperature measurements from 2011 to 2017 year (see Figure 14) at all our core sites.

Optimal eelgrass growth occurs between 5-8°C and plants are stressed above 15°C. For Cornet Bay the mean surface water temperatures are low compared to our other sites. The trend over the years in question is upward, but most of the variance can be explained by sampling dates. For Cornet Bay, our sampling dates have not been random, but have unintentionally been steadily getting later in June (June 9, 2011 to June 28, 2017 – see Table 2) with the exception of 2012 (July 11). Of note is that both 2009 and 2010 data sets were collected in August (27th and 3rd respectively). Perhaps the mean temperature does not tell the complete story.

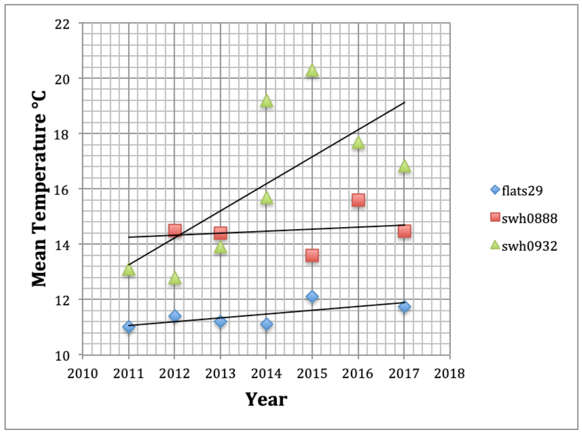

Figure 14. Mean Surface Water Temperatures of all three core sites from 2011 to 2017. Cornet Bay (flats29), Monroe Landing (swh0888) and Freeland Park (swh0932).

We can inspect the spatial distribution of surface water temperatures across the site. The images below (see Figure 15) show the temperatures have been slightly warmer in intertidal vs. subtidal areas between July11, 2012 and June28, 2017. The apparent change that occurred between 2012 and 2017 suggests the warming of the cooler water in the subtidal area. Unfortunately our data does not allow us to differentiate temperature changes within any year from those across several years.

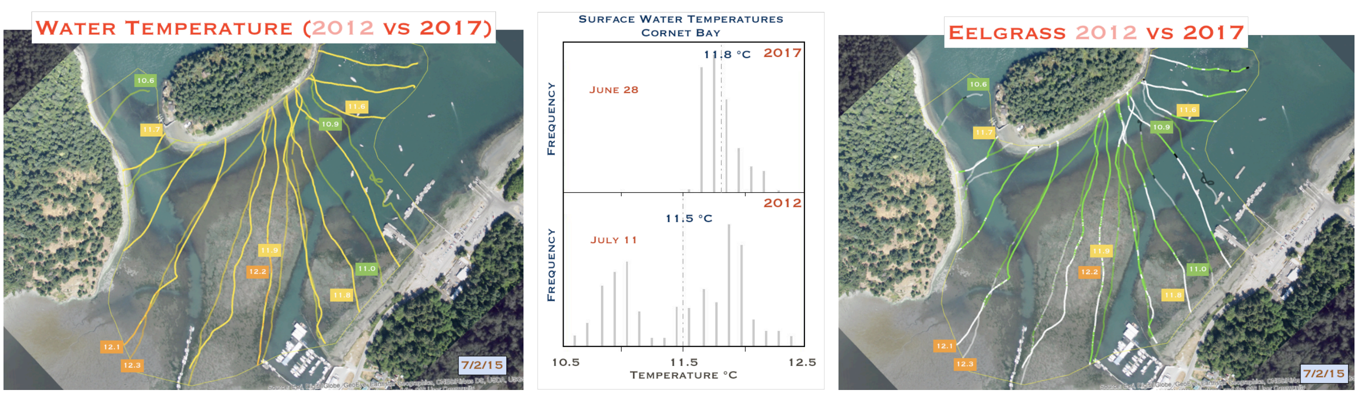

Figure 15. Comparison of surface water temperatures along underwater video transects between 2012 and 2017 (left). The temperature color range is narrow from 10°C (green) to 13°C (red). The 2012 transects are slightly transparent and the 2017 transects are opaque. The tags represent temperature measurements (°C) at specific locations.

For perspective, we do know the yearly ocean surface water temperature increased over time as documented by NOAA (see Figure 16 left). This map demonstrates the significance of a small temperature change (± 2°C). The correlation of NOAA's yearly water temperature measurements near Cornet Bay and our eelgrass bed area estimates in Cornet Bay appears to hold even including the 2009 and 2010 data from August (see Figure 16 right).

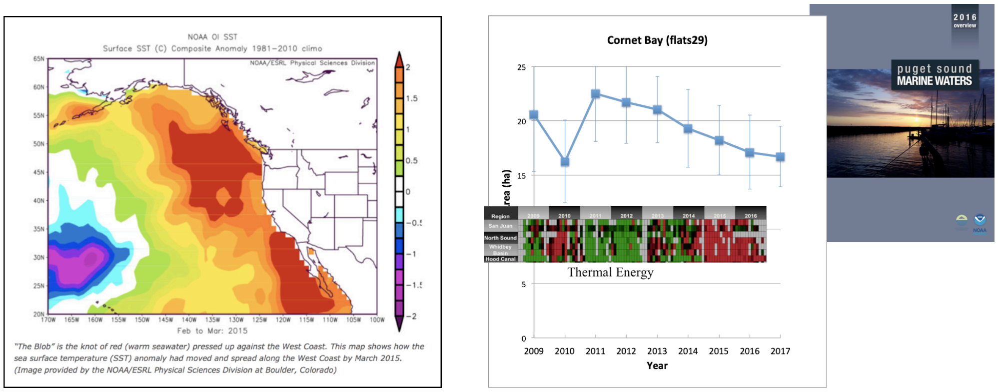

Figure 16. Surface water temperatures over the last few years near Cornet Bay.

A study of *Zm* density in the intertidal region (nearly all) of Padilla Bay reported lower densities of *Zm* growth during the period from 2011 to 2017 (see Figure 17). Their hypothesis was that increased water temperature decreased the survival of plants where, uncovered at low tides, temperatures became stressful. Perhaps we are seeing a similar response in the intertidal areas of Cornet Bay.

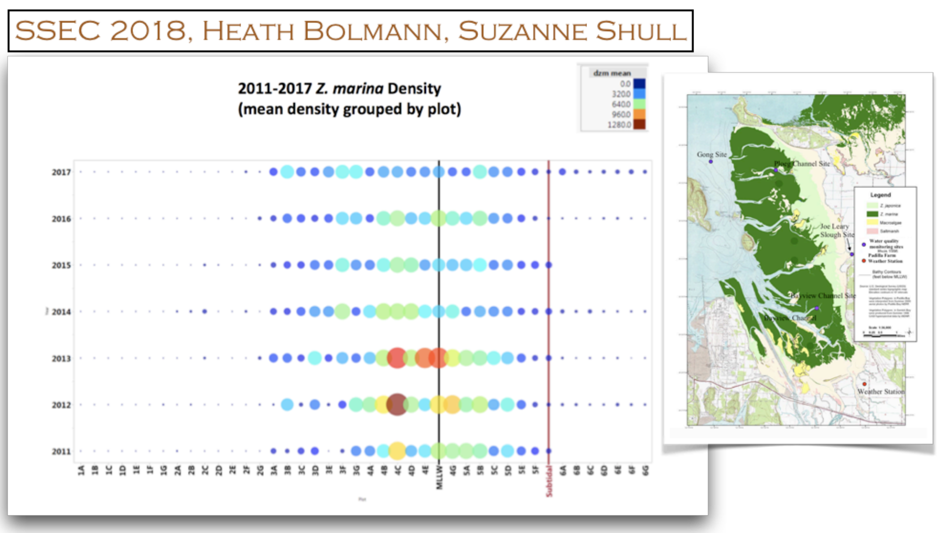

Figure 17.

The growth of eelgrass in Cornet Bay's intertidal area is sometimes very sparse compared to the subtidal areas. The plant density can be only one or two plants per square meter. However, the intertidal area at Cornet Bay is large. Losses in the intertidal areas could result in significant bed area loss, but perhaps only small losses of useful habitat (see Figure 13 lower right).

Sonar (flats29)

One day after the underwater video was collected on Cornet Bay, Albert Foster used sonar imaging to map the same area (see Figure 19). The analysis of the image resulted in an eelgrass bed area of 16.0 hectares. A small portion of the sampling polygon was not imaged so the lower bed area estimate by sonar appears likely. The sonar map boundaries agree well with the underwater video analysis data. We have yet to explore the use of the BioBases' Biovolume (volume of plant material) calculation since we have no comparative data for this feature.

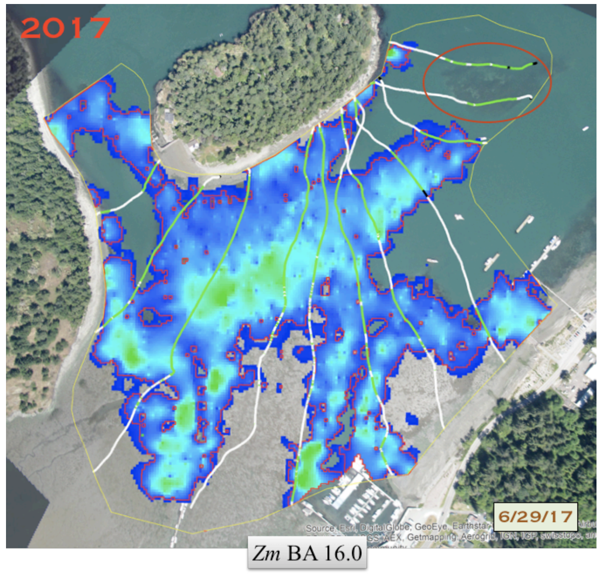

Figure 19. Sonar map and bed area measurement based on area within sampling polygon (green = high biovolume, blue = low biovolume). Red outline represents threshold of eelgrass boundary area. The red oval (upper right) represents missed sampling of the sonar data collection.

East of Monroe Landing, Penn Cove (swh0888)

The site East of Monroe Landing (swh0888) is the largest eelgrass bed area within Penn Cove. Penn Cove is fairly unique in that almost all of its fourteen sites each have less than 1 ha of eelgrass; most have none in our surveys. Whether this is due to natural conditions of he substrate or water quality due to human activity is not known. But, water quality has been an issue in the past.

The eelgrass bed area differences between 2016 and 2017 are not statistically different (Figure 20). It is tempting to interpret the aerial photo and sonar map (see Figure 21) as indicating an increase of eelgrass bed density, but scaling of the images are not standardized and many factors could be involved. It may be possible to score the underwater video for plant density, but it is not part of the protocol and would involve extensive method development to be conclusive. It is worth noting that the 2017 underwater video data were collected in August compared to July in 2016. The temperature at this site, like the eelgrass bed area has remained fairly constant near 15° in August (2016 was 15.6°C). This temperature is reported to be stressful to plants.

Observations from visual inspection of the eelgrass bed videos show: (1) sea urchins in the eastern transects (especially 4th transect from left at the deeper end), (2) an abundance of filamentous algae often mixed with the eelgrass that could be confused with seagrass by sonar and (3) more sea stars than remembered in the recent past.

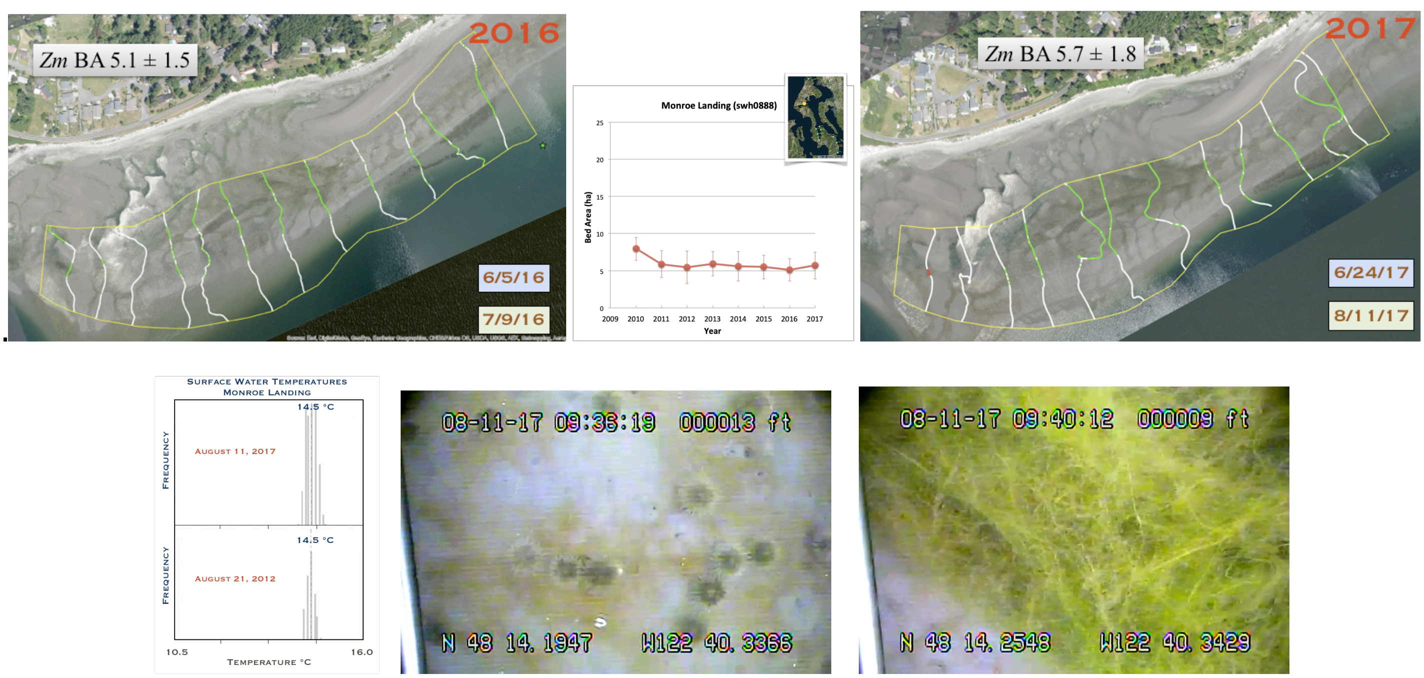

Figure 20. Aerial and Underwater Videography results for East of Monroe Landing (swh0888) in Penn Cove for 2016 and 2017 and historic Bed Area values from 2010.

The 2017 sonar map appears to overestimate the eelgrass bed area when compared 2016 and the 2017 underwater video analysis results (see Figure 21). Some areas of disagreement are obvious in Figure 21 (lower right image), but overall the data patterns match quite well. The effect of the filamentous algae will require further analysis.

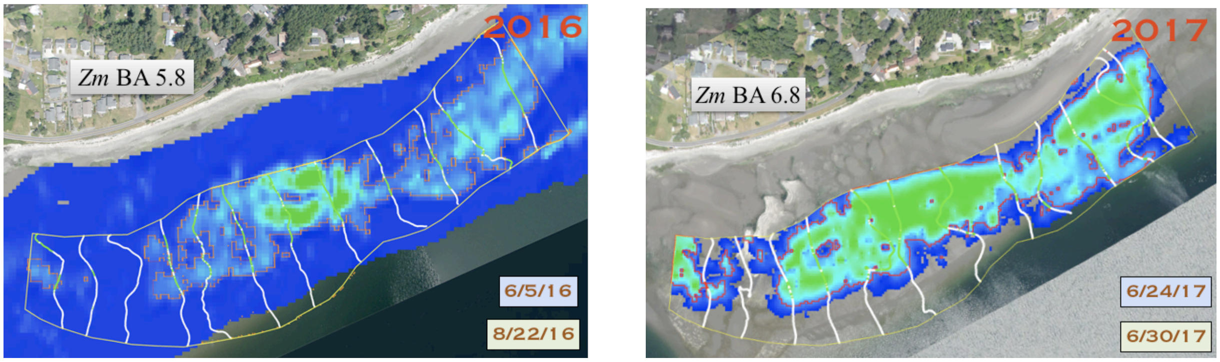

Figure 21. Sonar and Underwater Videography results for East of Monroe Landing (swh0888) in Penn Cove for 2016 and 2017.

Oak Harbor (swh0884)

Windjammer Park near the Oak Harbor marina (swh0884) is of interest because of significant new construction at the park and nearby. We established an area of interest in front of the park within the Oak Harbor site (swh0884) and drew a sampling polygon to survey this portion.

There appears to be very little eelgrass adjacent to the park or within the harbor in general (Figure 22). The eelgrass bed area was a 5.7 ha patch that appears to be connected to a very large bed just outside the harbor (swh0885 sampled in 2013 and 2014). The surface water temperatures ranged from 14.5 °C at the mouth of the harbor (lower left) to 16.5 °C at the interior of the harbor (upper right). Perhaps fresh water runoff, temperature, and boating activity all play a role in the eelgrass distribution.

The sonar map and bed area estimates agree well with the underwater video estimates.

Figure 22. Aerial and Underwater Videography results for Coupeville (swh0898) in Penn Cove for 2016 and 2013.

Freeland Park (swh0932)

Freeland Park is a core site in Holmes Harbor for which we have collected aerial and underwater videography data every year since 2009. The overall bed area remains about 15 hectares (see Figure 23) with small patches on *Zjaponica* in the shallows and a sea urchin bed near the east end (right side of photos – see 2014 report for more detail). Sonar results agree well with underwater videography.

On June 4th, 2014 we attempted to record underwater video data, but encountered issues with the electric trolling motor. We returned on July 3rd and successfully collected the data. This gave us our only opportunity to compare two sets of temperature data at the same site. Between June 4th and July 3rd the surface water temperature rose roughly 3.5°C. All of our recorded temperatures at Freeland Park are above 15 °C after 2013 regardless of when we sampled.

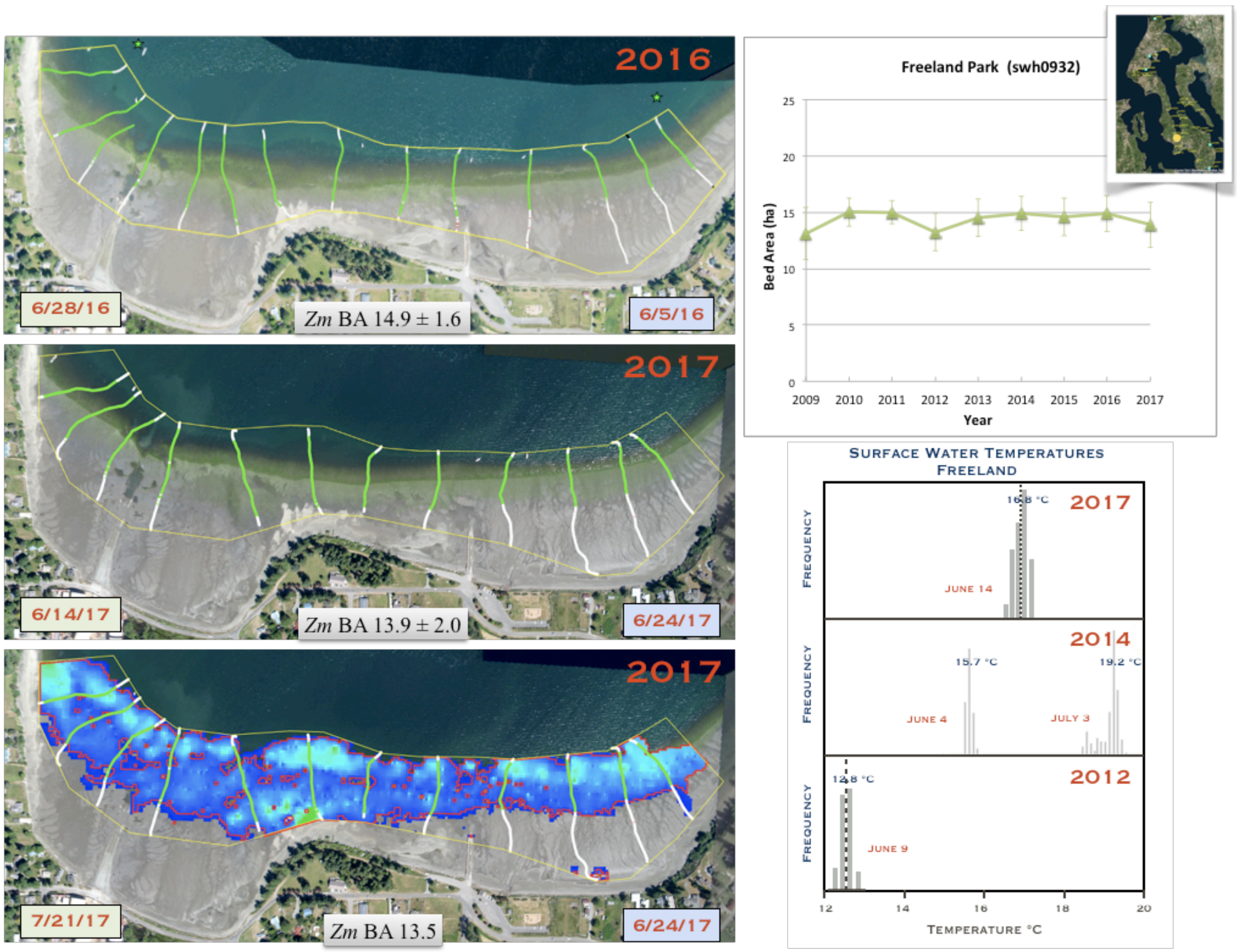

Figure 23. Aerial, Underwater Videography and Sonar results for Freeland Park (swh0932) in Holmes Harbor for 2015 and 2016 and historic Bed Area values from 2009.

South Summerhill Drive (swh0963)

The South Summerhill Drive site (swh0963) eelgrass assessment is of interest to Whidbey Camano Land Trust because a bulkhead was removed recently from the Waterman Land Trust Preserve (see Figure 24). Our methods are designed to measure changes at the scale of the 1000 meter site boundaries, so it is not surprising the much smaller bulkhead removal did not change our eelgrass bed area estimates to any significance. The removal was expected to cause feeder bluff mobilization and perhaps the transects in front of the bulkhead area show some change. The mean surface water temperature in 2015 was 16.5°C and in only 15°C in 2017.

The sonar map agrees well with the underwater video except on a steep slope (outer edge)

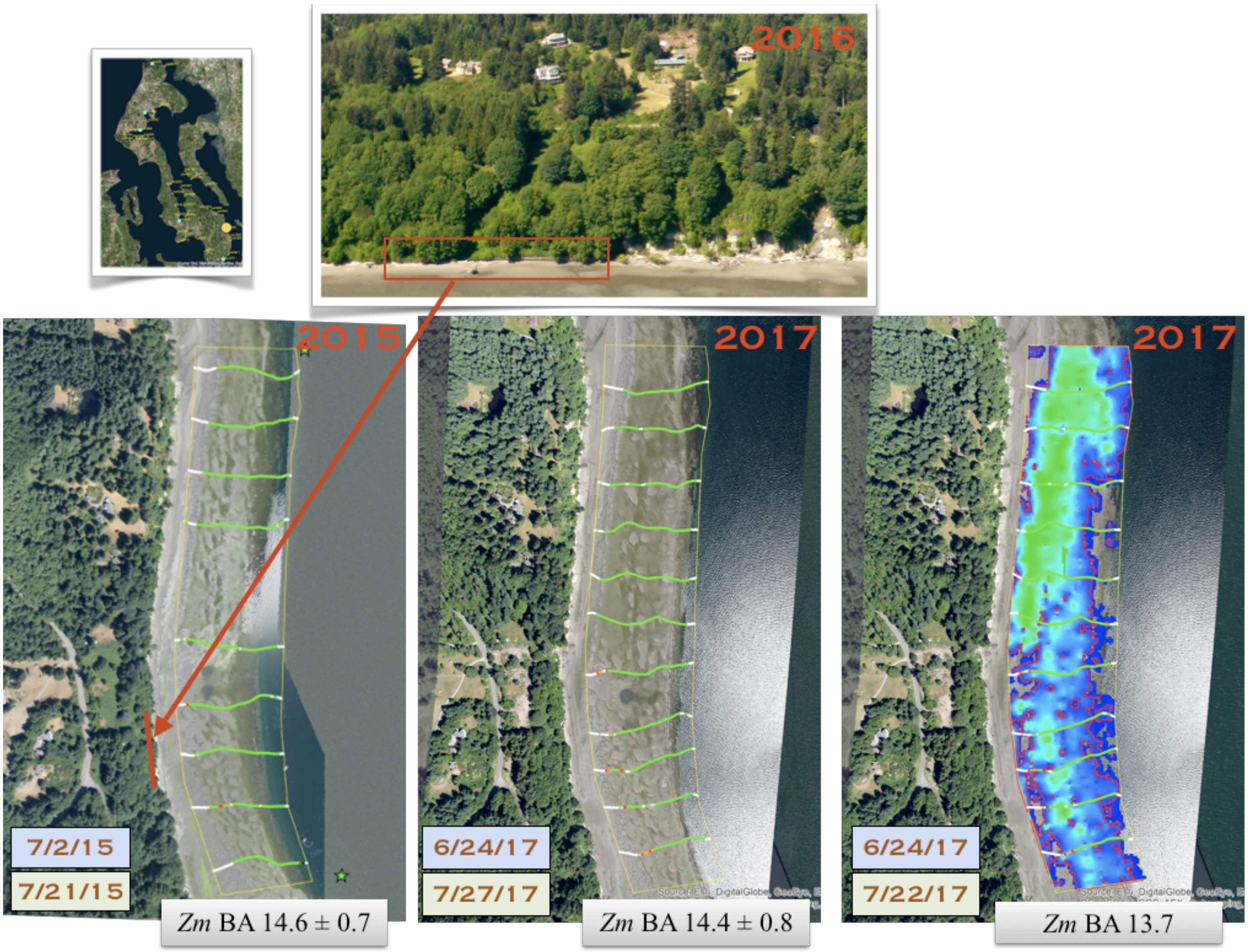

Figure 24. Eelgrass bed maps and area measurements by underwater video and sonar.

Possession Park (swh0973)

In late June we became aware there was a site on South Whidbey where eelgrass wasting disease had been identified with significant severity and prevalence (Figure 25 upper left). However, the exact coordinates of the site were not available to us until August, after our data collection season was completed. In an attempt to guess the site identity, the early 2017 aerial photographs were reviewed and an interesting feature was found (Figure 25 upper right) we believed might be eelgrass wasting disease at Possession Park (swh0973). We had sampled this site in 2011 (Figure 25 center left), but did not collect any video of the suspect area. On July 28th we sampled this site again making sure to collect video across the unusual dark area (Figure 25 lower center). Our results show the site's eelgrass bed area has not changed significantly since 2011, but more importantly, the suspicious dark area was simply kelp (see Figure 25 bottom). The reason we had not sampled this area in 2011 was it was too shallow. It appears that area was probably sluiced from the bluff some time ago. The mean surface temperature in 2011 was 16°C and 15.3 °C in 2017.

Albert also collected sonar data (Figure 25 center right). The sonar boundaries agree well with the underwater video transects except where the kelp is found.

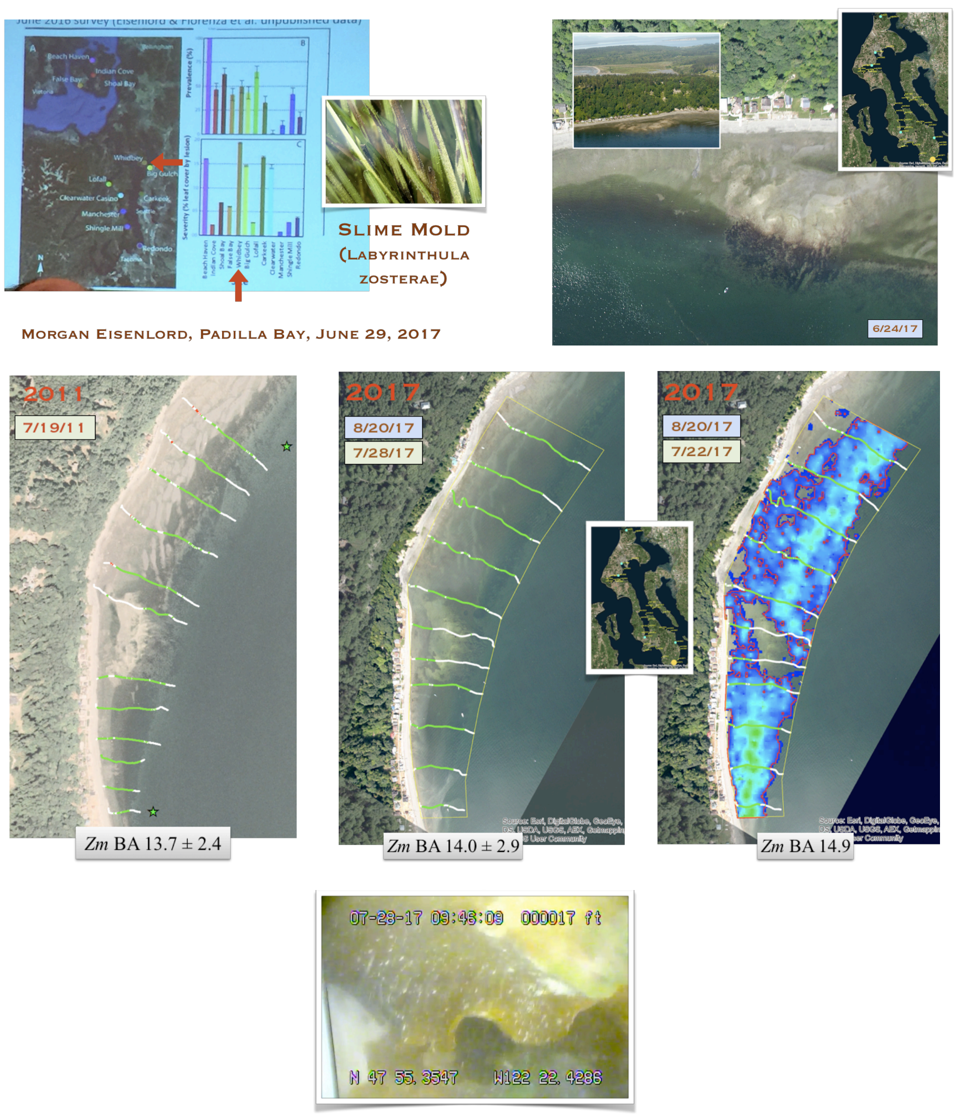

Figure 25. Slide from Eisenlord presentation, suspect area in Possession Park site and results eelgrass bed area results from 2011 and 2017. Only kelp found at suspect area.

Eelgrass Wasting Disease on South Whidbey

In early August Drew Harvell returned to Friday Harbor Labs and provided us with the coordinates of the eelgrass wasting study site; it turned out to be within the Glendale site (swh0971). We had surveyed that site in 2015 and the coordinates of the eelgrass wasting disease area coincided with transect number 4 from our outing (Figure 26). A review the underwater video found a perfectly normal appearing, dense eelgrass bed and only a few examples of what we believed were infected blades of grass. The eelgrass wasting disease team in Friday Harbor could not verify the disease from images, but needed actual blades of grass for DNA analysis. We did not pursue this further.

Apparently, this study site was chosen by Nick Tolmeri (NOAA) for another reason involving paired sites, the other site being near Mukilteo across the Saratoga Passage. The eelgrass wasting team added an effort to study the disease there; no further eelgrass wasting disease studies are planned at this site. We also learned that the disease is everywhere, but it is not known what level of severity and prevalence is required before a reduction in eelgrass bed area is seen. No eelgrass bed area loss was noticeable at this site in our visual assessment compared to surrounding transects or other sites.

Figure 26. Aerial and Underwater Videography results for swh0971 in 2015. Coordinates of eelgrass wasting disease study site (red circle) and snapshot of eelgrass suspected of having eelgrass wasting disease at the study site.

Comparison of Underwater Video and Sonar Eelgrass Bed Area Estimates

For 2017 we were able to complete underwater video analysis and sonar mapping bed area estimates at six sites: flats29, swh0888, swh0932, swh0963 and swh0973. These data points were added to our previous results from 2016. The correlation of bed area estimates between these methods for two years of data is shown in Figure 28.

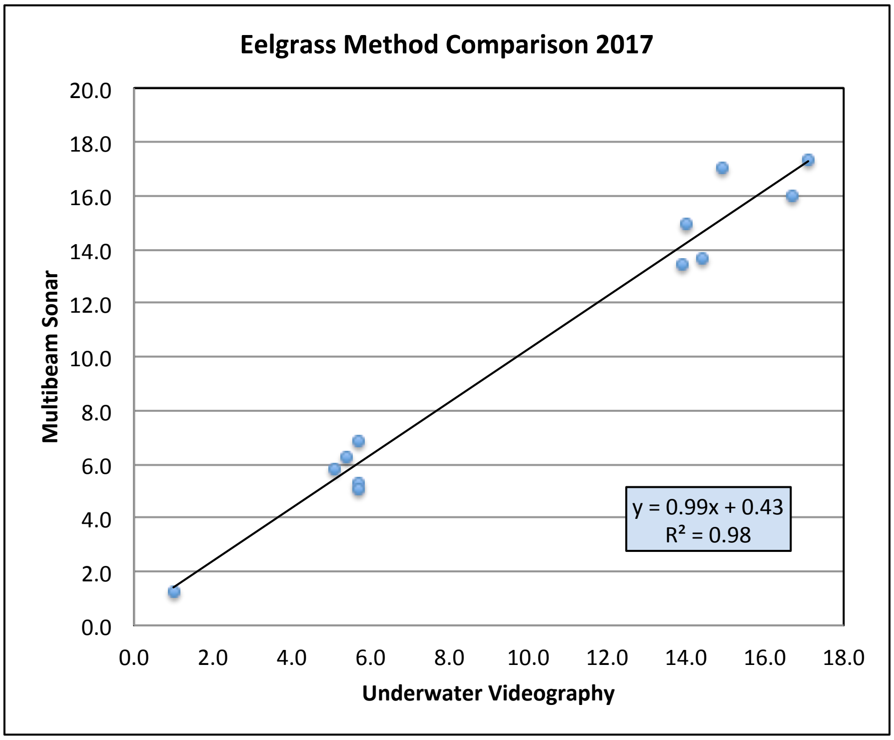

Figure 28. Comparison of Eelgrass Bed Area estimates by underwater video analysis versus sonar mapping in 2016 & 2017.

The graph shows a strong correlation between the two methods. However, our experience also demonstrates some limitations in this sonar method:

1> false positives in very shallow areas. This is often eliminated in our use of a sample polygon (yellow line), but not always.

2> false negatives on steep slopes because sonar results represent the average of an area and not a point.

3> inability to differentiate seagrass from some other submerged vegetation. Spot inspection by underwater camera is required.

4> artifacts of data processing (smoothing creates false impressions)

5> lack of resolution to detect sparse eelgrass density or small features (anchor scour, prop strikes)

6> distortion of sonar signal by wave action on the boat.

We will hopefully add three more data points in 2018. While we do not have any data on reproducibility of measuring the same area repeatedly, the correlation of the two methods (each of which have errors) appears quite good despite the known limitations above. There is work yet to do. The data processing and data reduction methods have not been optimized or described in full detail. Also, we currently have had the benefit of using our underwater video as a check on the accuracy of the sonar method. Going forward that check will have to come from a different underwater video process (spot checking) added to the sonar method.

If the objective of a project is to discover catastrophic changes in eelgrass beds, sonar should provide sufficient evidence with use of a second technique to verify. We have not concluded whether we can substitute sonar for underwater videography in our monitoring project.

Additional Sonar Maps in 2017

In addition to mapping all of the sites measured by underwater video, Albert demonstrated the capacity of sonar mapping (and him!) by including three more sites.

On July 20th Albert mapped the site **South of Pratt's Bluff** (swh0920) near Greenbank on Whidbey Island (see Figure 29c). This was a repeat from 2016 and Albert is working on a new eelgrass bed area analysis method.

A second additional site was **Barnum Point** (see Figure 29a). The Whidbey Camano Land Trust purchased a 37 acre low-bank, waterfront property at Barnum Point with intentions to preserve it as a County Park. There were reports of extensive eelgrass beds, but they had not been mapped. This is a very large, shallow site; too big for us to do by underwater videography. Even the aerial photography was challenging. Albert did map the site by sonar on July 22nd and found vegetation, but upon visual inspection, identified only a filamentous algae (see Figure 20). No further analysis of the map was done.

Albert collected data on a third additional site, **Langley Marina** (swh0957 see Figure 29b) on July 23rd. This site was last analyzed in 2015 by underwater video analysis and is of interest to the Port of South Whidbey. No analysis was done on this map yet. Albert continued collecting data beyond this site to the next two sites, but maps are not yet available.

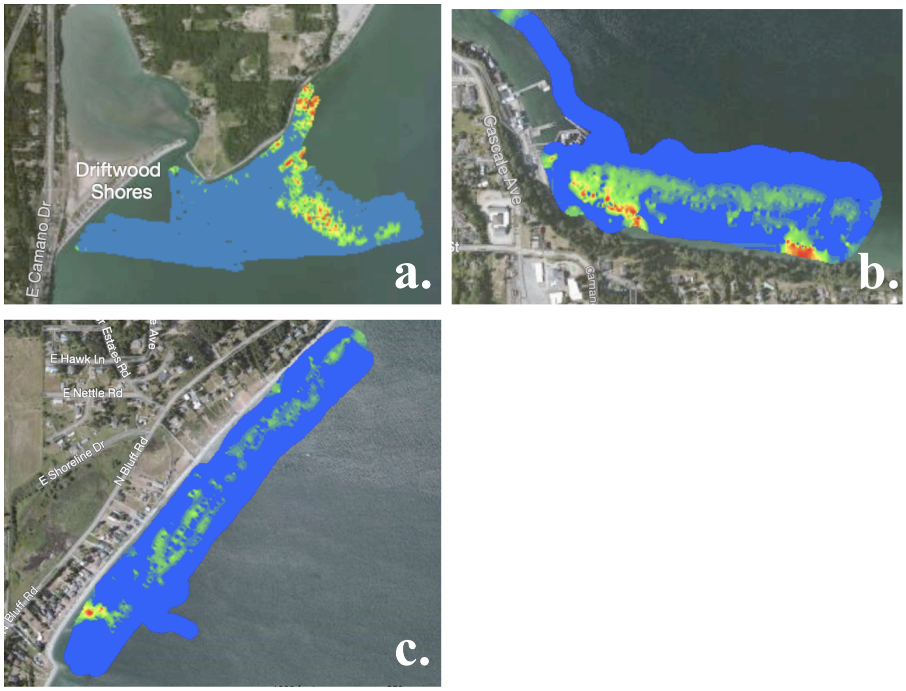

Figure 29. (a) Barnum Point reconnaissance, (b) Langley Marina – swh0957 and (c) S of Pratt's Bluff – swh0920

Conclusions

We have completed the analysis of all the data (aerial, underwater videography and sonar) gathered in 2017. The results were presented to the Island County Marine Resource Committee on April 4th, 2017. This report fulfills our responsibilities for this contract period. From our experience we have reached a number of conclusions about our results and processes:

• We believe the downward trend of eelgrass bed area at Cornet Bay is real. We have yet to prove the loss is from the intertidal regions, but it seems likely. Boating activity physically disturbs the eelgrass beds via anchor scour and propeller strikes but they most likely account for only a small losses. Future improvements at the Park may mitigate some of the problem. Our surface water temperature range would not suggest the eelgrass plants are thermally stressed. However, we have only a snapshot of temperature data; continuous temperature monitoring might be useful. The correlation between NOAA's sea and regional water temperatures and our eelgrass bed area decline is intriguing. Others (Thom 2009) have shown similar trends even larger than this wax and wane due to small changes in light or temperature. Continued monitoring is warranted.

• Surface water temperatures in Saratoga passage are warm enough to cause stress to *Zm* plants. Other methods to study plant density and growth characteristics at various sites would be required to measure this stress. It may be surprising that eelgrass bed area estimates are so stable.

• Measuring eelgrass bed area for 1000-meter sites is a blunt tool to study effects of stressors affecting small areas (bulkhead removals, propeller strikes, anchor scour, small beach modifications, etc.). A different protocol is needed for smaller disturbances.

• Eelgrass wasting disease is present in Island County eelgrass beds. The effect of the disease on eelgrass bed area is not obvious at this time.

• Sonar has great potential and capacity, but also has limitations in precision and accuracy. Data processing by C-Map is expensive ($2,500/year) and proprietary (black box). We have not determined how we will use this method going forward.

Acknowledgements

Our team (Tom Vos, Ken Urstad, Gregg Ridder, Mark Kennedy, Bob Gentz, Albert Foster and Neal Clark) is very appreciative for the help and guidance by Jeff Gaeckle , Lisa Ferrier (WADNR) and Suzanne Shull (NW Straits). We thank the Island County Marine Resource Committee, Kestutis Tautvydas (Project Lead, ICMRC) and Anna Toledo (Progam Manager, ICMRC) for their enthusiastic support for the project. The project, of course, would not have been possible without the funding support provided by the Northwest Straits; Thank You!

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Gregg Ridder

10/8/18