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2014 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 WADNR, that are of interest to ICMRC and WADNR and aligned with our project's goal, (2) to collect underwater video using methods developed by the Washington State Department of Natural Resources (WADNR) and (3) to collect aerial photographs of vegetation at very low tides for entire shoreline in regions of interest. Our measures of success for this project are the completion of data collection and the analysis of the data such that we detect and communicate the current status and biologically significant changes in eelgrass bed areas to the Island County Marine Resource Committee (ICMRC) and the NW Straits Commission.

Over the years we have determined our capacity for underwater videography measurement is about ten sites during the summer months. In 2014 we identified and completed underwater videography for ten sites within Island County. Three selections 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). Four additional sites were chosen with the ICMRC based on changes in human activity within the sites: bulkhead removal at Ala Spit (swh0851), discontinued ghost shrimp harvesting near Langley (swh0954), expansion at Langley Marina (swh0957) and new public access to shoreline at Robinson Park (cps0776). The three remaining sites were chosen with WADNR based on their previous measurements: increased eelgrass bed area trends at Blower's Bluff near Oak Harbor (swh0885), West Langley (swh0955) and Camp Diana West on Camano Island (swh1574). Aerial photography was completed all the sites above and many more constituting a survey of IC shoreline.

Results this year show our three core sites (flats29, swh0888 and swh0932) appear to have stable eelgrass bed areas compared to previous years, but may have some noteworthy changes within the sites. Due to strong currents we were unable to navigate the transects and measure the eelgrass bed area for Ala Spit (swh0851), but we did, for the first time, identify areas within the aerial photographs that are likely to be *Zm*. Two sites show statistically significant increases in eelgrass bed area compared to past measurements by DNR (swh0885 and swh0955). Two sites (swh0957 and swh1574) show slight trends of increasing eelgrass bed areas. Measurements and aerial images of last two sites (swh0954 and cps0776) will provide a baseline for future comparisons.

Methods

Underwater Videography

A complete description of our underwater videography method has been defined in the attached document: "Underwater Videography Manual v1_4.doc". Briefly, our method is modeled after techniques developed by WADNR (Jeff Gaeckle) 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:

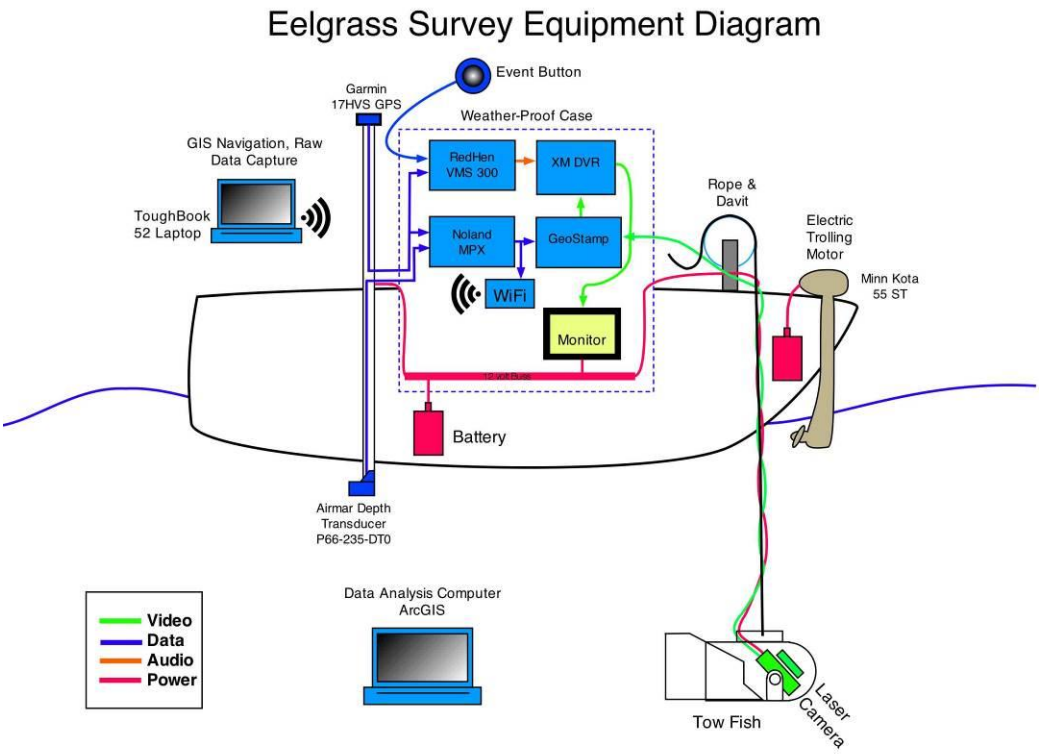


Figure 1. Equipment diagram for Beachwatcher's underwater video data collection.

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 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 analyzed by DNR 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 using ArcGIS 10 to a county map 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.

Mapping of Aerial and Underwater Videography Results

The Video Analysis spreadsheet files were imported into ArcGIS 10 and mapped onto aerial images that were geo-referenced to each site's basemap (usually Google Earth). 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 too difficult to determine from the video. A yellow line represents the sampling polygon used to calculate eelgrass bed areas. 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.

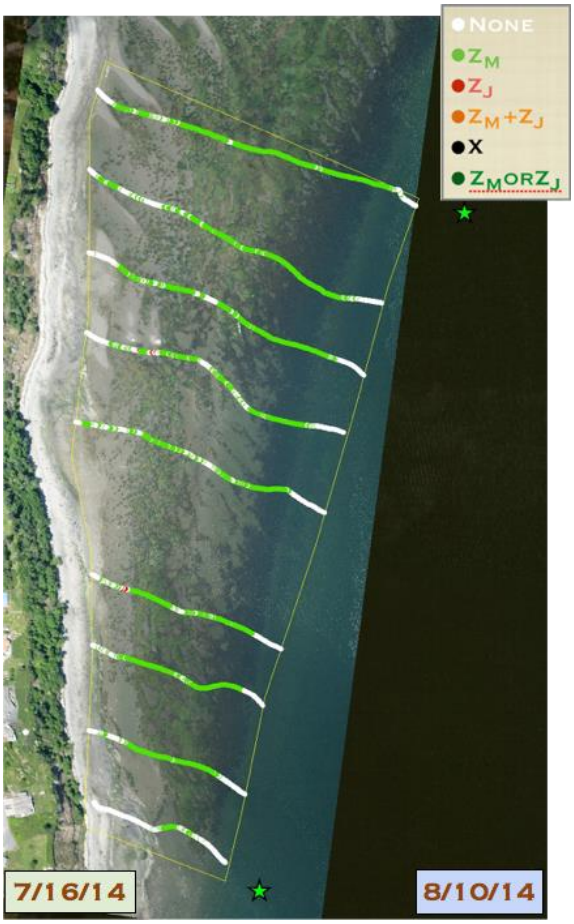


Figure 7. Example of mapping aerial photograph and underwater videography results

2014 Data Acquisition

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 to understand related changes in selected eelgrass bed areas over shorter periods of time (3-5 years).

We have three sites, Cornet Bay (flats29), Monroe Landing (swh0888) and Freeland Park (swh0932) we repeat every year so we can study year-to-year changes in areas of high human activity. Cornet Bay has shown continuing damage to eelgrass beds from boating activity and is an interesting study of bulkhead removal at the park. Monroe landing (swh0888), at the mouth of Penn Cove, is being studied because it is the boundary between good eelgrass growth outside the cove and nearly absent eelgrass growth inside Penn Cove. Freeland Park (swh0932) in Holmes Harbor was the site of damage to eelgrass beds by Nichols Brothers at the boat launching ramp, significant loss of eelgrass beds by a large storm event and frequent boat launches at the park.

On a three year cycle time we repeat other sites in Holmes Harbor and South Whidbey. We also sample individual sites associated with planned disruptions to the shoreline – in 2014 Robinson Park (cps0776), Langley Marina (swh0957), Ala Spit (swh0854) and a former shrimping site (swh0954). We usually try to pick one site from Camano Island and coordinate with WADNR sampling activities and needs (swh0885, swh0955 and swh1574).

Each year we consult with the IC MRC and WADNR before final selection. We also review our aerial photographs and results from previous years to develop the list of sites to study by underwater videography. We would always welcome input from other interested parties. Figure 7 is a map of our entire site list with those sampled by underwater videography in 2014 depicted in large blue dots.

Figure 7. Underwater videography sampling sites studied in 2014 (blue dots) are shown with other sites studied in previous years (yellow 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 the event. (see Appendices: "2014 Quick Report.doc")

The list of crew and sites for 2014 are shown in Table 1. All of our underwater video data collection was completed by August 15th 2014.

Date	Site	Captain	Equipment	Camera **
6/4/14*	swh0932	Ken Urstad	Gregg, Neal,Tom	Bob, Mark
6/18/14	flats29	Ken Urstad	Mark Kennedy	Bob Gentz
6/19/14	Ala Spit	Ken Urstad	Mark Kennedy	
7/3/14	swh0932	Ken Urstad	Gregg Ridder	Bob Gentz
7/16/14	swh0888	Ken Urstad	Tom Vos	Bob Gentz
7/31/14	swh0954	Ken Urstad	Bob Gentz	Kathy Fritts
8/1/14	swh0955	Ken Urstad	Bob Gentz	Kathy Fritts
8/2/14	swh0957	Ken Urstad	Bob Gentz	Finn Gatewood
8/3/14	cps0776	Ken Urstad	Tom Vos	Kathy Fritts
8/4/14	swh1574	Ken Urstad	Tom Vos	
8/15/14	swh0885	Ken Urstad	Gregg Ridder	
* Training run for equipment operators and equipment check				
** Camera operators were trained by equipment operators on the boat				

Table 1. Crew Schedule for 2014 Underwater Videography outings.

Aerial Photography Data Acquisition

Four flights were sufficient to cover all the eelgrass monitoring sites of interest in Island County. The map below (Figure 8 left) shows the track of the flight used to gather aerial photographs of shorelines in 2014. Four additional flights (Figure 8 right) were done to survey kelp beds, the eelgrass beds in the San Juan Islands and two sites for tribal research. Figure 9 shows the location of geo-tagged photos.

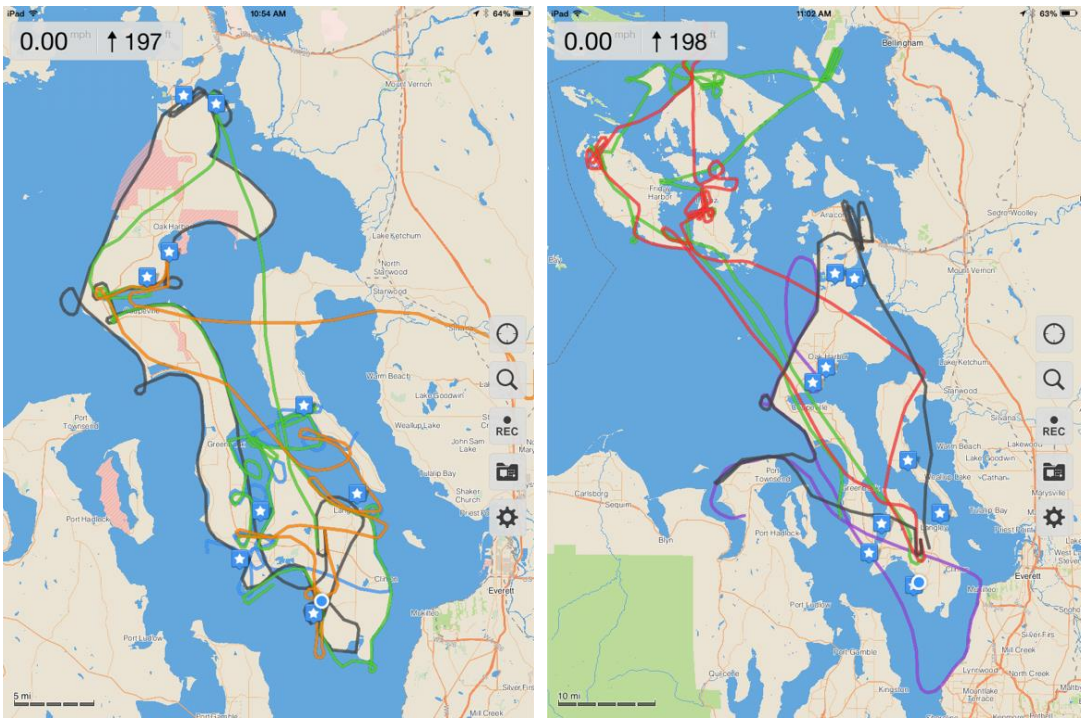


Figure 8. Galileo GPX tracks of some of the aerial eelgrass photography flights in 2014. Stars are points of interest and lines are randomly colored by flight date.

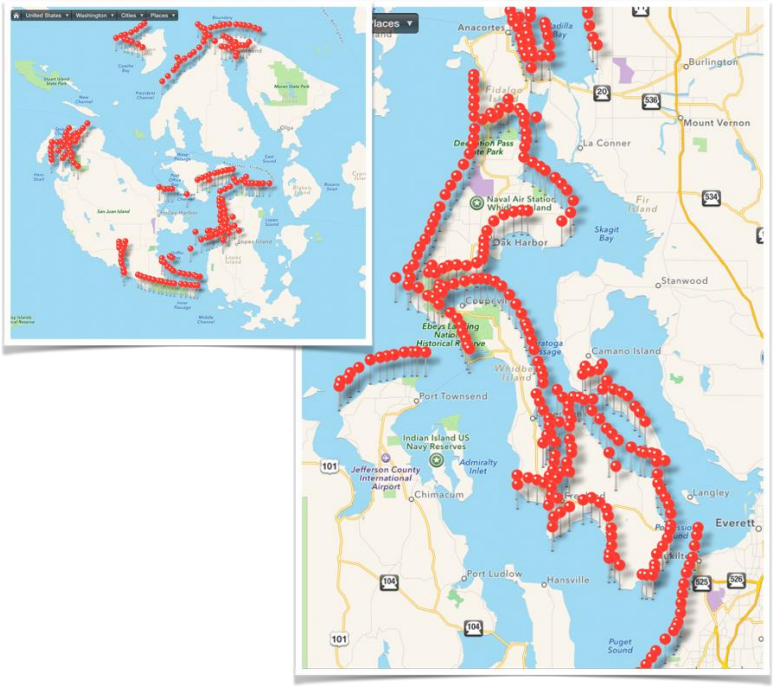


Figure 9. A small representative sampling of the geo-tagged photo positions identified by pins for multiple Counties in Puget Sound.

Data Preparation

By January 13th, 2014, all of the underwater video DVDs (see Appendices: "VideoLog.2014.pdf") and accompanying spreadsheets were prepared and sent to volunteers for video analysis. By March of 2014 the aerial photographs had been geo-tagged, made into panorama images for each of the ten sampling sites and geo-referenced to a base map. The geo-referenced aerial images and available video-analysis of the transects were superimposed on a base map to allow comparison of the two data sets (underwater video and aerial photography) by April.

Video Analysis

Analysis of the underwater video for the presence of eelgrass was completed by volunteers in March, 2015 using the video DVDs and spreadsheets produced in January 2014. The resulting Excel files containing the eelgrass scores for each site are attached (see Appendices: "2014 Video Analysis"). Scoring of the sites' videos was done by the volunteers as listed in Table 2.

Site	Name	Date(s)	Transects	Size (Gb)	Analyst	Complete
flats29	Cornet Bay	061814	11	15.4	Mark Kennedy	2/25/15
swh0851	Ala Spit	061914	1	1.6	Mark Kennedy	2/15/15
swh0885	Blower's Bluff	081514	10	6.1	Gregg Ridder	3/26/15
swh0888	Monroe Landing	071614	10	9.1	Gregg Ridder	3/24/15
swh0932	Freeland Park	060414 & 070314	10	4.9	Gregg Ridder	3/27/15
cps0776	Mutiny Bay Ramp	080314	11	2.9	Neal Clark	3/20/15
swh0954	N of Brooks Hill, Langley	073114	10	5.5	Gregg Ridder	3/24/15
swh0955	West Langley	080114	11	4.6	Gregg Ridder	3/24/15
swh0957	Langley Marina	080214	12	4.3	Gregg Ridder	3/27/15
swh1574	Camp Diana	080414	10	11.0	Neal Clark	5/4/15
Totals			96	65.4		
All data stored on LaCie/2014 and backup on Gregg's Synology NAS Drive						

Table 2. Schedule of Video Analysis Volunteers

Eelgrass Bed Area Estimates

The Video Analysis Files for 2013 were reformatted to DNR specifications by Neal Clark and submitted to Lisa Ferrier (DNR). Lisa has now provided the estimates of eelgrass bed areas using our data from 2010 to 2013 with their latest analysis programs. For 2014, we have done our own calculations of eelgrass bed areas by our own method (described and compared to DNR in the 2012 final report). The results of all the eelgrass bed area estimates over the last five years are presented in the Table 3. The results are grouped by site (colored by site to make comparisons over the years easier). The results for 2014 are highlighted in grey.

Results

A summary of *Zm* eelgrass bed area results (in hectares) is shown in Table 3.

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
cps0776	Mutiny Bay Boat Ramp, SW Whidbey	03-Aug-14	11	7.1	±	1.2
flats29	Cornet Bay, Whidbey*	27-Aug-09	7	20.6	±	5.3
flats29	Cornet Bay, Whidbey	03-Aug-10	10	16.2	±	3.8
flats29	Cornet Bay, Whidbey	09-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
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
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	06-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
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	02-Jul-10	12	1.0	±	0.6
swh0898	W of Lovejoy Point, Coupeville	13-Jul-13	11	1.2	±	0.7
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
swh0923	N of Dines Pt North, Whidbey	09-Aug-12	10	3.6	±	0.8
swh0927	Honeymoon Bay, Whidbey*	17-Aug-09	14	10.9	±	1.0
swh0927	Honeymoon Bay, Whidbey	07-Jul-12	12	10.2	±	1.1
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	07-Jun-11	11	15.0	±	1.0
swh0932	Freeland Park, Whidbey	09-Jun-12	10	13.2	±	1.6
swh0932	Freeland Park, Whidbey	31-May-13	13	14.5	±	1.7
swh0932	Freeland Park, Whidbey*	03-Jul-14	11	14.9	±	1.5
swh0934	NW of Lone Lake, Whidbey*	18-Jun-09	18	4.9	±	0.5
swh0934	NW of Lone Lake, Whidbey	06-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	07-Aug-12	12	9.1	±	0.6
swh0940	East of Dine's Point, Whidbey*	04-Jun-09	10	6.8	±	1.5
swh0940	East of Dine's Point, Whidbey	10-Aug-12	11	8.3	±	1.1
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
swh0954	N of Brooks Hill Rd, SE Whidbey*	31-Jul-14	10	20.6	±	1.8
swh0955	West Langley, SE Whidbey*	01-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*	02-Aug-14	12	11.0	±	1.4
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
swh0973	Possession, SE Whidbey	19-Jul-11	12	13.7	±	2.4
swh1565	Cama Beach, Camano Island	08-Aug-12	12	3.6	±	1.0
swh1570	Elger Bay, South Camano	26-Jul-13	11	18.2	±	2.1
swh1574	Camp Diana West, South Camano*	04-Aug-14	10	17.1	±	2.3
	* Zm Area calculated by Eelgrass Team, not DNR		1 ha = 2.47 Acres			

Table 3. Eelgrass Bed Areas by Site for the period from 2009 to 2014 (2009 and 2014 results were calculated by method developed by G. Ridder; 2010 to 2013 results were calculated by DNR from videography data we submitted to them). The 2014 data are highlighted.

In order to take a long term view of eelgrass bed area measurements, past results from WADNR were compiled along with our results for sites we have both sampled by underwater videography over the years (see Table 4).

		DNR		Team	
Year	Site	Bed Area	95%CI	Bed Area	95%CI
2006	swh0885	11.9	0.5		
2011	swh0885	13.6	1.1		
2013	swh0885	17.5	0.7	18	1.7
2014	swh0885			20.9	3.9
2003	swh0940	7.3	0.3		
2004	swh0940	7.1	0.4		
2005	swh0940	8.1	0.3		
2006	swh0940	7.9	0.4		
2007	swh0940	7.8	0.3		
2009	swh0940			6.8	1.5
2012	swh0940			8.3	1.1
2001	swh0943	18.5	0.8		
2002	swh0943	18.2	0.6		
2003	swh0943	17.8	0.3		
2004	swh0943	18.4	0.5		
2005	swh0943	19.2	0.4		
2009	swh0943			17.7	2
2012	swh0943			18	1.3
2005	swh0955	6.1	0.3		
2006	swh0955	7.4	0.2		
2007	swh0955	7.7	0.2		
2008	swh0955	8.2	0.4		
2009	swh0955	9.6	0.4		
2011	swh0955	12.7	0.5		
2014	swh0955			14.7	1.5
2006	swh0973	14.4	1.1		
2007	swh0973	12.4	0.9		
2008	swh0973	13.4	1.5		
2009	swh0973	12.6	1.2		
2010	swh0973	14.5	1.0		
2011	swh0973			13.7	2.4
2012	swh1574	15.7	1.6		
2013	swh1574	16.9	0.6		
2014	swh1574			17.1	2.3
Calculated by ICMRC Team					

Table 4. Eelgrass Bed Areas for sites where both WADNR and the ICMRC eelgrass team have measured over multiple years.

Results and Discussion by Site

The following pages contain the maps and discussion of results for each site sampled by underwater videography in 2014 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 bed 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.

The overall eelgrass bed area for 2014 (19.3 ± 3.6 ha) remained consistent with previous years at around 20 ha (see Figure 10). The overall pattern of eelgrass bed coverage also remained consistent with previous years (see Figure 11 left panel). The presence of propeller scars and anchor scouring are seen in the higher resolution 2014 aerial image as in all previous years. (see Figure 11 right panel)

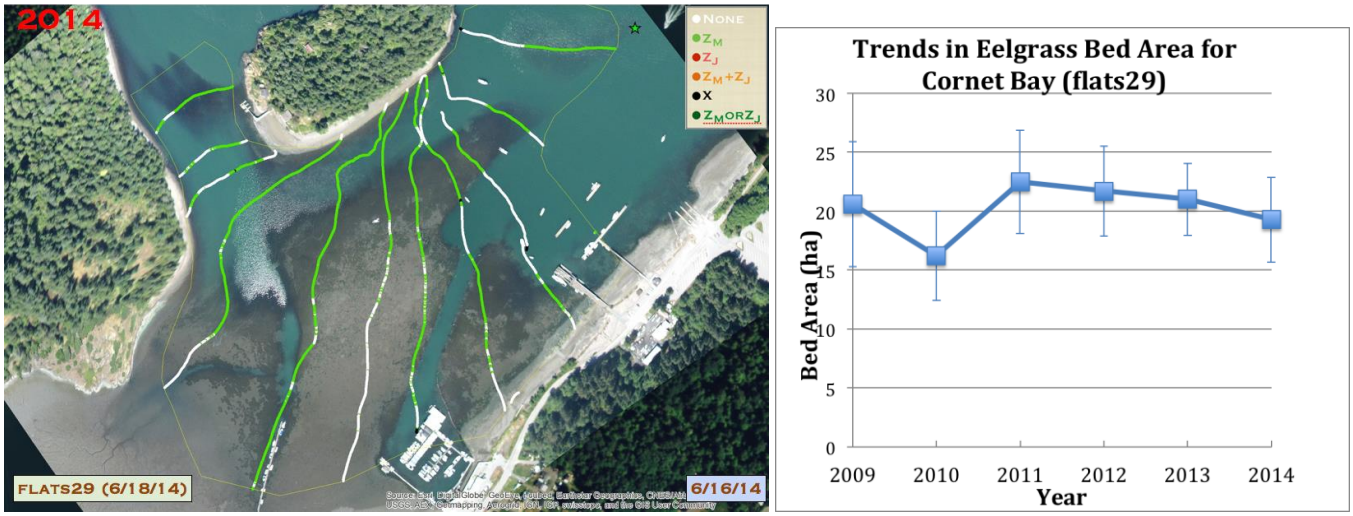


Figure 10. Aerial and Underwater Videography results for Cornet Bay in 2014.

Figure 11. 2013 Aerial and cumulative 2009-2013 (left) and Aerial photo of anchor scour and propeller scars.

Comparison of aerial photos taken in the summers of 2011 and 2013 (see Figure 12) suggested some loss of green vegetation near the construction site in 2012 (see yellow boxes). Since no underwater videography existed for this specific area, it was difficult to know the identity of the vegetation. In 2014, a reconnaissance run was completed near the waterline to inspect this area (see last panel of Figure 12). No eelgrass was found in the affected area.

Figure 12. A closer look at the construction site at Cornet Bay before and after bulkhead removal in 2012. Recovery of green vegetation does not appear to be *Zm* or *Zj* (last panel).

At this time, the construction appears to have had little effect on the eelgrass beds in Cornet Bay. However, every year we have documented the detrimental effects (anchor scour and propeller scars) of boating activity in the bay. Perhaps the approach of the "Voluntary Anchor-Out Project" in Port Townsend might be suitable to reduce the damage (personal communication with Caroline Gibson, NW Straits).

Ala Spit, Whidbey Island (swh0851)

Ala Spit is under study for the effect rip-rap removal in 2011 and a planned rock groin and concrete bulkhead removal in the future (http://www.islandcountyeh.org/uploads/Ala%20Spit-Feasibility-FINALwFigs.pdf). Measurement of eelgrass bed area below the spit was attempted in 2014, but because of rapid currents, we were not be able to follow transect lines perpendicular to the beach. A reconnaissance survey was conducted allowing us to identify potential eelgrass beds in the aerial photo (see Figure 13).

Figure 13. Aerial Image of Ala Spit for 2013 and results for 2014

A comparison of the photos might suggest an increase in the eelgrass bed area in 2014. However, it might also suggest increased turbidity of the water in 2013. Without underwater videography from 2013, the data is inconclusive.

Blower's Bluff, Oak Harbor (swh0885)

Blower's Bluff was added to our site selection list for 2013 and 2014 from consultation with WADNR. Our results for 2014 are shown in Figure 14 along with a graph of all known analyses of this site by WADNR and our data (ICMRC). The cumulative results show a statistically significant increase of eelgrass bed area from 2006. The results also show no significant difference in the bed area measurement and analysis between WADNR and ICMRC for 2013. To our knowledge, no cause has been proposed for the increase.

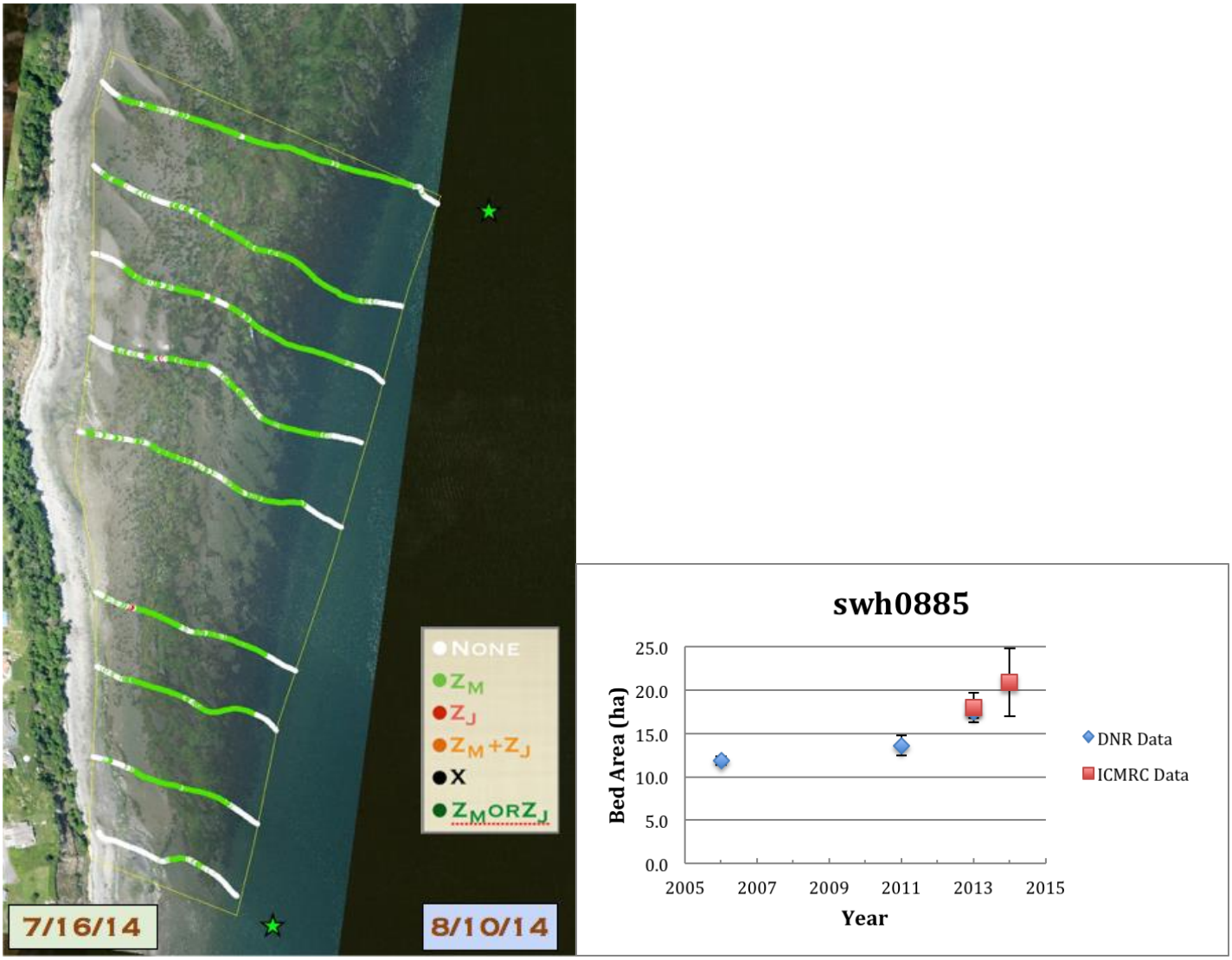


Figure 14. Aerial and Underwater Videography results for Blower's Bluff (swh0885) in 2014 along with graph of all known Bed Area analyses for this site.

East of Monroe Landing, Penn Cove (swh0888)

The site East of Monroe Landing on Penn Cove (swh0888) shows some visible change in *Zm* eelgrass bed area between 2010 and 2014 (see Figure 15.). While eelgrass bed area differences are not statistically significant, there is a clear loss of eelgrass bed area on the west (left side of photos) side of the site between 2014 and 2010 and an increase in eelgrass bed area on the east (right side of the photos) side of the site.

The loss of eelgrass on the left is clear in the underwater video frames from nearly identical places from 2014 and 2010 (see Figure 16). We have also observed a correlation between the appearance of green sea urchins and the loss of eelgrass. Whether there is causation by sea urchin grazing on eelgrass is not known, but there is some precedent in Alaska (NOAA Technical Memoradum NMFS-SFSC-240, P.M Harris). Whether the sea urchin population has increased due to the latest sea star decline has also been studied with inconclusive results (see http://urbanmarineecology.org/urchin-take-over/). For now we just have an interesting observation.

Figure 15. Aerial and Underwater Videography results for East of Monroe Landing (swh0888) in Penn Cove for 2014 and 2010. The numbered red dots in 2010 are random transect and the red boundary in 2010 defines the entire site, not the sampling area (yellow boundary in 2014).

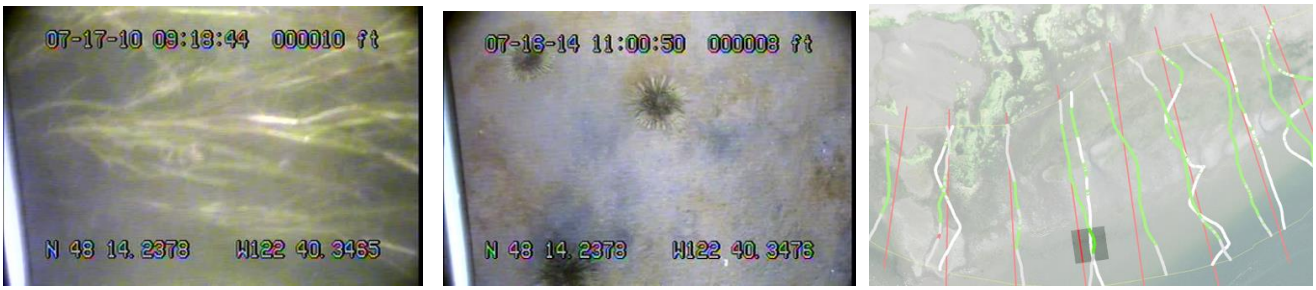
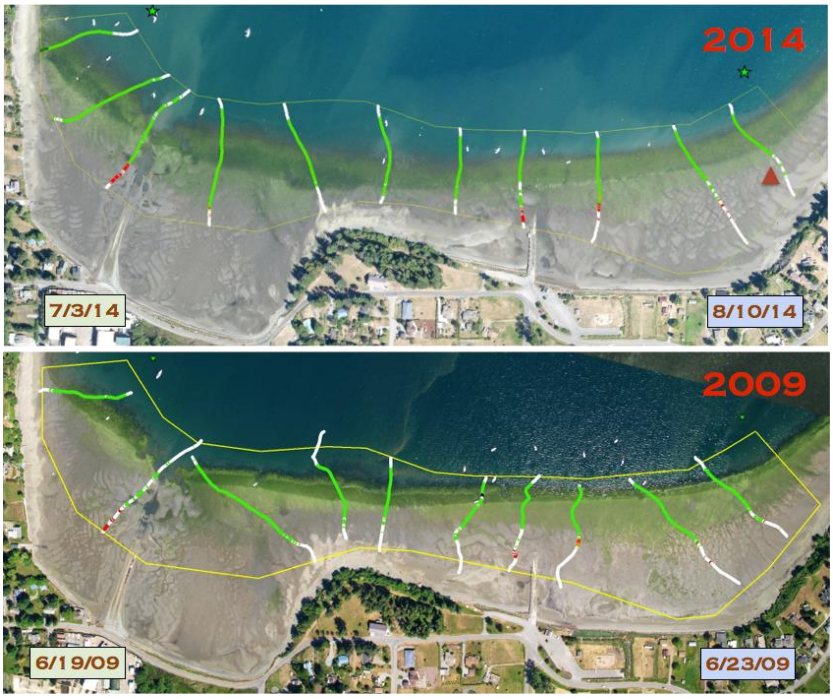


Figure 16. Underwater video frames from 2010 and 2014 for same position (dark box in last map).

Freeland Park, Holmes Harbor (swh0932)

Freeland Park is a core site in Holmes Harbor for which we have collected aerial and underwater videography data every year since 2009. So far no statistically significant changes have been observed (see Figure 17). However, the small area near the deep end of the Nichol's Brothers boat ramp (left side of photo) appears to have recovered eelgrass growth since a dredging incident in 2008.

Over the years we have consistently noted a small bed of sand dollars associated with sparse eelgrass growth on the eastern side of the site (red triangle on right side of 2014 photo in Figure 17 and photo in Figure 18). Amy Henry (graduate student at University of Chicago studying sand dollars in Orcas Island) is studying the relationship between sand dollars and eelgrass growth. Apparently there as a natural competition where sand dollars disrupt the seabed making it difficult for eelgrass to grow and where thick eelgrass growth can crowd out sand dollars. Human activity (e.g. digging for clams) might change the balance, but it does not suggest this observation is any cause for alarm.



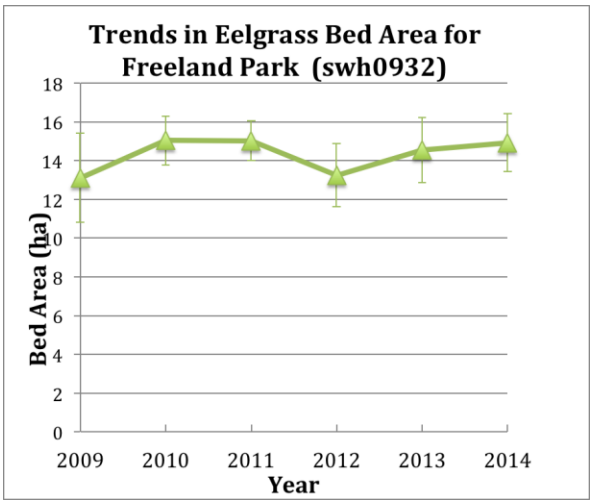


Figure 17. Aerial and Underwater Videography results for Freeland Park (swh0932) in Holmes Harbor for 2013 (top) and 2009 (bottom).

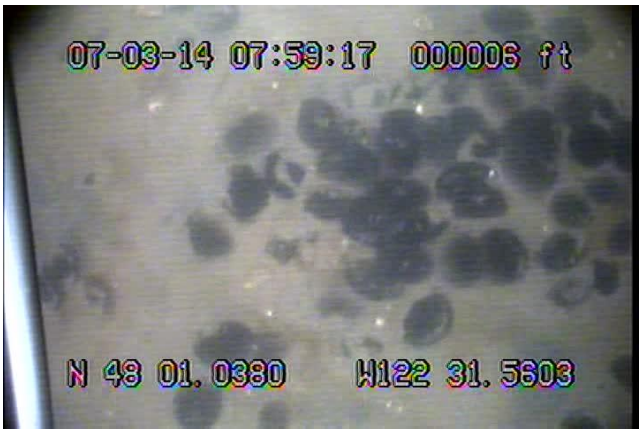


Figure 18. Sand dollar bed on the eastern side of site swh0932

Saratoga Road near Langley (swh0954)

Substantial erosion of what appeared to be a large eelgrass bed was suggested during an aerial survey of the shoreline west of Langley in 2011 (see Figure 19 – left photo). The suggestion by local experts was that this was probably due to collection of ghost shrimp by commercial shrimpers. A more recent photo in June 23rd, 2013 (see Figure 19 - right) showed significant increase in eelgrass bed area. This site was sampled by underwater video for eelgrass in 2014 and the results are shown in Figure 20. The site indeed contains a large *Zm* bed of over 20 ha (see Table 3), but its history and the cause of the increased bed area is not clear.

Figure 19. Aerial Images of swh0954 in 2011 and 2013

Figure 20. Results of Underwater Video and Aerial Photography of swh0954 in 2014

West Langley (swh0955)

This site just west of downtown Langley (swh0955) has been identified by WADNR as having increased eelgrass bed area. We measured this site in 2014 to compare directly with WADNR measurements (see Figure 21 - WADNR results for 2014 are not yet known), but it appears the site continues to increase in *Zm* bed area. As with the neighboring site (swh0954) the eelgrass increase could be associated with ghost shrimp harvesting, but the sites history of shrimping activity and cause of increase is not clear at this time. The site definitely has a history of whale feeding pits that reduce the ghost shrimp population in the shallows seen in aerial photos of both 2011 and 2012 (see Figure 22). No feeding pits were observed in aerial photos of either 2013 or 2014.

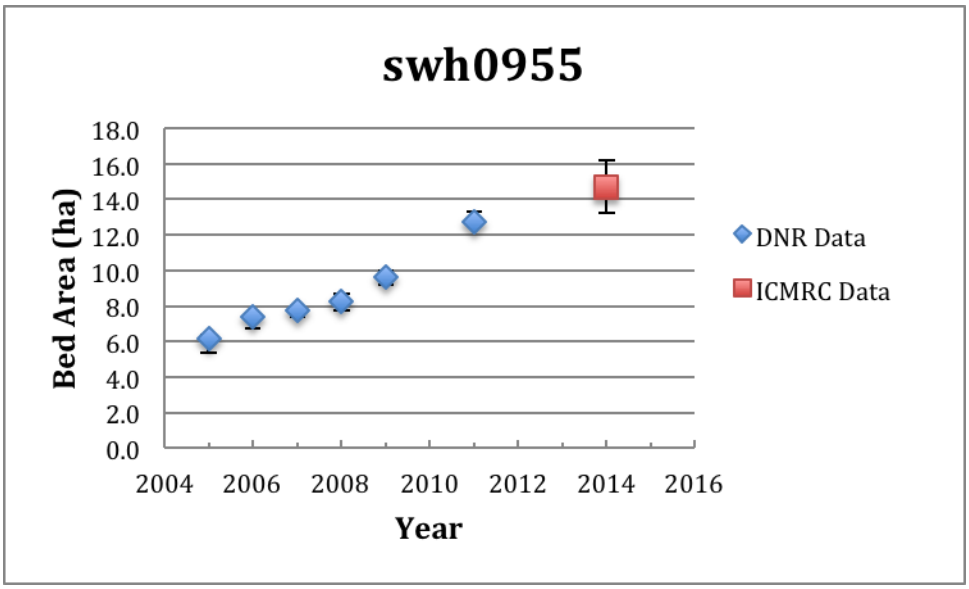


Figure 21. Underwater and Aerial results for 2014 of site west of downtown Langley (swh0955). Graph show clear increase in bed area over the last decade.

Figure 22. Aerial photo of whale feeding pits in the shallows of site swh0955 in April of 2012

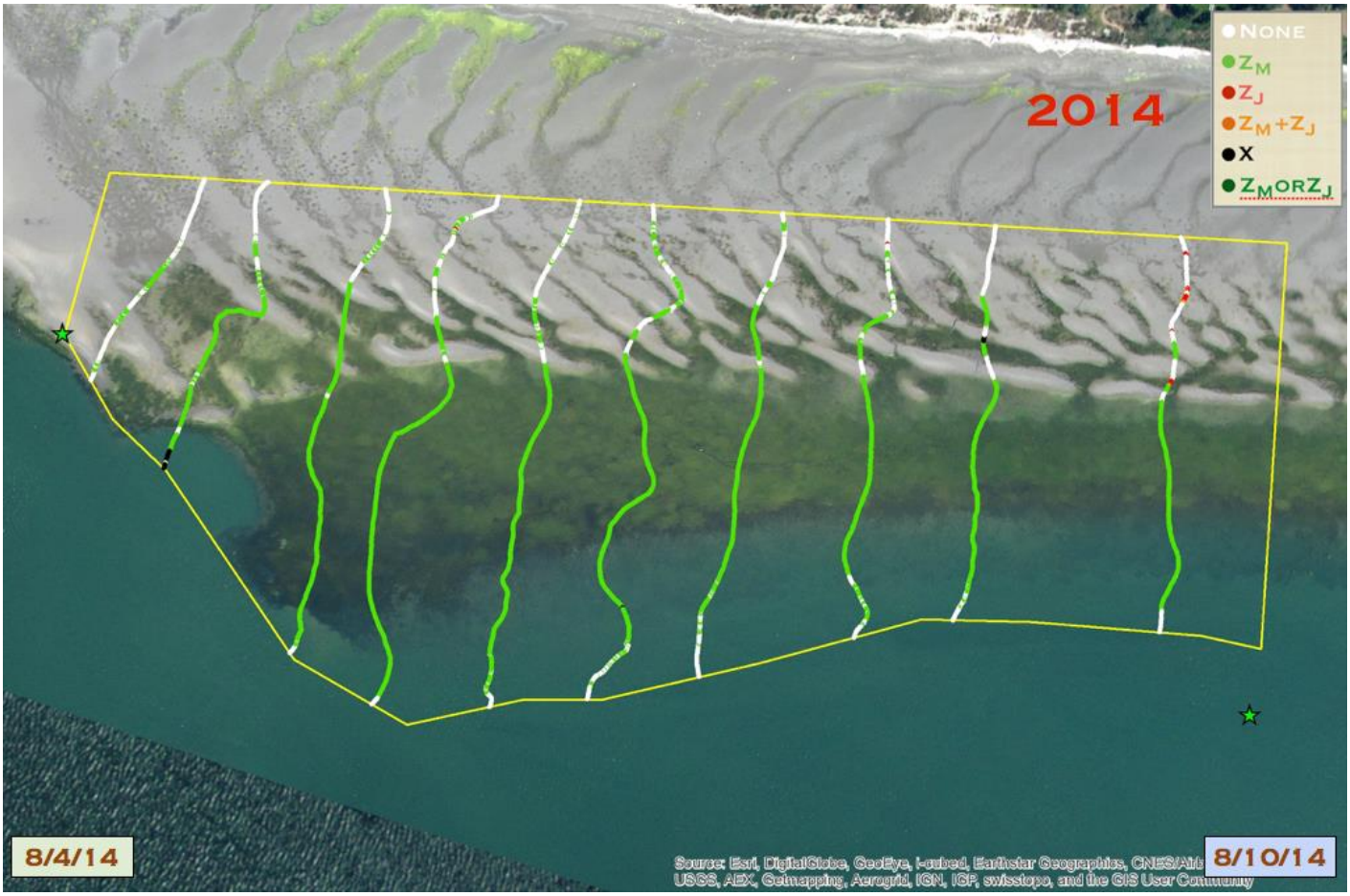
Port of South Whidbey, Langley Marina (swh0957)

Langley Marina has undergone a significant amount of dock reconstruction during the last few years. Our first measurement of the eelgrass bed area at this site was in 2011 where we found 9.1±1.5 hectares. In 2014 we returned to find the Zm bed area measure 11.0±1.4 hectares (see Figure 23). While this increase may not be statistically significant, the aerial photos and transect lines appear to include more area. It should also be noted that the 2011 underwater videography measurement and aerial photograph were taken earlier in the eelgrass growing season.

Figure 23. Results for Langley Marina (swh0957) from 2011 and 2014.

Camp Diana, Camano (swh1574)

This site on Camano Island was chosen because previous measurement by WADNR suggested an increase in eelgrass bed area. This year our first underwater videography results of this site shows a very slight trend compared with WADNR past results. This is a very large bed area measuring 17.1 ha.



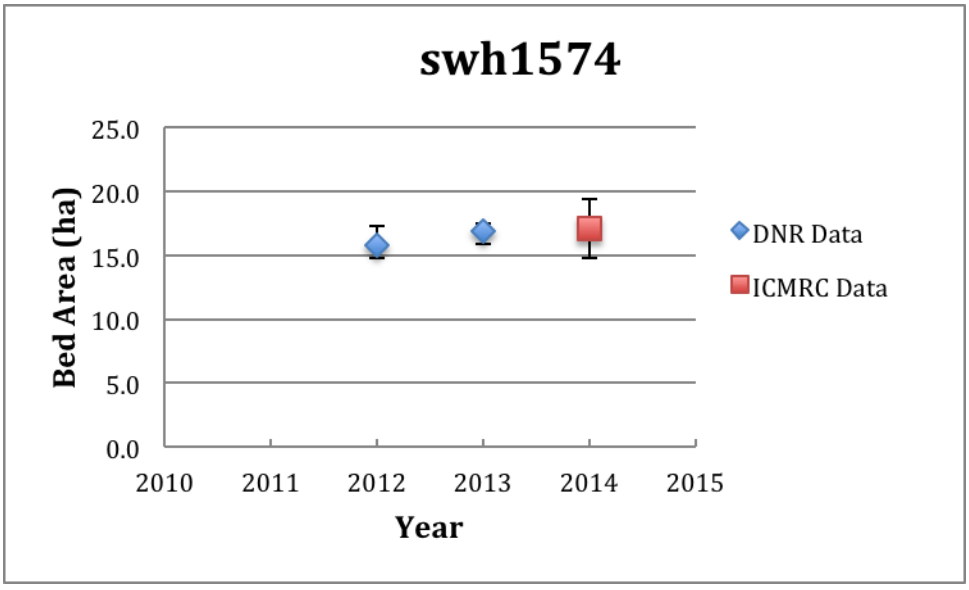


Figure 24. Aerial and Underwater Videography results for Camp Diana on South Camano Island (swh1574) for 2014.

Mutiny Bay Boat Ramp (cps0776)

This site on the west side of Whidbey Island is the site of a newly donated park (Robinson Park) and boat ramp (just to the right of Figure 25). From the aerial photograph, the pattern of growth appeared slightly different from most *Zostera marina* eelgrass beds. However, no differences in plant appearance were noted during the underwater video collection or analysis. Plant samples were taken from the beach at low tide (see Figure 26) provided evidence that the sea grass is *Phyllospadix* and not *Zostera marina*. This would be consistent with more wave action on the west side and the experience of WADNR (Jeff Gaeckle, personal communication).

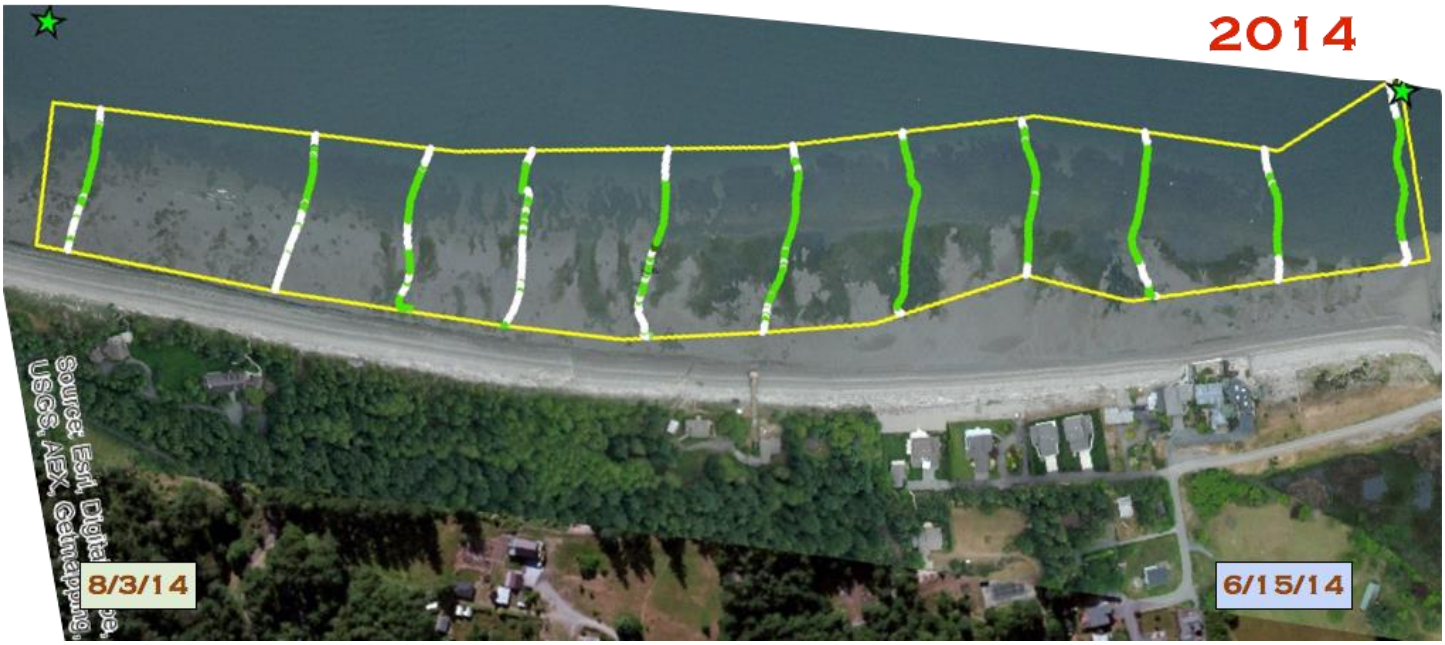


Figure 25. The 2014 results from Robinson Park (cps0776) on the west side of Whidbey Island.

Figure 26. Photograph of eelgrass sample taken at low tide from site cps0776 (labeled Phyllospadix). Samples of *Zm* and *Zj* collected elsewhere are shown for comparison.

Aerial Surveys of Other Regions in Puget Sound:

Kelp Beds

A team of citizen scientists lead by Caroline Gibson, Leal Dickson and Linda Rhodes has interest in measuring bull-kelp beds using kayaks and a method established in Island County by intern Emily Bishop. Aerial photographs of entire coastlines were acquired at a low tide and geo-referenced to a base map to test the value of the photos to help select sites for kayak studies. Below are two examples from Island and Jefferson County (see Figures 27 & 28). The Mukilteo to Edmonds Ferry Dock sequence is not shown. This effort will continue in 2015 and be reported elsewhere.

Kelp on West Beach, Whidbey Island, Island County

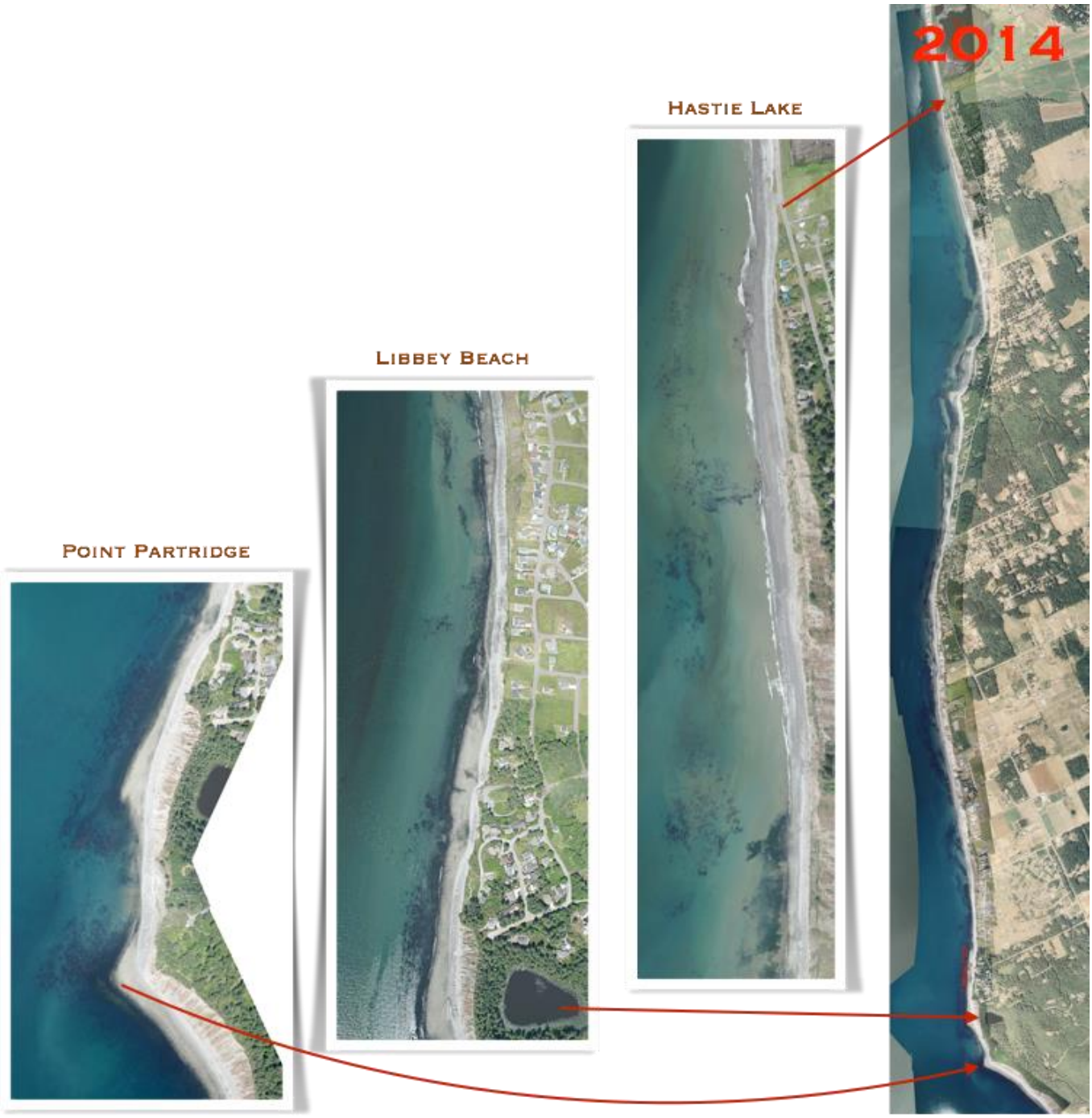


Figure 27. Selected areas of West Beach (right panel) were chosen to investigate bull-kelp bed growth.

Kelp on North Beach, Jefferson County

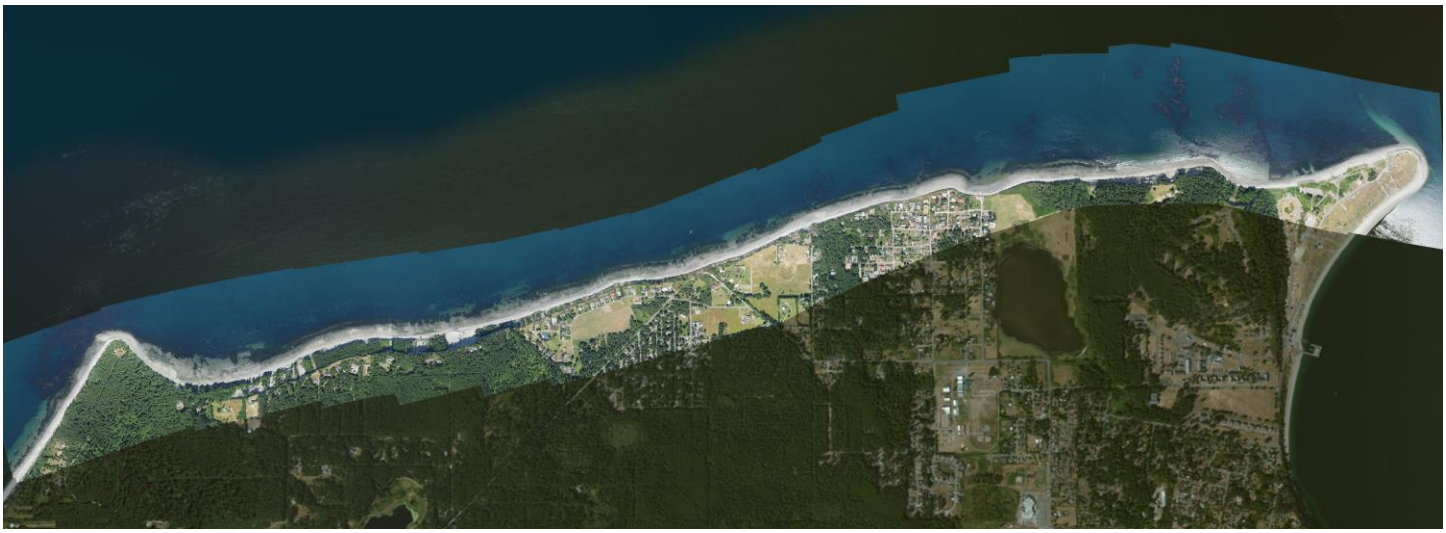


Figure 28. Bull-kelp at North Beach shoreline near Port Townsend.

Aerial Photos on the San Juan Islands

For 2014, a variety of sites were photographed for several projects. A map of the photos taken is shown in Figure 29.

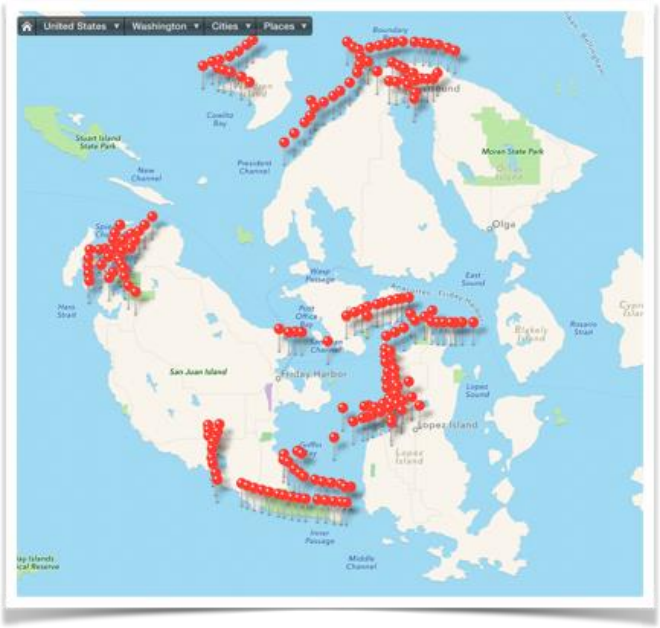


Figure 29. Map of aerial photographs taken in the San Juan Islands for 2014.

Eelgrass disease in San Juan County

For several years eelgrass-associated aerial photographs have been collected in the San Juan Archipelago in collaboration with Sandy Wyllie-Echeverria (Friday Harbor Labs). A major issue being studied in this region is an eelgrass wasting disease caused by the slime-mold organism, *Labyrinthula zostera* (see map in Figure 30 for list of sites being studied and visit the website http://depts.washington.edu/seagrass/disease-analysis-in-san-juan-archipelago/ for more detail). The images of Fisherman's Bay (see Figure 30) show the odd, brown appearance of "diseased" eelgrass beds

inside the bay (see Figure 30 insert) while eelgrass beds just outside the bay appear normal. We are looking for such changes in Island County as an indicator for the disease in our eelgrass bed areas; so far none have been seen. It is thought that the disease is limited to bays that have reduced tidal flushing.

Figure 30. Sites within San Jan County that are being studied for eelgrass wasting disease.

Sand Dollar Study on Orcas Island

As discussed earlier (see Freeland Park – swh0932) Amy Henry has been studying the relationship between sand dollars and eelgrass growth for her PhD thesis at the University of Chicago. For several years I have been sending her aerial photographs of her site at Crescent Beach, East Sound on Orcas Island (see Figure 31). Her studies and insights have helped us understand one more aspect of the competition and stress eelgrass undergo. Amy's site is shown in the insert demarked by white buckets and a transect line. Her study is defining the competition between eelgrass and sand dollars for the seabed.

Figure 31. Study of the relationship between sand dollars and eelgrass growth by Amy Henry at Crescent Beach.

Fidalgo Bay

The Samish Indian Nation DNR (Erin Lincata and Sam Barr) is mapping eelgrass in their tidelands in Fidalgo Bay. An image of the entire bay was produced to help prepare for the underwater videography of Sandy Wyllie-Echeverria and to compare with the aerial mapping by UAV (drones) with H. Gary Greene and Norman Maher. This UAV sampling will give us a one-to-one comparison of our aerial photography with drone technology for a small portion of Figure 32.

Figure 32. Panorama of Fidalgo Bay

Portage Bay

Marco Hatch, Director, National Indian Center for Marine Environmental Research & Education, and Sandy Wyllie-Echeverria, Friday Harbor Labs, have provided a course at the Norwest Indian College to teach eelgrass measurement techniques to students. An aerial map of Portage Bay (see Figure 33) was provided to assist the eelgrass mapping and to compare with aerial photography by UAV (drones) flown by Brad and Russ McMillan (data not available). This will add to our experience for future UAV activity in assessing eelgrass beds.

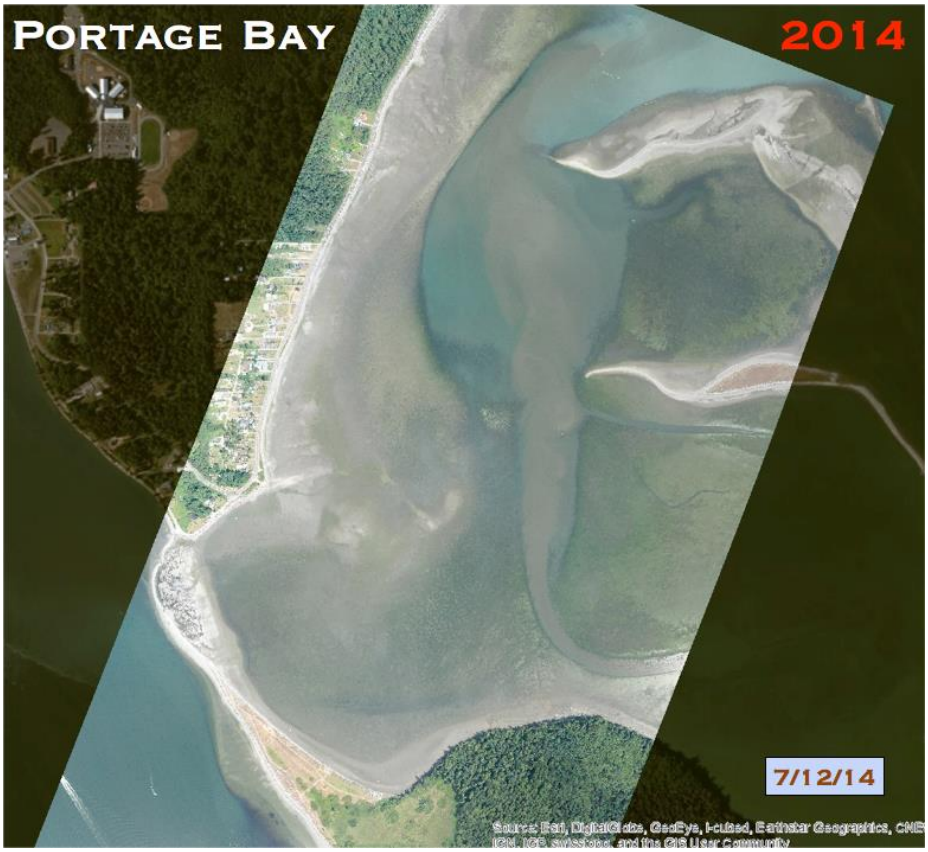


Figure 33. Geo-reference panorama of Portage Bay, Bellingham, WA

Conclusions

We have completed the analysis of all the data (aerial and underwater videography) gathered in 2014. The results were presented to the Island County Marine Resource Committee on April 1, 2014. This report concludes our responsibilities for the 2014 contract period. From our experience we have reached a number of conclusions about our process and results:

• Our core sites (flats29, swh0888 and swh0932) appear to be relative stable over the six years we have studied them. There are issues within each site, but none of the eelgrass bed areas have changed radically. The data for Cornet Bay (flats29) suggest the largest detrimental impact on eelgrass beds is boating activity. The data for Monroe Landing in Penn Cove (swh0888) suggests a shift in eelgrass distribution away from bay with possible involvement of increased sea urchin grazing. The data for Freeland Park (swh0932) show recovery from a single incident of damage at Nichols Bros boat launch in 2008, but no apparent damage from boating activity at Freeland Park. An interesting observation of sand dollar associated eelgrass loss appears to be of little concern.

• Several sites identified by WADNR to have increasing eelgrass bed areas are consistent with our recent data (swh0885, swh0955, swh1574). Adjacent sites of swh0954 and swh0957 also appear to have increasing eelgrass bed trends by our 2014 data. In general, we are encouraged our data appear to correlate well with WADNR data.

• The eelgrass beds at Robinson Park site (cps0776) appear to be *Phyllospadix* rather than *Zostera marina*. This is not unexpected, but a first experience for our team.

• Ala Spit (swh0851) has currents that prevented us from making quantitative measurement of the eelgrass bed area. However, we were able to identify probable eelgrass beds using underwater videography and aerial photography.

• To date we have monitored over 32 different sites and collected site data nearly 70 times including our recently completed 2015 data collection.

• Aerial photography is a complementary tool to underwater videography allowing us to gather data on more of the shoreline, but with lesser specificity. Aerial photography alone allows us to speculate on eelgrass bed changes, but must be confirmed by underwater videography. Upcoming UAV (drone) technology may become useful for eelgrass bed assessment in the future; we are participating in testing the possibilities.

• Storage and distribution of our raw data continues to present issues. We generate around 100Gb of raw data each year making it too difficult to share over the internet. The video and aerial photos of the seabed and near shore could be of interest for other purposes, but so far only reduced data (panoramas, GIS maps and graphs) are being shared over internet venues (SoundIQ). Physical transfer is becoming more plausible due to increased capacity and lower cost of SSD media.

• Aerial photography of bull-kelp beds will be added as a new focus for aerial photography in Island, Jefferson, San Juan and Snohomish Counties for 2015.

Acknowledgements

We'd like to thank our volunteers (Kathy Fritts and Finn Gatewood) who have helped us gather data in 2014. Our core group (Ken Urstad, Neal Clark, Gregg Ridder, Bob Gentz, Tom Vos, Mark Kennedy and

Don Meehan) is very appreciative for the help and guidance by a variety of experts in this field, especially Jeff Gaeckle, Fred Short and Lisa Ferrier (WADNR) and Sandy Wyllie-Echeverria (Friday Harbor Labs). Finally, we thank the Island County Marine Resource Committee (Frances Wood – MRC contact) and Anna Toledo/Kristen Stavros (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!

Gregg Ridder

9/15/14