

Snohomish County, Washington County-Wide Eelgrass Inventory

Final Report

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Submitted to

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Introduction

The Snohomish County Marine Resources Committee (MRC), a citizen-based advisory committee and member of the Northwest Straits Commission, is charged with addressing local marine issues and protecting and restoring marine waters, habitats and species within the marine ecosystems of Snohomish County.

A high priority for the Snohomish County MRC is monitoring and protection of nearshore habitats, as degradation of nearshore habitats affects all the living resources associated with those habitats and is a great threat to Puget Sound ecosystems. Specifically, the Snohomish County MRC's Nearshore Subcommittee has a long-term goal of identifying, protecting, and restoring nearshore habitat including eelgrass habitat.

To support the MRC's goals, Snohomish County is developing a comprehensive, county-wide eelgrass inventory and GIS data set. Previously, Snohomish County MRC partnered with local tribes, the Tulalip and Stillaguamish, to map intertidal eelgrass along the entire county marine shoreline using aerial photography and field verification. The objective of the current project is to conduct an eelgrass inventory in the subtidal areas and to synthesize all the existing spatial data sets delineating eelgrass within the county.

Scope of Work

The scope of work for this project included the following tasks:

(1) Compile existing eelgrass ESRI GIS data

Compile existing eelgrass ESRI GIS data from a variety of sources, including GIS data from the Washington Department of Natural Resources, county-wide GIS data of intertidal eelgrass beds along the entire marine shoreline, and other relevant data sets.

(2) Conduct field inventory of subtidal eelgrass bed locations

2.1- Underwater Video/Single Beam Acoustic Data Collection & Post-Processing

The purpose of the underwater video/single beam acoustic survey is to determine the deepwater edge of the eelgrass beds and to estimate the mean maximum eelgrass depth for each site (as defined by Washington DNR's Submerged Vegetation Monitoring Project).

The consultant will perform an underwater video and single beam (BioSonics) acoustic survey of deepwater edge from Picnic Point (starting surveys at the north edge of the previous Brightwater survey) to the northern-most point of Port Susan Bay in Snohomish County. This survey will cover the length of the county shoreline, approximately 70 km

in length, without re-surveying areas already surveyed by Washington DNR Submerged Vegetation Monitoring Project (SVMP).

Data will be collected using the zigzag transect method. The consultant will post-process the BioSonics depth data to obtain maximum eelgrass depth (and corresponding position) on each zig and zag of the transect. The consultant will not post-process all of the video data; video data will be used to validate the acoustic data when needed.

The result of the survey will be a string of points marking the deepwater edge of the eelgrass, from which the GIS analyst can create a line marking the deepwater edge. The consultant will compute the average maximum eelgrass depth and provide an associated position for the middle of each site with eelgrass. This will allow the GIS analyst to plot the maximum depths on a map.

2.2- Side scan Sonar Data Collection and Post-Processing

The purpose of this survey is to determine eelgrass positions as far inshore of the deepwater edge as possible from a single pass with the sonar.

The side scan sonar survey will cover the area between Picnic Point (the north edge of the previous Brightwater survey) to the northern-most point of Port Susan Bay in Snohomish County. This survey will cover the same 70 km of shoreline in the Underwater Video/Single Beam Acoustic Survey as described above. The consultant will follow the deepwater edge line created from the Underwater Video/Single Beam Acoustic Survey to maximize the efficiency of the side scan survey.

(3) Generate GIS data from subtidal eelgrass bed survey

4) Produce a final report describing survey and data processing methods and results

Methodology

Underwater Video/Single Beam Sonar Survey

Marine Resources Consultants conducted the underwater video/single beam sonar eelgrass survey on May 17, 18, 19, 21, and 22, 2007. On all survey days Ian Fraser and Frank Converse served as chief scientist and skipper, respectively.

Study Area

We defined the survey area to be the Snohomish County shoreline from Point to the northwestern-most point of Port Susan Bay, including Gedney Island. Within this area there are 59 “fringe” sites and 5 “flats” sites defined by the Washington State Department of Natural Resources (DNR) Submerged Vegetation Monitoring Project (SVMP) (See

Gaeckle et. al., 2007 for detailed discussion of DNR SVMP sampling protocols). A fringe site is a 1000 m length of shoreline as measured along the -20 ft isobath. A flats site is an area with extensive shallows, such as river deltas (e.g., Stilliguamish River delta, Snohomish River delta, and Tulalip Bay).

We did not survey 5 fringe and 3 flats sites that were previously sampled by the DNR SVMP (swh 1615, swh1625, swh1643, swh1647, swh1649, flats25, flats26, and flats28). In addition, 3 fringe sites near the Navy and Mill docks in Everett (swh1636, swh1637, and swh1638) were not surveyed due to request by the security personnel, and a portion of 1 fringe site at the Edmonds dive park and ferry terminal (swh1664) was not surveyed due to underwater hazards.

Survey Equipment and Methods

Vessel

We conducted sampling aboard the 36-ft *R/V Brendan D II* (Figure 1). We acquired position data using a sub-meter differential global positioning system (DGPS) with the antenna located at the tip of the A-frame used to deploy the camera tow fish. Differential corrections were received from the United States Coast Guard public DGPS network using the WGS84 datum. A laptop computer running Hypack Max hydrographic survey software stored position data, depth data from one echo sounder (Garmin), and user-supplied transect information onto its hard drive. Position data were stored in both latitude/longitude and State Plane coordinates (Washington South, US Survey Feet). All data were updated at 1 second intervals. Table 1 lists all the equipment used during this survey.



Figure 1: The *R/V Brendan D II*

Table 1: Survey equipment used onboard the *R/V Brendan D II* during the Snohomish County underwater videographic/single beam acoustic eelgrass survey.

Item	Manufacturer/Model
Differential GPS	Trimble AgGPS 132 (sub-meter accuracy)
Depth Sounders	BioSonics DE4000 system (including Dell laptop computer with Submerged Aquatic Vegetation software) Garmin FishFinder 250
Underwater Cameras (2)	SplashCam Deep Blue Pro Color (Ocean Systems, Inc.)
Lasers	Deep Sea Power & Light
Underwater Light	Deep Sea Power & Light RiteLite (500 watt)
Navigation Software	Hypack Max
Video Overlay Controller	Intuitive Circuits TimeFrame
DVD Recorder	Sony RDR-GX7
Digital VideoTape Recorder	Sony DVR-TRV330 Digital8 Camcorder

Video Data

We obtained underwater video images using an underwater camera mounted in a down-looking orientation on a heavy tow fish. Two parallel red lasers mounted 10 cm apart created two red dots in the video images as a scaling reference. We mounted a second forward looking underwater camera on the tow fish to give the winch operator a better view of the seabed. We deployed the tow fish directly off the stern of the vessel using the A-frame and winch. Video monitors located in both the pilothouse and the work deck assisted the helmsman and winch operator control the speed and vertical position of the tow fish. The weight of the tow fish kept the camera positioned directly beneath the DGPS antenna, thus ensuring that the position data accurately reflected the geographic location of the camera. A video overlay controller integrated DGPS data (date, time) and user supplied transect information (transect number and site code) into the video signal. We stored video images directly onto a Sony Digital8 videotape and onto a DVD-R disk.

Depth Data

Our primary depth sounder was a BioSonics DE4000 system. The advantage of this system is its ability to accurately measure distance between the transducer and the seabed, even when the seabed is covered with dense vegetation (e.g., eelgrass and/or macroalgae). Other depth sounders often measure distance only to the top of the vegetation canopy. The BioSonics system does not produce depth readings in real time. Instead, it records on a laptop computer all of the returning raw signals in separate files for individual transects. During post-processing, individual transect files were combined into larger files and processed through EcoSAV software (part of the BioSonics system). The output was a single text file with time, depth, and position data. These data were then merged with the tide correction data (see sub-section below) to give corrected depths. Our backup depth sounder was a Garmin FishFinder 250. Although this echo sounder provided real-time estimates of depth (which were recorded by the Hypack Max program), it often estimated depth only to the top of the vegetation canopy rather than to the seabed.

For both echo sounders, we mounted the portable transducers on poles attached to the starboard (Garmin) and port (BioSonics) corners of the transom. Since the DGPS antenna was mounted along the centerline of the vessel, each transducer was offset 1.5 m from the DGPS antenna. During analysis, we ignored this slight offset and assumed that depth readings from both depth sounders were taken at the location of the DGPS antenna.

Field Sampling Procedures

At most sites we used a single zigzag transect (Figure 2). At some sites the deepwater edge of the eelgrass was too shallow to conduct a zigzag transect. At these sites we conducted several straight-line transects perpendicular to the isobaths.

For each zigzag transect, the skipper positioned the vessel either as close as possible to shore or offshore of any possible eelgrass and the winch operator lowered the camera to just above the seabed. Visual references were noted and all video recorders and data loggers were started. If the transect started close to shore, the vessel proceeded offshore at approximately 45 degrees to the isobaths until eelgrass was no longer observed (or was not likely to be observed) and then turned 90 degrees back toward the shoreline. If the transect started offshore of any possible eelgrass, the vessel proceeded onshore at approximately 45 degrees until eelgrass was observed or it was too shallow to go closer to shore and then turned 90 degrees back offshore.

Regardless of the starting position the vessel proceeded in a zigzag pattern along the site. If eelgrass was present, each zig and zag crossed the deepwater edge of the eelgrass. If eelgrass was not present, the each zig and zag crossed the depth range where eelgrass was likely to be found.

As the vessel moved along the transect the winch operator raised and lowered the camera tow fish to follow the seabed contour. The field of view changed with the height above the bottom. The vessel speed was held as constant as possible (about 1 m/sec). The skipper watched the video monitor and clicked a toggle switch to the “on” or “off” position when eelgrass was present or absent. When the toggle was in the on or off position, the vessel track line on the navigation monitor was either red, or green, respectively. At the end of the transect, we stopped the recorders, retrieved the camera tow fish, and moved the vessel to the next sampling position. We maintained field notes for each transect.

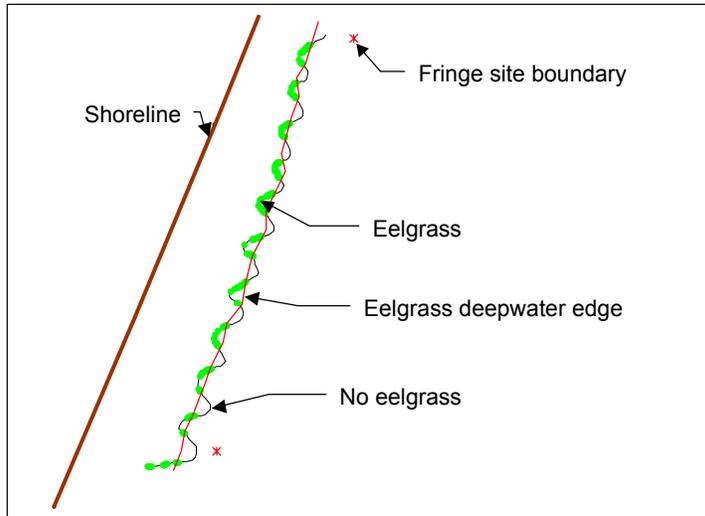


Figure 2: Example of a zigzag transect.

Underwater Video Data Post-Processing

We did not post-process the underwater videographic data. These data are archived and could be post-processed at a later date.

Single Beam Acoustic Data Post-Processing

We used the BioSonics echo sounder to gather bathymetry data. Raw depths collected from the echo sounder measure the distance between the seabed and the transducer. We applied three factors to correct these depths to the mean lower low water (MLLW) vertical datum:

- transducer offset (i.e., distance between the transducer and the water surface);
- predicted tidal height (i.e., predicted distance between the surface and MLLW);
- tide prediction error (i.e., predicted tidal height minus the observed tidal height at a reference station).

Corrected depth equals depth below the transducer plus the transducer offset minus the predicted tidal height plus the tide prediction error. We measured the transducer offsets directly each day. To get predicted tide heights at each fringe site we computed a weighted average of the predicted tide heights (using the computer program Tides and Currents Pro 3.0; Nobletec Corporation) for the two closest tide prediction stations, where the weights were inversely proportional to the distances from the fringe site to the two tide stations. We used the following prediction stations: Kayak Point (1129), Tulalip (1127), Everett (1123), Glendale (1121), and Edmonds (1035). We computed tide prediction errors by comparing the computer program predicted tide heights for the Seattle reference station (station ID 1049; 47 36.20 N, 122 20.20 W) with actual observed tide heights published by the National Oceanic and Atmospheric Administration on their web site (http://www.co-ops.nos.noaa.gov/data_res.html).

We merged all data (using time as the common field) into a single database file (tab delimited text file) and screened each data field for gross errors. We created maps in Hypack Max and AutoCad to illustrate the locations of seabed attributes. We estimated eelgrass parameters using DNR SVMP methods, as described in the next section.

Estimating Mean Maximum Eelgrass Depth

Maximum eelgrass depth refers to the deepwater boundary of eelgrass growth. Consider a zigzag transect that passes through the deepwater edge of an eelgrass bed on each zig and zag. If one records depth along each zig and zag, there will be a collection of maximum eelgrass depth measurements (one for each zig and zag). Our parameter of interest is the average of these maximum depth measurements. We used depths from BioSonics echo sounder to estimate this parameter.

Side Scan Sonar Survey

The side scan sonar data acquisition was conducted by Tony Petrillo of Blue Water Engineering Services, Inc. (BWES) of Port Townsend, WA. The side scan sonar and navigation systems were mobilized on the Brendan D II on Thursday, 24 May 2007. Field operations to acquire data were conducted on Friday, 25 May and Tuesday, 29 May 2007.

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

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

The track lines for the survey were pre-planned based on the existing aerial eelgrass mapping done by Snohomish County and the recent video-sonar mapping done by Marine Resources Consultants (NORRIS). There were a total of 24 track lines planned. Ten were north of Everett, 4 surrounded Hat Island, and 10 were south of Everett.

During survey, the SSS tow fish was deployed over the port side of the vessel directly below the DGPS antenna. Thus, there was no offset or layback. Because the tow fish was deployed over the port side, all track lines were run with the port side of the survey vessel facing shore. Thus, the SSS tow fish was always facing upslope. Track lines were laid out based upon an assumed offset of 25-50 ft to the deep side of existing eelgrass beds. All track lines were run at between 2 and 3 knots.

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

The SSS was set at high frequency for most of the first day of survey and low frequency for most of the 2nd day of survey. It was always set for 100 meters per channel

Post-Processing and Analysis

HYPACK Analysis

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

SSS Analysis

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

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

Digitizing

Digitizing of the side scan images was done in GIS as a collaborative effort between Sound GIS and BWES personnel. The GIS system had the capability of displaying the SSS images, the NORRIS eelgrass data and the Snohomish County (SNOCO) eelgrass

data simultaneously. The SSS data was displayed on the GIS screen and reviewed relative to the NORRIS and SNOCO data. Once SSS eelgrass images were identified on the screen relative to the NORRIS and SNOCO data a polygon was digitized around the eelgrass patches. For consistency, all digitizing was done with the images displayed at a scale of 1:2000. This was done for all 24 track lines.

In many cases, there was a great amount of detail of the size, shape and “patchiness” of the eelgrass beds. It became apparent early in the analysis that the SSS data was best used in conjunction with and calibrated by ancillary eelgrass mapping data.

Effectiveness of Side Scan Sonar for Eelgrass Mapping

The SSS data was effective at mapping eelgrass under certain conditions and inadequate under others. These conditions are listed in detail in the following section. During the survey, the NORRIS and SNOCO data was displayed on the HYPACK screen. It became apparent very early in the survey where the SSS was effectively mapping the eelgrass beds by comparing images from the SSS with the NORRIS and SNOCO eelgrass on the HYPACK screen.

Ancillary eelgrass data are necessary for ground truth data under all except the best of conditions to use SSS for eelgrass detection, there were conditions where the SSS did better than the NORRIS and SNOCO methods. The SSS is an effective tool to fill in the details between the NORRIS method track lines. The NORRIS method runs track lines in a quasi-sine wave across the near and far edges of eelgrass beds, and only detects data directly beneath the survey boat. The amplitude of this quasi-sine wave can vary many hundreds of feet. The SSS data can fill in the gaps between NORRIS track lines.

Recommendations

It is recommended that side scan sonar be used as an eelgrass mapping tool under certain conditions. SSS should not be used:

1. exclusively for mapping eelgrass where it is not supported by existing or ancillary eelgrass data or where a complementary mapping tool is used simultaneously,
2. to map eelgrass where it is known that the eelgrass is thin and sparse, and not lush,
3. where the inshore area is composed of coarse gravel or cobbles,
4. where the bathymetric contour is steep,
5. where there is dense particulate matter in the water column that can mask the SSS signal, or
6. to map shallow perimeter edge of an eelgrass bed at low tide.

SSS is effective at mapping eelgrass:

1. where historical or ancillary data support the presence of existing eelgrass beds,
2. at delineating the deep perimeter edge of lush eelgrass beds in great detail,

3. where the bathymetric contour is not steep,
4. where the substrate is fine sand or mud,
5. where there is not dense particulate matter in the water column,
6. where sea conditions allow straight and accurately-followed survey track lines, and the survey vessel operator is skilled at maintaining an accurate track line,
7. when low frequency (nominal 100 kHz) can be used (although this was sea condition and site dependant),
8. when mapping can take place closer to high tide,
9. when the transmit distance is specified at equal to or greater than 100 meters/channel (although this again is site dependant), and
10. when the offset distance from the boat to the eelgrass is about 25-30 meters.

GIS Compilation of Eelgrass Data Sets

Existing data sets delineating eelgrass beds within Snohomish County were acquired from various sources (Table 2).

Table 2: Existing GIS data sets for Snohomish County eelgrass

Source	Methods/ Technology	Survey Date(s)	Spatial Extent
Snohomish County Intertidal Habitat Survey	aerial photography and field survey	2003 (imagery) 2003 – 2005 (field work)	entire Snohomish County shoreline
King County Nearshore Habitat Mapping Project	side scan sonar, underwater video	1999	south of Picnic Point (approx lat/long: 47°52.8'N, 120°20'W), approximately 2 miles of shoreline
King County Pre-Construction Eelgrass Monitoring	side scan sonar, underwater video, dive survey	2004	Point Wells (approx lat/long: 47°46.7'N, 122°23.9'W)
Washington Department of Natural Resources Submerged Vegetation Monitoring Project	underwater video	2000 – 2006	Eight individual sites: swh1615 (S. of Kayak Point) flats25 (Tulalip Bay) swh1625 (S. of Tulalip Bay) flats26(Snohomish Delta N.) flats28 (Snohomish Delta S.) swh1643 (Edgewater) swh1647 (Mukilteo) swh1649 (Nelson's Corner)
Pentec Environmental / Port of Everett	underwater video	2004	Port of Everett Rail/Barge transfer facility (approx lat/long: 47°57.2'N, 122°17.3'W)

Polygon Boundaries

All data sets that delineated eelgrass boundaries as polygons were merged into a single ArcGIS polygon shapefile, with columns to indicate the presence of eelgrass, the species, and flags (0 or 1) for the various data source(s) (Table 3). This merged polygon data set included the interpretation from the newly collected side scan sonar data.

Table 3: Columns in Snohomish County eelgrass polygon shapefile.

Column Name	Contents
eelgrass	1 = eelgrass
species	Zostera marina Zostera japonica Zostera sp. Zostera spp.
sc_ihs	1 = source: Snohomish County Intertidal Habitat Survey
kc_1999	1 = source: King County Nearshore Habitat Mapping Project (1999)
kc_2004	1 = source: King County Pre-Construction Eelgrass Monitoring (2004)
pentec	1 = source: Pentec Environmental/Port of Everett
ssbwe_2007	1 = source: Blue Water Engineering Side scan Sonar (2007)
src_count	Number of source data sets that documented eelgrass in the polygon

In order to combine the data sets into one comprehensive coverage, some of the original data set detail had to be omitted. For example, the King County data sets include information about the density of the eelgrass beds, but this type of information is not available in all original data sets. Therefore, the original source data are also delivered to Snohomish County in case the additional detail is needed in the future.

Maximum Depth Points

Data from the underwater video/single-beam survey and Washington DNR's SVMP program are stored as X/Y point locations with an associated depth value (in feet relative to mean lower low water). The 2007 Snohomish County survey provides maximum eelgrass depth points for each section of the zigzag on the video/single-beam survey. These points were then combined with the maximum depth point from each transect at each of the eight sites surveyed by Washington DNR in previous years. Only the data from the latest WDNR survey are included in the merged data set. The following columns (Table 4) are included in an ArcGIS point shapefile of eelgrass maximum depth locations.

Table 4: Columns in Snohomish County eelgrass maximum depth points shapefile.

Column Name	Contents
site_code	Unique site code according to Washington DNR's SVMP naming conventions. These site codes are provided as a convenience for data summary, but do not imply comparability of these data to WDNR's statistically rigorous sampling scheme
Depft_MLLW	Depth of the eelgrass point relative to mean lower low water (MLLW) datum
source	MRC = Marine Resources Consultants WDNR = Washington DNR, SVMP
srvy_year	year of survey

Maximum Depth Segments

For ease of visualization and comparison between areas, maximum depth points were averaged across each of Washington DNR's sites or alongshore sampling segments. These values were then attached to Washington DNR's segmented -20 meter isobath line. The following columns are included in the shapefile (Table 5).

Table 5: Columns in Snohomish County eelgrass max depth linear summary shapefile.

Column Name	Contents
region	Washington DNR SVMP region code cps = Central Puget Sound GIS swh = Saratoga/Whidbey
site_code	Unique site code according to Washington DNR's SVMP naming conventions. These site codes are provided as a convenience for data summary, but do not imply comparability of these data to WDNR's statistically rigorous sampling scheme
maxdep_mn	Mean of the maximum depth values along the segment. Depth in feet relative to mean lower low water (MLLW). -9999 = site was surveyed, but no eelgrass was found
maxdep_std	Standard deviation of the maximum depth samples along the segment
count	Number of samples for calculating the mean maximum depth of the segment
source	MRC = Marine Resources Consultants WDNR = Washington DNR, SVMP
srvy_year	year of survey
surveyed	Flag to indicate if the segment was surveyed. A few areas could not be surveyed due to lack of access or hazards. 1 = surveyed 0 = not surveyed

Results

All existing and newly acquired data sources delineating intertidal and subtidal eelgrass were compiled and synthesized for use by Snohomish County for planning purposes.

Approximately 55 km of Snohomish County's estimated 70 km shoreline were newly surveyed for subtidal eelgrass using underwater video/single-beam sonar and side scan sonar technologies. An additional 12 km of the County's shore have been previously surveyed with underwater video by Washington DNR's Submerged Vegetation Monitoring Program.

Both intertidal and subtidal surveys indicate that eelgrass occurs along the majority of Snohomish County's shoreline. Approximately 87% of Snohomish County's shoreline has eelgrass present.

Maximum Eelgrass Depth

The subtidal video surveys covered depths ranging from +8 ft MLLW to -41 ft MLLW. Maximum eelgrass depths ranged from -1.37 ft MLLW to -24.92 ft MLLW. As seen in Figure 3, the maximum depth of eelgrass is more shallow in the northern areas of the county, and then becomes deeper in southern portions of the county. This is likely due to the decreased exchange of water and higher riverine inputs in these areas, leading to higher turbidity and decreased light penetration in the water column. No eelgrass was detected along approximately 5 km of the surveyed shore segments.

The maximum depth information from the video/single-beam sonar is consistent with other data sources and previous surveys by Washington DNR. The spatial trends in maximum eelgrass depth are consistent with DNR's more detailed results from a select number of sites within Snohomish County. Overall, maximum depth of eelgrass within Snohomish County, and especially in the Saratoga-Whidbey basin region, is lower than most other regions in Puget Sound and Straits of Juan de Fuca (Gaeckle et. al. 2007).

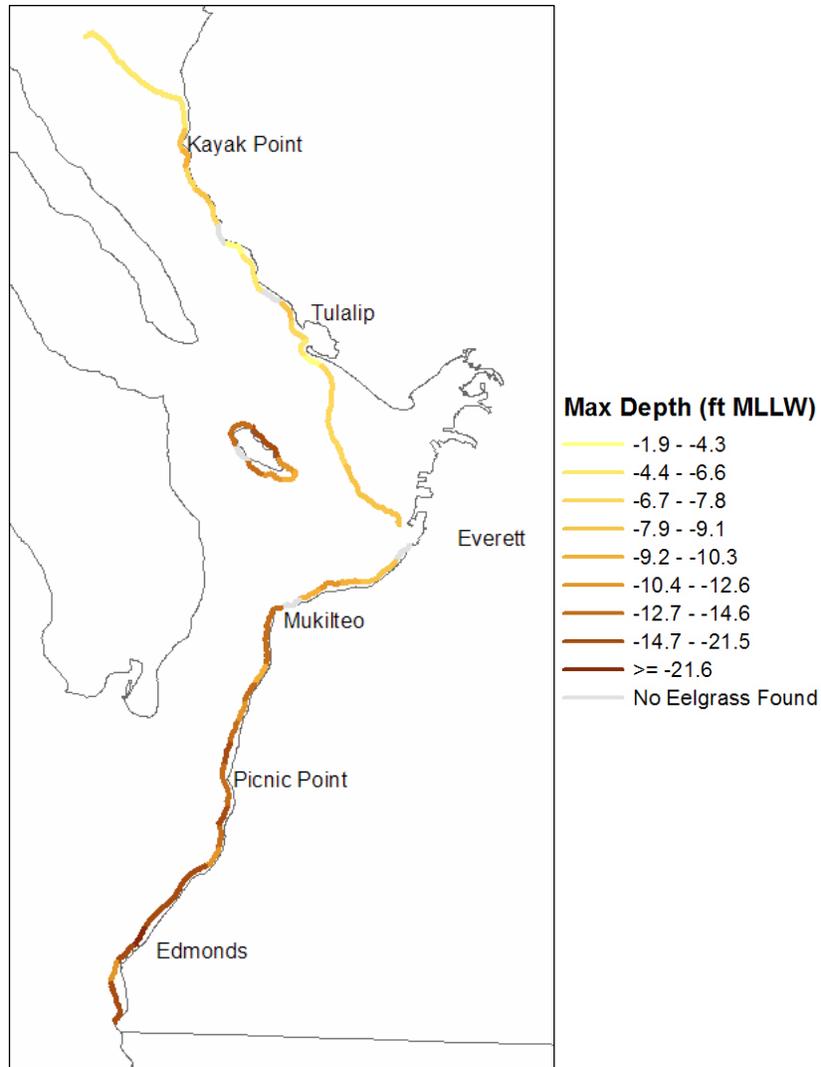


Figure 3: Mean eelgrass maximum depth by WDNR SVMP shoreline segments

Eelgrass Areal Coverage

Previously existing intertidal and subtidal eelgrass data sets delineated 1052.6 hectares of eelgrass within Snohomish County. The 2007 side scan sonar data delineated 146.7 hectares of eelgrass, 46.7 hectares of which were not delineated by previous data sets. The total area of eelgrass delineated within Snohomish County is 1099.3 hectares.

Comparison of Surveys

In areas where the eelgrass was shallower and/or the water clarity was high, Snohomish County’s intertidal habitat survey, using aerial photography, was quite complete and often captured the full extent of the eelgrass beds. In these cases, the subtidal video and

side scan sonar data generally tracked the boundaries delineated by the aerial survey. (Figure 4). This was the case for most of the County's shoreline north of Mukilteo, although there were some minor discrepancies between data sets in these areas.

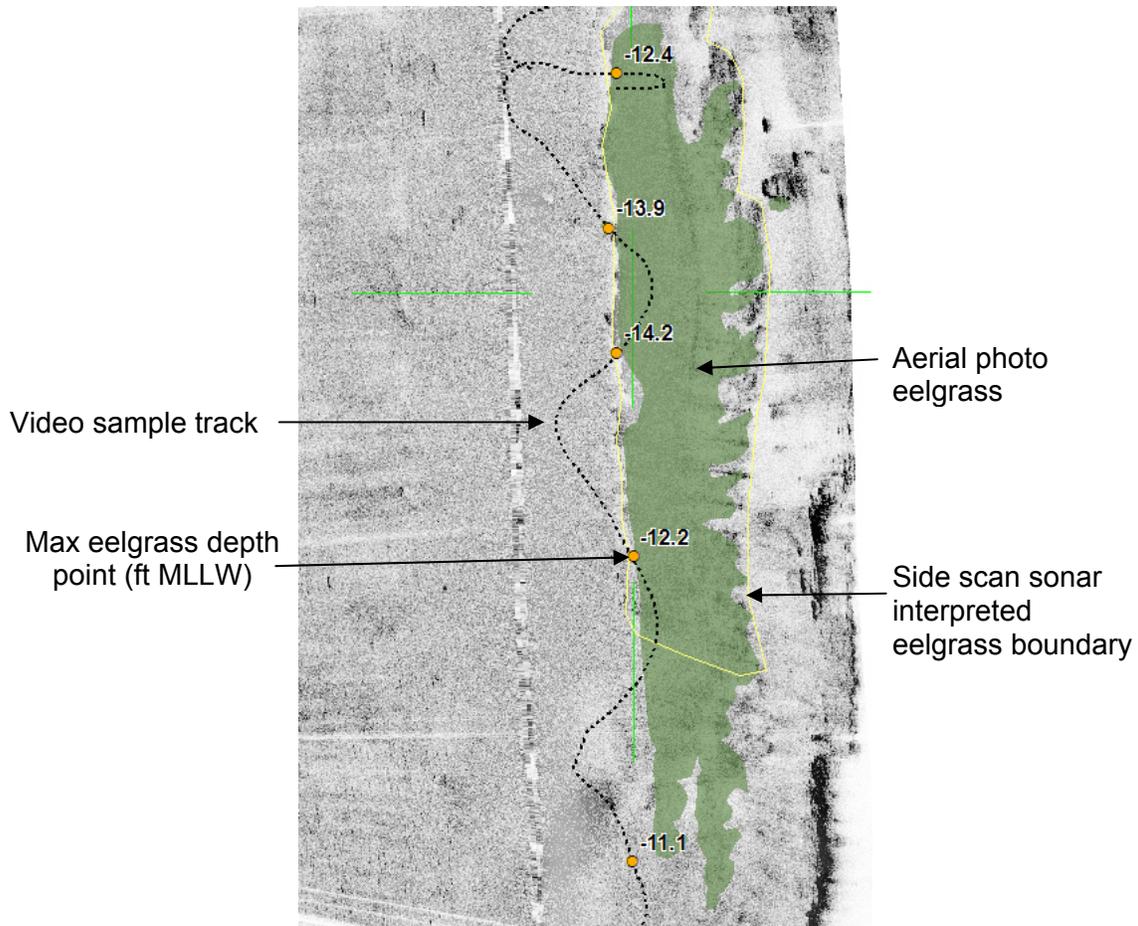


Figure 4: Sample survey area showing agreement between video, side scan sonar, and aerial photo interpretation of eelgrass bed locations.

In areas where the maximum depth limits are deeper, the subtidal video and side scan sonar detected and delineated additional eelgrass area that was not mapped with aerial photography. (Figure 5). These areas were generally south of Mukilteo.

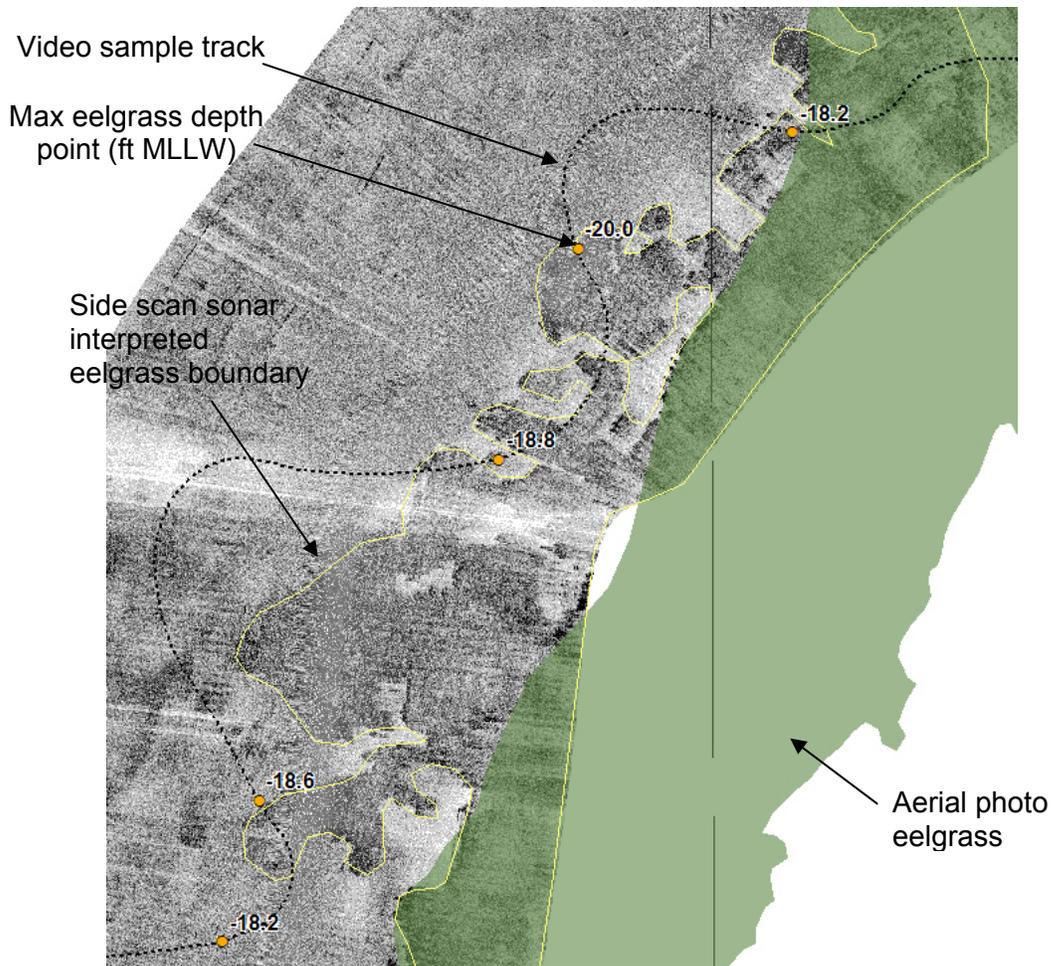


Figure 5: Sample survey area showing differences between video, side scan sonar and aerial photo interpretation of eelgrass bed locations.

The side scan sonar data showed eelgrass beds in great detail in areas including Port Susan, the Snohomish River delta, and south of Everett. The locations where the side scan sonar was not as effective included the areas near Kayak Point, some areas near Tulalip Bay and all around Hat Island. Most of the difficulties in side scan sonar interpretation were due to steep slopes, and coarse and/or rocky substrate.

Conclusions and Recommendations

These new surveys and compiled data sets provide a good overall delineation of eelgrass beds throughout the county for planning purposes. Use of these data for detailed site studies or permitting purposes is not recommended. A statistically rigorous change analysis would not be possible, due to the variety of data sets, survey years, and mapping techniques. However, large changes in eelgrass coverage would certainly be detectable if comparing future data to this data set.

The subtidal video/single-beam survey combined with the data from Washington DNR provides a good picture of the spatial trends in eelgrass bed maximum depth. Again, these data cannot be reliably compared to Washington DNR's statistically rigorous sampling approach, but provide a reasonable overview of eelgrass depth ranges. It is expected that large changes in maximum depth could be detected by future surveys using the same techniques.

Because of the relatively shallow depth limits of eelgrass in Snohomish County, the eelgrass boundaries delineated from aerial photography provide a nearly complete picture of eelgrass distribution. The underwater video provides a useful quantitative summary of the eelgrass depth distribution which can provide a baseline for future surveys. The side scan sonar is a useful for delineating deeper boundaries of eelgrass beds that are not detectable by the aerial photography, but the sites in Snohomish County that have these conditions are generally limited to the southern portions of the county.

References

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