NATURAL RESOURCES

Submerged Vegetation Monitoring Program

2000-2020 Geospatial Database User Manual

June 28, 2022

PUGET SOUND ECOSYSTEM MONITORING PROGRAM

WASHINGTON STATE DEPT OF NATURAL RESOURCES

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Acknowledgements

The Nearshore Habitat Program is part of the Washington Department of Natural Resources' (DNR) Aquatic Resources Division, the steward for state-owned aquatic lands. The Nearshore Habitat Program monitors and evaluates the status and trends of marine vegetation for DNR and the Puget Sound Partnership.

Program funding is provided primarily through DNR, in support of its mandate to sustainably manage aquatic resources. The Nearshore Habitat Program is grateful to several governmental entities that have provided funding for DNR to enhance eelgrass monitoring in their areas of interest. Entities that have funded specific studies include: the Suquamish Tribe, King County, the City of Bainbridge Island, the City of Bellingham, the DNR Aquatic Reserves Program and Washington State Parks.

The Friends of the San Juans has generously granted permission for DNR to include their data from 15 sites in the San Juan Islands with this dataset. This data greatly improves the representation of shallow embayments and support patterns of decline observed at a few sites.

Clallam County has also generously granted permission for DNR to include their data from 47 sites in the vicinity of the mouth of the Elwha River. Their surveys were repeated by DNR in later years as part of the broader effort to assess impacts of dam removal on the Elwha River.

A significant amount of data has been included in this dataset courtesy of the Island County Marine Resources Committee. This includes 37 sites within Island County.

Allison Bailey of Sound GIS contributed to database development and has developed data processing tools that are used by the monitoring program.

The Nearshore Habitat Program would like to give special recognition to Ian Fraser and Jim Norris of Marine Resources Consultants. Marine Resources Consultants led the initial design of the soundwide monitoring and continue to play a significant role in the success of the DNR eelgrass monitoring.

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Copies of this report may be obtained from:
http://www.dnr.wa.gov/programs-and-services/aquatics/aquatic-science

Contents

Executive Summary

The purpose of this user manual is to describe the structure and content of the 2000-2020 seagrass monitoring database that covers greater Puget Sound and is produced by the Washington Department of Natural Resources (DNR). The data are collected by DNR's Submerged Vegetation Monitoring Program (SVMP) in support of DNR's stewardship mandate to sustainably manage aquatic lands. These data provide the foundation of the Puget Sound Partnership's Eelgrass Indicators[1].

In addition to the soundwide study that underlies the statewide eelgrass indicators, the SVMP conducts many other seagrass monitoring studies that focus on particular sub-basins or particular sites of interest. These other studies are often conducted by DNR in collaboration with partner organizations. Data from all these studies are contained in the seagrass monitoring database. In addition, limited data collected by other organizations but following similar transect-based methods have been included in the database courtesy of Friends of the San Juans, Clallam County, and the Island County Marine Resources Committee.

The reason DNR monitors eelgrass is that it is an important natural resource of the marine nearshore that is utilized by many fish, bird and invertebrate species and provides high productivity to the nearshore system. DNR is the steward of state-owned aquatic lands and attached resources such as eelgrass and other seagrasses. Activities that potentially affect eelgrass must comply with existing regulations aimed at protecting eelgrass and other shoreline resources. Seagrass is also very sensitive to environmental degradation and is therefore a useful ecosystem indicator species.

This user manual has two main parts: a description of data collection methods and a description of the database structure. The description of methods includes the regional sampling design which is central to the soundwide study and the eelgrass indicators. The critical feature of the regional design is that is relies on a sample of sites selected from greater Puget Sound. It does not produce a comprehensive mapping of eelgrass throughout the study area. This allows for the use of intensive survey techniques that produce high quality data but would be prohibitive to apply on a comprehensive basis. The soundwide study area includes marine and estuarine areas of greater Puget Sound within Washington State. This includes areas east of Cape Flattery at the mouth of the Strait of Juan de Fuca, and south of Pt. Roberts. The extreme reaches of southern Puget Sound are excluded from the study area because eelgrass occurs rarely in this area.

[1] http://www.psp.wa.gov/vitalsigns/

The methods described also include the site sampling methods. These methods apply to all data housed in the database – data associated with the soundwide study as well as each of the other studies. The site sampling relies on towed underwater video deployed along random transects at the selected sites that is later classified for presence of native eelgrass (*Zostera marina*), surfgrass (*Phyllospadix* spp.) and non-native eelgrass (*Z. japonica*). This approach accurately distinguishes seagrass species and algae and is able to detect deep growing eelgrass that is inaccessible to methods typically used for large comprehensive surveys (e.g., aerial photography). Sampling generally occurs between May and September, the period of highest vegetation biomass.

The second main part of this user manual describes the database structure. This structure has been re-designed with the 2000-2020 database. The objective of the re-design was to include a small number of consolidated tables that would be more immediately useful than the database structure previously used. This section describes each table in the database, the attributes in each table and the possible attribute values where there is a limited number of categorical values. This section is very detailed and will be most useful as a reference for the user accessing individual tables.

The complete database is freely available for download from the DNR website in the form of two ArcGIS 10.x file geodatabases. The main geodatabase is accompanied by this user manual and ArcGIS 10.x map document and layer files to allow users to immediately interact with the data without the need to become familiar with the database structure. The second geodatabase contains the detailed transect data.

The key spatial layers from the database are also available as web (map) services. In this case, the transect data have been simplified to give a more efficient and responsive web service. For some users, access to the data through the web services might be preferable because DNR regularly updates these services as new monitoring data becomes available.

1 Introduction

1.1 Overview of the Submerged Vegetation Monitoring Program

The Submerged Vegetation Monitoring Program (SVMP) has conducted annual monitoring of the status and trends of native seagrass in greater Puget Sound since 2000. The native seagrasses monitored include the dominant eelgrass (*Zostera marina*) as well as the less abundant surfgrass (*Phyllospadix scouleri* and *P. serrulatus*). The SVMP uses the monitoring data to produce estimates of the area and change in area of these native species at individual sites and for the entire study area. Since eelgrass dominates, the SVMP typically refers to these as "eelgrass area" estimates but, in fact, they also include the area of surfgrass and are also referred to as native seagrass area estimates. Observations of the seagrass *Zostera japonica* are also recorded but these are excluded from SVMP area estimates because this species is non-native and has distinct resource management issues (Bando 2006; Hahn 2003; Mach et al. 2014, 2010; Shafer et al. 2013). Observations of all of these seagrasses classified annually between the years 2000 and 2020 are included in the eelgrass monitoring dataset that is described in this user manual.

The Washington State Department of Natural Resources (DNR) implements the SVMP. DNR initiated eelgrass monitoring in its role as steward of state-owned aquatic lands and the attached or embedded resources such as eelgrass. State-owned aquatic lands in Washington total 2.6 million acres (1.1 million hectares) and include all subtidal areas and a substantial amount of the state's intertidal lands. The legislature has stipulated management guidelines for state-owned aquatic lands that balance various uses that include "fostering water-dependent uses" and "ensuring environmental protection" (RCW 79.105.030). Eelgrass provides a suite of ecological functions and is a sensitive indicator of estuarine health. Given the key ecological functions of eelgrass and its value as a resource under DNR's management, the tracking of seagrass resources by the SVMP serves DNR's legislative mandate. Eelgrass monitoring is a defined agency performance measure to track DNR's duty to sustainably manage lands. It also serves a mandate of the Puget Sound Partnership to track indicators of ecosystem health and conduct the coordinated, integrated monitoring and assessment needed for these indicators.

The SVMP is one component of the regional monitoring program known as the Puget Sound Ecosystem Monitoring Program. This is a multi-agency effort mandated by the state legislature (RCW 90.71.060) to monitor diverse physical and biotic aspects of the greater Puget Sound ecosystem. The SVMP eelgrass monitoring data provide the basis for a vital sign that has been used for integrated assessments of Puget Sound (Puget Sound Action

Team 2002, 2005, 2007; Puget Sound Partnership 2010, 2012, 2013, 2015; Puget Sound Water Quality Action Team 2000).

Washington State agencies recognize the value of seagrass as an aquatic resource and provide it special protections. The Washington Department of Fish and Wildlife (WDFW) has designated seagrass areas as habitats of special concern (WAC 220-660-320) under its authority to regulate construction projects in state waters (RCW 77.55.021). The Washington Department of Ecology has designated eelgrass as critical habitat (WAC 173-26-221) under its statutory authority in implementing the state Shoreline Management Act (RCW 90.58). In 2011, the Puget Sound Partnership adopted a restoration target for native seagrass that reflects a 20% gain in area by 2020 relative to a 2000-2008 baseline (Puget Sound Partnership 2011).

To satisfy broad data needs, the SVMP can produce results at a range of spatial scales (site, region, soundwide, or other scales of interest; Figure 1) based on sampling of eelgrass beds at randomly selected sites and a small number of permanent sites selected non-randomly. At each site visited, the site is sampled with underwater video surveys. The video is classified for the presence of seagrass species. These classified survey data are the core of the SVMP dataset.

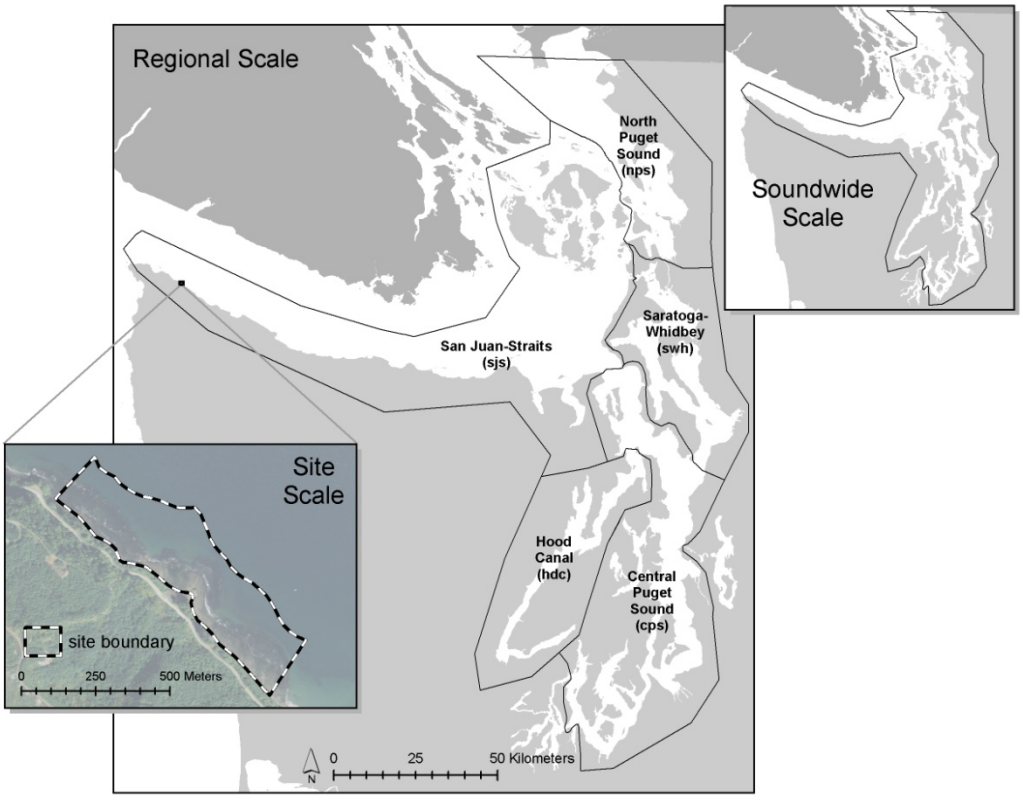


Figure 1. The SVMP monitors eelgrass condition at soundwide, regional, and site scales throughout greater Puget Sound, WA. Letters in parentheses indicate the abbreviations used for each sub-basin, or region.

Products of the monitoring program are made available to help with the management of eelgrass resources throughout greater Puget Sound. The SVMP releases periodic monitoring reports that include summaries and analysis of the monitoring data (Berry et al. 2003; Christiaen et al. 2016, 2017a, 2019, 2022; Dowty et al. 2005; Gaeckle et al. 2007, 2008, 2009, 2011; Nearshore Habitat Program 2015). In addition, the detailed spatial data are available as a web download and through an interactive mapping web application (see Online Access below).

The majority of the SVMP monitoring effort follows a soundwide monitoring design so that the sample data can be used to generate statistical estimates of native seagrass area over greater Puget Sound. This effort is referred to as the soundwide study. The SVMP collects additional data that does not contribute to soundwide estimates but are associated with other sites of interest; often in association with partners that have a more localized area of interest. The database described in this User Manual contains data from many different such studies. Data from all studies follow the same site sampling methods, but only data from the soundwide study were designed to contribute to soundwide estimates of native seagrass area. Partners that have provided funding for DNR to enhance monitoring in specific areas include the Suquamish Tribe, King County, the City of Bainbridge Island, the City of Bellingham, the DNR Aquatic Reserves Program, and Washington State Parks. In addition, Friends of the San Juans, Clallam County and the Island County Marine Resources Committee have given permission for portions of their monitoring data to be included in SVMP data distributions. All of the DNR monitoring that generated data included in this dataset relied on vessels, equipment and field expertise of Marine Resources Consultants (MRC). MRC is also responsible for the general site sampling approach and the broader design of the SVMP soundwide study. Data included courtesy of Friends of the San Juans and Clallam County was also collected by MRC. The Island County Marine Resources Committee collected their data with their own vessel and equipment (see Ridder 2018 for related work).

1.2 Objective of Manual

The purpose of this manual is to describe the publicly distributed database in sufficient detail for new users to navigate the database. The format and structure of the database is described, and the attributes of each data layer are defined. This manual also describes the data collection methods that include the regional sampling design and site sampling methods.

1.3 Online Access

There are three ways to access the SVMP monitoring data online. First, GIS users may wish to download the data to manipulate the data directly within GIS software. This user manual is primarily intended to support work with the downloaded data. Second, if the user wishes to add a specific component of the data to a map within an application, it may be more expedient to utilize a web map service. The map services can be utilized within web, desktop (ArcMap, ArcGIS Pro) or mobile applications. Third, an existing web application is available to access the data on a map in a browser without any GIS expertise.

In addition to distributing the data, the SVMP publishes monitoring reports that include detailed methodology, results summaries and analyses at the site, sub-region and soundwide scales. These are available on the main SVMP web page:
http://www.dnr.wa.gov/programs-and-services/aquatics/aquatic-science/nearshore-habitat-eelgrass-monitoring

DNR provides these geographic data "as is." DNR makes no guarantee or warranty concerning the accuracy of information contained in the geographic data. DNR further makes no warranties, either expressed or implied as to any other matter whatsoever, including, without limitation, the condition of the product, or its fitness for any particular purpose. The burden for determining fitness for use lies entirely with the user. Although these data have been processed successfully on DNR computers, no warranty, expressed or implied, is made by DNR regarding the use of these data on any other system, nor does the fact of distribution constitute or imply any such warranty.

In no event shall the DNR have any liability whatsoever for payment of any consequential, incidental, indirect, special, or tort damages of any kind, including, but not limited to, any loss of profits arising out of use of or reliance on the geographic data or arising out of the delivery, installation, operation, or support by DNR.

1.3.1 Download Data

The database itself is distributed as two separate downloads of Zip archives, each containing an ArcGIS version 10 file geodatabase. There are direct links to the download files on the SVMP web page:
https://www.dnr.wa.gov/programs-and-services/aquatics/aquatic-science/nearshore-habitat-eelgrass-monitoring

One Zip archive contains a geodatabase with the transect point data and is relatively large (4.5 GB on disk). The second Zip archive contains a geodatabase with three spatial layers and a table, as well as this user manual document and ArcMap 10.6.1 map document (.mxd) and layer (.lyr) files.

A simple base map is distributed with the download data and included in the ArcGIS map document. The base map includes boundaries for Oregon State, Washington State and the adjacent area of Canada. This simple base map is included for convenience and may not be suitable for many mapping needs. The Washington State boundary was derived from public data maintained by the Washington Department of Natural Resources but with the lower Columbia River shoreline added based on the Continually Updated Shoreline Product (CUSP) maintained by NOAA's National Geodetic Survey. The Canadian boundary was derived from data distributed without restriction by the Humanitarian Information Unit of the Office of the Geographer in the U.S. Department of State. The Oregon State boundary was obtained from the Oregon-Washington Office of the Bureau of Land Management.

The data are available as two separate downloads of Zip archives:

SVMP_distribution.zip: This archive contains the main database in the format of an Esri ArcGIS 10 file geodatabase. This geodatabase contains

	all the spatial and tabular data that is distributed except for the transect point data. An ArcGIS map document and this user manual are also included in this Zip archive.
SVMP_transect.zip:	This archive contains an Esri ArcGIS 10 file geodatabase with the transect point data.

1.3.2 Map Services

In addition to web downloads, the key components of the SVMP dataset are available as Esri web map services published by DNR. Some users may find that these services provide more convenient access to the data as these services can readily be added to web or desktop applications such as ArcMap or ArcGIS Pro.

The key SVMP spatial layers are layers within two published map services. The organization of these layers into services may change in the future. Therefore, it is best to access the layers directly through the DNR GIS data access portal:
https:/data-wadnr.opendata.arcgis.com.

1.3.3 Web Applications

An interactive mapping web application is hosted on ArcGIS Online. It allows for interaction with the main spatial and tabular elements of the dataset without any GIS expertise. The application can be accessed on this DNR web page:
http://www.dnr.wa.gov/programs-and-services/aquatics/aquatic-science/puget-sound-eelgrass-monitoring-data-viewer

In addition, an ArcGIS Storymap is available with interactive maps and graphical results:
https://wadnr.maps.arcgis.com/apps/webappviewer/index.html?id=83b8389234454abc8725827b49272a31

2 Data Collection

2.1 General Approach

Remote sensing techniques are widely used for seagrass mapping. Airborne remote sensing is particularly widely used and offers efficiency in mapping large areas (Bulthuis 1995, Cunha et al. 2005, Ferguson and Korfmacher 1997, Fletcher et al. 2009, Hernández-Cruz et al. 2006, Kendrick et al. 2000, Moore et al. 2000, Mumby et al. 1997, Ward et al. 1997, Young et al. 2008). However, these approaches are unable to reliably discriminate between seagrass species in mixed beds or between seagrass and macroalgae (Mumby et al. 1997; Ward et al. 2004). These approaches also cannot map deeper subtidal beds (Pasqualini et al. 1999). Other remote sensing techniques, such as acoustic monitoring of seagrass beds, can provide reliable detection of subtidal seagrass beds (Sabol et al. 2002), but are limited in that they cannot discriminate between seagrass species. In this study, these limitations are critical since one objective is to distinguish eelgrass (*Z. marina*) from *Z. japonica* and macroalgae, and a large portion of the eelgrass distribution in greater Puget Sound is subtidal (Hannam et al. 2015; Phillips 1974).

To overcome these limitations, when the Submerged Vegetation Monitoring Program (SVMP) was initiated in 2000, it selected towed underwater video along transects as the main data collection methodology (Ardizzone et al. 2006, Grizzle et al. 2008, Lirman et al. 2008, McDonald et al. 2006, Norris et al. 1997). Initially, the sole focus of the SVMP was the "soundwide" study whose objective was the characterization of greater Puget Sound as a whole. The use of underwater towed video is a relatively intensive technique and to apply it feasibly across the greater Puget Sound study area, it is used within a sampling framework that provides for regional estimates of eelgrass area based on video surveys at a modest number of sites.

A user needs assessment indicated that the anticipated users of the dataset are primarily interested in site-level data. This report describes the methods of site sampling with underwater video transects and the format of the site data. Also, the regional sampling design is described (sampling frames, stratification and estimation) for users interested in these details to generate regional estimates. The detailed description of the regional sampling design will be superfluous to users only interested in eelgrass distribution and status at the site level.

2.2 Study Area and Regions (Sub-Basins)

The study area is restricted to the marine waters of Washington State east of Cape Flattery, and includes the U.S. portions of the Strait of Juan de Fuca and the southern Strait of Georgia, Hood Canal, Puget Sound proper and several other smaller basins (Figure 2). These collective marine waters are referred to here as greater Puget Sound but are also known as the U.S. portion of the Salish Sea. The extreme reaches of southern Puget Sound are excluded from the annual monitoring study area because eelgrass occurs rarely in this area (Berry et al. 2001). The study area includes approximately 3,550 km of shoreline. The entire study area is subject to mixed semidiurnal tides with tidal range generally increasing with distance from the mouth of the Strait of Juan de Fuca. Mean spring tidal range varies from approximately 2.4 m at Cape Flattery to 4.4 m at Olympia.

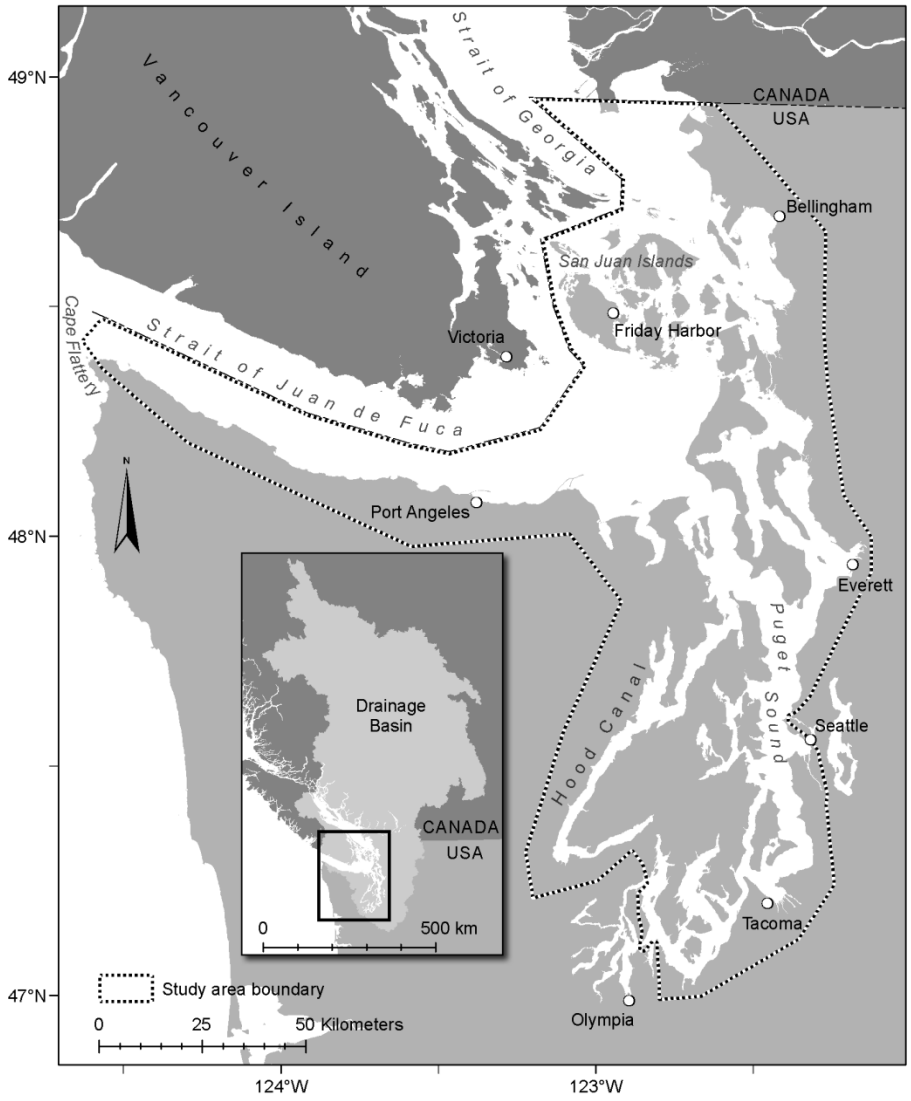


Figure 2. Greater Puget Sound and the SVMP soundwide study area, Washington State (USA).

There are six species of seagrasses in greater Puget Sound although not all have been observed in the SVMP transect data: *Phyllospadix torreyi* Watson, *P. scouleri* W. J. Hooker, *P. serrulatus* Ruprecht et Acherson, *Ruppia maritima* L., *Z. marina* L. and the introduced species *Z. japonica* Ascherson et Graebner (Harrison and Bigley 1982, Phillips 1984, Wyllie-Echeverria and Ackerman 2003). Eelgrass (*Z. marina*) is the dominant seagrass of greater Puget Sound (Berry et al. 2001) as well as the entire Pacific coast of North America (Wyllie-Echeverria and Ackerman 2003). The classified video transect data included in this dataset groups all observations of *Phyllospadix* species together as *Phyllospadix* spp. Furthermore, while *Z. marina* and *Phyllospadix* spp. are tracked separately, they are also tracked in a combined native seagrass category.

The study area was divided into five sub-basins. These are referred to as regions (see Figure 1, p.4). Previously, SVMP results were aggregated on a region basis, but this is not currently done as part of standard data analysis.

2.3 Studies

The data contained in the 2000-2020 dataset originates from several different sampling efforts, denoted here as studies. As noted earlier, when the SVMP initiated sampling in 2000, a primary objective was to collect data that could be used to generate estimates of eelgrass area over the entire greater Puget Sound study area. This sampling effort has continued each year since and is denoted as the "soundwide" study. Sites are selected for sampling primarily by simple random selection. This soundwide study has continued to be at the core of SVMP activities.

Between 2004 and 2012, the SVMP conducted additional sampling within five focus areas in greater Puget Sound. This effort is denoted as the "focus area" study. Sites were randomly selected within one focus area each year with a five-year rotation to sample all five focus areas. The intent was to generate eelgrass area and change estimates within subareas of greater Puget Sound.

DNR has also sampled many sites as part of other studies that typically have a specific geographic area of interest or sites with eelgrass considered to be of particular interest (Figure 3, Table 1). Results from these studies are typically included in the periodic monitoring reports produced by DNR (Berry et al. 2003; Christiaen et al. 2016, 2017a, 2019; Dowty et al. 2005; Gaeckle et al. 2007, 2008, 2009, 2011; Nearshore Habitat Program 2015). The Sites of Concern study generated its own DNR report (Ferrier and Berry 2010) and a component of the Eelgrass Stressor-Response Program (Stressor) also generated its own report (Gaeckle 2016).

Several projects were conducted by DNR with partners that had specific geographic areas of interest. These studies each generated their own reports. They include the Suquamish study (Christiaen et al. 2018), the City of Bainbridge Island study (Christiaen et al. 2017b), the King County study (Christiaen et al. 2020), the City of Bellingham study (Gaeckle 2009a), the Echo Bay study (Reeves 2006) and the Quartermaster Harbor study (Reeves 2005). The Aquatic Reserves study was a cross-program effort within DNR involving the

Nearshore Habitat and Aquatic Reserves Programs that surveyed eelgrass at aquatic reserves (Gaeckle 2009b).

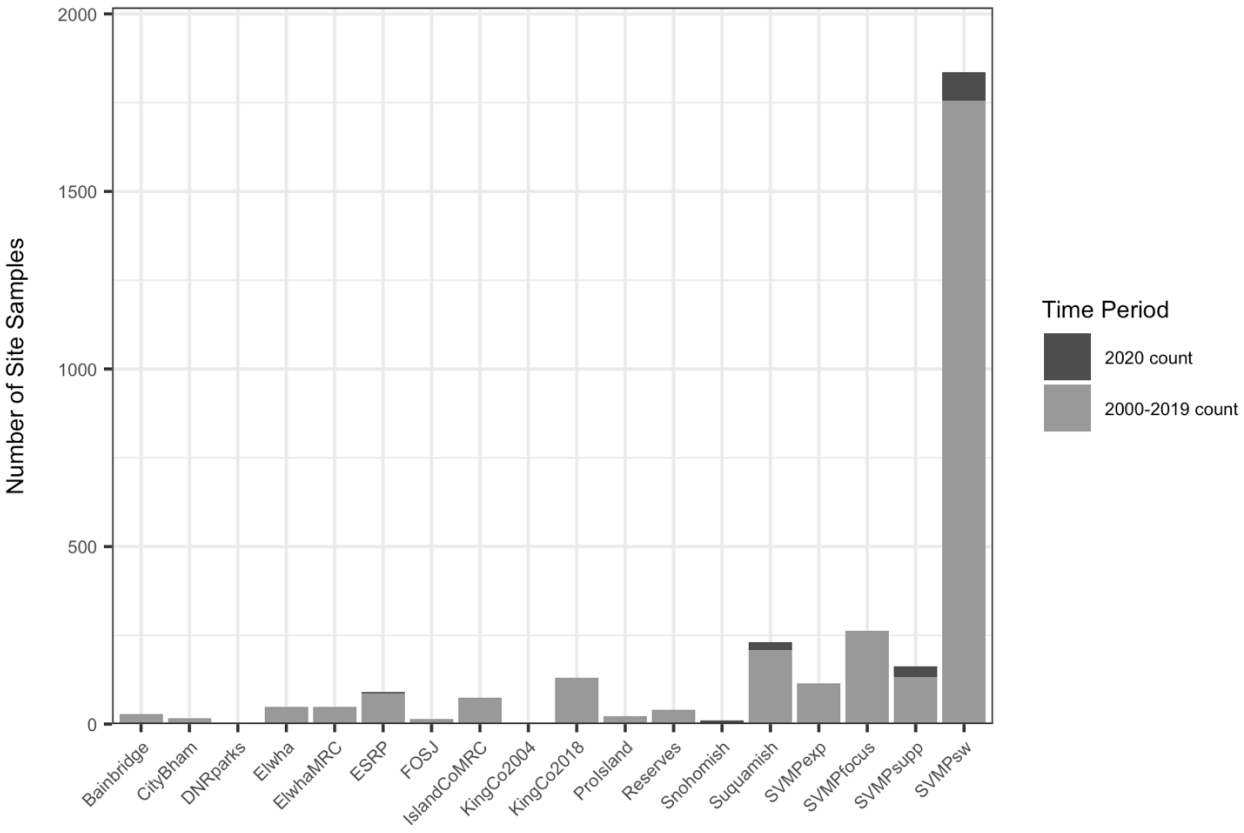


Figure 3. Number of site samples contained in the 2000-2020 dataset broken down by study. A site sample is a set of video surveys collected for estimating native seagrass area at a particular site on a particular sampling occasion. Recent sampling activity (2020) is distinguished from that reflected in the last SVMP data release (2000-2019). Each study is represented by a code along the *x*-axis that is described in Table 1 (p.13).

In 2003, the Friends of the San Juans (FOSJ) collaborated with the University of Washington and Marine Resources Consultants (MRC) in a study that surveyed sites within the San Juan Islands (Friends of the San Juans 2004). A subset of data from this study is included in the 2000-2019 dataset courtesy of Friends of the San Juans.

In 2006 and 2009, Clallam County contracted MRC to lead specific surveys within the county (Norris and Fraser 2007, 2009) and a subset of that data is included in the 2000-2015 dataset courtesy of Clallam County.

The Island County Marine Resources Committee has collected several years of underwater eelgrass surveys within Island County (https://www.islandcountymrc.org/projects/eelgrass-survey/). Survey data and site results spanning 2010-2016 from this effort are included in the 2000-2019 dataset courtesy of the Island County Marine Resources Committee.

2.4 Sampling Frames and Stratification

Surveying of the entire shoreline of greater Puget Sound with underwater video on an annual basis is not a viable approach. This is due to the magnitude of effort needed to cover 3,550 km of shoreline. Since the soundwide study must generate estimates that are representative of the entire study area, on repeated occasions, it must rely on sampling of the shoreline. To ensure unbiased estimates, the soundwide study relies on simple random sampling of the shoreline. This, in turn, first requires a well-delineated population that is then divided into a list of comprehensive and exclusive sample units (sites) from which to draw random samples. This comprehensive list is the sampling frame. The soundwide study actually uses two sampling frames (flats and fringe).

Table 1. List of studies and the associated number of site samples (N) as represented in the 2000-2020 dataset. A site sample is a set of video surveys intended to estimate native seagrass area at a site on a given occasion. Most of the data in the dataset have been generated by DNR, in some cases in partnership with other governmental entities. Data from studies unrelated to DNR are included in the dataset courtesy of Friends of the San Juans, Clallam County and the Island County Marine Resources Committee.

study code	study name	N	organizations
SVMPsw	SVMP soundwide study	1835	DNR
SVMPfocus	SVMP focus area study	262	DNR
Suquamish	Suquamish study	231	DNR and the Suquamish Tribe
SVMPsupp	SVMP supplementary study	162	DNR
KingCo2018	King County 2018 study	131	DNR and King County
SVMPexp	SVMP experimental methods study	114	DNR
ESRP	Eelgrass Stressor-Response Study	90	DNR
IslandCoMRC	Island County Marine Resources Committee	74	Island County Marine Resources Committee
Elwha	Elwha study	49	DNR
MRC-Elwha	MRC-Elwha Nearshore study	48	Marine Resources Consultants and Clallam County
Reserves	DNR Aquatic Reserves study	40	DNR (Nearshore Habitat and Aquatic Reserves Programs)
Bainbridge	Bainbridge Island study	28	DNR and the City of Bainbridge Island
ProIsland	Protection Island study	22	DNR
CityBham	City of Bellingham study	16	DNR and the City of Bellingham
FOSJ	Friends of the San Juans 2003 study	15	Marine Resources Consultants and Friends of the San Juans
KingCo2004	King County 2004	4	DNR and King County DNR
DNRparks	Echo Bay study (Sucia Island State Park)	2	DNR and Washington State Parks

Beyond supporting simple random sampling within the soundwide study, the frames are generally useful as a standardized index to sections of shoreline. As a result, the frames have also been used by all the other studies represented in the dataset as a framework for more localized surveying. A small proportion of effort within the ESRP and Aquatic Reserves studies have delineated study sites that do not coincide with the site boundaries of the soundwide study sampling frames.

The target population of the monitoring is all potential eelgrass habitat within the study area. This potential habitat was delineated in a GIS as those subtidal and intertidal areas bounded by the ordinary high water line and the -6.1 m isobath (-20 ft) (all depth values presented are relative to Mean Lower Low Water, MLLW). In practice, sampling has not been constrained by the -6.1 m isobath in the cases where eelgrass was found to extend to greater depths. The -6.1 m isobath was derived from the gridded bathymetric data produced by the Washington Department of Fish and Wildlife (Nysewander et al. 2005). Ordinary high water was represented by a spatial data layer maintained by DNR in a GIS and derived from 1:12,000 orthorectified aerial photographs.

The potential eelgrass habitat was first divided into two categories, flats and fringe, based primarily on geomorphological considerations. A separate sampling frame was developed for each category. The flats category includes embayments, tide flats and river deltas – potential habitat that is best represented as areal sample units. Potential habitat in the fringe category falls into a narrow band parallel to the shoreline and is well represented by linear sample units.

Flats potential habitat was manually delineated on bathymetric maps within the overall area of potential habitat. The flats sampling frame is mostly made up of sample units (sites) that are discrete areas of flats potential habitat (e.g., individual embayments) although in some cases large areas of contiguous potential habitat were subdivided into multiple sites.

The sampling frame for the fringe potential habitat was constructed by dividing the -6.1 m isobath into 1000 m segments. Each 1000 m segment represents a fringe site (Figure 4). In some cases, small isobath segments could not be placed in a 1000 m segment, for example around islands where the total isobath length would not be an even multiple of 1000 m, or where fringe potential habitat meets flats potential habitat. Such residual segments were denoted as orphans, were excluded from the frame, and led to a deviation of 3% between the target (2,465 km) and sampled fringe populations (2,396 km).

A small number of changes were made to the flats and fringe sampling frames following the first year of sampling (2000). These changes were significant because they involved Padilla Bay, the site of the largest eelgrass bed within the study area (Figure 5). The frames have been static since 2001.

For the purposes of the soundwide study, each of the two sampling frames have been stratified to optimize precision of estimates of soundwide eelgrass area and also to accommodate different designs within different strata (e.g., annual census of fixed sites in one stratum and rotating samples within other strata). Four sites from the flats frame and two from the fringe frame were purposively selected and placed in the “core” stratum. These sites were selected to represent a range of geographic locations, habitat types and management concerns (Figure 6). Each of the six sites is surveyed each year so the core stratum is censused rather than sampled. Core sites are assigned site codes with the prefix “core” – e.g., core001, core002.

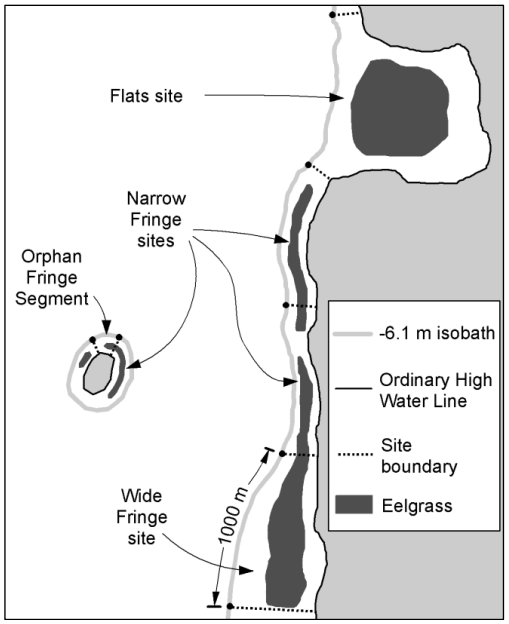


Figure 4. Diagram of potential eelgrass habitat divided into two categories, flats and fringe, based primarily on geomorphological considerations. Flats potential habitat includes large, shallow embayments. The sampling frame for the fringe potential habitat was constructed by dividing the -6.1 m isobath into 1000 m segments where each segment delineates a sample unit, or site. Isobath segments <1000 m were considered orphans and excluded from sampling. Fringe sites were placed in wide and narrow strata depending on the width of the potential habitat.

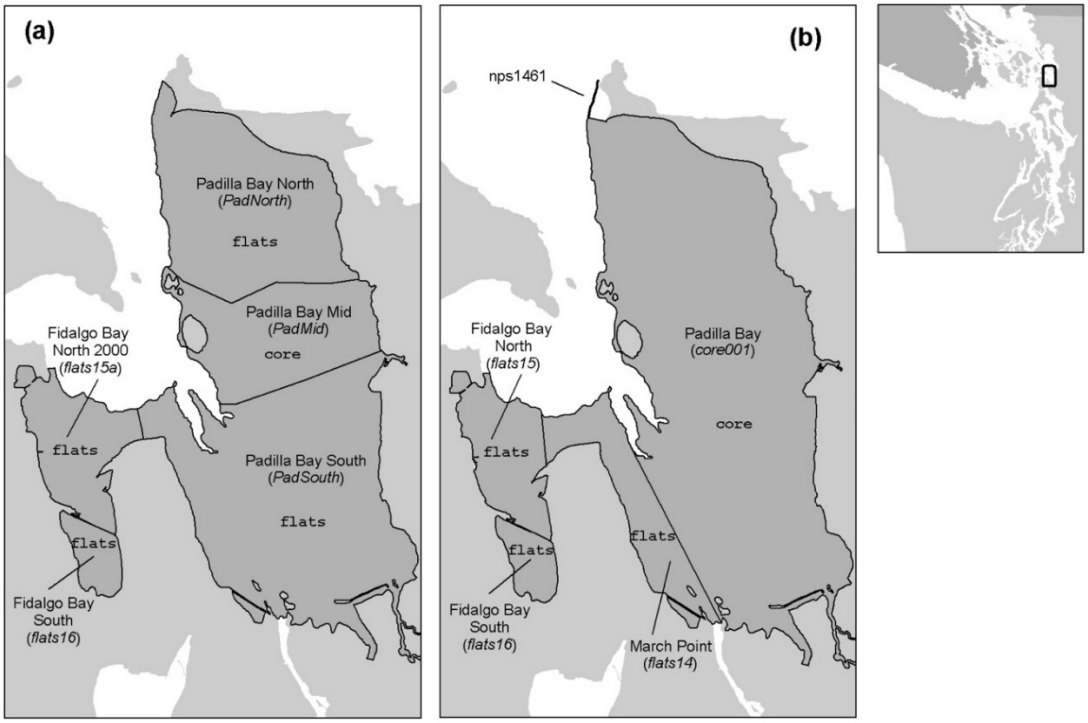


Figure 5. The flats sampling frame in Padilla and Fidalgo Bays in (a) 2000 and (b) afterwards. In 2000, the Padilla Bay Mid site was in the core stratum. Afterwards the majority of the bay was in the core stratum in site core001. Note that the boundary of the Fidalgo Bay North site was adjusted after 2000. This site in the 2000 frame was given a unique site code (flats15a) to distinguish it from the altered site in the post-2000 frame (flats15). Also note that a new site, nps1461, was added to the fringe sampling frame at the northern end of the bay after 2000. In 2000, this potential habitat was part of the flats sampling frame.

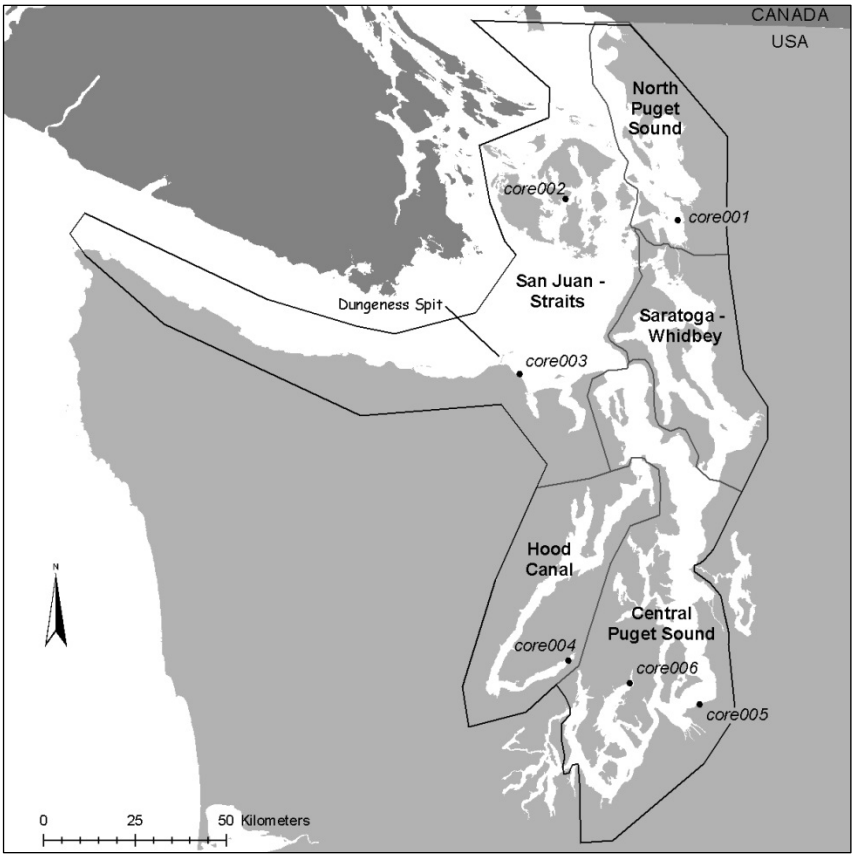


Figure 6. Locations of the six core sites in the greater Puget Sound study area.

The flats sampling frame (n = 74 sites) is divided into three strata. The bulk of the sites (n = 67) are in the "rotational flats" stratum. Four sites were placed in the core stratum as described above. Three sites (flats11, flats12, flats20) were placed in the "persistent flats" stratum. The persistent flats stratum was created after the 2003 sampling to isolate anomalous sites to improve precision of stratum estimates. Previously, these three sites had been included in the main flats stratum (see Dowty 2005 for more detail). All flats sites are assigned site codes with the prefix "flats" – e.g., flats01, flats20.

The fringe sampling frame (n = 2,393) is also divided into three strata. Two sites were placed in the core stratum as described above, and the remaining sites were divided into "narrow fringe" and "wide fringe" strata in 2001 based on the width of the potential habitat at each site (Figure 4). If the distance between ordinary high water and the -6.1 m isobath segment was less than 305 m for a majority of the site, the site was placed in the narrow fringe stratum (n = 1,965). Sites with greater habitat width were placed in the wide fringe stratum (n = 426). This stratification (narrow/wide) was introduced in 2001 as an improvement on the stratification employed in the initial year of monitoring (2000) which placed all fringe sites west of Dungeness Spit in a "low abundance" stratum and all other fringe sites in a "high abundance" stratum.

The sampling frames and stratification, including the changes made over the period of SVMP monitoring, are represented in the database. The various sampling frames and stratification are also summarized in Table 2 (p.19).

For the focus area study, the stratification follows that of the soundwide study but nested within focus areas except for the case of the San Juan Islands/Cypress Island focus area. In the latter case, a custom stratification was designed based on pre-existing data. The details of this stratification are described in the attributes of the site_info table and the strata_extrap table within the database.

2.5 Site Selection and Replacement

This section addresses the methods of site selection and replacement for the soundwide and focus area studies for strata that use data from a sample of sites as the basis for regional extrapolations. To avoid biased regional estimates in these cases, the sample selection must follow specific methodology. For the other studies, the site results themselves are typically of primary interest. In these cases, the sites are not treated as a sample of a larger regional population and site selection is unconstrained.

Site selection refers to the procedure for selecting individual sites for field surveys from the set of sites that make up the soundwide strata (soundwide study) or that make up the focus area strata (focus area study). For strata that are represented by a sample of sites, the site selection is conducted with simple random selection (SRS) where each site in the stratum has an equal probability of being selected. For the core stratum and the persistent flats stratum there is no need to select sites because all sites are subject to field surveys each year – i.e. the core and persistent flats strata are subject to annual census rather than sampling.

Sample replacement refers to how the sample is handled across multiple sampling occasions (years). The most common sample replacement policy for the soundwide study has been 20% sample rotation which was implemented after 2001 (the 2000 samples were retained in 2001). Under this policy, 20% of the sites in the sample are replaced each year in a way that leads to each selected site remaining in the sample for five consecutive occasions before being rotated out of the sample. This is also referred to as partial sample replacement. This 20% sample replacement policy was selected as a compromise between competing goals of optimizing estimates of overall eelgrass abundance (which would call for a newly drawn sample each occasion) and optimizing estimates of change (which would call for a fixed sample across occasions) (Cochran 1977, Patterson 1950, Rao and Graham, 1964).

In 2015, a new policy was introduced that was referred to as “3 rotating panels”. Under this policy, there are three fixed samples of sites, or panels, and the sample used each year rotates through the three panels. The samples collected in 2004, 2009 and 2014 were selected to be the three panels. The five-year intervals between these years ensures, in concept, that the samples are independent, i.e., there are no sites in common between the three panels. In practice, there are a small number of sites (n=6) shared across panels. The shift to this new design was prompted by increasing emphasis on change assessment and

followed simulation studies that showed sub-optimal performance of the 20% sample replacement for trend analysis. The advantage of the 3 rotating panels over a simple fixed sample is that the footprint of the overall sample across the population is three times as large, albeit with lower sampling frequency of individual sites (once every three years vs. annual).

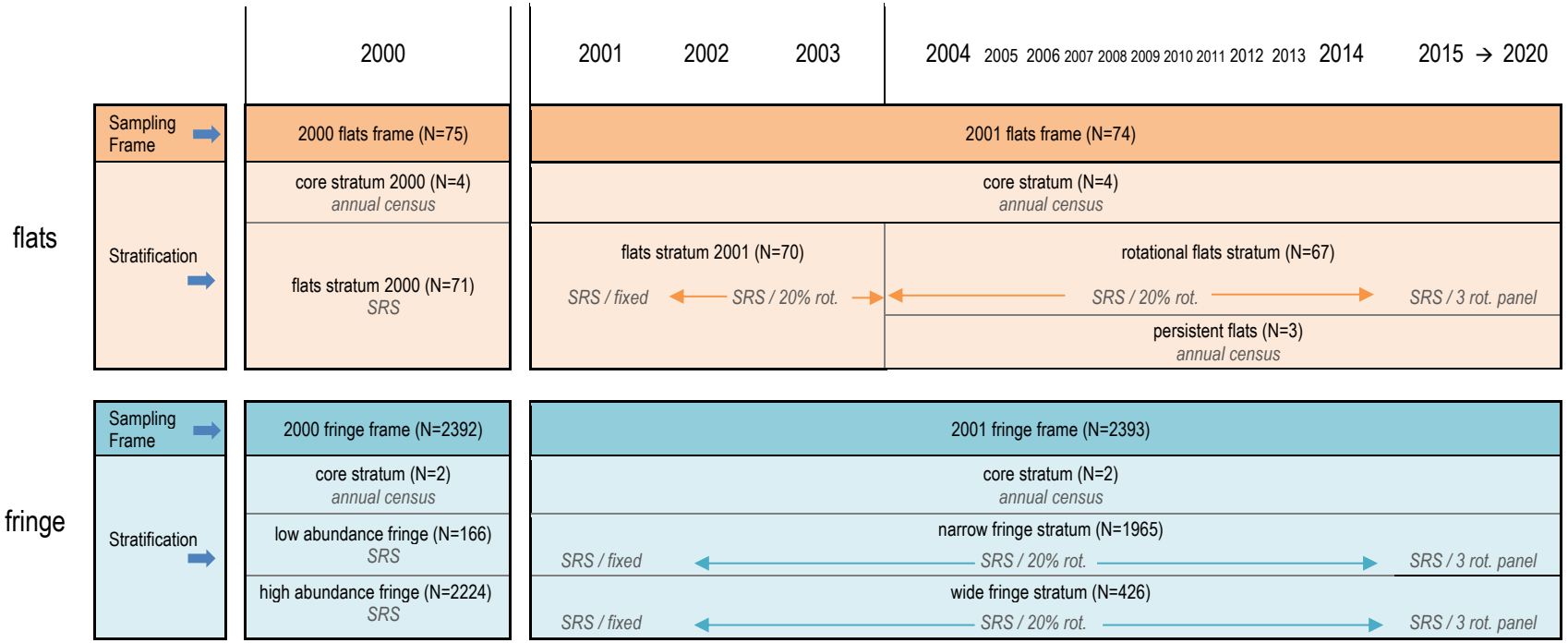
The core and persistent flats strata are annually censused (all sites are surveyed) rather than sampled so there is no sample replacement policy in these cases. The sample selection and replacement policies for characterizing strata are summarized in Table 2.

Table 2. Summary of how sampling of strata in the soundwide study area has changed over the duration of the SVMP soundwide study.

This table summarizes the sampling frames, stratification of the frames, and sampling (or census) of the resulting strata. This is the first stage of sampling. In this context a sample is a collection of sites that are representative of a stratum. Transect sampling of selected sites is not represented in this table. Transect sampling represents a second stage of sampling that is discussed in the next section (2.6).

This table shows the sampling frames and stratification for both categories of potential eelgrass habitat (flats and fringe) for 2000-2020. For each stratum the method of sample selection and sample replacement policy are indicated in smaller gray italics font. Strata are either represented by an annual census of all sites or a sample of sites selected by simple random selection (SRS). The sample replacement policies for sampled strata include fixed (no sample replacement), 20% rotation (partial sample replacement) and 3 rotating panels.

This summary information in this table only pertains to the soundwide study and the focus area study – studies that use data to make estimates that represent SVMP strata.



2.6 Transect Selection and Replacement

The soundwide study has a two-stage sampling design. In such a design, the population of interest (e.g., a soundwide stratum) is represented by a sample (of randomly selected sites). The second stage of sampling occurs when the selected sites are themselves sampled rather than comprehensively mapped. The second stage of sampling is accomplished with transect sampling based on underwater video surveys. For soundwide strata that are censused, as well as the studies that do not rely on a regional sampling framework, the transect sampling of sites is the only stage of sampling. Sample selection and replacement methods are also required for the transect sampling of sites and those are discussed in this section.

The most common method for transect selection across all studies has been simple random selection (SRS). The procedure entails creating a line, or curve, parallel to shore. This line is referred to as the median line and it encompasses the alongshore dimension of the site. Points along the line are randomly selected and shore-normal lines are drawn through the points to generate survey lines.

Other selection methods were introduced later in the monitoring study but with increasing frequency in recent years. In 2013, stratified random sampling with one transect per stratum (STR) was introduced on an experimental basis. The procedure entails dividing the median line at a site in equal length segments with each segment spanning approximately 100 meters of shoreline. Then one point is randomly selected from each median line segment and these are the anchor points for the shore-normal survey lines. In a small number of cases, the selection of points along the median line has relied on systematic selection (SYS) where the midpoint of each median line segment was used as the anchor points for the shore-normal survey lines, resulting in equidistantly spaced transects.

A unique transect selection method was utilized only for the Elwha study. For the sites in this study, a pre-existing sample of transects, typically SRS, were utilized (courtesy of Clallam County). A subset of these SRS transects (coded SUBJ_SRS) was purposively (also subjectively or non-randomly) selected but with an intent to select transects that were evenly spaced (e.g., resembling a systematic sample). Other transect selection methods that appear in the database include a purposive selection from a pre-existing systematic sample (SUBJ_SYS) and an ad-hoc placement of transects made in the field with an effort to have them evenly spaced (AHSYS) thereby resembling a more formal systematic selection.

Lastly, transects that are non-randomly, or subjectively, selected (SUBJ) have been regularly used as part of each of the projects within the dataset. These are used as reconnaissance to generally assess the spatial characteristics of the eelgrass at a site.

Initially, sample replacement for transect sampling consisted of complete sample replacement – i.e., a new random sample was drawn for each sampling occasion. New samples were used exclusively until 2011 when fixed transect samples with no replacement, or “repeat transects”, were introduced on an experimental basis. Starting in

2016, the standard SVMP practice was to use fixed transect samples for the soundwide study as well as all other studies where sites were being revisited. Of course, any occasion where a site is being sampled for the first time relies, by necessity, on a new draw of transects. Transects can be made up of multiple discrete segments, each of which gets is own survey. There are rare cases (n = 3) where the replacement policy (new vs. repeat) varies across the segments for a given transect. In these cases the replacement policy for the transect is coded as "mixed".

The number of transects broken down by transect selection and replacement methods and year are shown in Figure 7 with all studies aggregated. Since 2016, STR has surpassed SRS to become the most frequent selection method. Since 2017, repeat transects have surpassed newly selected transects to become the most frequent.

Repeat transects are visually assessed in the field and later in the office for spatial proximity to the original transect being repeated. Repeat transects that don't meet standards of proximity are flagged as failed repeats. The annual rate of failure has varied from 0% (2011) to 0.6% (2013).

2.7 Site-Level Sampling Methods

At each site sampled, continuous underwater video is recorded along several line transects using a modification of the methods of Norris et al. (1997). Random transects are restricted to a pre-defined polygon that is described below. The video data are post-processed to document seagrass presence and absence. Sampling takes place during relatively high tides so the sampling vessel is most likely to reach the shallow extent of native seagrass (eelgrass and/or surfgrass). Generally, sampling takes place with tides of +1.8 m MLLW or higher but this can vary by site and scheduling restrictions. While the dataset also contains observations of *Z. japonica*, transects frequently do not extend to the shallow edge of *Z. japonica* occurrence and therefore often do not represent the entire spatial extent of *Z. japonica*. At sites with *Phyllospadix scouleri*, the shallow edge of native seagrass also is often inaccessible to the sampling vessel.

Site sampling has predominantly been a three-step process:

1. Reconnaissance video is collected with real-time interpretation prior to sampling to confirm eelgrass presence and to provide a gross spatial characterization of eelgrass presence at the site.
2. If eelgrass is present, an "eelgrass polygon" is delineated which encompasses all eelgrass observations in the reconnaissance and other areas deemed to have some likelihood of eelgrass presence. At sites previously sampled, the previous eelgrass polygon and transect data are available and less effort is allocated to reconnaissance. Eelgrass polygons will only span a portion of the longshore dimension of a site if that best reflects the eelgrass distribution at the site.
3. Random video surveys are collected within the eelgrass polygon. The general target is to collect a minimum of 11 random surveys per site in most cases, but this number varies depending on previously observed variance and tidal conditions. The transects span the width of the eelgrass polygon perpendicular to shore. The mean boat speed along the transects is approximately 0.9 m s^{-1}.

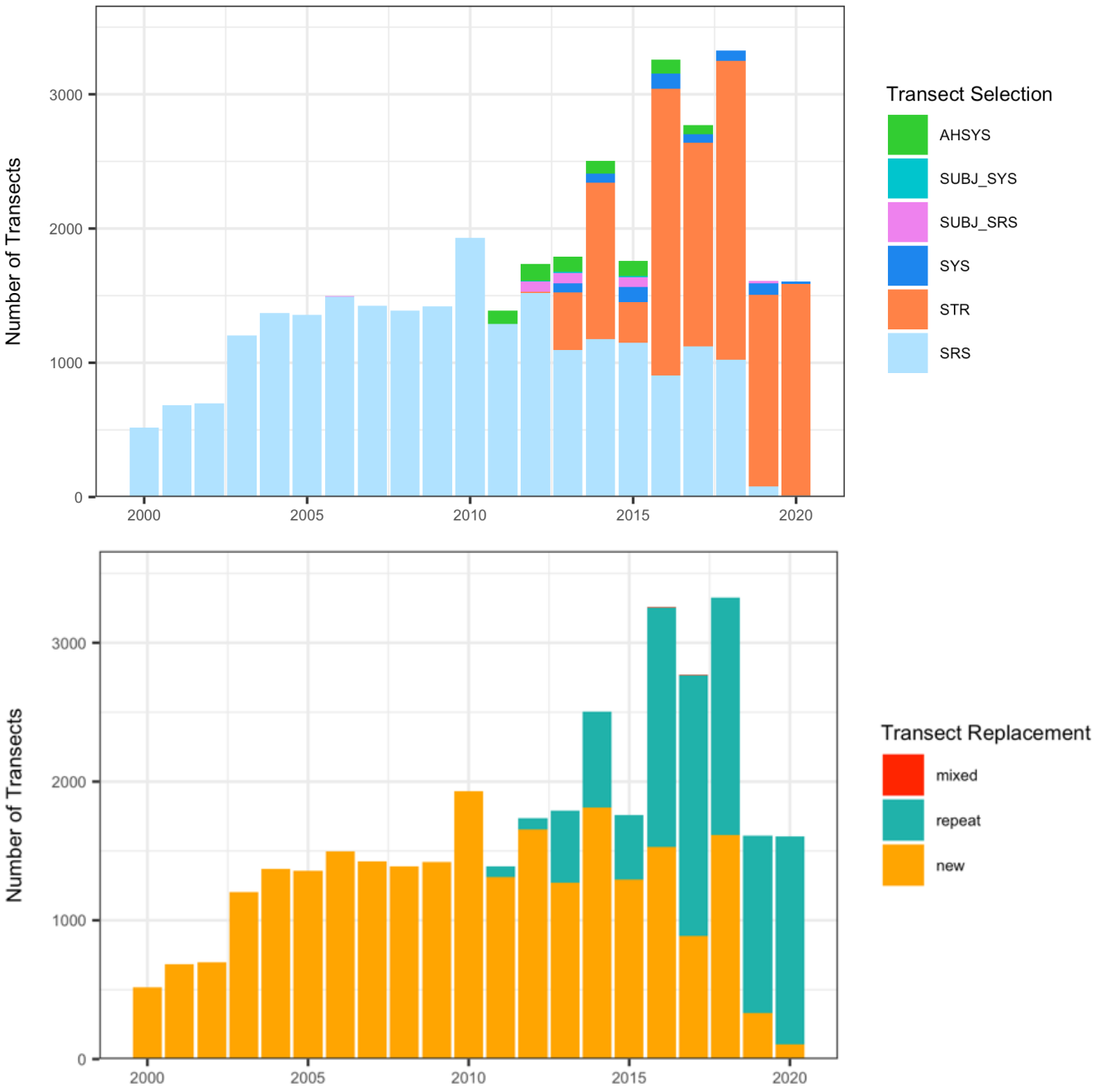


Figure 7. Numbers of transects contained in the 2000-2019 dataset by year and transect selection (top) and replacement (bottom) categories when all studies are pooled. Transect selection methods are simple random selection (SRS), stratified random selection with one transect per stratum (STR), systematic selection (SYS), subjective selection from a pre-existing SRS selection (SUBJ_SRS) or a pre-existing SYS selection (SUBJ_SYS) or an ad-hoc systematic selection (AHSYS). Sample replacement policies are total sample replacement with a new random draw each occasion (new), or a fixed sample that is repeatedly surveyed (repeat) over time. There are three cases of "mixed" replacement that are not visible but occur in 2016 and 2017. These summaries only include planned transects and only transects derived from successful surveys (excludes aborted or obstructed surveys).

When STR transect selection was introduced to the SVMP in 2012, it was integrated with a new site sampling process that has been used exclusively for STR site samples. The main difference is that the eelgrass polygon spans the entire longshore dimension of the site regardless of the eelgrass distribution. Reconnaissance is then not necessary but may be used to characterize the shallow and deep limits of eelgrass at the site without regard to the longshore distribution of eelgrass. STR sampling also differs from other SVMP sampling in the treatment of sites where eelgrass is absent. Typically, if reconnaissance leads to an assessment that a site has no eelgrass or surfgrass, then no eelgrass polygon is delineated and no random surveys are collected. With STR sampling, the random STR surveys are collected regardless of seagrass presence at the site.

In cases where obstacles (e.g., buoys, moored boats, submerged rocks, dense surface canopy-forming kelp) forced the boat to deviate from the transect more than 25% of the total transect length, then the transect was discarded and another randomly selected. In cases where obstacles precluded sampling over greater than 25% of the area at a site, the site was coded as "obstructed" and not sampled. In cases where eelgrass was observed but in such low abundance that transect sampling was not practical, the site was coded as "trace". In the attribute tables for trace sites, vegetation occurrence fields are coded to indicate eelgrass is present, but the numeric estimate of eelgrass area is set to zero.

The random video transects are the basis for estimating site eelgrass area and the depth range of the bed. In concept, these transects are straight lines that are locally perpendicular to the shore, although actual transects depart from these conditions to varying degrees.

At all sites, specimens were collected as needed for species identification particularly in mixed beds of *Z. marina* with *Z. japonica* or *Phyllospadix* spp.

2.7.1 Survey Equipment

The sampling has been conducted primarily from an 11 m research vessel. The vessels and survey equipment have been supplied through a contract with Marine Resources Consultants (MRC) of Port Townsend, Washington (with the exception of data associated with the Island County Marine Resources Committee study). When monitoring was initiated in 2000, the underwater camera used was a SeaCam 2000 (DeepSea Power and Light, San Diego) but this was replaced by the SuperSeaCam in 2003 because of its greater light sensitivity. In 2005 a two camera system was introduced that had a forward-looking camera to help with camera height adjustment. These cameras were the SplashCam Deep Blue Pro Color (Ocean Systems, Inc.). In 2015, a high-definition camera was initially used (SplashCam Deep Blue HD) but after cable problems the previous camera (Deep Blue Pro Color) was brought back into service. In recent years, the main camera has alternated between standard and HD cameras.

The main camera is mounted with a downward-looking orientation on a towfish that is approximately 45 kg. The towfish is deployed off the stern using a cargo boom and boom winch. An operator uses the boom winch to control camera height while viewing real-time video. A 250W underwater light (RiteLite, Deep Sea Power and Light) was initially mounted on the towfish for use when there is insufficient ambient light. This was replaced

by a 500W RiteLite in 2005. Parallel lasers (Deep Sea Power and Light) mounted 10 cm apart are used to create red dots in the video images as a scaling reference.

Depths were initially measured with a Garmin Fishfinder 240 but a BioSonics DE 4000 Series echosounder was introduced in 2002 to be able to consistently find the bottom depth below a thick canopy of eelgrass and other marine vegetation. In 2015, the BioSonics instrument was replaced with the MX model.

The antenna of a differential GPS is mounted at the top of the cargo boom so its location coincides with the video camera. Initially the GPS was a Trimble AgGPS 132 but more recently the GPS has been a Hemisphere VS330 with Satellite Based Augmentation System (SBAS). Video was initially recorded on VHS tape but starting in 2004 the video was recorded on both 8 mm tape (DV format) and DVD. In 2012, video was also stored on hard drives in DV format. A video overlay stamps the time on the video continuously with updates at one-second intervals. Since 2013, hard drives have been the primary media for storing video with formats including DV and the Apple ProRes format.

Since 2004, a 5 m aluminum skiff has been occasionally used for sampling at a few sites that presented navigation challenges and might otherwise have been discarded due to obstacles. In these cases, underwater video was not collected along the transects. Instead, eelgrass presence was interpreted from the BioSonics echosounder data (Sabol et al. 2002). A video camera was lowered to validate questionable acoustic signals and seagrass samples were collected for species identification.

2.7.2 Video Post-Processing

All underwater video from the random transects is reviewed and classified in the office. In concept, the video is used to classify each 1 m increment of a 1 m-wide belt transect into presence/absence categories for eelgrass (*Z. marina*), surfgrass (*Phyllospadix* spp.) and *Z. japonica*. This results in a classification with a nominal 1 m^2 resolution. Variations in density and percent cover within each 1 m^2 unit are not captured. Video quality was recorded for each 1 m^2 unit as good or poor. Video quality was classified as poor when the vegetation could not be classified due to high turbidity or very low light conditions.

In practice, all video frames with the same 1-second GPS time stamp are classified as a single unit. The dimension of each classified unit in the along-track direction is determined by boat speed which is variable but generally in the range of 0.5 – 1.3 m s^{-1}. The video processors use the recorded laser beams as a scale reference. The width of the transect that is classified is nominally 1 m wide in the cross-track dimension but this is approximate and depends on camera height above the sediment surface.

Seagrass presence is assessed only when the video processor has reasonable certainty that there is at least one rooted plant within the video frame. If a plant is visible but appears to be rooted to either side of the 1 m-wide belt it is not considered. In practice, the video processors often make a subjective determination on whether a plant is rooted within the classification area, particularly when poor water clarity obscures the substrate.

The training for the video classification has been refined each year to maximize accuracy and consistency between processors. Starting in 2004, processor precision has been tracked using a subset of actual video data. Reeves et al. (2007) describe the precision within and between processors.

For the sites sampled with the skiff, where no video data is collected, the BioSonics echosounder data has been processed to determine eelgrass presence or absence. In these cases, the video quality field is a more general data quality field.

Occasionally, the eelgrass polygon is adjusted as part of post-processing. This is done where the field-delineated polygon did not encompass all eelgrass observed during reconnaissance. It is also done where transects do not span the initial polygon, in which case the polygon is contracted to the area sampled by the transects. While post-hoc eelgrass polygon adjustment is allowed under limited circumstances in the cross-shore dimension, it is prohibited in the long shore dimension.

2.8 Estimation

A site is considered sampled when either a random sample of transects is surveyed with underwater video, or reconnaissance leads to a determination that there is no seagrass present at the site. For sites where random transects are surveyed, estimates are made of site eelgrass area and standard error. In addition, the mean maximum and mean minimum eelgrass depth and standard errors are estimated.

For site results associated with a study with a regional sampling design (i.e., the soundwide for focus area studies), the site results are used to make estimates of eelgrass area and standard error for each stratum and for the overall total. Only the site-level results are contained within the 2000-2019 database but the estimators are presented here for both site-level and regional statistics. The eelgrass area estimators follow Skalski (2003).

2.8.1 Site Estimates

For the purposes of estimation, each transect is clipped to the extent that spans the eelgrass polygon. Portions of transects that fall outside the polygon are discarded for the purposes of estimation. The transect portion within the eelgrass polygon is reduced to two length values – the total length of the segment, L, and the length of the segment that contains eelgrass, l. Transect points that are flagged with a poor data flag (e.g., due to poor visibility) are treated as missing data and do not contribute to these lengths. Transect i gives an observation of eelgrass fraction p_i given by the ratio

$$p_i = \frac{\boldsymbol{l_i}}{\boldsymbol{L_i}}. \qquad \textbf{Equation 1}$$

The mean fraction over the eelgrass polygon is estimated from all m transect observations as

$$\hat{\bar{p}} = \frac{\sum_{i=1}^{m} l_i}{\sum_{i=1}^{m} L_i}. \qquad \textbf{Equation 2}$$

The estimator for site eelgrass area is given by

$$\hat{X} = E \cdot \hat{\bar{p}}. \qquad \textbf{Equation 3}$$

where E is the area of the eelgrass polygon. The sample variance of p is estimated as (Cochran 1977, equation 2.45, p.32)

$$\widehat{Var}(p) = \frac{\sum_{i=1}^{m}\left(l_i - \hat{p}L_i\right)^2}{(m-1)\bar{L}^2} \quad \textbf{Equation 4}$$

and the variance of the estimated mean fraction is estimated as

$$\widehat{Var}(\hat{p}) = \frac{\sum_{i=1}^{m}\left(l_i - \hat{p}L_i\right)^2}{(m-1)m\bar{L}^2} \quad \textbf{Equation 5}$$

where

$$\bar{L} = \frac{\sum_{i=1}^{m} L_i}{m}.$$

The variance of the estimate of site eelgrass area is expressed as

$$\widehat{Var}\left(\hat{X}\right) = E^2 Var(\hat{p}) \quad \textbf{Equation 6}$$

and the standard error of the estimate of site eelgrass area is given by

$$\widehat{SE}\left(\hat{X}\right) = \sqrt{\widehat{Var}\left(\hat{X}\right)}. \quad \textbf{Equation 7}$$

If the maximum depth of eelgrass observed on transect i is D_i, and the minimum depth is d_i, then the mean maximum eelgrass depth and mean minimum eelgrass depth at the site are estimated as

$$\hat{\bar{D}} = \frac{\sum_{i=1}^{m} D_i}{m},\ \hat{\bar{d}} = \frac{\sum_{i=1}^{m} d_i}{m}. \quad \textbf{Equation 8}$$

The sample variances of the depth observations are estimated as

$$\widehat{Var}(D) = \frac{\sum_{i=1}^{m}\left(D_i - \hat{\bar{D}}\right)^2}{m-1},\ \widehat{Var}(d) = \frac{\sum_{i=1}^{m}\left(d_i - \hat{\bar{d}}\right)^2}{m-1} \quad \textbf{Equation 9}$$

and the variances on the estimates of the means are given by

$$\widehat{Var}\left(\hat{\bar{D}}\right) = \frac{\widehat{Var}(D)}{m},\ \widehat{Var}\left(\hat{\bar{d}}\right) = \frac{\widehat{Var}(d)}{m} \quad \textbf{Equation 10}$$

2.8.2 Flats Stratum Estimates

This section addresses estimation for flats strata that are sampled. These include the flats stratum 2000, the flats stratum 2001 and the rotational flats stratum (see Table 2, p.19). The persistent flats stratum is censused and is handled separately (section 2.8.4).

The estimator for the area, B, of the flats stratum is expressed as

$$B = \left[\frac{\sum_{j=1}^{n}\widehat{X_J}}{\sum_{j=1}^{n} a_j}\right] \cdot \sum_{j=1}^{N} a_j = \left[\frac{\sum_{j=1}^{n}\widehat{X_J}}{\sum_{j=1}^{n} a_j}\right] \cdot A \quad \textbf{Equation 11}$$

where

a_j = the area of the jth site in the flats stratum,
n = the number of sites in the sample of the flats stratum,
N = the total number of sites in the flats stratum,
A = the total area of sites in the flats stratum.

The variance of the estimated eelgrass area for the flats stratum is given by (see Skalski 2003 for derivation)

$$\widehat{Var}(\hat{B}) = N^2\left(1-\frac{n}{N}\right)\frac{\sum_{j=1}^{n}\left(X_j - a_j\hat{R}\right)^2}{n(n-1)} + \frac{N\sum_{j=1}^{n}\widehat{Var}(\widehat{X_j})}{n} \quad \textbf{Equation 12}$$

where

$$\hat{R} = \frac{\sum_{j=1}^{n}\widehat{X_j}}{\sum_{j=1}^{n}a_j}.$$

The standard error of the estimate of flats stratum eelgrass area is given by

$$\widehat{SE}(\hat{B}) = \sqrt{\widehat{Var}(\hat{B})}. \quad \textbf{Equation 13}$$

2.8.3 Fringe Stratum Estimates

This section addresses estimation for fringe strata that are sampled. These include the narrow fringe stratum, wide fringe stratum and the low and high abundance strata used in 2000 (see Table 2, p.19). Extrapolation from the sample to the stratum considers the stratum population as a collection of 1000 m line segments on the -6.1 m isobath.

Estimation for the fringe strata has an element to account for the errors in the fringe sampling frame ("orphans", see p.14). If L_T is the total length of the -6.1 m isobath that meet the criteria of the fringe stratum (sites + orphans) and L_N is the total length of the sampling frame within the fringe stratum (sites only), then the estimate for the sampled population (the sampling frame within the stratum) is expanded by the multiplier

$$\frac{L_T}{L_N}.$$

The estimator for eelgrass area within a fringe stratum is then

$$\hat{B} = \left(\frac{L_T}{L_N}\right)\left[\frac{N}{n}\sum_{i=1}^{n}\widehat{X_i}\right]. \quad \textbf{Equation 14}$$

The variance of the eelgrass area estimate is estimated as

$$\widehat{Var}(\hat{B}) = \left(\frac{L_T}{L_N}\right)^2\left[\frac{N^2\left(1-\frac{n}{N}\right)s_{\hat{X}}{}^2}{n} + \frac{N}{n}\sum_{i=1}^{n}\widehat{Var}(\widehat{X_i})\right] \quad \textbf{Equation 15}$$

where

$$s_{\hat{X}}^2 = \frac{\sum_{j=1}^{n}(X_i-\bar{X})^2}{n-1}, \text{ and}$$

$$\bar{X} = \frac{\sum_{k=1}^{n}\widehat{X_k}}{n}.$$

The standard error of the fringe stratum eelgrass area estimate is given by

$$\widehat{SE}(\hat{B}) = \sqrt{\widehat{Var}(\hat{B})}. \quad \textbf{Equation 16}$$

2.8.4 Censused Stratum Estimates

The strata subject to a census include the core and persistent flats strata. The sites within the stratum are not sampled but rather an estimate of eelgrass area is made for each site in the stratum.

The stratum estimate of eelgrass area is given by

$$\hat{B} = \sum_{i=1}^{n} \hat{X}_i. \quad \textbf{Equation 17}$$

The variance of the eelgrass area estimate is estimated by

$$\widehat{Var}\left(\hat{B}\right) = \sum_{i=1}^{n} \widehat{Var}\left(\hat{X}_i\right) \quad \textbf{Equation 18}$$

and the standard error is estimated as for the other strata (Equation 16).

2.8.5 Total Soundwide Eelgrass Area Estimate

The total soundwide eelgrass area is estimated simply as a sum of the stratum estimates:

$$\widehat{B_T} = \sum_{i=1}^{q} \widehat{B}_i \quad \textbf{Equation 19}$$

where

$\hat{B}_i$ = the estimated eelgrass area for stratum *i*,

q = the number of strata.

The variance of the total eelgrass area estimate is estimated by

$$\widehat{Var}\left(\widehat{B_T}\right) = \sum_{i=1}^{q} \widehat{Var}\left(\widehat{B}_i\right) \quad \textbf{Equation 20}$$

and the standard error is estimated as

$$\widehat{SE}\left(\widehat{B_T}\right) = \sqrt{\widehat{Var}\left(\widehat{B_T}\right)}. \quad \textbf{Equation 21}$$

3 Geospatial Database

Over the course of the 21 years of monitoring that are represented in the 2000-2020 database, the database has grown in size and complexity. The monitoring database contains records for 3,328 site samples, 39,781 video surveys and 15.2 million transect points where aquatic vegetation has been classified. At the outset of the monitoring program, the data structure was relatively simple – a selected site had one site visit in a given calendar year and the visit generated one site sample (set of transects). This has evolved to a point where a selected site may have more than one site visit per year and a single site visit may generate multiple site samples of different types. Furthermore, an individual video survey may generate multiple transects, each of which is a member of a different site sample.

The complex monitoring data created challenges and necessitated considerable effort in the database design to accommodate this complexity. The monitoring database now includes 25 tables that include 10 spatial layers. In the past we have made this monitoring database available as web downloads. To meet common visualization and analysis needs, a user typically needed to construct custom data tables from the monitoring database.

Starting with the release of the 2000-2020 monitoring data, we now produce for public distribution a more consolidated set of spatial layers and tables as web downloads. These tables are intended to be easier to navigate and immediately ready to support a wide range of visualization and analysis needs.

This section describes the tables in the new design, the attributes of each table and the values for each attribute.

3.1 Overview

The database is distributed as two ArcGIS version 10 file geodatabases, each contained in a separate Zip archive download. Spatial data are in State Plane projection, Washington South zone, with a NAD83 HARN datum in US Survey feet.

Several terms are defined below that are necessary to fully understand the table values in the download database. All table attributes and attribute values are described in section 3.4 (p.32).

A **site** refers to a specific polygon within the SVMP sampling frames (see section 2.4, p.13) that delineates a section of potential seagrass habitat.

A **site sample** is typically a set of random transects collected at a site for the purposes of making an eelgrass area estimate. But it also includes cases where reconnaissance indicates no eelgrass is present at a site.

Site samples have **study associations** that reflect the purpose of the data collection. Typically for a given field season there will be many site samples associated with a particular study. Any site samples collected as part of work with partner organizations, or supported by a specific contract, would be designated by a unique study in the database. But there are also some cases where a single site sample serves multiple functions and is associated with multiple studies.

As the number of site sampling methods increased and as multiple methods were applied during a single site visit, the situation arose where samples overlapped and a single video survey served the needs of multiple site samples. More specifically, data from one underwater video survey was used as part of two or even three site samples. This led to the development of separate concepts associated with the terms video **survey** and **transect**. The term survey refers to the underwater video collected along a linear path with a starting and ending point determined by when the camera is in place and the video recording equipment begins and ends recording. The term transect refers to either the entire survey or, more commonly, a specific portion of the survey that has a specific purpose in a sampling context and is clipped with a specific sample polygon. Transects can also be non-random and not clipped by a sample polygon as in the case of reconnaissance transects.

In a small number of cases, a transect is made up of multiple distinct **segments**. This happens, for example when a sand bar or small island in the middle of site interrupts the survey line. In such a case, each segment is represented by its own video survey. The segments are combined to make a single transect.

The survey data itself is in the form of point data collected at one second intervals with nominal spacing of 1 meter along the survey line. The actual spacing varies and is dependent on boat speed.

3.2 Metadata

Metadata is included with each data element in the SVMP download dataset. This metadata is integrated into the geodatabases. Much of the information in this user manual is replicated in the metadata for easy access within a GIS environment.

In addition, each of the two Zip archives available for download (section 1.3.1, p.6) includes metadata files in html format describing the data contained within the associated Zip archive.

3.3 Database Design

The two geodatabases that are available for download fit together in one database design as shown in Figure 8. Connectors are used to show the relationships between tables, but these tables were designed to be used as stand-alone objects.

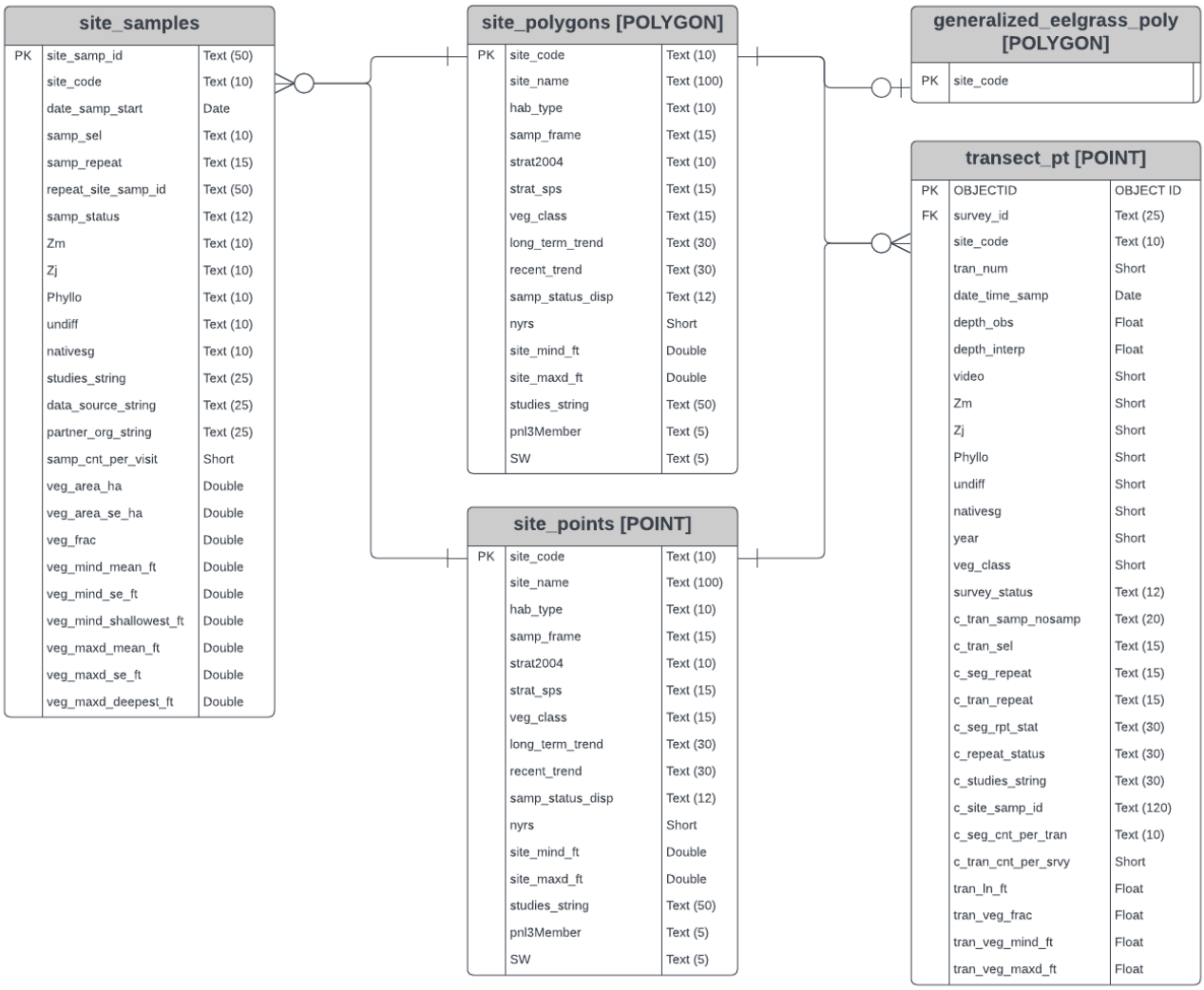


Figure 8. The consolidated tables that make up the 2000-2020 SVMP dataset available for in the form of two web downloads. One download contains just the transect_pt table and associated geometry. The other download contains the other four tables and their geometry.

3.4 Table Descriptions

3.4.1 Site Points and Site Polygons

Sites are represented in both a point layer and a polygon layer. The point layer is most convenient when visualizing many sites over a large area. The polygon layer is best for visualizations focusing on one site or a small number of sites.

Outside of the geometries, the associated tables of the point and polygon layers are identical in structure. The description below applies to both tables (Table 3). There are two sites that were delineated for special purposes within existing site polygons of the SVMP frames. These two sites are only present in the polygon layer, not the point layer:

- flats15aqr – Fidalgo Bay Aquatic Reserve
- sgn2906 – SeagrassNet site

Table 3. Attributes of the site_points and site_polygons attribute tables.

attribute	data type	description
OBJECTID	Integer	unique ID automatically generated by ArcGIS
site_code	Text (10)	Unique alphanumeric code identifying each site.
site_name	Text (100)	Unique name assigned to each site, typically with reference to nearby landmarks or locations.
hab_type	Text (10)	attribute used to group features as a set Domain: **flats** = habitat associated with embayments, deltas, shoals that is not linear in nature **fringe** = habitat occurring in relatively narrow bands parallel to shore
samp_frame	Text (15)	Sampling frame association of each site. This includes true sampling frames intended for regional sampling as well as simple groupings of individual sites delineated for special studies. Domain: **flats** = the SVMP flats frame **fringe** = the SVMP fringe frame **orphan** = SVMP fringe orphans (fringe potential habitat that falls outside the fringe frame **flats_sps** = flats frame in the south Puget Sound (SPS) region **fringe_sps** = fringe frame in the SPS region **orphan_sps** = fringe orphan within the SPS region **outf2013** = 2013 outfall study sites on Orcas Island **reserves** = WA DNR Aquatic Reserve sites **seagrassnet** = site delineated for the SeagrassNet monitoring network
strat2004	Text (10)	Association of site with SVMP stratification in place since 2004. Domain: **core** = core stratum **flr** = rotational flats stratum **flp** = persistent flats stratum **frn** = narrow fringe stratum **frw** = wide fringe stratum **none** = site not associated with this stratification
strat_sps	Text (15)	Stratification within the south Puget Sound region. Domain: **flr_sps** = rotational flats stratum within SPS region **frn_sps** = narrow fringe stratum within SPS region

		frw_sps = wide fringe stratum with SPS region **orphan_frn_sps** = narrow fringe orphan within SPS region **orphan_frw_sps** = wide fringe orphan within the SPS region **none** = site not associated with the SPS region stratification
veg_class	Text (15)	The seagrass species observed at the site. Domain: **Zm** = eelgrass **Zm_Zj** = eelgrass and Zostera japonica mix **Zj** = Zostera japonica **Zm_Phyllo** = eelgrass and surfgrass mix **Phyllo** = surfgrass **no_grass** = no native seagrass observed at the site **no_data** = the site has not been surveyed
long_term_trend	Text (30)	Long-term trend in native seagrass abundance. Domain: **increase** = native seagrass abundance has increased **decline** = native seagrass abundance has declined **no_trend** = no evidence of trend in native seagrass abundance **nograss** = no native seagrass seagrass was observed at the site **trace** = native seagrass observed but only at trace quantities that were insufficient to make a trend assessment. **insufficient_data** = the site has been sampled but there is insufficient data to make a trend assessment. **not_classified** = data from external organization was not assessed for trend **no_data** = the site has not been surveyed
recent_trend	Text (30)	Recent trend in native seagrass abundance based on latest 6 years Domain: **increase** = native seagrass abundance has increased **decline** = native seagrass abundance has declined **no_trend** = no evidence of trend in native seagrass abundance **nograss** = no native seagrass seagrass was observed at the site **trace** = native seagrass observed but only at trace quantities that were insufficient to make a trend assessment. **insufficient_data** = the site has been sampled but there is insufficient data to make a trend assessment. **not_classified** = data from external organization was not assessed for trend **no_data** = the site has not been surveyed
samp_status_disp	Text (12)	The sampling status of the site - whether the site has been selected for sampling and the outcome of the sampling. Domain: **sampled** = the site has been successfully sampled **obstructed** = the site has been selected for sampling but was not successfully sampled due to obstruction. **no_data** = the site has not been selected for sampling or was not successfully sampled due to technical or logistical reasons.
nyrs	Short	The number of times the site has been surveyed. Most sites have only been surveyed once per year, so this is equivalent to the number of years the site has been surveyed. A small number of sites have been surveyed more than once in a given year so the value is not equivalent to the number of years the site has been surveyed.
site_mind_ft	Double	The minimum depth (highest elevation) at which native seagrass was observed at the site. The value is in feet relative to MLLW.
site_maxd_ft	Double	The maximum depth at which native seagrass was observed at the site. The value is in feet relative to MLLW.
studies_string	Text (50)	A concatenated string of study codes for all the studies that the site has been associated with. The study codes are separated by a single underscore.
pnl3Member	Text (5)	Indicates whether the site is a member of one of the three SVMP soundwide rotating panels.

		Domain: **TRUE** = the site is a member of the three SVMP rotating panels **FALSE** = the site is not a member of the three SVMP rotating panels
SW	Text (5)	Indicates whether the site has been surveyed as part of the SVMP soundwide study. Domain: **TRUE** = the site is a member of the three SVMP rotating panels **FALSE** = the site is not a member of the three SVMP rotating panels

3.4.2 Site Samples

Each record in this table represents a site sample. A site sample is typically a set of randomly selected transects but could be based on reconnaissance that determines that no native seagrass is present. Each site in the database will typically have been surveyed on multiple occasions and have multiple records in this table. Selected estimates based on the site sample are included as attributes.

Table 4. Attributes of the site_samples table.

attribute	data type	description
OBJECTID	Integer	Unique ID automatically generated by ArcGIS
site_samp_id	Text (50)	Unique site sample ID string
site_code	Text (10)	Unique alphanumeric code identifying each site
date_samp_start	Date	Date on which the sampling was initiated for this site sample
samp_sel	Text (10)	The selection method used to select the sample of transects. Domain: **SRS** = simple random selection **STR** = stratified random selection with one transect per site sub-section **SYS** = systematic selection with midpoints of each site sub-section **SUBJ** = subjective (non-random) selection **SUBJ_SRS** = subjective selection of transects from a pre-existing SRS sample **SUBJ_SYS** = subjective selection of transects from a pre-existing SYS sample **AHSYS** = "ad hoc" systematic; transects placed in the field with intent to resemble SYS placement.
samp_repeat	Text (15)	Sample replacement policy over multiple sampling occasions Domain: **new** = newly drawn independent sample **repeat** = repeat surveys of previously drawn sample (i.e., no sample replacement or a fixed sample over time) **mixed** = a sample not previously surveyed as a complete sample (in this sense a 'new' sample) but either containing a mix of new and repeat transects or containing repeat transects from a mix of previous sampling occasions
repeat_site_samp_id	Text (50)	The site_samp_id of the sample being repeated for repeat samples. This is a foreign key related to the primary key (site_samp_id) of the same table. **NA** = not a repeat sample so this attribute not applicable
samp_status	Text (12)	Status of sample. Domain: **sampled** = sample successfully completed **obstructed** = sample not successfully completed due to obstruction **exception** = sample data collected but did not conform to protocols; may or may not have led to site estimates
Zm	Text (10)	The presence of eelgrass (Zostera marina) in the sample. Domain:

		present = eelgrass is present **absent** = eelgrass is absent **trace** = trace amounts of eelgrass were observed **no-data** = there is no data on eelgrass presence from this sample
Zj	Text (10)	The presence of Zostera japonica in the sample. Domain: **present** = Zostera japonica is present **absent** = Zostera japonica is absent **trace** = trace amounts of Zostera japonica were observed **no-data** = there is no data on Zostera japonica presence from this sample
Phyllo	Text (10)	The presence of surfgrass in the sample. Domain: **present** = surfgrass is present **absent** = surfgrass is absent **trace** = trace amounts of surfgrass were observed **no-data** = there is no data on surfgrass presence from this sample
undiff	Text (10)	The presence of undifferentiated native seagrass in the sample (eelgrass and/or surfgrass). Domain: **present** = undifferentiated native seagrass is present **absent** = undifferentiated native seagrass is absent **trace** = trace amounts of undifferentiated native seagrass were observed **no-data** = there is no data on undifferentiated native seagrass presence from this sample
nativesg	Text (10)	The presence of native seagrass in the sample. This combines the results of Zm, Phyllo and undiff attributes. Domain: **present** = native seagrass is present **absent** = native seagrass is absent **trace** = trace amounts of native seagrass were observed **no-data** = there is no data on native seagrass presence from this sample
studies_string	Text (25)	The studies associated with the sample in the form of a study code. If a sample has multiple study associations, the study codes are concatenated together and separated by an underscore.
data_source_string	Text (25)	The organization that was the source for the sample data.
partner_org_string	Text (60)	Organization that was a partner in the study that led to the collection of the sample.
samp_cnt_per_visit	Short	The total number of site samples collected during the site visit when the site sample was collected.
veg_area_ha	Double	The estimated area of native seagrass based on the site sample in hectares (ha).
veg_area_se_ha	Double	The estimate of standard error for the estimate of native seagrass area based on the site sample in hectares (ha).
veg_frac	Double	The estimate of mean vegetated fraction within the sampled area (sample polygon) based on the sample.
veg_mind_mean_ft	Double	The mean minimum depth (shallowest elevation) at which native seagrass was observed in the sample. The value is in feet relative to MLLW.
veg_mind_se_ft	Double	The estimate of standard error on the estimate of mean minimum depth (shallowest elevation) at which native seagrass was observed in the sample. The value is in feet relative to MLLW.
veg_mind_shallowset_ft	Double	The minimum depth at which native seagrass was observed in the sample. The value is in feet relative to MLLW.
veeg_maxd_mean_ft	Double	The mean maximum depth at which native seagrass was observed in the sample. The value is in feet relative to MLLW.
veg_maxd_se_ft	Double	The estimate of standard error for the estimate of mean maximum depth of native seagrass based on the sample. The value is in feet relative to MLLW.

veg_maxd_deepest_ft	Double	The maximum depth at which native seagrass was observed in the sample. The value is in feet relative to MLLW.

3.4.3 Generalized Eelgrass Polygons

For sites that have been surveyed and have observations of native seagrass, a generalized eelgrass polygon has been created. This polygon indicates the general area where native seagrass has been present at the site. The polygon does not indicate the area of a continuous seagrass bed. It may contain areas of continuous seagrass bed and it may contain bare areas interspersed with seagrass.

Table 5. Attributes of the generalized_eelgrass_polygons attribute table.

attribute	data type	description
OBJECTID	Integer	unique ID automatically generated by ArcGIS
site_code	Text (8)	unique code to represent the site

3.4.4 Transect Points

The transect point data is the product of the vegetation classification of the video survey data. It consists of points at a nominal 1 meter spacing along the survey line. The actual spacing will vary and depends on boat speed as the video is being collected.

In the data available for download, the transect point data is contained within one Esri file geodatabase, but the data have been separated into annual feature classes (e.g. tran_pt_2000, tran_pt_2001, …) to facilitate comparisons across years. The structure of the attribute table is identical for each annual transect point feature class (Table 6).

Table 6. Attributes of the annual transect point attribute tables.

attribute	data type	description
OBJECTID	Integer	unique ID automatically generated by ArcGIS
survey_id	Text (25)	Unique ID for the survey
site_code	Text (10)	Unique ID for each site
tran_num	Short	Number assigned to survey in the field. The number is unique across all surveys within a site visit.
date_time_samp	Date	Date and time at which the video was collected at the survey point
depth_obs	Float	Observed depth of the point in feet (MLLW) based on an adjusted depth sounder result
depth_interp	Float	Observed depth of the point supplemented with interpolated depth where observations were missing. Values in feet (MLLW). Large segments of missing data were left unaltered.

video	Short	Data quality at the survey point. This attribute is primarily used to flag poor video due to high turbidity that prevents a reliable vegetation classification. It is also used to identify transect points that are not intended to be considered part of the survey, such as when the vessel is backing into place to start the survey. In such a case the quality is classified as poor so these points are excluded from analysis. In more recent surveys, a new attribute value (-1) was introduced for these cases. The attribute is not only a video quality flag because it is also used to assess quality of transect points that rely on BioSonics echosounder data at sites where video is not collected. Domain: **0** = poor quality **1** = good quality **-1** = data not to be used for calculation of transect summaries since point is not part of the formal survey (such as when positioning the boat prior to start of survey). But seagrass presence may still be recorded at such points. **-9999, -99** = missing data
Zm	Short	Presence of eelgrass (Zostera marina) at the transect point. Domain: **0** = absent **1** = present **-9999** = missing data
Zj	Short	Presence of Zostera japonica at the transect point. Domain: **0** = absent **1** = present **-9999, Null** = missing data
Phyllo	Short	Presence of surfgrass at the transect point. Domain: **0** = absent **1** = present **-9999, Null** = missing data
undiff	Short	Presence of undifferentiated native seagrass at the transect point. Domain: **0** = absent **1** = present **-9999, Null** = missing data
year	Short	The year that the transect point was surveyed. This is extracted from the date_time_samp attribute to facilitate symbolization by survey year.
veg_class	Short	A single vegetation class that integrates the presence data for eelgrass, Z. japonica, surfgrass and undifferentiated native seagrass. Domain: **0** = no seagrass present **1** = eelgrass present **2** = eelgrass and Z. japonica present **3** = Z. japonica present **4** = eelgrass and/or surfgrass present **5** = surfgrass present **9** = missing data
survey_status	Text (12)	Status of the survey. Domain: **surveyed** = Survey completed as intended. **obstructed** = Survey not valid due to obstruction. May have been interrupted or completed but with significant spatial deviation from intended survey to avoid obstructions. **aborted** = Survey interrupted and not completed. **replaced** = Survey completed but rejected (typically for poor spatial conformance of repeat survey with target survey line and followed by a replicate

		survey which is the preferred survey for analysis. This survey may be valid for some analyses. **missing-data** = Survey completed but not usable due to missing data associated with a technical problem, typically with the video or GPS data. **outside-site** = Survey successfully completed but located outside site boundary and therefore does hot contribute to the estimate made form the site sample. **Null** = Survey status information not available due to transect point not matching record in surveys table.
c_tran_samp_nosamp	Text (20)	Indicates whether the transect that is based on the survey is a member of a site sample or not. Domain: **sample** = The transect based on the survey is associated with a site sample. For multi-transect surveys, each transect has the value "sample". For cases of multi-segment transects, each segment of the transect has the value "sample". **no-sample** = The transect based on the survey is not associated with a site sample. These are recon transects. **no-sample__sample** = The survey is associated with two transects, one with the value "no-sample" and one with the value "sample". **not_available, Null** = Attribute value not available due to transect points not matching any records in the surveys table, or the segment record not matching any records in the transects table.
c_tran_sel	Text (15)	The selection method used for the transect associated with the survey. For surveys associated with multiple transects, multiple selection methods are possible for a single survey. In these cases, the selection method strings are concatenated together and separated by double underscores. Domain: **SRS** = Survey is the basis of a transect selected by simple random selection **STR** = Survey is the basis of a transect selected by stratified random selection with one transect per stratum **SYS** = Survey is the basis of a transect selected by systematic selection **SUBJ** = Survey is the basis of a transect selected subjectively (non-random). **AHSYS** = Survey is the basis of a transect selected by ad-hoc systematic selection in the field. **SUBJ_SRS** = Survey is the basis of a transect that was subjectively selected from a pre-existing SRS sample of transects. **SUBJ_AHSYS** = Survey is the basis of a transect that was subjectively selected from a pre-existing AHSYS sample of transects. **SUBJ_SYS** = Survey is the basis of a transect that was subjectively selected from a pre-existing SYS sample of transects. **SRS__STR** = Survey is the basis of two different transects, one selected by SRS and one by STR. **STR__SYS** = Survey is the basis of two different transects, one selected by STR and one by SYS. **SRS__SUBJ_SRS** = Survey is the basis of two different transects, one selected by SRS and one by SUBJ_SRS. **STR__SUBJ_SRS** = Survey is the basis of two different transects, one selected by STR and one by SUBJ_SRS. **SUBJ__SUBJ_SRS** = Survey is the basis of two different transects, one selected by SUBJ and one by SUBJ_SRS. **SUBJ__SUBJ_SYS** = Survey is the basis of two different transects, one selected by SUBJ and one by SUBJ_SYS. **not_available, Null** = Value not available in small number of instances due to transect points not matching any records in the surveys table or the segment record not matching any records in the transects table.
c_seg_repeat	Text (15)	Indicates whether the segment based on the survey was a newly selected segment or a repeat survey of a previously selected segment. Domain:

		new = The survey is associated with a newly selected segment. **repeat** = The survey is a repeat survey of a previously selected segment. **new__repeat** = The survey is assoiated with multiple segments (and hence multiple transects). These include a segment with the value "new" and a segment with the value "repeat". **Null** = Value is not available due to transect points not matching any records in the segments table.
c_tran_repeat	Text (15)	Transect retention policy when sampling over multiple occasions. Domain: **new** = The survey is associated with a newly selected transect. **repeat** = The survey is a repeat survey of a previously selected transect. **mixed** = The survey is associated with a multi-segment transect including a segment that is "new" and a segment that is "repeat". **new__repeat** = The survey is associated with multiple transects that include "new" and "repeat" transects. **mixed__repeat** = The survey is associated with multiple transects that include "mixed" and "repeat" transects. **not_available** = Value not available due to failure of transect points to match any records in surveys table or failure of associated segment to match any records in the transects table.
c_seg_rpt_stat	Text (30)	The repeat status of the segment associated with the survey. The repeat status assesses the spatial proximity of repeat segments to the target segment. This attribute is only relevant for repeat transects. Domain: **acceptable** = The segment associated with the survey had acceptable spatial proximity to the target line. **failed** = The segment associated with the survey failed to meet spatial proximity criteria. **not_applicable** = The segment that is based on the survey is associated with a newly selected transect. Consequently, the repeat status of the segment is not applicable. **acceptable__failed** = The survey is associated with multiple repeat segments (and transects) which include a segment with acceptable spatial proximity to the target and a segment that failed to meet the spatial proximity criteria. **acceptable__not_applicable** = The survey is associated with multiple segments (and transects) which include a repeat segment with acceptable spatial proximity to the target, and a newly selected segment for which the repeat status is not applicable. **not_available, Null** = Value is not available due to failure of transect points to match a record in the surveys table or failure of the segment to match a record in the transects table.
c_repeat_status	Text (30)	Repeat status of the transect associated with the survey. The repeat status assesses the spatial proximity of repeat transects to the target transect. This attribute is only relevant for repeat transects. Domain: **acceptable** = The transect associated with the survey has acceptable spatial proximity to the target transect being repeated. **failed** = The transect associated with the survey failed to meet spatial proximity criteria relative to the target transect being repeated. **not_applicable** = The segment that is based on the survey is associated with a newly selected transect. Consequently, the repeat status of the segment is not applicable. **acceptable__failed** = The survey was associated with multiple transects that include instances of acceptable and failed spatial proximity to the target transects being repeated. **acceptable__not_applicable** = The survey was associated with multiple transects that include instances of acceptable spatial proximity and a new transect for which this attribute is not applicable.

		not_available, Null = Value not available due to failure to match transect points to records in the surveys table or failure to match the associated segment with a record in the transects table.
c_studies_string	Text (30)	The studies associated with the survey in the form of study codes. If the survey is associated with a transect that is part of a sample with multiple studies associations, the study codes are concatenated and separated by a single underscore (example: KingCo2018_SVMPsw). If the survey is associated with multiple transects (and site samples) associated with different studies, the study codes are concatenated with a double underscore (example: Suquamish__SVMPfocus).
c_site_samp_id	Text (120)	The unique ID of the site sample(s) associated with the survey. In cases of multi-transect surveys, a survey will be associated with more than one site sample, in which case the values of site_samp_id are concatenated together and separated by a double underscore.
c_seg_cnt_per_tran	Text (10)	A string that indicates whether the transect associated with the survey is a multi-segment transect. The string contains the integer number of segments in the transect with a prefix of "n_". For surveys that are associated with multiple transects, the number of segments for each is concatenated together and separated by an underscore. For example: n_1 = survey associated with one transect containing one segment n_1_2 = survey associated with two transects; one with one segment, and one with two segments. A value of “n” with no integers indicates the value is not available due to a lack of matching records in the data tables.
c_tran_cnt_per_srvy	Short	The number of segments (and transects) associated with the survey. This number is most commonly one but can be more in cases where multiple site samples are collected in one site visit. In a small number (about 5%) of cases, the survey is associated with 2 or even 3 segments (and transects). The value -9 indicates the value is not available due to a database problem that prevents matching the survey with this transect summary information.
tran_ln_ft	Float	Length of the transect associated with the survey in US Survey feet. For surveys associated with multiple transects, the length of the first transect encountered is used, but the lengths would typically have the same value.
tran_veg_frac	Float	Vegetated fraction of the transect associated with the survey as a numeric value. For surveys associated with multiple transects, only one value is selected for this attribute, although these values would typically be equivalent. -99.0 indicates missing data.
tran_veg_mind_ft	Float	Minimum depth (highest elevation) where vegetation was observed along the transect in feet (MLLW). -9999 indicates missing data.
tran_veg_maxd_ft	Float	Maximum depth where vegetation was observed along the transect in feet (MLLW). -9999 indicates missing data.

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