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Submerged Vegetation Monitoring Program

2000-2019 Geospatial Database User Manual

December 21, 2019

PUGET SOUND ECOSYSTEM MONITORING PROGRAM

WASHINGTON STATE DEPT OF NATURAL RESOURCES

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MONITORING PROGRAM

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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.

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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 2000-2019 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 Vital Sign[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 of these studies are contained in the seagrass monitoring database. In addition, limited data collected by other organizations but following 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.

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

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

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 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 file geodatabases. The main geodatabase is accompanied by this user manual and an ArcGIS map document 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 2019 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.

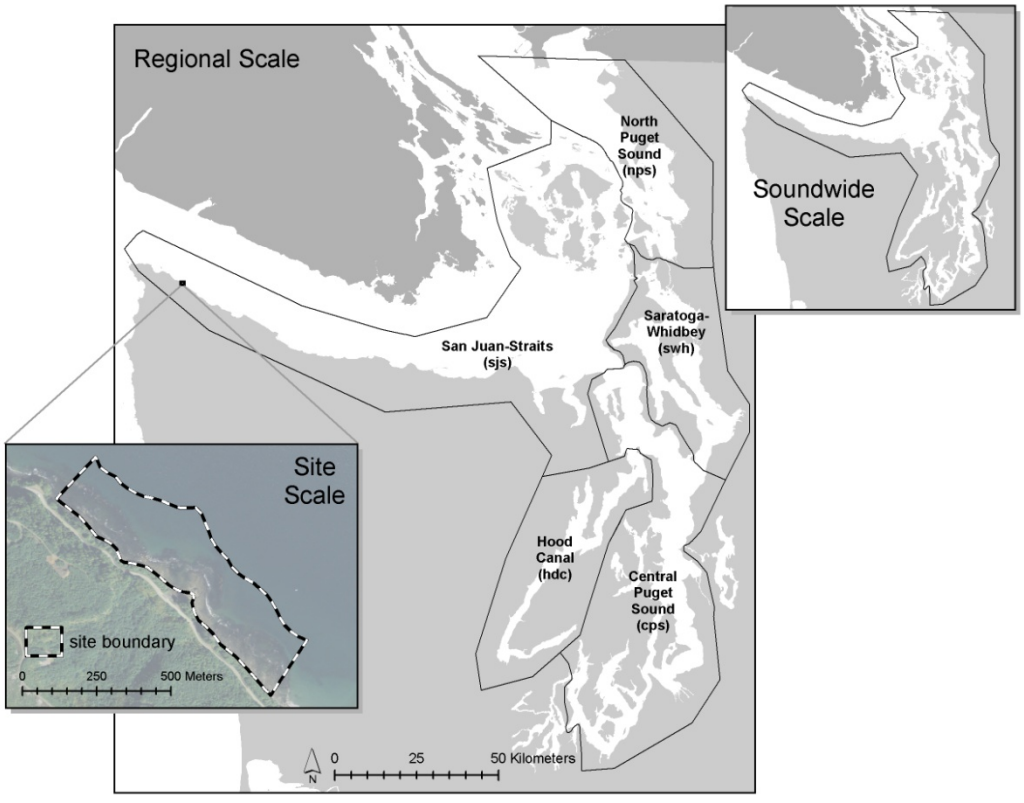


Figure 1. The SVMP monitors eelgrass condition at soundwide, regional, and site scales throughout greater Puget Sound, WA. Letters in parentheses indicate the abbreviations used for each sub-basin, or region.

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; 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, a 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 a set of two ArcGIS version 10 file geodatabases containing related tables and spatial data layers that are available for web download. This user manual, an ArcGIS 10.6.1 map document and html metadata are distributed with the geodatabases. These are available for download through the DNR GIS data access portal: https:/data-wadnr.opendata.arcgis.com.

Also, 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

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 Application

The 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

This data viewer application can also be found with a web search on “Puget Sound seagrass monitoring”.

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.

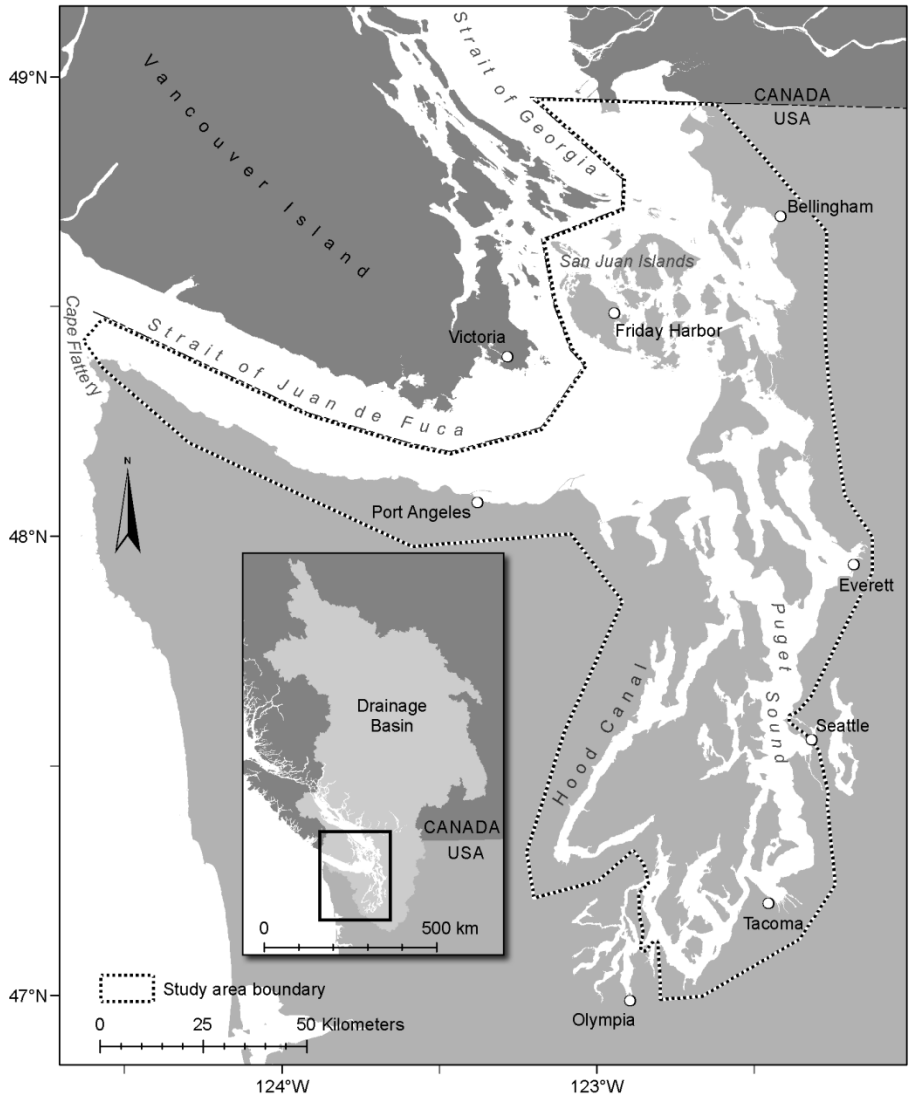


Figure 2. Greater Puget Sound and the SVMP soundwide study area, Washington State (USA).

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 2000-2019 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).

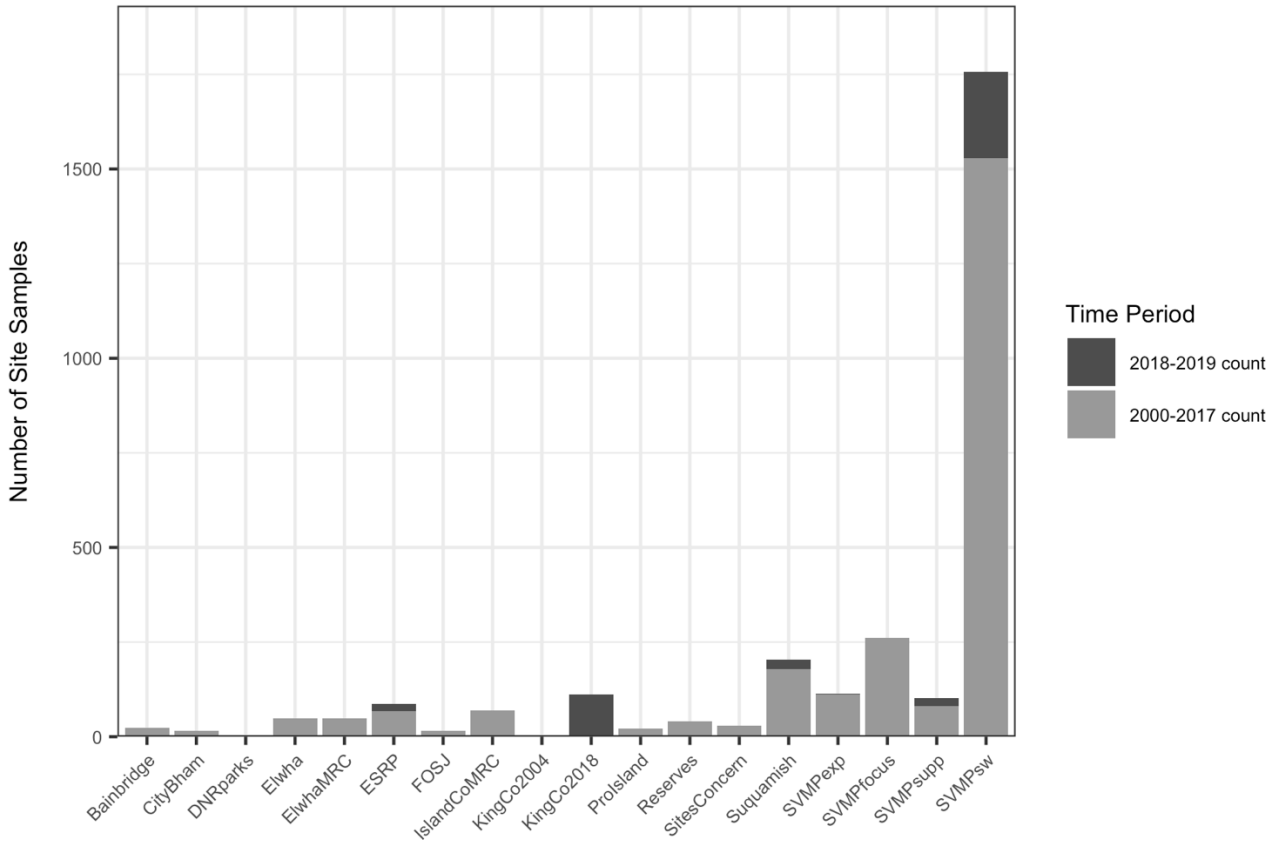


Figure 3. Number of site samples contained in the 2000-2019 dataset broken down by study. A site sample is a set of video surveys collected for estimating native seagrass area at a particular site on a particular sampling occasion. Recent sampling activity (2018-2019) is distinguished from that reflected in the last SVMP data release (2000-2017). Each study is represented by a code along the *x*-axis that is described in Table 1. There is a total of 2,498 site samples collected from 714 unique sites. Posthoc samples (see p.31) are not included.

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 2000-2019 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	1756	DNR
SVMPfocus	SVMP focus area study	262	DNR
Suquamish	Suquamish study	204	DNR and the Suquamish Tribe
SVMPexp	SVMP experimental methods study	114	DNR
KingCo2018	King County 2018 study	111	DNR and King County
SVMPsupp	SVMP supplementary study	103	DNR
ESRP	Eelgrass Stressor-Response Study	87	DNR
IslandCoMRC	Island County Marine Resources Committee	69	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)
SitesConcern	Sites of Concern	29	DNR
Bainbridge	Bainbridge Island study	24	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.

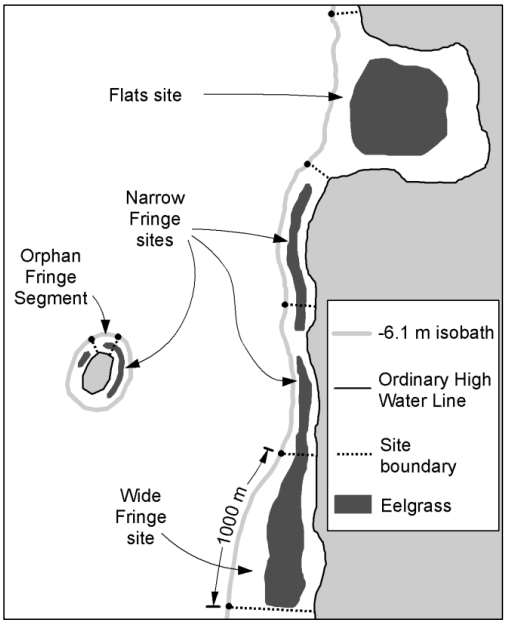


Figure 4. Diagram of potential eelgrass habitat divided into two categories, flats and fringe, based primarily on geomorphological considerations. Flats potential habitat includes large, shallow embayments. The sampling frame for the fringe potential habitat was constructed by dividing the -6.1 m isobath 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.

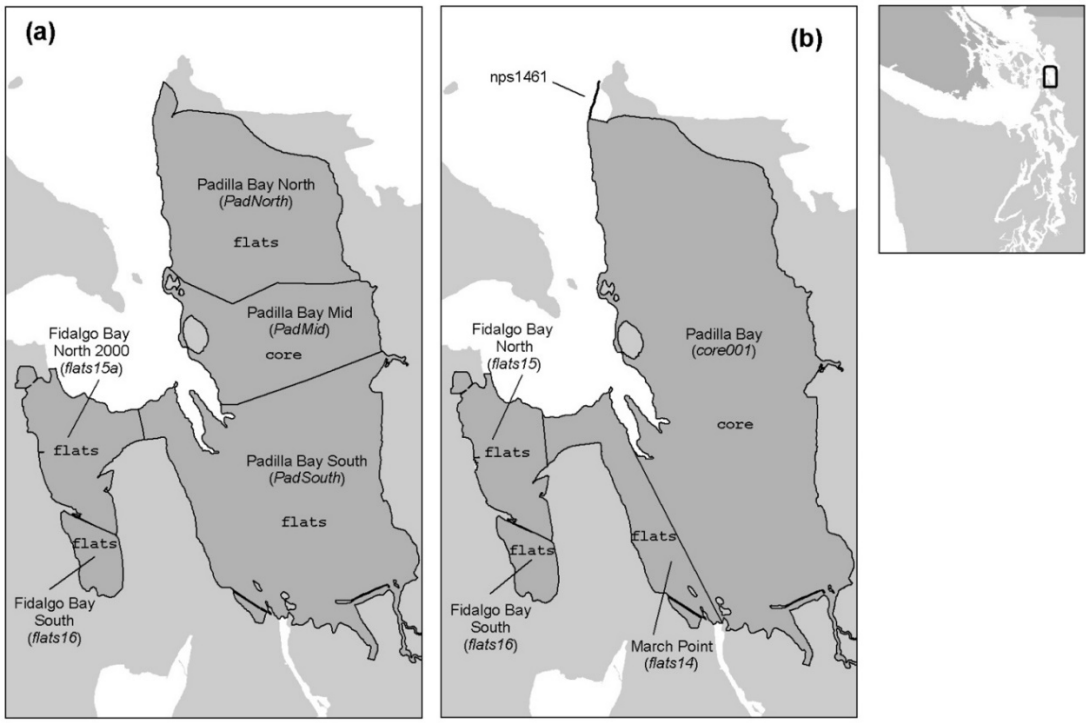


Figure 5. The flats sampling frame in Padilla and Fidalgo Bays in (a) 2000 and (b) afterwards. In 2000, the Padilla Bay Mid site was in the core stratum. Afterwards the majority of the bay was in the core stratum in site core001. Note that the boundary of the Fidalgo Bay North site was adjusted after 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.

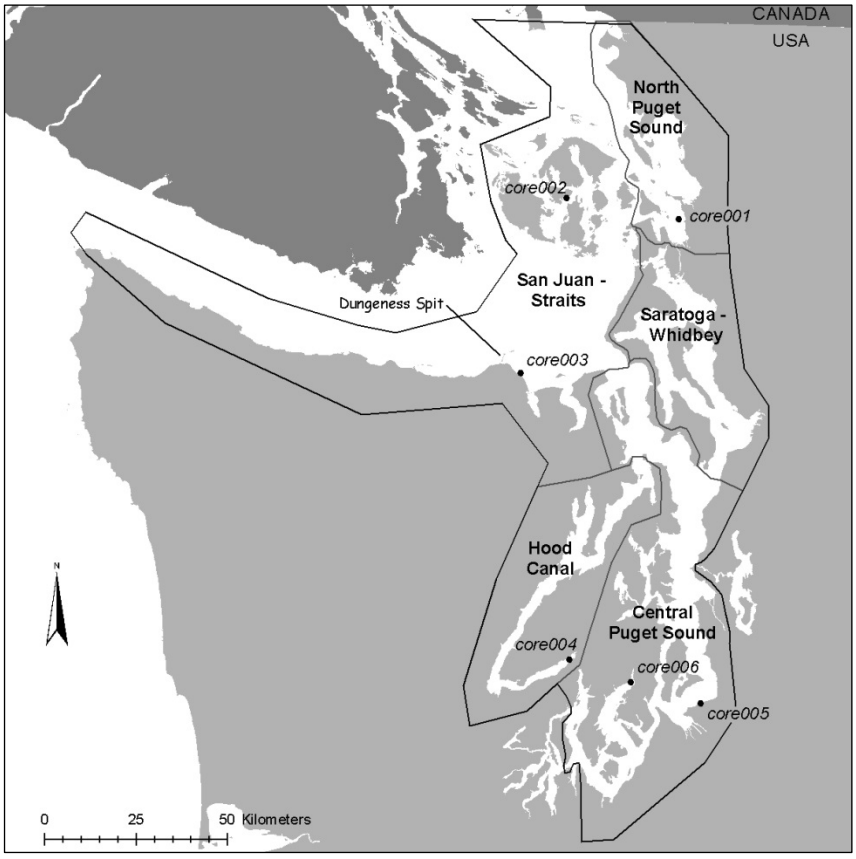


Figure 6. Locations of the six core sites in the greater Puget Sound study area.

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 a number of data layers and tables included in the database (Table 2). The various sampling frames and stratification are also summarized in Table 3 (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.

Table 2. Data elements in the 2000-2019 dataset that pertain to sampling frames and stratification. These elements are characterized in greater detail in section 3, (p.29).

data element name	data element type	description
site_poly_display	polygon feature class	Polygon features used in the ArcGIS map document accompanying the dataset. Includes features for all sites in the current flats sampling frame, the fringe sampling frame and fringe orphans within the SVMP study area as well as the southern reaches of Puget Sound. Also includes three sites that are not members of the SVMP frames (from site_poly_special feature class).
site_poly_2001	polygon feature class	Polygon features for all sites in the current flats sampling frame, the fringe sampling frame and fringe orphans within the SVMP study area as well as the southern reaches of Puget Sound.
site_poly_2000	polygon feature class	Polygon features for all sites in the 2000 flats sampling frame, the fringe sampling frame and fringe orphans within the SVMP study area as well as the southern reaches of Puget Sound.
site_poly_special	polygon feature class	Polygon features for the small number of sites sampled (n=5) that are not members of the SVMP sampling frames.
site_ln_2001	line feature class	Line features along the deep edge of all sites in the current frames and fringe orphans within the SVMP study area as well as the southern reaches of Puget Sound. These features associated with fringe sites are critical in estimation (section 2.8, p.25)
site_ln_2000	line feature class	Line features along the deep edge of all sites in the 2000 frames and fringe orphans within the SVMP study area as well as the southern reaches of Puget Sound. These features associated with fringe sites are critical in estimation (section 2.8, p.25)
site_info	non-spatial table	Table with attributes for all sites that associate each site with sampling frames and stratification.

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).

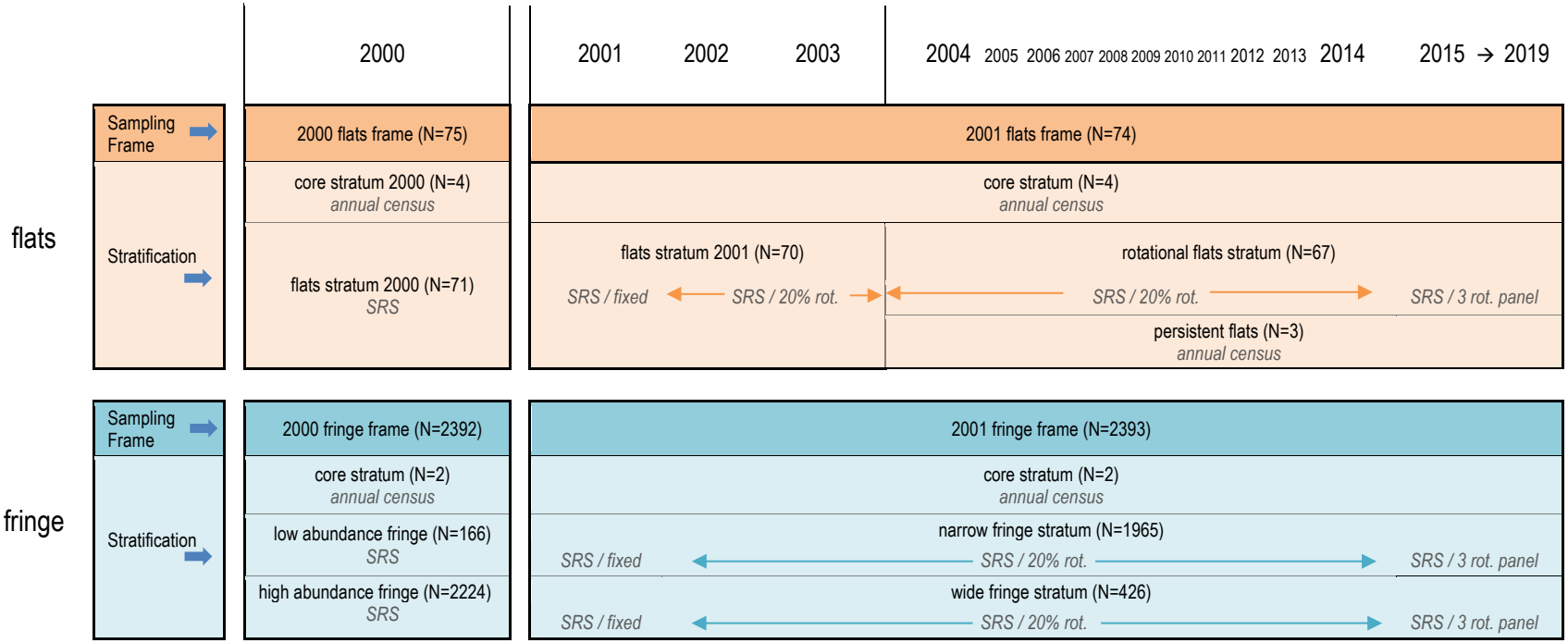
The core and persistent flats strata are annually censused (all sites are surveyed) rather than sampled so there is no sample replacement policy in these cases. The sample selection and replacement policies for characterizing strata are summarized in Table 3.

Table 3. Summary of how sampling 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 2000-2019. 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 are also relevant 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}.

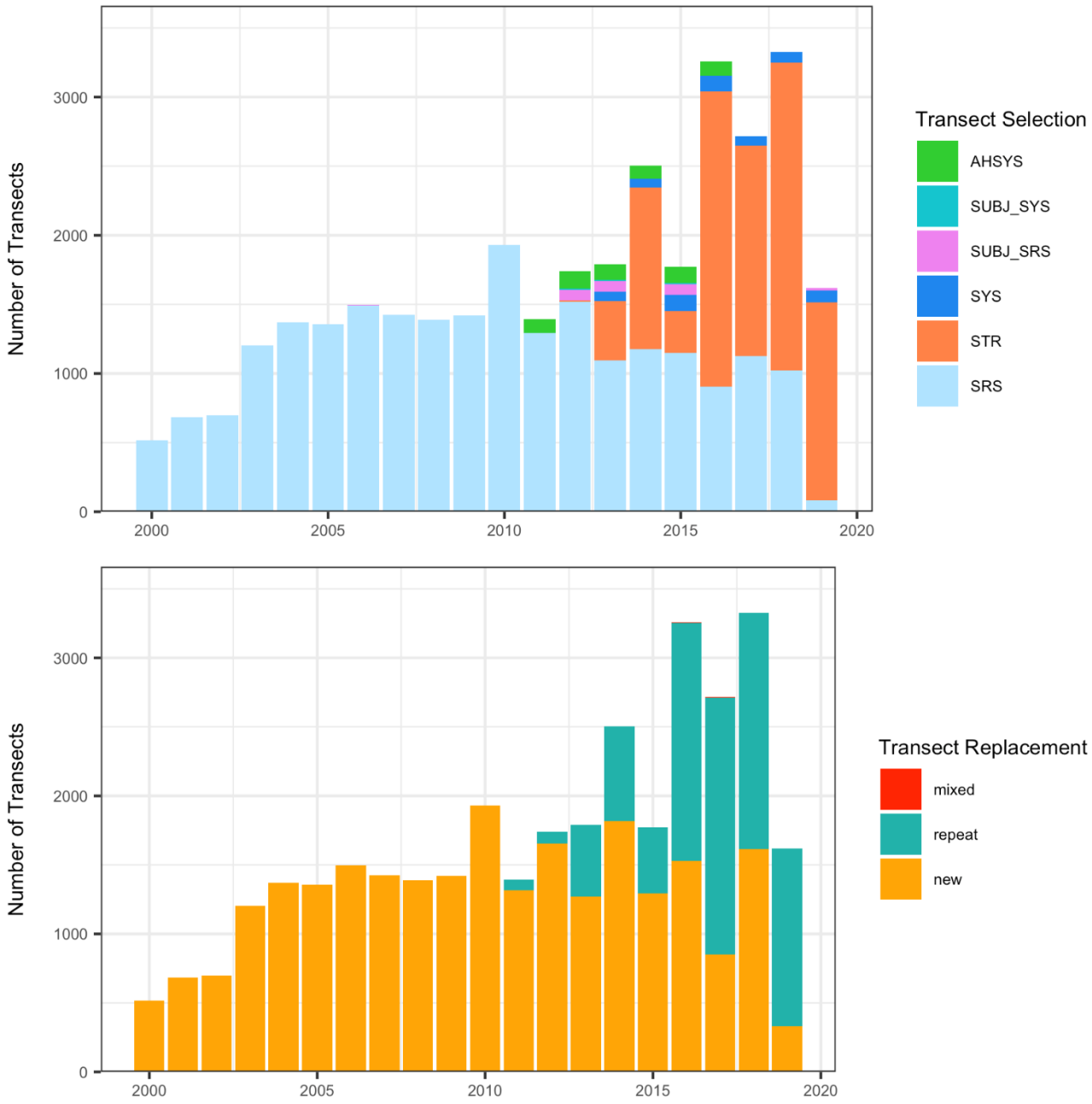


Figure 7. Numbers of transects contained in the 2000-2019 dataset by year and transect selection (top) and replacement (bottom) categories when all studies are pooled. Transect selection methods are simple random selection (SRS), stratified random selection with one transect per stratum (STR), systematic 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 (posthoc transects – see p.31 – are excluded) 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 2016, the SplashCam Deep Blue HD camera was used again. In 2017, the main camera reverted to the SplashCam Deep Blue Pro Color.

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)

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

and the variance of the estimated mean fraction is estimated as

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

where

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

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

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

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 3, 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)

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

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

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

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 3, 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

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

The variance of the eelgrass area estimate is estimated as

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

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

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

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

$\widehat{B}_i$ = 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 20 years of monitoring that are represented in the 2000-2019 database, the database has grown in size and complexity. The database contains records for 3,184 site samples, 38,005 video surveys and 14.2 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. This section describes the tables in the design, the attributes of each table and the values for each attribute.

3.1 Overview

The database is distributed as an ArcGIS version 10 file geodatabase. Spatial data are in State Plane projection, Washington South zone, with a NAD83 HARN datum in US Survey feet.

3.1.1 Table Relationships

We use the term "database" to denote a set of tables with relationships between them based on pairs of primary and foreign keys. These relationships were critical in the population of these tables and subsequent detection and elimination of errors. All of the fundamental relationships between tables are represented in Figure 8 (p.34) but they have not been added to the ArcGIS file geodatabase using the mechanism provided in ArcGIS – the relationship class. This reflects the fact the preparation of the database largely utilized software other than ArcGIS (Microsoft Access and R).

All keys are concatenated strings that combine a number of attributes. This approach facilitated the initial population of the new database design but resulted in some very long keys and data redundancy in some cases. It is possible that eventually we will migrate to more traditional numeric keys as our work with the database evolves.

3.1.2 Basic Concepts

Several data entities and attributes were created to adequately represent the monitoring data. These are introduced here to help the user navigate the database.

A **site sample** is typically a set of random transects collected at a site for the purposes of making an eelgrass area estimate. But the definition must be broadened to accommodate cases where reconnaissance indicates no eelgrass is present at a site. Such a case would be represented by a record in the site_samples table and would also have a record in the site_results table even though there are no associated random transects.

The transect data (or reconnaissance observations) that make up a site sample are collected during a single **site visit**. The site visit can be thought of as a physical visit to a site but in practice the definition must be more flexible. Collection of video surveys for a site sample may take place over multiple days requiring multiple physical visits. For the purposes of the database, all the data collected for a site sample are associated with one site visit and represented by a single record in the site_visits table. By this definition, a site visit may span multiple, even disjunct, days. In recent years, as different site sampling methods have been introduced, there are cases where one site visit will be associated with multiple site samples.

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. Each association between a site sample and a study is represented by a record in the study_associations table. If a user is interested only in randomly selected sites, the study_associations table provides the starting point for selecting this data. Only the soundwide and focus area studies are certain to have randomly selected sites, but these are selected from different spatial domains.

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 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. Surveys are tracked in the surveys table and transects are tracked in the transects table. Both tables must be referenced to fully understand the data elements (Table 4).

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 characterized by its own video survey. The segments are combined to make a single transect.

Table 4. Interpretation of different combinations of attributes from the surveys and transects tables. Both tables must be referenced for interpretation.

survey_status attribute value (surveys table)	tran_repeat attribute value (transects table)	repeat_status attribute value (transects table)	interpretation
surveyed	new	NA	Good new transect.
	repeat	failed	Rejected repeat transect due to poor spatial proximity to target line. Transect may still have value for abundance estimate for given sampling occasion.
		acceptable	Good repeat transect.
replaced	new	NA	Indicates problem identified in the field that led to a replicate survey which is the one to be used for analysis
	repeat	failed	Rejected repeat transect due to poor spatial proximity to target line. A replicate transect was surveyed which is the one to be used in analysis.
missing-data	new	NA	unusable transect
	repeat	failed	unusable transect
obstructed	new	NA	survey not completed
	repeat	failed	survey not completed

The **posthoc sample** was introduced to meet the needs of repeat sample surveys. When repeat surveys were introduced on an experimental basis, a pre-existing site sample was selected to be repeated. The eelgrass polygon in such cases would frequently be adjusted relative to the original set of surveys based on new information not available prior to the original surveys. In order to conduct a change assessment between the times of the original and repeat surveys, the original surveys were clipped to the more recent eelgrass polygon to be spatially consistent with the repeat sample. This revision to the original sample is referred to as a posthoc sample. In the database it is an additional sample, attributed as posthoc, and does not replace the original sample. The posthoc samples are only to be used for change analysis, not for extrapolated eelgrass area estimates.

3.1.3 Dates

It is possible for a single transect point (i.e., a classified area of 1 m^2 nominal area) to be associated with four different dates. This is rare but non-intuitive and therefore deserves explanation. First, the point will be associated with the date (and time) at which the video of the point was recorded. This is reflected in the date_time_samp attribute in the transect_pt table. Second, each transect needs a unique date to help distinguish among transects. This is the date at which the first point on the transect was surveyed. It is reflected in the date_survey_start in the surveys table. Typically, all points on the video survey will have the same date but the date_survey_start attribute is particularly valuable for night surveys where a single survey includes two consecutive dates when spanning midnight.

Third, the date at which surveying is initiated for a site sample is reflected in the date_samp_start attribute in the site_samples table. This associates a single date with each site sample, even when the surveying spans multiple, sometimes disjunct, days. Fourth, the date at which the site visit was initiated is associated with each transect point. This date is recorded in the date_visit_start attribute in the site_visits table. This date gives each site visit a single unique date and is particularly useful when multiple site samples are collected during a single multiple-day site visit.

In summary, the four date attributes related to each transect point are

date_time_samp = date and time when a transect point was surveyed (transect_pt table)
date_survey_start = date at which a video survey was initiated (surveys table)
date_samp_start = date at which a site sample was initiated (site_samples table)
date_visit_start = date at which a site visit was initiated (site_visits table)

3.1.4 File Structure

The SVMP database is separated across two zip archives of Esri ArcGIS 10 file geodatabases (see section 1.3, p.5, for online access). The main reason for dividing the database into separate files was to isolate the very large transect point data from the other data. Then if users want to see site results or general polygons where eelgrass has been observed they do not need to be encumbered by downloading the transect point data.

3.1.5 Database Design

The increased complexity of the data collected and generated by the SVMP has led to a greater reliance on basic relational database design principles. The benefit of this approach is more flexible data structures, less data redundancy and a greater ability to ensure data integrity. The trade-off is that data elements that have logical connections can be separated across multiple tables. Future SVMP data releases may include fewer tables that have been aggregated from the original tables through a series of table joins.

The database design is represented in terms of an entity-relationship (ER) diagram (Figure 8). Each table represents a single data entity with records in the table representing instances of the entity. The tables are connected with lines indicating where there are relationships between the tables and the nature of the relationship.

The ER diagram (Figure 8) contains both attribute tables associated with spatial features and non-spatial tables. The tables have been grouped into four categories to help navigate the diagram (Table 5).

Table 5. Four groups used to organize tables in the SVMP database design (Figure 8).

Table Group	Description
Basic data collection	Data directly related to the collection of video surveys at sites without regard to how the data are organized into samples of individual sites or of soundwide sampling strata.
Site sample information	Information that organizes the basic data into samples of sites including attributes of those samples and associations with specific studies.
Results	Transect-level and site-level results and vegetation occurrence summaries. Larger scale results (soundwide sampling strata) are not currently included in the database.
Sampling frames and stratification	Spatial data that divides the SVMP target populations into discrete sites (the sampling frames) as well as sites delineated for other studies that do not coincide with the SVMP sampling frames. Information on the various stratifications used for these sampling frames is included.

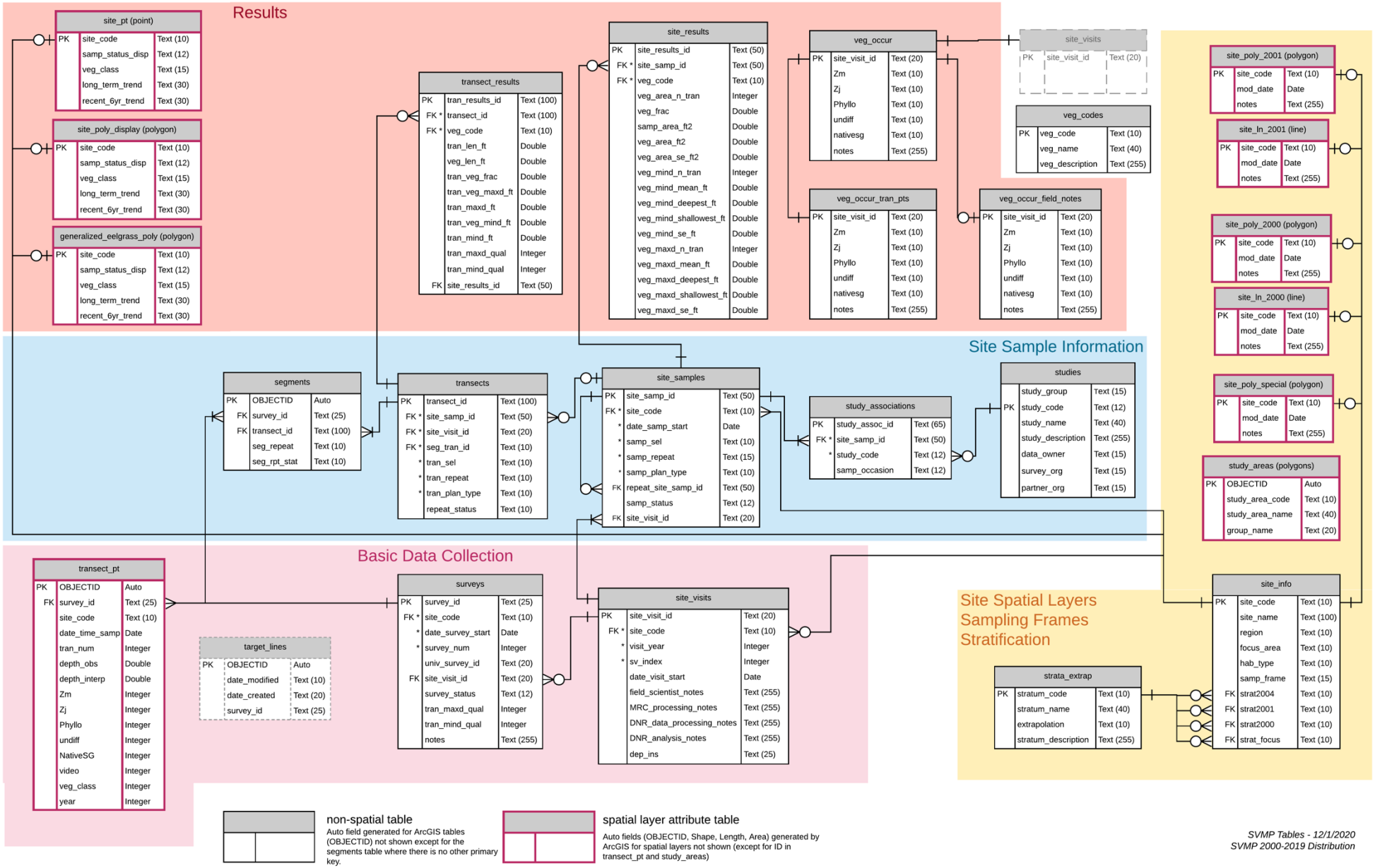


Figure 8. Entity-Relationship (ER) diagram of the SVMP database.

3.2 Sampling Frames and Stratification

3.2.1 Site Polygon Layers

Three different site polygon layers are described here as a group since they share the same attributes and have similar purpose. These three layers are in listed in Table 6. The shared attributes are listed in Table 7.

Table 6. Three site polygon layers that represent SVMP sampling frames as well as delineated sites that are not part of the sampling frames.

feature class name	description
site_poly_2000	Sites as delineated in 2000 that comprehensively cover the potential habitat in greater Puget Sound while being mutually exclusive. These include the sites of the SVMP 2000 sampling frames (flats and fringe) and fringe orphans as well as sites outside the sampling frames in south Puget Sound. For sites in the 2000 flats sampling frame, the polygon areas provide values used in generating estimates for 2000 (section 2.8.2, p.26).
site_poly_2001	Sites as delineated in 2001 that comprehensively cover the potential habitat in greater Puget Sound while being mutually exclusive. These include the sites of the SVMP 2001 sampling frames (flats and fringe) and fringe orphans as well as sites outside the sampling frames in south Puget Sound. These sampling frames have been in use since 2001. For sites in the 2001 flats sampling frame, the polygon areas provide values used in generating estimates for 2001-2019 (section 2.8.2, p.26).
site_poly_special	Sites delineated for special projects that are not part of the SVMP sampling frames. These sites do not form an alternate sampling frame intended for regional monitoring. They are a collection of individual sites created for different projects that do not coincide with sites in the SVMP sampling frames.

Table 7. Attributes in the tables for the site_poly_2000, site_poly_2001 and site_poly_special data layers.

attribute	data type	description
site_code	Text (10)	unique alphanumeric code identifying each site, e.g., core001, cps1245, flats22.
mod_date	Date	last date a modification was made to the record
notes	Text (255)	description of changes to the record or other notes about the site

3.2.2 Site Line Layers

Two different site line layers are described here as a group since they share the same attributes and have similar purpose. These layers originate from the -6.1 m isobath that has been segmented to indicate site boundaries. While line segments are present that bound flats sites, the main purpose of these layers was to develop the fringe sampling frames (each associated with one 1000 m segment on the isobaths) and to provide values needed for fringe stratum estimation – namely the number of sites within each stratum and the total length associated with the stratum (includes orphans).

The attributes in the associated tables are the same as those in the site polygon layers (Table 7).

Table 8. Two site line layers that represent SVMP sampling frames and are used for estimation with fringe strata.

feature class name	description
site_ln_2000	Line segments corresponding with the 2000 SVMP sampling frames and fringe orphans as well as south Puget Sound sites. Segment lengths are used in estimation for strata used with the 2000 fringe sampling frame (section 2.8.3, p.27).
site_ln_2001	Line segments corresponding with the 2001 SVMP sampling frames and fringe orphans as well as south Puget Sound sites. Segment lengths are used in estimation for strata used with the 2001 fringe sampling frame (section 2.8.3, p.27).

3.2.3 study_areas Polygon Layer

Features in this layer delineate the SVMP study area and other regions that are meaningful for different studies. There are five features representing the SVMP regions that have been used as the basis for summarizing SVMP results. There are five features representing the SVMP focus areas that were used for the 2004-2012 focus area study. In addition, there is a feature delineating the south Puget Sound region that is part of greater Puget Sound but is excluded from the SVMP study area. The attributes are described in Table 9.

Table 9. Attributes of the study_areas polygon layer.

attribute	data type	description
OBJECTID	Integer	unique ID automatically generated by ArcGIS
study_area_code	Text (10)	short code to represent study area
study_area_name	Text (40)	name of study area
group_name	Text (20)	attribute used to group features as a set domain: **SVMPfocus** = feature is one of the set of SVMP focus areas **SVMPregion** = feature is one of the set of SVMP regions **Null** = feature is not grouped with other features

3.2.4 site_info Table

This table has a record for each site with attributes associating sites with a sampling frame and stratum. Attributes also place sites within SVMP regions and focus areas. The scope of the table is a union of the site_poly_2000, site_poly_2001 and site_poly_special layers. The attributes are described in Table 10.

Table 10. Attributes of the site_info table.

attribute	data type	description
site_code	Text (10)	Unique alphanumeric code identifying each site, e.g., core001, cps1245, flats22.
site_name	Text (100)	Unique name for site.
region	Text (10)	Name of region where site is located. Domain:

attribute	data type	description
		cps = Central Puget Sound **hdc** = Hood Canal **nps** = North Puget Sound **sjs** = San Juan Islands / Strait of Juan de Fuca **sps** = South Puget Sound **swh** = Saratoga Passage / Whidbey Basin
focus_area	Text (10)	Name of SVMP focus area where site is located. Domain: **cps** = Central Puget Sound **hdc** = Hood Canal **nps** = North Puget Sound **sj-cyp** = San Juan Islands & Cypress Island **swh** = Saratoga Passage / Whidbey Basin **none** = site not located within an SVMP focus area
hab_type	Text (10)	Geomorphic habitat category to which site belongs. Domain: **flats** = flats habitat associated with embayments, deltas, shoals **fringe** = fringe habitat occurring in relative narrow bands parallel to shore
samp_frame	Text (15)	Sampling frame association. This includes true sampling frames intended for regional sampling as well as simple groupings of individual sites delineated for special studies. Domain: **flats** = SVMP flats frame **fringe** = SVMP fringe frame **orphan** = SVMP fringe orphan (outside of fringe frame) **flats_sps** = South Puget Sound flats frame **fringe_sps** = South Puget Sound fringe frame **orphan_sps** = South Puget Sound fringe orphan **elwha** = Elwha study sites **outf2013** = 2013 Outfall study sites (part of Stressor study) **reserves** = DNR Aquatic Reserves sites **seagrassnet** = SeagrassNet site (part of Stressor study)
strat2004	Text (10)	Association of site with SVMP stratification in place starting in 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
strat2001	Text (10)	Association of site with SVMP stratification in place during 2001-2003. Domain: **core** = core stratum **fl2001** = flats stratum 2001 **frn** = narrow fringe stratum **frw** = wide fringe stratum **none** = site not associated with this stratification
strat2000	Text (10)	Association of site with SVMP stratification in place in 2000. Domain: **core** = core stratum 2000 **fl2000** = flats stratum 2000 **frhi** = high abundance fringe stratum **frlo** = low abundance fringe stratum **none** = site not associated with this stratification
strat_focus	Text (10)	Association of site with the stratification used for the SVMP focus area study. Domain: **core** = core stratum

attribute	data type	description
		flr = rotational flats stratum **flp** = persistent flats stratum **frn** = narrow fringe stratum **frw** = wide fringe stratum **fla** = flats absent stratum (sites thought to have no seagrass) **flo** = flats other stratum (sites thought to have seagrass or status unknown) **fra** = fringe absent stratum (sites thought to have no seagrass) **fro** = fringe other stratum (sites thought to have seagrass or status unknown) **none** = site not associated with this stratification

3.2.5 strata_extrap Table

This table contains a description and the extrapolation method for each stratum represented in the database. The table attributes are described in Table 11.

Table 11. Attributes of the strata_extrap table.

attribute	data type	description
stratum_code	Text (10)	Short code to represent stratum. Domain: **core** = core stratum **fl2000** = flats stratum 2000 **fl2001** = flats stratum 2001 **flr** = rotational flats stratum **flp** = persistent flats stratum **frn** = narrow fringe stratum **frw** = wide fringe stratum **frhi** = high abundance fringe stratum **frlo** = low abundance fringe stratum **fla** = flats absent stratum (sites thought to have no seagrass) **flo** = flats other stratum (sites thought to have seagrass or status unknown) **fra** = fringe absent stratum (sites thought to have no seagrass) **fro** = fringe other stratum (sites thought to have seagrass or status unknown) **none** = assigned to sites that are not members of any stratum in a particular stratification
stratum_name	Text (40)	Name of stratum.
extrapolation	Text (10)	Type of extrapolation used in estimation for stratum. Domain: **area** = area-based extrapolation **length** = length-based extrapolation **none** = stratum estimates don't rely on extrapolation
stratum_description	Text (255)	Description of stratum.

3.3 Basic Data Collection

3.3.1 site_visits Table

The site_visits table contains a record for each site visit represented in the database. The site visit was defined earlier (p.30) but can be thought of as representing physical presence at the site for the purposes of sampling. Attributes are described in Table 12.

Table 12. Attributes of the site_visits table.

attribute	data type	description
site_visit_id	Text (20)	Unique key for site visit generated by concatenating site_code, visit_year and sv_index.
site_code	Text (10)	Unique alphanumeric code identifying each site, e.g., core001, cps1245, flats18.
visit_year	Integer	Year of site visit.
sv_index	Integer	Integer counter for multiple site visits within a calendar year. Domain: **1** = first visit to site in the calendar year **2** = second visit to site in the calendar year
date_visit_start	Date	Date on which the site visit was initiated.
field_scientist_notes	Text (255)	Notes from the scientist in the field.
MRC_processing_notes	Text (255)	Notes from Marine Resources Consultants from their processing.
DNR_data_processing_notes	Text (255)	Notes from DNR during processing.
DNR_analysis_notes	Text (255)	Notes from DNR during analysis.
dep_ins	Text (25)	Depth sounder used during surveying: **Garmin** = Garmin depth sounder, model unspecified **BioSonics_DE** = BioSonics DE Echosounder **BioSonics_MX** = BioSonics MX Echosounder **BioSonics_MX + DE** = BioSonics DE and MX used simultaneously **MRC Depth Sounder** = unspecified depth sounder used for Island County Marine Resources Committee surveys

3.3.2 surveys Table

The surveys table contains a record for each video survey collected. This includes surveys collected for random transects as well as non-random reconnaissance surveys. The attributes are described in Table 13.

Table 13. Attributes of the surveys table.

attribute	data type	description
survey_id	Text (25)	unique key for survey generated by concatenating site_code, date_survey_start and survey_num.
site_code	Text (10)	unique alphanumeric code identifying each site, e.g., core001, cps1245, flats22.
date_survey_start	Date	date on which survey was initiated

attribute	data type	description
survey_num	Integer	number assigned to survey in the field. The number is unique across all surveys within a site visit.
univ_tran_id	Text (20)	survey line followed when the video survey was collected. This allows repeated surveys to be associated with each other. The values are unique across all surveys and generated by concatenating site_code and an integer.
site_visit_id	Text (20)	foreign key for the site_visit during which the survey was collected.
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 (subset of the aborted case) 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 previous survey) 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 not contribute to the estimate made from the site sample. **not-surveyed** = survey not conducted due to oversight during field visit.
tran_maxd_qual	Integer	flag indicating whether the survey captured the maximum depth of native seagrass along the survey line. domain: **0** = maximum native seagrass depth not captured **1** = maximum native seagrass depth captured
tran_mind_qual	Integer	flag indicating whether the survey captures the minimum depth of native seagrass along the survey line. **0** = minimum native seagrass depth not captured **1** = minimum native seagrass depth captured
notes	Text (255)	field notes or processing notes accompanying the survey

3.3.3 tran_pt_YYYY Layers

The transect_point data are organized into annual layers. These are by far the largest component of the SVMP database. Combined, these layers contain data on over 14 million transect points. The attributes in the associated tables are described in Table 15.

The tables includes binary attributes (presence/absence) for four basic vegetation categories populated during video classification: eelgrass (Zm), *Z. japonica* (Zj), surfgrass (Pspp) and undifferentiated native seagrass (undiff). A fifth binary vegetation category, is derived from these to represent native seagrass presence. If the Zm, Pspp and undiff fields as a group indicate absence, then native seagrass is absent. If any of Zm, Pspp or undiff are present, then native seagrass is present. Otherwise the native seagrass field is coded as missing data (Null). A data quality attribute (video) is used to indicate missing data when poor video prevents classification due to turbidity or low light conditions, or other data issues prevent classification at the few sites samples where video was not collected, and classification relies on BioSonics echosounder data.

In addition, there is an integrated vegetation classification that is a coded value attribute (Table 14).

Table 14. Relationship between the integrated vegetation classification and the four binary vegetation categories with values of 0 (absent), 1 (present) or -9999 (no data). This is a subset of the combinations in the transect point data to serve as examples.

Zm	Zj	Phyllo	undiff	Veg class code	Veg class
0	0	0	0	0	No seagrass present
0	0	-9999	0		
1	0	0	0	1	Eelgrass
1	0	-9999	0		
1	1	0	0	2	Eelgrass and *Z. japonica* mix
0	1	0	0	3	*Z. japonica*
0	0	0	1	4	Eelgrass and/or Surfgrass
0	0	1	1		
1	0	0	1		
1	0	0	1		
1	0	1	1		
0	0	1	0	5	Surfgrass
-9999	-9999	-9999	-9999	9	Missing data

Table 15. Attributes of the annual transect point tables (tran_pt_2000, tran_pt_2001,…., tran_pt_2019).

attribute	data type	description
OBJECTID	Integer	Unique ID automatically generated by ArcGIS.
survey_id	Text (25)	Foreign key identifying the survey to which the point belongs.
site_code	Text (10)	Unique alphanumeric code identifying each site, e.g., core001, cps1245, flats22.
date_time_samp	Date	Date and time at which the video was collected at the point.
tran_num	Integer	Number assigned to survey in the field. The number is unique across all surveys within a site visit.
depth_obs	Double	Observed depth of the point in feet (MLLW) based on a depth sounder result. **-9999** = missing data
depth_interp	Double	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. -**9999** = missing data
Zm	Integer	Presence of eelgrass (*Zostera marina*) at the transect point. Domain: **0** = absent **1** = present **-9999** = missing data **-99** = missing data
Zj	Integer	Presence of *Zostera japonica* at the transect point. Domain: **0** = absent **1** = present **-9999** = missing data **Null** = missing data
Phyllo	Integer	Presence of surfgrass (*Phyllospadix* spp.) at the transect point.

attribute	data type	description
		Domain: **0** = absent **1** = present **-9999** = missing data **Null** = missing data
undiff	Integer	Presence of undifferentiated native seagrass at the transect point. This vegetation category is classified as present when both eelgrass and surfgrass are known to be present at a site but a definitive classification at the transect point is not possible. Domain: **0** = absent **1** = present **-9999** = missing data **Null** = missing data
NativeSG	Integer	Presence of native seagrass at the transect point. This reflects the presence of either eelgrass or surfgrass. Domain: **0** = absent **1** = present **-Null** = missing data
video	Integer	Data quality at the transect 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. 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** = poor data in terms of being a section of a survey not intended to be included as part of a transect when making seagrass abundance estimates. Typically, these points indicate video was recorded while the vessel was backing into place to begin a survey. These sections of survey may have good video and may have reliable classification of seagrass presence. **-9999** = missing data **-99** = missing data
veg_class	Integer	A single vegetation class that integrates the presence data for eelgrass, *Z. japonica*, *Phyllospadix* spp. and undifferentiated native seagrass. Domain: **0** = no seagrass present **1** = eelgrass **2** = eelgrass and *Z. japonica* mix **3** = *Z. japonica* **4** = eelgrass and/or surfgrass mix **5** = surfgrass **9** = missing data
year	Integer	The year that the transect point was surveyed. This is extracted from the date_time_samp attribute to facilitate symbolization by survey year.

3.4 Site Sample Information Tables

3.4.1 studies Table

The studies table is simply a list of studies whose data are housed in the database and the codes used for each study. The attributes of the studies table are described in Table 16.

Table 16. Attributes of the studies table.

attribute	data type	description
study_group	Text (15)	Group to which the study belongs. Domain: **collaborative** = study was conducted by DNR with a partner organization **external data** = study conducted by an external organization. Data included courtesy of this organization. **stressor** = study included sites selected to investigate changing seagrass or causal factors for changing seagrass. **regional design** = study is based on a regional sampling design that allows for region-scale estimates of seagrass abundance and change based on a sample of sites.
study_code	Text (12)	Short code for study (see Table 1, p.13, for domain of codes).
study_name	Text (40)	Name of the study.
study_description	Text (255)	Description of the study.
data_owner	Text (15)	Value indicates whether DNR is an owner of the data or, if not, which organization is the data owner. For collaborative studies, the partner organization is also a data owner although this is not explicitly indicated in the attribute values.
survey_org	Text (15)	Organization that provided the survey vessel and equipment and conducted the surveys. Domain: **MRC** = Marine Resources Consultants of Port Townsend. **Island Co MRC** = Island County Marine Resources Committee.
partner_org	Text (15)	The organization that partnered with DNR's Submerged Vegetation Monitoring Program (SVMP) for a particular study.

3.4.2 study_associations Table

Each record in this table associates a site sample with a study. The attributes are described in Table 17.

Table 17. Attributes of the study_associations table.

attribute	data type	description
study_assoc_id	Text (65)	Unique ID generated by concatenation of site_samp_id and study_code.
site_samp_id	Text (50)	Foreign key that relates each association to the site sample involved.
study_code	Text (12)	Foreign key that relates each association to the study involved.
samp_occasion	Text (12)	A study-specific string that is used to group samples from a range of sampling dates as part of the same sampling occasion for the purposes of analysis. This is commonly a specific year in the form of a string.

3.4.3 site_samples Table

Each record in this table represents a unique site sample. A sample may consist of a collection of random transects or it may consist of a field determination that no seagrass is present with or without accompanying reconnaissance transects. The attributes of the site_samples table are described in Table 18.

Table 18. Attributes of the site_samples table.

attribute	data type	description
site_samp_id	Text (50)	Unique site sample ID generated by concatenation of site_code, date_samp_start, samp_sel, samp_repeat and samp_plan_type.
site_code	Text (10)	Unique alphanumeric code identifying each site, e.g., core001, cps1245, flats22.
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. Domain: **SRS** = simple random selection **STR** = stratified random selection with one transect per stratum **SYS** = systematic selection **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 but without the benefit of randomly generated start or GIS to ensure even spacing.
samp_repeat	Text (15)	Sample replacement policy over multiple sampling occasions. Domain: **new** = newly drawn independent sample (complete replacement) **repeat** = repeat surveys of previously drawn sample (no replacement; fixed) **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
samp_plan_type	Text (10)	Type of planning that led to the sample. Domain: **planned** = a sample planned prior to or during the site visit **posthoc** = a sample selected after the site visit to meet new requirement
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 applicable, not a repeat sample
samp_status	Text (12)	Status of sample. Domain: **sampled** = sample successfully surveyed **obstructed** = sample not successfully surveyed due to obstruction **exception** = sample either surveyed but with methodological exception relative to planned protocols or sample collected in a way to not be usable.
site_visit_id	Text (20)	Site visit during which sample was collected. Foreign key to site_visits table.

3.4.4 transects Table

Each record in this table represents a unique transect. Both random transects and non-random reconnaissance transects are included. Random transects will be members of a site sample that is reflected in the value of the site_samp_id attribute. Non-random transects that are not members of a site sample have a value of "no-sample" for the site_samp_id attribute. All the attributes for the table are described in Table 19.

Table 19. Attributes of the transects table.

attribute	data type	description
transect_id	Text (100)	Unique ID for transect generated by concatenating site_samp_id, site_visit_id, seg_tran_id, tran_sel, tran_repeat and tran_plan_type
site_samp_id	Text (50)	Foreign key that identifies the site sample of which the transect is a member. **no-sample** = the transect is not a member of a sample.
site_visit_id	Text (20)	Site visit during which sample was collected. Foreign key to site_visits table.
seg_tran_id	Text (10)	An alphabetic transect identifier that is unique within each site sample (or site visit in the case of recon transects). In most cases this attribute has a length of two (e.g., "aa", "ab", "ac") but in cases of multi-segment transects the length is four characters (e.g., "aaaa", "bbbb").
tran_sel	Text (10)	The selection method used to select the transect. Domain: **SRS** = simple random selection **STR** = stratified random selection with one transect per stratum **SYS** = systematic selection **SUBJ** = subjective (non-random) selection **SUBJ_SRS** = subjective selection from pre-existing SRS sample **SUBJ_SYS** = subjective selection from pre-existing SYS sample **AHSYS** = "ad hoc systematic", transects placed in the field with intent to resemble SYS but without the benefit of randomly generated start or GIS to ensure even spacing.
tran_repeat	Text (10)	Sample replacement policy for transects over multiple sampling occasions. Domain: **new** = newly selected transect **repeat** = repeat surveys of previously drawn transect **mixed** = multi-segment transect with both new and repeat segments
tran_plan_type	Text (10)	Type of planning that led to this transect. Domain: **planned** = a transect planned prior to or during the site visit **posthoc** = a transect selected after the site visit to meet new requirement
repeat_status	Text (10)	Quality assessment of repeat transects. This is primarily an assessment of spatial proximity of a repeat survey to the initial survey but also reflects other problems (e.g., equipment problems) that result in an unacceptable repeat transect. Domain: **NA** = not applicable (not a repeat transect) **acceptable** = successful repeat transect with acceptable spatial proximity to target survey line **failed** = failed repeat due to spatial deviation from target survey line or other problem. **replaced** = transect exists but was rejected (typically for poor spatial conformance of repeat survey with previous survey) and replaced by a transect based on a replicate survey which is the preferred transect for analysis. This transect may be valid for some analyses.

3.4.5 segments Table

Each record in this table represents a transect segment. In most cases there will be a 1:1 relationship between the segments and transects table but in cases of segmented transects there will be multiple segments related to one transect. In most cases there will be 1:1 relationship between the segments and surveys tables but in cases where a survey is utilized by multiple site samples (e.g., SRS and STR) there will be multiple segments associated with one survey.

Table 20. Attributes of the segments table.

attribute	data type	description
survey_id	Text (25)	Unique key for survey that is a foreign key to the surveys table.
transect_id	Text (100)	Unique key for transects that is a foreign key to the transects table.
seg_repeat	Text (10)	Sample replacement policy for segments over multiple sampling occasions. Domain: **new** = newly selected segment **repeat** = repeat surveys of previously drawn segment
seg_rpt_stat	Text (10)	Quality assessment of repeat segments. This is primarily an assessment of spatial proximity of a repeat survey to the initial survey but also reflects other problems (e.g., equipment problems) that result in an unacceptable repeat segment. Domain: **NA** = not applicable (not a repeat transect) **acceptable** = successful repeat transect with acceptable spatial proximity to target survey line **failed** = failed repeat due to spatial deviation from target survey line or other problem.

3.5 Results Tables

The tables in the results group include tables with the quantitative results associated with transects (transects_results table) and with site samples (site_results table). There are also vegetation occurrence tables that summarize categorical data on seagrass species presence by site visit (veg_occur tables).

In addition there are three data layers that were generated to facilitate user interaction with the data (site_pt, site_poly_display and generalized_eelgrass_poly layers). These layers are used within the ArcGIS map document included with the dataset (for use with Esri ArcMap or ArcGIS Pro) and by the online interactive map (see section 1.3, p.5). These three layers have redundant attributes to make the same set of basic site information easily available by selecting features within any of the three layers.

3.5.1 site_pt Layer

The site_pt layer includes a point for every site in the 2001 sampling frames (flats and fringe), the fringe orphans, and the sites outside the SVMP study area in south Puget Sound. In addition, there are points for three sites from the site_poly_special layer that do

not coincide with the SVMP sampling frames (outf455, outf457, outf458). These three additional sites have been sampled but the surrounding SVMP sites have not been sampled. Points were not included for sites outside the SVMP frames where the surrounding SVMP sites have been sampled (sgn2906 – SeagrassNet site near Dumas Bay and flats15aqr – the DNR Aquatic Reserve within Fidalgo Bay).

The attributes of the site_pt layer are described in Table 21.

Table 21. Attributes of the site_pt, site_poly_display and generalized_eelgrass_poly layers.

attribute	data type	description
site_code	Text (10)	Unique alphanumeric code identifying each site, e.g., core001, cps1245, flats22.
samp_status_disp	Text (12)	Status of the site sampling at the site. This attribute summarizesf the samp_status attribute in the site_samples table for all samples collected at a site. Domain: **sampled** = the site has been successfully sampled **obstructed** = the site has not been sampled due to obstruction **not_sampled** = the site has not been selected for sampling or sampling was not successful for technical or logistical reasons.
veg_class	Text (15)	The seagrass species present at the site, summarized from all available site visits. Domain: **no_data** = the site has not been sampled **no_grass** = no seagrass was observed at the site **Zm** = Eelgrass **Phyllo** = Surfgrass **Zj** = Z. japonica **Zm_Zj** = Eelgrass and Z. japonica mix **Zm_Phyllo** = Eelgrass and Surfgrass mix
long_term_trend	Text (30)	Classification of the site with respect to the long-term trend in native seagrass over time. This is based on trend analysis and spatial review of transect point data for sites sampled over multiple occasions. Domain: **increase** = native seagrass abundance has increased **decline** = native seagrass abundance has declined **no_trend** = no evidence of trend in native seagrass abundance **no_data** = the site has not been sampled **limited_data** = the site has been sampled but there is insufficient data to make a trend assessment. **no_grass** = no seagrass was observed at the site **trace** = native seagrass observed but only at trace quantities that were insufficient to make a trend assessment. **obstructed** = the site was visited but not sampled due to obstruction. Trend was not assessed. **not classified (nonDNR data)** = only data from external organization available, not assessed for trend.
recent_6yr_trend	Text (30)	Classification of the site with respect to the recent (6 year) trend in native seagrass over time. This is based on trend analysis and spatial review of transect point data for sites sampled over multiple occasions. Domain: **increase** = native seagrass abundance has increased **decline** = native seagrass abundance has declined **no_trend** = no evidence of trend in native seagrass abundance **no_data** = the site has not been sampled **limited_data** = the site has been sampled but there is insufficient data to make a trend assessment.

attribute	data type	description
		no_grass = no seagrass was observed at the site **trace** = native seagrass observed but only at trace quantities that were insufficient to make a trend assessment. **obstructed** = the site was visited but not sampled due to obstruction. Trend was not assessed. **not classified (nonDNR data)** = only data from external organization available, not assessed for trend.

3.5.2 site_poly_display Layer

This layer includes polygons for every site in the 2001 sampling frames (flats and fringe), the fringe orphans, and the sites outside the SVMP study area in south Puget Sound. In addition, there are polygons for three sites from the site_poly_special layer that do not coincide with the SVMP sampling frames (outf455, outf457, outf458). These three additional sites have been sampled but the encompassing SVMP sites have not been sampled. Polygons were not included for sites outside the SVMP frames where the surrounding SVMP sites have been sampled (sgn2906 – SeagrassNet Dumas Bay, and flats15aqr – the DNR Aquatic Reserve site in Fidalgo Bay).

The attribute table for this layer is identical to that for the site_pt layer and is described in Table 21.

3.5.3 generalized_eelgrass_poly Layer

This layer was generated to display the general area where eelgrass occurs at each site sampled. To create this layer the first step was to dissolve all the annual eelgrass polygons by site. In order to avoid a confusing display when sites not in the current SVMP sampling frames fall within sampled SVMP sites, the resulting dissolved polygons were deleted for the following sites:

flats15aqr
sgn2906
padnorth
padmid.

In addition, the dissolved polygons were deleted for the sites either with no seagrass or sites where expansive eelgrass polygons were not representative of the distribution. These sites include:

hdc2323
hdc2345
sjs2632
swh1645.

3.5.4 transect_results Table

This table contains a record for each transect that is a member of a site sample. Each record includes transect analytical results. The attributes are described in Table 22.

Table 22. Attributes of the transect_results table.

attribute	data type	description
tran_results_id	Text (100)	Unique code identifying the transect result. This is a concatenation of transect_id and veg_code.
transect_id	Text (100)	Unique ID for transect generated by concatenating site_samp_id, survey_id, tran_sel, tran_repeat and tran_plan_type. Foreign key to link with transects table.
veg_code	Text (10)	Code for vegetation type represented in the transect result. Only "nativesg" is used in this database.
tran_len_ft	Double	Length of the transect in feet (US Survey feet)
veg_len_ft	Double	Vegetated length of the transect in feet (US survey feet)
tran_veg_frac	Double	Vegetation fraction along the transect
tran_veg_maxd_ft	Double	Maximum depth where vegetation was observed along the transect in feet (MLLW) **-9999** = no data (no vegetation or missing data)
tran_maxd_ft	Double	Maximum depth along the transect in feet (MLLW) **-9999** = missing data
tran_veg_mind_ft	Double	Minimum depth where vegetation was observed along the transect in feet (MLLW) **-9999** = no data (no vegetation or missing data)
tran_mind_ft	Double	Minimum depth along the transect in feet (MLLW) **-9999** = missing data
tran_maxd_qual	Integer	Flag indicating whether the survey captured the maximum depth of eelgrass along the survey line. Domain: **0** = maximum native seagrass depth not captured **1** = maximum native seagrass depth captured
tran_mind_qual	Integer	Flag indicating whether the survey captures the minimum depth of eelgrass along the survey line. Domain: **0** = minimum native seagrass depth not captured **1** = minimum native seagrass depth captured
site_results_id	Text (50)	Unique code for the associated site result to which this transect result contributes. Foreign key to link with the site_results table.

3.5.5 site_results Table

This table includes a record for each successful site sample. The record contains the analytical results for the site sample. The attributes are described in Table 23. Area values in units of square feet refer to the US Survey foot, while the various depth values in feet refer to the international foot.

Table 23. Attributes in the site_results table.

attribute	data type	description
site_results_id	Text (50)	unique code identifying the site result. This is a concatenation of site_samp_id Und veg_code.

attribute	data type	description
site_samp_id	Text (50)	Unique site sample ID generated by concatenation of site_code, date_samp_start, samp_sel, samp_repeat and samp_plan_type. Foreign key to link to site_samples table.
veg_code	Text (10)	Code for vegetation type represented in the transect result. Only “nativesg” is used in this database.
veg_area_n_tran	Integer	Number of transects used for vegetation area estimate
veg_frac	Double	Estimated vegetated fraction
samp_area_ft2	Double	Eelgrass (sample) polygon area in square feet
veg_area_ft2	Double	Estimated vegetation area in square feet
veg_area_se_ft2	Double	Estimated standard error of estimate of vegetation area in square feet
veg_mind_n_tran	Integer	Number of transects used in mean minimum depth estimate
veg_mind_mean_ft	Double	Estimate of mean minimum depth of vegetation in feet (MLLW)
veg_mind_deepest_ft	Double	Deepest observed value for minimum depth of vegetation in feet (MLLW)
veg_mind_shallowest_ft	Double	Shallowest observed value for minimum depth of vegetation in feet (MLLW)
veg_mind_se_ft	Double	Estimated standard error of estimate of mean minimum depth in feet
veg_maxd_n_tran	Integer	Number of transects used in mean maximum depth estimate
veg_maxd_mean_ft	Double	Estimate of mean maximum depth of vegetation in feet (MLLW)
veg_maxd_deepest_ft	Double	Deepest value for maximum depth of vegetation observed in feet (MLLW)
veg_maxd_shallowest_ft	Double	Shallowest value for maximum depth of vegetation observed in feet (MLLW)
veg_maxd_se_ft	Double	Estimated standard error of estimate of mean maximum depth in feet

3.5.6 veg_occur Tables

There are three closely related tables containing information on vegetation occurrence summarized by site visit (Table 24). These three tables contain identical attributes and are described here as a group. Two of the tables (veg_occur_tran_pts and veg_occur_field_notes) serve as sources that are integrated in the third table (veg_occur).

Table 24. Description of the three related vegetation occurrence tables.

vegetation occurrence table name	description
veg_occur_tran_pts	Vegetation occurrence as summarized from the transect point data.
veg_occur_field_notes	Vegetation occurrence observations from field notes.
veg_occur	Overall vegetation occurrence that combines information from the veg_occur_tran_pts and veg_occur_field_notes tables.

The vegetation occurrence attributes in the veg_occur table are based on values from field notes (veg_occur_field_notes) if available. Otherwise they are based on summaries from the transect point data (veg_occur_tran_pts). Most records based on field notes are related to cases where the absence of seagrass was determined in the field and no video was collected (and therefore no transect point data). The next most common case is a field determination that eelgrass was present in trace amounts but none was observed in the transect data.

The native seagrass occurrence attribute (nativesg) is determined from the Zm, Phyllo and undiff attributes. The value is determined in a sequence of up to three steps:

1. If Zm or Phyllo or undiff is present, then nativesg is present.
2. If Zm and Phyllo and undiff are absent, then nativesg is absent.
3. If Zm or Phyllo or undiff is trace, then nativesg is trace.
4. Otherwise nativesg is coded as missing data.

The attributes of the vegetation occurrence tables are described in Table 25.

Table 25. Attributes of the vegetation occurrence tables.

attribute	data type	description
site_visit_id	Text (20)	Unique key for site visit generated by concatenating site_code, visit_year and sv_index. Foreign key that links with the site_visits table.
Zm	Text (10)	Presence of eelgrass assessed during site visit. Domain: **present** = eelgrass is present **absent** -= eelgrass is absent **trace** = eelgrass was observed but abundance was too low to estimate **no-data** = missing data
Zj	Text (10)	Presence of *Z. japonica* assessed during site visit. Domain: **present** = *Z. japonica* is present **absent** -= *Z. japonica* is absent **trace** = *Z. japonica* was observed but abundance was too low to estimate **no-data** = missing data
Phyllo	Text (10)	Presence of surfgrass assessed during site visit. Domain: **present** = surfgrass is present **absent** -= surfgrass is absent **trace** = surfgrass was observed but abundance was too low to estimate **no-data** = missing data
undiff	Text (10)	Presence of undifferentiated native eelgrass assessed during site visit. Domain: **present** = undifferentiated native seagrass is present **absent** -= undifferentiated native seagrass is absent **trace** = undifferentiated native seagrass was observed but abundance was too low to estimate **no-data** = missing data
nativesg	Text (10)	Presence of native seagrass assessed during site visit. Domain: **present** = native seagrass is present **absent** = native seagrass is absent **trace** = native seagrass was observed but abundance was too low to estimate **no-data** = missing data
notes	Text (255)	Notes regarding vegetation assessment during site visit.

3.5.7 veg_codes Table

This table lists all the vegetation codes used within the database. The attributes of the table are described in Table 26.

Table 26. Attributes of the veg_codes table.

attribute	data type	description
veg_code	Text (15)	Short code to represent vegetation type. Domain: **Zm** = eelgrass **Zj** = *Z. japonica* **Phyllo** = surfgrass (*Phyllospadix* spp.) **undiff** = undifferentiated native seagrass **nativesg** = native seagrass
veg_name	Text (40)	Vegetation name associated with veg_code.
veg_description	Text (255)	Notes regarding vegetation type.

3.6 Metadata

Metadata is included with each data element in the SVMP distribution 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 GIS software. Metadata is commonly viewed using the Esri ArcCatalog, ArcMap or ArcGIS Pro applications.

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

All metadata was written using the FGDC standard as a template, but the metadata does not strictly adhere to the standard and would not pass a formal validation.

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