US Army Corps of Engineers ®
Seattle District

COMPONENTS OF A COMPLETE EELGRASS DELINEATION AND CHARACTERIZATION REPORT

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Contents

PREFACE

This document was developed by Dr. Deborah Shafer Nelson, U.S. Army Engineer Research and Development Center at the request of the Seattle District and Headquarters, U.S. Army Corps of Engineers, with funding provided through the Wetlands Regulatory Assistance Program.

Purpose

This document provides technical guidance and procedures for identifying and delineating eelgrass (*Zostera* spp.) that may be subject to regulatory jurisdiction under Section 404 of the Clean Water Act (33 U.S.C.1344) or Section 10 of the Rivers and Harbors Act (33 U.S.C.403). It has been developed to assist applicants and/or their consultants within the geographic area covered by the Seattle District U. S. Army Corps of Engineers when a characterization of eelgrass is requested to evaluate proposed work within marine waters. Note: This document was developed for eelgrass; however, we encourage the user to document other marine species, such as kelp, as that information may be required for the overall characterization of the project site. Also, although this guidance is specifically for eelgrass, it may be applicable for other types of seagrasses.

Qualifications

Eelgrass mapping and monitoring surveys should be performed by someone who has demonstrated the ability to identify eelgrass species present within the project area, and conduct ecological surveys.

Survey Timing

Sampling shall be conducted during periods when above-ground material is present in sufficient quantities to be readily observable: June 1 through October 1. If multi-year surveys are planned, they should all be done at the same time of year to avoid seasonal biases in the results. Survey results will be valid for a period of 1 year. If it has been more than 1 year but less than 3 years since the last survey, then at a minimum, the mapped boundaries of the eelgrass and macroalgae beds must be re-verified to ensure that they have not changed. If more than 3 years have elapsed since the last eelgrass/macroalgae mapping survey, a new complete mapping survey shall be conducted.

Overview of Eelgrass Survey Types: Tier 1 and Tier 2

Depending on the type and scale of the proposed project, either a Tier 1 level eelgrass survey or a Tier 2 survey is recommended. The requirements for Tier 1 and Tier 2 surveys are described in detail in subsequent sections.

Tier 1: survey is considered a reconnaissance level survey that captures basic information such as presence/absence and eelgrass bed spatial distribution. A Tier-1 survey is generally applicable when the project will avoid work in eelgrass and therefore only requires identification of the eelgrass boundaries.

Tier 2: survey is intended to be a more rigorous quantitative characterization for work with the potential for direct impacts to eelgrass resources and is generally applicable to projects such as dredging, commercial-scale marinas, large aquaculture projects, cable and pipeline installation projects involving trenching and filling, and construction of small-scale ocean energy structures (e.g., tidal or wave energy, wind energy). For large projects, it may be more efficient to use a combination of Tier 1 and Tier 2 surveys. Tier 1 reconnaissance surveys conducted over large areas can be used to target specific areas where more detailed eelgrass resource maps may be needed.

Defining and Delineating Eelgrass Bed Boundaries

The uppermost boundaries of seagrass growth are controlled by desiccation and temperature stress (Boese et al. 2005), but can also be locally influenced by activities such as shellfish harvest and reflective energy from shoreline armoring (Short and Wyllie-Echeverria 1996). The lower boundary, or maximum depth of seagrass growth can be directly related to the submarine light environment (Duarte 1991). Within these limits, seagrass bed patterns range from continuous or semi-continuous over hundreds of meters to patchy distributions ranging from a meter to tens of meters in the longest dimension (Fonseca and Bell 1998).

Potential *Z. marina* habitat in the Pacific Northwest may be classified as either fringe or flats based on its geomorphic setting (Berry et al. 2003). Fringe *Z. marina* habitats are areas with relatively linear shorelines where potential *Z. marina* habitat is limited to a narrow band by bathymetry. Identification of eelgrass bed boundaries in fringe sites is relatively straightforward. Flats *Z. marina* sites are shallow embayments with extensive broad shallows that appear to have little slope within the vegetated zones. Delineation of eelgrass beds in flats sites can be more challenging because they are often highly fragmented and very dynamic on both spatial and temporal scales. Bed patchiness increases with increasing wave exposure and tidal current speed. For more information on the influence of landscape setting and physical exposure on eelgrass bed configuration, see Appendix A.

One of the two methods described below shall be used to define eelgrass habitat and delineate eelgrass bed boundaries. Although the two methods are slightly different, in practice the results of eelgrass delineations done with either method would be expected to be similar[1].

If the eelgrass bed is composed of many individual patches, and the distance between adjacent patches is 5m or less, then it is not necessary to delineate each individual patch. The outer perimeters of the patchy areas may be delineated as described below and noted as patchy on the site description.

> **Eelgrass Delineation Method A:** An eelgrass bed is defined as a minimum of 3 shoots per 0.25 m^2 (1/4 square meter) within 1 meter of any adjacent shoots. To identify the bed boundary, proceed in a linear direction and find the last shoot that is within 1 meter of an adjacent shoot along that transect. The bed boundary (edge) is defined as the point 0.5 meter past that last shoot, in recognition of the average length of the roots and rhizomes extending from an individual shoot (Washington Dept. of Natural Resources (WADNR) 2012).
>
> **Eelgrass Delineation Method B:** *The California Eelgrass Mitigation Policy and Implementing Guidelines* (NOAA Fisheries 2014) identify eelgrass bed edge as follows: any eelgrass within one square meter quadrat and within 1 meter of another shoot.

[1] In cases where the delineation is part of the support for a proposed permit, is required to meet programmatic Endangered Species Act consultations, or as proposed mitigation, the appropriate buffer should be included in maps/drawings. Once the bed edge is identified using either Method A or B, delineate an un-vegetated perimeter zone around the edge of each bed or patch. Un-vegetated areas within this perimeter zone may have eelgrass shoots a distance greater than 1 meter from another shoot, and may be internal as well as external to areas of vegetated cover. See Figure 1 in Appendix A for example. The required width of the un-vegetated perimeter may vary by project type. Applicants should also be aware of local and state requirements for eelgrass surveys, as these may differ from the guidance presented here. In that case, identify the larger perimeter zone.

Tier 1 Surveys

A Tier 1 survey is considered a reconnaissance level survey for those projects that propose to avoid work in eelgrass. A Tier 1 survey captures basic information such as presence/absence, eelgrass bed spatial distribution, including maximum and minimum depth distribution, approximation of the total area of the eelgrass bed, and a qualitative assessment of eelgrass cover. Appendix B provides a sample data sheet and eelgrass habitat map suitable for Tier 1 surveys.

Tier 1 Data Collection Methods.

Intertidal sites shall be sampled by walking or wading during low tides. Divers will usually be needed to collect information at subtidal sites.

For very large sites, alternative remote sensing methods such as underwater photography, hydroacoustic surveys or aerial photography may be used to determine eelgrass bed locations. For more information on these methods, see the section on Eelgrass Survey and Mapping Methods. However, if any of these remote sensing methods is used to prepare maps of eelgrass distribution, additional data must also be collected (and submitted) using walking, wading or diver surveys to verify the remotely sensed data.

Tier 1 Transect Layout.

For linear projects (e. g. pipelines), establish a single transect aligned along the centerline of the project footprint. Otherwise, establish a series of sample transects perpendicular to shore spaced between 5 to 25 feet apart. For projects that are not adjacent to the shoreline, orientate transects relative to another physical reference, such as a channel boundary or depth gradient. Transects must also be referenced to a permanent feature at the site to ensure repeatability.

At sites where the eelgrass beds are smaller, with patchy or discontinuous distributions, sample transects should be closely spaced (5 to10 feet). For sites containing relatively contiguous eelgrass beds, or for projects involving very large areas, transects spaced at intervals of 15 to 25 feet apart are appropriate. At least one transect should be aligned along the proposed centerline of the project. Locate additional transects at distances of 10 and 25 feet from the outer edges of the proposed project footprint. Transects should extend at least 25 feet waterward of the project footprint, or to the outer margin of the eelgrass bed.

Along each transect, determine the location of the boundaries of the eelgrass beds or patches according to the instructions for either Method A or B for delineating the boundaries of eelgrass habitats. Applicants are also encouraged to note the location of any macroalgae, especially kelp species, if present.

Tier 1 Field Data Collection and Reporting.

The following data shall be recorded in the field and included in the survey report:

1. Site name, sample date and time of day (start and finish);
2. The names of the person(s) conducting the survey; and whether Method A or Method B was used to delineate the eelgrass bed(s).

For each survey transect, record the following information:

3. Record the GPS coordinates, elevation (relative to mean lower low water (MLLW)), and distance along the transect of the upper and lower boundaries of the eelgrass and macroalgae beds or patches, by species. **NOTE:** If dwarf eelgrass (*Zostera japonica*) is present, there may be multiple eelgrass zones (e.g. an upper intertidal zone of pure *Z. japonica*, a mid-intertidal zone of *Z. japonica* mixed with *Z. marina*, and a pure *Z. marina* zone). In this case, record the GPS coordinates, elevation (relative to MLLW) and distance along transect for the upper and lower boundaries of each zone along each survey transect In mixed beds, it can sometimes be difficult to distinguish between the two *Zostera* species. For further information on identification of *Z. marina* and *Z. japonica*, see Appendix C.
4. Using either a 0.25 square meter (Method A) or 1.0 square meter quadrat (Method B) , record estimates of eelgrass and macroalgae percent cover, by species, along each transect at intervals equal to the transect spacing, forming a sample grid pattern. For example, if the transects are spaced 10 feet apart, record species' percent cover in sampling stations at 10-foot intervals along the transects. In addition, record species' percent coverage at both the beginning and end of each transect. Categorical estimates of percent cover may be used [e.g, absent or 0%; 1-10% cover; 11-25% cover; 26-50% cover; and > (greater than) 50% cover].

5. Applicants are also encouraged to record notable biological observations (e.g., the presence of flowering eelgrass shoots, shellfish, crabs, fish, marine mammals, shorebirds or waterfowl, sediment type (e.g., silt, mud, sand, shell, etc).

Tier 1 Preparation of Habitat Maps.

Prepare an eelgrass and macroalgae habitat distribution map using the GPS coordinates taken from the survey data. The map shall include the following information:

a) Site name, sample date and times, names of the persons collecting the data;
b) Boundaries of the project area and site plan; and north arrow;
c) Accurate bathymetric contours (local vertical datum of MLLW) at intervals of not more than 1 foot;
d) Scale and measures of distance along the axis of the transects;
e) Locations of all sample transects and sampling stations;
f) Locations of upper and lower boundaries of *Z. marina* and *Z. japonica* (if present) eelgrass beds, and, if buffer proposed, an unvegetated perimeter around bed edges;
g) Estimated percent cover of eelgrass and macroalgae [e.g, absent or 0%; 1-10% cover; 11-25% cover; 26-50% cover; and > 50% cover] at each quadrat sample point.

Tier 1 Reporting Requirements.

In addition to the maps of eelgrass distribution within the project area described above, the report shall also include the following:

1) Calculations of total project acreage;
2) Calculations of eelgrass acreage (total area of all eelgrass beds and patches as defined previously; by species);
3) Calculations of eelgrass habitat acreage, by species
   For contiguous beds, eelgrass habitat acreage is the area of all contiguous beds, plus, if buffer proposed, the area of the un-vegetated perimeter around the bed edge.
   For patchy beds, eelgrass habitat area includes the cumulative area of the individual patches, including any un-vegetated areas between patches that are less than 16 feet (5 meters) apart, plus, if buffer proposed, the area of the un-vegetated perimeter

around the bed edge. Note that un-vegetated areas may include areas with single eelgrass shoots that are more than 1 meter apart.

4) Data sheets showing the information collected on each transect (see Example in Appendix A).
5) (Recommended) Notable biological observations (the presence of flowering eelgrass shoots, shellfish, crabs, fish, marine mammals, shorebirds or waterfowl, etc.

Tier 2 Surveys

A Tier 2 survey is intended to be a more rigorous quantitative characterization for work with the potential for direct impacts to eelgrass resources and is generally applicable to larger-scale projects, such as dredging, commercial-scale marinas, large aquaculture projects, cable and pipeline installation projects involving trenching and filling, and construction of small-scale ocean energy structures (e.g., tidal or wave energy, wind energy).

Tier 2 surveys should be designed to be replicated, because multi-year surveys may be required to establish baseline conditions in some sites, and post-construction surveys may be required to determine the extent of potential eelgrass impact or be used to monitor the success of eelgrass compensatory mitigation projects.

It is important to note that the spatial scale of large coastal development projects can have potentially larger impacts on eelgrass and may require more extensive site analysis and evaluation than is presented in this guidance. Likewise, compensatory mitigation projects involving eelgrass may require environmental assessments beyond the scope of this guidance. Applicants should also be aware of local and state requirements for eelgrass surveys, as these may differ from the guidance presented here.

Tier 2 Transect Layout.

For linear projects (e. g. pipelines), establish a single transect aligned along the centerline of the project footprint. Otherwise, establish a series of sample transects perpendicular to shore at the appropriate spacing, typically 5 to 16 feet (2 to 5 meters) apart. Transect spacing for Tier 2 surveys will generally be closer than for Tier 1 surveys. For projects not adjacent to the shoreline, orientate transects relative to another physical reference, such as a channel boundary or depth gradient. Transects must also be referenced to a permanent feature at the site to ensure repeatability. If multi-year surveys are being conducted to detect changes in eelgrass condition over time, or assess potential impacts, the locations of sample transects shall be fixed, not random, and should be permanently marked so that they can be sampled repeatedly over time.

Tier 2 surveys, maps and reports shall include all of the information identified above for a Tier 1 survey.

In addition, Tier 2 surveys shall include quantitative quadrat sampling for eelgrass density as described below. Along each transect line, place a 0.25-m^2 (1/4 square meter) or 1.0 m^2 (1 square meter) quadrat sampling frame at intervals equal to the transect spacing, forming a sample grid pattern. For example, if the transects are spaced 5 feet apart, place the quadrat sampling frame at 5-foot intervals along the transect. Placement of the quadrat relative to the transect line at each sampling station may be done randomly (e.g., coin toss) or by consistently placing the quadrat on one side or the other for all sampling stations. Quantitative sampling of eelgrass shall be limited to areas no deeper than the deepest natural eelgrass patch found in the vicinity of the project.

For each quadrat sample location, native eelgrass (*Z. marina*) shoot density (number of native eelgrass shoots present in the quadrat sampling frame) shall be recorded. If 0.25 m^2 sample quadrats are used, then raw data values of eelgrass shoot density shall be converted to numbers of shoots per m^2 (square meter). For non-native eelgrass (*Z. japonica*) or macroalgae, categorical estimates of percent cover [e.g, absent or 0%; 1-10% cover; 11-25% cover; 26-50% cover; and greater than 50% cover] may be recorded in lieu of shoot density for each quadrat sample. A minimum of thirty samples per site will be taken within the eelgrass or macroalgae zone.

Eelgrass Survey and Mapping Methods

Method 1: Walking or Wading (Tier 1 and 2)

This method should be used if the site is intertidal. The shallow, or inshore, edge of the bed is usually clearly visible at low tide. At each site, establish a series of transect lines according to either Tier 1 or Tier 2 survey methods. An observer with a handheld Geographic Positioning System GPS unit shall walk or wade along each transect and record the locations of the upper and lower boundaries of eelgrass beds or zones, using either Method A or B for delineating the boundaries of the eelgrass beds. If the water is clear, the deep or offshore edge of the eelgrass bed may be visible with the naked eye from the boat or with the use of a bathyscope (underwater viewing box). GPS coordinates and water depth can be taken according to either Tier 1 or Tier 2 survey methods to track the deep edge of the bed.

Method 2: Snorkelers or Divers (Tier 1 and 2)

If the water, even at low tide, does not allow observation of the bottom, then snorkelers or divers shall be used to identify the boundaries of any eelgrass present onsite. Safety issues such as the potential for strong tidal currents in some areas should also be considered.

For Tier 1 surveys, a series of buoys can be used to mark the upper and lower edges of the bed to identify their locations. The scope, or length, of the line on the buoy needs to be minimized to the greatest extent possible. Having a large amount of scope on the line can lead to significant under/overestimate of actual eelgrass extent. Once the boundaries are marked with buoys, then a vessel can be maneuvered from buoy to buoy recording GPS coordinates.

Tier 2 surveys will require a series of quantitative samples along transects using 0.25 m^2 or 1.0 m^2 quadrats (see Tier 2 methods above).

Method 3: Underwater Photography (Tier 1 only)

Underwater videography can be particularly useful for detecting and mapping the presence of eelgrass over large study areas that may be difficult to sample using more intensive methods such as diver transects. At each site, establish a series of transect lines running perpendicular to the shoreline that begin just outside the boundaries of the proposed project area, making sure that the transects cover the entire project area. Record underwater imagery along each transect and identify the locations of all visible eelgrass beds or patches. However, it may not always be possible to distinguish among Pacific Northwest seagrasses (e.g. *Z. marina*, *Z. japonica* and *Phyllospadix* spp.) (Berry et al. 2003). Where multiple seagrass species occur, verification shall be performed using Methods 1 or 2 above to verify species identification.

Method 4: Hydroacoustic Mapping (Tier 1 only)

If the site is very large, hydroacoustic surveys may be considered as an alternative to the methods outlined above for a Tier 1 survey. Because detection and mapping of eelgrass using hydroacoustic equipment is not limited by water clarity, this method is particularly suitable for turbid water conditions. Depending on the heterogeneity of the eelgrass beds, the size of the area, and the desired degree of survey resolution, transect spacing may vary from as little as 25 ft to more than 100 ft. However, ground-truthing using wading, divers, or underwater photography must be performed to verify the hydroacoustic mapping classifications.

Limitations: Hydroacoustic surveys are not suitable for very shallow waters (less than 0.75 m) where access by small boats is limited. The hydroacoustic survey system is not currently capable of reliably distinguishing between underwater vascular plants (e.g. eelgrass) and macroalgae (e.g., kelp). In tidal waters, the information on canopy height is unreliable unless the surveys were conducted at slack tide.

Method 5: Aerial Photography (Tier 1 only)

If the site is extremely large, aerial photography obtained from the state or other sources may be used to provide background information on the likely presence or absence of eelgrass at a particular site. However, it shall not be used as the only source of information. It is not possible to reliably distinguish between eelgrass and macroalgae, or between different species of eelgrass or other seagrasses, using aerial imagery. Aerial photography is also likely to underestimate eelgrass coverage because eelgrass occurring in deeper waters can appear dark and may not be detected. Ground-truthing using any of Methods 1through 3 above must be performed to verify the mapping classifications determined from aerial photography.

APPENDIX A : THE INFLUENCE OF LANDSCAPE SETTING ON EELGRASS BED CONFIGURATION

Shallow eelgrass populations form characteristic landscapes with a configuration that is highly related to the level of physical exposure. Seagrass bed patterns range from continuous or semi-continuous over hundred of meters to patchy distributions ranging from a meter to tens of meters in the longest dimension (Fonseca and Bell 1998). Bed fragmentation generally increases with increasing wave exposure and tidal current speed (Fonseca and Bell 1998). Therefore, the geomorphic setting and hydrodynamics of the nearshore zone have a strong influence on seagrass distribution and bed structure.

Potential *Z. marina* habitat in the Pacific Northwest may be classified as either fringe (Figure 1) or flats (Figure 2) based on its geomorphic setting (Berry et al. 2003). These classifications are analogous to the tidal fringe and flats classes of wetlands in the Hydrogeomorphic (HGM) wetland classification system (Smith et al. 1995).

2.1 Fringe Eelgrass Habitats

Fringe *Z. marina* habitats are areas with relatively linear shorelines where potential *Z. marina* habitat is limited to a narrow band by bathymetry. Fringe eelgrass beds may be contiguous or nearly contiguous over long sections of linear shorelines (Figure A1). The fringe category is further classified into narrow fringe and wide fringe based on a 305 m (1000 ft) threshold width separating ordinary high water and the –20 ft depth contour (Berry et al. 2003) (Figure A1).

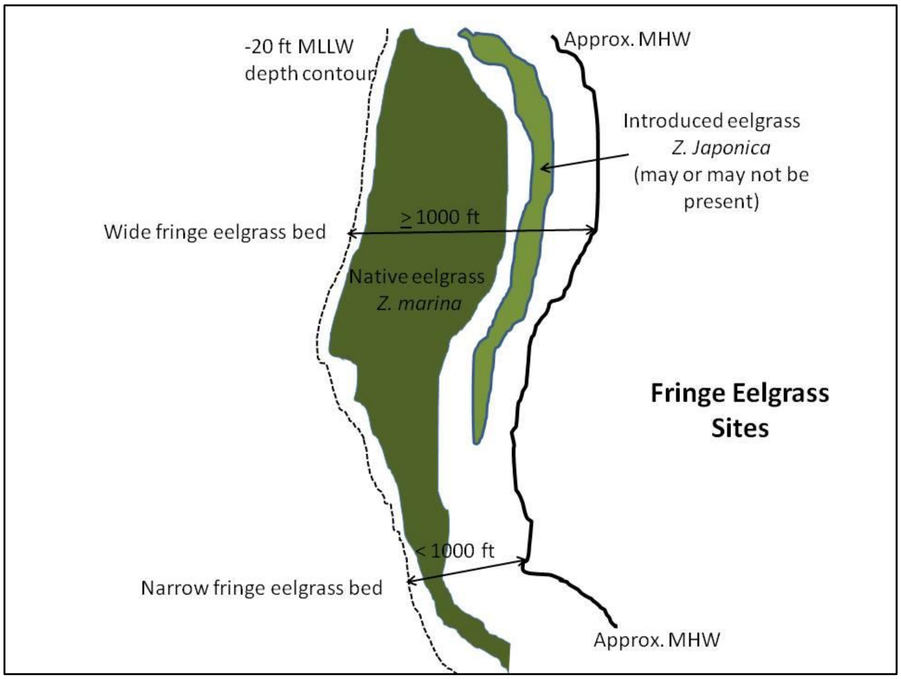


Figure A1. Illustration of fringe geomorphic classifications of eelgrass sites (modified from Berry et al. 2003).

2.2 Flats Eelgrass Habitats

Flats *Z. marina* sites are shallow embayments with extensive broad shallows that appear to have little slope within the vegetated zones. Slightly more than half of the total area of *Z. marina* habitat in Puget Sound is characterized as flats; one large embayment, Padilla Bay, contains approximately 20% of the *Z. marina* in Puget Sound (Berry et al. 2003). Flats sites may be further sub-classified into river-influenced flats such as river deltas, and tide-influenced flats (pocket beaches and other sites that lack a significant source of freshwater and associated sediment input) (Figure A2). Periodic pulses of sediment in river- influenced flats sites may generate shallow shoal complexes that can be highly dynamic over timeframes of months to years, leading to a continually changing mosaic of eelgrass patches interspersed with unvegetated shoals (Marbà et al. 1994).

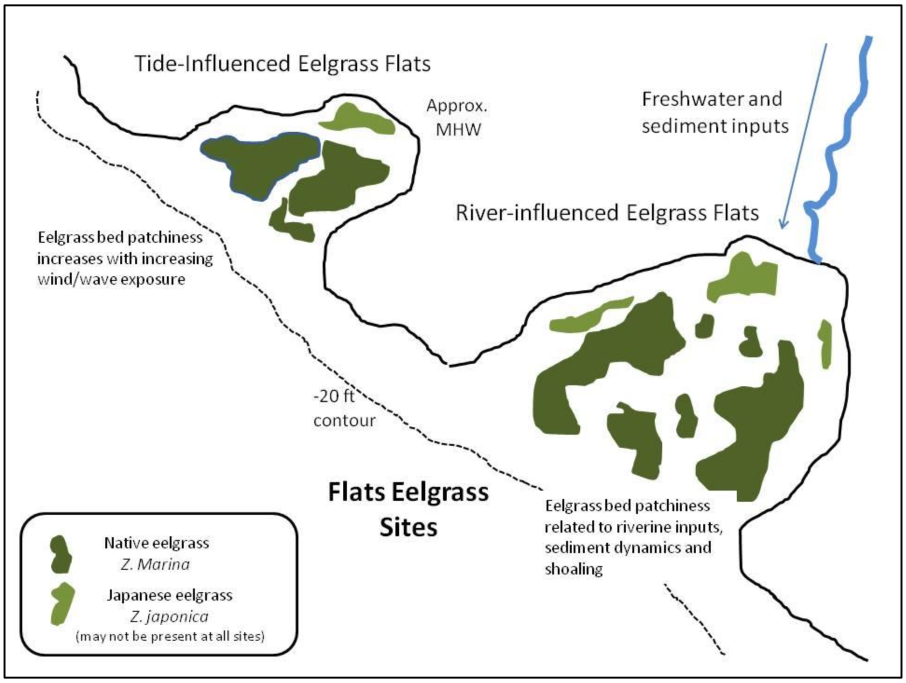


Figure A2. Illustration of flats geomorphic classifications of *Z. marina* habitats (modified from Berry et al. 2003).

3.0 SPATIAL AND TEMPORAL VARIATION IN EELGRASS BED LOCATION

Within eelgrass habitat, eelgrass is expected to fluctuate in density and patch extent and can expand, contract, disappear, and re-colonize areas within suitable environments based on prevailing environmental factors (e.g., turbidity, freshwater flows, wave and current energy, bioturbation, temperature, etc.). Because the maximum depth of seagrass colonization is controlled by light availability, tracking the deep edge of growth can provide information on the quality of the estuarine light environment over time relative to local and regional water quality standards. Upslope movements (deep → shallow) in the location of the deep bed edge have been used as an indicator of some type of chronic disturbance, either natural or anthropogenic, that results in increased turbidity and reduced light availability for seagrasses.

Eelgrass meadows in Puget Sound are characterized by substantial interannual variability that appear to be related to the occurrence of El Niño climate events, emphasizing the importance of multi-year surveys to adequately characterize seagrass abundance and distribution in a particular area (Nelson 1997). Vegetated eelgrass areas on the Pacific coast can expand by as much as

5 meters (m) and contract by as much as 4 m annually (Washington Dept of Natural Resources 2012). To account for these normal fluctuations, Fonseca et al. (1998) recommends that seagrass habitat include the vegetated areas as well as presently unvegetated spaces between seagrass patches.

Patterns in eelgrass bed ‘patchiness’ or fragmentation are related to the degree of exposure to disturbance from wind, waves and tidal currents. Wind-generated wave dynamics and tidal currents create sediment movement, which may either bury plants, expose roots and rhizomes or during heavy storms even uproot entire plants (Kirkman and Kuo 1990). Plant burial was found to be an important mechanism of gap formation in a seagrass system in Tampa Bay, USA (Bell et al. 1999) and the patch dynamics of *Zostera marina* vegetation in Rhode Island, USA was likewise thought to be controlled by sediment movement (Harlin and Thorne-Miller 1982).

Eelgrass patches may be constantly moving even during periods when a relatively constant total eelgrass area suggests stable conditions in the population. For example, although the total area of eelgrass was quite stable in the 1980s in Amager, Denmark, where a complex system of alternating eelgrass belts and sandbars is found, about 55 % of the eelgrass changed between two consecutive mappings (Frederiksen et al. 2004). The mechanism behind is probably that extrinsic disturbance factors constantly change growth conditions in the exposed areas and keep the eelgrass populations in a state of continuous re-colonization. The maps showed that the eelgrass belts migrated in a northeasterly direction and the sandbars migrated in the same direction. Outer sandbars feed the inner sandbars with sediment and substantial transportation of sand thus occurs along the sandbars (Frederiksen et al. 2004). This sediment movement most likely led to either burial or erosion on the western edges of the eelgrass patches and new growth mainly occurred in the eastern parts. Similar patterns have been observed in the eelgrass beds associated with a flood tide delta in Rhode Island, USA (Harlin and Thorne-Miller 1982), and in Tillamook Bay, OR. Comparison of historic eelgrass maps and aerial imagery in Tillamook Bay suggests that eelgrass associated with shallow sandy shoals may have become buried or eroded over time, then became re-established in different locations as the shoals shifted in response to current or sediment pulses (Figure A3). Other areas in the Pacific Northwest that exhibit this pattern include eelgrass beds near the mouth of the Dungeness River in northern Washington.

Figure A3. Historic maps of eelgrass distribution on river-influenced flats in Tillamook Bay, OR (shown as light green polygons) superimposed on more recent aerial photography, showing apparent changes in the location of the eelgrass beds over time in an area with dynamic sediment movement and shoaling.

APPENDIX B: Example Data Sheet and Eelgrass Habitat Maps for Tier 1 Surveys

Site:		**Date:**			**Observers:**
Transect No. X		**Start Time:**			**Stop Time:**
GPS Positions:		**Transect Start:**			**Transect End:**
Eelgrass Boundaries		**Upper:**			**Lower:**
Station	Distance (m or ft)	% Cover Species Present *Z. marina*	*Z. japonica*	Macroalgae	Notes
1	2			25	Ulva Substrate: sand/shell
2	7		10	15	Upper boundary of *Z. japonica* zone
3	12		45	20	
4	17		60		Substrate: sand
5	22		45		
6	28		80		
7	35	5	60		Upper boundary of mixed *Z. marina and Z. japonica* zone
8	40	20	50		
9	43	50	10		Lower boundary of mixed *Z. marina* and *Z. japonica* zone
10	45	55			Upper boundary of *Z. marina* zone
11	50	70			
12	55	80			Dense Z. marina, flowering shoots present
13	60	65			Substrate: muddy sand

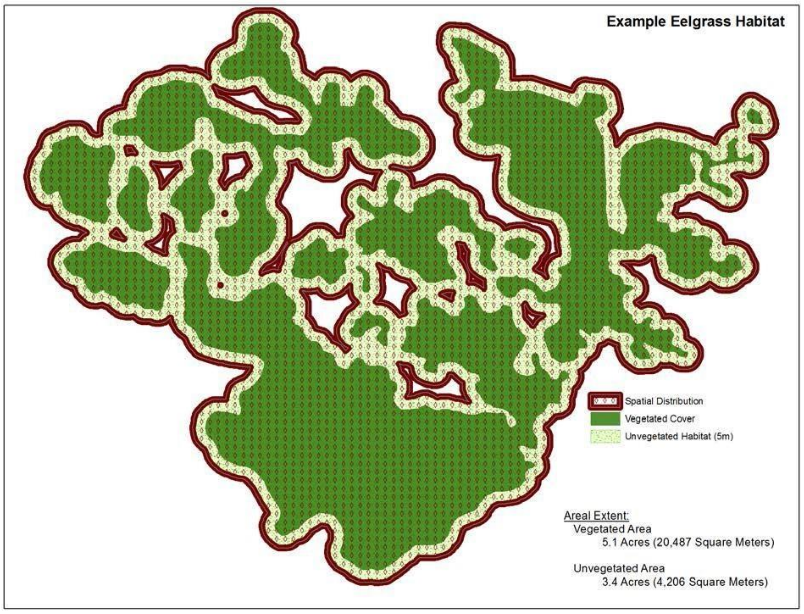


Figure B1. Graphic depiction of eelgrass habitat definition including spatial distribution and aerial coverage of vegetated cover and unvegetated eelgrass habitat (from NOAA Fisheries 2014; California Eelgrass Mitigation Policy and Implementing Guidelines).

APPENDIX C : Identification of *Zostera marina* and *Zostera japonica*

Zostera marina (eelgrass) Status: Native

Habitat: marine to brackish waters, lower intertidal and shallow subtidal; sandy to muddy sediments.

Zostera marina is the most widely distributed seagrass in the world. It's range spans the area from Alaska to California on the West Coast and is also found on the North American East Coast, Europe, Asia, and the Middle East. Common in low intertidal and subtidal zones to a depth of 20-30 feet along sheltered areas with sandy or muddy beaches. Leaf blades are usually about ½ inch (8-10 mm) wide but may be narrower. The blades reach a length of 10 ft (3 m) and are flat. This species blooms from June through August. The inflorescence (flower clusters) grow on the tips of long shoots separate from the leaf blades.

Ecology: Eelgrass habitats play an important role as foraging habitat for juvenile salmonids, particularly chum and Chinook. Pacific eelgrass stands also provide habitat for other important fishes and shellfish including Dungeness crab, starry flounder, and sturgeon. Spawning Pacific herring utilize eelgrass as a substrate to deposit eggs. Pacific eelgrass beds also harbor species of infauna and epifauna including polychaetes, gastropods, bivalves, amphipods, echinoderms, and other crustaceans that are known prey of many commercially valuable fish and invertebrates. Eelgrass meadows are also important foraging habitats for many species of migratory geese, ducks, and swans. Pacific Black Brant feed almost exclusively on eelgrass (both native and introduced) and their populations can be affected by declines in eelgrass abundance. Eelgrass leaves, roots, and rhizomes attenuate wave energy and provide shoreline stabilization. Eelgrass beds also sequester carbon and may play a role in minimizing the effects of ocean acidification, thus helping to mitigate the effects of global climate change.

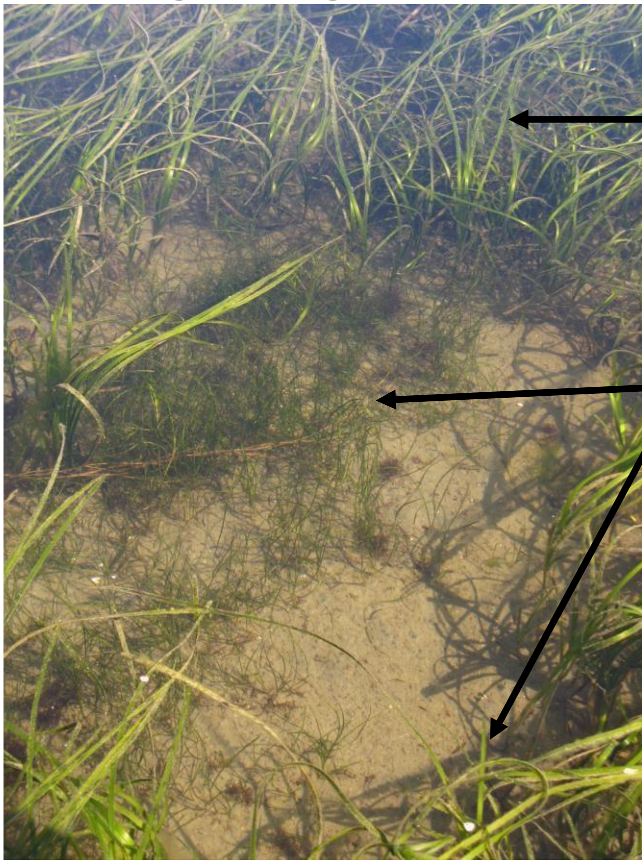
Zostera japonica (dwarf eelgrass) Status: Introduced

Habitat: marine to brackish waters, lower intertidal and shallow subtidal; sandy to muddy sediments. It typically occupies the upper to mid-intertidal zone at a higher elevation than the native eelgrass, *Z. marina*.

Z. japonica forms dense stands in shallow, sheltered bays and estuaries. In its native range, it occurs from Korea and Japan northward to the Kamchatka Peninsula in Russia. In North America, this species ranges from southern British Columbia to Humboldt Bay, California, and is expected to continue expanding its range. In the northern part of its range in North America (British Columbia), *Z. japonica* lives as an annual, overwintering as buried seeds. Towards the southern part of its established range in North America, it occurs as a short-lived perennial. It is listed as a Class C noxious weed in California and Washington, but is not listed on the federal invasive species list. It reproduces vegetatively through rhizomatous cloning and sexually through seed production. The habitat structure provided by this species may perform similar functions as native eelgrass; in particular, additional research is needed to verify its role in fisheries species utilization. This species is known to be an important food source for many species of migratory waterfowl, especially Pacific Black Brant. The dispersal of the seeds, both within and between estuaries, may be aided by waterfowl species.

Den Hartog, C. 1970. The Sea-Grasses of the World. North-Holland Publishing Company. Amsterdam, Netherlands. 272 pp.

Distinguishing Native and Introduced Eelgrass



Zostera marina

Native Eelgrass

(typical)

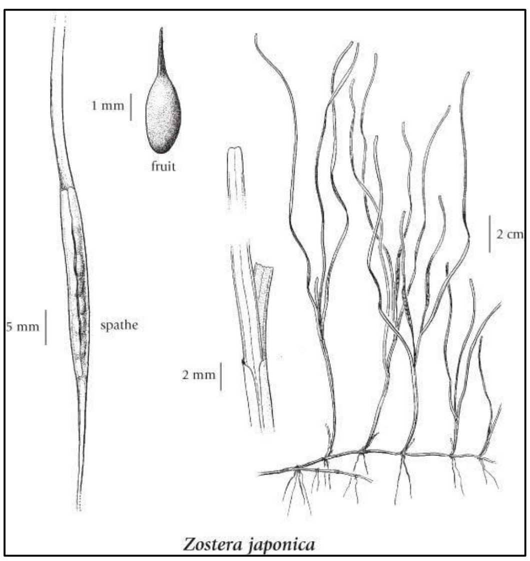
Zostera japonica

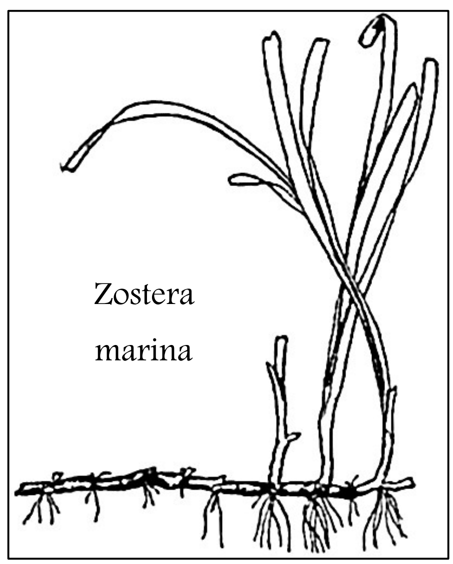
Japanese eelgrass

Introduced

IMPORTANT:

Leaf size is NOT a reliable indicator. *Z. marina* can sometimes look very similar to *Z. japonica*!





DISTINGUISHING CHARACTERISTIC
Z. japonica **has roots in pairs at each rhizome node.**
Z. marina **has roots in bundles at each rhizome node.**

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