Dynamics of seagrass (*Zostera spp.)* edges and landscape characteristics in Washington State.

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Introduction

Seagrasses comprise essential nearshore habitat that is decreasing globally. In Washington State, policies are in place in an effort to protect and sustain healthy native seagrass habitat. Creating a 'no disturbance buffer' between seagrass bed edges and any activities of potential impact is a commonly applied resource protection measure. Washington Department of Natural Resources requires a 25 foot (7.62m) protective buffer distance between native eelgrass, *Zostera marina*, and authorized uses on state-owned-aquatic lands. However, because eelgrass is a deciduous, flowering plant that can reproduce sexually or clonally, the location of bed edges change with time, making it a challenge to create buffers of a set distance.

Objectives

- Determine if the current 25 foot edge buffer is too small (or large) to accommodate the natural variation of *Z. marina* movement observed in the field.
- Evaluate relationship between landscape characteristics and edge dynamics.
- Assess and compare edge dynamics of non-native *Z. japonica* with native eelgrass dynamics.

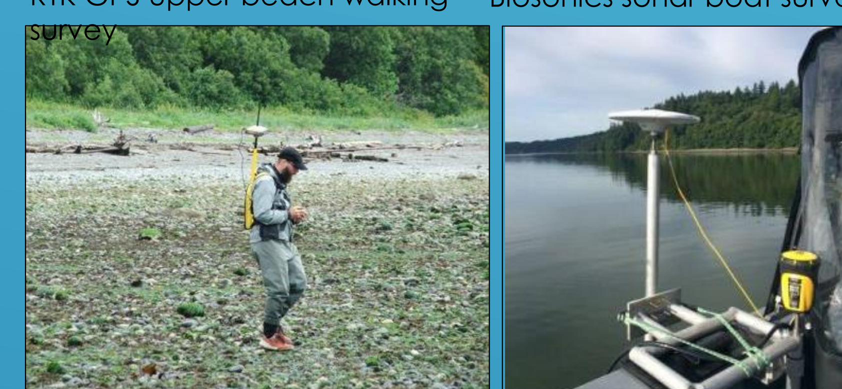
Fig. 1. Dynamics of eelgrass bed edges and landscape characteristics

Fig. 2 Site Locations

Fig 3. Survey equipment.

RTK GPS upper beach walking survey

Biosonics sonar boat survey



Field Methods

Upper and lower edge movement and landscape characteristics (bed size, beach shape, bed patchiness, eelgrass density, sediment grain size and organic content) (Fig. 1)of *Z. marina* and the non-native seagrass *Z. japonica* beds were measured at fifteen marine sites (Fig. 2) in Washington State between 2013-2015. Data were evaluated for relationships between edge dynamics and landscape characteristics and additional environmental variables such as latitude, seagrass bed classification type (i.e. flats, narrow or wide fringes) and tidal elevation.

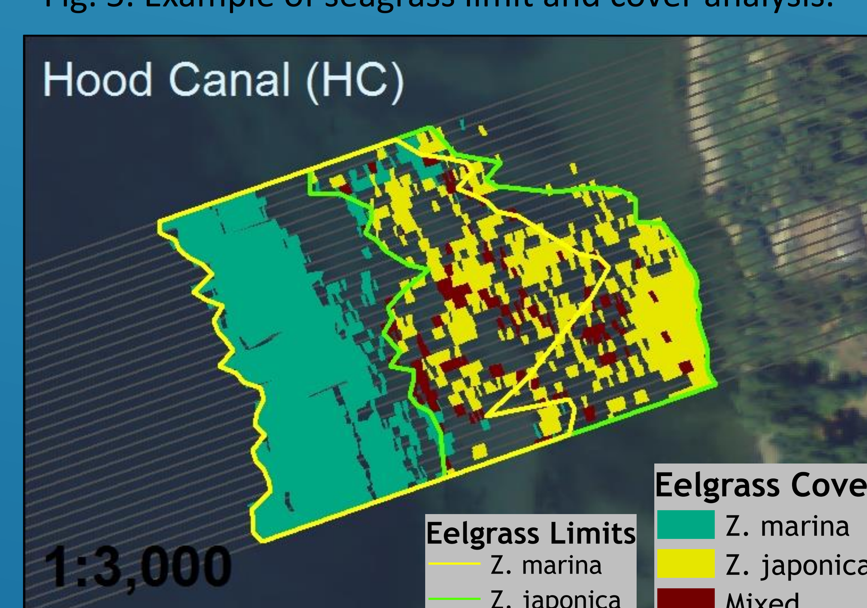
Survey-grade GNSS receivers were used to collect elevation data and map seagrass location of each species along a 150 m length of beach. Survey transects were spaced 5m apart and sampling points were collected at approximately 1m intervals. The land-based surveys were conducted at extreme low tides by walking the uncovered portions of the transects with real time kinematic (RTK) GPS receivers (Fig. 3). In addition, along the shoreward edge, seagrass presence/absence and density counts were sampled in 1/4 meter plots located in a fixed 50 by 5m sampling grid (Fig. 4). Substrate samples were also collected above and below the grid. The submerged and deep edge of the eelgrass beds were surveyed from a boat using a Biosonics single beam DTX sonar. Data collected in the field were imported into ESRI ArcGIS for analysis.

Fig. 4. Fixed grid upper edge survey

GIS Analysis

Survey points were transformed to line-intercept transects that represent the presence/absence of seagrass along each meter buffered by 0.5m to create a continuous 1m wide swath (Fig. 5). Points representing the shoreward and seaward limits of seagrass types at each site were identified and edge lines were mapped using a nearest neighbor rule. Euclidean allocation was used to model seagrass coverage across the entirety of each site. The resulting polygons are used to analyze coverage patterns.

Fig. 5. Example of seagrass limit and cover analysis.



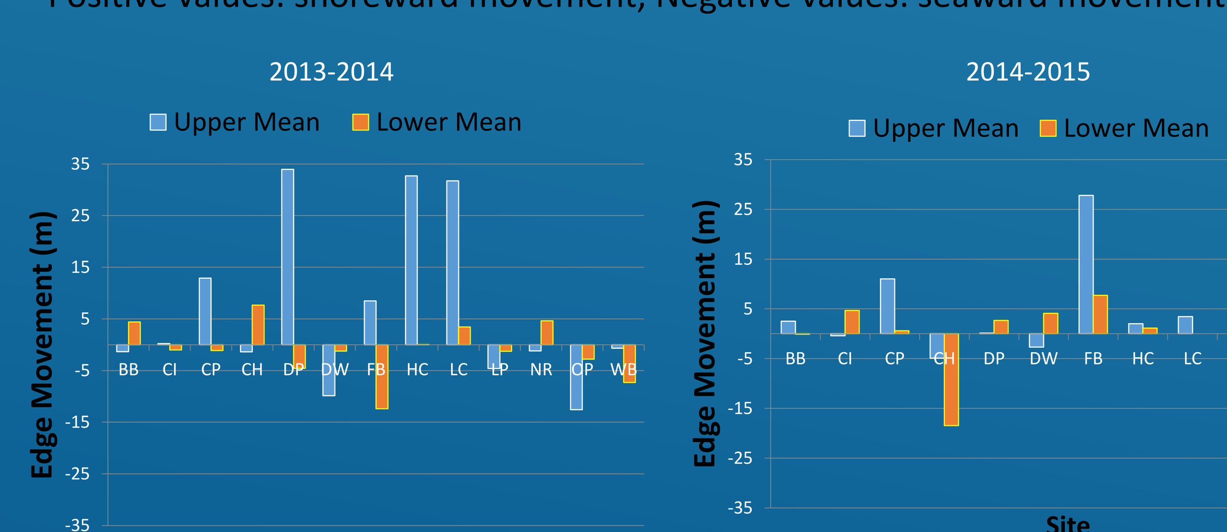
Results

Edge Dynamics

Characteristics: The location of the upper and lower edge of both species moved over the two year sampling period (Fig. 6). At the majority of sites, average annual changes in *Z. marina* edges were within 5 m, though the mean change for the upper edge ranged as high as 34 m shoreward. The greatest changes observed were upper edge shoreward movement. Movement direction and magnitude were not consistent at sites from one year to the next.

Relationships: Neither the mean nor maximum amount of movement were significantly related to latitudinal gradient (north to south), tidal elevation, slope (Spearman rank, p>0.05), or seagrass bed classification type (Kruskal-Wallis, p>0.05).

Fig. 6. Mean movement of lower and upper Z. marina edges
Positive values: shoreward movement, Negative values: seaward movement



Coverage

Characteristics: Uninterrupted coverage (an indication of contiguous vs. patchy habitat) between the edges varied considerably by site. *Z. marina* coverage ranged from <5 to >90%. Sites with highest *Z. japonica* coverage had patchier *Z. marina* beds, (Fig. 7). Average beach slopes of *Z. marina* beds ranged between 0.7-4.7%, and were found at tidal elevations between -7.2 to +1.50 m (MLLW). No significant change in proportion of seagrass species was detected from 2014-2015

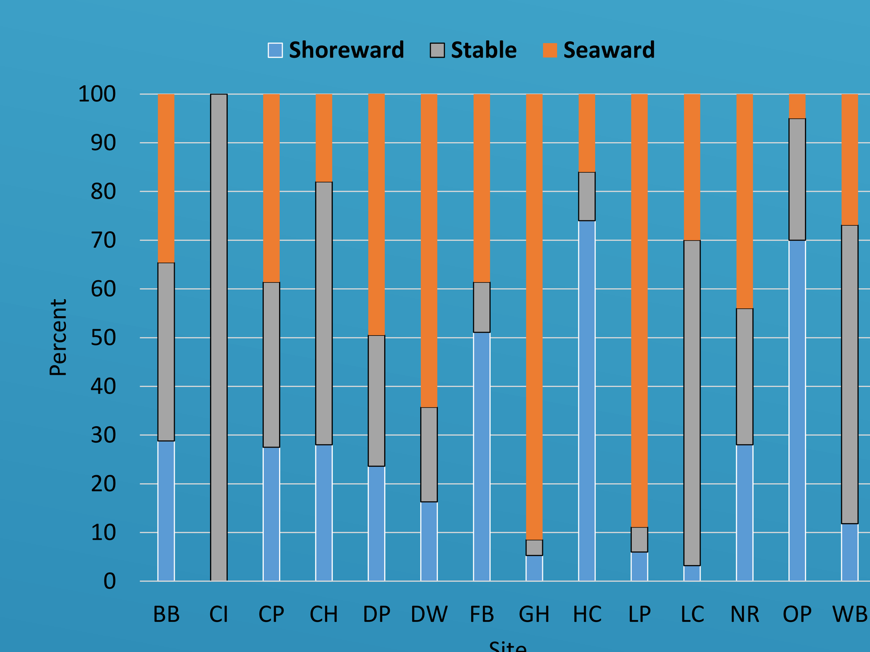
Relationships: Slopes were not significantly related to average edge movement or total area (Spearman rank, p>0.05). The mean and maximum tidal elevations of *Z. marina* beds were strongly correlated with the latitudinal gradient (north to south). (Spearman correlation coefficients ranging from 0.58-0.73 , p<0.05).

Landscape Elements

Characteristics: Most *Z. marina* cover occurred as meadows (>1000 m^2), ranging in size from1348-106,261 m^2 (Fig. 8). The remaining *Z. marina* occurred either as patches (10-1000 m^2) or nodes (<10 m^2).

Relationships: Total area, and landscape distribution (meadow, patch, or node) were not significantly related to mean beach slope (Spearman rank, p>0.05). Number of *Z. marina* nodes was strongly correlated with the latitudinal gradient – with greater number of node found in northern sites (Spearman rank coefficient of 0.55, p<0.05). Total area, patch and node numbers did not vary significantly by sea grass classification type (flats, narrow or wide fringe) (Kruskal-Wallis, p>0.05). A moderately strong inverse relationship was found between mean beach slope and mean patch area in 2014 (Spearman rank coefficient -0.57, p<0.05). A strong positive correlation was found between the mean beach elevation of patches and nodes and latitudinal gradient of the study sites in 2014 (Spearman rank coefficients of 0.69 to 0.70, p<0.05). No significant change in proportion of landscape type was detected between study years.

Fig 9. *Z. marina* movement at fixed grid on upper edge showing proportion of eelgrass that moved shoreward, seaward or remained stable at each site (2014).



Bed Characteristics & Environmental Parameters

To further analyze potential environment controls of *Z, marina* bed dynamics, the 15 sample sites were grouped based on shared characteristics, including degree of edge movement, stability of beds, seagrass area cover, patch and node numbers, beach slope and mean tidal elevation. Table 1 shows grouping of sites by color-coded shared characteristic.

Several significant differences between the relative groups emerged:

- More dynamic beds had significantly more patches and total area;
- More stable, larger beds had significantly lower area and numbers of patches and nodes;
- Sites with steeper slopes were more stable, had significantly lower numbers of patches and nodes;
- Tidal elevation had no significant impact on area, or the number of patches and nodes.

Discussion & Recommendations

Management relevant findings from this study include documentation of upper edge movement greater than the 7.62 m (25 ft) DNR protective buffer.

Fig. 7. Proportions of seagrass species coverage at each site (2015).

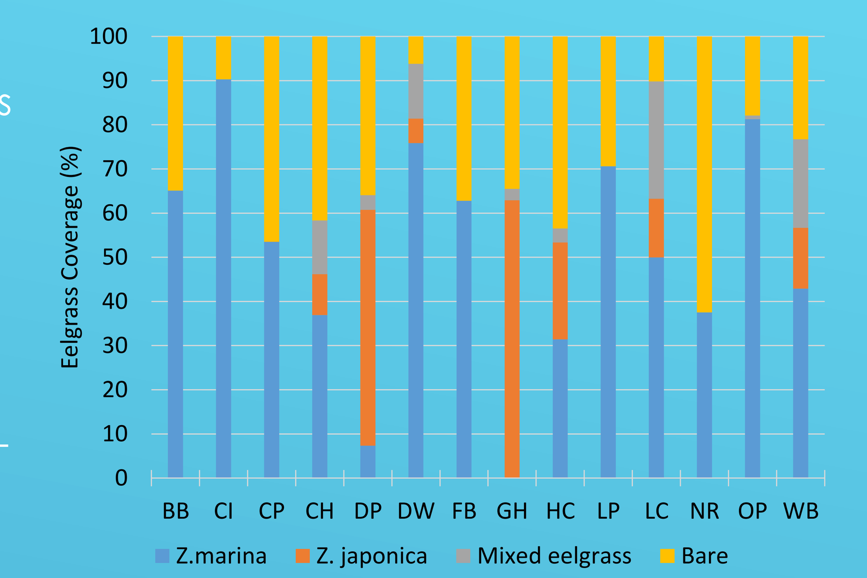
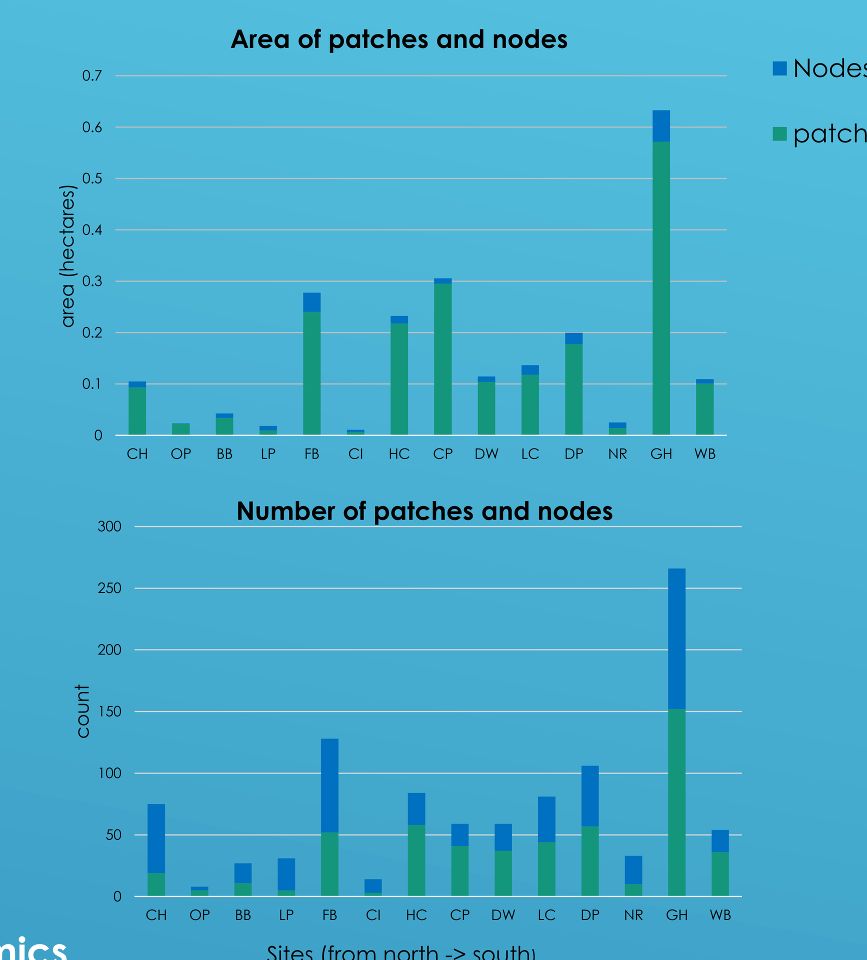


Fig. 8. *Z. marina* landscape size characteristics (2014).



Upper Grid Edge Dynamics

Characteristics: Movement of *Z. marina* varied considerably among the 15 sites surveyed at the 50 m upper grid (Fig. 9). The stable proportions of the grid edge ranged from 3.2-100.0%. A greater proportion of seaward (86.6-91.5%) versus shoreward (44.8-74.0%) was detected. The mean upper grid edge movement for each site ranged from 0.75 to 1.5 m. Maximum movements measured ranged from 2.5-5.0 m.

Relationships: Neither the proportional direction of grid edge movement, nor the mean or maximum distances moved were significantly related to beach slope, mean sediment size, organic content, latitudinal gradient of study sites (Spearman rank, p>0.05 or by seagrass classification (flats, narrow or wide fringe)(Kruskal-Wallis, p>0.05).

Table 1. Grouping of sample sites based on relative differences in *Z. marina* bed characteristics and related environmental conditions

The lower edge is more stable than the upper edge.

On the upper edge, patchier areas are more dynamic, have a flatter beach slope, and are found at lower elevation than contiguous areas.

Mixed *Z. marina* & *Z. japonica* edges were patchier and more dynamic than contiguous native eelgrass edges