May 1st, 3:30 PM - 5:00 PM

Eelgrass (Zostera marina) biomass models for predicting restoration potential in Puget Sound

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An eelgrass (*Zostera marina*) biomass model for predicting restoration potential in Puget Sound

Kate E. Buenau, Lyle F. Hibler, And Ronald M. Thom

Salish Sea Ecosystem Conference
Seattle, WA

May 1, 2014
Eelgrass Restoration Site Selection for Puget Sound

Puget Sound Hydrodynamic Model → Eelgrass Biomass Model → Suitability Maps/Site Selection

Eelgrass Monitoring/Historical Extent → Suitability Maps/Site Selection

Test Planting/Monitoring → Suitability Maps/Site Selection

Expert Knowledge → Suitability Maps/Site Selection

Shoreline Planning → Suitability Maps/Site Selection
Objectives

- Develop a dynamic eelgrass model to help predict restoration potential
- Adapt existing model to *Z. marina* with local data
- Use output from Puget Sound hydrodynamic model
- Focus on factors that vary spatially

Why use a dynamic model?

- Integrate environmental conditions over time
- Interactions between controlling factors
- Climate and management scenarios
Biomass model

Aboveground biomass (mol C/m²)

\[ C_{a,t+1} = C_{a,t} + \Delta t \left[ (1 - \tau)P(I_z, T, S)C_{a,t} \left( 1 - \frac{C_{a,t}}{\kappa} \right) - R_a(T)C_{a,t} - M_a C_{a,t} \right] \]

\[ C_{b,t+1} = C_{b,t} + \Delta t \left[ (\tau - \delta)P(I_z, T, S)C_{a,t} \left( 1 - \frac{C_{a,t}}{\kappa} \right) - R_b(T)C_{b,t} - M_b C_{b,t} \right] \]

Belowground biomass (mol C/m²)

Photosynthesis

Respiration

Translocation and exudation of carbon

Density dependence

Mortality

Adapted from Burd and Dunton 2001, Eldridge et al. 2004, Kaldy and Eldridge 2006
Biomass model – current focus

Aboveground biomass (mol C/m²)

\[ C_{a,t+1} = C_{a,t} + \Delta t \left[ (1 - \tau) P(I_z, T, S) C_{a,t} \left( 1 - \frac{c_{a,t}}{\kappa} \right) - R_a(T) C_{a,t} - M_a C_{a,t} \right] \]

Belowground biomass (mol C/m²)

\[ C_{b,t+1} = C_{b,t} + \Delta t \left[ (\tau - \delta) P(I_z, T, S) C_{a,t} \left( 1 - \frac{c_{a,t}}{\kappa} \right) - R_b(T) C_{b,t} - M_b C_{b,t} \right] \]

Photosynthesis

Respiration

Translocation and exudation of carbon

Density dependence

Mortality

Local data

May 1, 2014
Not currently included

- Seasonal differences in mortality
- Use of carbon stored belowground
- Nutrients
- Desiccation
- Substrate
- Wave energy

Future development

Post-processing with spatial datasets
Physiological data from Sequim Bay eelgrass population

**Graph 1:** Proportional change in gross primary production vs. salinity (psu)

**Graph 2:** Respiration (mol C/(mol C hr)) vs. temperature (C)

*Note: The graphs illustrate the relationship between environmental variables and biological indicators in the Sequim Bay eelgrass population.*
Temperature-Photosynthesis relationship—what function?

From Burd and Dunton 2001 (for *Halodule wrightii*)
Temperature-Photosynthesis relationship—what function?

(ΔAIC = 6.7)
Photosynthesis relationship with light and temperature

Gross primary productivity (mol C/(mol C hr))

Light (mol/(m^2 day))

Temperature (C)

GPP (mol C/(mol C hr))

Temperature (C)

Light (mol/(m^2 day))
Model input for Sequim Bay

Monthly averages derived from Marine Water Quality Monitoring Program (WA Ecology) Secchi depth data

Weather Research and Forecasting Model (UW) light inputs, attenuated through water depth

Model output for Sequim Bay

- **Attenuation Coefficient**
  - $K_{\text{PAR}}$ (1/m)
  - Jan, Apr, Jul, Oct, Jan

- **Water Temperature**
  - Temperature (C)
  - Jan, Apr, Jul, Oct, Jan

- **PAR at Canopy**
  - Daily Mean PAR (molC/m$^2$/day)
  - Jan, Apr, Jul, Oct, Jan

- **Salinity**
  - Salinity (psu)
  - Jan, Apr, Jul, Oct, Jan

- **Photosynthetic Production**
  - Daily Mean GPP (molC/(molC m$^2$ h))
  - Jan, Apr, Jul, Oct, Jan

- **Respiration**
  - Respiration (molC/(molC m$^2$ h))
  - Jan, Apr, Jul, Oct, Jan

- **Growth Rate**
  - Daily Mean Growth Rate (molC/(molC m$^2$ h))
  - Jan, Apr, Jul, Oct, Jan

- **Aboveground Biomass**
  - Biomass (molC/m$^2$)
  - Jan, Apr, Jul, Oct, Jan
Comparison of Sequim Bay (thin lines) and Hood Canal (thick lines)
Spatial inputs

Temperature (°C)

Salinity (psu)

Attenuation ($K_{PAR}$, 1/m)

Means of yearlong time series

Olympia

Seattle

Bellingham

May 1, 2014
Sound-wide results (index)

-1m NAVD88

-5m NAVD88
Comparison with eelgrass growth data

Cumulative Change in Biomass (mol C/m²)

Date

Modeled

Observed

6/20 7/10 7/30 8/19
Conclusions

- Use of data collected in Puget Sound improved spatial patterns of biomass predictions
- Predictions are best used as a relative measure, with consideration of characteristics of particular sites
- Significant data needs remain
Data needs

- Nearshore light attenuation
- Physiological data over broader range of conditions and local populations
- More biomass data with light and temperature for validation
- Belowground physiology
- Seasonal changes in physiology and mortality
Thank you!

Contributors
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