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20% More Eelgrass in Puget Sound by 2020: Restoration Site Selection

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Speaker
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20% More Eelgrass in Puget Sound by 2020: Restoration Site Selection

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Salish Sea Conference
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May 1, 2014
Objective

Puget Sound Partnership Goal – Restore 20% more eelgrass by 2020

Present extent = 20,300ha (F. Short, WDNR, Oct. 2013)

Historical losses have occurred but are not well quantified

Recent (since 2000) losses are indicated

Objective of study –

- Locate specific areas where eelgrass could be restored to meet the (~4,000 ha) recovery goal.
- Restore, Enhance, Conserve, Protect
Approach to Find Sites

Ecosystem-wide assessment, then site specific tests

- Models
- Planner Survey
- Site Evaluation
- Suitability Maps
- Manuscript with Strategy
Controlling Factors

Eelgrass 
Structure/Health
- Shoot density
- Patch or meadow area
- Shoot abundance
- Aboveground biomass
- Belowground biomass
- Growth rate
- Flowering
- Genetic diversity

Eelgrass Stressor Study
(Thom et al. 2011)

Stressors

Controlling Factors

Competition

Light

Substrata

Energy

Local adaptation

Temperature

Salinity

Herbivory

Nutrients

Shoot density

Patch or meadow area

Shoot abundance

Aboveground biomass

Belowground biomass

Growth rate

Flowering

Genetic diversity

Invasive species

Nutrient-driven harmful algal blooms

Suspended sediment

Sea level rise

Overwater structures

Aquaculture

Bioturbation

Storms

Construction

Boat grounding/anchoring

Armoring

Dredging/filling

Propeller wash/boat wake

Anthropogenic contaminants

Disease

Organic matter discharge/sulfides

Sea temperature rise

Freshwater input

Overfishing

Sea temperature rise

Invasive species

Sea level rise

Overwater structures

Temperate

Bioturbation

Construction

Aquaculture

Dredging/filling

Propeller wash/boat wake

Anthropogenic contaminants

Disease

Organic matter discharge/sulfides

Freshwater input

Overfishing
Minimum ~3 mol quanta m$^{-2}$ d$^{-1}$, during spring and summer.
Temperature vs Leaf Net Productivity (NPP) and Respiration (R)
(Thom et al. in review)
* Maximum NPP 6-17°C
* Severe decline in NPP and increase in R above 25°C
* NPP:R greatest at about 5-9°C
* Growth declines with temp.
Eelgrass Biomass Growth Model

Biomass after 1 year at 3m NAVD depth (molC m⁻²)

(Initial biomass = 2.0 molC/m²)
Total Area by Depth Suitable for Eelgrass (Predicted growth ≥2.0 molC m⁻²)

<table>
<thead>
<tr>
<th>Depth Bin</th>
<th>Depth (m) NAVD88</th>
<th>Area (ha)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.5 to -1.5</td>
<td>10,721</td>
</tr>
<tr>
<td>2</td>
<td>-1.5 to -2.5</td>
<td>75,523</td>
</tr>
<tr>
<td>3</td>
<td>-2.5 to -3.5</td>
<td>4,739</td>
</tr>
<tr>
<td>4</td>
<td>-3.5 to -4.5</td>
<td>3,762</td>
</tr>
<tr>
<td>5</td>
<td>-4.5 to -5.5</td>
<td>3,993</td>
</tr>
<tr>
<td>6</td>
<td>-5.5 to -6.5</td>
<td>2,737</td>
</tr>
<tr>
<td>7</td>
<td>-6.5 to -7.5</td>
<td>2,422</td>
</tr>
<tr>
<td>8</td>
<td>-7.5 to -8.5</td>
<td>1,513</td>
</tr>
<tr>
<td>9</td>
<td>-8.5 to -9.5</td>
<td>348</td>
</tr>
<tr>
<td>Sum</td>
<td></td>
<td>105,758</td>
</tr>
</tbody>
</table>

*Not corrected for substrata or disturbances/stressors
*Does exclude elevation with high desiccation potential

Present extent = 20,300ha
Test Plots

- 23 sites were examined
  - 12 with eelgrass
  - Genetic samples from 8 sites

- Test plots in 3 major regions
  - Larger sites
  - Landscape scale issues (e.g., south Sound)
  - Unexplained absence of eelgrass

- Plantings done 5-14 June 2013
  - 5 sites, total of 9 plots.
Donor stock from stockpile at MSL and nearby meadows
Light & Temperature Sensors at all Sites
## Test Planting Results (after 10 Months)

<table>
<thead>
<tr>
<th>Site</th>
<th>Shoots planted</th>
<th>Area planted (m²)</th>
<th>Shoots counted</th>
<th>Survival</th>
<th>Mean end density (shoots m⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amsterdam Bay shallow</td>
<td>720</td>
<td>36</td>
<td>11</td>
<td>1.5%</td>
<td>0.31</td>
</tr>
<tr>
<td>Amsterdam Bay deep</td>
<td>720</td>
<td>36</td>
<td>14</td>
<td>1.9%</td>
<td>0.39</td>
</tr>
<tr>
<td>Joemma SP shallow</td>
<td>712</td>
<td>36</td>
<td>775</td>
<td>108.8%</td>
<td>21.53</td>
</tr>
<tr>
<td>Joemma SP deep</td>
<td>712</td>
<td>36</td>
<td>930</td>
<td>130.6%</td>
<td>25.83</td>
</tr>
<tr>
<td>Zangle Cove</td>
<td>872</td>
<td>45</td>
<td>539</td>
<td>61.8%</td>
<td>11.98</td>
</tr>
<tr>
<td>Liberty Bay (NW site)</td>
<td>600</td>
<td>30</td>
<td>8</td>
<td>1.3%</td>
<td>0.27</td>
</tr>
<tr>
<td>Liberty Bay (SE site)</td>
<td>720</td>
<td>36</td>
<td>3</td>
<td>0.4%</td>
<td>0.08</td>
</tr>
<tr>
<td>Westcott middle bay</td>
<td>472</td>
<td>25</td>
<td>81</td>
<td>17.2%</td>
<td>3.24</td>
</tr>
<tr>
<td>Westcott head of bay</td>
<td>448</td>
<td>25</td>
<td>0</td>
<td>0.0%</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Westcott Bay

- Site of unexplained loss of ~16ha of eelgrass
- Head of Bay
  - Depths -4m to -6m
  - Five 5m long transects
  - Covered ~100m
  - 448 shoots
- Middle of Bay
  - Depths -5m to -9m
  - Five 5m long transects
  - Covered 56m
  - 472 shoots
- Observations
  - Head of Bay, all eelgrass gone
  - Middle Bay, about 25% remained
Head of the Bay

Middle Bay

Westcott Bay
Integrated Daily Photosynthetic Photon Flux Density in Eelgrass Zone – South Puget Sound

Integrated Daily PPFD (mol m$^{-2}$ d$^{-1}$)

- S. Sound - shallow (-1.0 m MLLW)
- S. Sound - deep (-1.5 m MLLW)
- S. Sound - air

3 mol m$^{-2}$ d$^{-1}$
PAR at Eelgrass Canopy Depth

2013 Daily PAR average between 10:00 and 2:00

PAR (umol m\(^{-2}\) s\(^{-1}\))

- Westcott Bay
- Anderson Island
Climate Variation and Eelgrass Density (Thom et al. in review)

Clinton Ferry Terminal
(Summer, 1997 – 2006)

- Greatest densities occur during neutral to slightly positive
  Oceanic Niño Index
- Variation may be driven by water Temperature and mean
  sea level
Survey Results

- Survey was sent out to 1,000 recipients
- A total of 147 responded; 50% categorized themselves as Natural Resource Manager, Marine Biologist, and Nearshore/Estuarine Scientist
- Over 80% of respondents considered themselves to have a “good” or “excellent” understanding of the functions and values of eelgrass, its abundance and distribution throughout Puget Sound, and the stressors that affect it.
- Dredging and filling, shoreline development and water quality were identified as having a large impact to eelgrass at discrete locations in PS, as well as in PS as a whole in its current state.
- 78% of respondents indicated that changing policies that protect eelgrass from direct impacts (dredging, overwater structures, mooring buoys) would enhance eelgrass in PS
- 90% of respondents indicated that changing policies that protect eelgrass from degrading environmental conditions (e.g. poor water quality, nutrient loading) would enhance eelgrass in PS
- 75% of respondents indicated that changing policies that require greater project compliance (e.g. larger mitigation ratios, higher transplant criteria) would enhance eelgrass in PS
<table>
<thead>
<tr>
<th>Region</th>
<th>Shoreline Length (miles)</th>
<th>Sites in Sampling Frame for Eelgrass Survey (sq miles)</th>
<th>Overwater Structure Area (acres)</th>
<th>Overwater Structure Density (acres/shoreline mile)</th>
<th>Percent Shoreline Armored</th>
<th>305(b) Sediment Contaminant Occurrences in Eelgrass Survey areas (a)(b)</th>
<th>303(d) Water Quality Occurrences (a)(c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hood Canal</td>
<td>245</td>
<td>28</td>
<td>63</td>
<td>0.258</td>
<td>21.29%</td>
<td>0.14</td>
<td>2.34</td>
</tr>
<tr>
<td>North Puget Sound</td>
<td>250</td>
<td>98</td>
<td>184</td>
<td>0.736</td>
<td>31.71%</td>
<td>3.08</td>
<td>0.74</td>
</tr>
<tr>
<td>Saratoga-Whidbey</td>
<td>343</td>
<td>100</td>
<td>144</td>
<td>0.419</td>
<td>21.67%</td>
<td>0.21</td>
<td>0.30</td>
</tr>
<tr>
<td>South Puget Sound</td>
<td>206</td>
<td>25</td>
<td>66</td>
<td>0.322</td>
<td>26.96%</td>
<td>0.00</td>
<td>2.56</td>
</tr>
<tr>
<td>Central Puget Sound</td>
<td>734</td>
<td>81</td>
<td>803</td>
<td>1.095</td>
<td>47.61%</td>
<td>1.00</td>
<td>2.3</td>
</tr>
<tr>
<td>San Juan</td>
<td>454</td>
<td>33</td>
<td>90</td>
<td>0.199</td>
<td>4.29%</td>
<td>0.42</td>
<td>0.85</td>
</tr>
<tr>
<td>Straits</td>
<td>220</td>
<td>46</td>
<td>47</td>
<td>0.215</td>
<td>15.38%</td>
<td>0.00</td>
<td>0.61</td>
</tr>
<tr>
<td>Puget Sound</td>
<td>2,451</td>
<td>410</td>
<td>1,398</td>
<td>0.571</td>
<td>27.09%</td>
<td>1.04</td>
<td>1.09</td>
</tr>
</tbody>
</table>

(a). One site may have multiple contaminant issues.
(b). Count, class 2, 4, or 5 per square mile of eelgrass survey area.
(c). Count, class 5 per square mile of eelgrass survey area.
<table>
<thead>
<tr>
<th>Present (Site and Landscape) Conditions</th>
<th>Suitable</th>
<th>Unsuitable</th>
</tr>
</thead>
<tbody>
<tr>
<td>+Zm, then conserve/ enhance</td>
<td>+Zm, then conserve/ enhance</td>
<td></td>
</tr>
<tr>
<td>-Zm, then plant $$</td>
<td>-Zm, then plant $</td>
<td></td>
</tr>
<tr>
<td>Create suitable habitat, abate stressors, then plant $$$$</td>
<td>Abate stressors, then plant $$$</td>
<td></td>
</tr>
</tbody>
</table>

**Unsuitable**

**Suitable**

**Emerging Restoration Strategy - Is it stressors or recruitment issues…or both?**
Implement Actions to Promote Resilient Populations (Thom et al. 2012. Estuaries and Coasts 34:78-91)

- Understand carrying capacity and limiting factors of various depths, sediment types in different regions and sites
- Improve ecosystem processes
  - Abate water quality issues on watershed/landscape scale
  - Abate excessive (unnatural) sources of suspended sediment
  - Remove obvious sources of stress and disturbance
- Plant minimum viable populations
  - Utilize appropriate genetic stocks
  - Plant at appropriate density
- Enhance sources of renewal
  - Plant near existing meadows
  - Enhance below-ground development
  - Improve chances of seeds reaching the restoring sites
- Adaptively manage sites
Summary

- Large area *potentially* suitable for eelgrass that is currently barren of eelgrass
- Test plantings showed variable success in transplant survival indicating site suitability
  - Suitability may be driven by light, temperature, local adaptation, and ability to escape early mortality
  - Water quality may be affecting large regions, and needs further evaluation
- Regulatory actions should be implemented in areas where obvious improvement will take place
- Natural recovery appears to be occurring in some restoring areas (e.g., Nisqually Delta, Skokomish Delta)
Conclusions

► Restoring 4,000ha by 2020 is a grand challenge
  ■ Recruitment limitation (low seed production, slow rhizome spread)
  ■ Minimize donor stock impact
  ■ Natural variation in ‘ocean conditions’
  ■ Climate change (R. Takesue et al.)
  ■ Human disturbances continue on site and landscape scales
  ■ Regulatory issues need to be resolved (disturbances, permits)
  ■ Loss of eelgrass continues in some areas (F. Short, WDNR)

► Can we expand the carrying capacity of the system for eelgrass?
  ■ Abatement of physical constraints and disturbances
  ■ Improvement in water clarity

► Consider a trajectory of net improvement through time in controlling factors and eelgrass area as an indicator of progress toward goal
Future

- Final manuscript June 2014 – with recommendations
- Additional funding to implement restoration efforts –
  - National Estuary Restoration Program grant (restoring deltas)
  - Port Gamble
  - State Restoration Fund
- Need to –
  - Define role of watershed conditions in degrading nearshore water quality
  - Investigate regulatory approaches to enhancing eelgrass recovery
    - Reduce disturbances on site and landscape scales
    - Facilitate permitting process
  - Enhance predictive capability of model
  - Resolve nearshore data needs (bathymetry, light conditions, water quality, phytoplankton, suspended sediment, eelgrass presence)
  - Understand spatial aspects of genetic variation
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