The assessment of nutrient, metal, and organic contaminant concentrations in eelgrass (Zostera marina L.) in Puget Sound, WA (USA): A project overview

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Metals, Nutrients, and Organic Contaminants in Eelgrass (Zostera marina L.)

Jeffrey Gaeckle
Nearshore Habitat Program
Washington State Department of Natural Resources (DNR)

Salish Sea Ecosystem Conference
30 April 2014
• DNR manages aquatic lands and resources throughout Puget Sound

• Eelgrass is an embedded resource that has important ecosystem values
Toxicity Pathways in Seagrass Meadows

CONTAMINANT TROPHIC TRANSFER (GRAZING)
- Planktonic Herbivores
- Epibenthic Meio-Macrofauna
- Infaunal Meio-Macrofauna

MODIFYING FACTORS
- Temperature
- Irradiance
- Nutrients
- Salinity

DRIFT and EXPORT

CONTAMINANT TOXICITY and BIOACCUMULATION (Blades, Epiphytes, and Grazers)

MODIFYING FACTORS
- Dissolved Oxygen
- Sulphide Concentrations
- Total Organic Carbon

SEDIMENT TOXICITY and CONTAMINANT BIOACCUMULATION (Rhizome, Roots, Epibenthic and Infaunal Species)

LITTER DECOMPOSITION

(Lewis & Devereux 2009)
Trace elements and oil related contaminants

- Document background levels in sediment, bivalves and eelgrass in the event of an oil spill
- Higher PAH levels in eelgrass were observed at sites closest to the oil refinery infrastructure
  - PAHs: 0.05 – 0.17 µg gww⁻¹
- Higher arsenic levels associated with the March Point Landfill
  - Arsenic: 2-8 µg gdw⁻¹
Project Objectives

• Baseline assessment of nutrients, metals, and organic contaminants in eelgrass (*Zostera marina*) throughout Puget Sound
  – Spatial distribution
  – Proximity to outfalls
  – Co-locate with Mussel Watch sites

• Assess the effects of an outfall *modification* on eelgrass
  – Installation
  – Removal
  – Upgrade in treatment

(L. Ferrier)
Site Selection

- Spatially distributed
- Impacted and pristine areas
- Access (safety at night)
- Permission
- Assistance
- Co-location with other research
  - eelgrass (USFW 1994)
  - mussels (Lanksbury et al. 2012)
Baseline Data

FIELD – January 8-14, 2013

- Triplicate 0.25 m² samples of eelgrass
- Rinsed with seawater
- Stored at 6°C until processed at the DNR Aquatic Botany Lab

LAB – January 8-25, 2013

- Eelgrass processing – aboveground and belowground compartments
- Metals - inductively coupled plasma mass spectrometry (ICPMS) and cold vapor atomic absorption (Hg-CVAA)
  - arsenic, cadmium, chromium, copper, iron, lead, nickel, vanadium, zinc, and mercury
- Organic contaminants – gas chromatography/mass spectrometry
  - polyaromatic hydrocarbons (PAHs)
  - polychlorinated biphenyls (PCBs)
  - polybrominated diphenyl ethers (PBDEs)
  - persistent organic pollutants (POPS).
- Eelgrass tissue – elemental analyzer
  - C and N - δ¹⁵N and δ¹³C
LEAD

- $\mu$g gdw$^{-1}$ (mean ± SE)
- aboveground
- belowground
- only 8 sites presented
  - 4 highest values
  - 4 lowest values
COPPER

- \( \mu g \text{ gdw}^{-1} \) (mean ± SE)
- aboveground
- belowground
- only 8 sites presented
  - 4 highest values
  - 4 lowest values
ZINC

- μg gdw\(^{-1}\) (mean ± SE)
- aboveground
- belowground
- only 8 sites presented
  - 4 highest values
  - 4 lowest values
<table>
<thead>
<tr>
<th>LOCATION</th>
<th>Cu</th>
<th>Pb</th>
<th>Zn</th>
<th>REFERENCE</th>
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</thead>
<tbody>
<tr>
<td>Limfjord, Denmark</td>
<td>16.6</td>
<td>37.5</td>
<td>175</td>
<td>Brix et al. 1983</td>
</tr>
<tr>
<td>(max)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limfjord, Denmark</td>
<td>4.8</td>
<td>1.1</td>
<td>78</td>
<td>Brix et al. 1983</td>
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<tr>
<td>(means)</td>
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<td>Yaquina Bay, OR</td>
<td>10</td>
<td>-</td>
<td>29</td>
<td>Kaldy 2006</td>
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<td>Ayamonte, Spain</td>
<td>36</td>
<td>16</td>
<td>215</td>
<td>Stenner &amp; Nickless 1975</td>
</tr>
<tr>
<td>LaRábida, Spain</td>
<td>1350</td>
<td>1800</td>
<td>1480</td>
<td>Stenner &amp; Nickless 1975</td>
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<tr>
<td>(max)</td>
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<tr>
<td>Cadiz Bay, Spain</td>
<td>9</td>
<td>6</td>
<td>100</td>
<td>Stenner &amp; Nickless 1975</td>
</tr>
<tr>
<td>Padilla Bay, WA</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>USFW 1994</td>
</tr>
<tr>
<td>Puget Sound, WA</td>
<td>16.0-74.1</td>
<td>0.1-0.5</td>
<td>56.6-106.6</td>
<td>This study</td>
</tr>
</tbody>
</table>

**Evidence of Toxicity**
- >10 ppm dose
  - 10 days
  - ↓ growth rate
- >100 ppm dose
  - 5 days
  - ↓ N₂ fixation
- >10 ppm dose
  - 10 days
  - ↓ growth rate

Review by Lewis & Devereux 2009
Source vs. Sink

How much of a particular metal is cycled or stored?

• Assuming there are
  – 8-10 million kg of aboveground eelgrass biomass in PS
  – 2-5 million kg of belowground eelgrass biomass in PS

<table>
<thead>
<tr>
<th></th>
<th>ABOVEGROUND</th>
<th>BELOWGROUND</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>(kg)</td>
<td>(kg)</td>
</tr>
<tr>
<td>Cu</td>
<td>250 – 300</td>
<td>10 – 30</td>
</tr>
<tr>
<td>Pb</td>
<td>2</td>
<td>120 – 280</td>
</tr>
<tr>
<td>Zn</td>
<td>650 – 800</td>
<td>0.1 – 0.4</td>
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</table>

• Few things to consider
  – Standing stock calculation only
    • Eelgrass produces new leaves every 7-20 days
    • Eelgrass shoots have on average 5 leaves
    • Therefore, 3-10 times calculated value may be cycled or stored in one year
  – Eelgrass is only one component of the plant community in Puget Sound
PAH (high molecular weight)

- 20 analytes
- ng gww\(^{-1}\) (mean ± SE)
- aboveground
- belowground
- only 8 sites analyzed
Orcas Island Outfall Assessment

- Eelgrass bed characteristics
  - Area
  - Depth distribution

- Plant parameters
  - Morphology
  - Tissue concentrations
    - Nutrient
    - Metals
    - Organic contaminants

- Environmental parameters
  - Photosynthetically available radiation (PAR)
  - Temperature
### Orcas Island Eelgrass

<table>
<thead>
<tr>
<th>EELGRASS</th>
<th>West</th>
<th>Center</th>
<th>East</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (ha ± SE)</td>
<td>4.1 ± 0.1</td>
<td>1.5 ± 0.1</td>
<td>1.3 ± 0.2</td>
</tr>
<tr>
<td>Shallow Depth (m ± SE)</td>
<td>-0.6 ± 0.0</td>
<td>-0.1 ± 0.1</td>
<td>-0.4 ± 0.2</td>
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<tr>
<td>Deep Depth (m ± SE)</td>
<td>-8.4 ± 0.2</td>
<td>-6.6 ± 0.1</td>
<td>-4.4 ± 0.1</td>
</tr>
</tbody>
</table>
NEXT

- Complete analysis with the remaining organic contaminant data from the sound-wide and Orcas Island sites
- Explore the potential of nutrient, metal, and organic contaminant cycling (aboveground tissue) and storage (belowground tissue)
- Monitor eelgrass and environmental parameters at Orcas Island after the installation of the new, shallower, outfall
  - Eelgrass area and distribution
  - PAR and temperature
  - Nutrients, metals, and organic contaminants
- Research threshold effect concentrations under environmental conditions similar to Puget Sound
Partners and Volunteers

Nearshore Habitat Program
- Helen Berry
- Lisa Ferrier
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- Andrew Ryan
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- Puget Sound Corps

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Laboratories
- Gina Ylitalo (NOAA-Montlake Lab)
- Katherine Bourbonais (KCEL)
- Connie Harrington (USFS)
- Ben Harlow (WSU)

Site Contacts and Assistance
- Puget Sound Corps (WCC team, Birch Bay, Cypress Island, Anderson Island, Sandy Bay)
- Port of Orcas Island Airport (Orcas Island)
- FHL, Pema Kitaeff and divers (Orcas Island)
- Padilla Bay NERR (D. Bulthuis & H. Bohlmann, Padilla Bay)
- Megan Black (Thompson Spit)
- Al Bahl (Big Gulch Wastewater Treatment Facility, Big Gulch)
- Lincoln Lohr (Big Gulch)
- Seattle Parks and Recreation (Barbara DeCaro, 4-Mile Rock)
- Arlene Bac and Holly White (Holly)
- Cathy Short (Holly)
- Archdiocese of Seattle (Dumas Bay)
- Neifert Family (Anderson Island)

Consultants
- Marine Resources Consultants

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