Coastal protection via vegetation

Maike Paul, Ph.D.
Coastal protection is protection from storm floods.
Coastal protection is more than storm flood protection

- Dimensioning of structures/measures in time and space
- Maintenance during lifetime
- Adaptation to future challenges
Ecosystem services in coastal protection

- Wave and flow reduction
- Shoreline stabilisation
- Adaptation to sea-level rise

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Thanks to James Tempest for the video
15-20% reduction over 40 m length

Möller et al., 2014, Nature Geoscience
Plants break under wave forcing

Rupprecht et al., 2017, Ecological Engineering
### Same order of magnitude for attenuation by seagrass

<table>
<thead>
<tr>
<th>Species</th>
<th>Shoot density m$^{-2}$</th>
<th>Submerged ratio</th>
<th>Wave height red. %</th>
<th>Length of meadow (m)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ruppia maritima</em></td>
<td>&gt;1000</td>
<td>1:1</td>
<td>50</td>
<td>compared to unvegetated site</td>
<td>Newell and Koch, 2004*</td>
</tr>
<tr>
<td><em>Zostera noltii</em></td>
<td>4164</td>
<td>&lt;7:1</td>
<td>20</td>
<td>95</td>
<td>Paul and Amos, 2011*</td>
</tr>
<tr>
<td><em>Thalassia testudinum</em></td>
<td>1100</td>
<td>Approx. 4:1</td>
<td>30</td>
<td>39</td>
<td>Bradley and Houser, 2009*</td>
</tr>
<tr>
<td><em>Halodule wrightii</em></td>
<td>1900-2870</td>
<td>&lt;1:1</td>
<td>25.0</td>
<td>1</td>
<td>Fonseca and Cahalan, 1992**</td>
</tr>
<tr>
<td><em>Syringodium filiforme</em></td>
<td>230-1350</td>
<td>&lt;1:1</td>
<td>26.5</td>
<td>1</td>
<td>Fonseca and Cahalan, 1992**</td>
</tr>
<tr>
<td><em>Thalassia testudinum</em></td>
<td>850-1500</td>
<td>&lt;1:1</td>
<td>27.8</td>
<td>1</td>
<td>Fonseca and Cahalan, 1992**</td>
</tr>
<tr>
<td><em>Zostera marina</em></td>
<td>750-1000</td>
<td>&lt;1:1</td>
<td>18.9</td>
<td>1</td>
<td>Fonseca and Cahalan, 1992**</td>
</tr>
<tr>
<td><em>Zostera noltii</em> artificial Z. noltii</td>
<td>13400</td>
<td>1.2:1</td>
<td>22.8</td>
<td>1</td>
<td>Bouma et al., 2005</td>
</tr>
<tr>
<td><em>artificial Z. noltii</em></td>
<td>500-4000</td>
<td>3:1</td>
<td>6.2-7.1</td>
<td>1</td>
<td>Paul et al., 2012</td>
</tr>
<tr>
<td><em>artificial Z. noltii</em></td>
<td>500-4000</td>
<td>2:1</td>
<td>6.2-7.7</td>
<td>1</td>
<td>Paul et al., 2012</td>
</tr>
<tr>
<td><em>artificial Z. noltii</em></td>
<td>500-2000</td>
<td>1:1</td>
<td>5.9-6.6</td>
<td>1</td>
<td>Paul et al., 2012</td>
</tr>
<tr>
<td><em>artificial Z. noltii</em></td>
<td>8000</td>
<td>3:1</td>
<td>8.5</td>
<td>1</td>
<td>Paul et al., 2012</td>
</tr>
<tr>
<td><em>artificial Z. noltii</em></td>
<td>8000</td>
<td>1:1</td>
<td>12.6</td>
<td>1</td>
<td>Paul et al., 2012</td>
</tr>
</tbody>
</table>

* Field data ** averaged over a range of treatments

Paul, 2017
Marine Pollution Bulletin
Natural dynamic of plant parameters

mean shoot density per m²

Paul & Amos, 2011, JRG- Oceans
Canopy height changes with flow velocity

Paul & Gillis, 2015
Marine Ecology Progress Series
Flow velocity changes with canopy height

![Diagram showing flow velocity changes with canopy height](image)

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Flow velocity changes with canopy height

Mean of all profiles: 0.10 m/s

Velocity profiles

Plant position

Flow velocity changes with canopy height
Flow reduction leads to sedimentation

ca. 50 times seagrass height

Flow velocity  Bed shear stress
Turbulence  Wave energy  Sedimentation
Soil stability independent of aboveground biomass

Spencer et al., 2015
Earth Surface Processes and Landforms
Storms contribute to salt marsh accretion

Schürch et al., 2012
Estuaries and Coasts
Processes apply to all sediment types

Pellworm, Germany
muddy

Isle of Wight, UK
sandy

approx. 1 m
Dunes as extremely sandy locations

Figlus et al., 2017
Coastal Dynamics
Soil erosion is even reduced by young plants

adapted from
Figlus et al., 2017
Coastal Dynamics
## Vegetation’s role in coastal protection

<table>
<thead>
<tr>
<th></th>
<th>Seagrass</th>
<th>Salt marsh</th>
<th>Dune vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave attenuation</td>
<td>up to 20% per 95 m (low energy)(^1)</td>
<td>~80% per 160 m (low energy)(^2) up to 20% per 40 m (high energy)(^3)</td>
<td>unknown</td>
</tr>
<tr>
<td>Bed stabilisation</td>
<td>Yes</td>
<td>Yes(^4)</td>
<td>Yes(^5)</td>
</tr>
<tr>
<td>Adaptation to sea-level rise</td>
<td>Yes</td>
<td>19–22 mm/yr(^6)</td>
<td>unknown</td>
</tr>
</tbody>
</table>

Thank you for your attention

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RELEEZE
Initial Phase

GradVeg
PA 2547/1-1