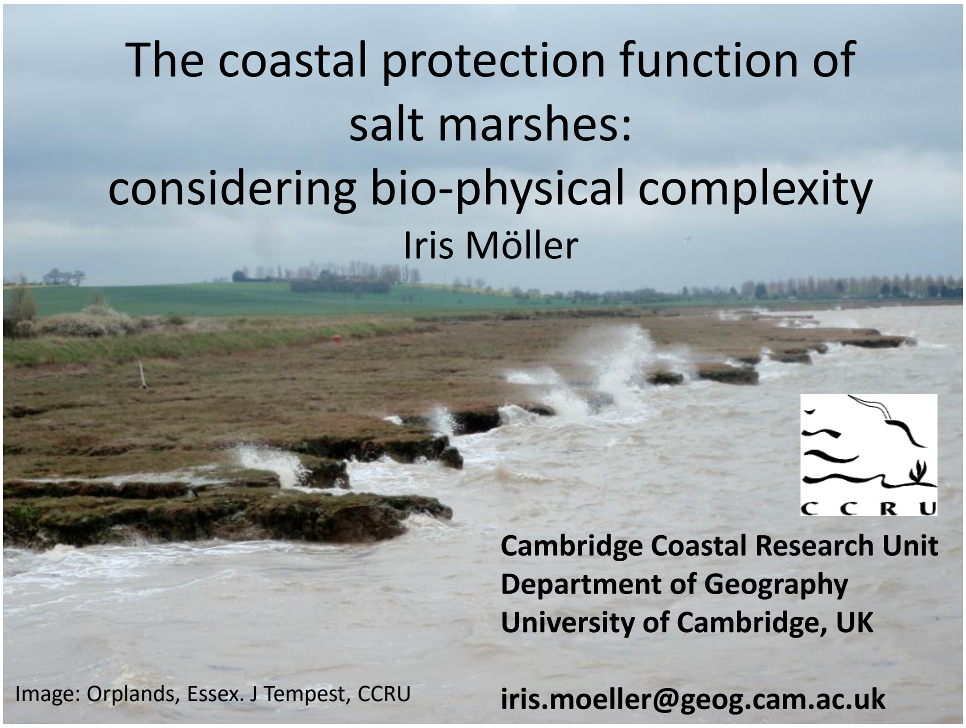

The coastal protection function of salt marshes: considering bio-physical complexity

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Image: Orplands, Essex. J Tempest, CCRU

FAST
FORESHORE ASSESSMENT USING SPACE TECHNOLOGY
Starting Date: 01/01/2014 · Duration: 48 months

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n° 607131.

www.fast-space-project.eu

RISC-KIT
www.risckit.eu
2013-2017

tessa
Toolkit for Ecosystem Service Site-based Assessment
Anglia Ruskin University · BirdLife International · rspb giving nature a home · Tropical Biology Association · UNEP WCMC · University of Cambridge

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www.thesaltmarshexperiment.wordpress.com

CBESS
bess biodiversity & ecosystem service sustainability
2012-2016
Coastal Biodiversity and Ecosystem Service Sustainability
synergy.st-andrews.ac.uk/cbess/

Lots of individuals…

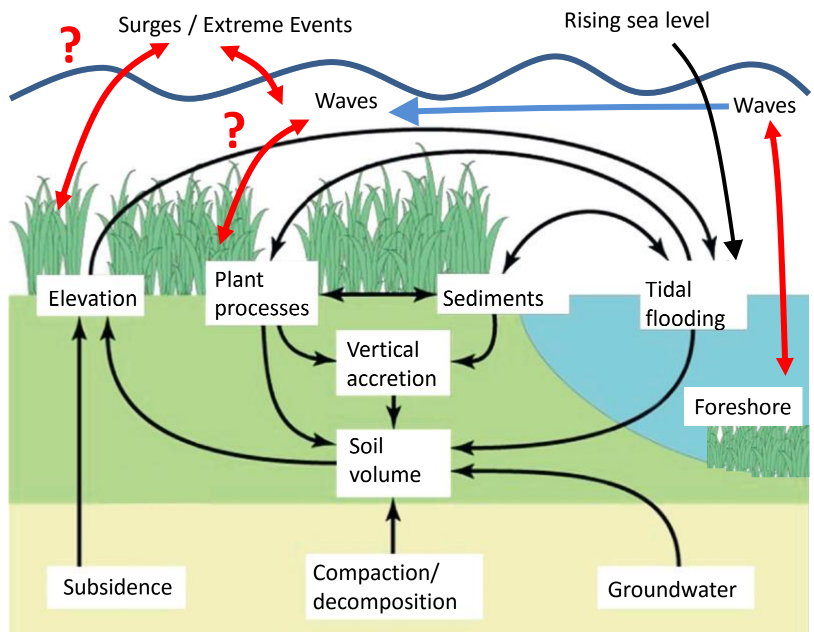
Dr Tom Spencer, Dr Anna McIvor, Ben Evans
James Tempest, Franziska Rupprecht, and many more!

Surge dissipation
Wave dissipation → ‘coastal protection’
Erosion protection

Image: Tillingham, UK. I. Möller

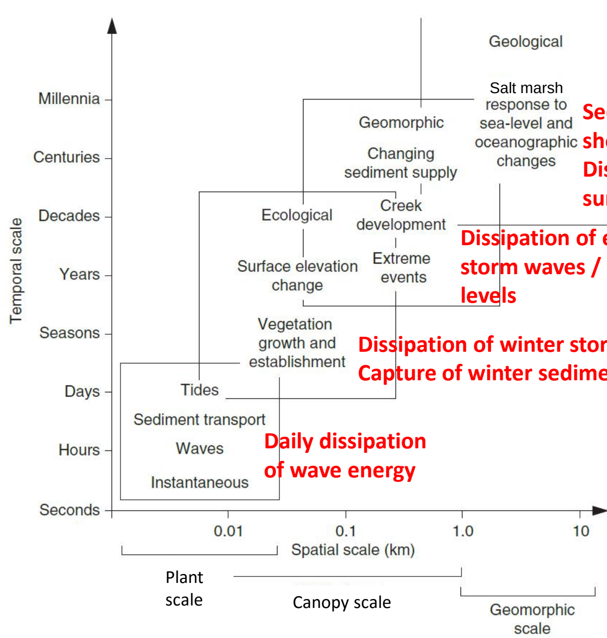
Complexity Issues

1. **Scaling up**: Processes are non-linear in space → small lab scale cannot be scaled up (e.g. to storm surge)
2. **Variability**: spatial and temporal complexity (e.g. different plant species & seasonal canopy change) → extrapolation not possible
3. **Temporal non-linearity**: Over longer time scales (> event), biogeomorphological feedback becomes more important relative to instantaneous processes



Spencer and Möller, 2013
(modified with permission from Cahoon et al., 1999. Current Topics in Biogeochemistry 3, 72–88)

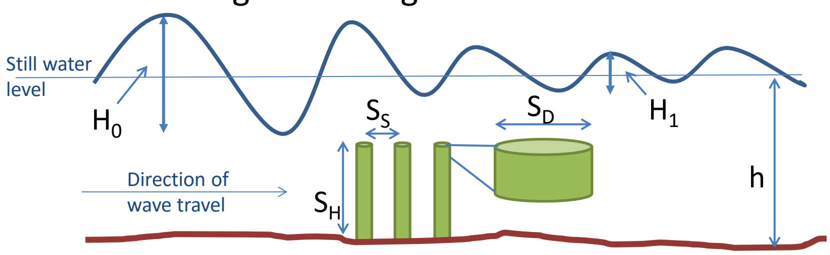
Scales of bio-physical interactions and complexity



Based on:
Spencer and Möller, 2013
Cowell and Thom, 1994
Perry et al. 2008

Example: wave dissipation

Based on 'wave shear stress coefficients' or 'drag force' acting on the vegetation



$$\frac{H_0 - H_1}{H_0} = \frac{\alpha x}{1 + \alpha x} \text{ (reg. waves)} \qquad \alpha = A \frac{S_D}{S_S^2} C_D k \left[\frac{\sinh^3 kS_H + 3 \sinh kS_H}{\sinh kh (\sinh 2kh + 2kh)} \right]$$

e.g. artificial seaweed of Asano et al. (1993) and Dubi and Torum (1997), Kelp of Mendez and Losada (2004)

Dalrymple *et al*. (1984) and Kobayashi *et al.* (1993)

Example: wave dissipation

PROBLEM:

- **Complex but important vegetation characteristics are ignored (buoyancy, geometry)** - e.g. cylinders to approximate plants
- **Empirical calibration is required** to get accurate value for C_D (plant-induced drag)

Photo: Marco Schmidt (cc license)

Solutions

1. Scaling up: **Observe in true-to-scale setting** (field or lab) (then use to calibrate and validate models)
2. Variability: Observe variability and/or apply and test **aggregation** methods (field and model)
3. Temporal non-linearity: Implement **long-term observation / monitoring, time-space substitution** (then use to calibrate and validate models)

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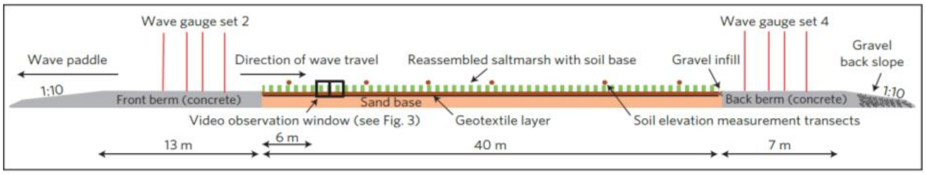
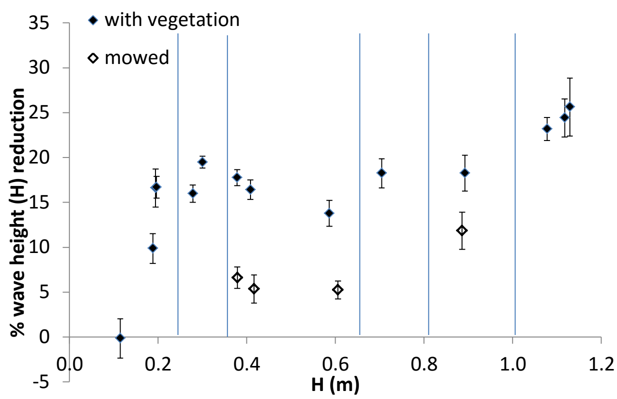
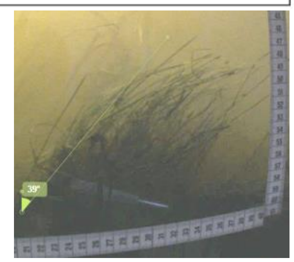
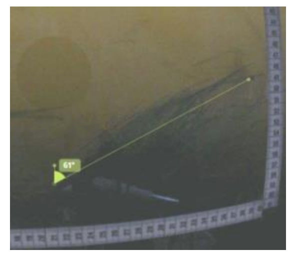
Möller, I. Kudella, M., Rupprecht, F., Spencer, T., Paul, M., van Wesenbeeck, B.K., Wolters, G., Jensen, K., Bouma, T.J., Miranda-Lange, M., Schimmels, S. 2014. *Nature Geoscience* 7, 727-731
www.thesaltmarshexperiment.wordpress.com









Möller et al 2014. *Nature Geoscience* 7, 727-731
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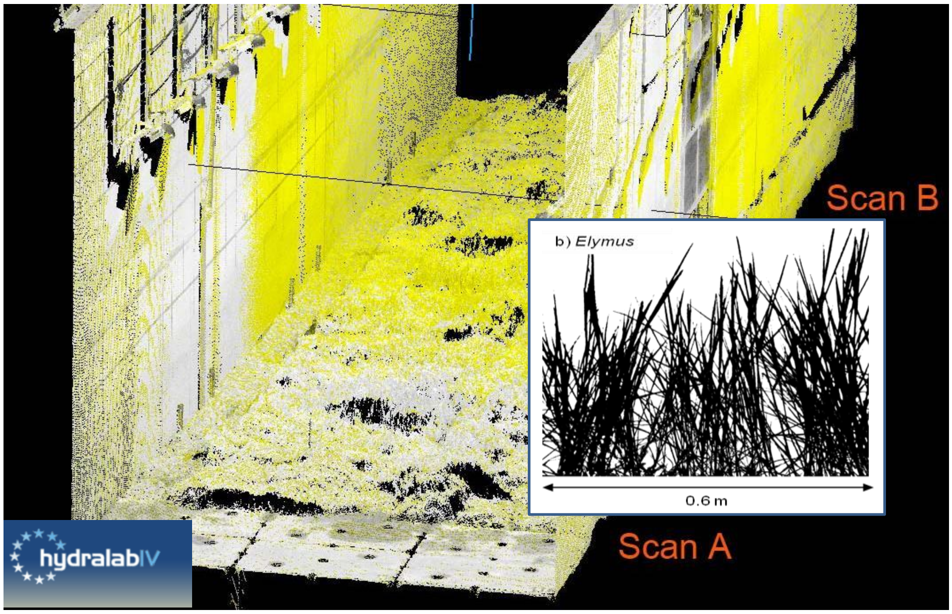
Möller 2006, ECSS, 69, 337-351

Aggregating plant structure

J. Tempest (PhD student, U. Cam)



Solutions

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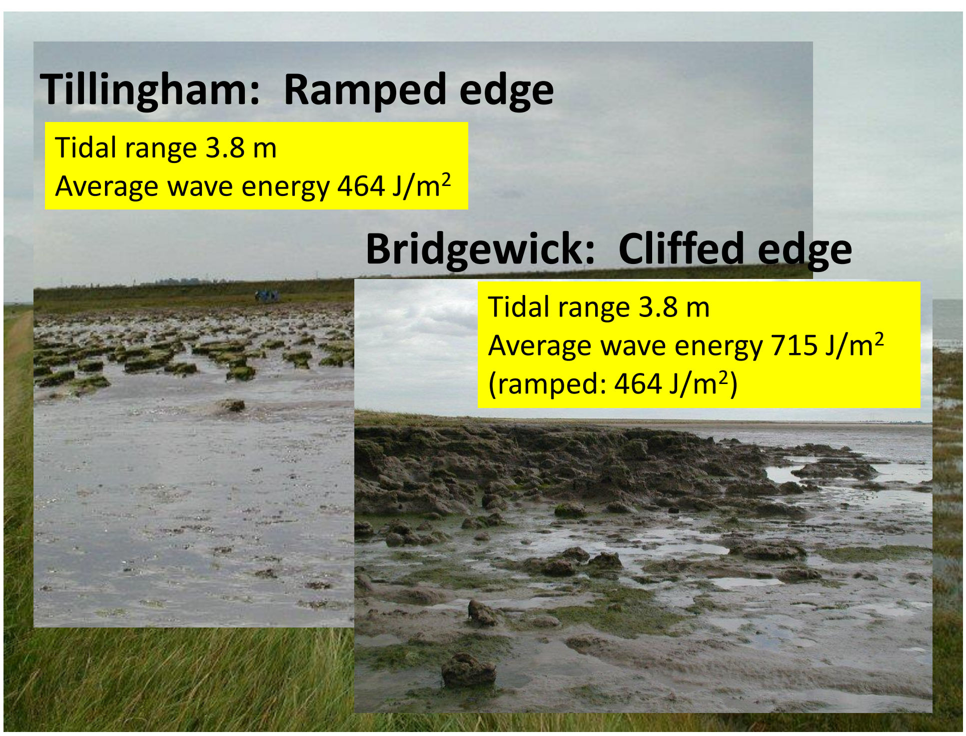
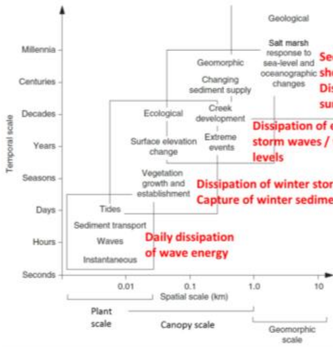

Tillingham: Ramped edge
Tidal range 3.8 m
Average wave energy 464 J/m2
Bridgewick: Cliffed edge
Tidal range 3.8 m
Average wave energy 715 J/m2
(ramped: 464 J/m2)

Scales of bio-physical interactions and complexity



Based on:
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Solutions

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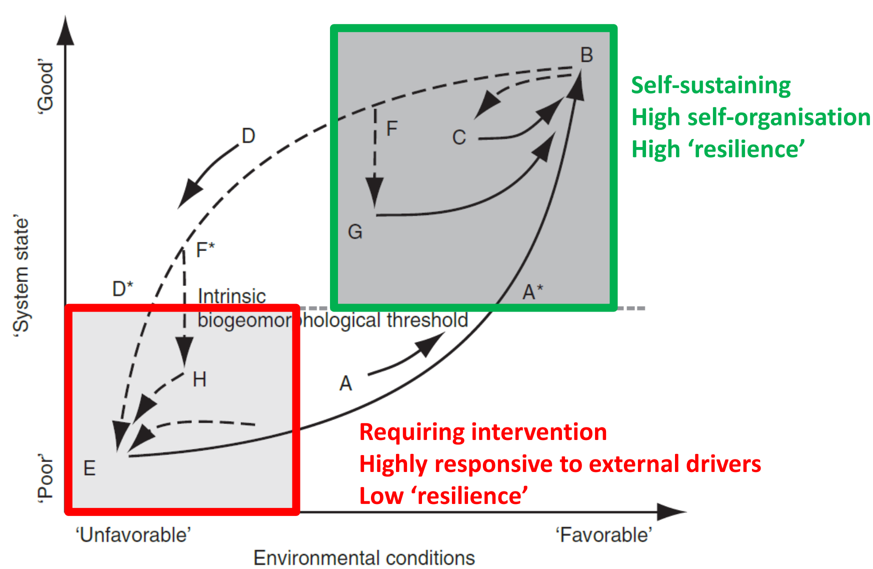
Additional slides for discussion

Key Remaining Issues

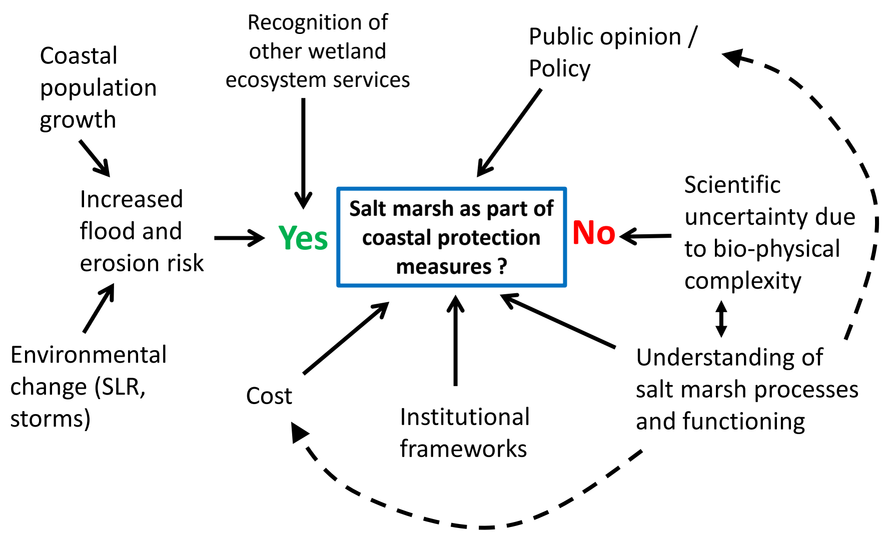
- How do marsh surface properties (vegetation types/properties and topography) link to wave dissipation?
- Marsh stability over a range of time-scales, both laterally and vertically?
- ‘Thresholds’ and ‘recovery times’ – under what conditions and sequencing of events can salt marshes prevail over decadal time scales

Management through recognition of drivers and thresholds

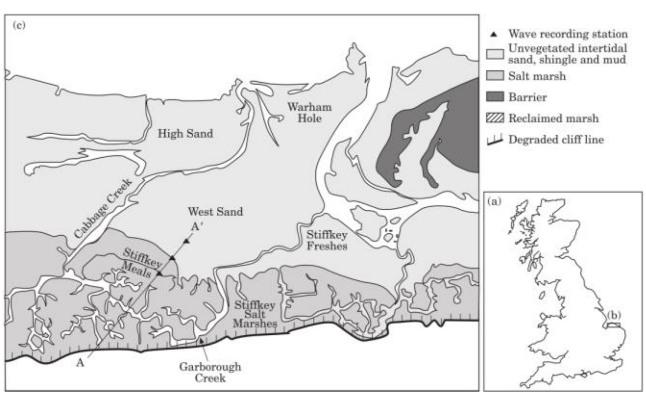


Spencer and Möller, 2013

Using salt marshes as coastal protection



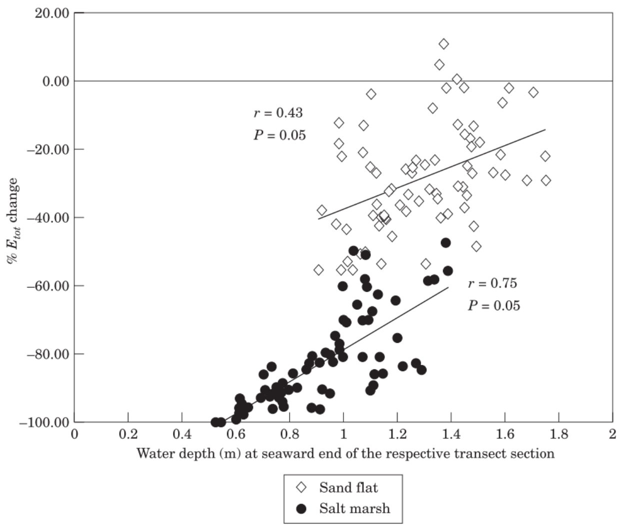
Aggregation: N Norfolk, UK



Möller *et al.* (1996) *Journal of Coastal Research* 12(4), 1009-1016

- Mixed NW European marsh
- Macro-tidal (4.7-6.6 m tidal range)
- 1 transect, 3 measurement stations, 2 x 200 m
- Wave H > 40 cm

Water-depth dependency of wave energy dissipation



Energy loss over 200 m:

29% (sand flat)

82% (marsh)

Möller *et al.* (1999) *Estuarine, Coastal and Shelf Science* 49(3), 411-426