Mosselwad - Hydrodynamics

Effects of hummocks in intertidal mussel beds on local flow patterns

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1. Problem definition

Shellfish reefs are able to stabilize sediment and attenuate wave forcing (Bosje et al., 2011). Oportunities for mussel bed restoration in the Dutch Wadden Sea (Fig 1) are explored. For this purpose we need a better understanding of the processes that influence mussel bed stability.

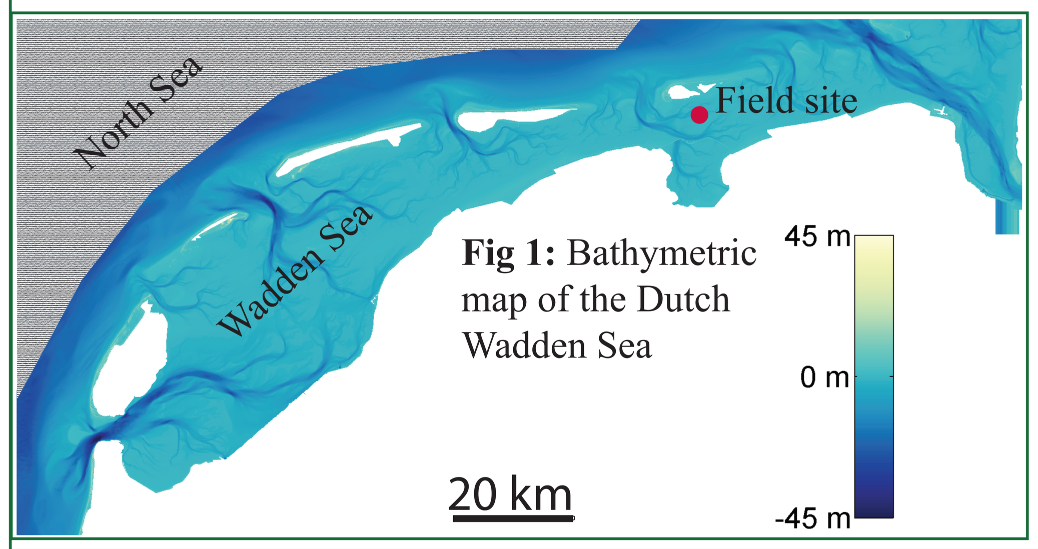

Fig 1: Bathymetric map of the Dutch Wadden Sea

Fig 2: Example of flat mussel bed (left) and a hummock type mussel bed (right).

Observations show that some beds remain flat while others develop elevated patches (hummocks). Having previously investigated flat mussel beds (Donker et al., 2012) we now focus on the effects of hummock formation on local flow dynamics.

2. Objectives

1) Determine the effects of an hummock on local flow patterns.
2) Calculate the bed shear stresses caused by flow.
3) Evaluate the effect of changes in hummock geometry.

3. Methods

Field measurements during 4 weeks
- Location sandy shoal with mussel bed (Fig 1)
- Velocities in gully and on hummock (Fig 3)
- Nortek ADV 32 Hz
- Bathymetry (3d laserscanner + dGPS)

Model study using SWASH (Zijlema, et. al., 2011)
- Non-hydrostatic model
- Idealized mussel hummock (Set-up see Fig 4)
- Observations used as boundary conditions
- Prescribed flow on left hand boundary
- 10 m sponge layer at right hand boundary to damp reflections
- Periodic boundary conditions North and South

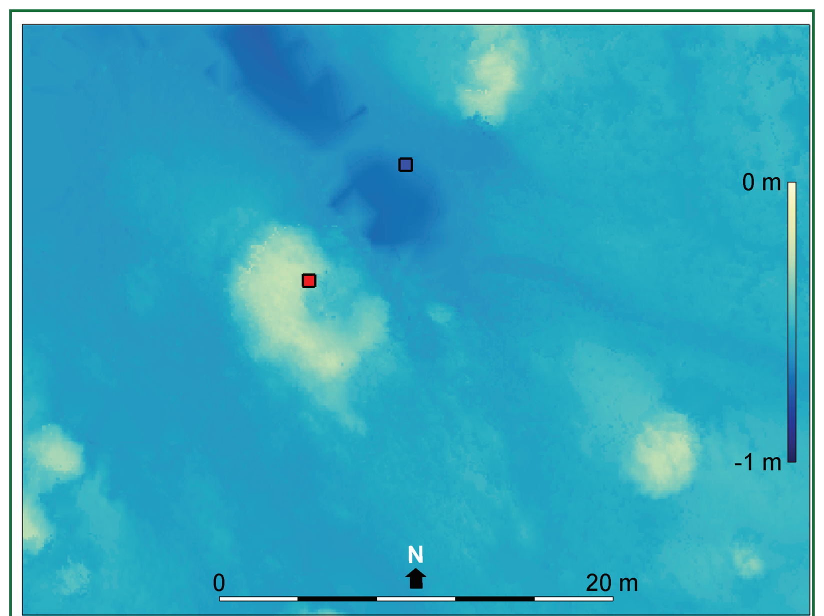

Fig 3: Bathymetric map with sensor locations. ADVs located 15 cm above hummock and 28 cm above gully centre.

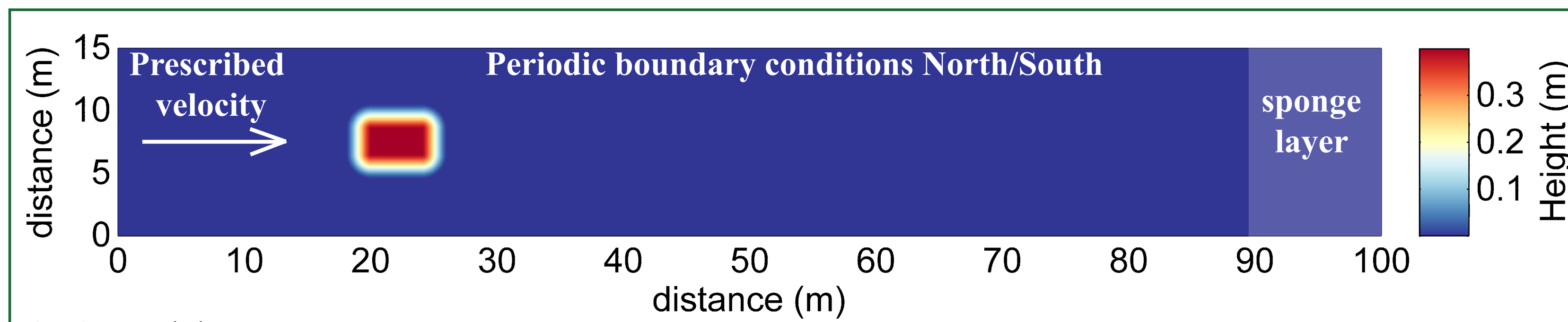

Fig 4: Model set-up

4. Results

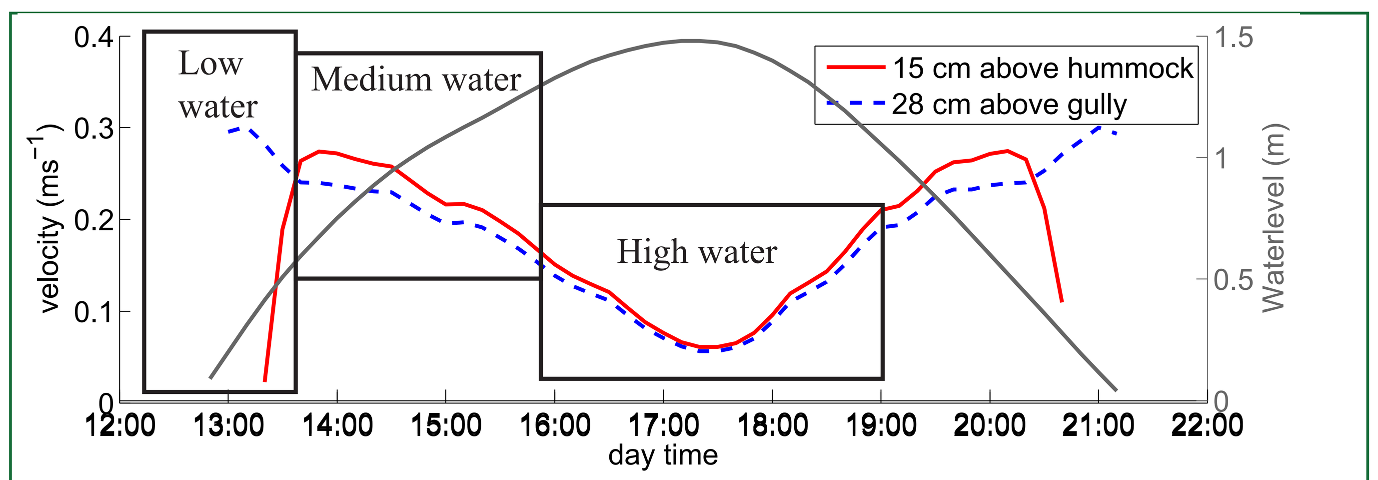

Fig 5: Observations of flow velocity on top of the hummock and in the adjecent gully.

Field observations

Results (Fig 5) reveal:

Low water:
- Drop in flow over hummock
- Increase in gully flow

Rising tide
- Flow over hummock is larger

High water
- Velocities above hummock and gully are similar

(Hummock sensor is located closer to bed)

Model results

Low water (Fig 6a)
- Flow routed around hummock
- Large drop in velocities over hummock

Rising tide (Fig 6b)
- Large increase over hummock and in gully
- Strong acceleration over hummock

High water (Fig 6c)
- Small increase over hummock and gully
- Increase larger over hummock

Increasing hummock length (Fig 7a)
- Gradual change from flow acceleration to flow routing

Increasing hummock width (Fig 7b)
- Flow area decreases, all velocities increase

Increasing surface roughness (Fig 7c)
- Reduces flow acceleration and increases routing

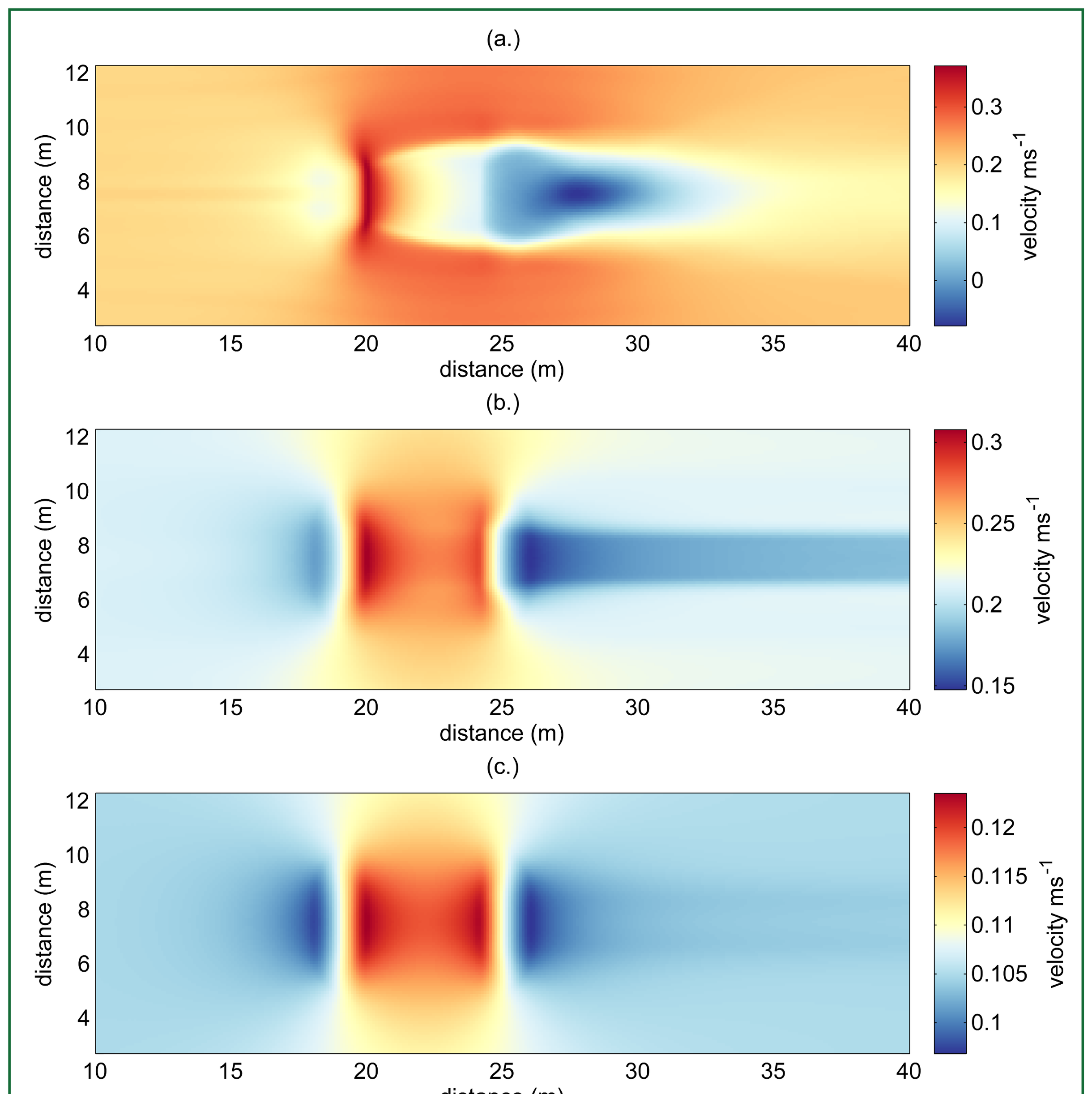

Fig 6: Spatial distribution of depth averaged flow velocities for (a.) low water (0.4 m), (b.) rising tide (0.6 m) and (c.) high water (1.4 m).

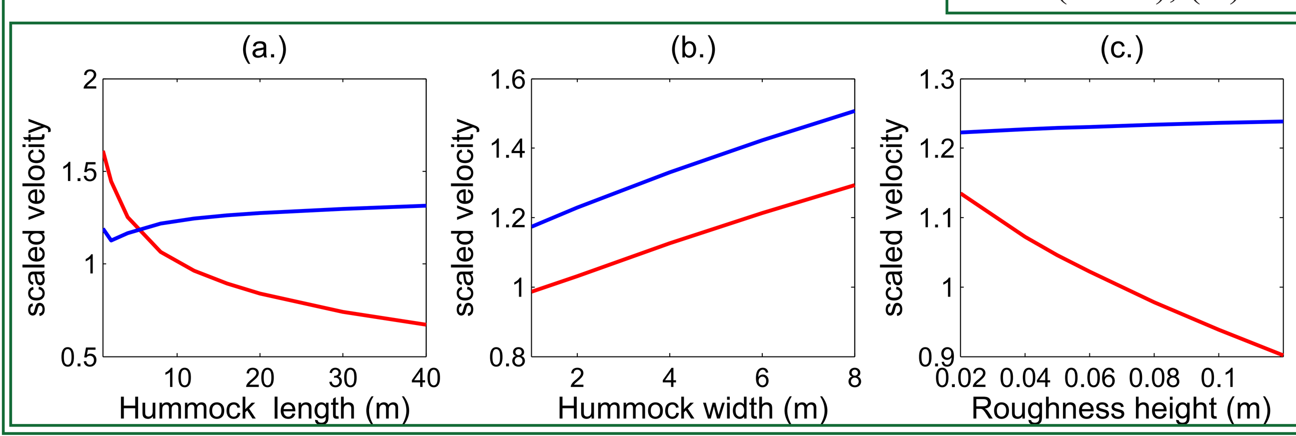

Fig 7: Effects of changes in hummock length (a.), width (b.) and surface roughness (c.) on the ratio between flow acceleration (red) and flow routing (blue). The standard case for this sensitivity analysis is hummock length 8m, width 2m, rougness height of 0.05m on the hummock and 0.02 m on the sandy shoal.

5. Conclusions

Effects on local flow patterns:
- Flow acceleration over hummock for medium water
- Flow routing around hummock for low water
- Wake zones in front and behind hummock
- Highest velocities (shear stresses) are found at front edge

Effects of hummock geometry:
- Increasing length causes regime shift from acceleration to routing
- Rougher hummock results in similar effects as increasing hummock length
- Hummock width does not influence flow regime

6. Outlook

We demonstrate that hummocks have a strong influence on flow patterns. Since flow patterns are also important in supplying food to mussel beds, this will also affect the availability of food.

Predict effect hummock on food availability
- SWASH model output (Velocities, Viscosity)
- Uptake model based on Simpson et al., (2007)
- 3D model runs for effects of hummock on vertical variation in flow and mixing

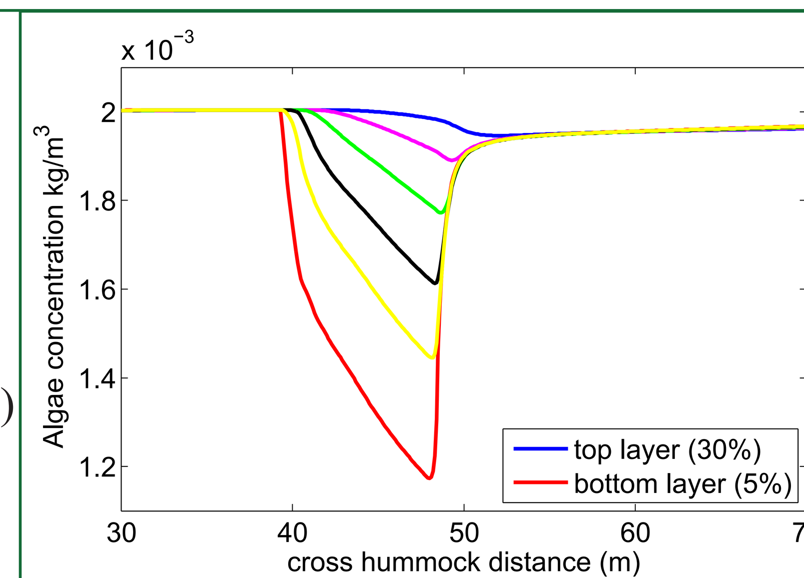

Fig 8: Modelled effect of hummock on food concentration on a transect over the hummock.

7. Contact information

If you have questions please contact me:

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Presentation time:
2/27/2014 (5:00-6:00 pm)

8. References

Borsje B.W., et. al., (2011), How ecological engineering cvan serve in coastal protection. Ecological Engineering 37, p113-122
Donker J.J.A., et. al., (2013),Wave focing over an intertidal mussel bed, Journal of Sea Research 82, p54-66
Simpson J. H., et. al., (2007), The interaction of tidal advection, diffusion and mussel filtration in a tidal channel, Journal of Marine Systems 68, p556-568
Zijlema M., et. al., (2011), SWASH: An operational public domain code for simulating wave fields and rapidly varied flows in coastal waters, Coastal Engineering 58(10), p992–1012

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