The role of biological-hydrodynamic interactions in determining the functioning of benthic ecosystems

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Shallow coastal areas

- Hotspots for biogeochemical transformations
- High biodiversity
- Epibenthic organisms common
Epibenthic organisms

• Many considered to be “ecosystem engineers”
  – Jones et al. 1994 OIKOS 69:373-386
  – Allogenic: change via transforming materials
  – Autogenic: change via own physical structures

• Interactions with hydrodynamics
What are bio-hydrodynamic interactions?

- Unidirectional flow
- Waves (orbital flow)
- Canopy water flow (Qc)
- Shear stress
- Canopy reconfiguration
- Mixing (TKE)
- Freestream layer
- Mixing, turbulent boundary layer
- Low movement layer

Species:
- C. racemosa
- C. taxifolia
- C. prolifer
- Z. noltii
- C. nodosa
- P. oceanica
Inter-specific differences in ammonium uptake:

N uptake rates and $Q_c$ of *C. nodosa* ~ double *Z. noltii*

Mass transfer

Morris et al. 2008
- \( \text{NH}_4 \) uptake is spatially explicit
- Waves dampen spatial effect

Morris et al. 2008, Brun et al. In prep
Inter-specific boundaries

Cymodocea nodosa  Caulerpa prolifera
\(^{15}\text{NH}_4\) with inert marker (uranine)

Distribution of tracer and plant samples = N uptake corrected for \([^{15}\text{N}\text{_{water}}]\)
Vertical position determines uptake of functional groups

Mass transfer

Uptake (µmol N (g DW)⁻¹ h⁻¹)

- Epiphytes
- C. nodosa
- C. proliferans
- Gracillaria sp.

U (m s⁻¹)

0.000 0.010 0.020 0.030
Trapping is linked to species-specific canopy properties

Surface area of structures within flume (m$^2$)

$k \sim$ probability that particles are removed from the water column

Hendriks et al. 2009
Food availability

- Seagrasses influence feeding of cockles
- Animal communities have group specific food preferences

Brun et al. 2009, Morris et al. in prep
Increase in macrofauna abundance and species diversity

Abundance (individual m\(^{-2}\))

Species density (number m\(^{-2}\))

Gonzalez-Ortiz et al. In prep
Autogenic effects on macrofauna abundance

Mimics exclude allogenic engineering effects

Brun et al. In prep
Spatially-explicit effects on macrofauna abundance

S. Plana
Surface filter feeder

H. diversicolor
Deposit feeder

Brun et al. In prep
Summary

- Biometric measures *indicate* autogenic effects on near-bed hydrodynamics
- Potential effects on; particle trapping, bed protection, food availability and N uptake
- *Spatially-explicit* influence on biodiversity and *presumably* ecosystem metabolism-carbon burial
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