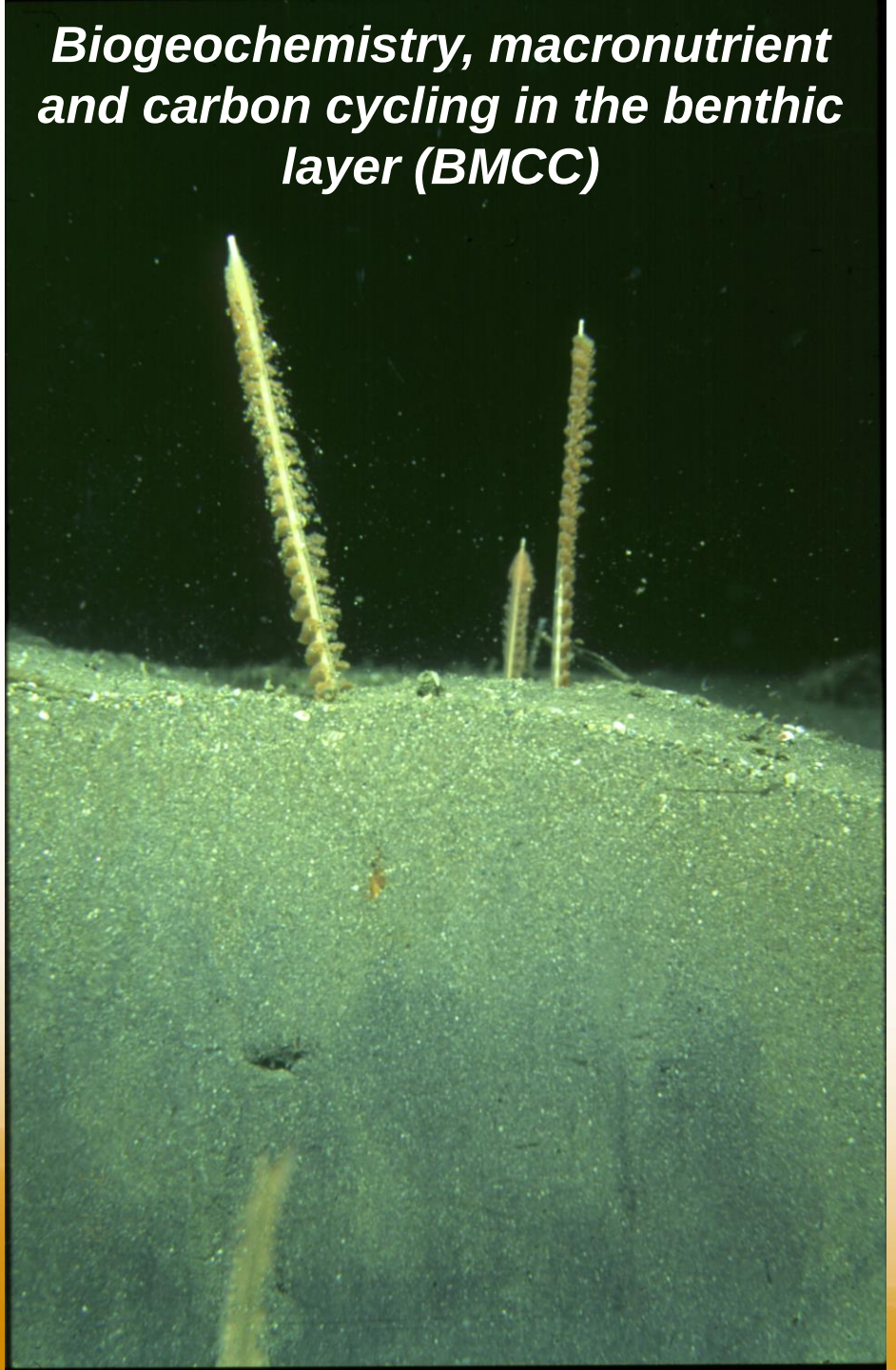

NERC SCIENCE OF THE ENVIRONMENT

Department for Environment Food & Rural Affairs

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Use of 1D models to explore organic carbon cycling

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Yuri Artioli, (PML)

Data
Natalie Hick et al. (SAMS)

Shelf Sea Biogeochemistry final science meeting,
5th–6th June 2017, University of Winchester

PML Plymouth Marine Laboratory

Cefas

Objectives

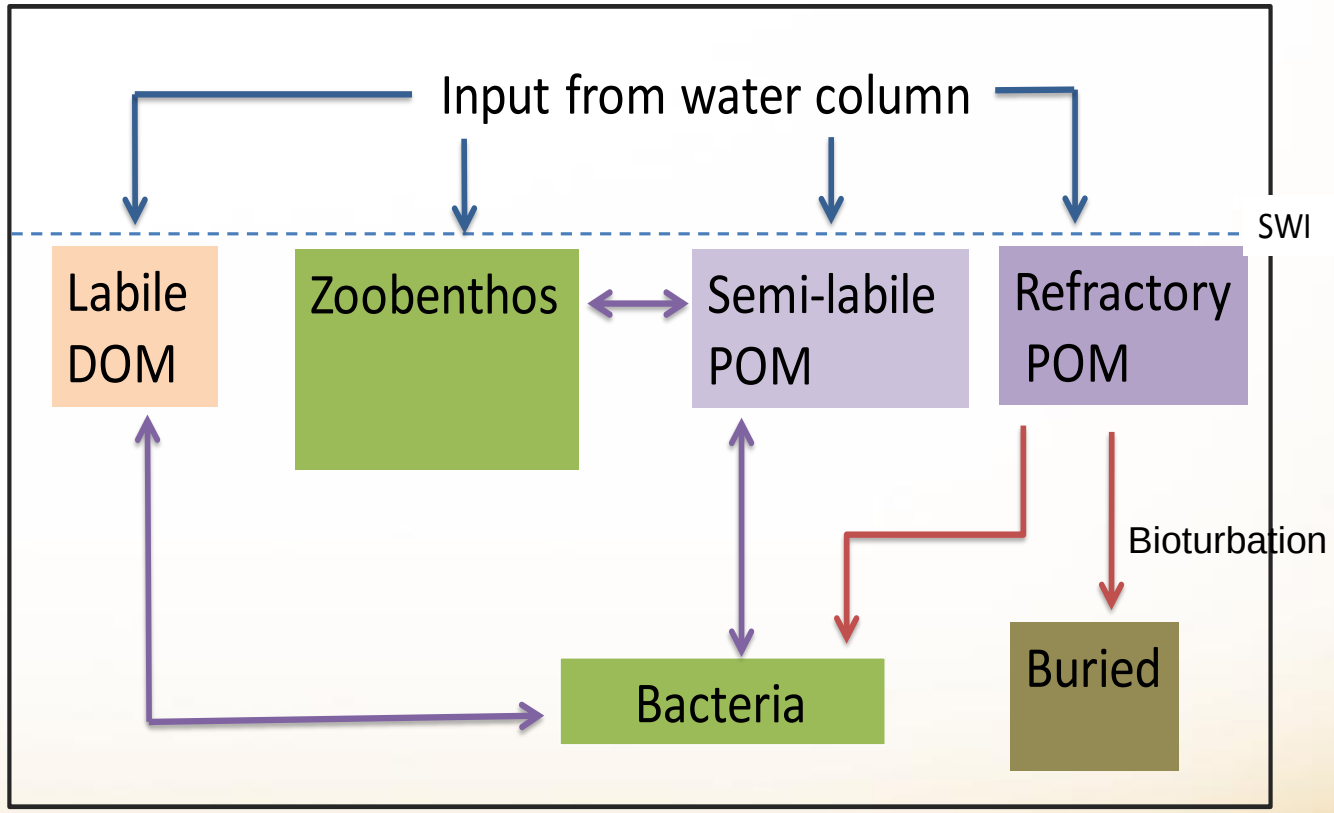
- Understand budgets and order of magnitude of fluxes - especially potential for long term burial
- Compare model with observed pools of organic carbon in bed
- Examine sensitivity of carbon burial to process parameters
  - Water column productivity
  - Bioturbation

Methods

1 D water column+benthic biogeochemical model (ERSEM) at SSB benthic sites

ERSEM Model: Benthic carbon cycle

- Water column phytoplankton & detritus
- Incorporated to bed via suspension feeders and direct settling
- Direct settled split into DOM, POM(SL), POM(R)
- Refractory POM can be further
  1. Consumed by bacteria yielding more labile forms
  2. Buried (made biological unavailable). Burial rate function of bioturbation



Bioturbation ~ Etur x (1 + mtur x Biology)

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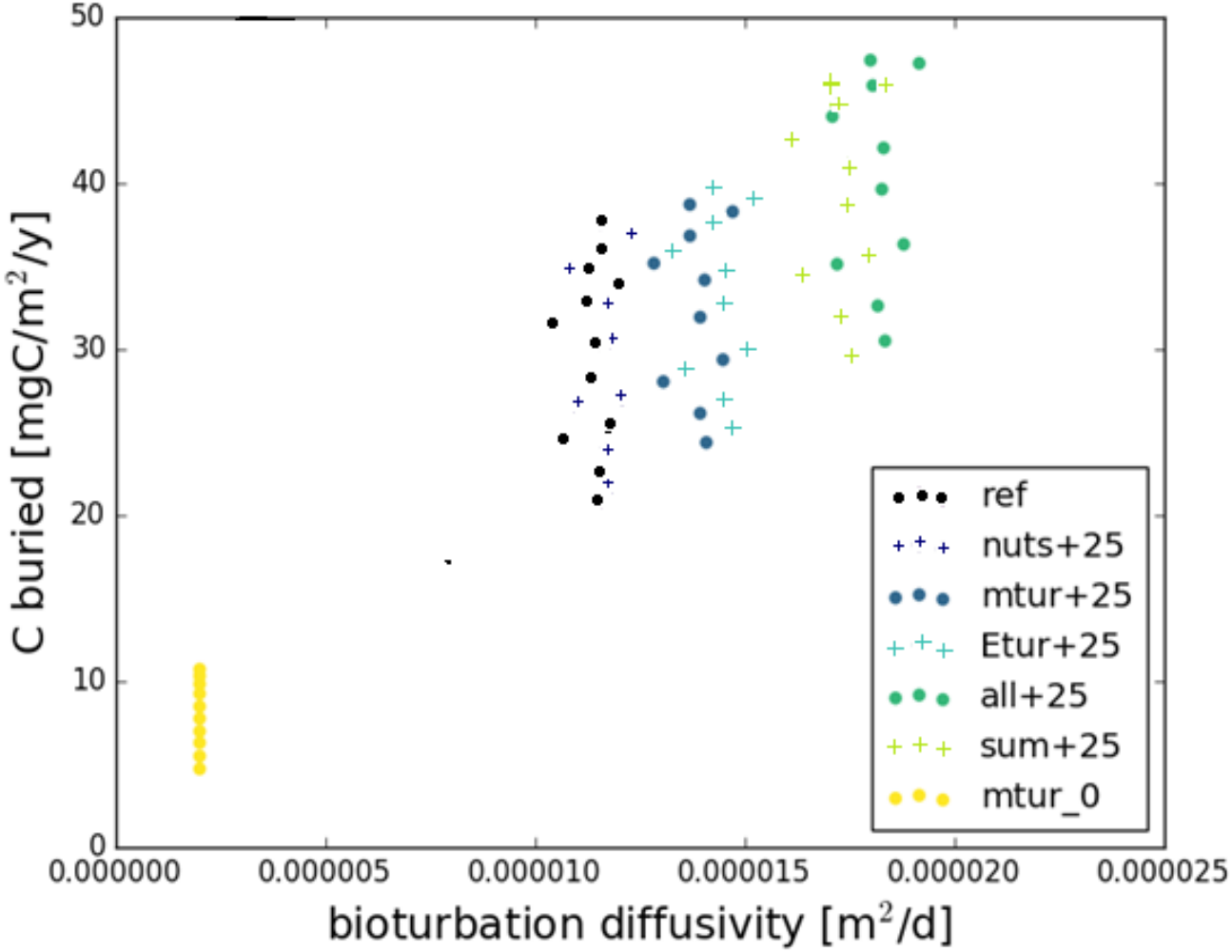
Exploring sensitivity of carbon burial rate to model parameters

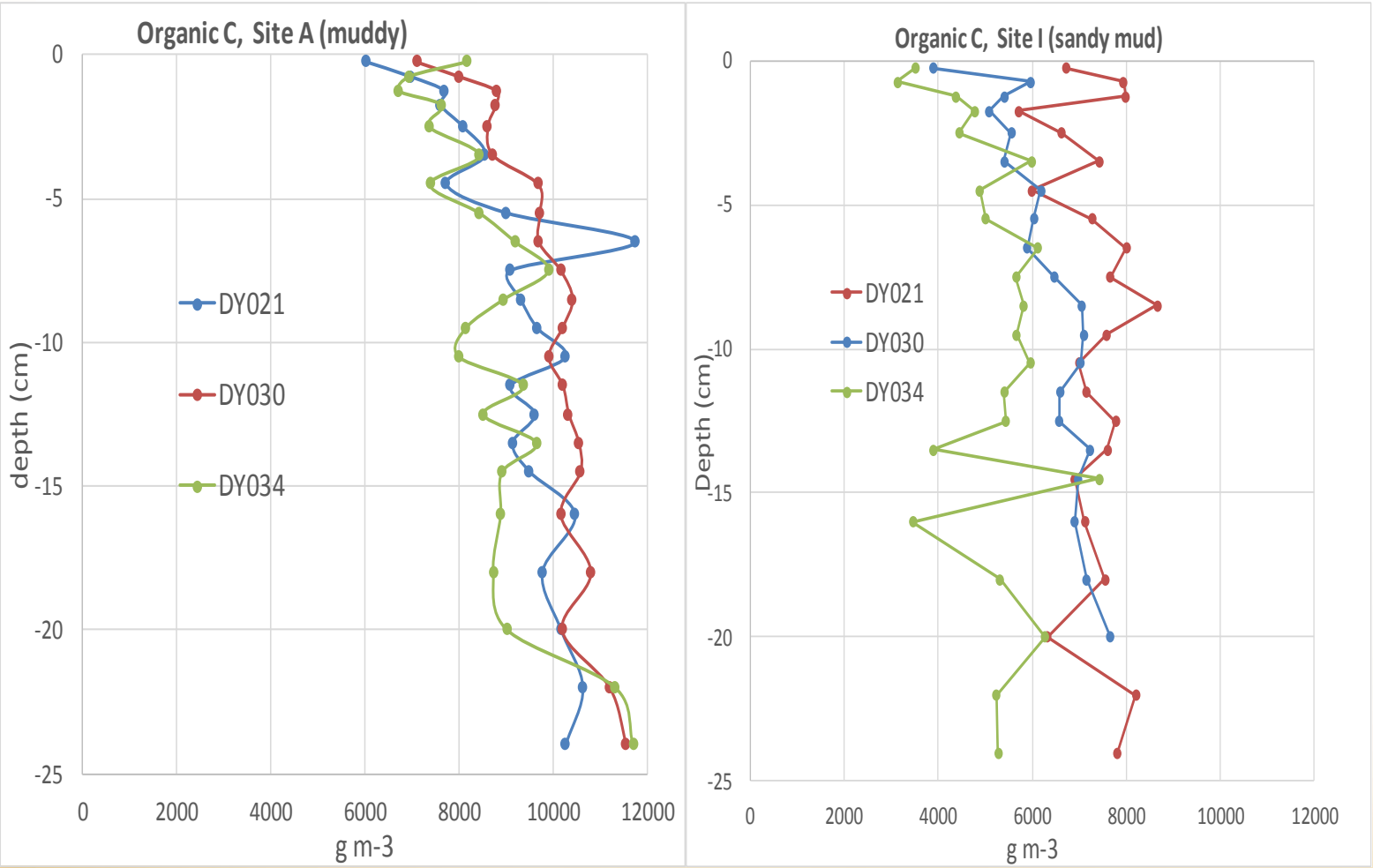
10 years simulation at L4 (Western Channel

REFerence run
nuts+25% increase all pelagic nutrients
mtur+25% increase faunal bioturbation
Etur+25% of faunal & background bioturbati
All+25% all of the above
Sum+25 sum of the first 3 scenario
Mtur_0 no faunal bioturbation

Bioturbation is the major driver of C buri
Important interannual variability



Observed benthic carbon pool



Site A shows some increase with depth, site I more uniform (and 2/3 magnitude)

Total amount, 1500-2500 g C m^{-2} in top 25cm.

Assuming shelf seas GPP ~100 g C m^{-2} y^{-1}, this is about 10-20 x Gross PP

If ~1% GPP is buried then ~2500 years to accumulate observed POC content in top 25cm.

NB Organic C only ~15-20% of inorganic C

Data Natalie Hicks, et al. (SAMS)

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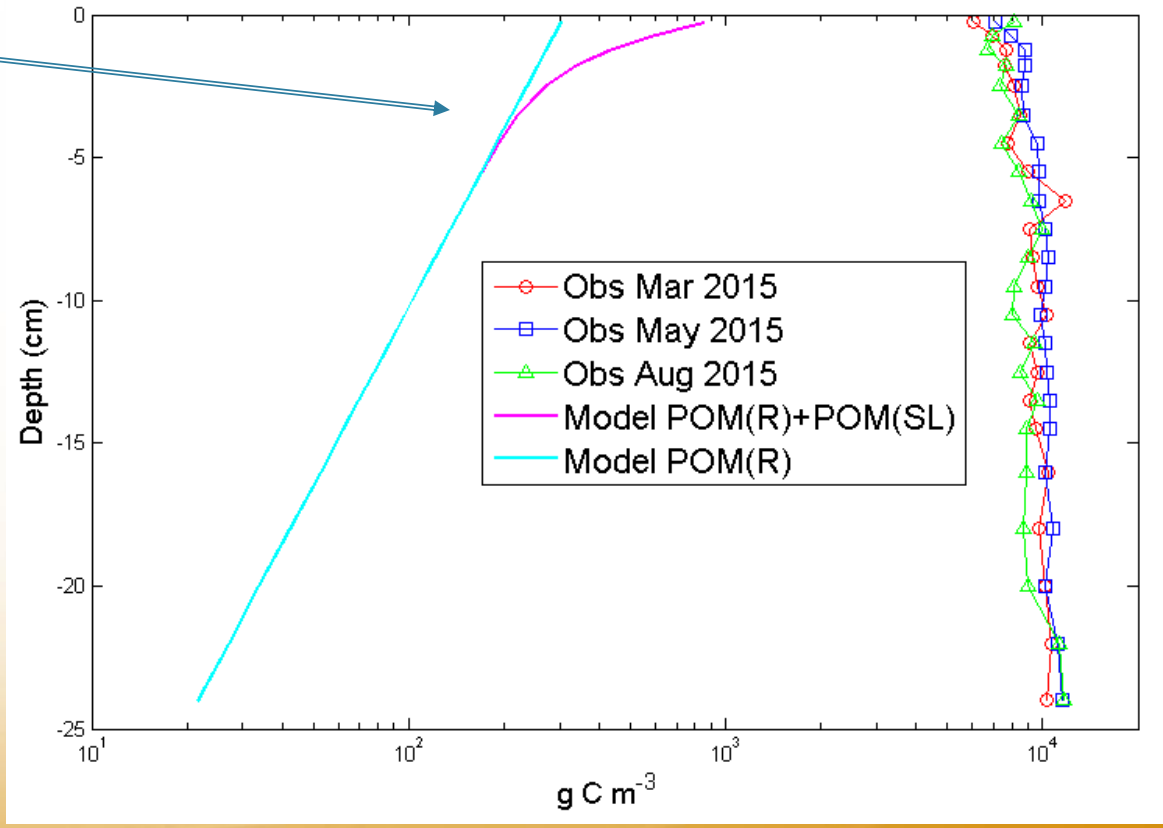
Comparison with observed benthic carbon pool

Model assumes decreasing exponential POC profile with depth, $Q(z) \sim Q\, e^{-z/D}$ characterised by 1) in bed total Q, 2) average depth D

- Model POC is biologically ‘available’ component
- Model POC value sufficient to reproduce observed order of magnitude of benthic processes.
- Model 1-2 orders of magnitude less than observed total POC

Benthic organic C with depth (site A, muddy)



Data, N. Hicks et al. (SAMS)

Carbon breakdown in bed

Given we know the flux of carbon degradation e. g. via CO2 efflux and these are broadly correct terms of order of magnitude with model

1. Most of observed POC is biologically active but being consumed very slowly (& ERSEM degradation rates are wrong)

2. Small amount of observed POC is biologically active, is being consumed relatively quickly, and most of observed POC is inactive (& ERSEM rates are roughly correct)
    - So what is remaining measured carbon? - accumulated marine carbon? terrestrial inputs? geological relic from ice age?

Summary

1. Taken at face value, comparison observed with model suggests a large amount biologically inactive carbon Celtic sea sediments.
   - Qu, What is the observed carbon in the bed?

2. ERSEM benthic model includes a biologically unavailable carbon pool via buried POM.
   - Modelled accumulation into this pool is sensitive to bioturbation and relatively insensitive to water column productivity.
   - However, not so clear that burial is conceptually the correct mechanism as ‘inactive’ carbon may be present even near the surface.

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