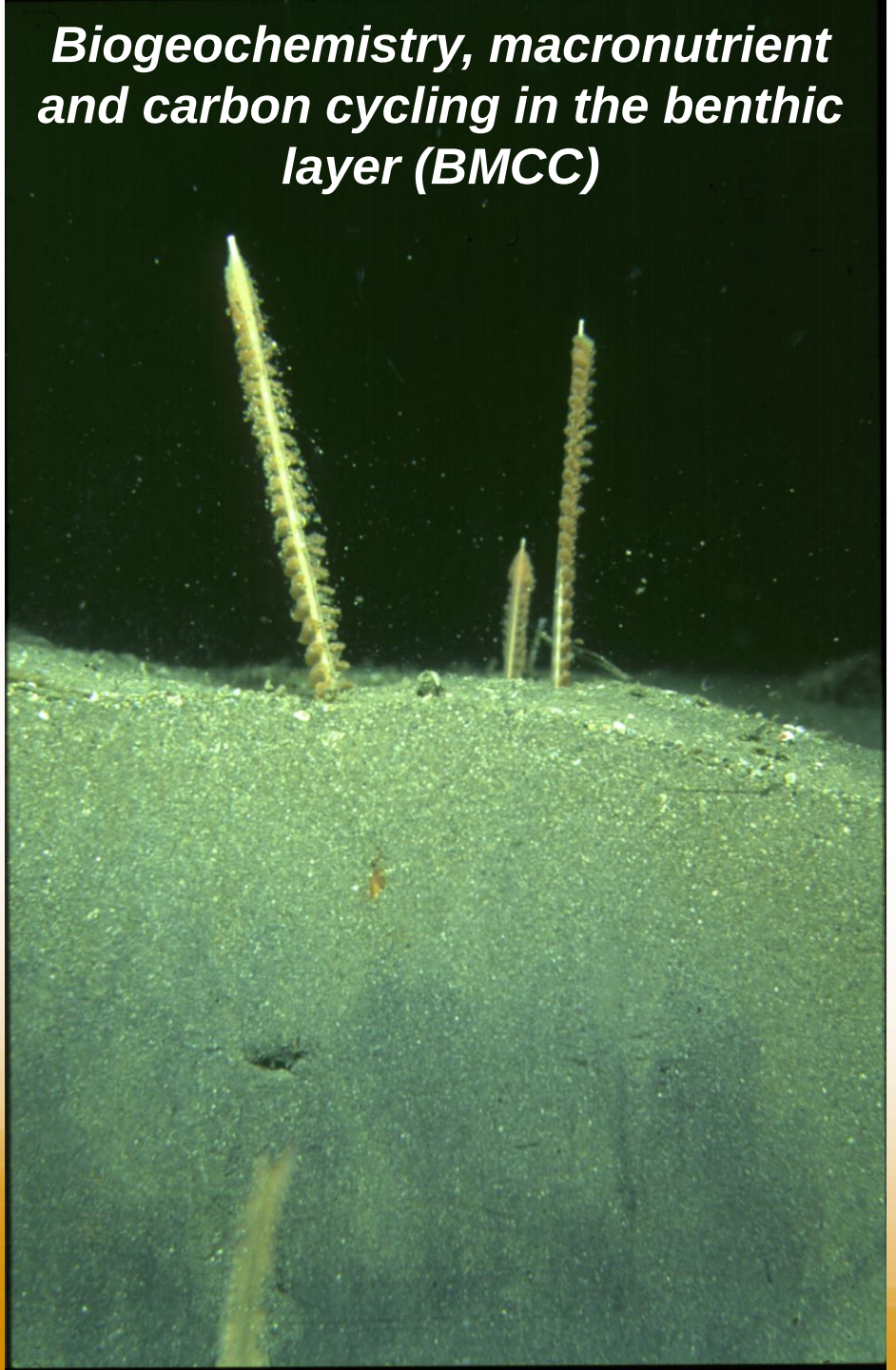
Biogeochemistry, macronutrient and carbon cycling in the benthic layer (BMCC)



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ERSEM Modelling comparison with SSB data. Benthic Oxygen

Modelling

John Aldridge, Luz Garcia (Cefas),

Observations

- Briony Silburn, Dave Sivyer, Tom Hull (Cefas)
- Natalie Hicks (SAMS)
- Charlie Thompson, Helen Smith (NOC, Southampton)
- Vas Kitidis (PML)

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

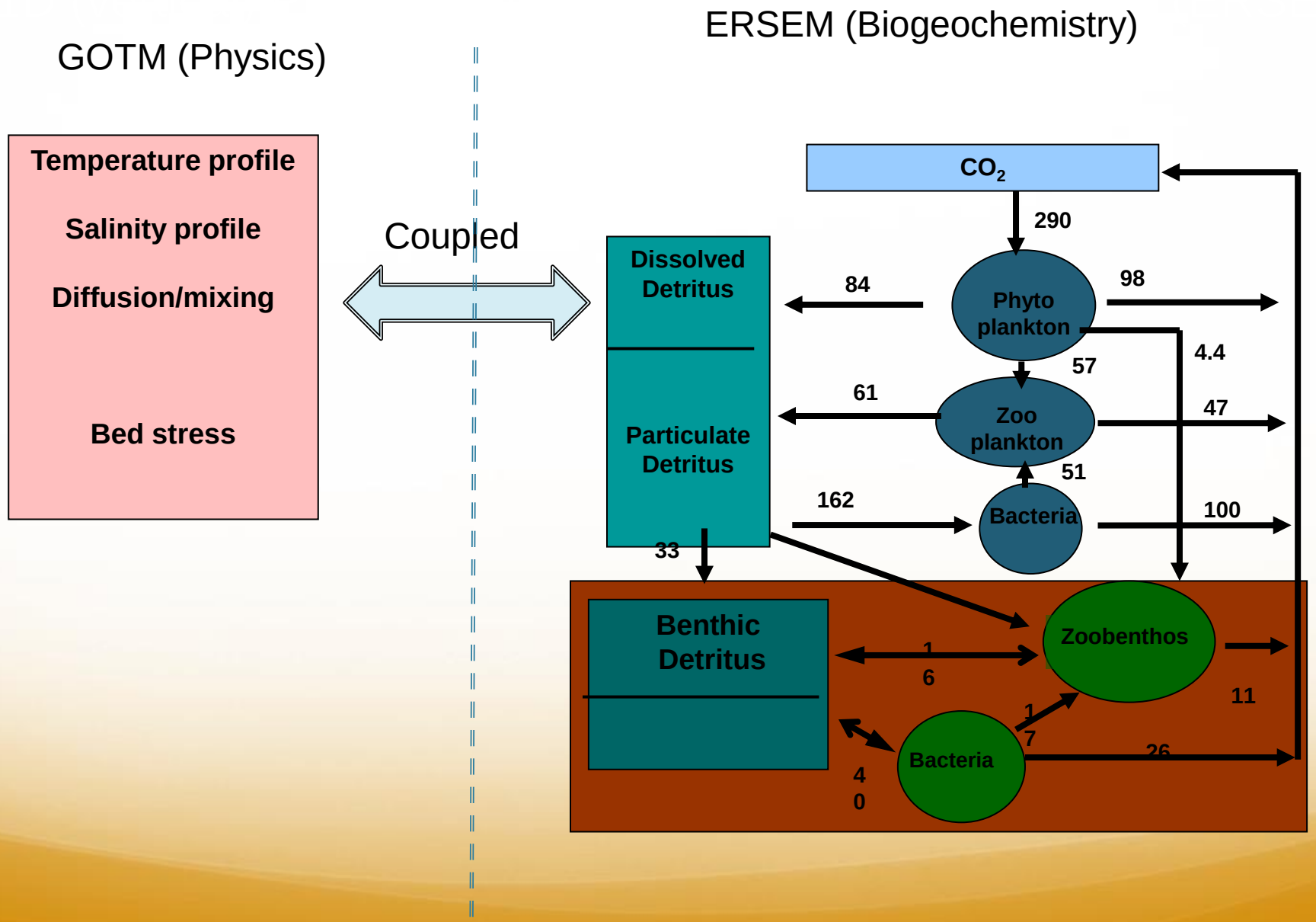
Cefas

Outline

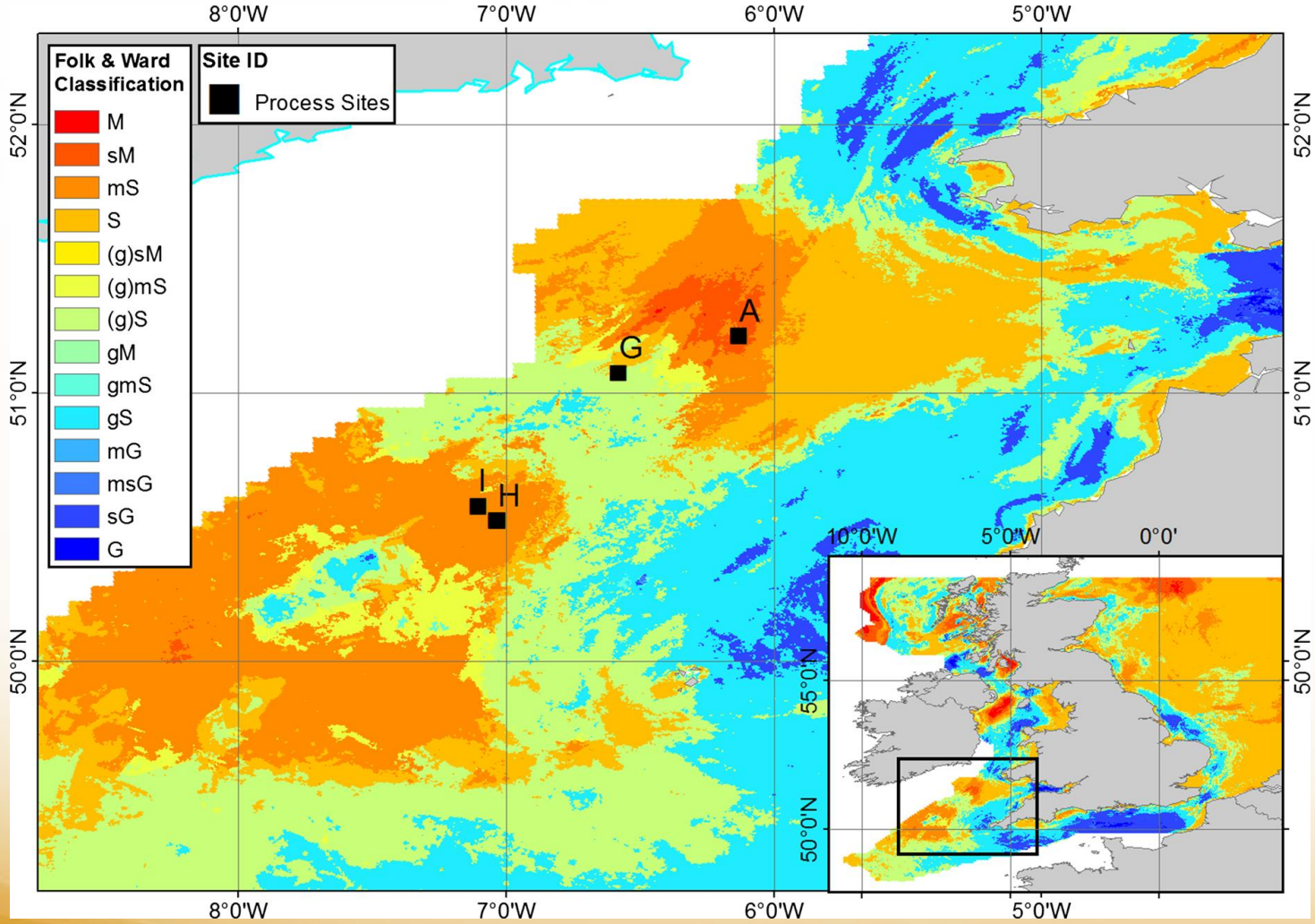
- Brief description of ERSEM model
- 1D setup at SSB benthc sites
- Modification to represent permeable sediments
- Comparison with Pelagic variables
- Oxygen uptake, oxic layer depth comparison (site A, G)

  -- independent measurements so some idea of observational uncertainty
- Suggestions for further analysis/model development

Models: GOTM(1D)-ERSEM(1D)



SSB Benthic Sites



Model setup at 5 SSB sites: Benthic A , G, H, I + Candy Floss

This talk, focus on 'end member' sites A (muddy) and G (sandy)

At all sites model forcing uses:

- Tides - TPX (Oregon Sate University)
- Met forcing – ECMWF winds, cloud, air temperature, humidity
- Bed sediment - observed porosity from 1st SSB cruise data

Models are 1D water column + benthic. No 3D advective effects

Model baseline parameterisation:

- L4 parameters (offshore Plymouth) for nutrients/light regime/BGC.
- Then applied site specific SSB pelagic calibration.
- Minimal benthic calibration (used parameters 'out of box')

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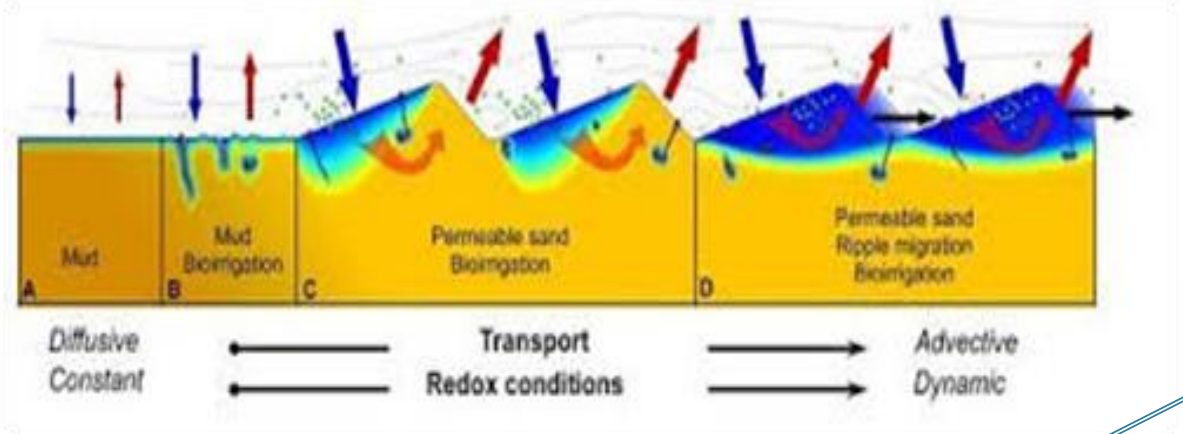
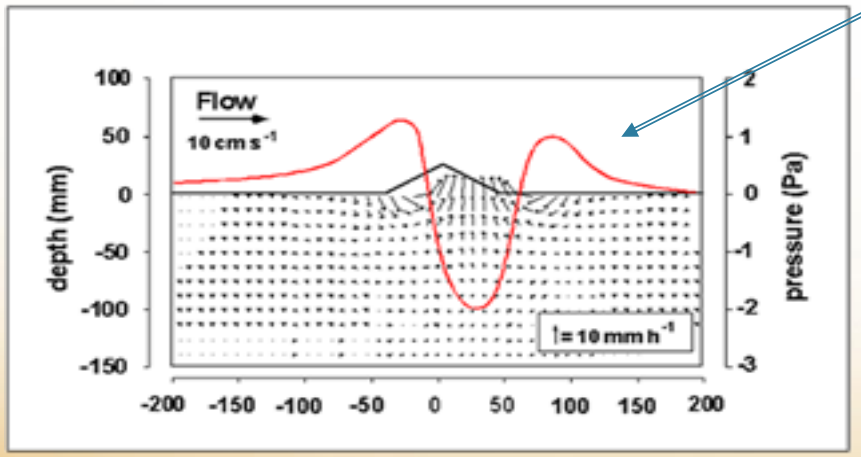
Permeable sediments





ΔP related to nearbed speed and bed form steepness.

Flow rate $w_a \sim k\,\Delta P / \lambda$

w_a = *average flow velocity*
k = sediment permeability
ΔP = pressure difference along bedform
λ = ripple wavelength

Other key quantity is depth of advective zone

$d_A \sim h$,

where *h* = ripple height.

Include addition to in-bed diffusion coefficient

$$K = (K_0 + K_{adv})\ I_{bio}$$

$$K_{adv} = a_2\, w_a\ d_A$$

a_2 calibrated on SSB data

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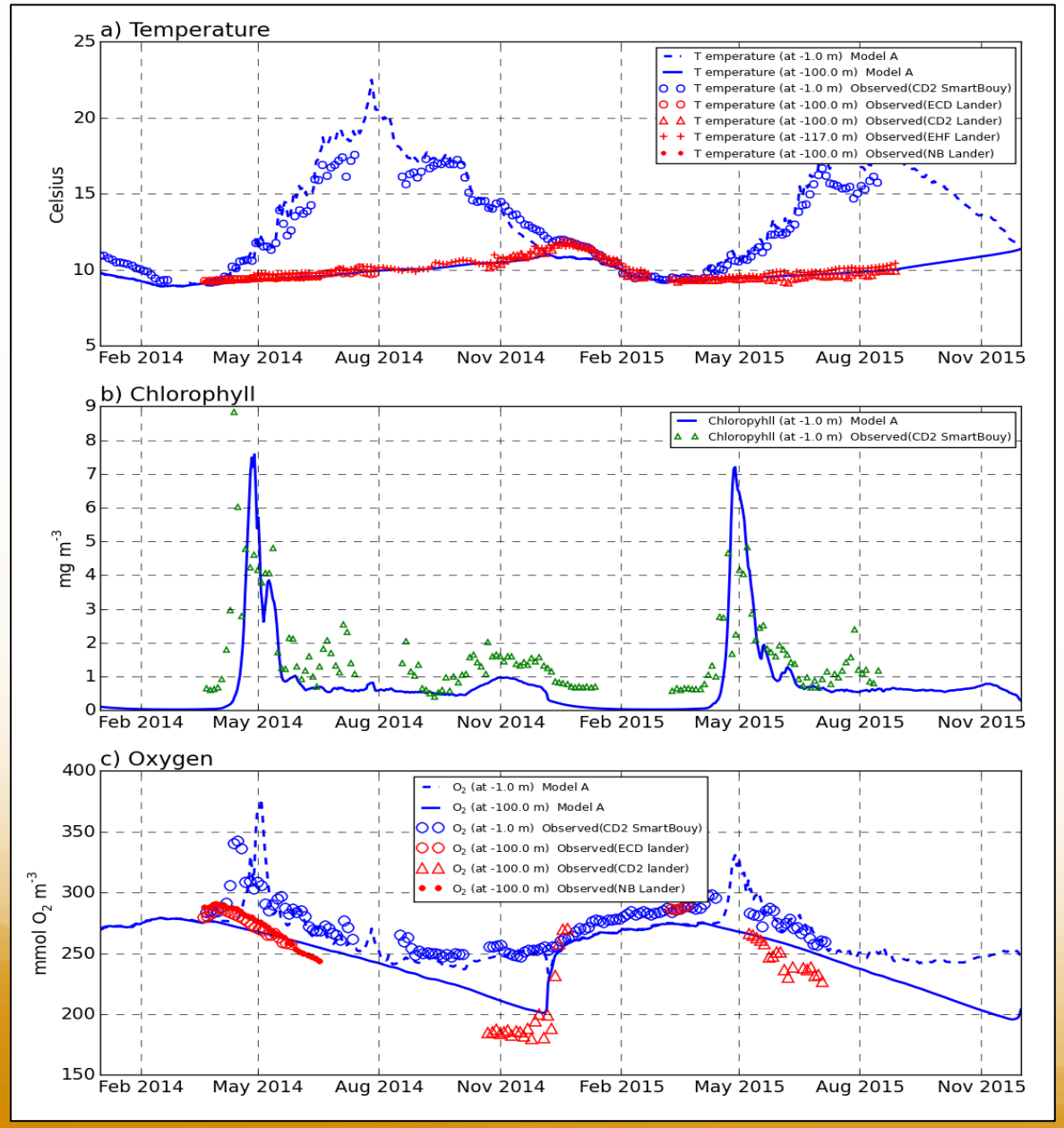
Water column comparison



For subsequent benthic comparison need to ensure no major discrepancies in pelagic model component

Adjustments to compensate for
1) lack of advective effects in 1D model
2) site specific water properties

Bottom temperatures ‘relaxed’ to observed values

SPM light attenuation adjusted to match observed spring bloom timing

Summer nutrient flux added to maintain observed summer production

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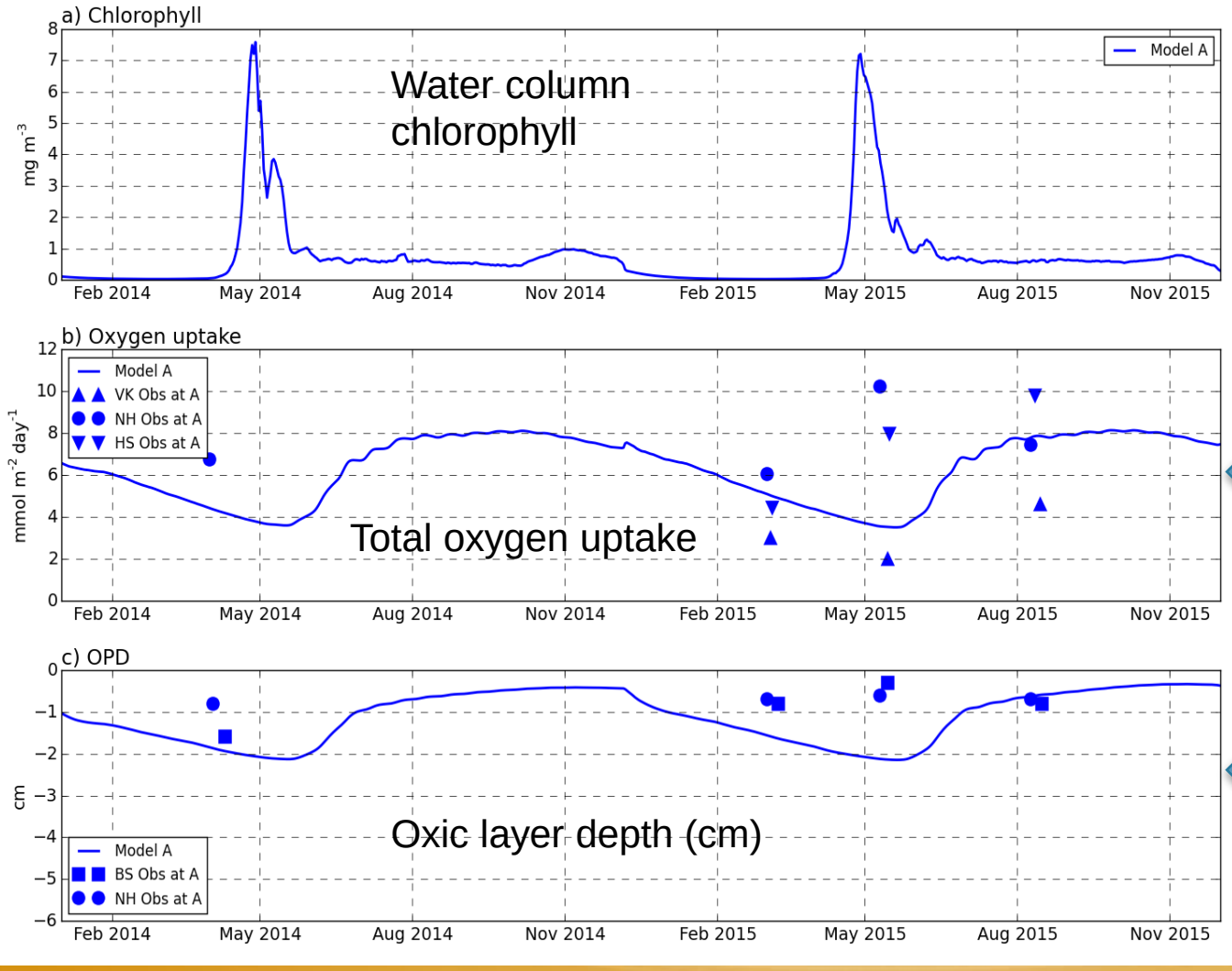
Benthic oxygen Site A



- Model uptake right order of magnitude.
- Model decrease over winter/spring due to run down in organic matter.
- Fast response to spring bloom (although scatter). Model slower.

- Independent obs. very consistent 2015, difference in 2014
- Model overestimate oxic layer in spring

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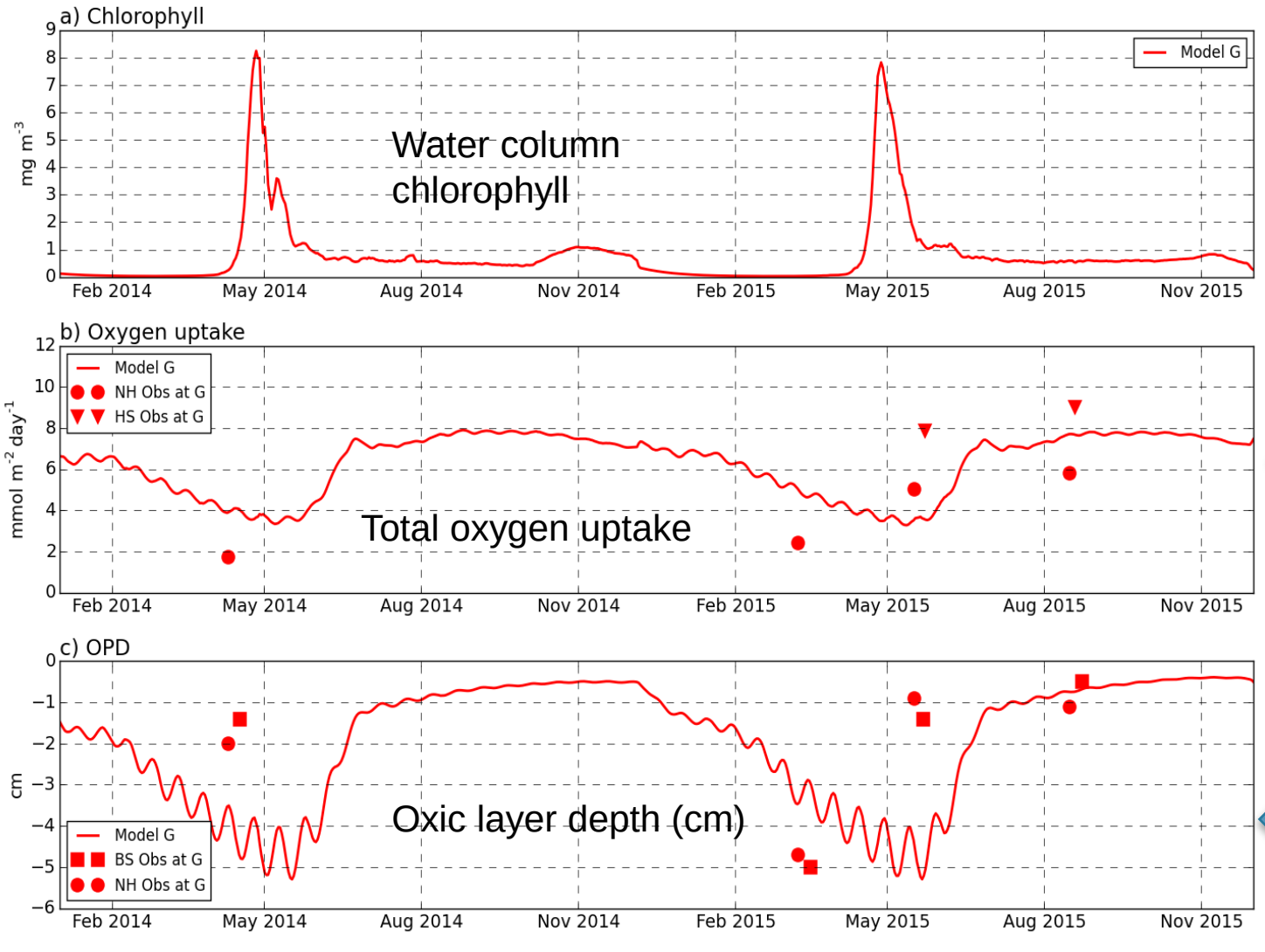
Benthic oxygen site G



- Model uptake again right order of magnitude
- Maybe too high pre-bloom?

- Permeable modification captures deeper layer observed pre-bloom 2015 (but not 2014), (but admittedly fitted via 'a_2' constant.
- Good agreement late summer
- Model again slower response to observed uptake during spring bloom.

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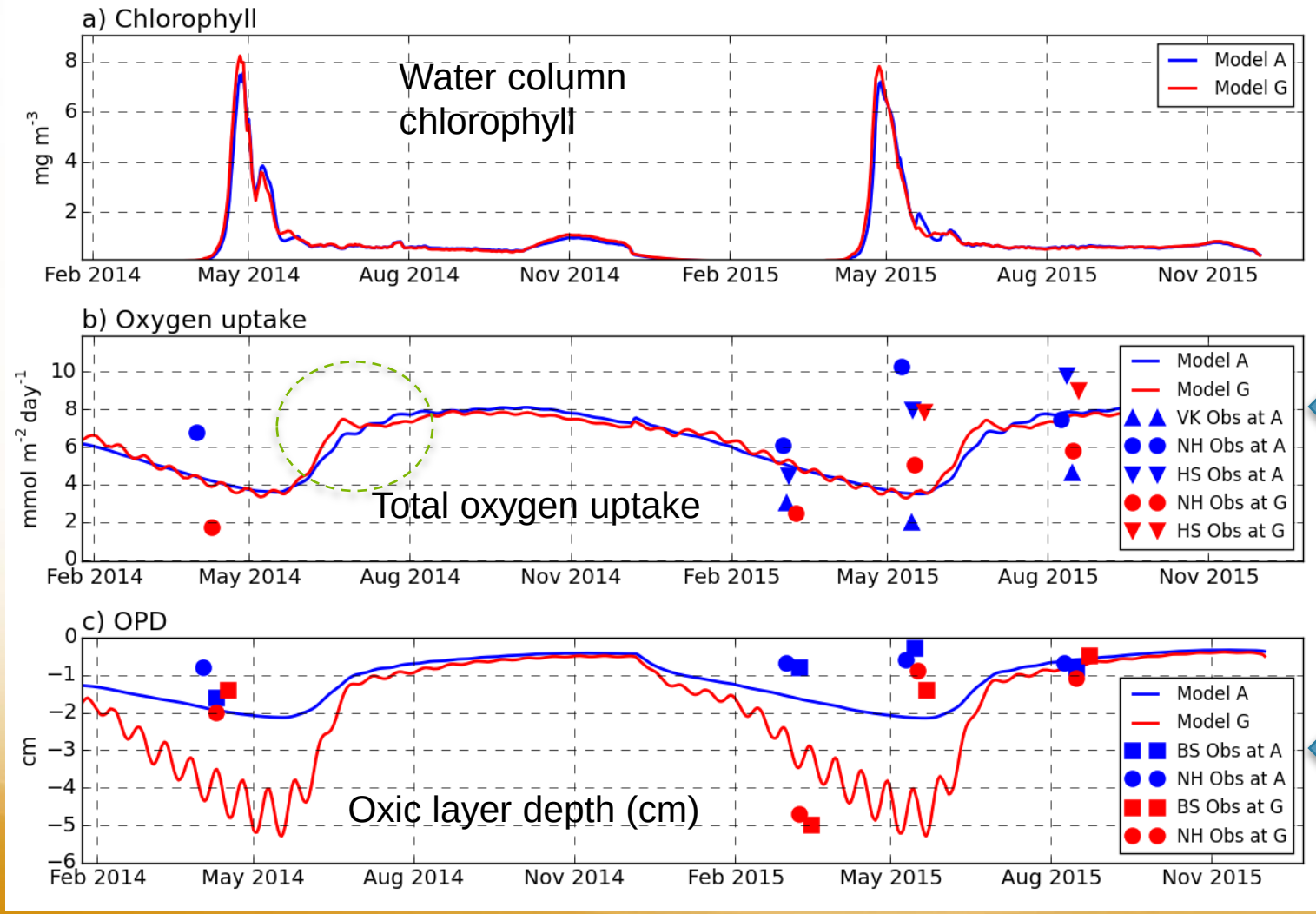
Sites A and G plots overlaid



Permeable modification seems to have minimal impact on oxygen uptake compared to non permeable site A.

Observationally, apart from pre-bloom 2015, relatively little difference in OPD between sites

Next steps ?

Contributions to oxygen uptake

Can we account for total observed uptake from individual contribution e.g.

- respiration of observed faunal and bacterial biomass,
- nitrification, etc

How does that compare with model ?

Permeable sediments

Can develop further to include effects seem in other studies (e.g. increased oxygen uptake rates)

Anammox

- Observations suggest important and will influence oxygen budget
- In principle could (with effort) add anammox to model.
- BUT to be predictive need to know what controls relative importance of anammox/denitrification pathways.

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Final points

- Modelled oxygen uptake consistent with the range of observed values
- Model oxic layer depth generally overestimated at site A
- Permeable sediment modification - mixed success
- Comparison with SSB observations suggest possible model parameter changes (but care drawing general conclusions from single sets of measurements & restricted range of sites)
- Further work might relate observed oxygen budget to measured bacterial/faunal biomass to be compared with model
- Do we need to include anammox in benthic models ? How do we predict when this pathway is important compared to denitrification?