Implementing iron in the SSB-ERSEM model

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Why?

Shelf Seas Biogeochemistry – WP3

Understanding shelf Fe cycling and export

Modelling can help

Test hypothesis emerging from the fieldwork

Adding spatial and temporal resolution

Look at processes hard to measure in the field

Science questions

?

Is the shelf a source of iron to the open ocean?

How important is the sediment pool as a source compared to the recycling of organic material?

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History of ERSEM/BFM

Creation of a marine ecosystem model that

- has multiple functional groups within each trophic level
- couples both the pelagic and benthic compartment
- is based on internally varying nutrient ratio's

MAST project ERSEM I 1990 - 1993

ERSEM II 1993 - 1996

1995 **ERSEM**

ERSEM
HCMR (G)
Hamburg Uni (D)
PML (UK) → SSB ERSEM

2006 **BFM**

ERSEM-BFM
NIOZ-CEFAS (NL,UK)
shelf seas model

BFM
INGV-OGS (I)
global oceanic model

More modular structure and generic approach

European Regional Seas Ecosystem Model

Biogeochemical Flux Model

J.W. Baretta, J.G. Baretta-Bekker (DHI, DK)
P. Ruardij (NIOZ, NL)
W. Ebenhöh, C. Kohlmeier (Oldenburg, D)
G. Radach, H.-J. Lenhart (Hamburg U, D)
N. Pinardi, M. Zavatarelli (Bologna U, I)
M. Vichi (INGV, I)
Ph. Radford , J. Blackford (PML, UK)
M. Heath, W.S.C. Gurney (Strathclyde U, UK)
J.G. Ollason (Aberdeen U, UK)
A. Cruzado, R. Varela (CSIC, E)

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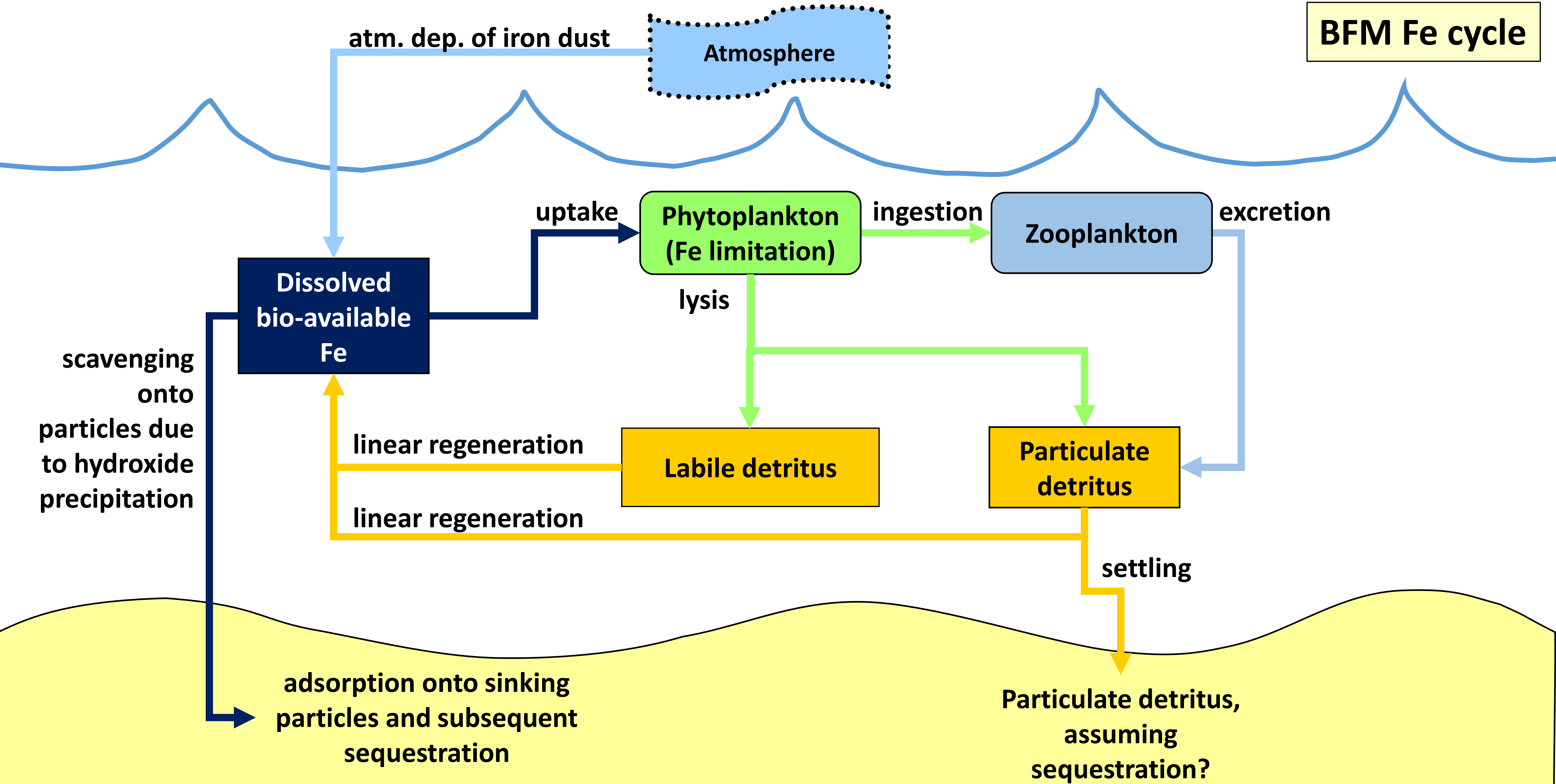
BFM Fe cycle



Phytoplankton Fe is directly transferred to particulate detritus if eaten by zooplankton, similar to Si

Vichi *et al* 2007

SSB meeting Liverpool 2014

Identification of weaknesses in the current SSB-ERSEM Fe implementation

- lack of speciation
- lack of photochemical processes (quota not tied to photo-acclimation)
- use of a constant scavenging rate
- lack of ligand representation
- internal Fe quota in need of improvements/updating
- lack of Fe in zooplankton/bacteria
- constant sedimentation flux
- scavenging rates not particle dependent
- uptake determined mainly by size

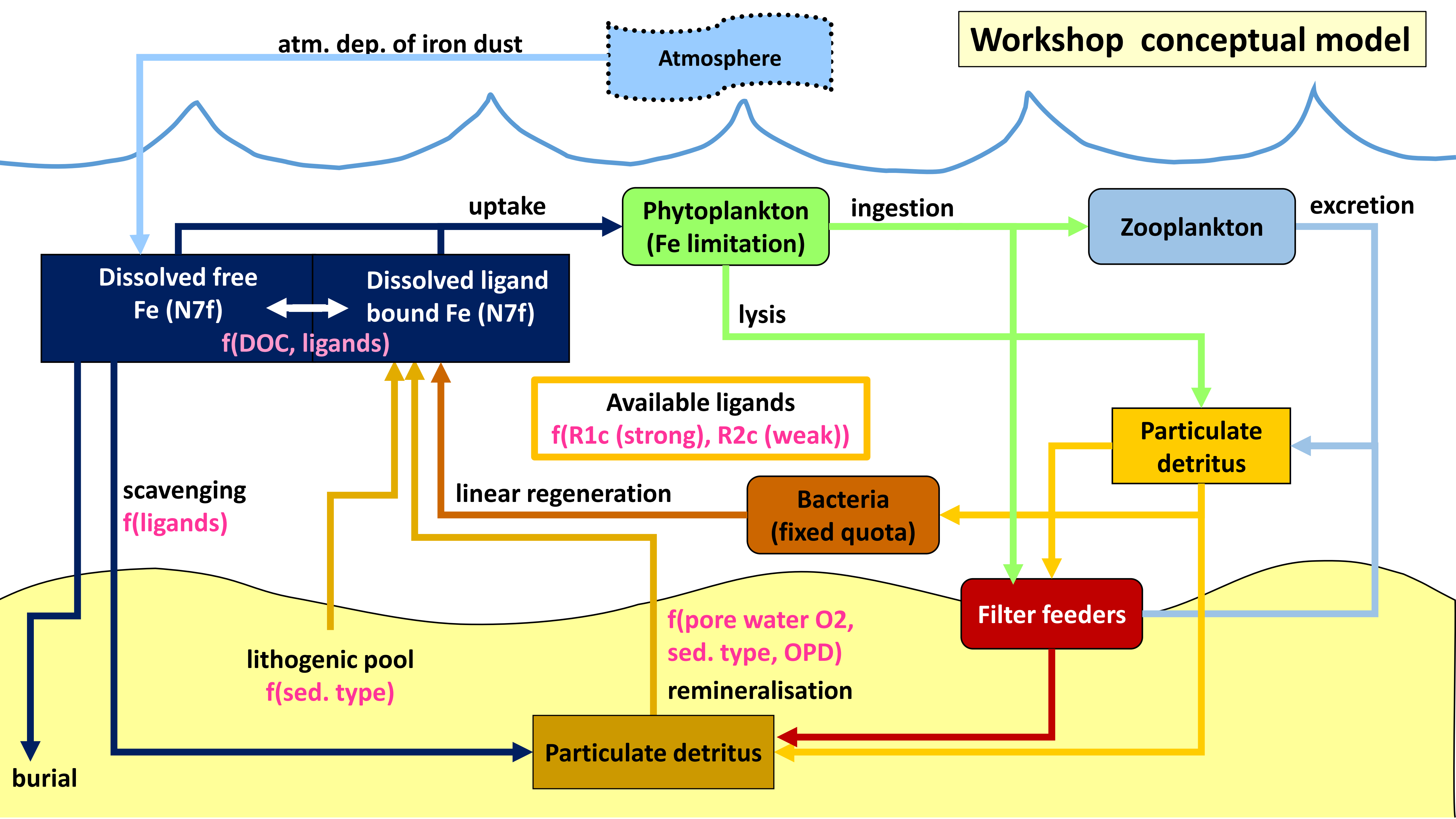
particulate Fe ⇋ colloidal Fe ⇋ dissolved Fe

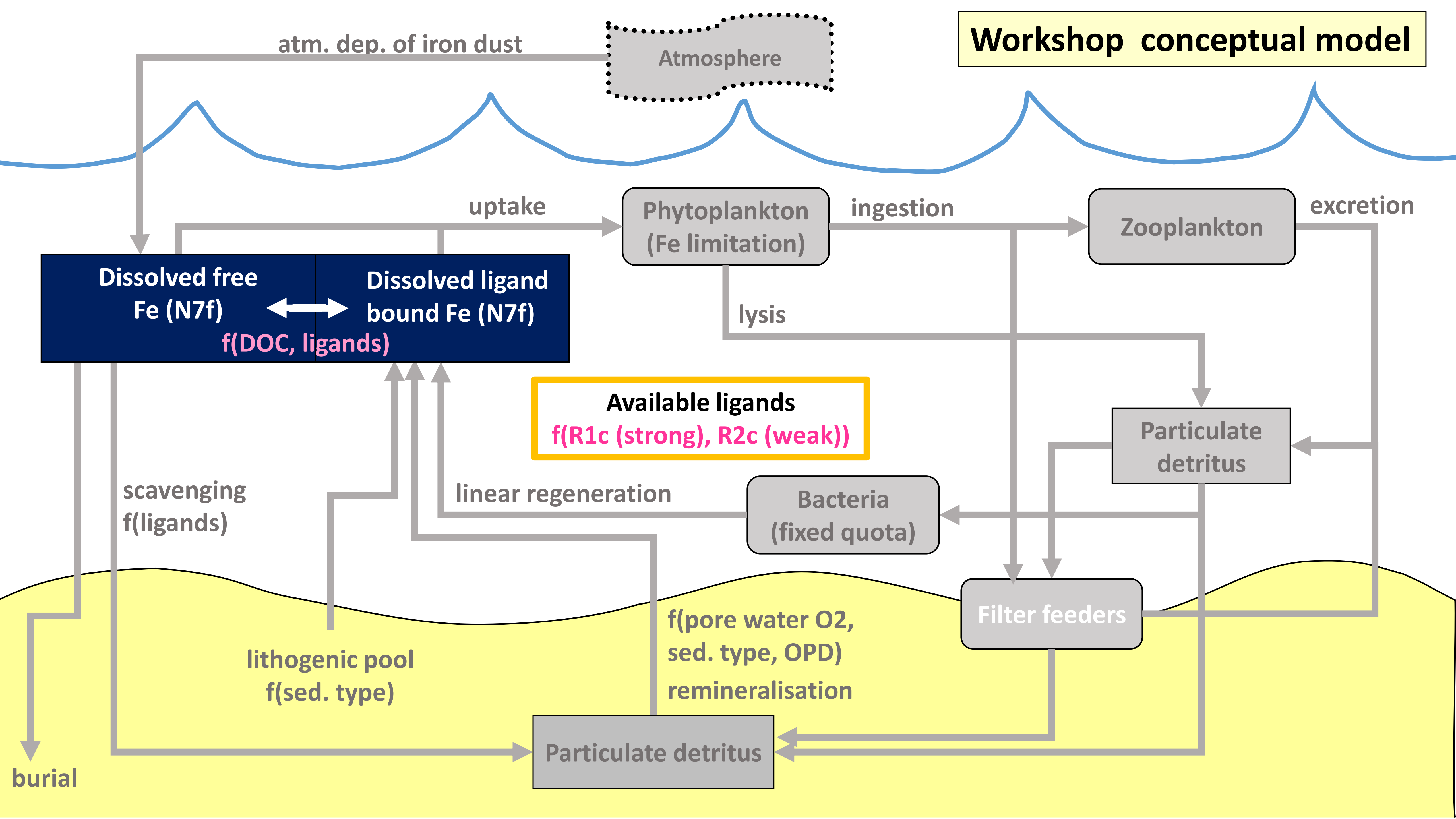
SSB workshop London 2016

Creation of conceptual Fe model for implementation in SSB-ERSEM

Determine which weaknesses are essential to the science questions the model could help answer and are feasible to implement

- seasonal changes
- distinction in sediment sources of Fe supply to the water column


Workshop conceptual model
Atmosphere
atm. dep. of iron dust
uptake
Phytoplankton
(Fe limitation)
ingestion
Zooplankton
excretion
Dissolved free
Fe (N7f)
Dissolved ligand
bound Fe (N7f)
f(DOC, ligands)
lysis
Available ligands
f(R1c (strong), R2c (weak))
Particulate
detritus
scavenging
f(ligands)
linear regeneration
Bacteria
(fixed quota)
Filter feeders
f(pore water O2,
sed. type, OPD)
lithogenic pool
f(sed. type)
remineralisation
Particulate detritus
burial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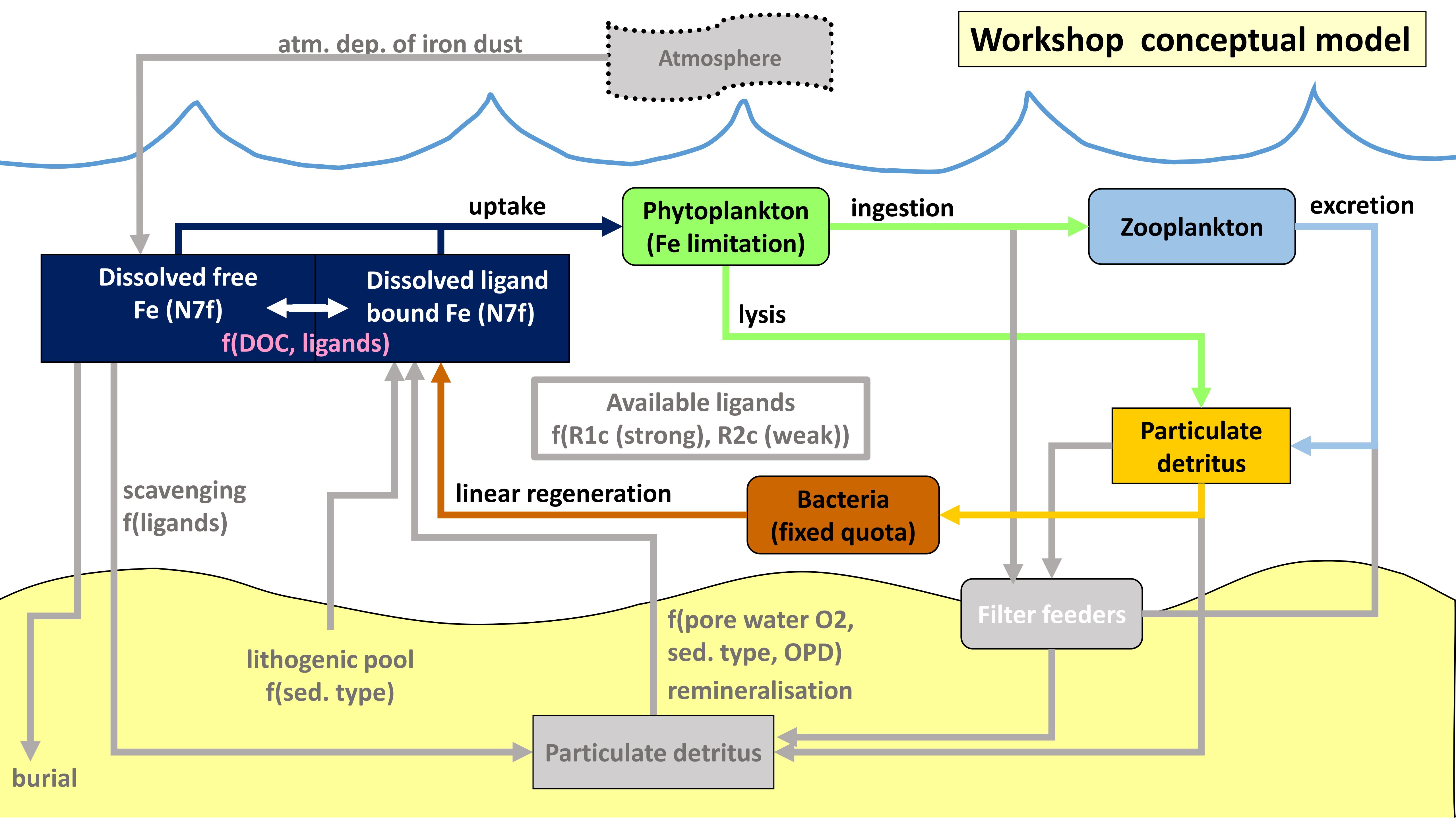

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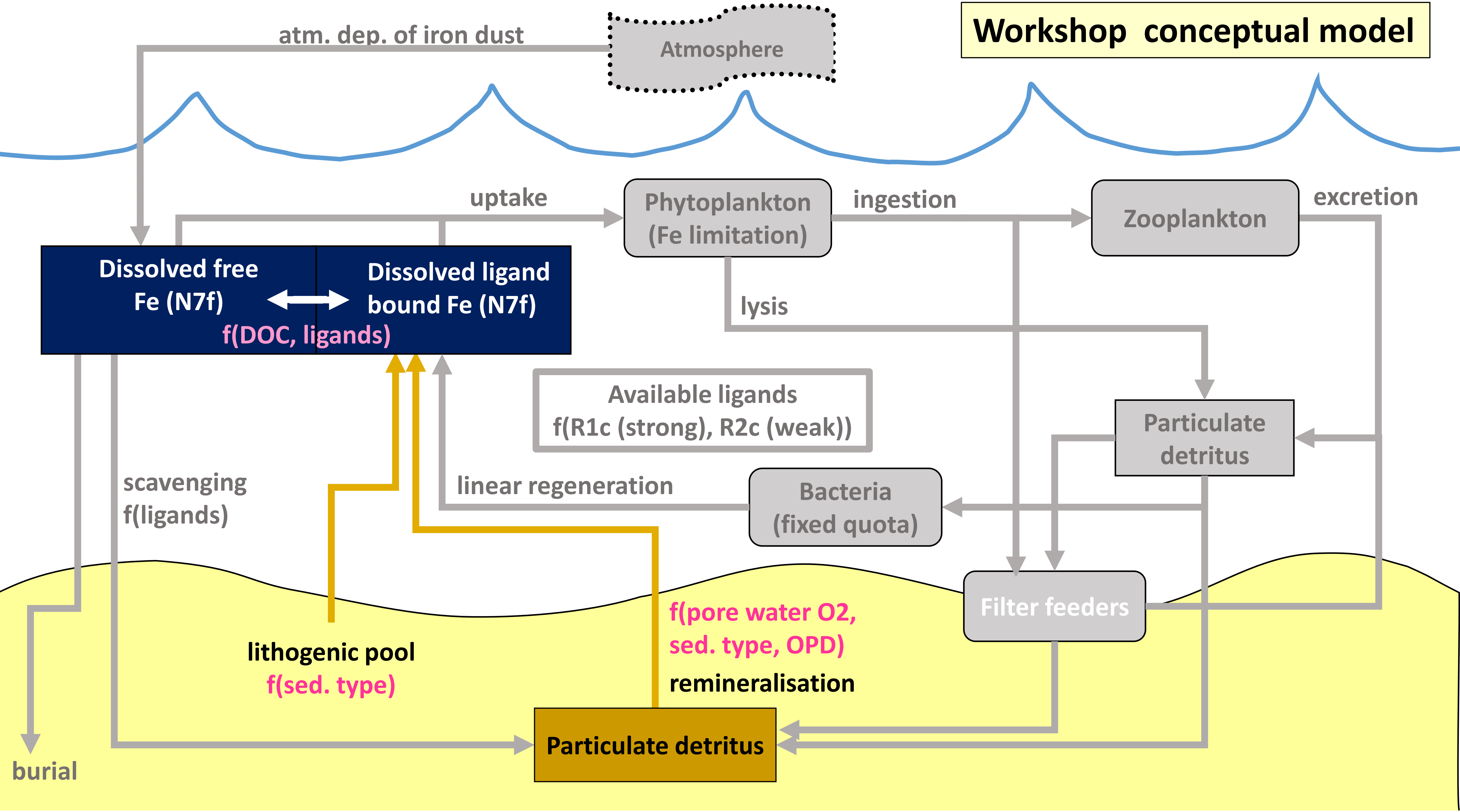

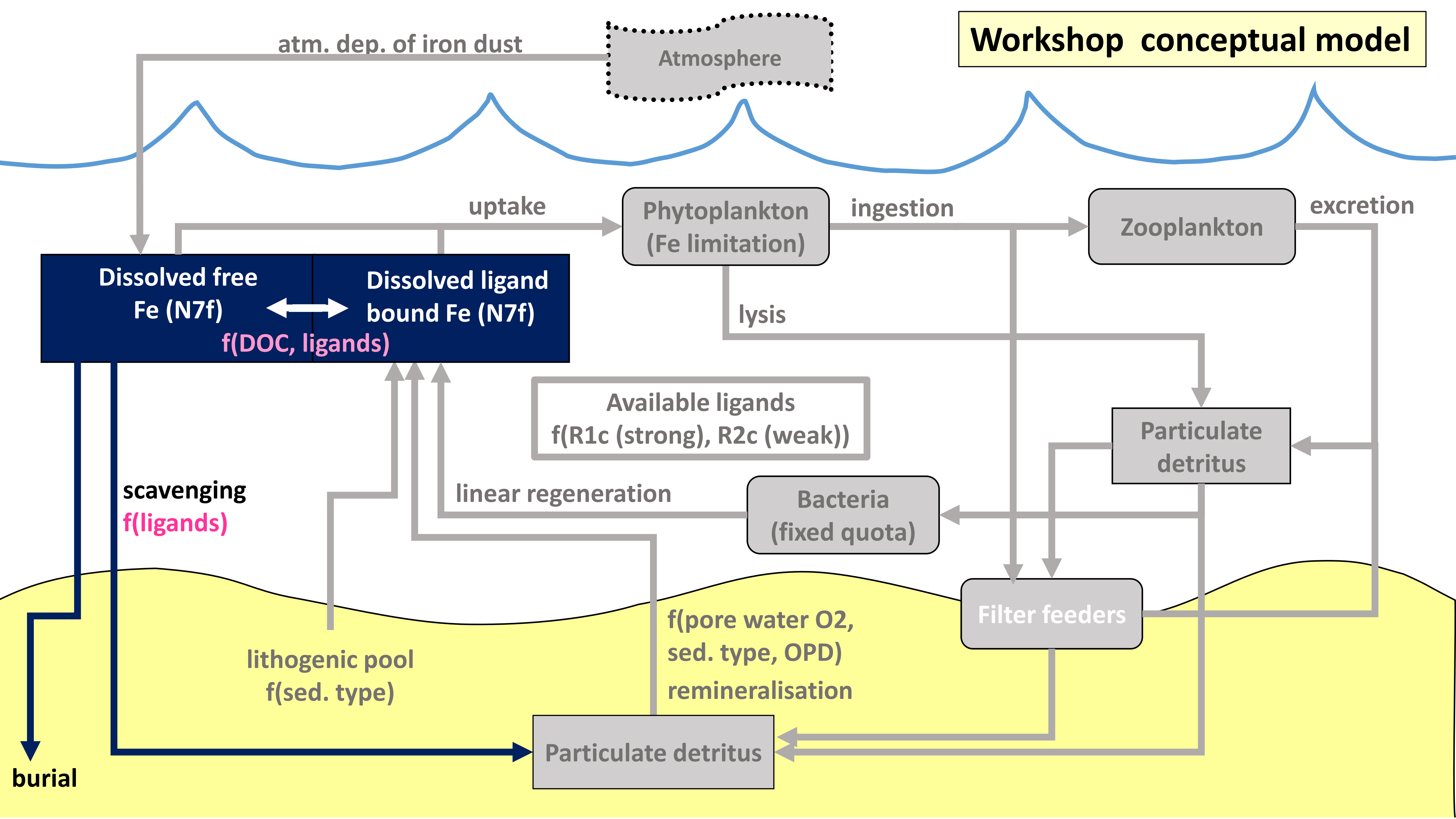

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burial

Dynamic scavenging rate due to particle sinking

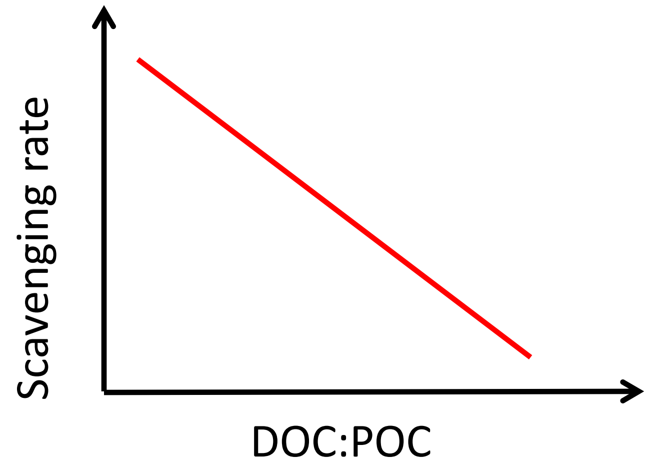
General assumptions

The adsorption of iron into particles is assumed to be regulated by the amount of DOC (assumed to be a proxy of organic ligands) relative to POC:

Particulate iron subject to sinking

$$\frac{\partial Rf}{\partial t} = max\left[0, \left(1 - \frac{\varphi}{\varphi_{eq}}\right)\right] \cdot N7f \cdot \delta$$

Iron "available" for phytoplankton (both free and bound to DOM)



Where:

$$\varphi = \frac{DOC^{tot}}{POC}$$

DOC^{tot}= labile+semilabile

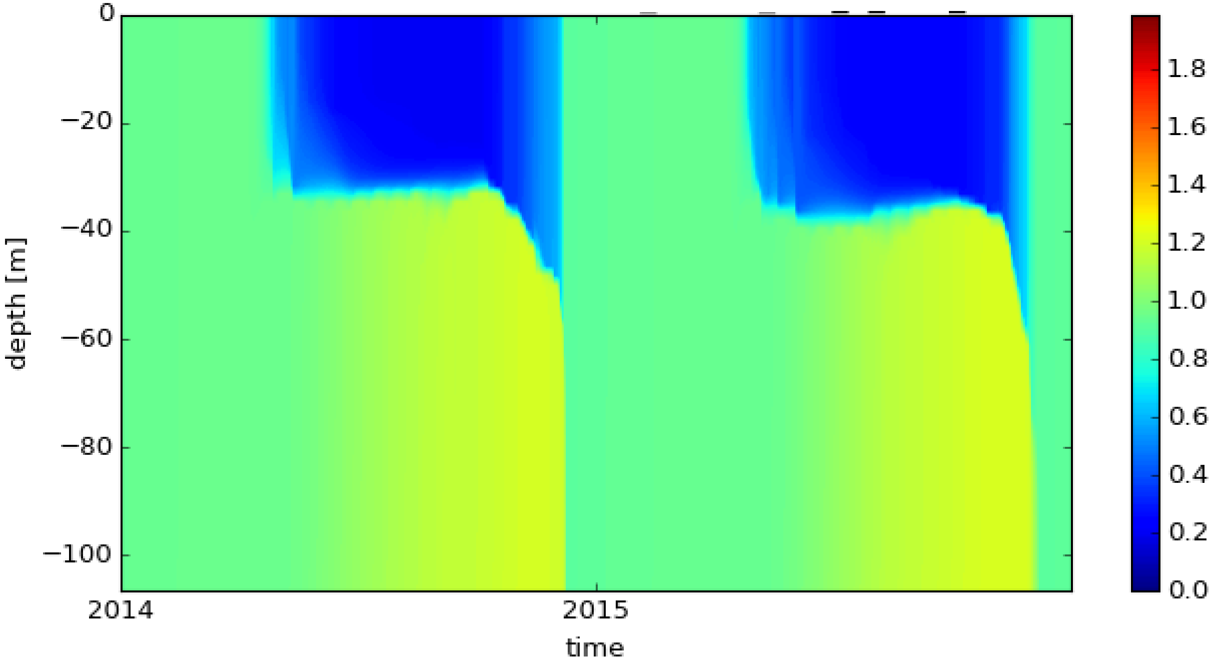
φ_{eq} is a parameter representing the DOC to POC ratio above which iron is stabilised by ligands and δ (d^{-1}) represents the time scale of the process

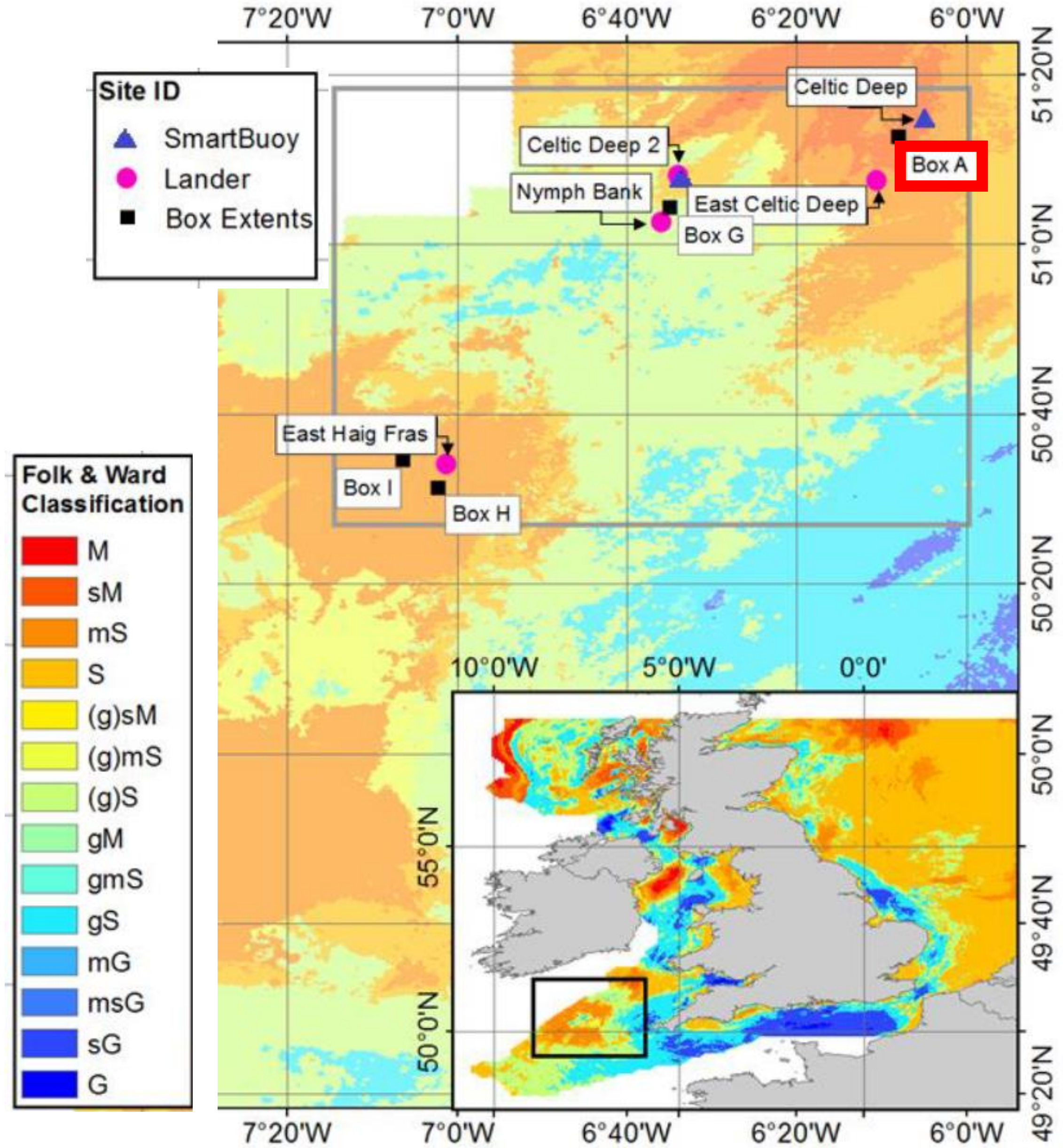
SSB observations

Model set up available for Benthic A site
CANDYFLOSS site requires calibration

But what does the seasonal signal look like?

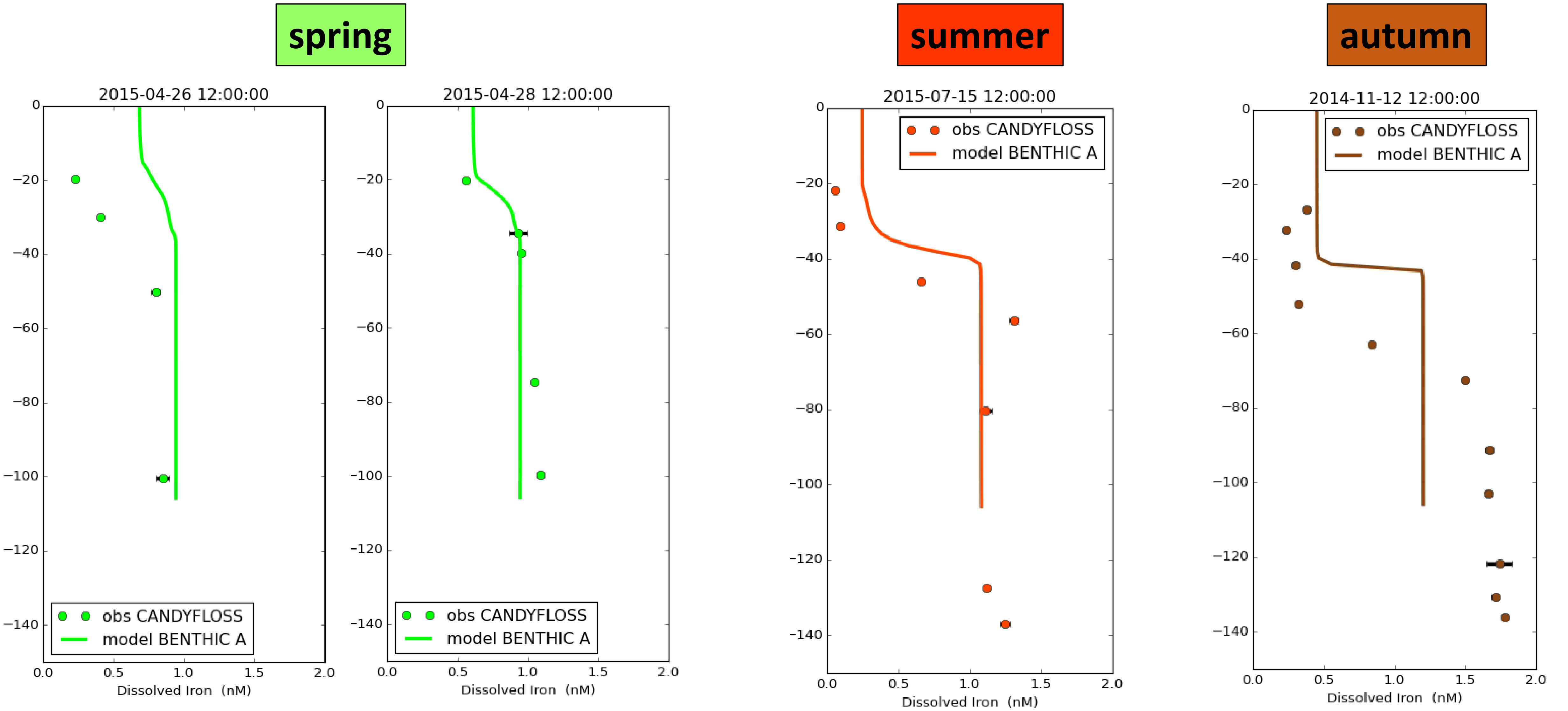
Iron [µmol/m³]





Comparison to CANDYFLOSS data

Data courtesy of Maeve Logan (Un. of Southampton)



Comparison to CANDYFLOSS data

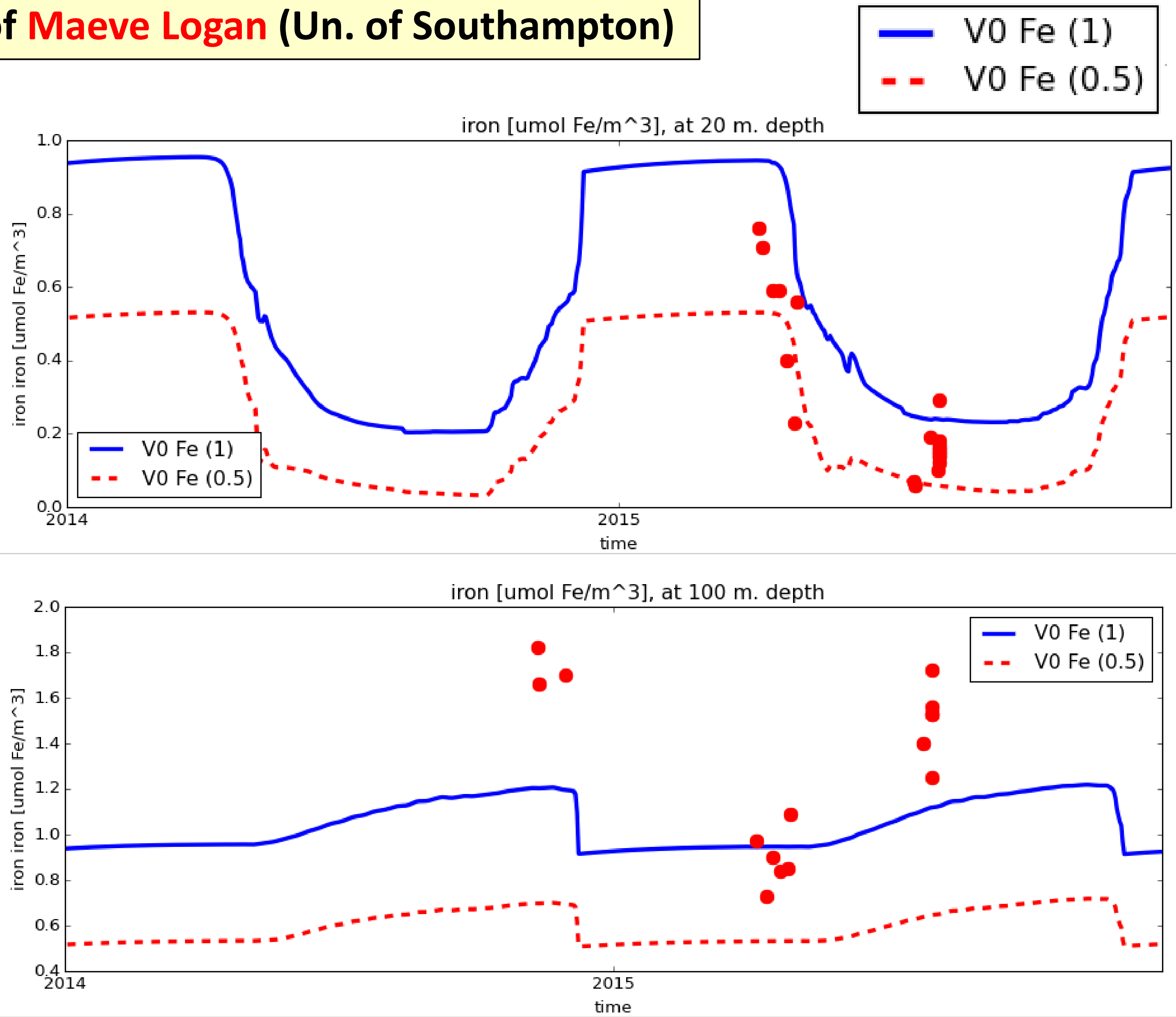
Data courtesy of Maeve Logan (Un. of Southampton)

20 m

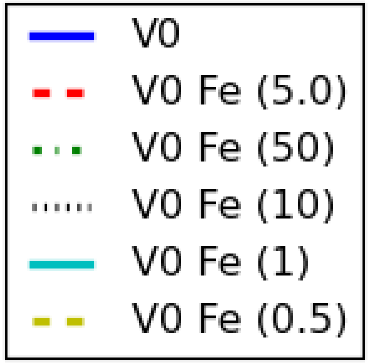
Drawdown in SML is captured ...

but variability in BML too low in model

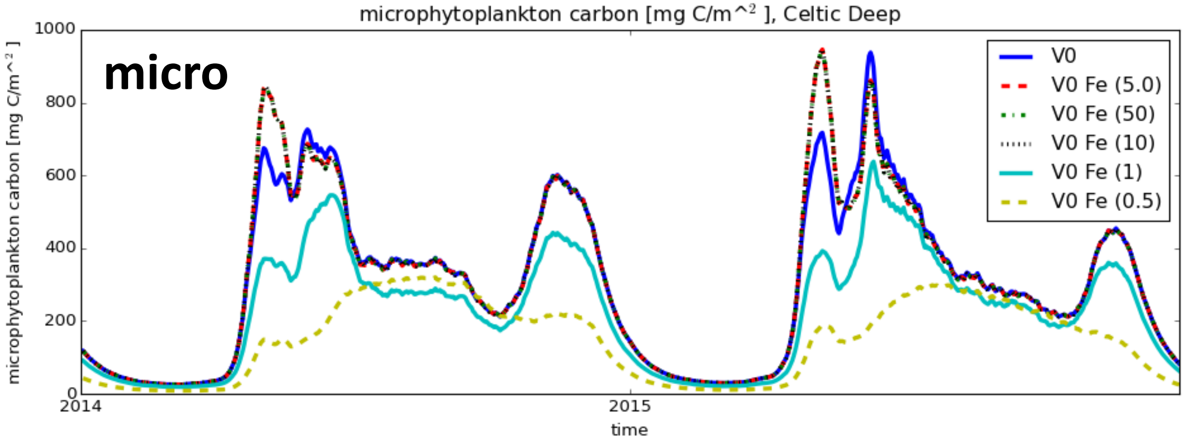
100 m

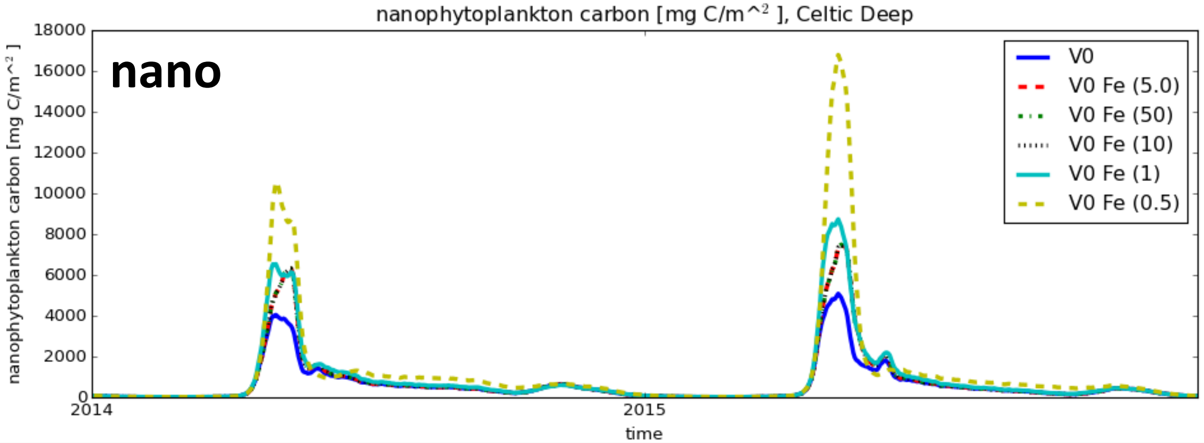


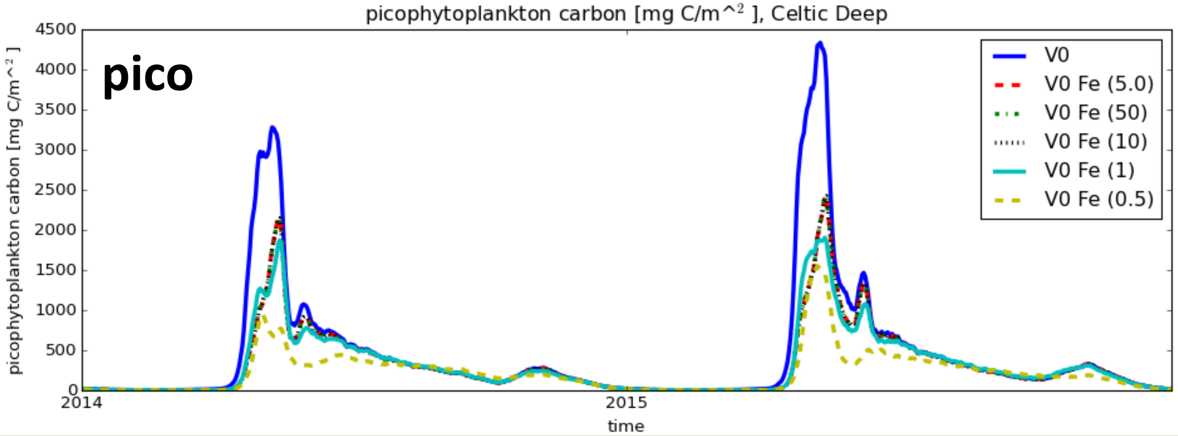
Biological response to changing Fe

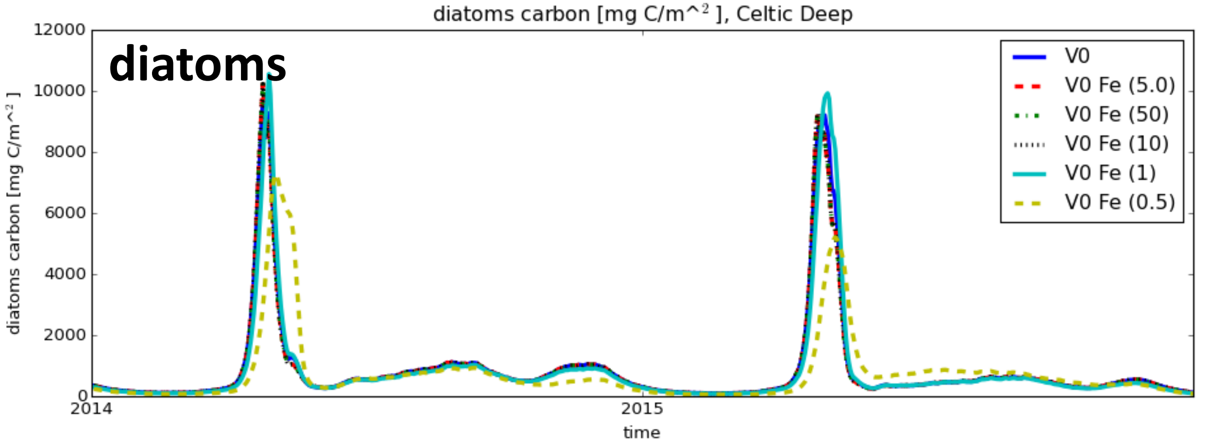


Saturation for large values of Fe, limitation favours nanophytoplankton









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Work is ongoing ...

Still a lot to do:

- implementations (lithogenic pool, ligands, quota's dependent on photo-acclimation, sediment flux to pelagic, bacterial storage)

- set-ups

- validation, including benthic observations

Thank you!