Upscaling the impact of coastal hypoxia from species to ecosystem function. The case of bioturbation in the Black Sea.

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CHALLENGE: from species traits to ecosystem functions, with a focus on bioturbation.

WHY? : To upscale the effect of variations in benthic species functions on benthic-pelagic coupling and biogeochemical cycles of C and N.

HOW? : Development of a functional biogeographic model coupled with a circulation-biogeochemical model.

WHERE? : The Black sea where seasonal bottom hypoxia occured at the end of summer.

LOCAL APPROACH

Experimental data sets

Macrobenthos data

EROS data set, August 1995.
Wijsman et al., 1999.

BENTHOX data sets collected during the EMBLAS
1 & 2 cruises.
(Plante et al., in prep.)

Sampling sites during EROS21, August 1995

Environmental data
In-situ data:
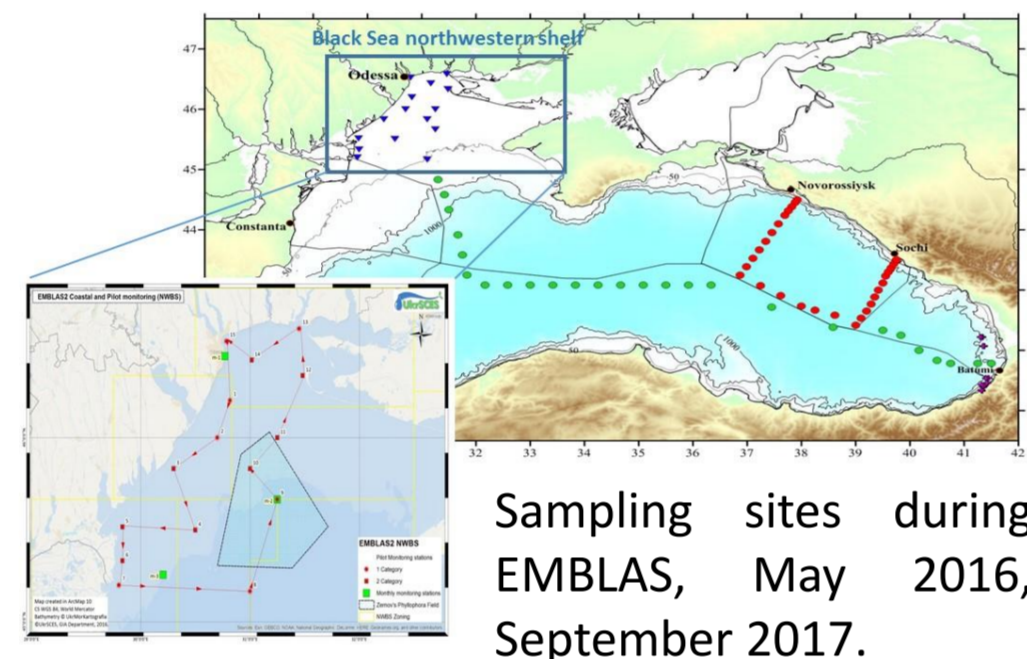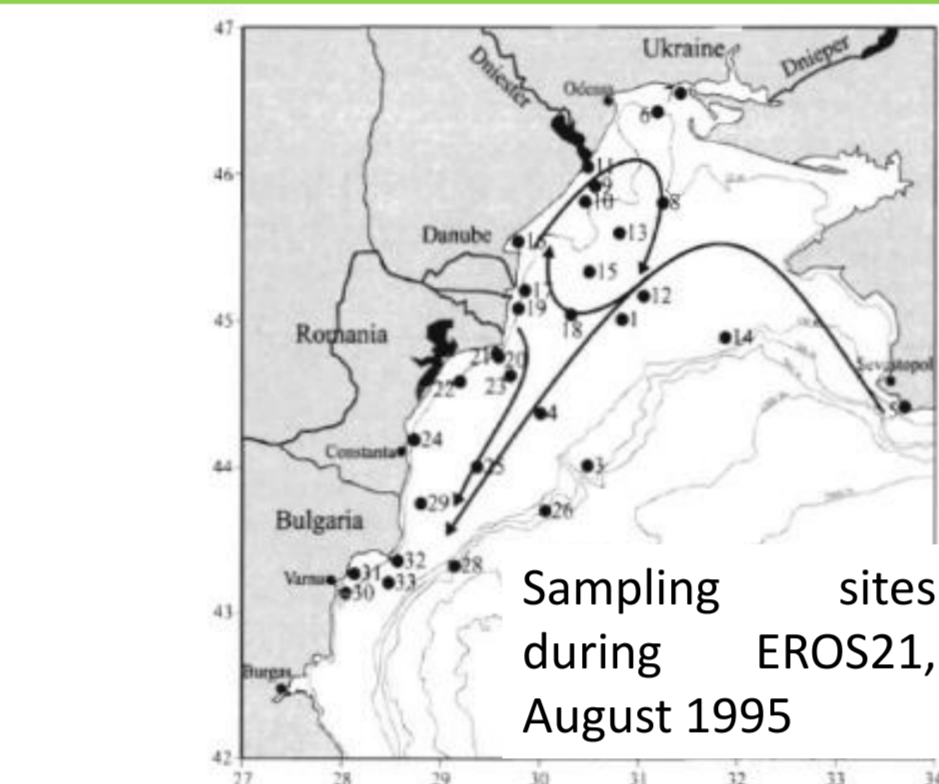grain size, OrgC, TotN, Tot P
Bottom water nutrient concentrations

Model variables:
Physical variables:
Température, Salinity,
Total shear stress, Water age,
Turbuelnt Kinetic Energy

Sampling sites during EMBLAS, May 2016, September 2017.

Biogeochemical variables
Oxygen, Hypoxia index, PAR,
Flux of POC to the bottom
Carbon in the sediment ..

A TRAIT-based approach

Example of bioturbation traits

TRAIT	Modalities	
Method of sediments reworking (Reworking mode: Ri)	(1)	Epifauna that bioturbate at the sediment-water interface,
	(2)	surficial modifiers (<1-2cm)
	(3)	upward/downward conveyors that actively transport sediment to/from the sediment surface
	(4)	Biodiffusors
Propensity to move through the sedimentary matrix (Mobility :Mi)	(1)	in a fixed tube
	(2)	limited movement, sessile, but not in a tube
	(3)	slow movement
	(4)	free movement via burrow system

Increasing activity

Increasing impact on the sediment turnover
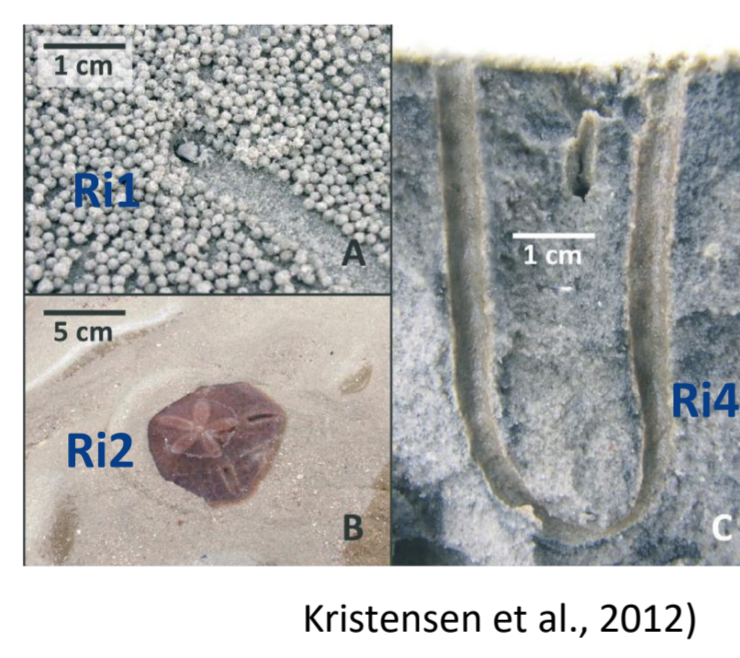
Kristensen et al., 2012)

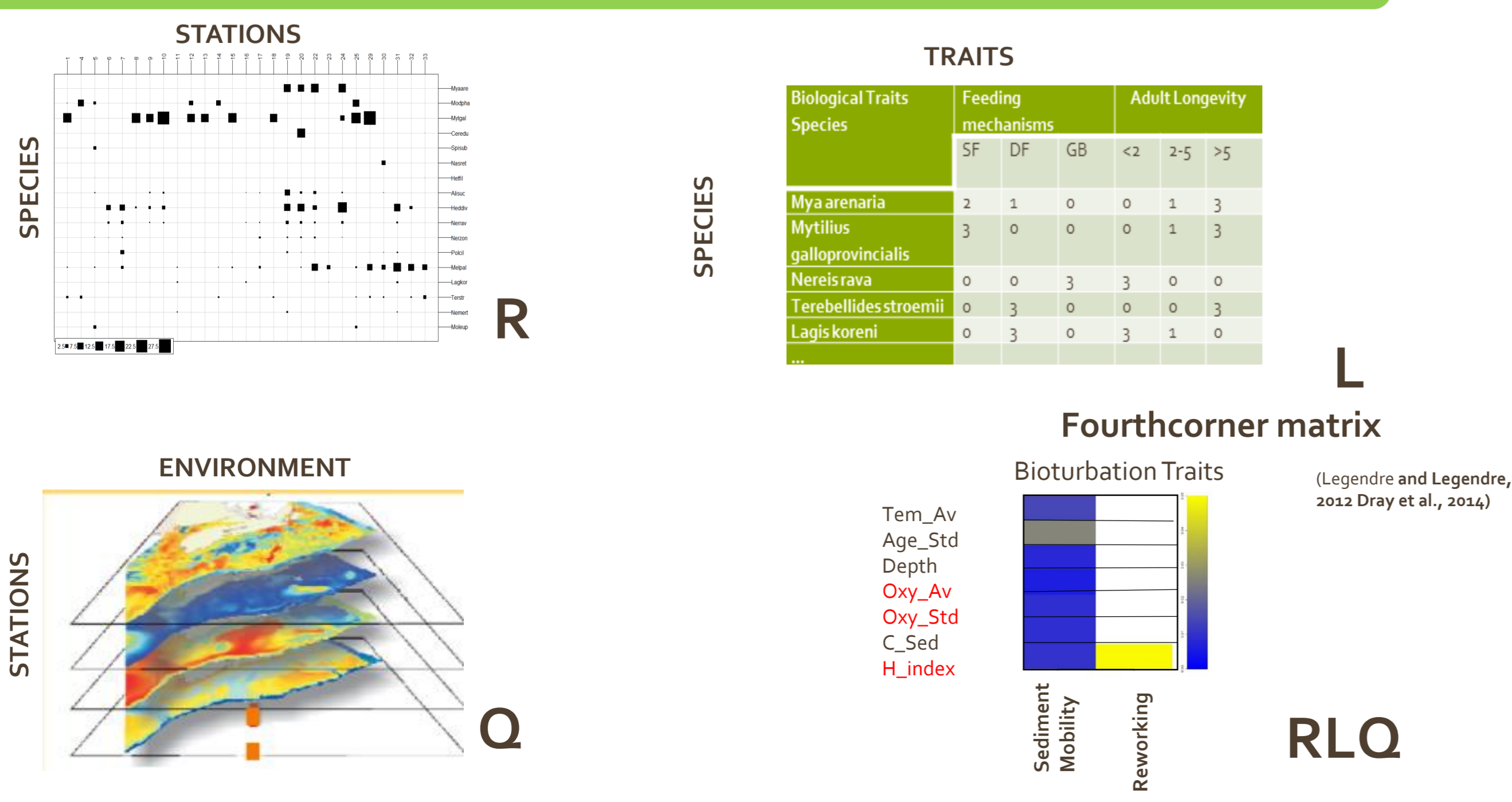Traits estimated for the 72 species from Queiros et al., 2013

Bioturbation Potential of the community (BPC)

Per capita effect of each species on sediment mixing

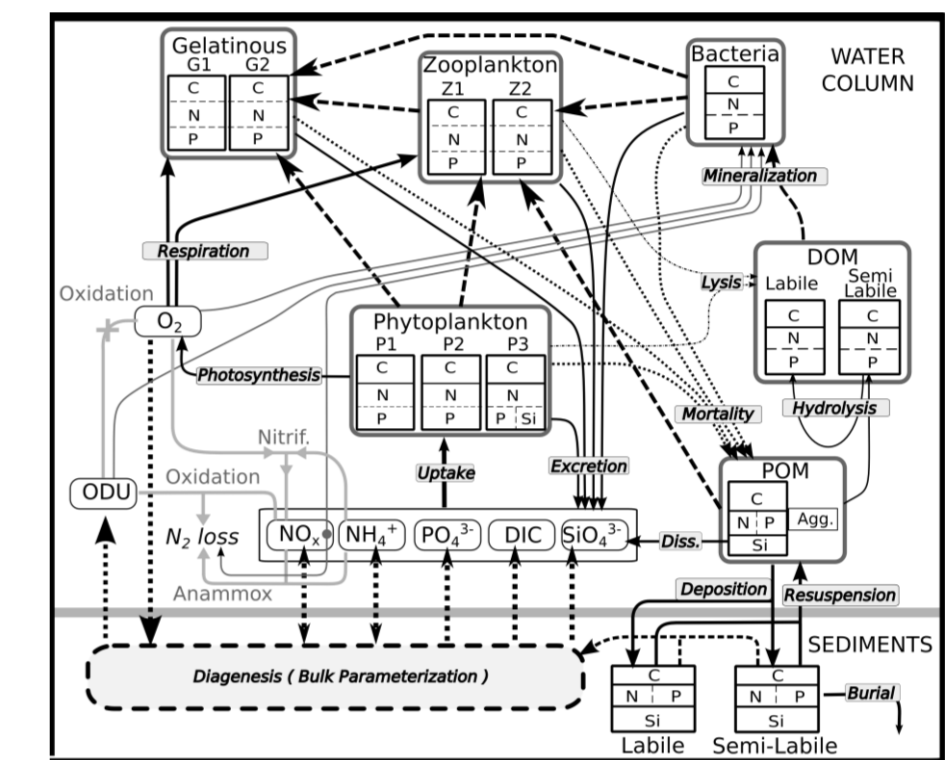$$BPi = Bi^{0,5} * Mi * Ri$$

Solan et al., 2004 Science).

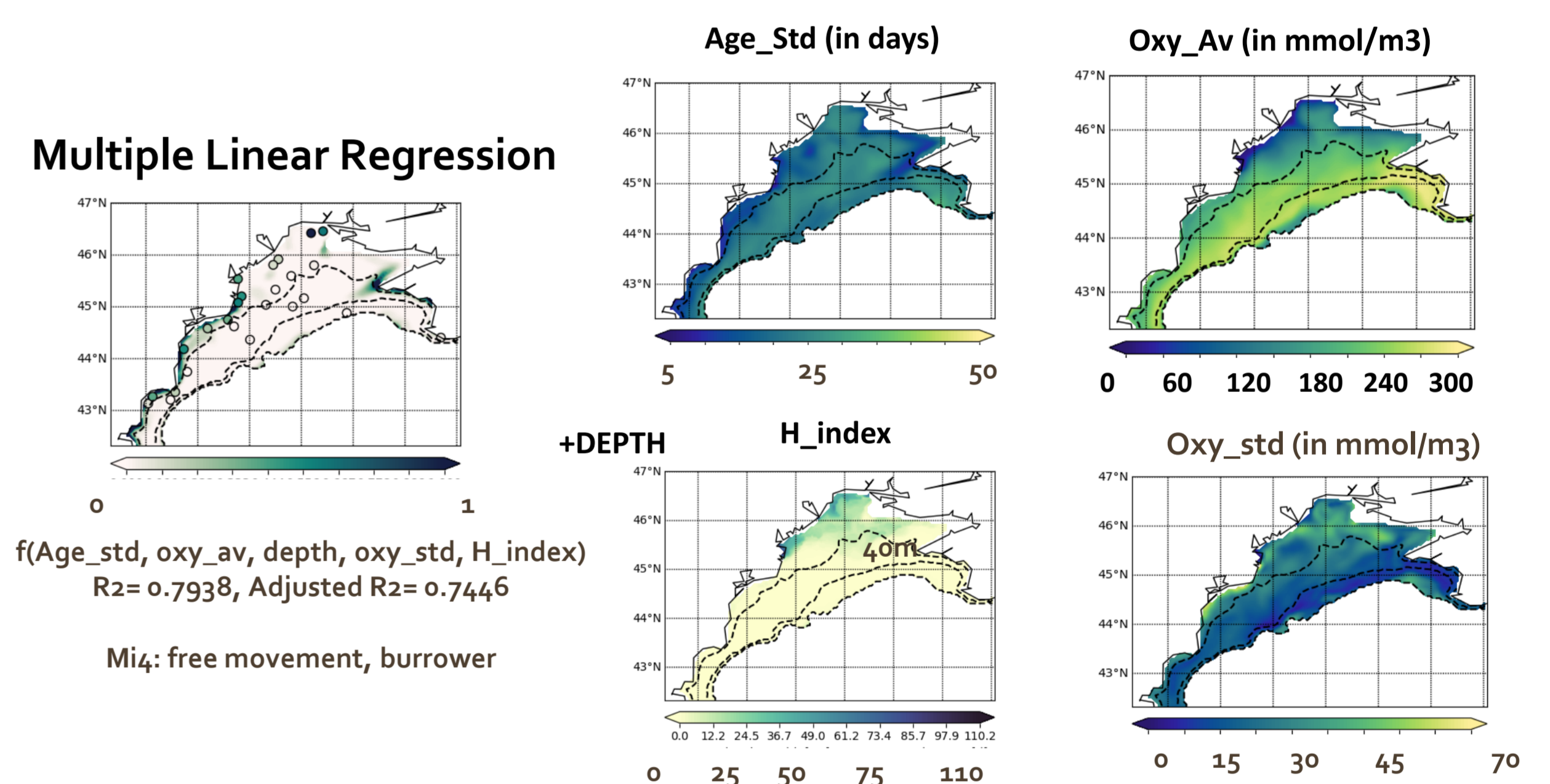### Species-Trait-Environment: RLQ Approach

STATIONS

SPECIES

R

TRAITS

Biological Traits Species	Feeding mechanisms			Adult Longevity		
	SF	DF	GB	<2	2-5	>5
Mya arenaria	2	1	0	0	1	3
Mytilus galloprovincialis	3	0	0	0	1	3
Nereis rava	0	0	3	3	0	0
Terebellides stroemi	0	3	0	0	0	3
Lagis koreni	0	3	0	3	1	0

L

Fourthcorner matrix
Bioturbation Traits

(Legendre and Legendre, 2012 Dray et al., 2014)

Tem_Av
Age_Std
Depth
Oxy_Av
Oxy_Std
C_Sed
H_index

Sediment Mobility / Reworking

ENVIRONMENT

STATIONS

Q

RLQ

ECOSYSTEM APPROACH

The Black Sea physical and biogeochemical model

BAMHBI
Biogeochemical modeling system
1/36°x1/27° horiz. res
31 vert. levels
ECMWF an/fc atm. forcing

CMEMS BLACK SEA MFC

Mapping of the traits

Multiple Linear Regression

Age_Std (in days)

Oxy_Av (in mmol/m3)

+DEPTH   H_index

Oxy_std (in mmol/m3)

f(Age_std, oxy_av, depth, oxy_std, H_index)
R2= 0.7938, Adjusted R2= 0.7446

Mi4: free movement, burrower

Mapping of bioturbation to feed biogeochemical models

BPC

Mi4

Ri4   Ri1

Local random transport of particles

Hediste diversicolor

Sediment mixing paramters (Db, lm)

Model parameterization
Non-local and local transport of particles and solutes (ventilation)
Li=injection pocket depth

Li=injection pocket, pumping rate, diffusion enhancement factor,

Meysman et al., 2016
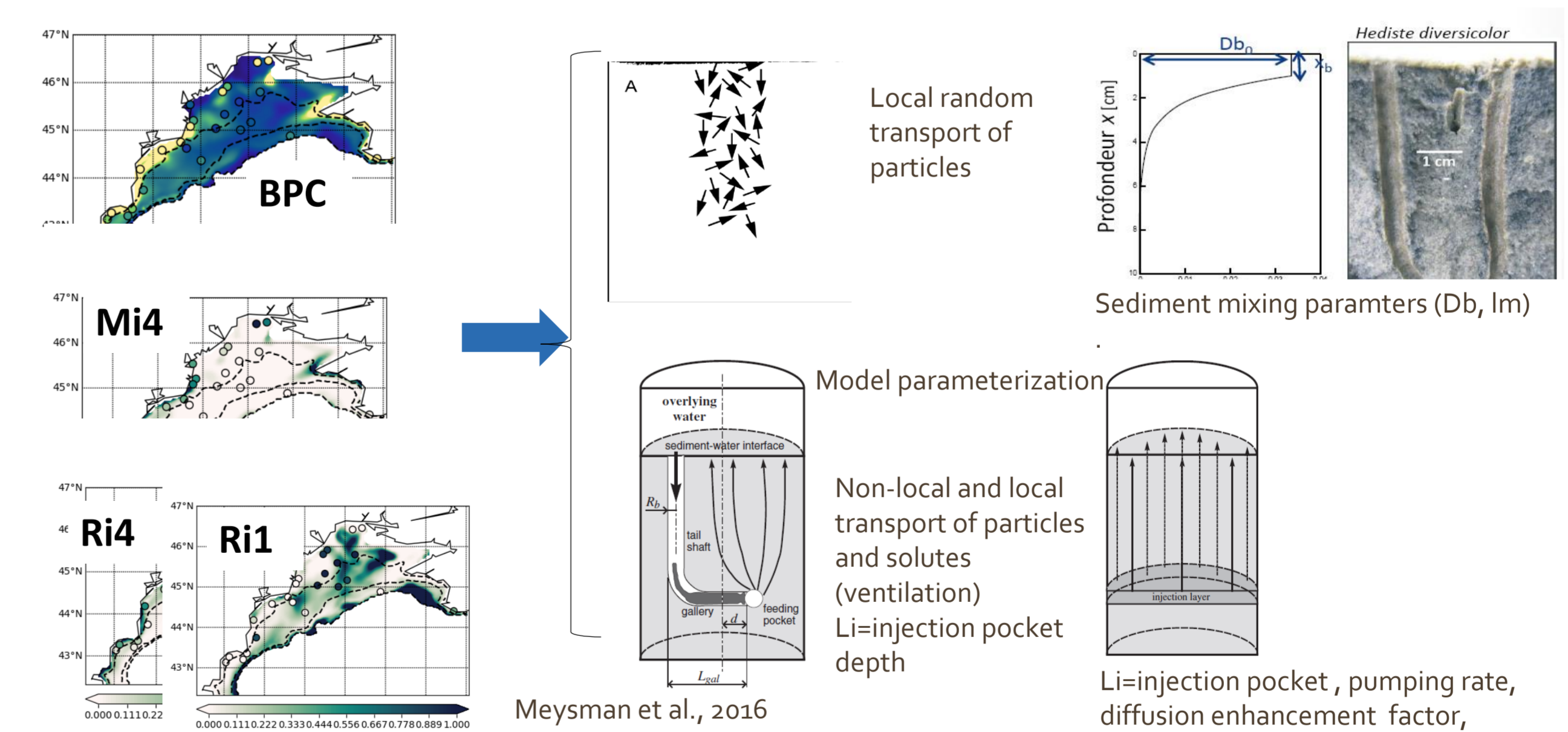
Challenge to link bioturbation traits with model parameters: link is not straitghforward

Sensitivity of the benthic model parameters to changing mixing length (lm)

Lm=2cm

Lm=10cm

f pdenit

bwO2

Cmin

Cmin
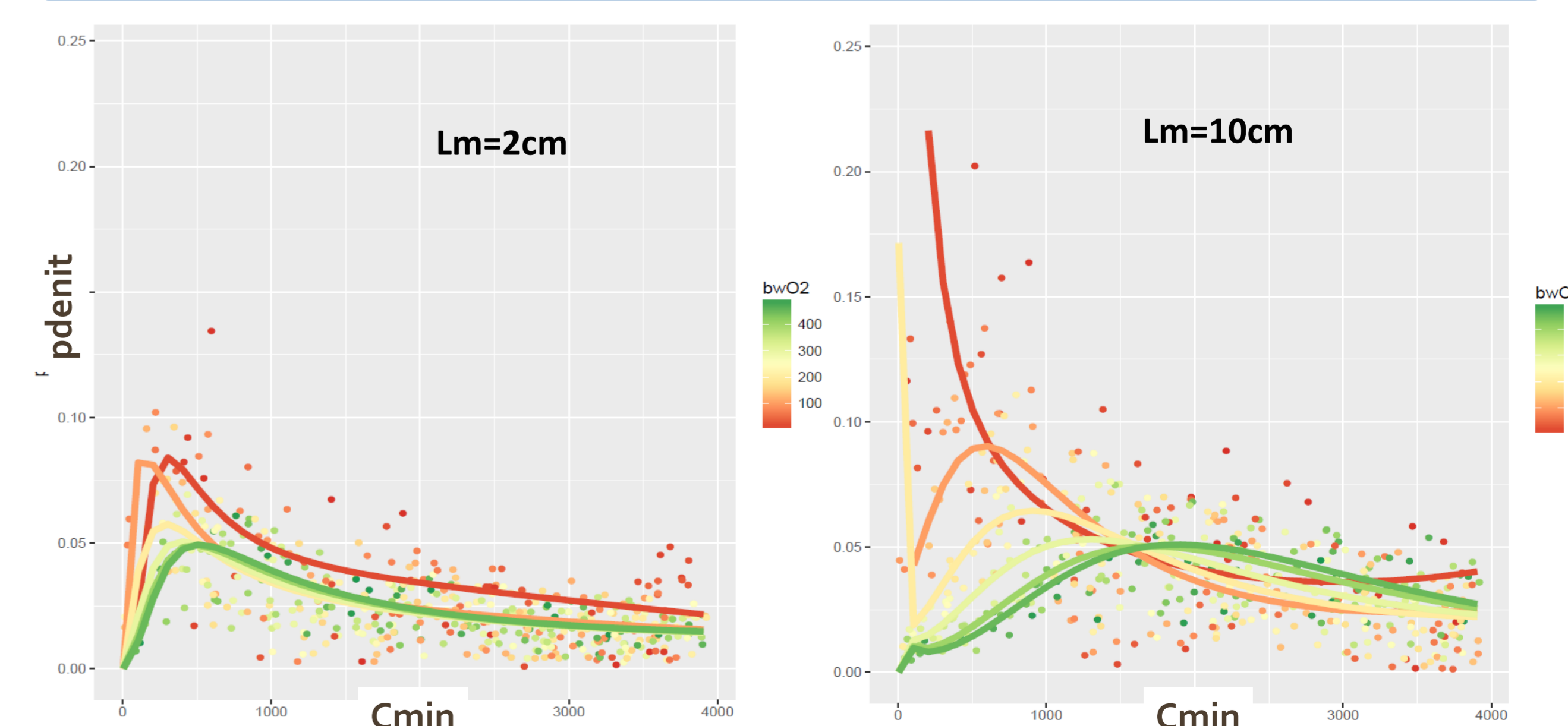
Sensitivity studies performed with a diagenetic model shows that a modification of lm increases the contribution of denitrification to benthic degradation (more in Capet et al., poster in the same session).