Upscaling the impact of coastal hypoxia from species to ecosystem function. Bioturbation on the Black Sea Shelf.

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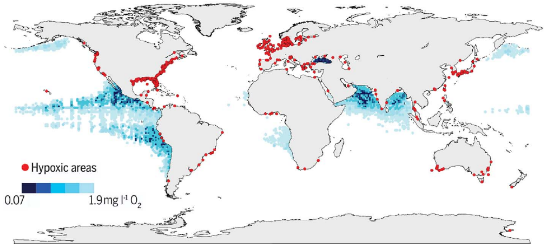
Question & Approach

Coastal Hypoxia

Coastal hypoxia



Breitburg et al, 2018

Question & Approach

Coastal Hypoxia

Macrobenthos

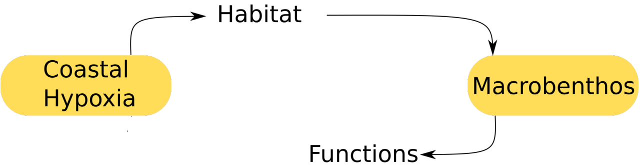
Macrobenthos

Question & Approach

Habitat

Environmental Conditions (eg. T°, light, orgC, $[O_2]$) shape **populations**

Question & Approach

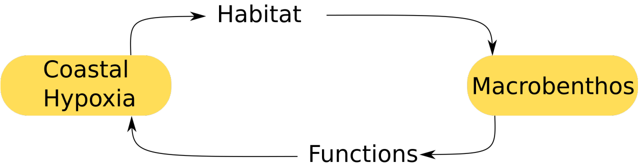


Functions

Services

- Providing food, shelter
- Regulating erosion, eutrophication, carbon burial

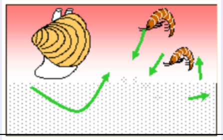
Question & Approach



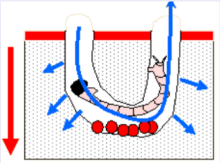
Functions

Impact on biogeochemical cycling

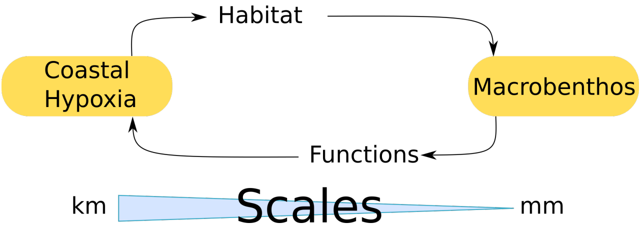
Bioturbation



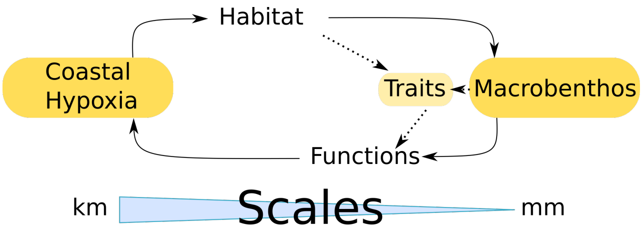
Bioirrigation



Question & Approach



Question & Approach

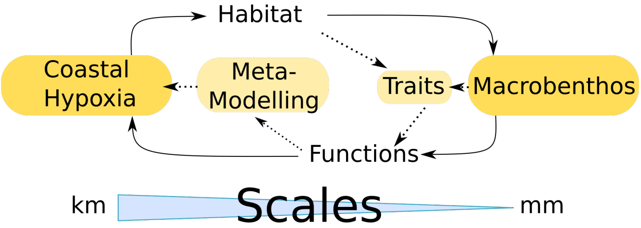


Traits

Modalities of behavior :

- Mobility
- Feeding type
- ..

Question & Approach



Meta-Modelling

- Involve different models at different process scales
  - **Focus model**: Diagenetic model, 1D, 50cm of sediments
  - **General model**: Biogeochemical model, 500km the Black Sea
- **Meta-Modelling**: To mimic the Focus model in the General Model

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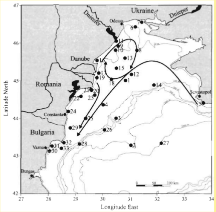
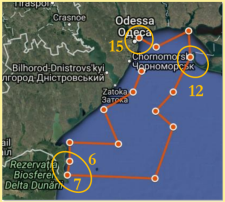
Soetart et al, 2000

Results

Trait Mapping

Stations

August 1995	May 2016	August 2017
		
Wijsman et al., 1999		EMBLAS Environmental monitoring in the Black sea
~30 stations	~15 stations	~7 stations

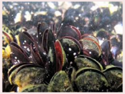
Results

Trait Mapping

Species

VanVeen Grabs

Allita Succinea



Mytilus Galloprovincialis

Abundance and biomass
of dominant macrobenthic species

Results

Trait Mapping

Traits

Traits

- **Method of sediments reworking**
- **Propensity to move through the sediment**
- Max sediment dwelling depth
- Feeding mechanisms
- Diet
- Larval development mechanisms
- Propagule dispersal
- Larval type
- Degree of attachment
- Relative adult mobility
- Adult life habitLongevity
- Maximum adult size
- Tolerance to disturbance

Modalities

TRAIT	Modalities
Method of sediments reworking (Reworking mode: Ri) **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) **Mi**	(1) in a fixed tube (2) limited movement, sessile, but not in a tube (3) slow movement (4) free movement via burrow system

Results

Trait Mapping

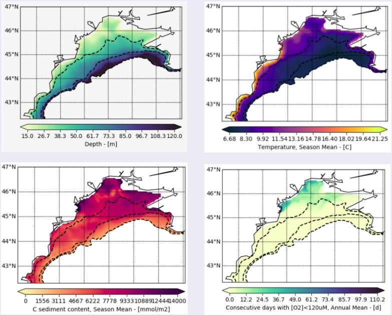
Environ.

In-Situ
Median Grain Size
Silt Content
OrgC, TotN

Model (3D GHER-BAMHBI)

Physics:
- Temperature
- Salinity
- Age of bottom waters
- Bottom stress

Biogeochemistry:
- Hypoxia / Oxygen
- OrgC rain / sed. content
- PAR

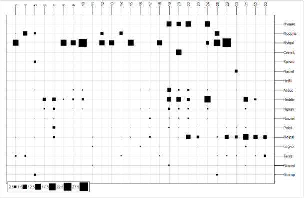


Results

Trait Mapping

Stations

Traits



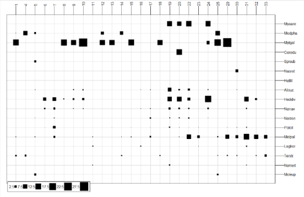
Species

Environ.

Results

Trait Mapping

Stations



Traits

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

Species

Environ.

Queiros et al, 2015

Results

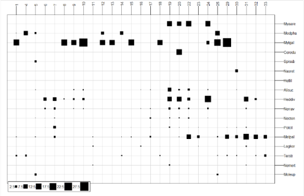
Trait Mapping

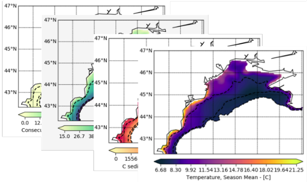
Stations

Traits

Species

Environ.





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Results

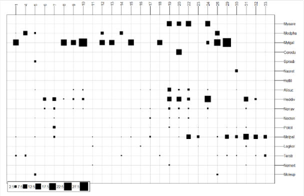
Trait Mapping

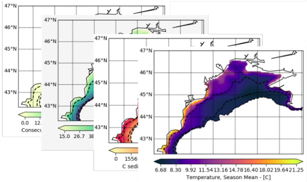
Stations

Traits

Species

Environ.





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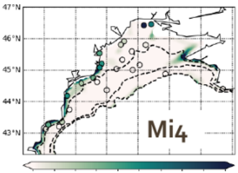
...						

?

Results

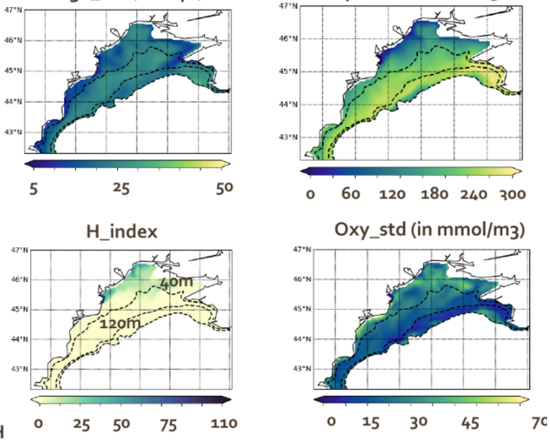
Trait Mapping

Multiple Linear Regression



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

Mi4: free movement, burrower

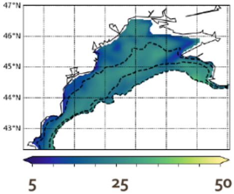


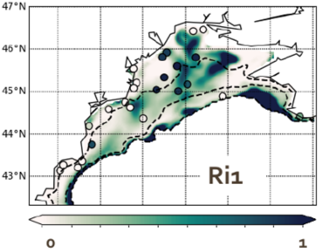
+DEPTH

Results

Trait Mapping

Age_Std (in days)



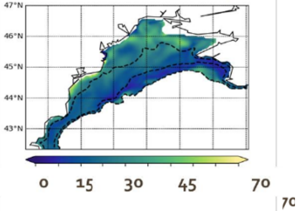


f(Age_std, oxy_std, depth)
R2= 0.41, Adjusted R2= 0.3428

Ri1: Epifauna

+DEPTH

Oxy_std (in mmol/m3)

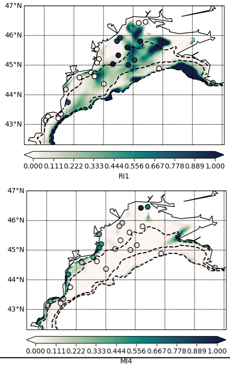


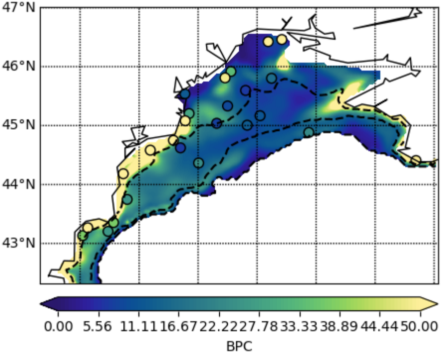
Results

Trait Mapping

Bioturbation Community Potential (BP_c)

$$\mathrm{BP_c} = \sum_{i=1}^{n\ species} \sqrt{\mathrm{Biomass}_i}.\mathrm{Mobility}_i.\mathrm{Reworking}_i$$

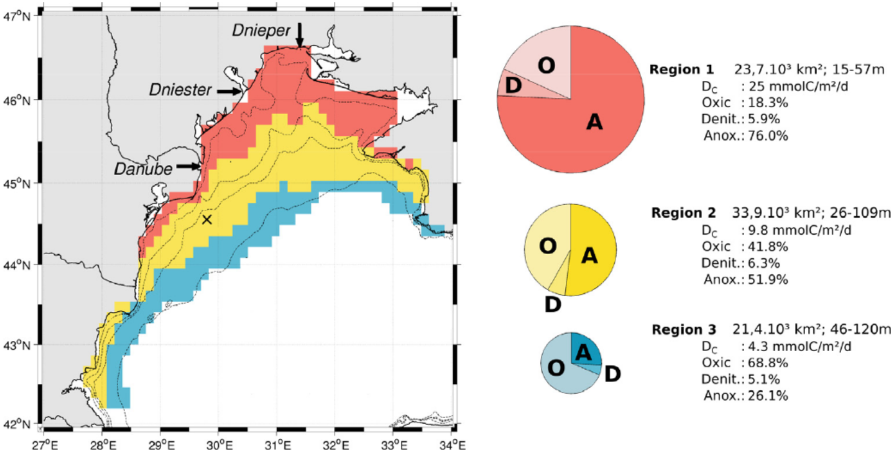




Solan et al, 2004

Results

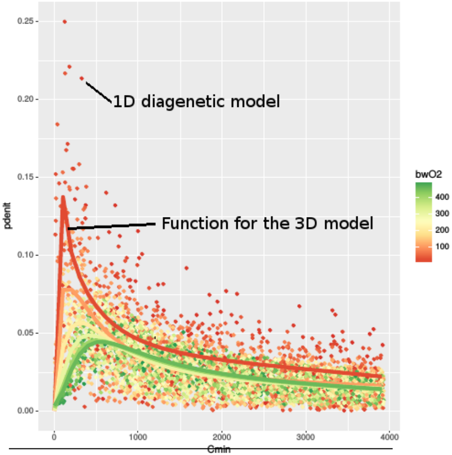
Diagenetic Modelling



Capet et al, 2016

Results

Diagenetic Modelling

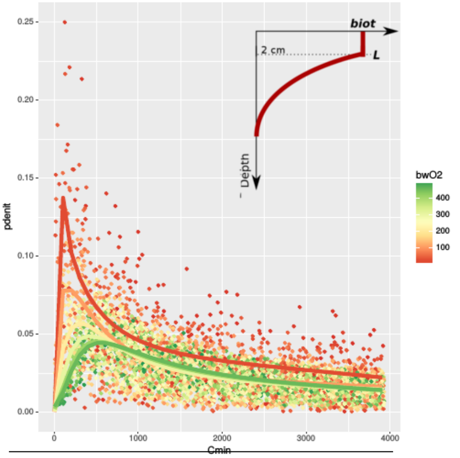


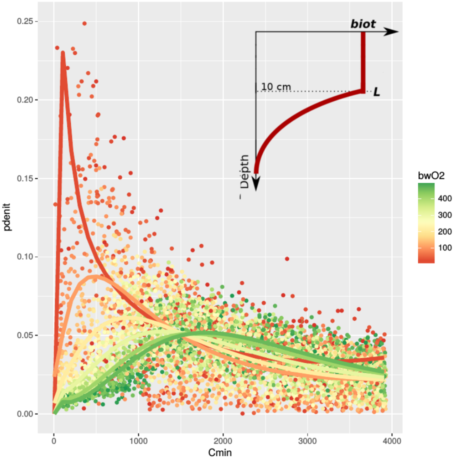
Denitrication ratio as a function of:

- Benthic respiration
- Bottom oxygen concetration

Results

Diagenetic Modelling





Results

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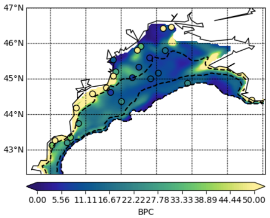

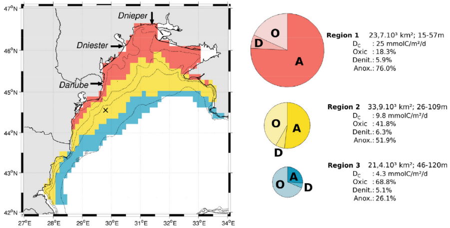

Conclusions

- Sediments are a nightmare for marine modellers ..

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- .. but should be considered to resolve shelf biogeochemistry

Conclusions

- Sediments are a nightmare for marine modellers ..
- .. but should be considered to resolve shelf biogeochemistry
- We propose a methodology to do so in large scale oceanic models

Conclusions

Thank for your attention

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