

COCKLES

Co-Operation for Restoring Cockle Shellfisheries
and its Ecosystem-Services in the Atlantic Area

4th ANNUAL MEETING

Scientific seminar, 9th March 2021

WP8: Quantifying biodiversity, economic and societal benefits
from cockles

WP Leader: NERC

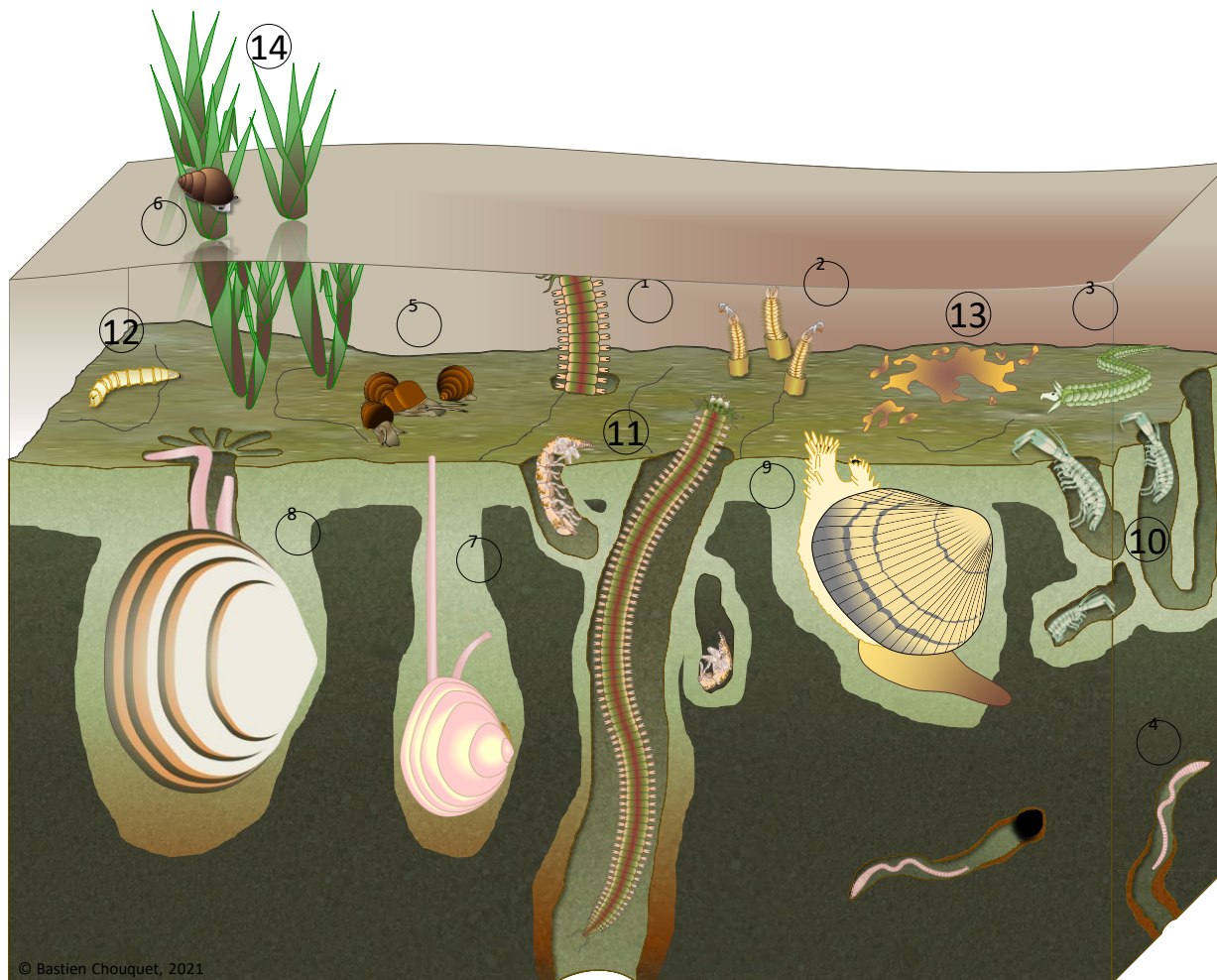


An overview over the influence of Cockle populations on sediment erodability along Sand/mud gradients

Francis Orvain, Annabelle Dairain, Olivier Maire, Anaïs Richard, Amélie Lehuen, Guillaume Meynard, Aurélie Ciutat, Alicia Romero, Mathilde Bue, David Carrs, Lawrence Jones



Diversity of actions of cockles on sediment properties



Annélides

1. *Hediste diversicolor*
2. *Eteone longa*
3. *Pygospio elegans*
4. *Baltidrilus costatus*

Mollusques

5. *Peringia ulvae*
6. *Assiminea grayana*
7. *Limecola balthica*
8. *Scrobicularia plana*
9. *Cerastoderma edule*

Arthropodes

10. *Corophium volutator*
11. *Cyathura carinata*
12. *Hydrophorus oceanus* (larve)

Végétaux

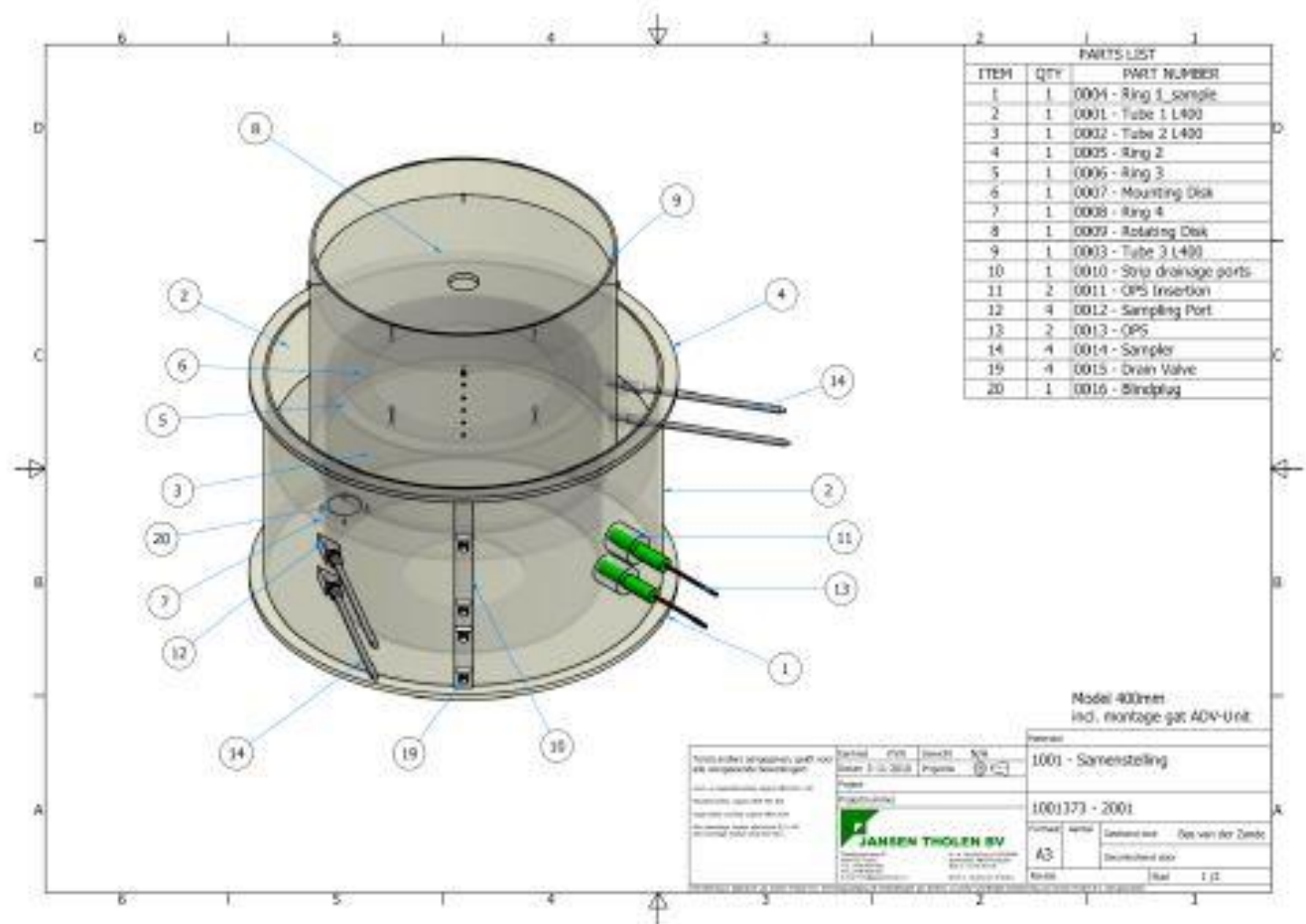
13. *Microphytobenthos* (communauté de micro-algues)
14. *Spartina maritima*

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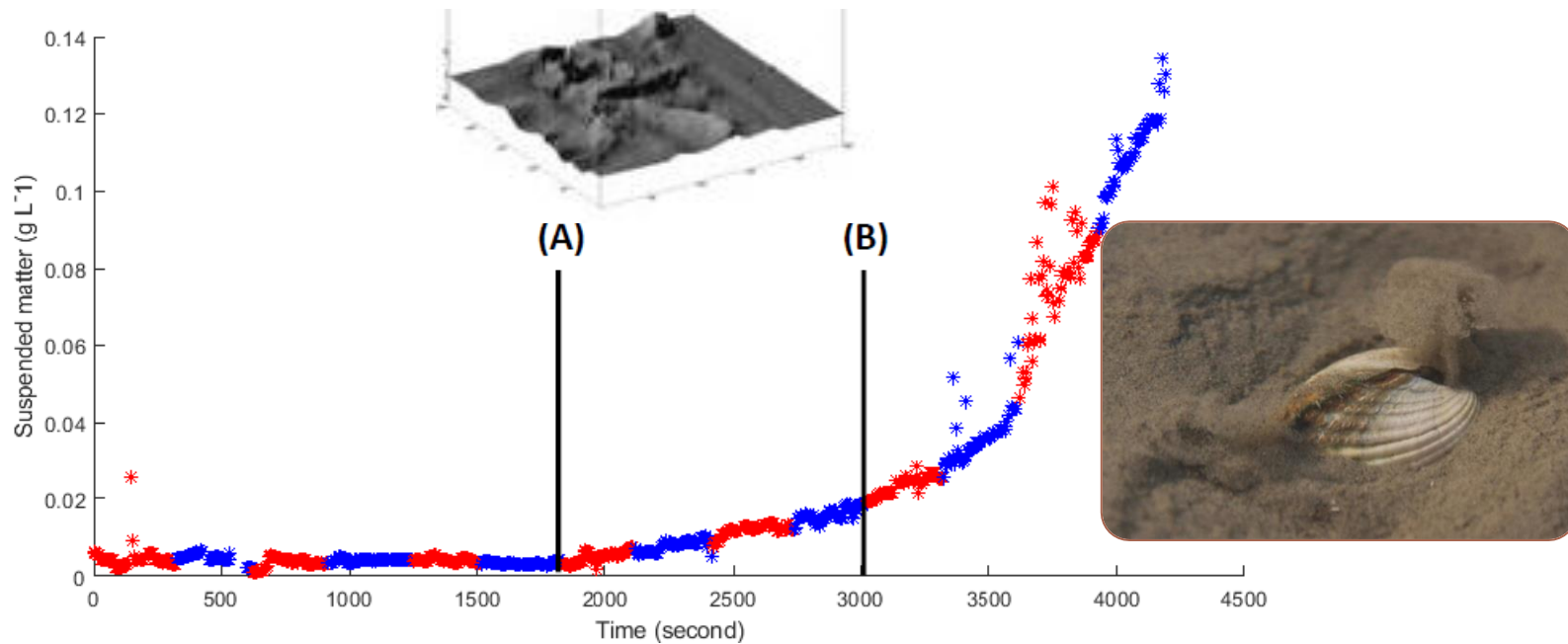
Different methodologies to measure sediment erodability

Erodimeter
(Orvain, LeHir ...)

Annular flume
(Cozzoli,
Herman,
Widdows, Li...)

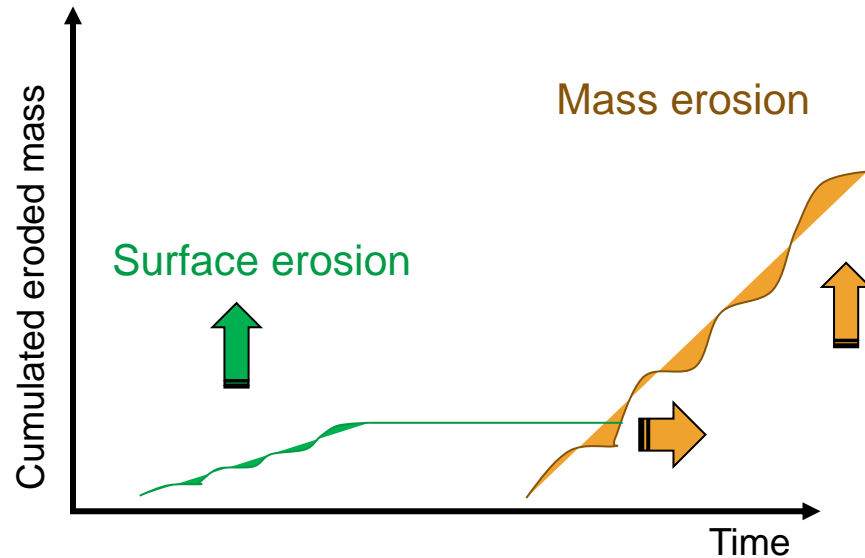


2 different types of erosion : A : Fluff layer (chronic) and B : mass bed erosion (catastrophic)



Dairain et al 2020 : Sediment Stability : can we disentangle the effect of bioturbating species on sediment erodability from their impact on sediment roughness (Mar Env Res)

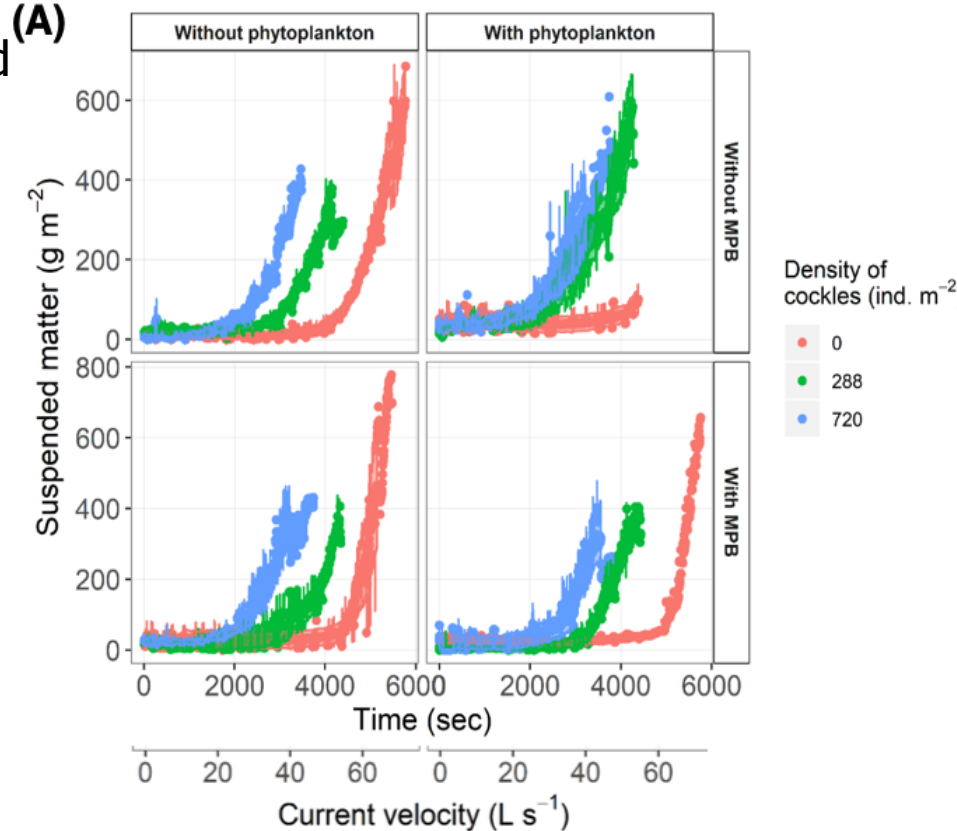
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Erosion experiments on cockles with/without phytoplankton and microphytobenthos+ development and comparison with or without parasitism

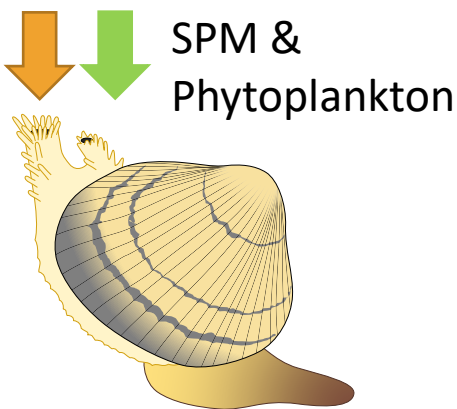
- A. Dairain, O. Maire, G. Meynard, A. Richard, T. Rodolfo-Damiano and F. Orvain (2020). Sediment stability: can we disentangle the effect of bioturbating species on sediment erodability from their impact on sediment roughness? Marine Environment Research
- A. Dairain, O. Maire, G. Meynard, and F. Orvain (2020). Does parasitism influence sediment stability? Evaluation of trait-mediated effects of the trematode *Bucephalus minimus* on the key role of cockles *Cerastoderma edule* in sediment erosion dynamics . Science of Total Environment



Diversity of actions of cockles on sediment properties

Somes stabilising mechanisms

Filtration



Soissons et al 2019 : Sandification vs. muddification of tidal flats by benthic organisms: A flume study

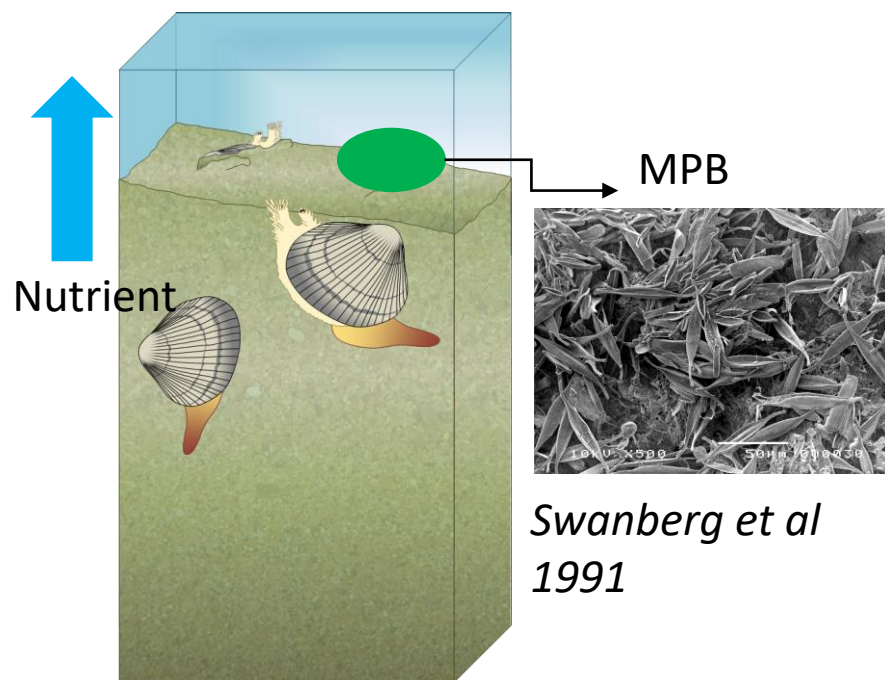
Bioturbation (Mixing)



Mixing sand/mud stratification can increase bed stability

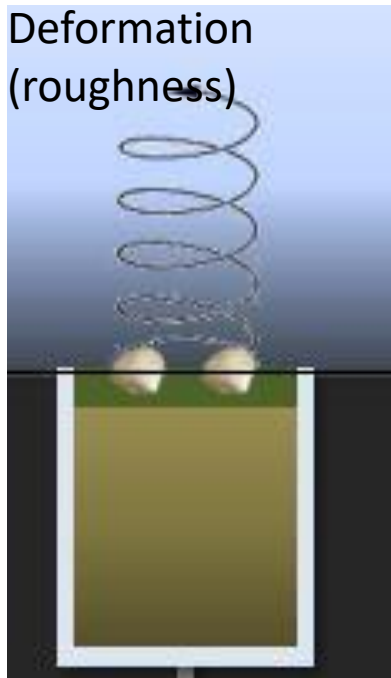
Anais Richard, Olivier Maire : Mesurements of bioturbtion rates Study in progress

Bioirrigation (nutrient diffusion)

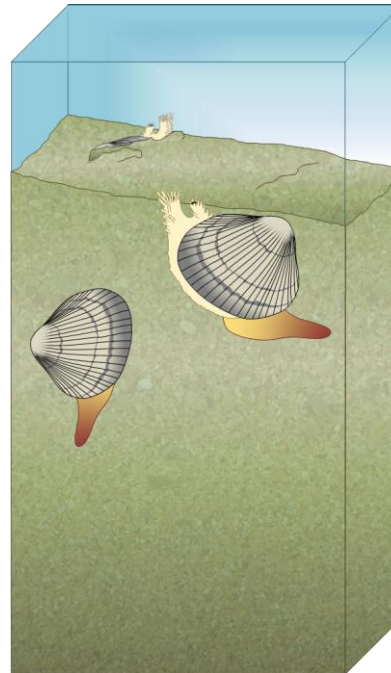


Diversity of actions of cockles on sediment properties

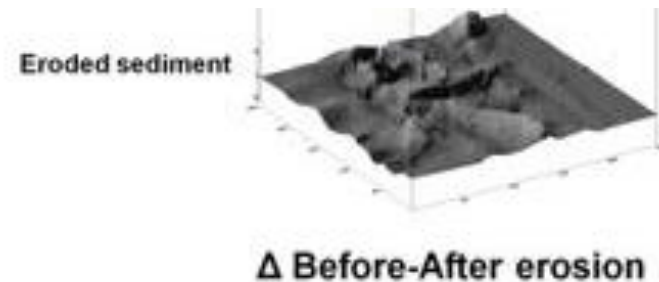
Somes destabilising mechanisms



Burying : Mass erosion



Tracks & Biodeposits = Fluff layer formation



Ubertini 2012

Rakotomalala et al 2015

Li et al 2017

Cozzoli et al 2018

Ciutat et al 2006

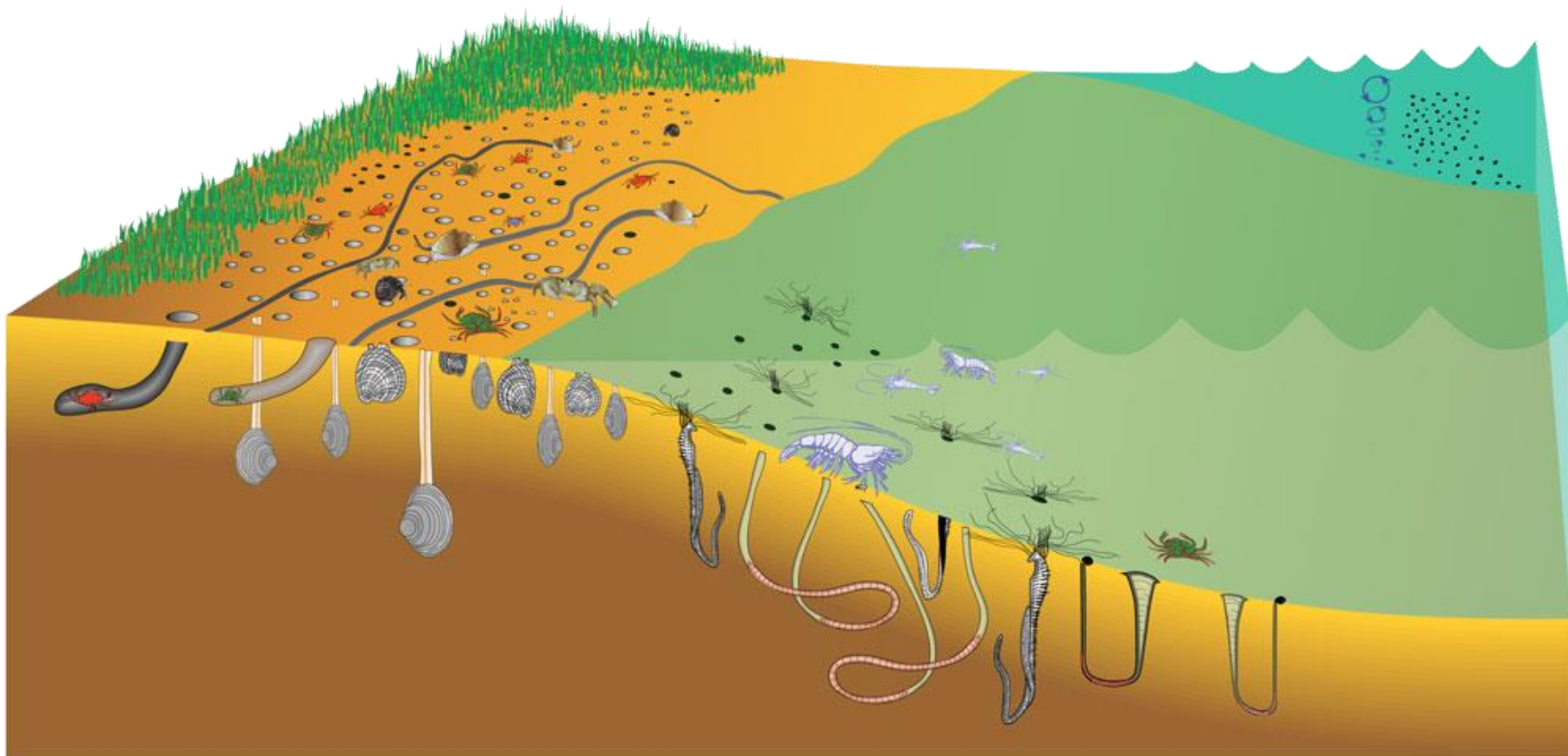
Widdows et al 2007

Dairain et al 2020 , Mar Env Res

Dairain et al 2020 : Science of Total Environment

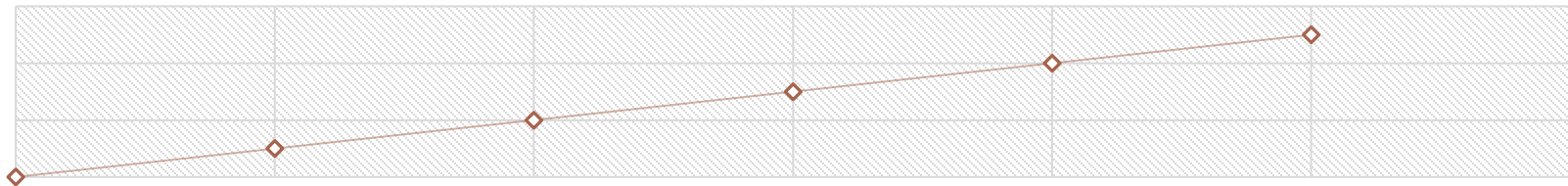
Ciutat et al 2007

What is happening.... Along a velocity gradient ... and sand-mud interaction ? Where are cockles efficient ?

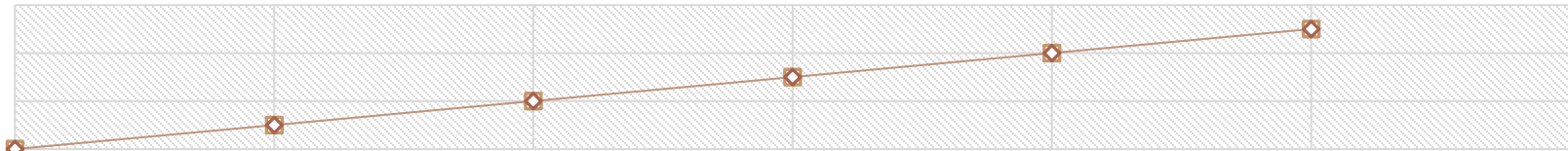


Destabilising actions are dominant on muddy sediments

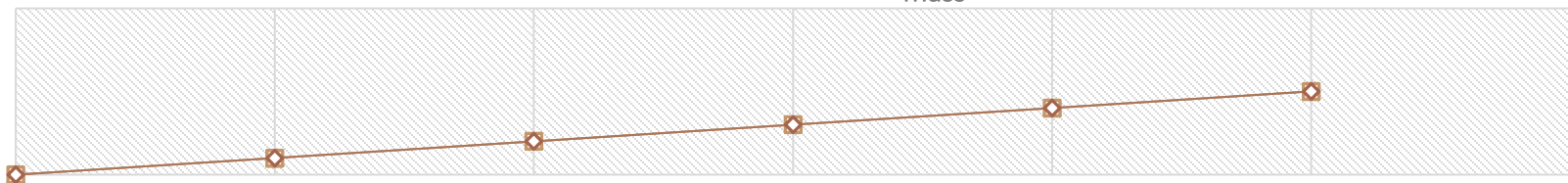
Roughness effect



Fluff layer erosion (Q_{btb})



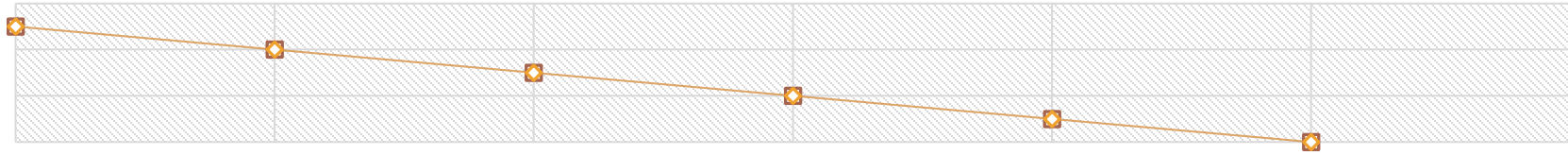
Bed disruption (Q_{mass})



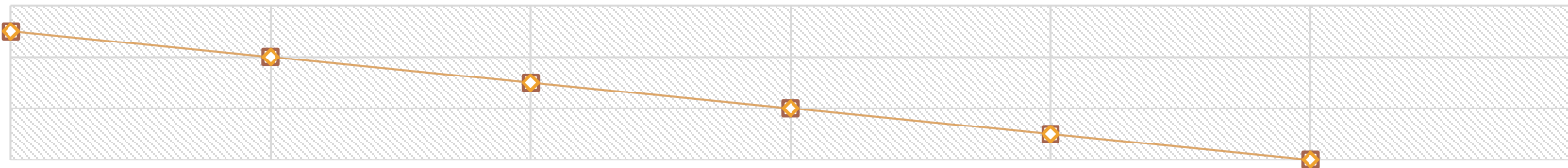
Sand —————→ Mud

Stabilising actions are dominant on sandy sediments

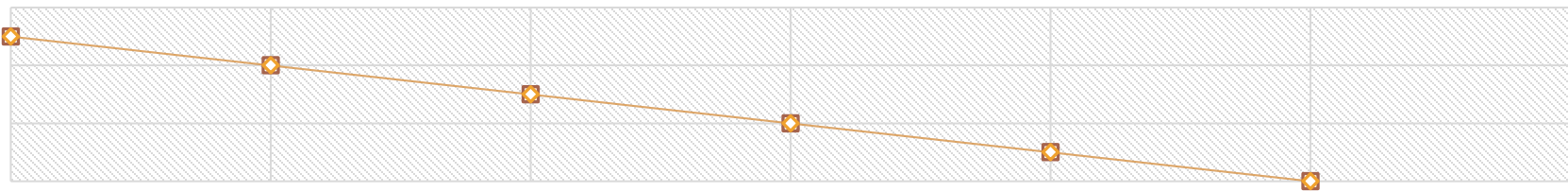
Filtration



Bioturbation and stratification disturbance



Bioirrigation and EPS secretion by biofilm (Synergy cockles - MPB)



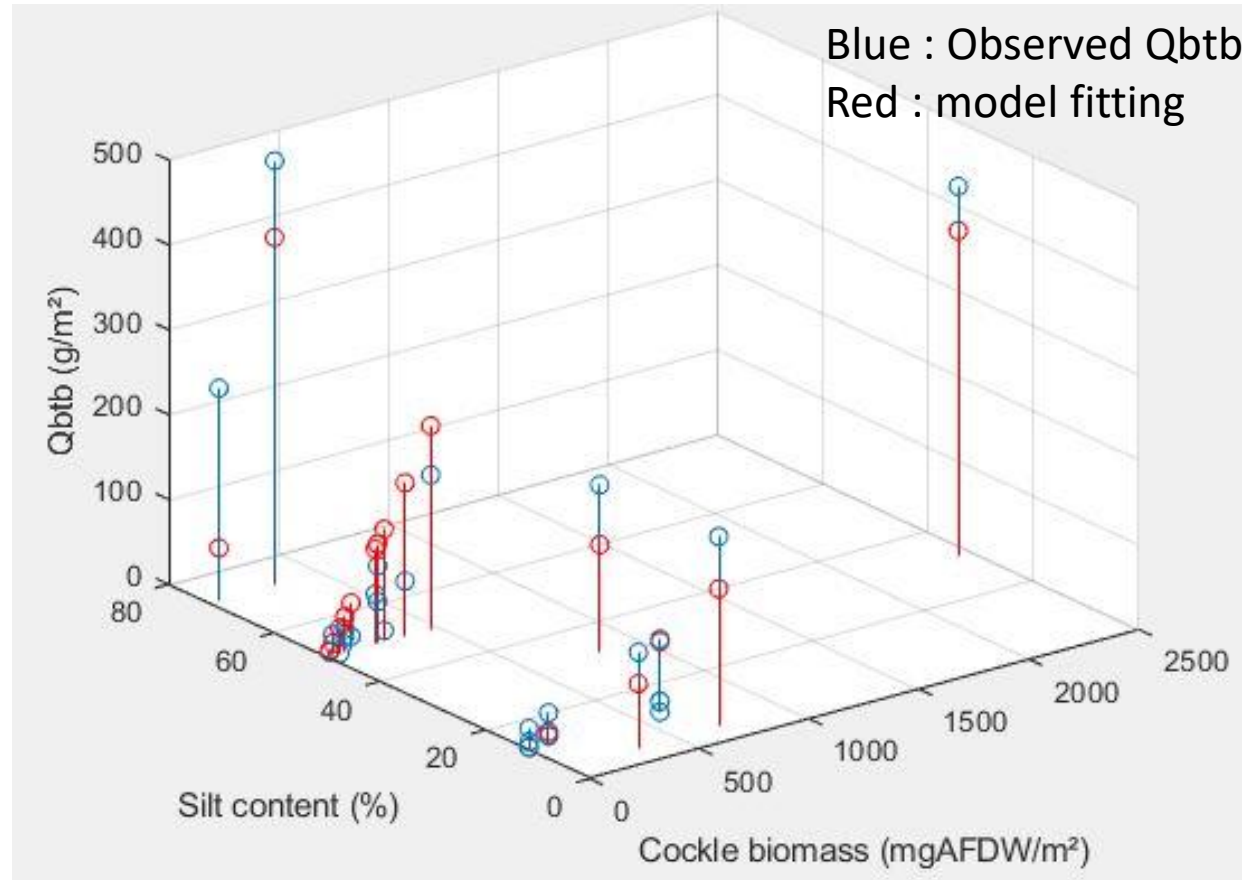
Sand —————→ Mud

The most relevant effect : Fluff layer erosion (Q_{btb} in g/m^2 during one tidal immersion cycle)

MUD

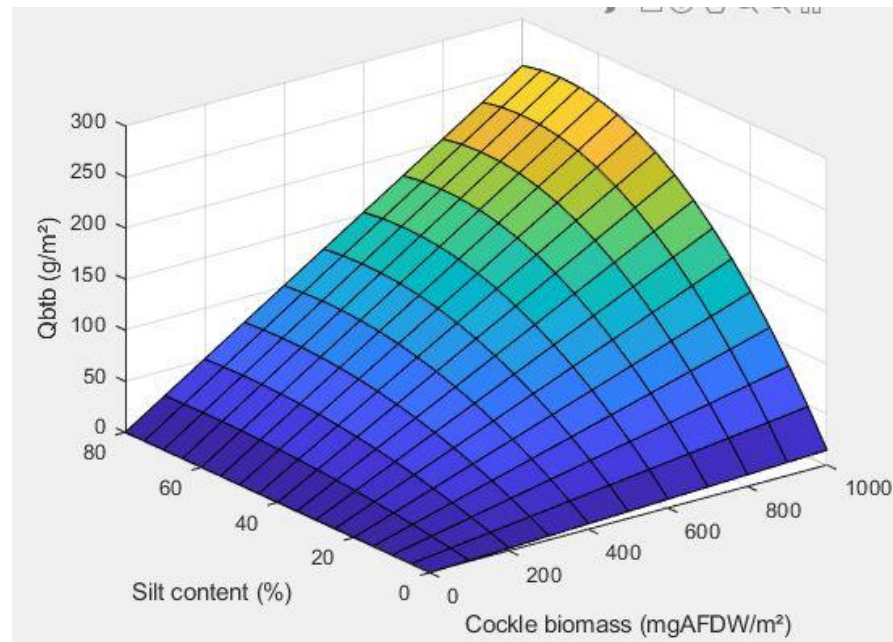
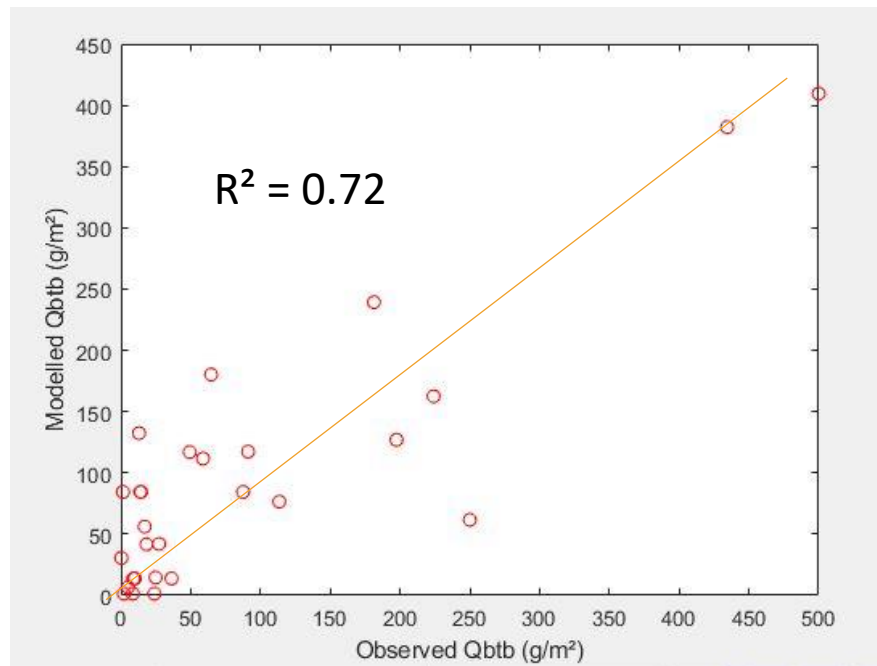
Ciutat et al 2006
Rakotomalala et al 2015
Li et al 2017
Cozzoli et al 2018
Dairain et al 2020

SAND



Synthesis from literature

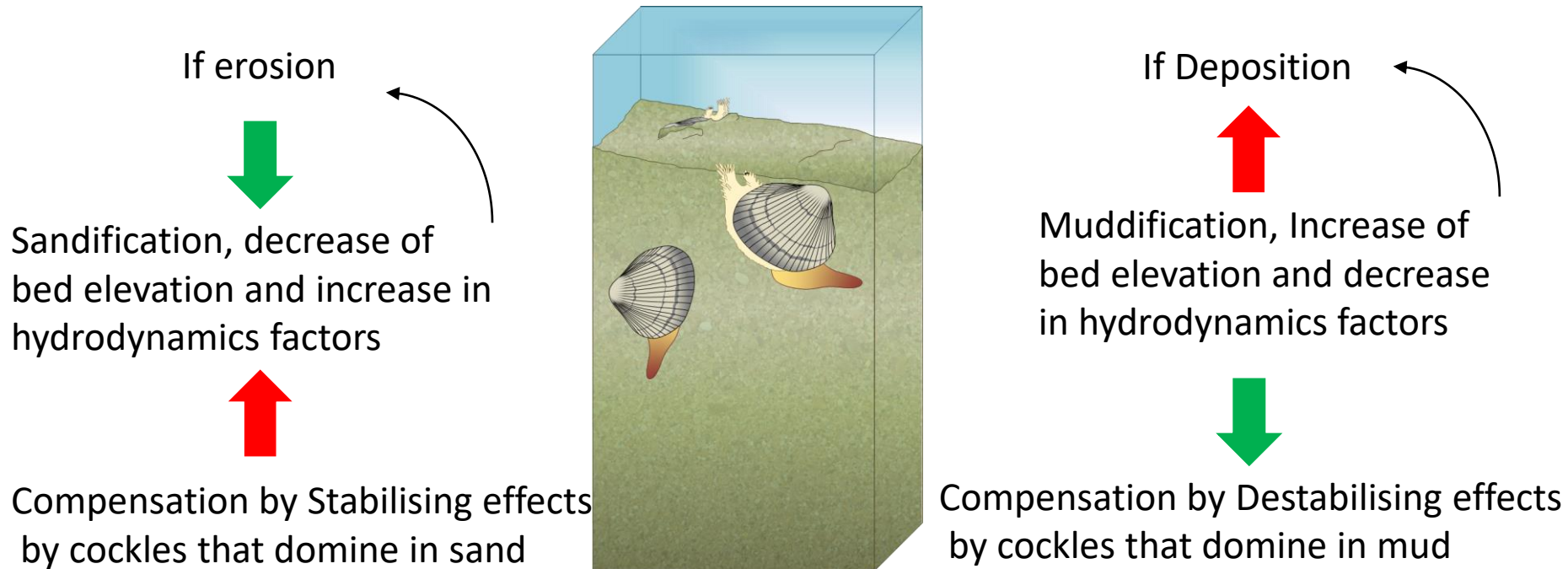
The most relevant effect : Fluff layer erosion (Q_{btb} in g/m^2 during one tidal immersion cycle)



Q_{btb}	250	g/m^2
Sediment density	1400	g/L
Bed erosion	0,0018	dm per tide
Bed erosion	0,1	dm per month

Synthesis from literature

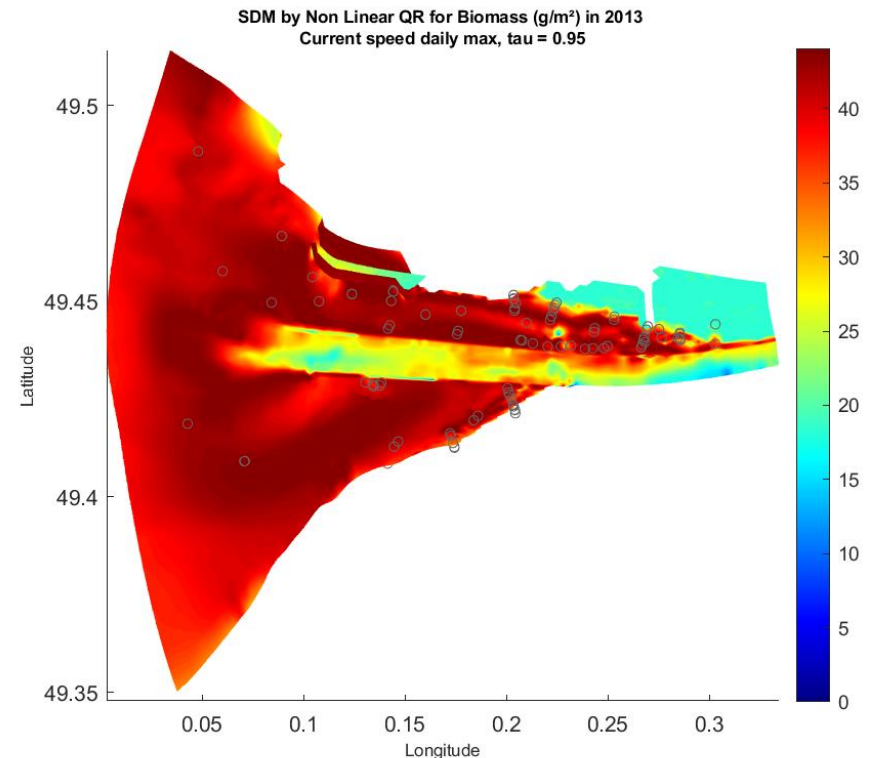
CONCLUSION : When the sediment composition changes, cockles activity make the sediment remains Sand/mud mixture, i.e. their optimal habitat



COCKLES could thus be resilient to any morphosedimentary changes

Perspective : Model response of population dynamics of cockles to physical factors accounting for long-term effects and bioturbation

- Species Distribution Model :
Quantile regression on cockle population density (Amélie Lehuen, Francesco Cozzoli, Peter Herman, Tjeerd Bouma and Francis Orvain)
- Combination of biological data and physical model
 - Seine Estuary Benthos data base 1990-2018
 - 3D model of sediment transport (MARS3D) – Ifremer Dhysed (F. Grasso, P. Le Hir, B. Thouvenin)
- Projection in future scenarios (global warming and increase in erosion)



$$\tau = 0.95 \quad Biom = 26.2 * 0.9 * \sqrt{2\pi} * e^{-0.5 * \left(\frac{Current\ maxi - 1.1}{0.9} \right)^2}$$

Perspectives : MELTING POTES

- 3y project with Phd Amélie Lehuen, supervised by Francis Orvain
- Upgrade of physical model by addition of bioturbation in sediment transport
 - Accounting for feedback loops
- Widen data
 - Biological data
 - Physical condition by working on other estuaries models (DELFT3D)
- Projection to 2050-2100 with climate change effects on
 - Bathymetry
 - Flow of the Seine
 - Extreme climatic events
- Effect of population dynamics

