

# COCKLES

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

**4<sup>th</sup> ANNUAL MEETING**

**Scientific seminar, 9<sup>th</sup> March 2021**

WP8: Quantifying biodiversity, economic and societal benefits  
from cockles

WP Leader: NERC

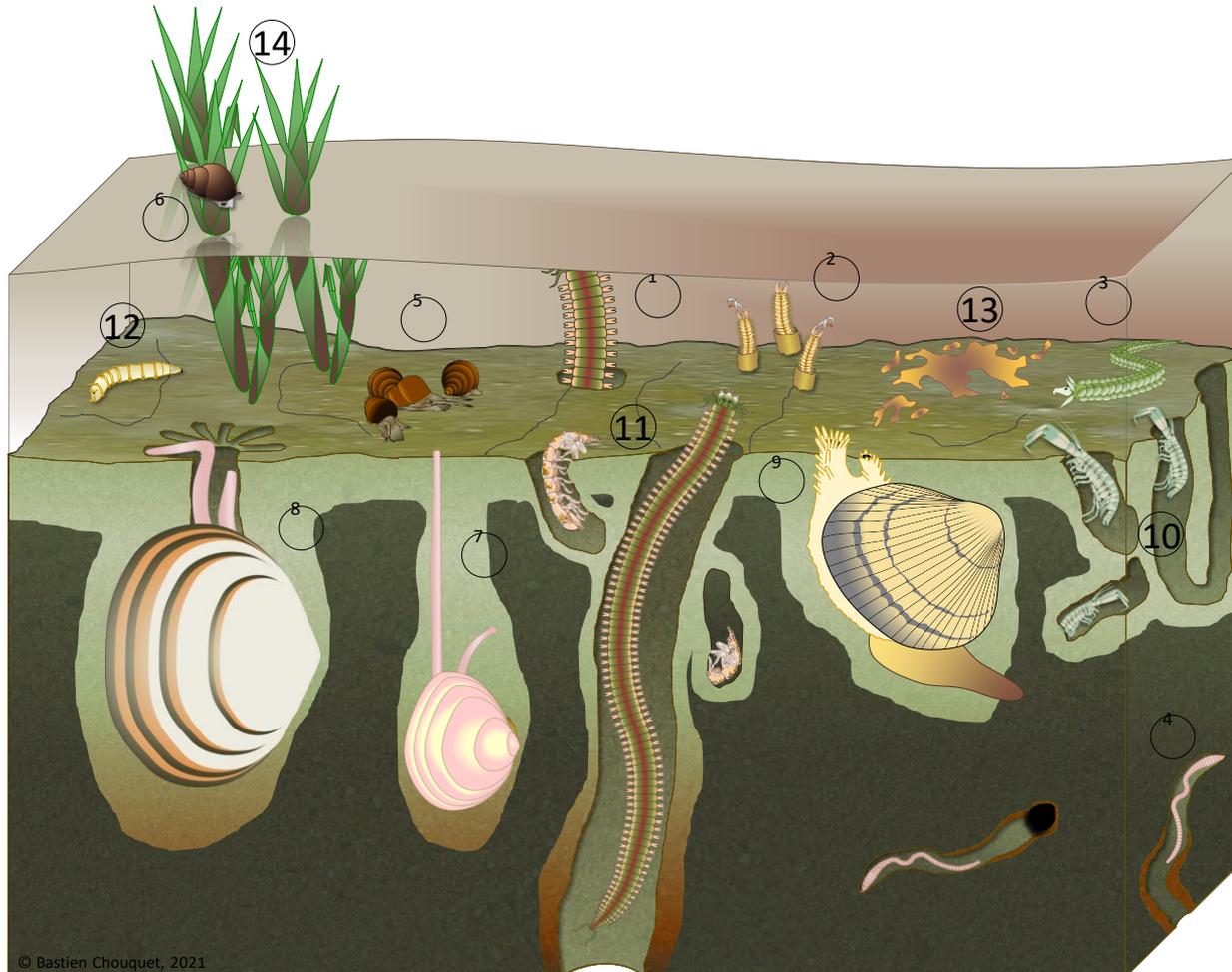


# **An overview over the influence of Cockle populations on sediment erodability along Sand/mud gradients**

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)

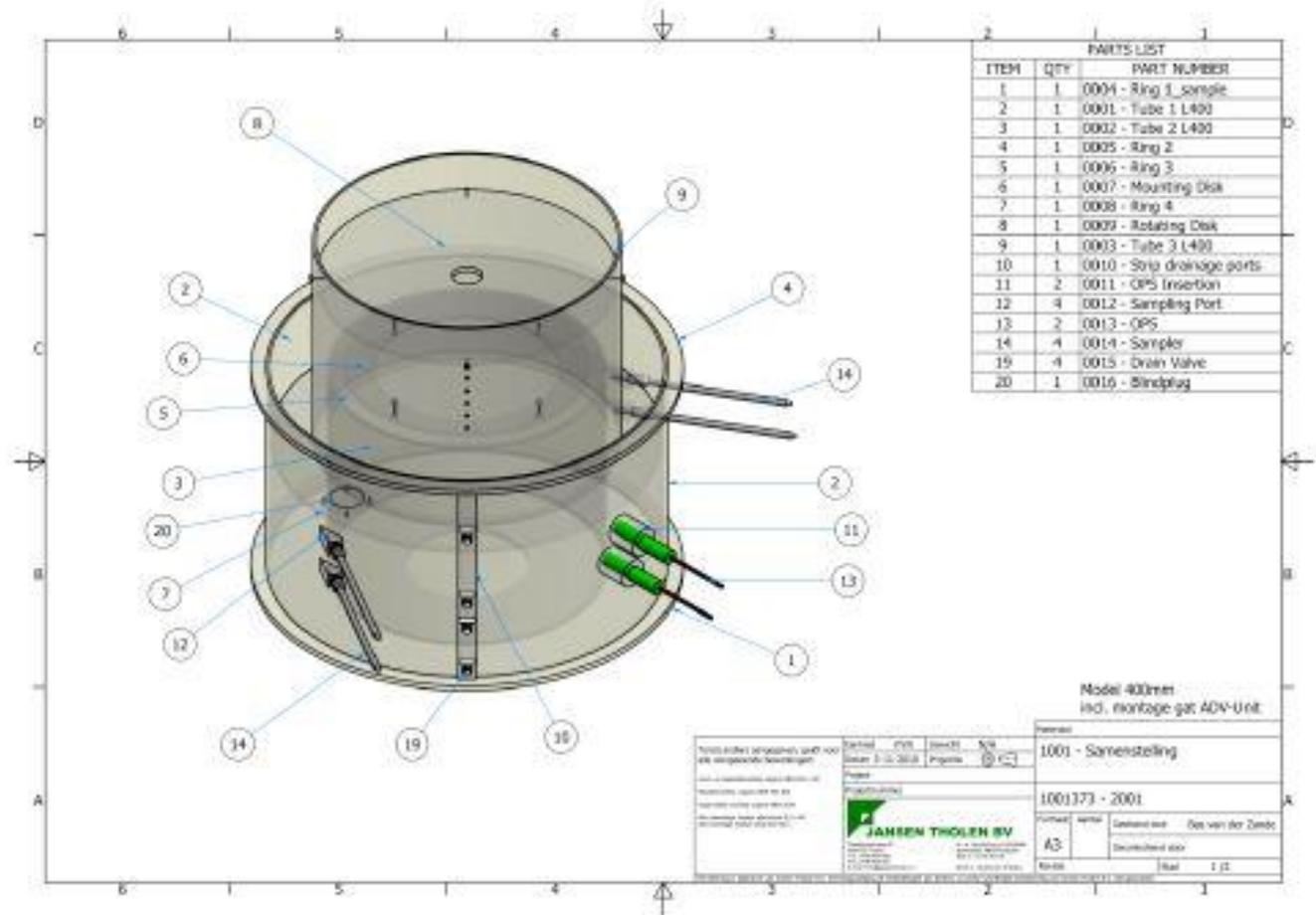
## Végétaux

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

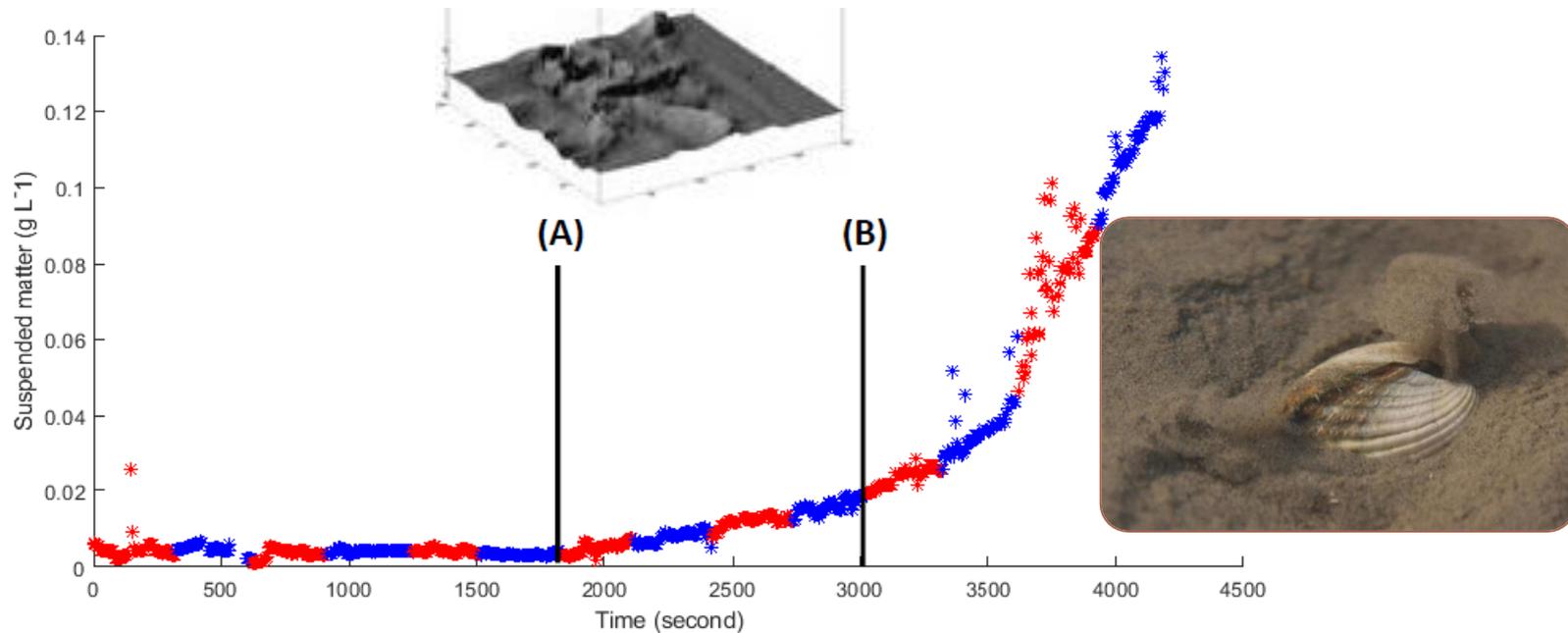
# Different methodologies to measure sediment erodability

Erodimeter  
(Orvain, LeHir ...)

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

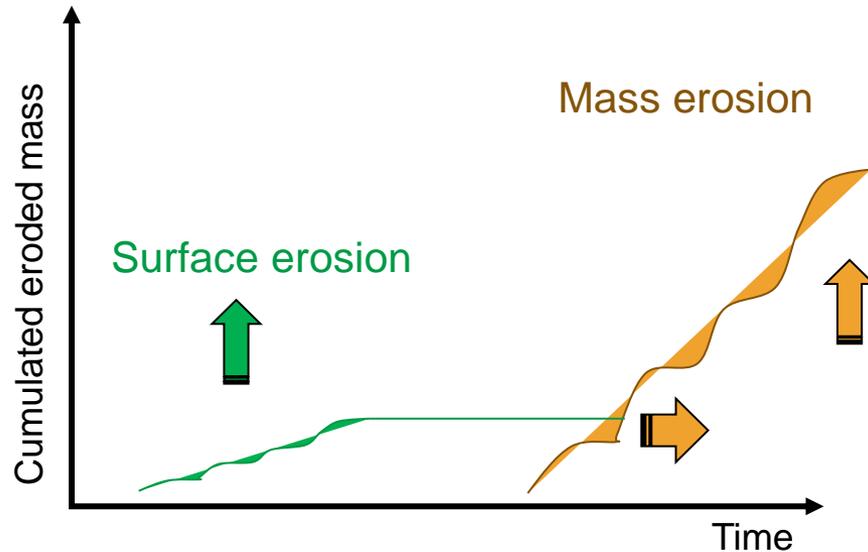


2 different types of erosion : A : Fluff layer (chronic) and B : mass bed erosion (catastrophic)



*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)*

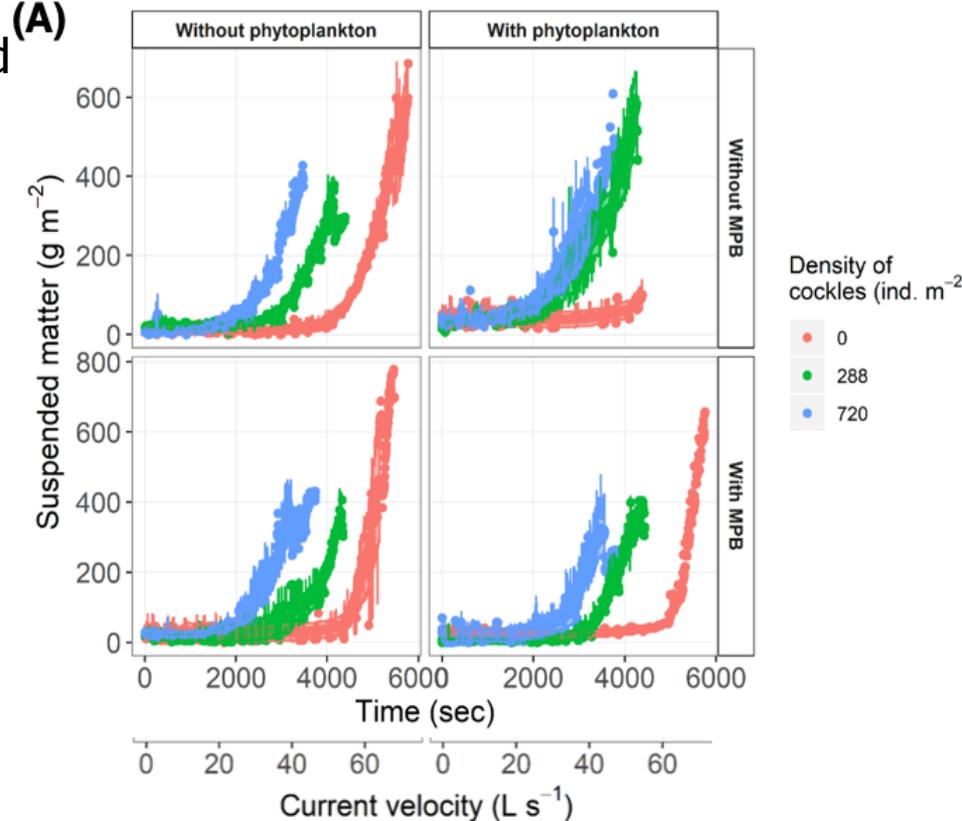
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# Erosion experiments on cockles with/without phytoplankton and microphytobenthos+ development and comparison with or without parasitism

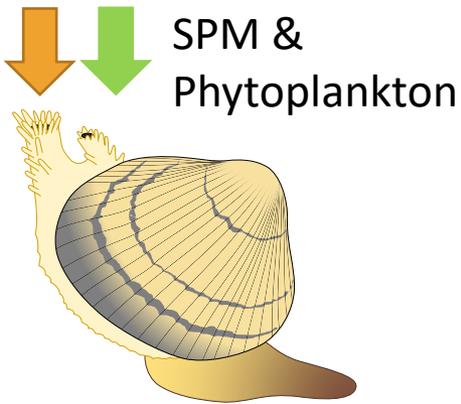
- A. Dairain, O. Maire, G. Meynard, A. Richard, T. Rodolfo-Damiano and F. Orvain (2020). Sediment stability: can we disentangle the effect of bioturbating species on sediment erodability from their impact on sediment roughness? Marine Environment Research
- A. Dairain, O. Maire, G. Meynard, and F. Orvain (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*

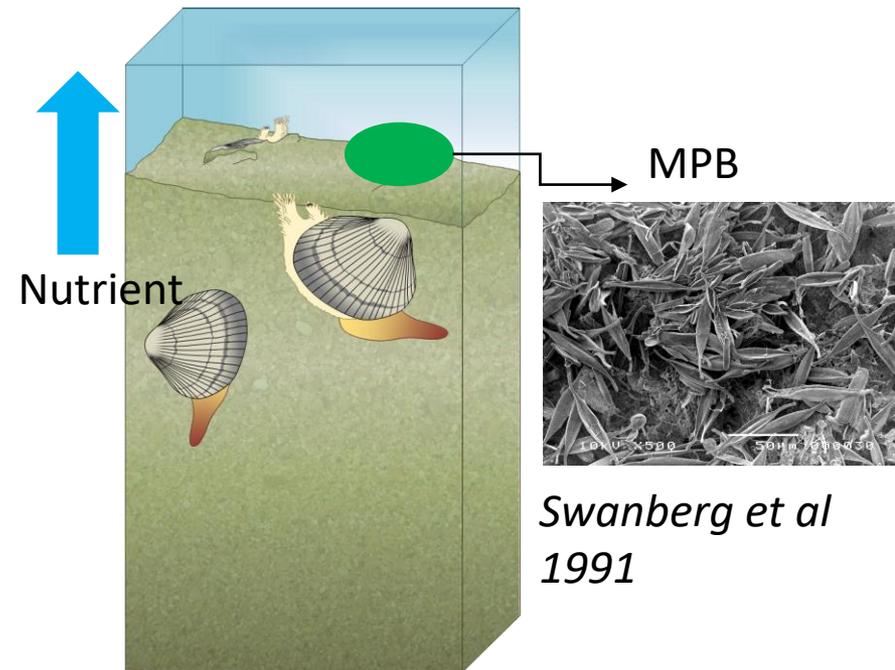
### Bioturbation (Mixing)



Mixing sand/mud stratification can increase bed stability

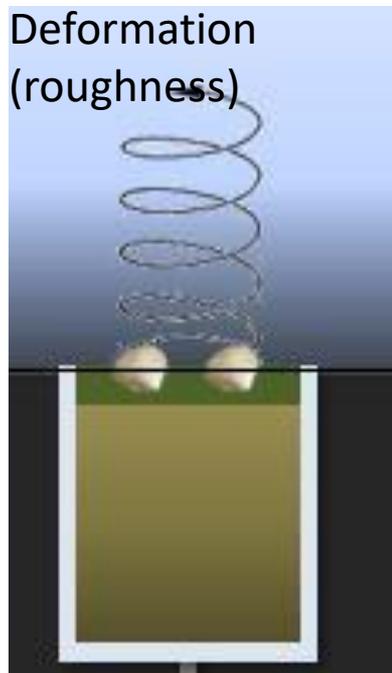
*Anais Richard, Olivier Maire : Measurements of bioturbation rates Study in progress*

### Bioirrigation (nutrient diffusion)

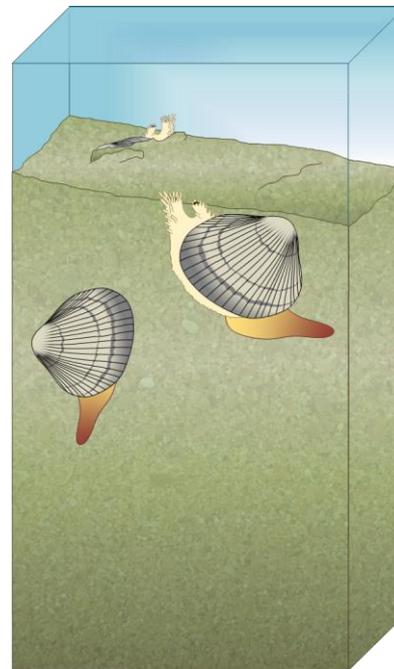


# Diversity of actions of cockles on sediment properties

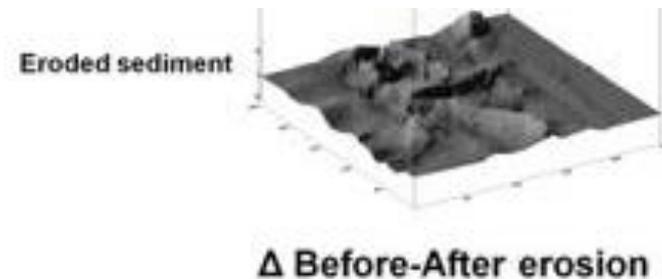
## Somes destabilising mechanisms



## Burying : Mass erosion



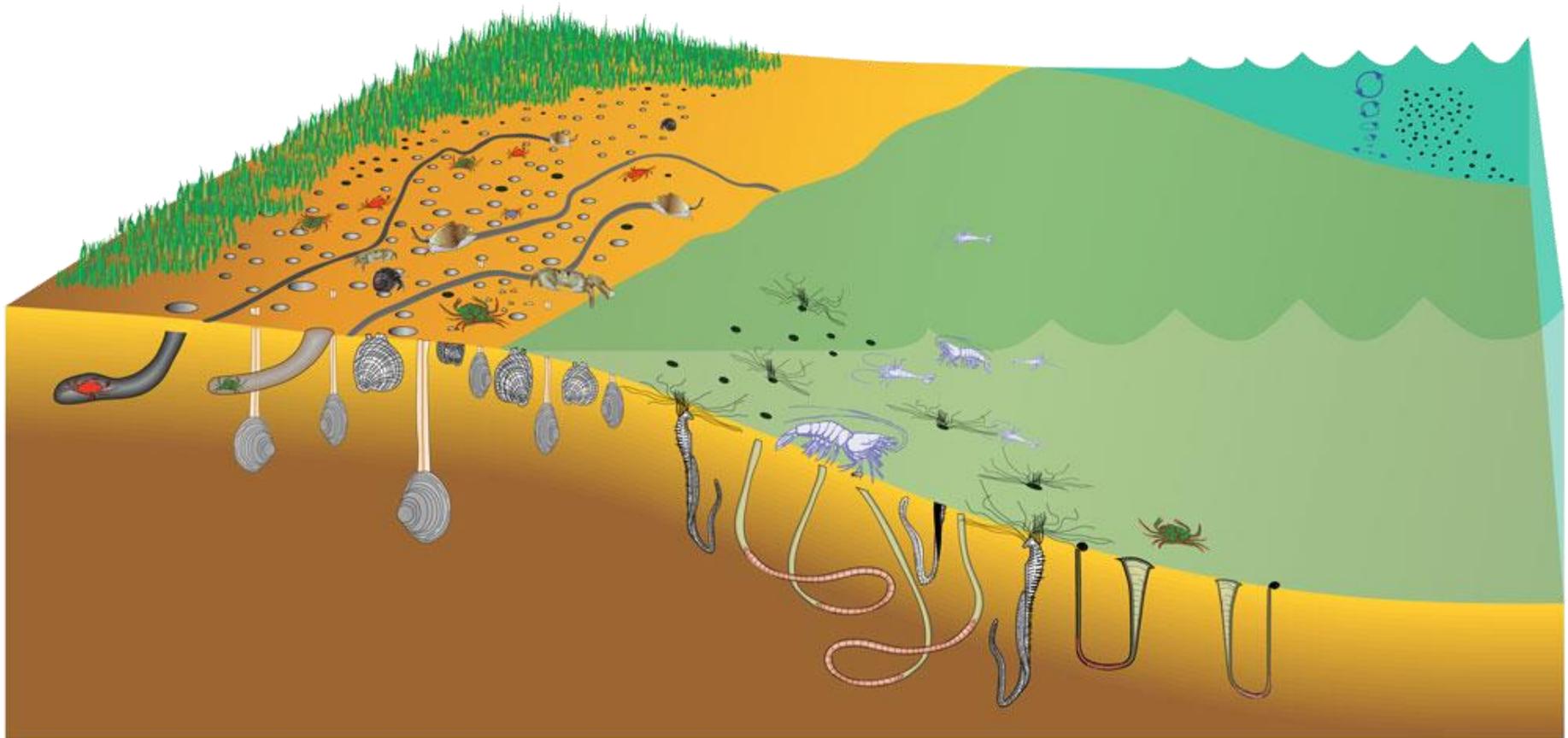
Tracks & Biodeposits  
= Fluff layer formation



*Ubertini 2012*  
*Rakotomalala et al 2015*  
*Li et al 2017*  
*Cozzoli et al 2018*  
*Ciutat et al 2006*  
*Widdows et al 2007*

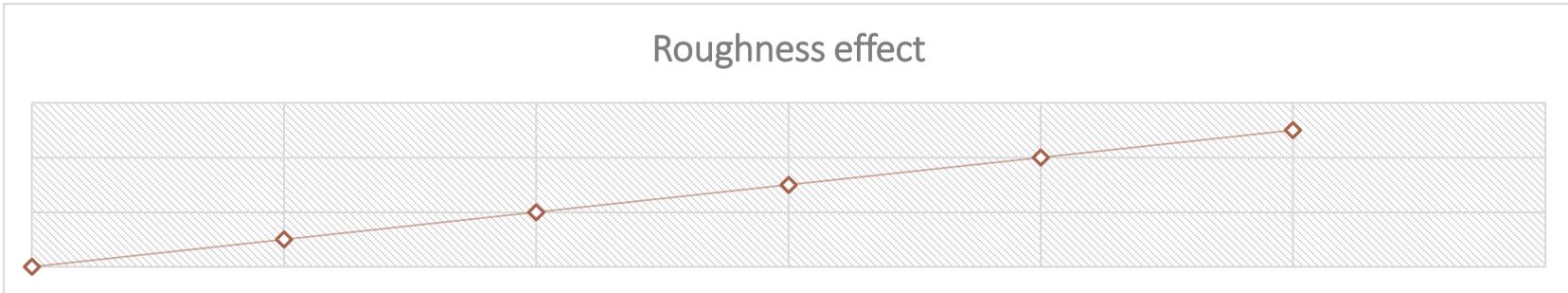
*Dairain et al 2020 , Mar Env Res*  
*Dairain et al 2020 : Science of Total Environment*  
*Ciutat et al 2007*

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

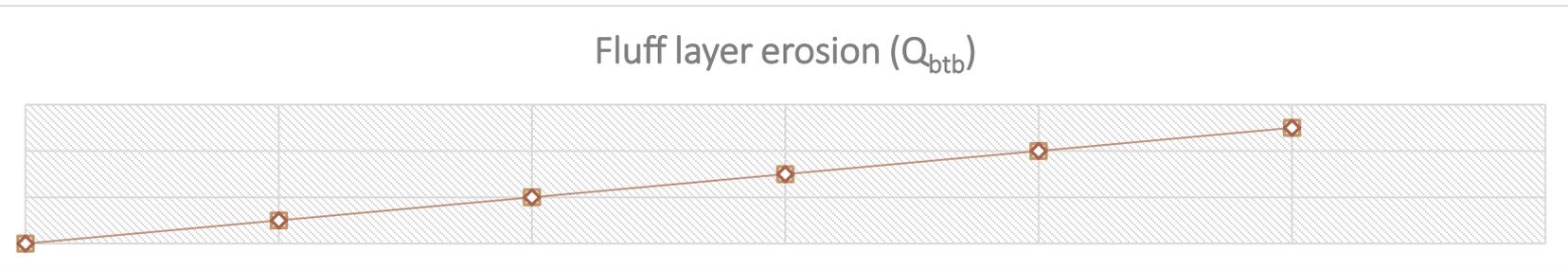


# Destabilising actions are dominant on muddy sediments

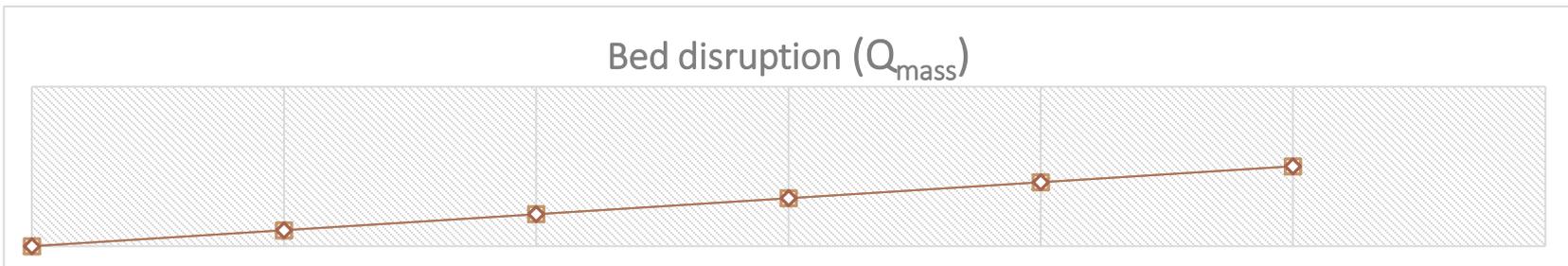
Roughness effect



Fluff layer erosion ( $Q_{btb}$ )



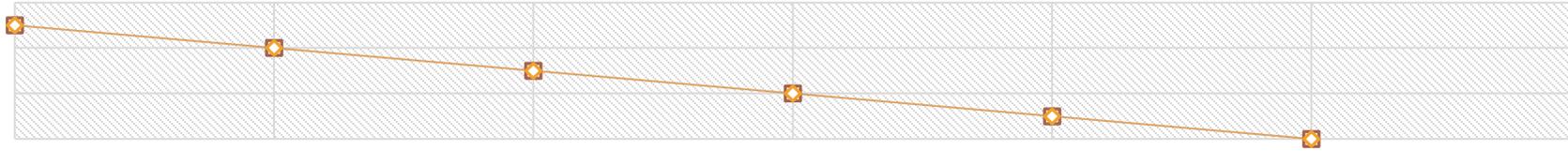
Bed disruption ( $Q_{mass}$ )



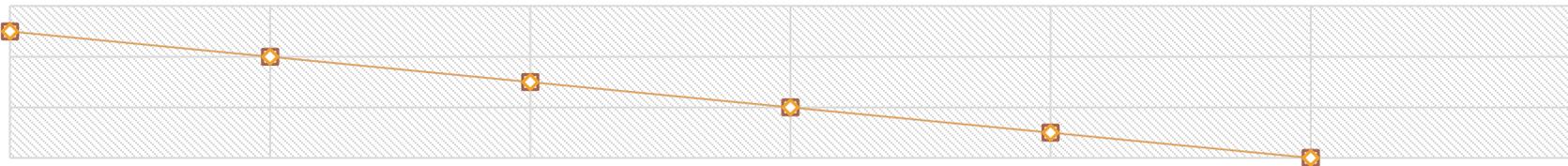
Sand  Mud

# Stabilising actions are dominant on sandy sediments

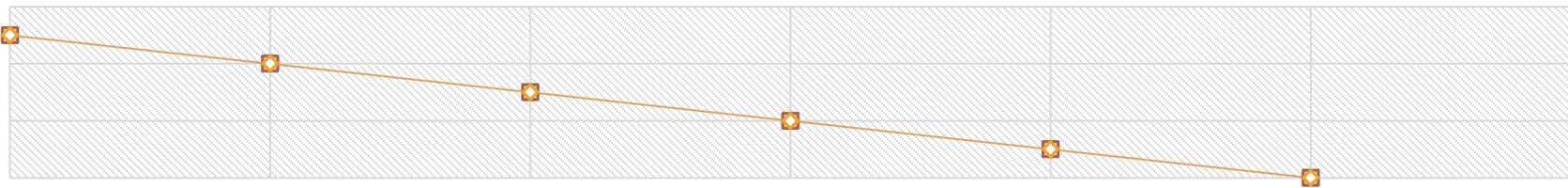
Filtration



Bioturbation and stratification disturbance



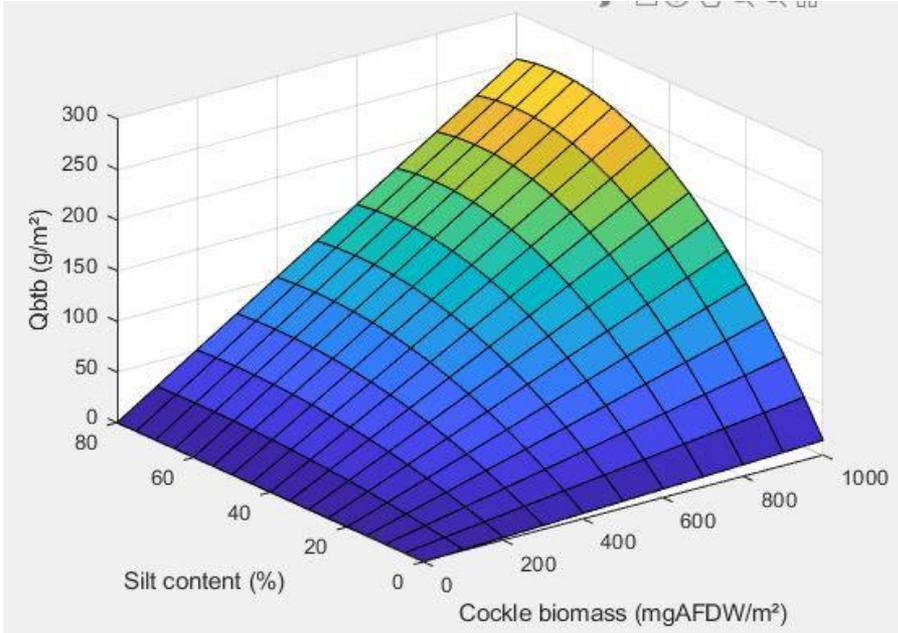
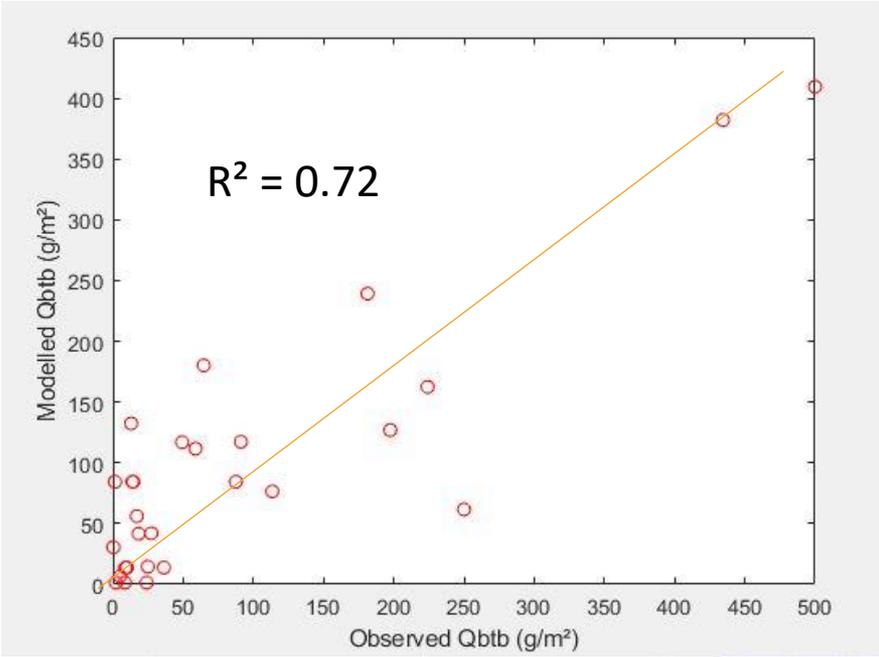
Bioirrigation and EPS secretion by biofilm (Synergy cockles - MPB)



Sand —————> Mud



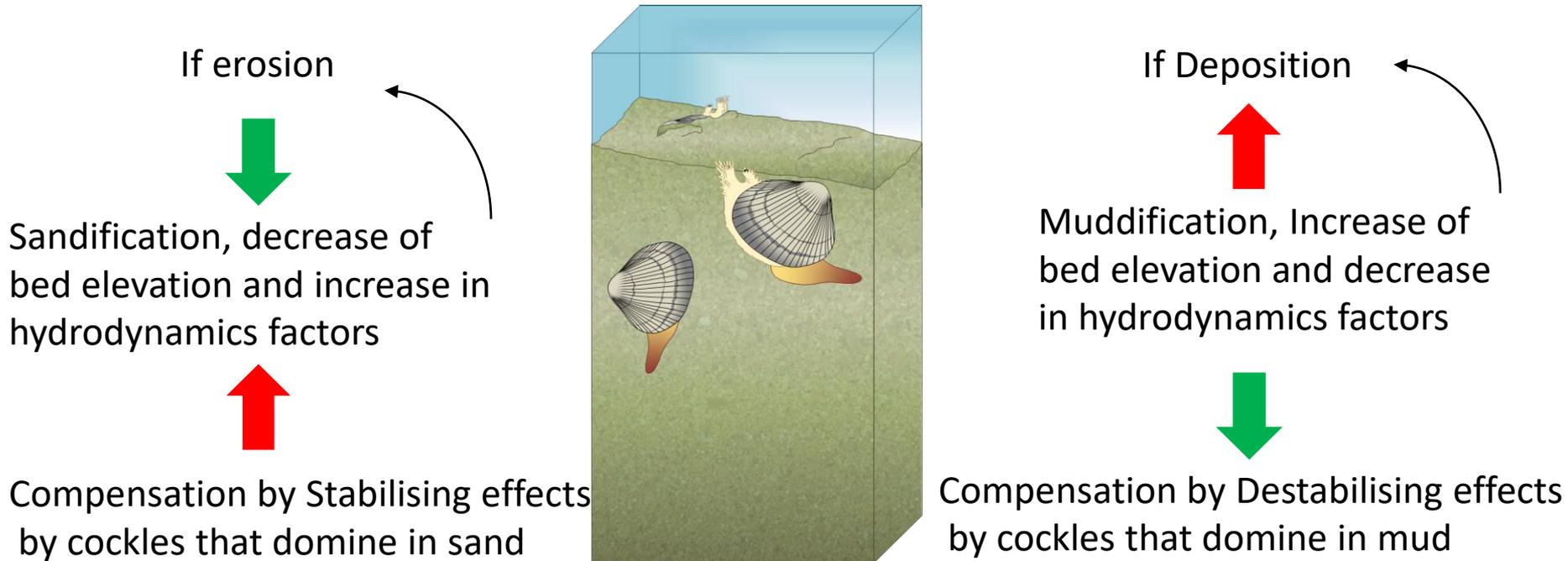
The most relevant effect : Fluff layer erosion ( $Q_{btb}$  in  $g/m^2$  during one tidal immersion cycle)



$Q_{btb}$	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

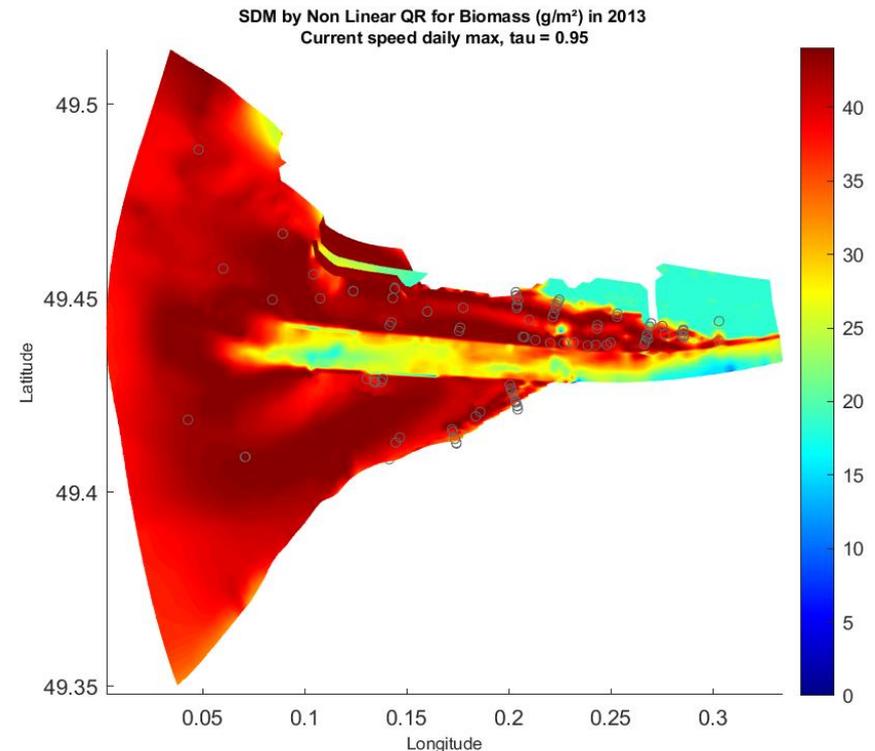
**CONCLUSION :** When the sediment composition changes, cockles activity make the sediment remains Sand/mud mixture, i.e. their optimal habitat



**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)



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

## 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

