# A three-Dimensional ecological model to optimize shellfish culture in the Baie des Veys (Normandy, France)

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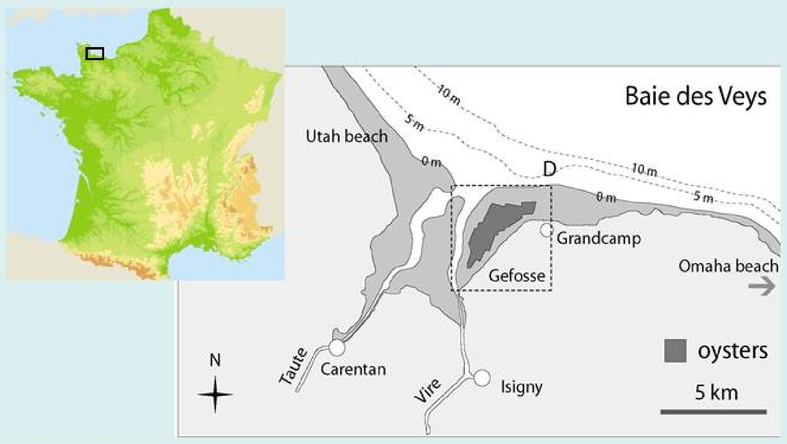
## Introduction

The **OGIVE** project aims to develop operational tools used to sustain shellfish culture in Normandy.

The objectives of the present study are:
• to develop a 3D ecological model of the Baie des Veys, which is a pilot site for the OGIVE project,
• to use it to answer a large panel of questions, through scenarios defined in a participatory approach with the main actors of the bay.
Some scenarios were dedicated:
• to examine the effect of modification of the rearing densities on growth performances,
• to explore impact of changes of nutrients inputs from watershed in relation with environmental objectives.

## Study area

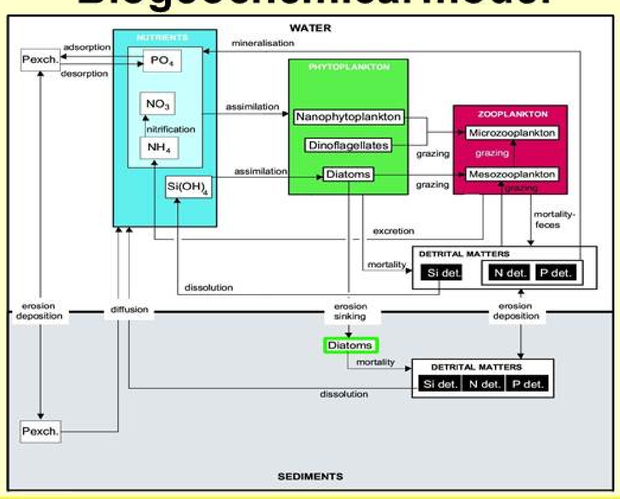
The Baie des Veys is located on the French Coast of the English channel. It is an open intertidal estuary (37 km$^2$) with an important oyster farming activity (standing stock = 10 200 t) located on the east part of the bay.




## Methods

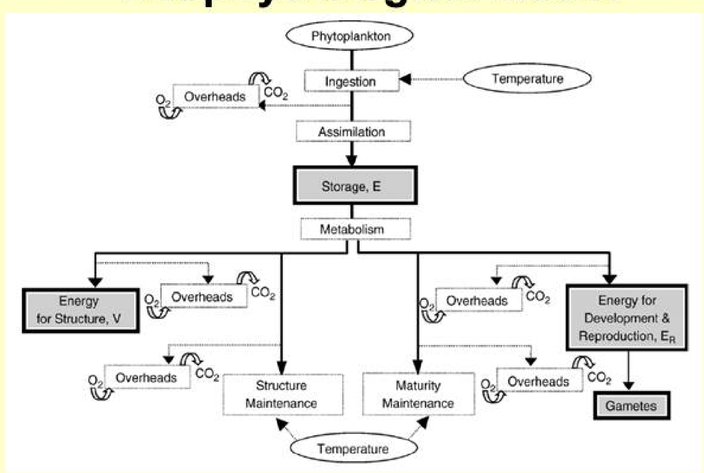
The ecological model results from the coupling of the MARS 3D hydrodynamical model (Lazure and Dumas, 2008) adapted to the study area (horizontal resolution = 200m), a biogeochemical sub-model simulating primary production (i.e. trophic ressources for oysters) and an ecophysiological model simulating oyster growth and reproduction.

### Biogeochemical model




• based on a NPZD model
• 4 nutrients (nitrate, ammonium, phosphate, silicates)
• 3 phytoplankton groups (diatoms, dinoflagellates,nanophytoplankton)
• 2 zooplankton sizes (micro and mesozooplankton)
• Detrital matters splitted between the different elements (N,Si,P)

### Ecophysiological model



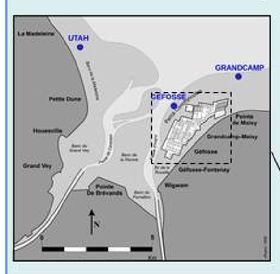

*from Pouvreau et al, 2006*

- Based on the Dynamic Energy Budget Theory
- 3 state variables:
  - Reserves
  - Structure
  - Reproduction

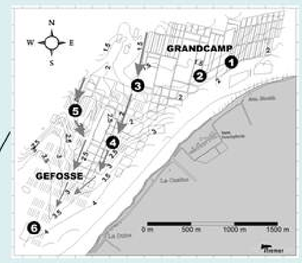
## Results & Conclusion

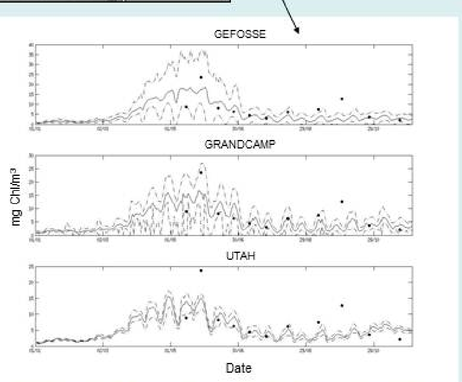
### 1. Standard simulation

Validation of the model for the year 2002:
• Comparison with chlorophyll *a* data (3 stations of the domain)
• Comparison with oyster growth data (5 stations of the cultivated area)

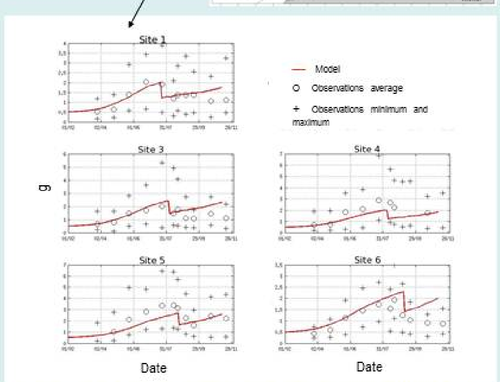



**Good agreement between simulated results and observations**

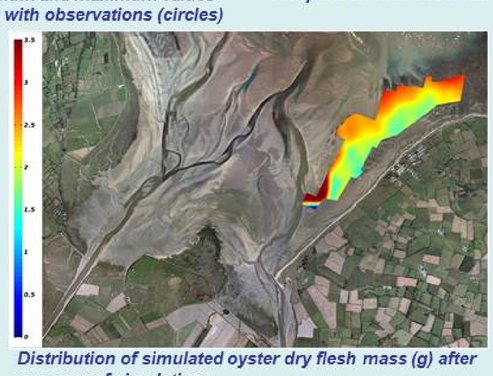



*Variation of simulated surface chlorophyll a concentration (mean value = solid line, minimum and maximum values = dashed lines) and comparison with observations (circles)*




*Variation of simulated oyster dry flesh mass (line) and comparison with observations (symbols)*

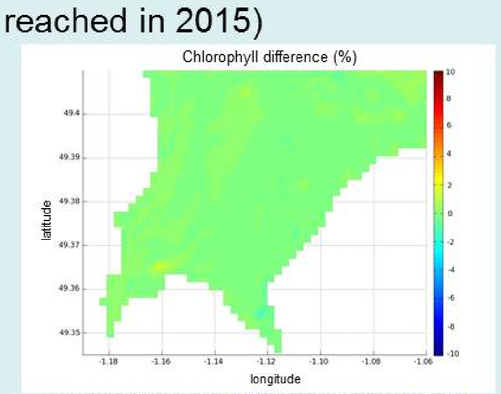


*Distribution of simulated oyster dry flesh mass (g) after one year of simulation*

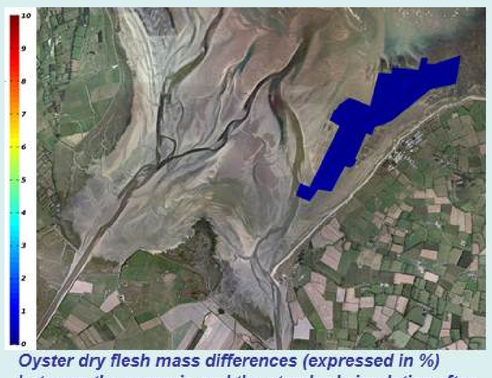
**Spatial variation of oyster growth in relation with bivalve density and bathymetry**

### 2. Scenarios

**a. 30% reduction of the nitrogen inputs watershed** (objective supposed to be reached in 2015)



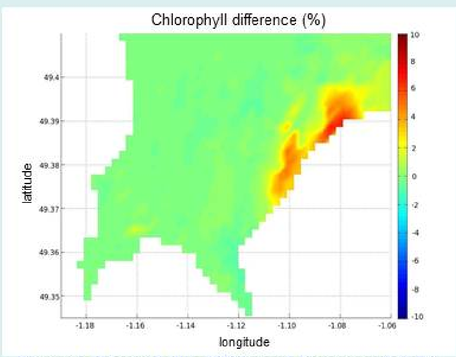

*Average chlorophyll a differences (expressed in %) between the scenario and the standard simulation over one year*



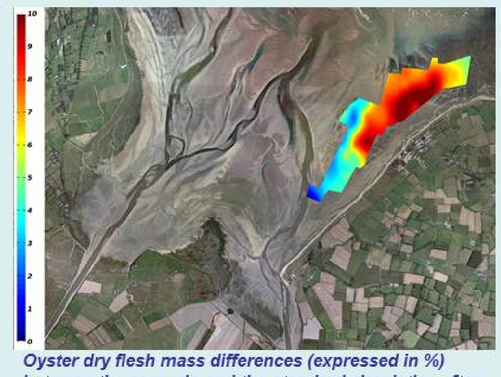
*Oyster dry flesh mass differences (expressed in %) between the scenario and the standard simulation after one year*

**► no major impact on average annual chlorophyll *a* concentration and thus on oyster growth**

**b. 20% reduction of the total oyster biomass**




*Average chlorophyll a differences (expressed in %) between the scenario and the standard simulation over one year*



*Oyster dry flesh mass differences (expressed in %) between the scenario and the standard simulation after one year*

**► increase of available phytoplancton, on the cultivated area**
**► heterogeneous increase of oyster dry flesh mass**

• In the bay, nitrate inputs from the watershed are very important. Despite a reduction of 30%, nitrogen is still in excess compared with phosphorus and then does not limit primary production.
• Oyster density acts as a negative feedback on oyster growth. An homogeneous 20% reduction of cultivated biomass leads to a spatially heterogeneous increase of growth performance.
• This study completed with scenarios about cultivated area restructuration and competition with other bivalves (cultivated and wild) will provide informations about shellfish culture sustainability related with environment evolution.

***References:***
*Pouvreau, S., Bourles, Y., Lefèbvre, S., Gangnery, A., Alunno-Bruscia, M. 2006. Application of a dynamic energy budget model to the Pacific oyster, Crassostrea gigas, reared under various environmental conditions. Journal of Sea Research, 56, 156-167.*
*Lazure, P., Dumas, F. 2008. An external-internal mode coupling for a 3D hydrodynamical model for applications at regional scale (MARS). Advances in water resources, 31, 2, 233-250.*