The land-ocean continuum

From Si cycling to ICZM

Olivier Ragueneau, LEMAR-IUEM,
and all participants of MOITEM and Si-WEBS projects

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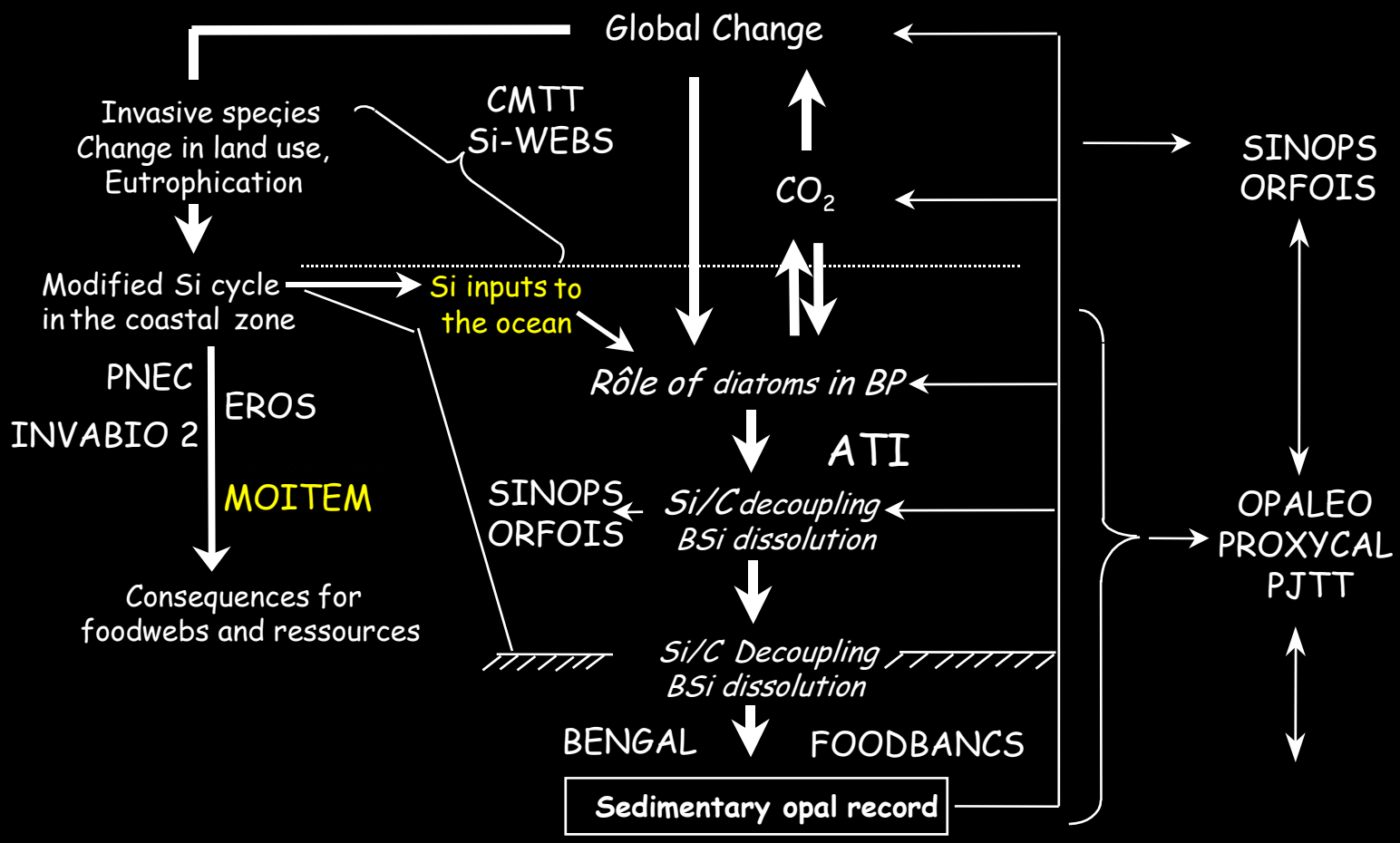
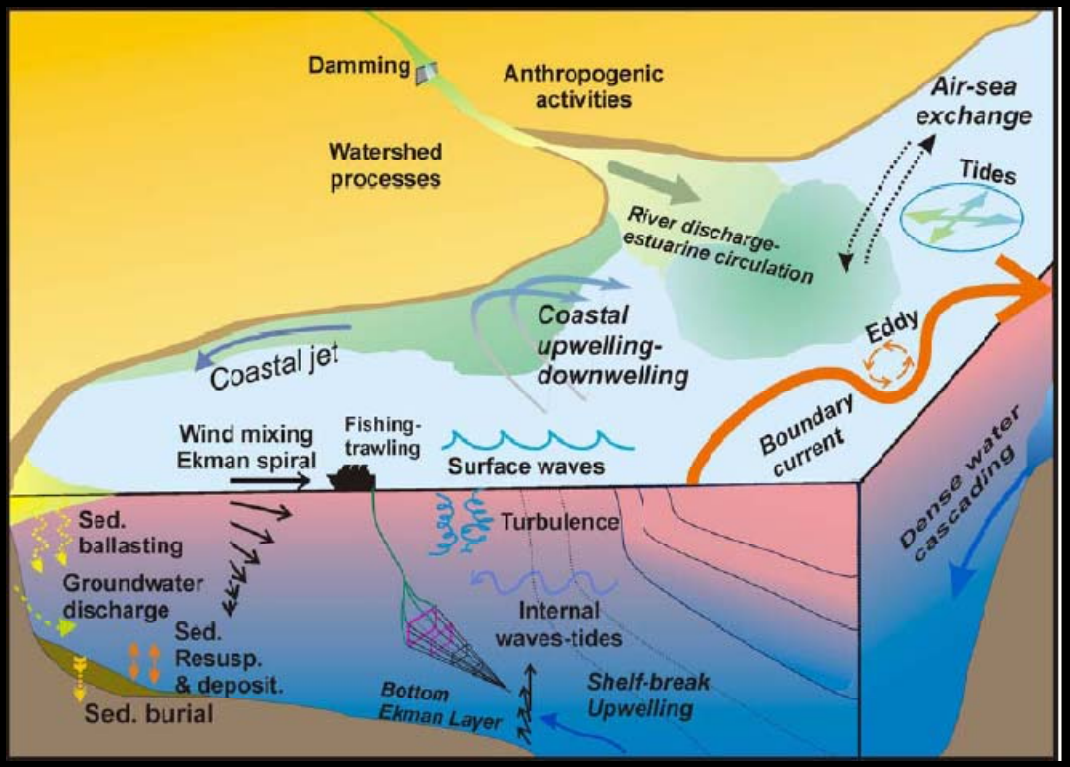
Si and the carbon cycle



Importance and complexity of continental margins



CO_2 sources and sinks, nutrient filter, budgets

Functioning of ecosystems, ressources

Anthropic perturbations

Continental Margins as a filter for DSi inputs to the ocean

Paradigme 1: Alteration of oceanic DSi inventory may alter the functioning of the biological pump on glacial/interglacial time scales

- Increased Si delivery from rivers (Froelich et al., 1992)
- Increased Si delivery from Antarctic ice sheet (Pollock, 1997)
- Increased Si delivery from dust inputs (Harisson, 2000)

Problem: temporal changes in DSi river inputs are poorly known

Paradigme 2: Si and C cycle tightly connected on margins, where the missing Si sink may be located

- Decreasing sink in Southern ocean (Pondaven et al., 2000)
- Margins as the missing sink (DeMaster 2002)

Quantification of the CM's filter

Build-up of Si biogeochemical budgets on margins

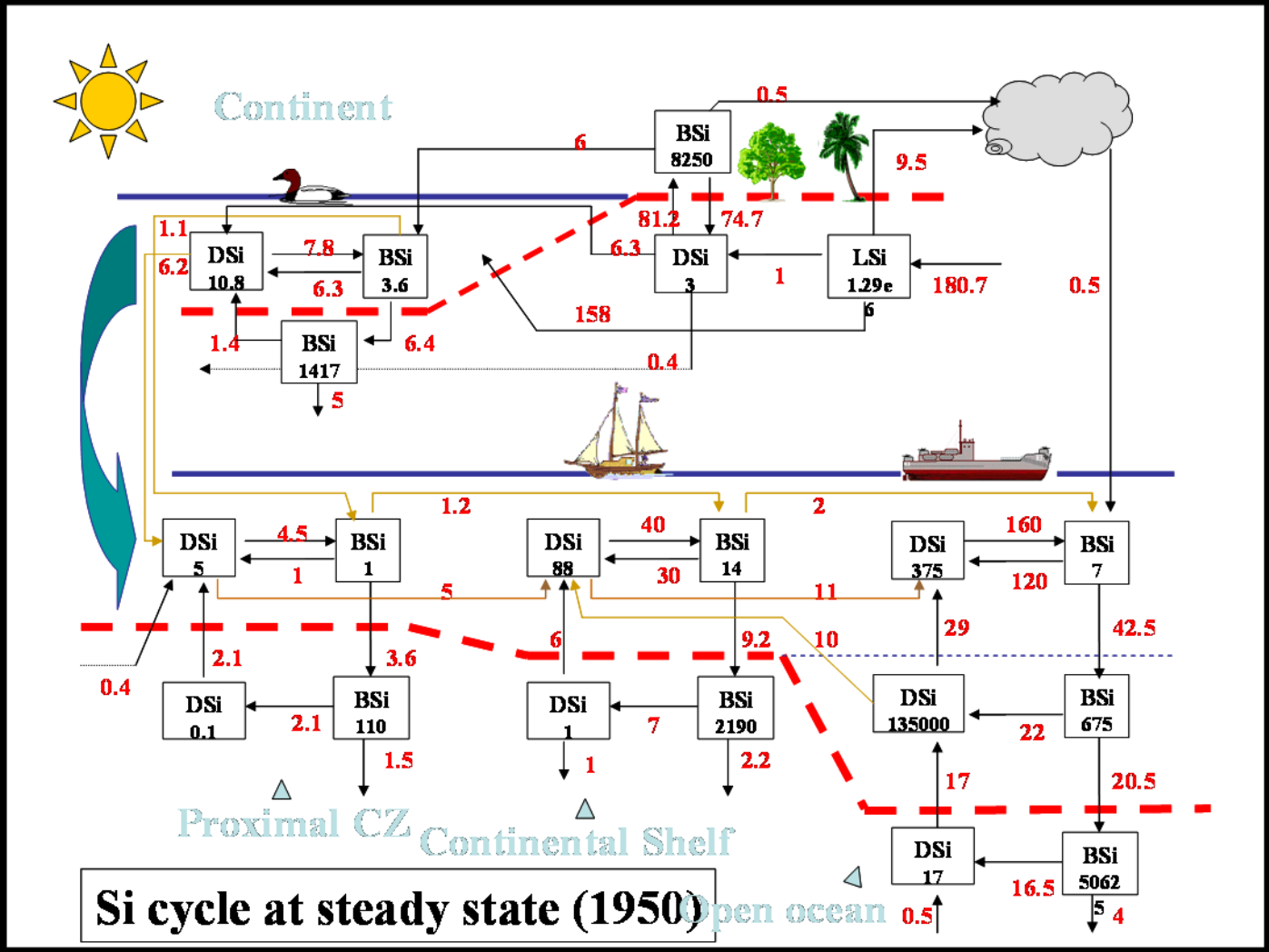
Global box model of Si cycling along the LOC

Mechanistic modeling of Si transformations along the LOC

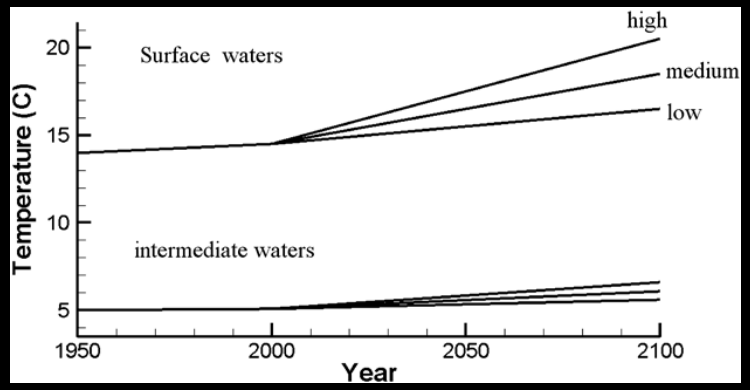
Problem : heterogeneity of continental margins

Si transformations along the LOC

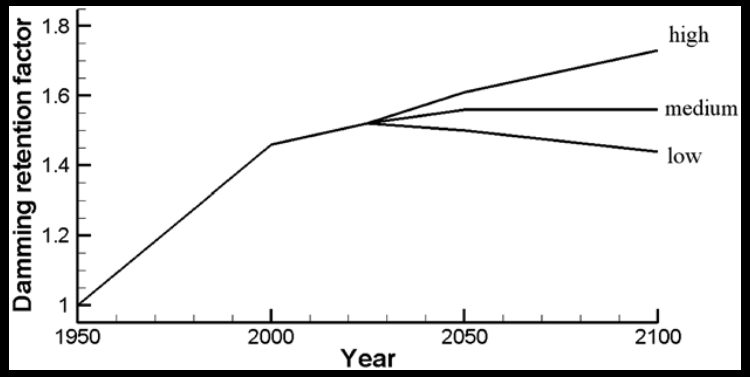
Laruelle et al., GBC, 2009



Scenarios combining damming and climate change



From IPCC

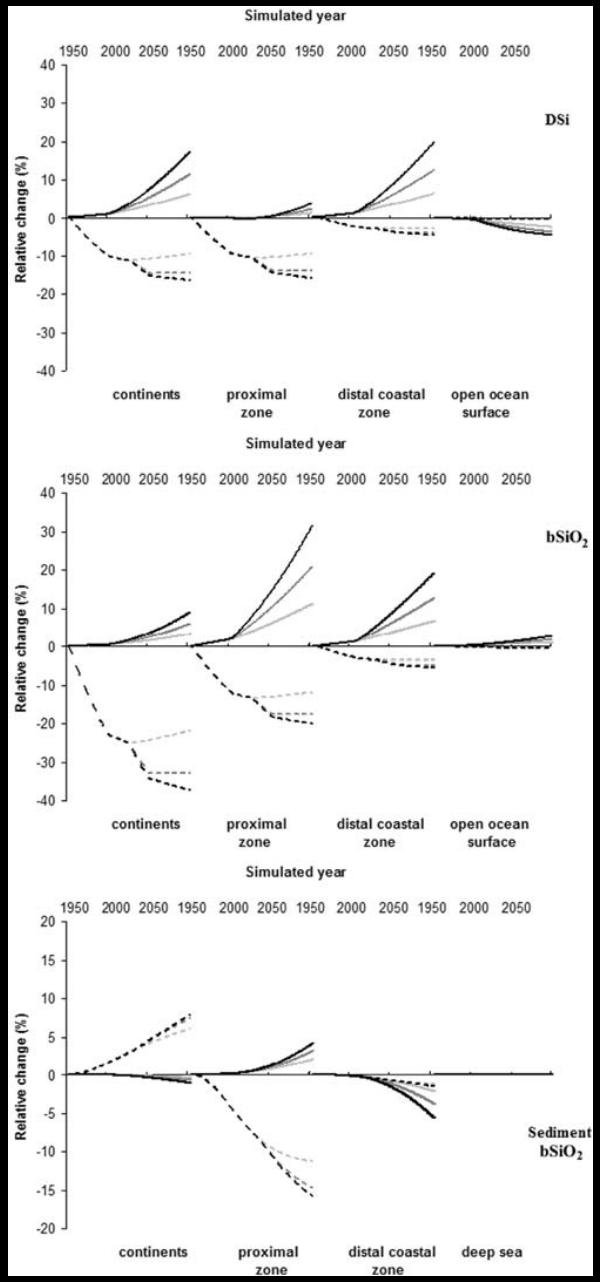


From Gleick, 2003, UN 2005

dSi

bSiO2

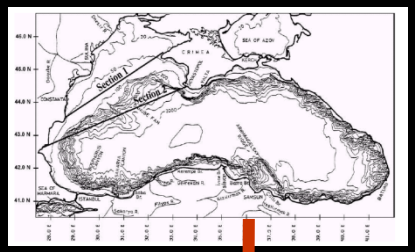
bSiO2



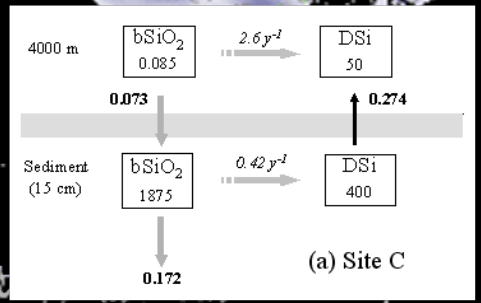
Regional budget construction

Ragueneau et al. (2002, 2005)

Michalopoulos et al. (in prep.)



Gallinari et al. (2009)

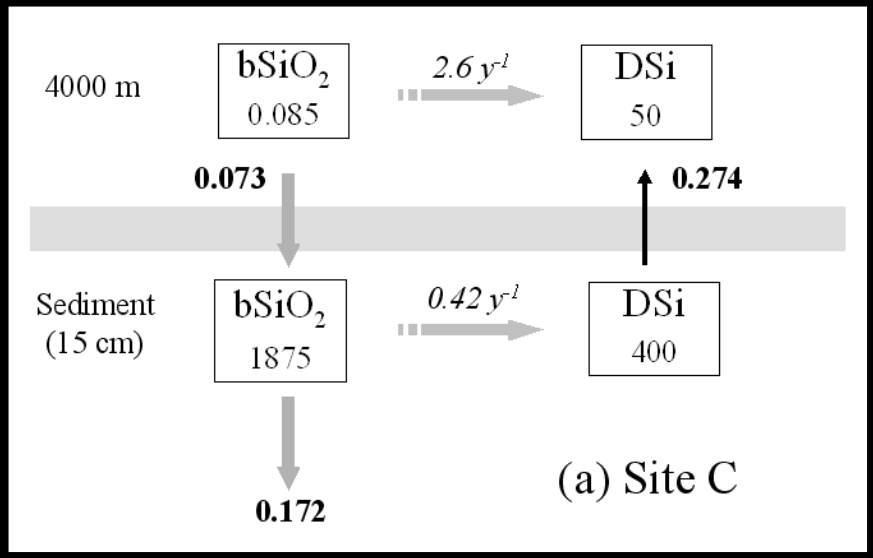


Ragueneau et al. (2009)

From budget and process studies

5 Tmol Si / y

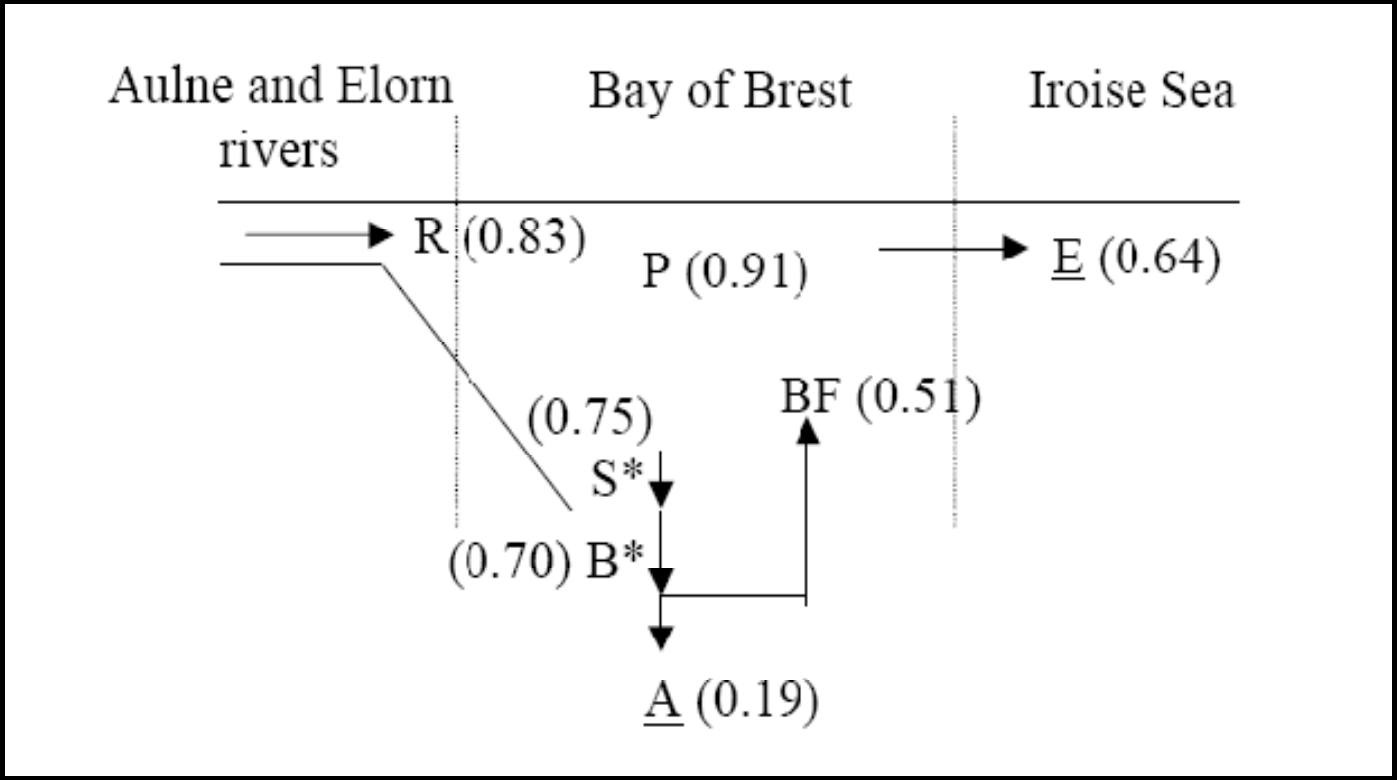
5-10 Tmol Si / y



Ragueneau et al., 2009, BIOZAIRE DSRII

Need to explore Si inputs to the ocean through downslope transport and redissolution

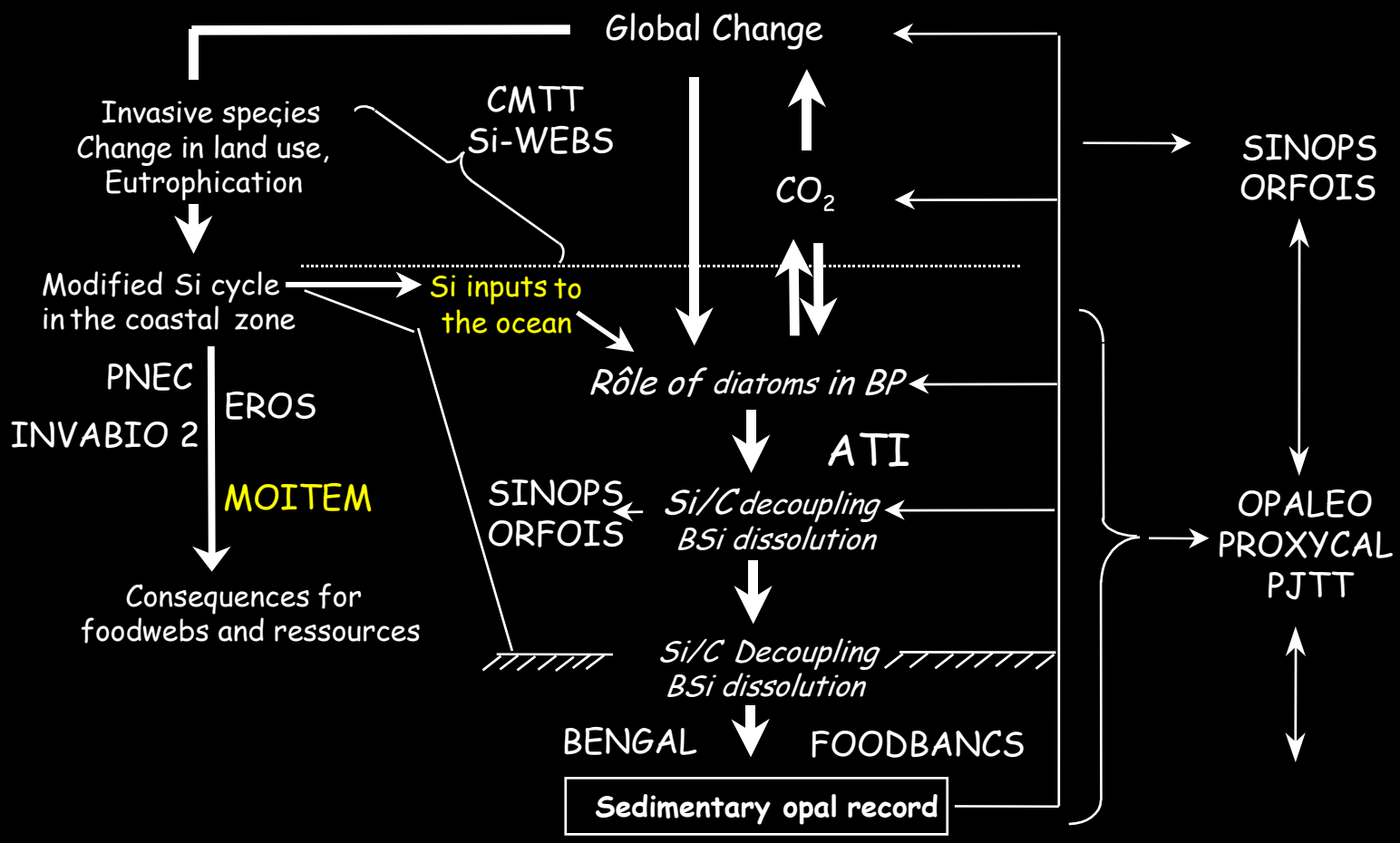
Annual cycle of Si in the Bay of Brest



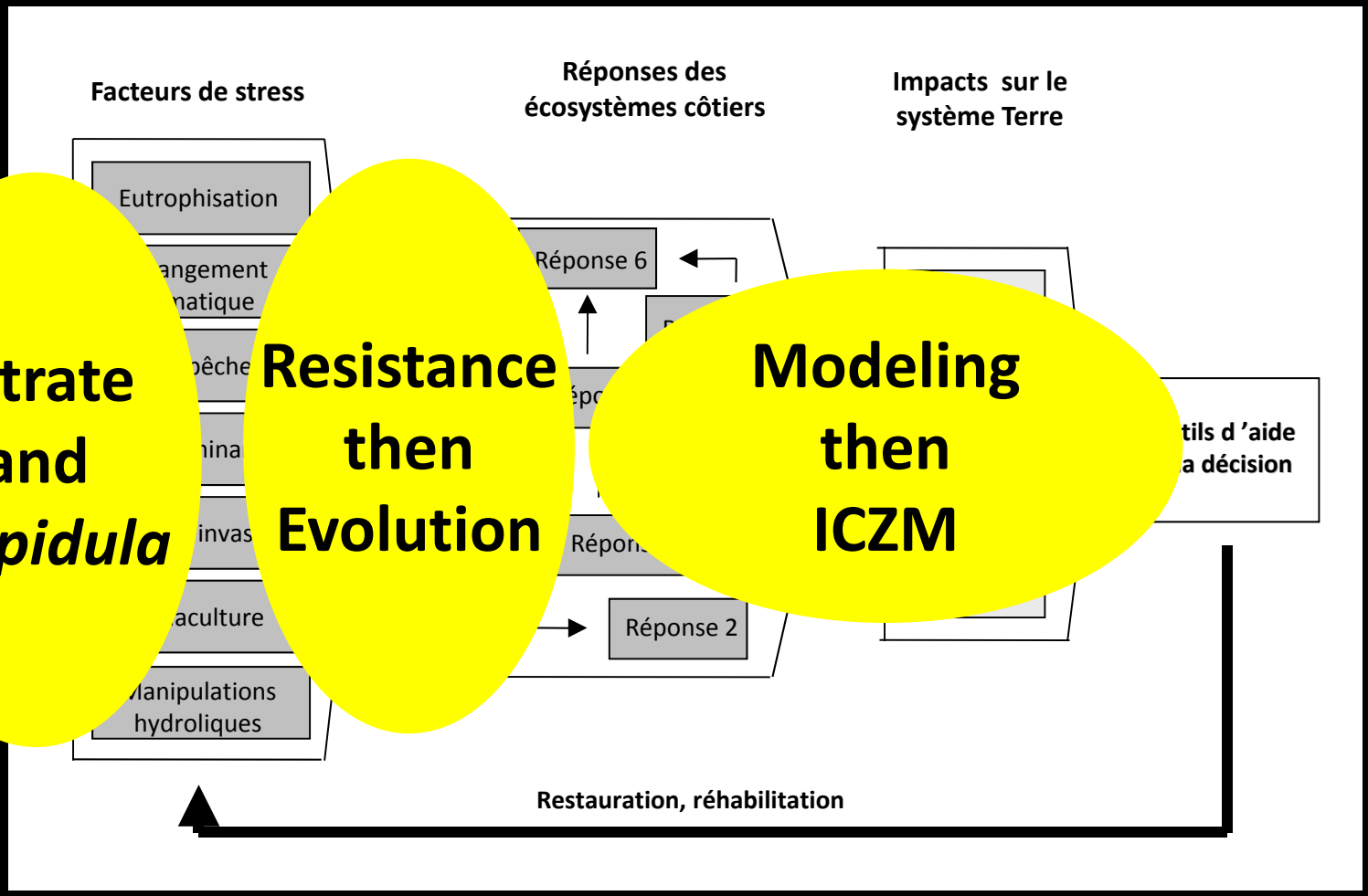
Ragueneau et al., 2005, Biogeochemistry

Increasing biodeposition (through invasive species benthic suspension feeders, plants…) as a third route for decreasing Si inputs to the coast ?

Si and the carbon cycle



New conceptual model of eutrophication (Cloern, 2001)



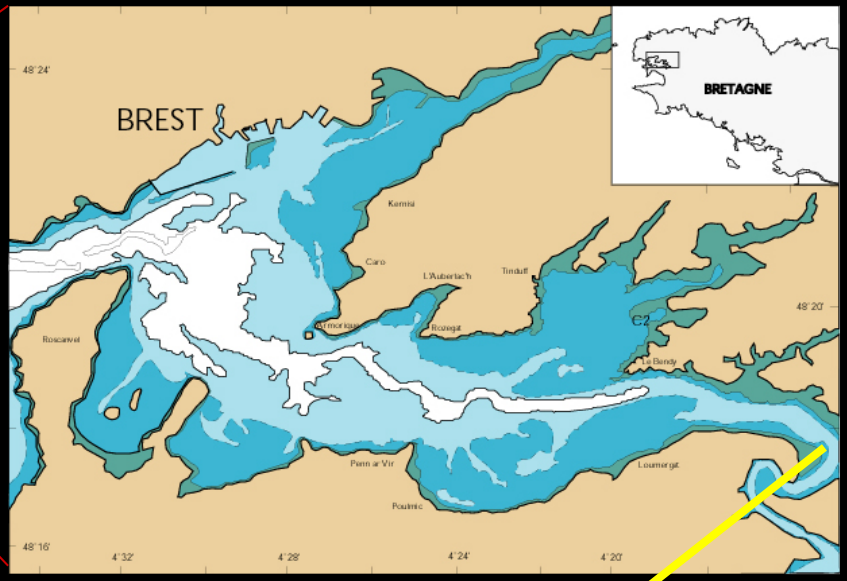
Nitrate and *Crepidula*

Resistance then Evolution

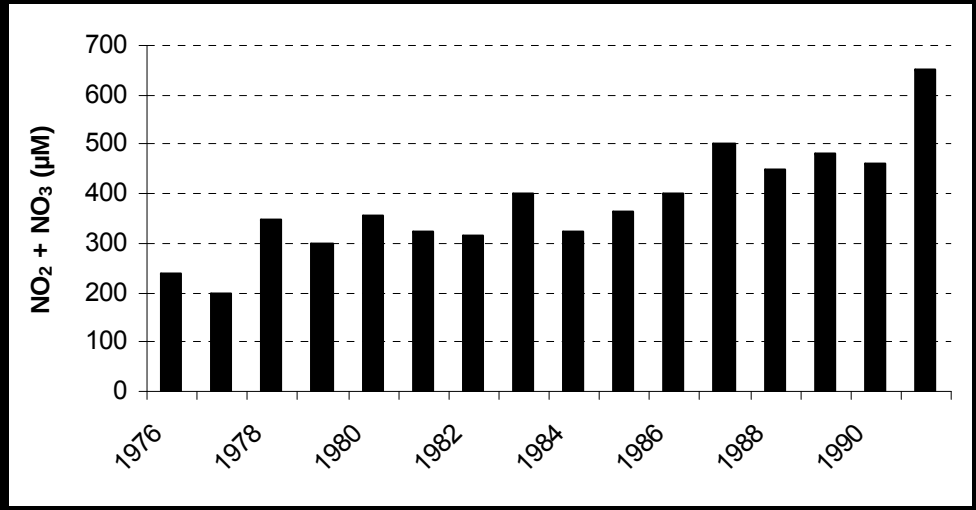
Modeling then ICZM

The Bay of Brest ? « un cas d'école !! »

The Bay of Brest



Increasing inputs of nitrate

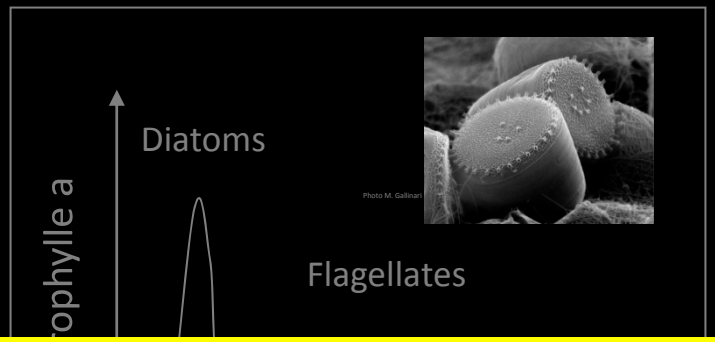


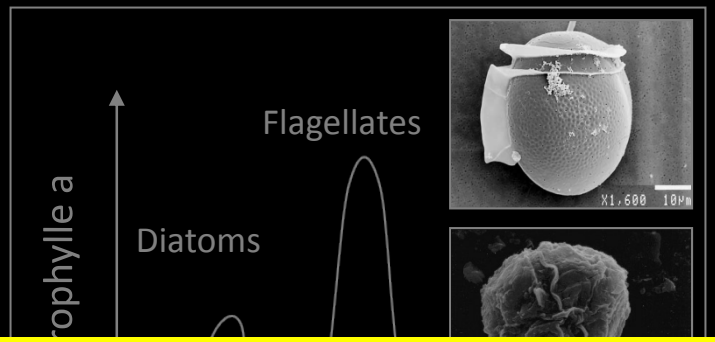
Problems linked to nitrate

Les photographies de la figure 2 montrent l'évolution saisonnière du phénomène en Baie de Saint-Efflam (Côtes d'Armor).

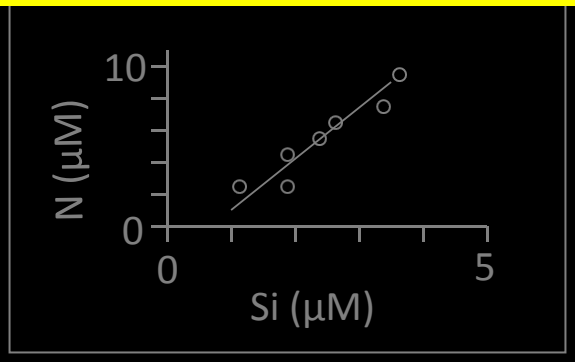
Figure 2 . Evolution saisonnière typique d'une marée verte à ulves sur la plage de Saint-Efflam (Côtes d'Armor). Démarrage printanier *(en haut à gauche)*, apogée en juillet *(en haut à droite)*, dessèchement et putréfaction estivale des dépôts de haut de plage *(en bas à gauche)*, ramassage estival par les pouvoirs publics *(en bas à droite)*

Importance of Si:N, Si:P ratios

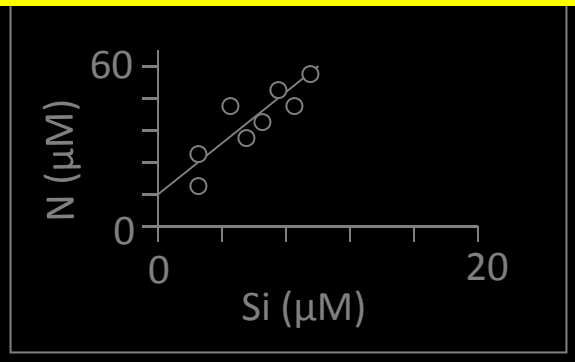




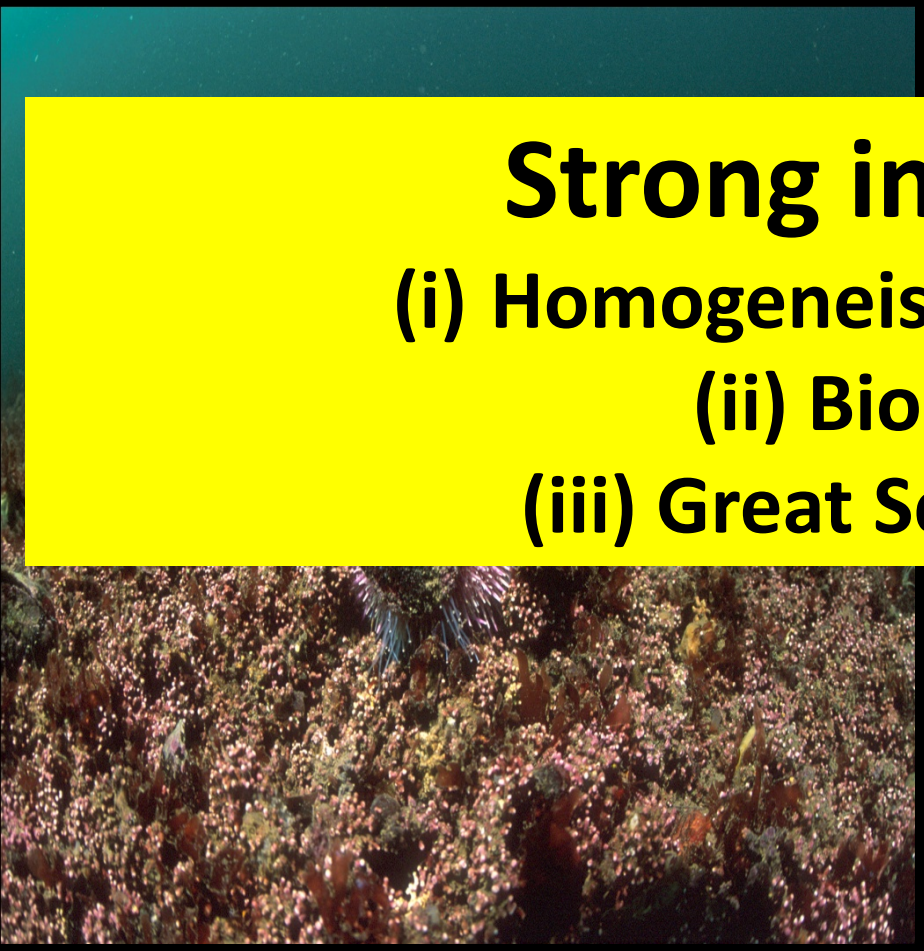
Importance of Si recycling



North Sea,
Adriatic Sea,
Mississipi, Danube,
Bay of Brest



Invasion of the Bay of Brest By *Crepidula fornicata*



Strong impacts on:

(i) Homogeneisation of bottoms

(ii) Biodiversity

(iii) Great Scallop Fishery

Possible links between the two perturbations

Limitation of algal developments

Changes in the seasonality of primary production

Control of nutrient cycling

Impacts on retention and recycling of Si

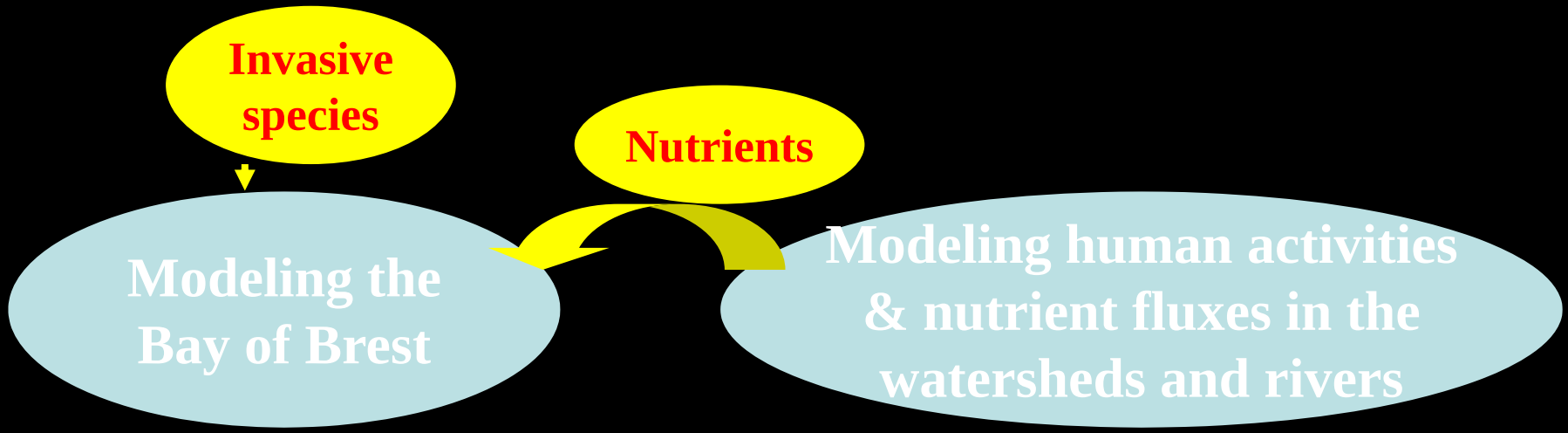
The *Crepidula* paraddox

Resistance to distrophy

Erosion of biodiversity

Endangers the Great Scallop fisheries

MOITEM



Objectives of MOITEM:

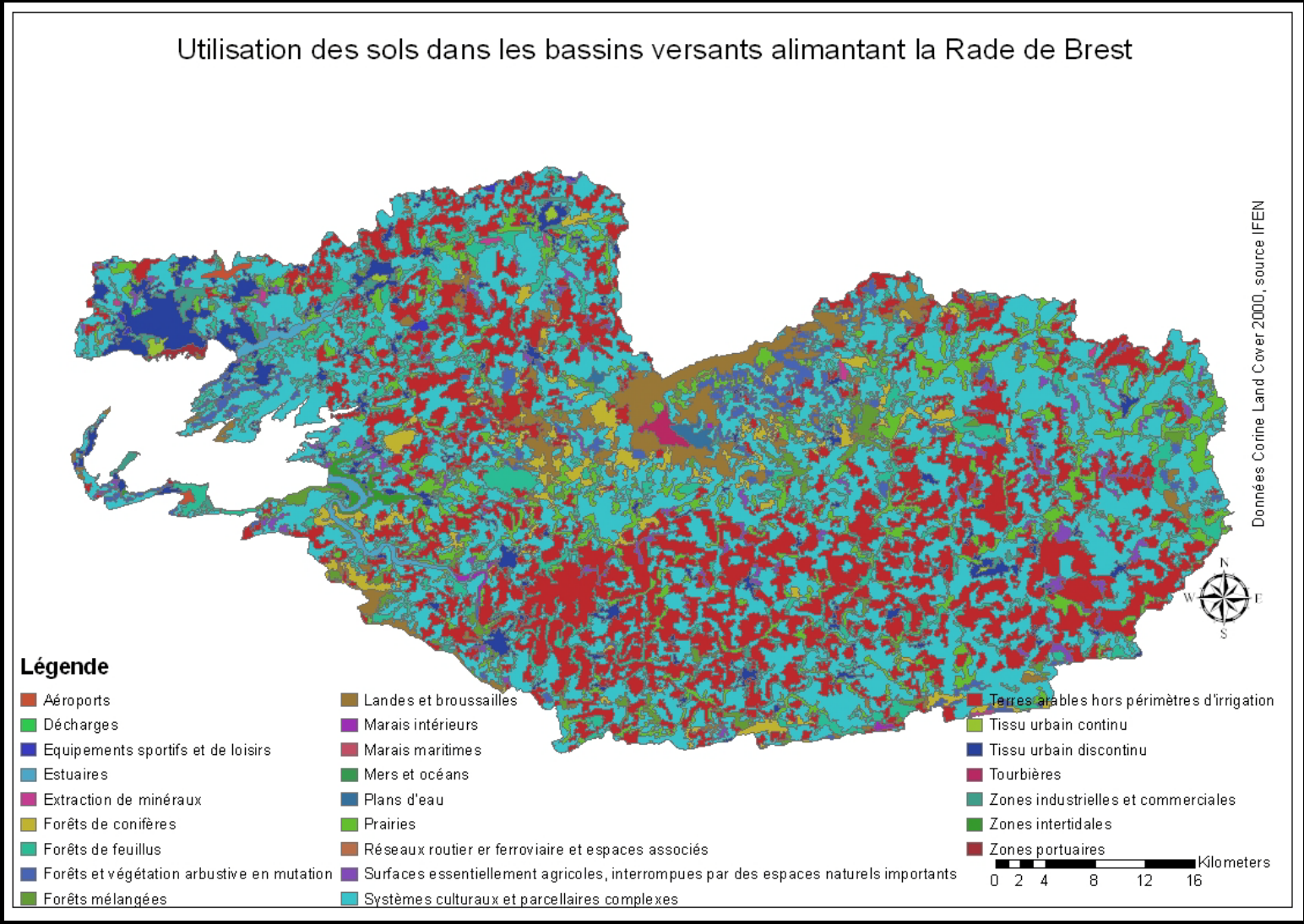
Develop a land-ocean model, from human activities on the watersheds to the functioning of the Bay of Brest ecosystem

Run scenarios with changes in human practices and control of the proliferation of *Crepidula fornicata*

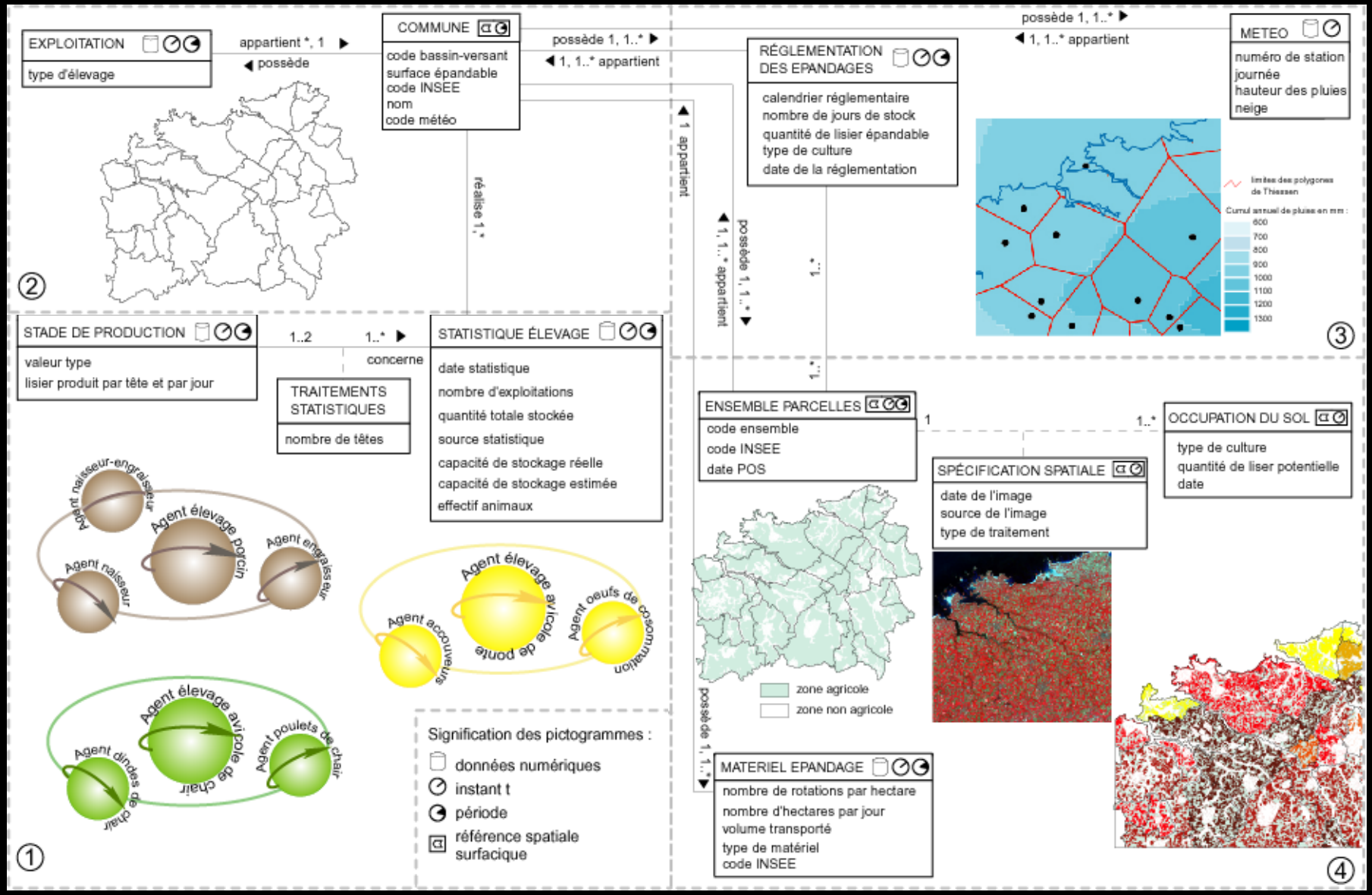
Link to HSS to develop an ICZM project

Data collection in watersheds

(SAS-Rennes P. Durand & J. Jaffrain)

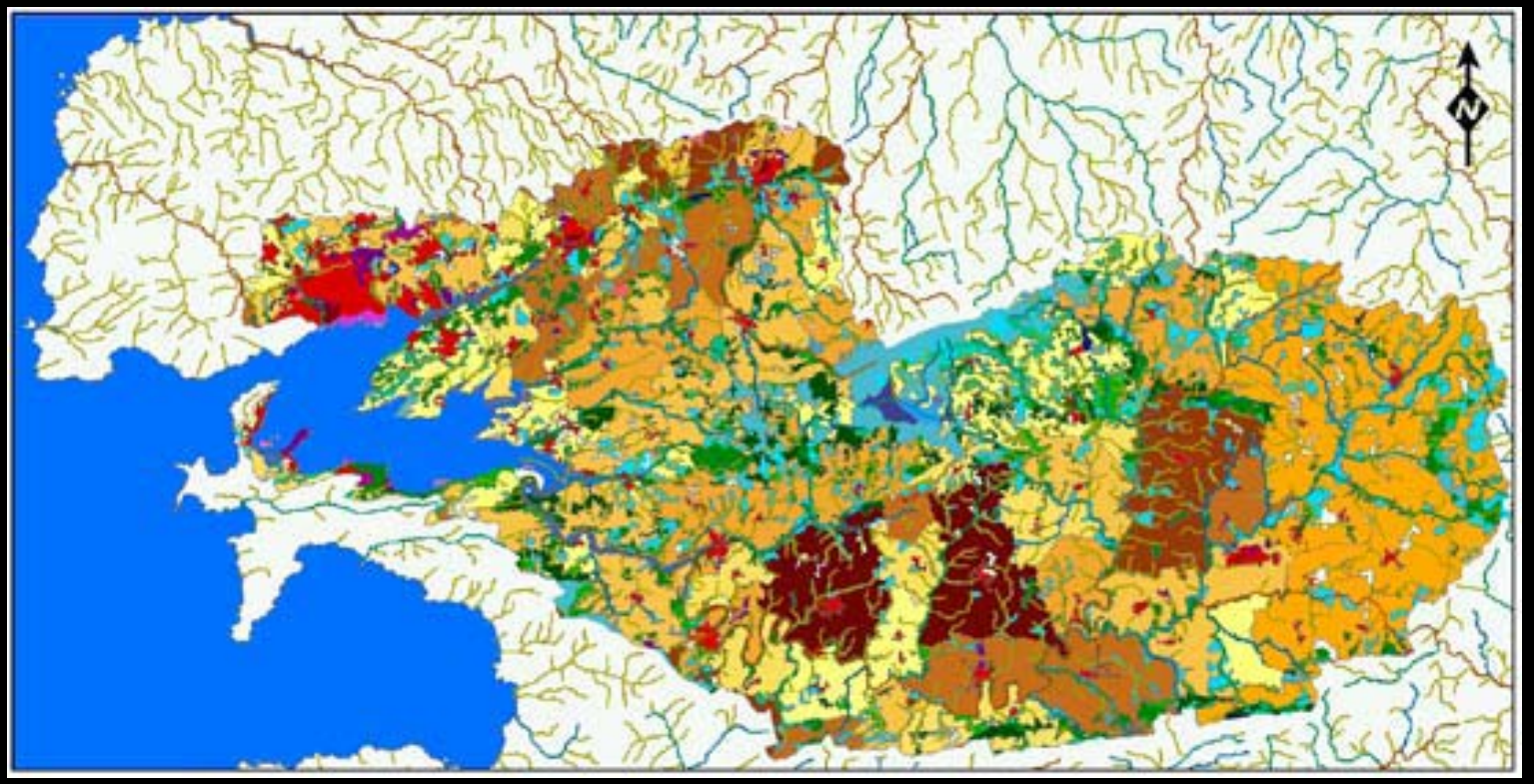


Nitrate emissions from agriculture



(GEOMER-Brest, C. Tissot)

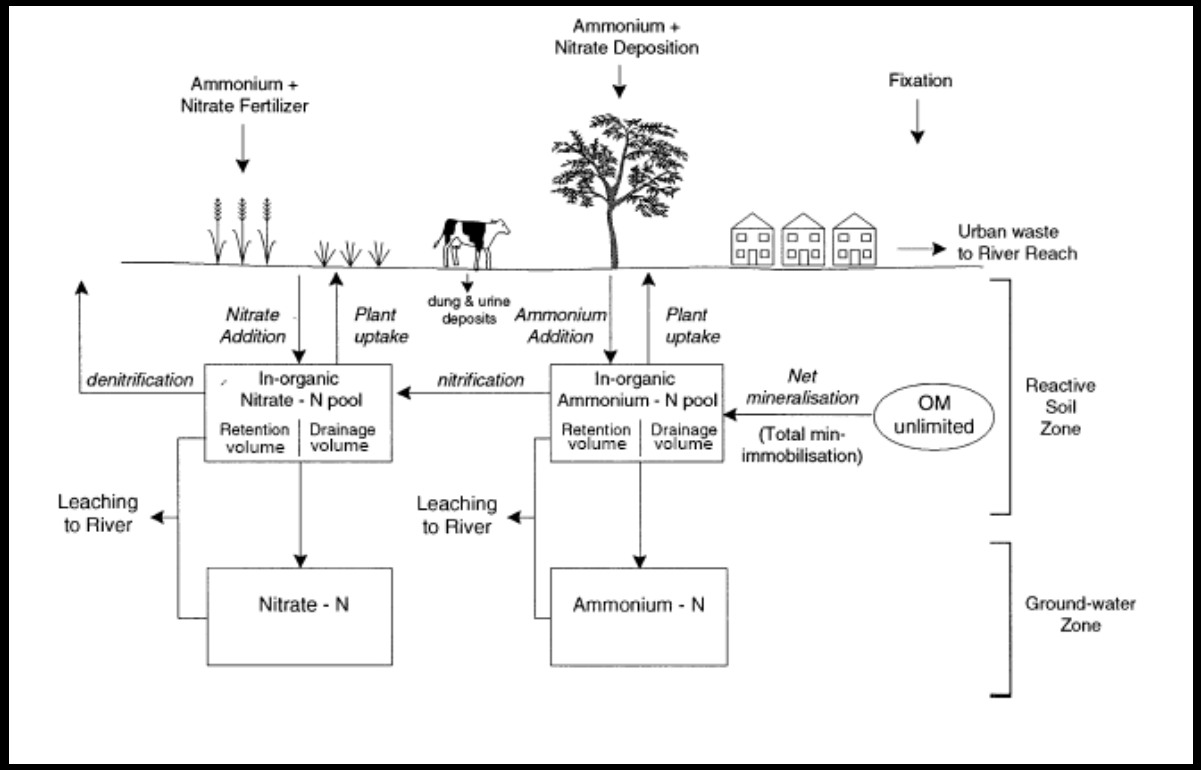
Dynamic map of « épandages »



(GEOMER-Brest, C. Tissot)

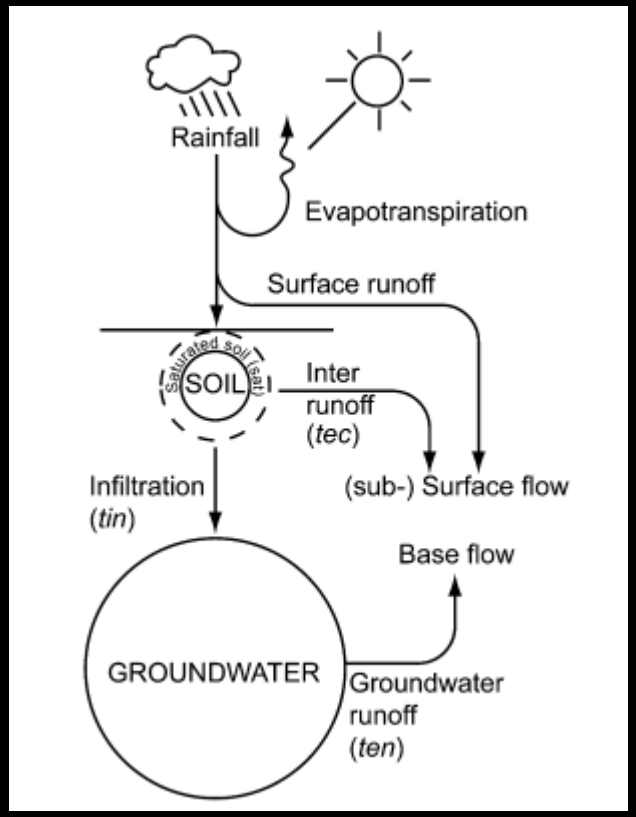
Watershed model (INCA)

(SAS-Rennes
P. Durand & J. Jaffrain)

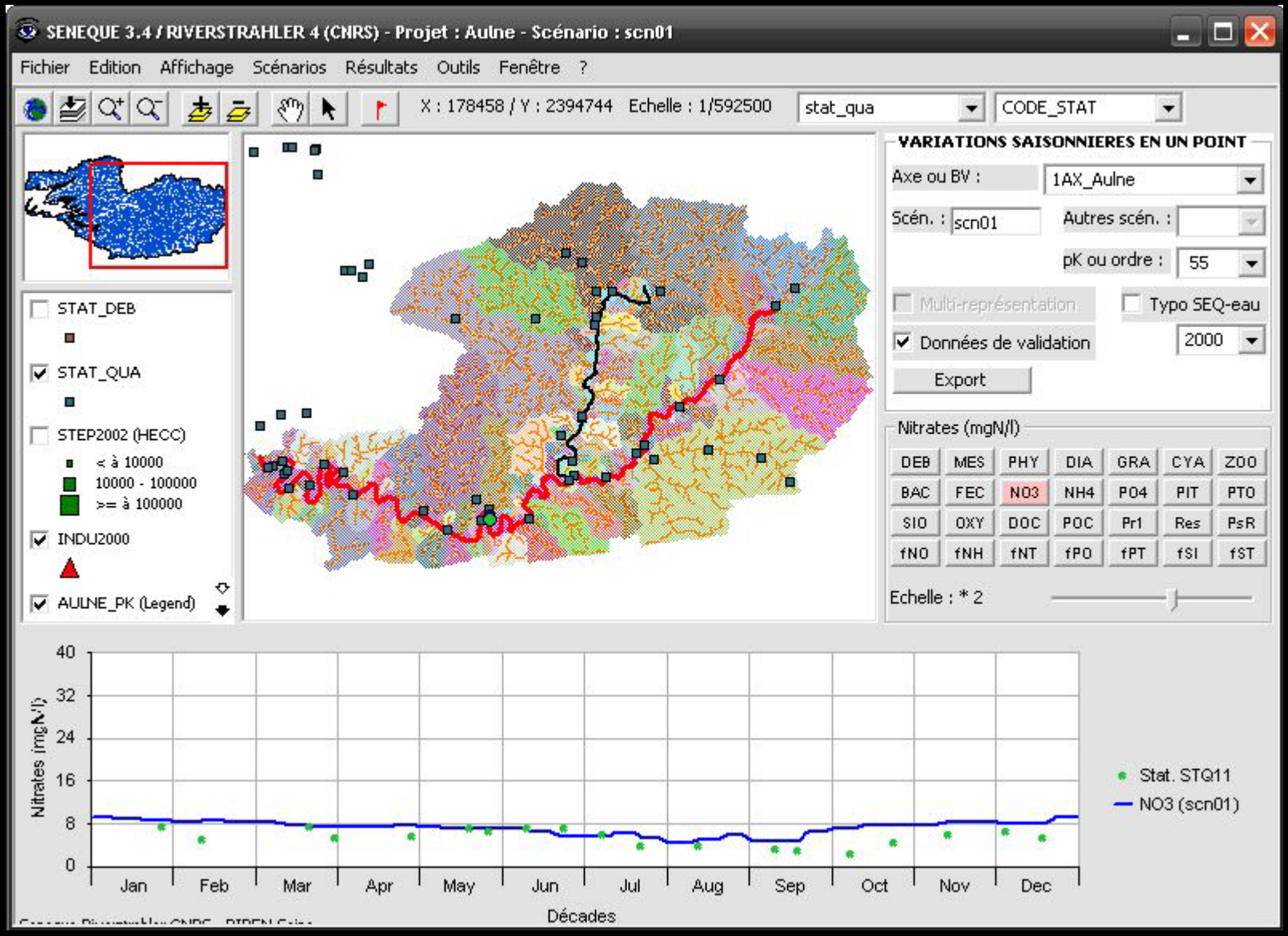


(Sysiphe-Paris, G. Billen & J. Garnier)

River model (Riverstrahler)

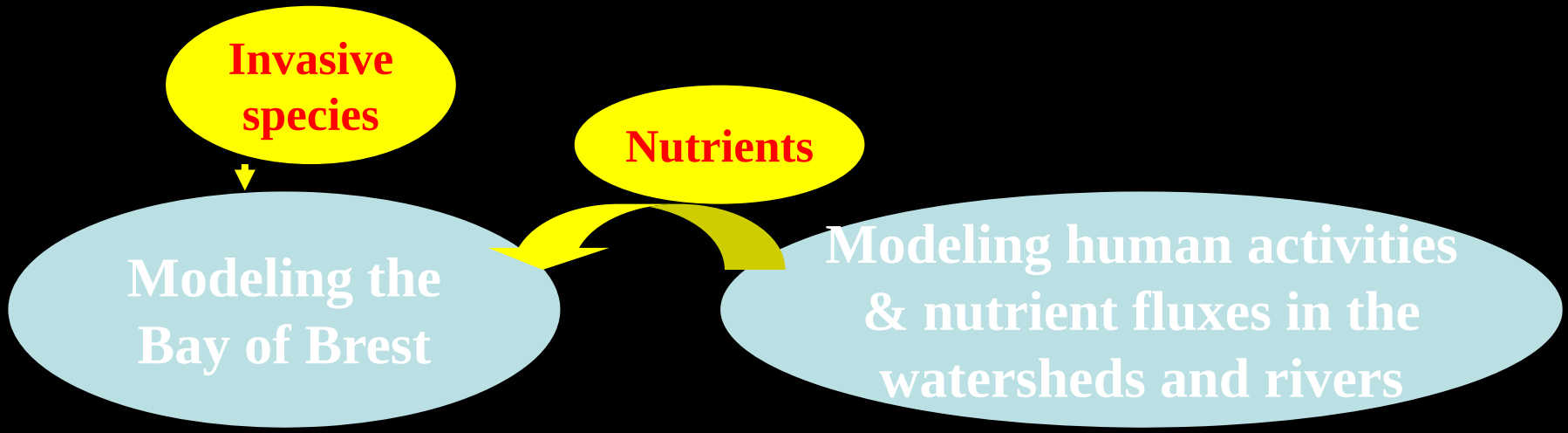


Modeling nutrient fluxes



(GEOMER, SAS & Sysiphe-Paris)

MOITEM



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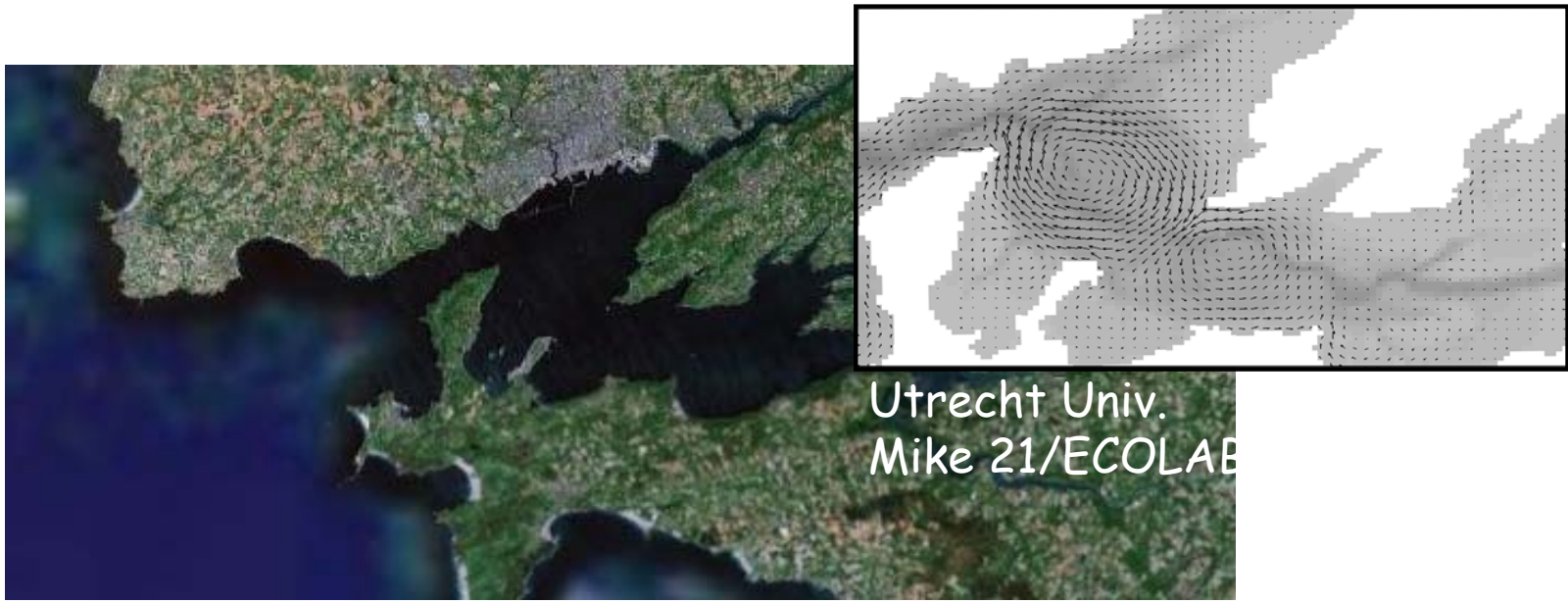
Modeling the Bay of Brest



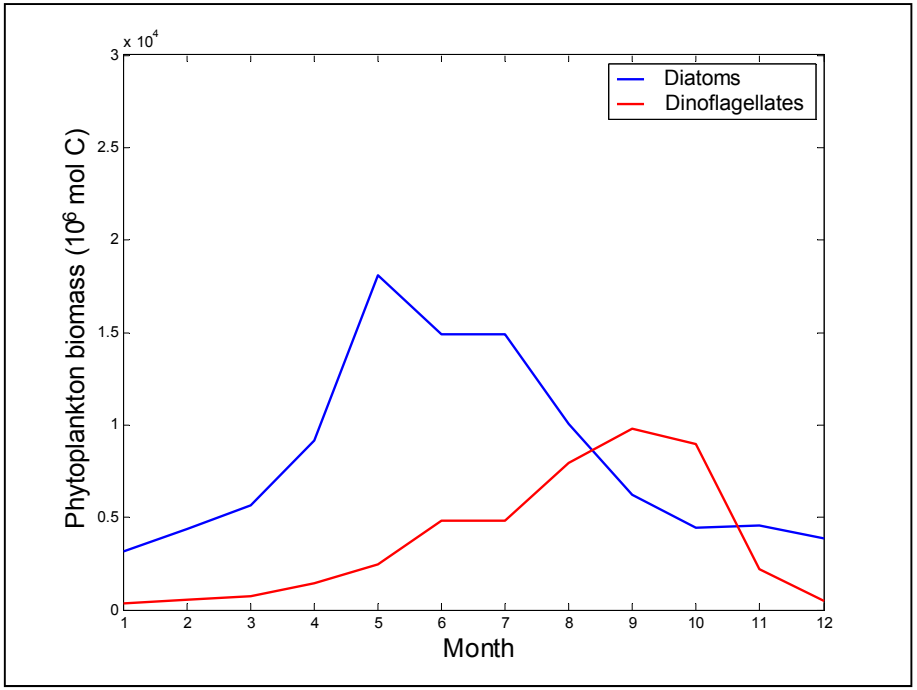
Coupled physical-biological model, benthic-pelagic coupling
Simplified (but realistic ☺) biological model

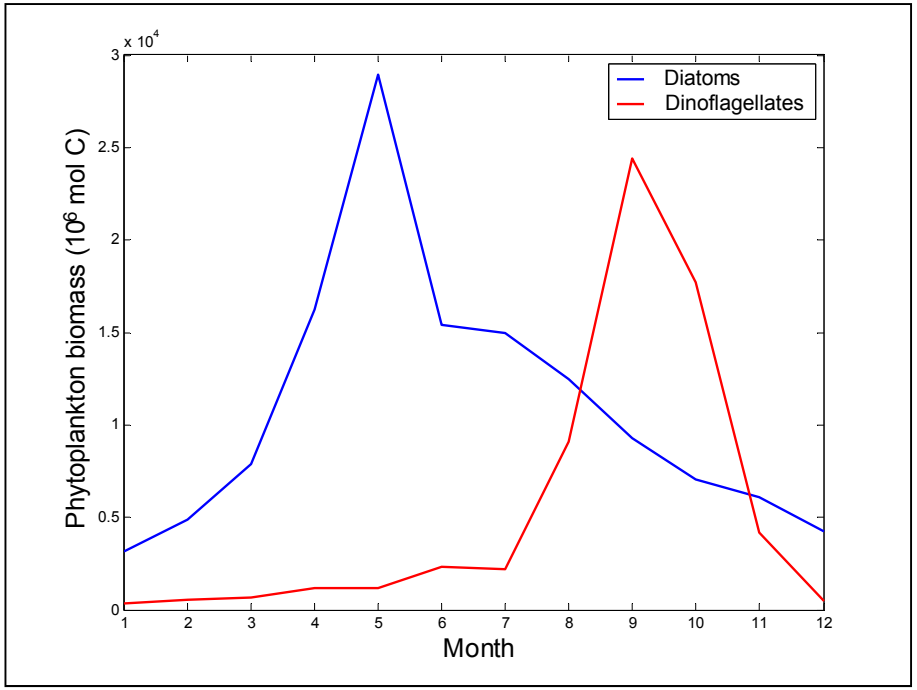
Useful to study the ecosystem functionning and evolution
Useful to determine the impact of the invasive species ***Crepidula fornicata***

Hypothesis to be tested

C. fornicata controls phytoplankton dynamics through the Si cycle

Scenarii: Year 2001 (Laruelle et al., MEPS 2009)

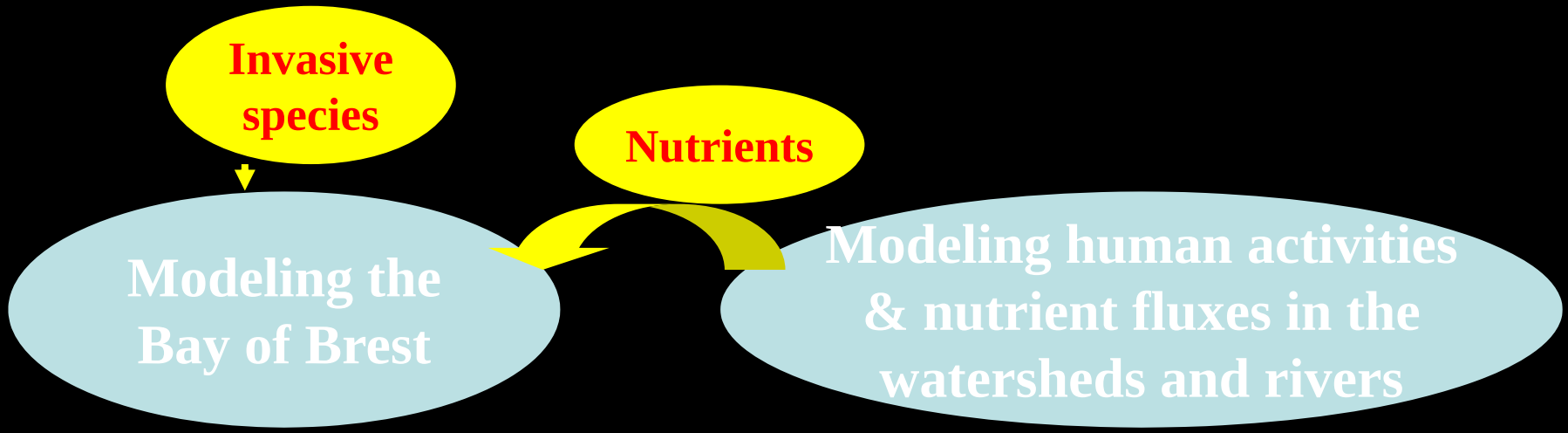




With *Crepidula fornicata*

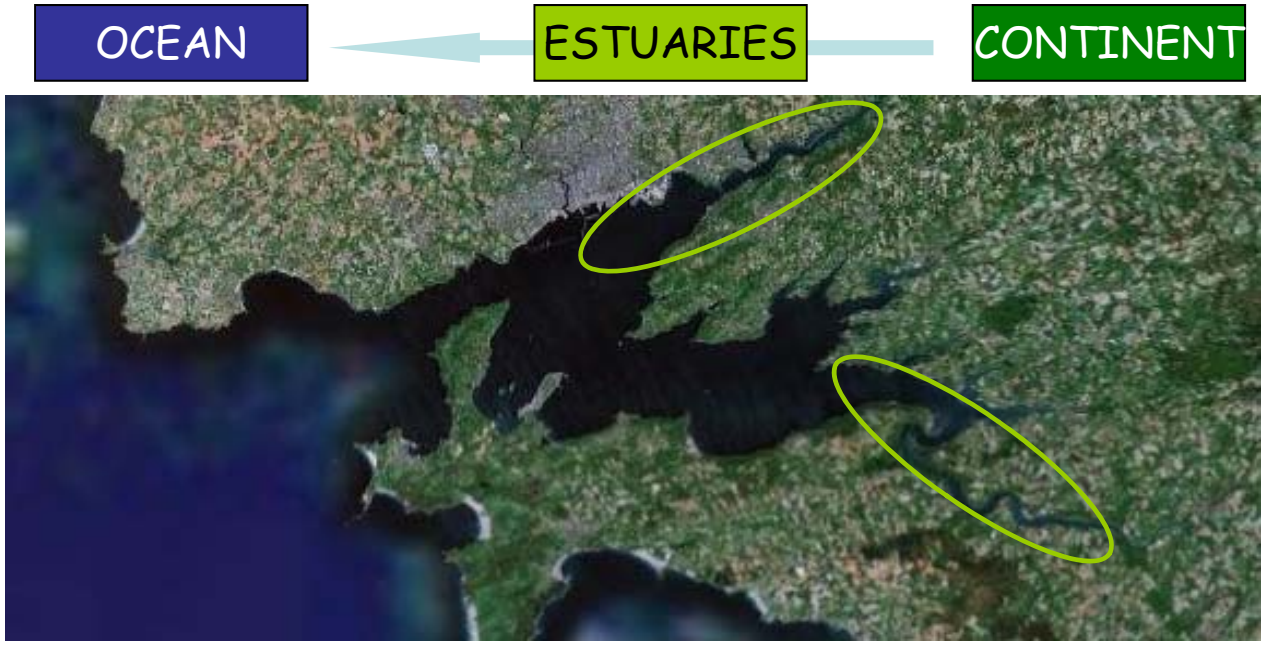
Without *Crepidula fornicata*

MOITEM



Need a good estuarine model !

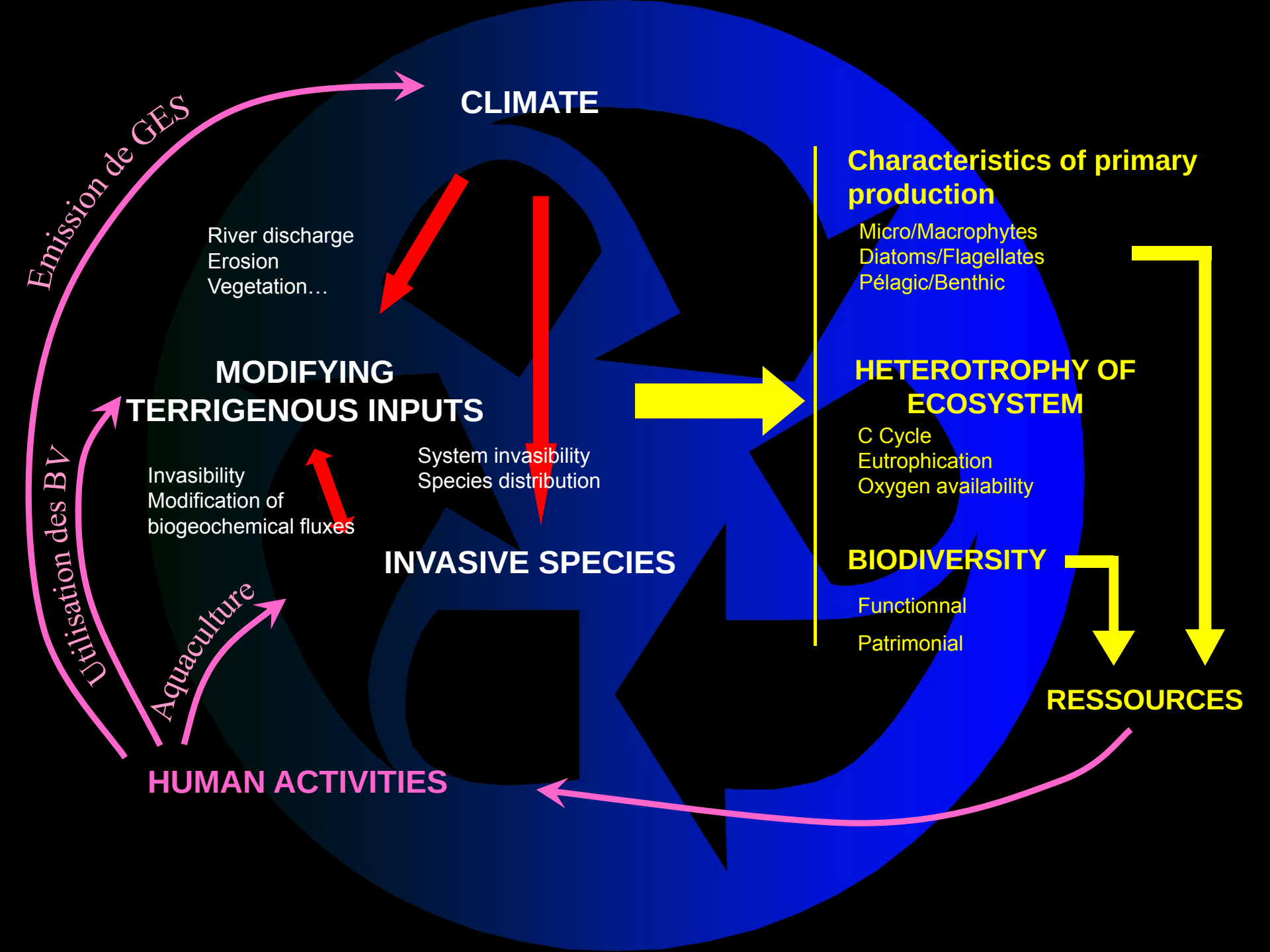
MOITEM-estuaires (EC2CO)

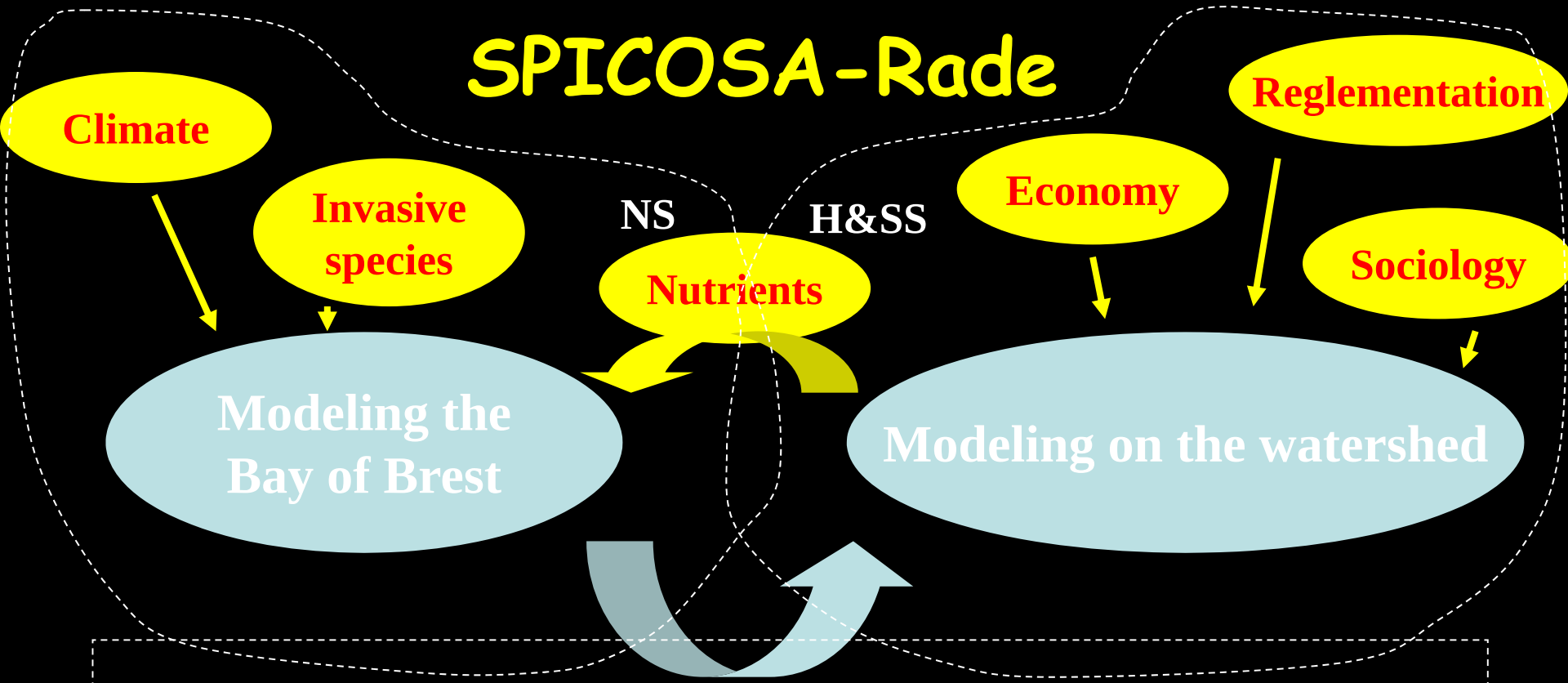


Objectives : to study the fate of river inputs (dissolved AND partic
upon estuarine mixing

Methodology : seasonal surveys along Aulne and Elorn estuaries
emphasis on small and short time scales
production and degradation, water column and sedimen

Collaborations : LEMAR (Si, OM), Chimie Marine (N), DYNECO (P),
ECOBIO, LSCE, LGE


CLIMATE
Emission de GES
River discharge
Erosion
Vegetation…
MODIFYING
TERRIGENOUS INPUTS
Utilisation des BV
Invasibility
Modification of
biogeochemical fluxes
System invasibility
Species distribution
INVASIVE SPECIES
Aquaculture
HUMAN ACTIVITIES
Characteristics of primary production
Micro/Macrophytes
Diatoms/Flagellates
Pélagic/Benthic
HETEROTROPHY OF ECOSYSTEM
C Cycle
Eutrophication
Oxygen availability
BIODIVERSITY
Functionnal
Patrimonial
RESSOURCES



Towards a systemic approach in the Bay of Brest

- System definition, formulation
- Co-construction of the scenarios
- ESE Analysys of the scenarios
- Help for decision making ?

Science in society

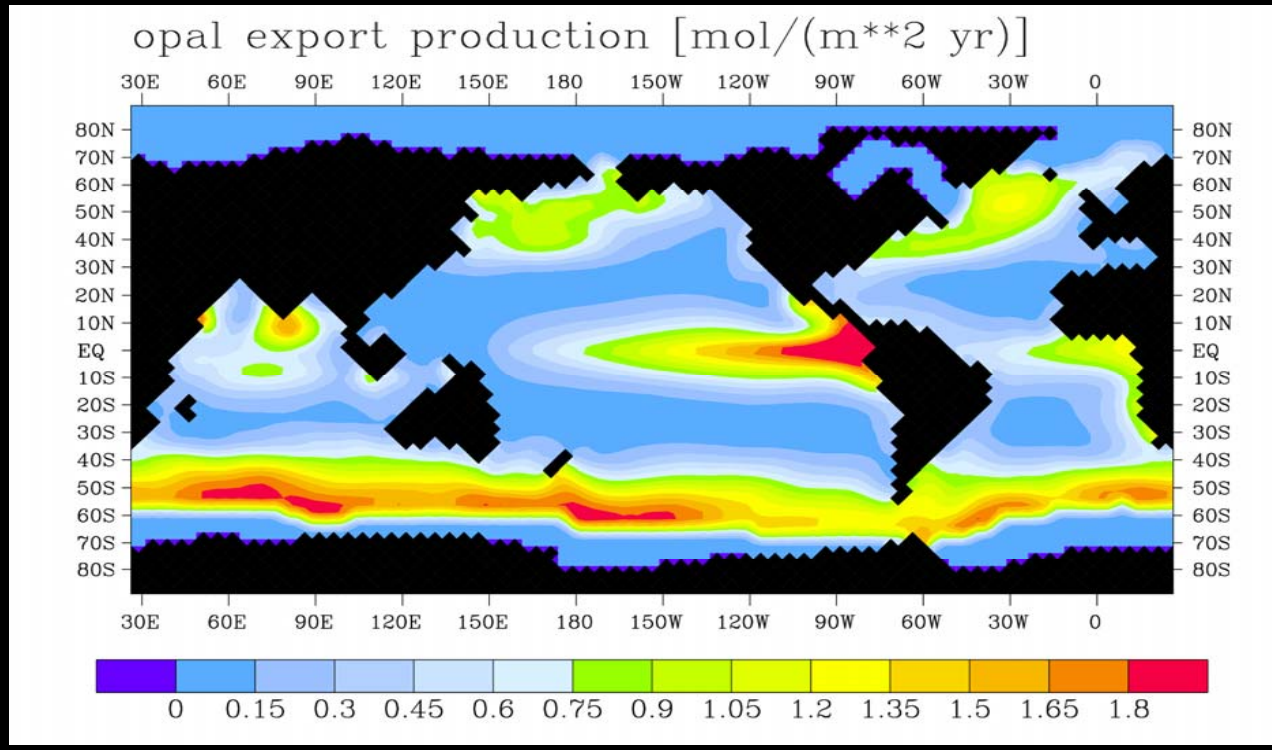
Approche originale de l'hétérogénéité des marges continentales

A. Typologie

B. Modélisation de la Rétention du Si

C. Filtre appliqué à la base de données globale en rivières

D. Régionalisation des apports de Si à l ’océan



MOITEM

Climat

Espèces invasives

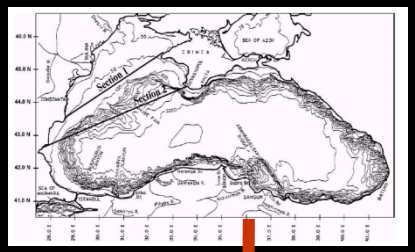
Nutriments

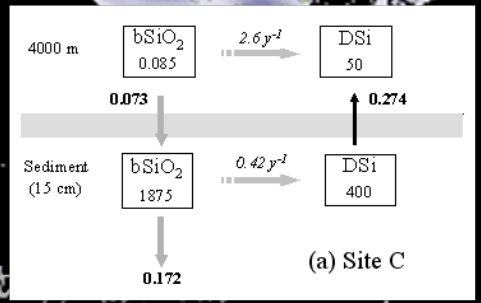
Modélisation Rade et estuaires

Modélisation des activités humaines sur les BV

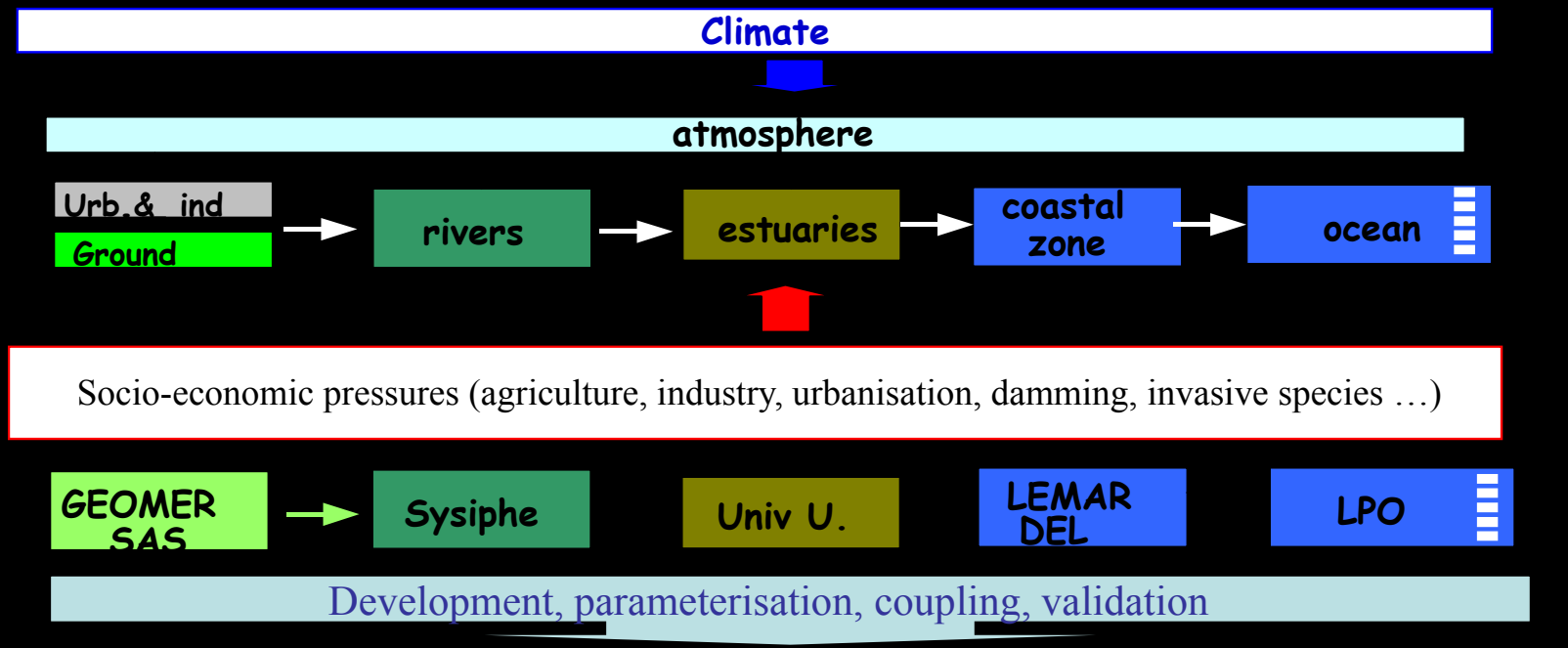
Si-WEBS

Margins and the silica sink





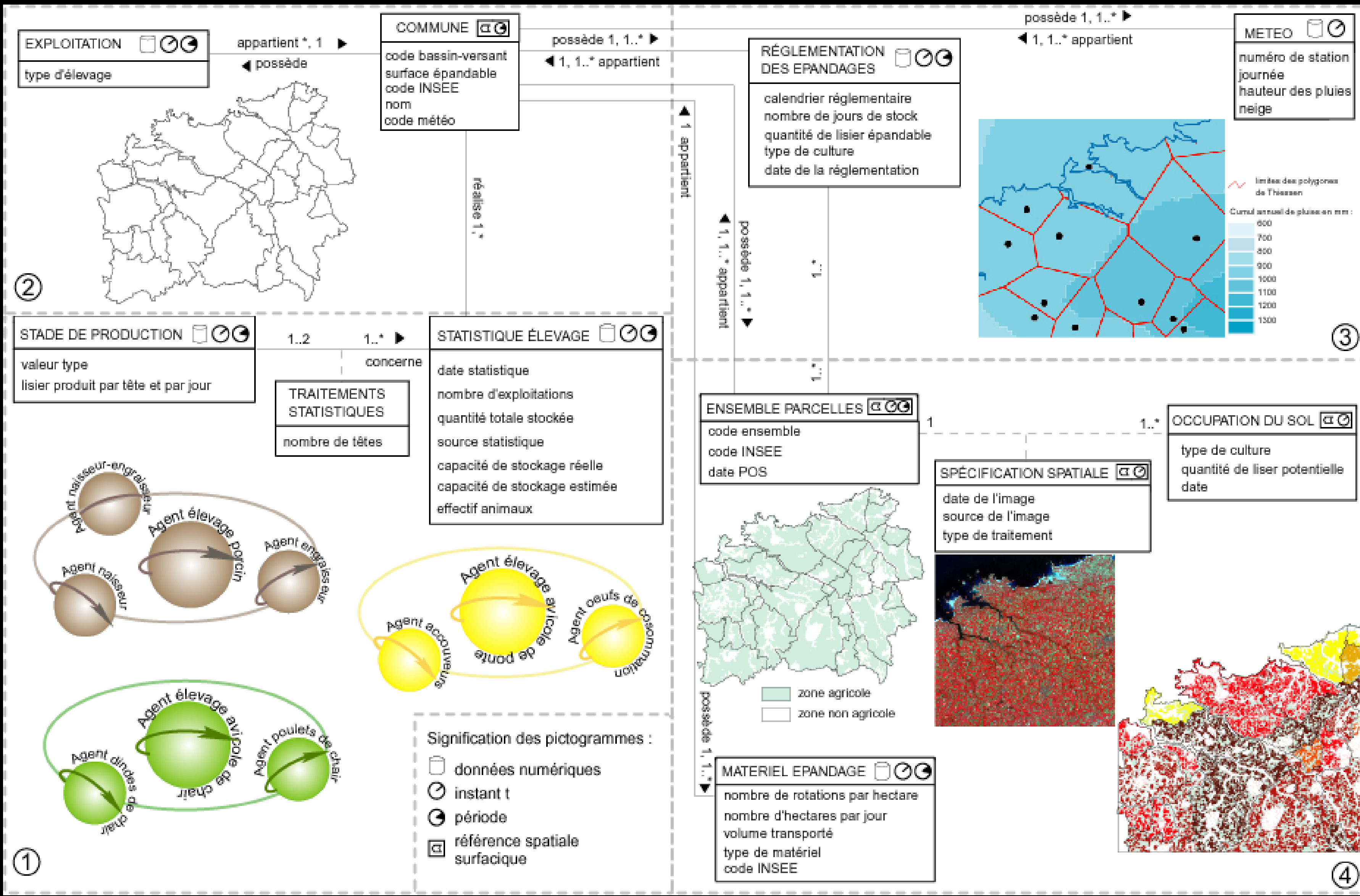
MOITEM: Modeling land-ocean interactions in the Bay of Brest



Land-Ocean model

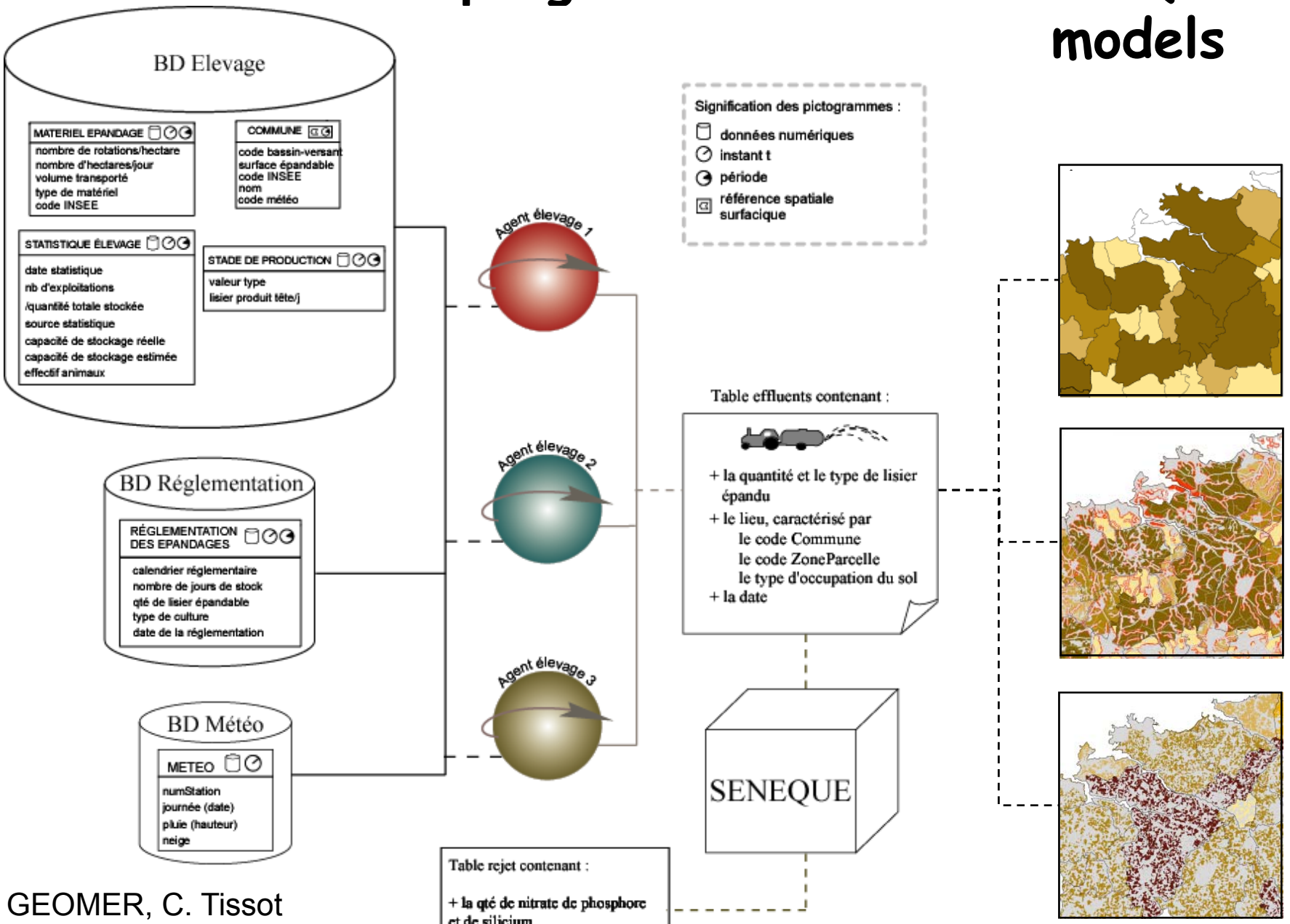
Functioning of the Bay of Brest

Help for decision making



EXPLOITATION
type d'élevage
appartient *, 1
possède
COMMUNE
code bassin-versant
surface épandable
code INSEE
nom
code météo
possède 1, 1..*
1, 1..* appartient
RÉGLEMENTATION DES EPANDAGES
calendrier réglementaire
nombre de jours de stock
quantité de lisier épandable
type de culture
date de la réglementation
possède 1, 1..*
1, 1..* appartient
METEO
numéro de station
journée
hauteur des pluies
neige
limites des polygones de Thiessen
Cumul annuel de pluies en mm :
600
700
800
900
1000
1100
1200
1300
réalise 1..*
1 appartient
1, 1..* appartient
possède 1, 1..*
1..*
1..*
2
3
STADE DE PRODUCTION
valeur type
lisier produit par tête et par jour
1..2
1..*
concerne
TRAITEMENTS STATISTIQUES
nombre de têtes
STATISTIQUE ÉLEVAGE
date statistique
nombre d'exploitations
quantité totale stockée
source statistique
capacité de stockage réelle
capacité de stockage estimée
effectif animaux
ENSEMBLE PARCELLES
code ensemble
code INSEE
date POS
1
1..*
OCCUPATION DU SOL
type de culture
quantité de liser potentielle
date
SPÉCIFICATION SPATIALE
date de l'image
source de l'image
type de traitement
zone agricole
zone non agricole
possède 1, 1..*
MATERIEL EPANDAGE
nombre de rotations par hectare
nombre d'hectares par jour
volume transporté
type de matériel
code INSEE
Agent naisseur-engraisseur
Agent élevage porcin
Agent naisseur
Agent engraisseur
Agent élevage avicole de ponte
Agent accouveurs
Agent oeufs de consommation
Agent élevage avicole de chair
Agent dindes de chair
Agent poulets de chair
Signification des pictogrammes :
données numériques
instant t
période
référence spatiale surfacique
1
4

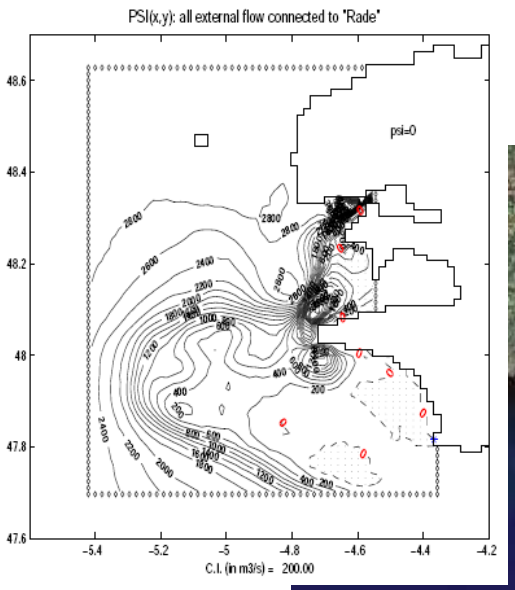
Coupling of DAHU and SENEQUE models

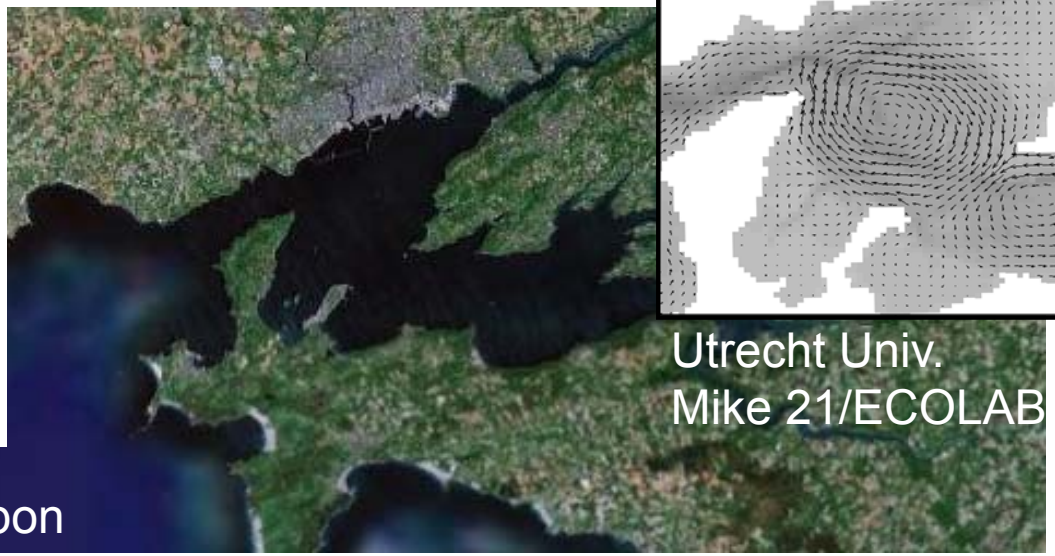


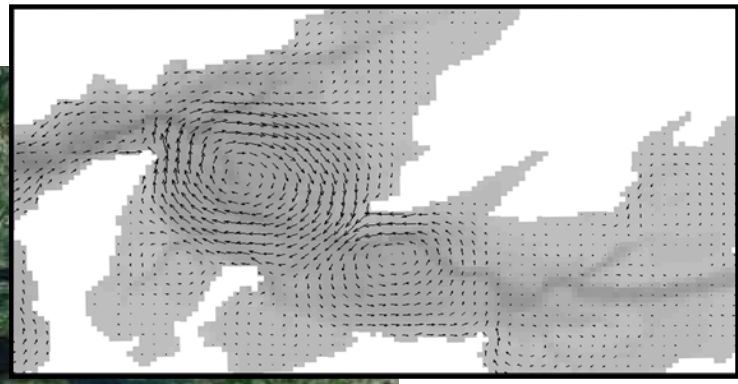
GEOMER, C. Tissot
SAS (CAREN), Paris VI

Modeling the Bay of Brest

Ph.D. Lemar: M. Raimonet







Utrecht Univ.
Mike 21/ECOLAB

Ph.D. LPO: G. Campbon

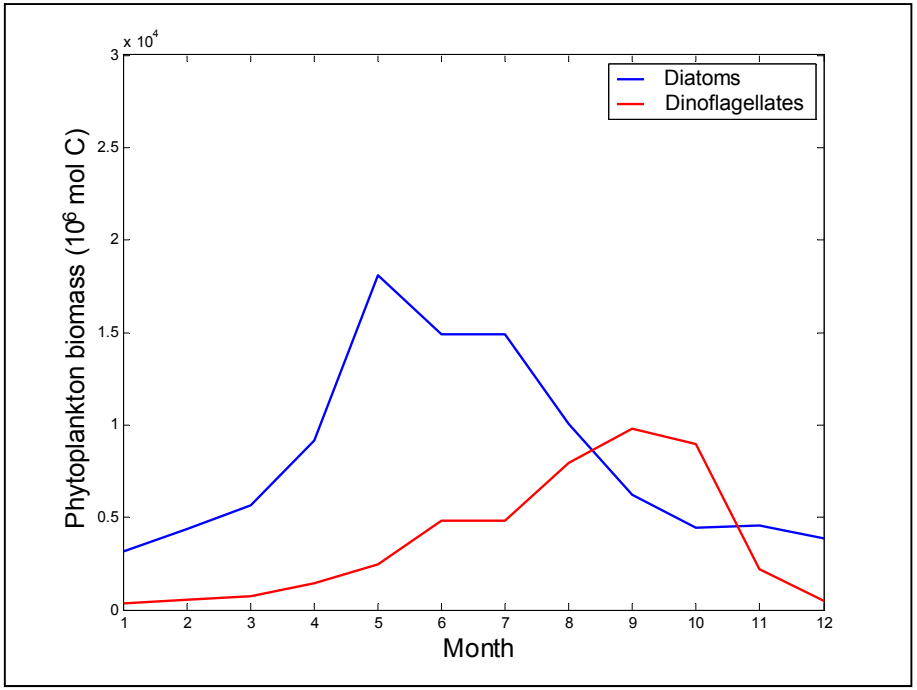
Coupled physical-biological model, benthic-pelagic coupling
Simplified (but realistic ☺) biological model

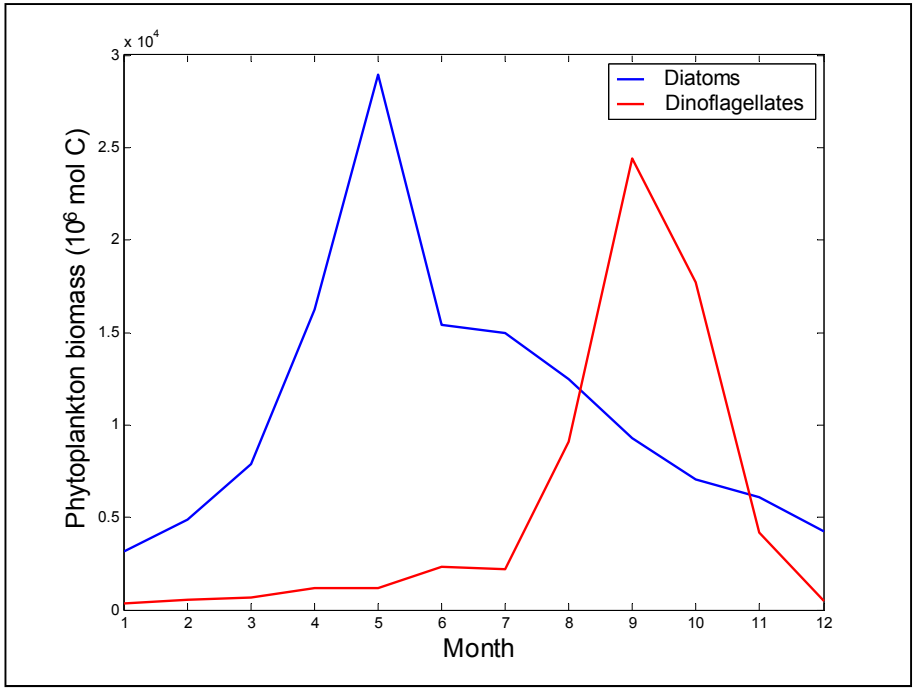
Useful to study the ecosystem functionning and evolution
Useful to determine the impact of the invasive species
Crepidula fornicata

Hypothesis to be tested

C. fornicata controls phytoplankton dynamics through the Si cycle

Scenarii: Year 2001 (Laruelle et al., MEPS, accepted)

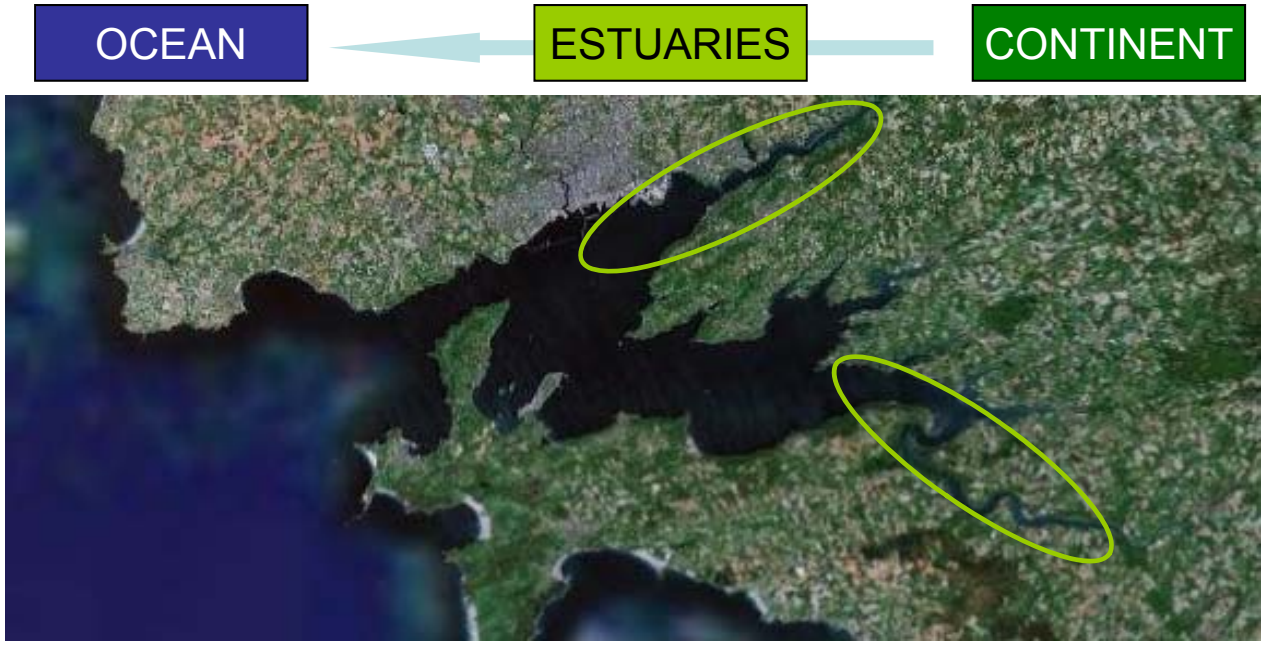




With *Crepidula fornicata*

Without *Crepidula fornicata*

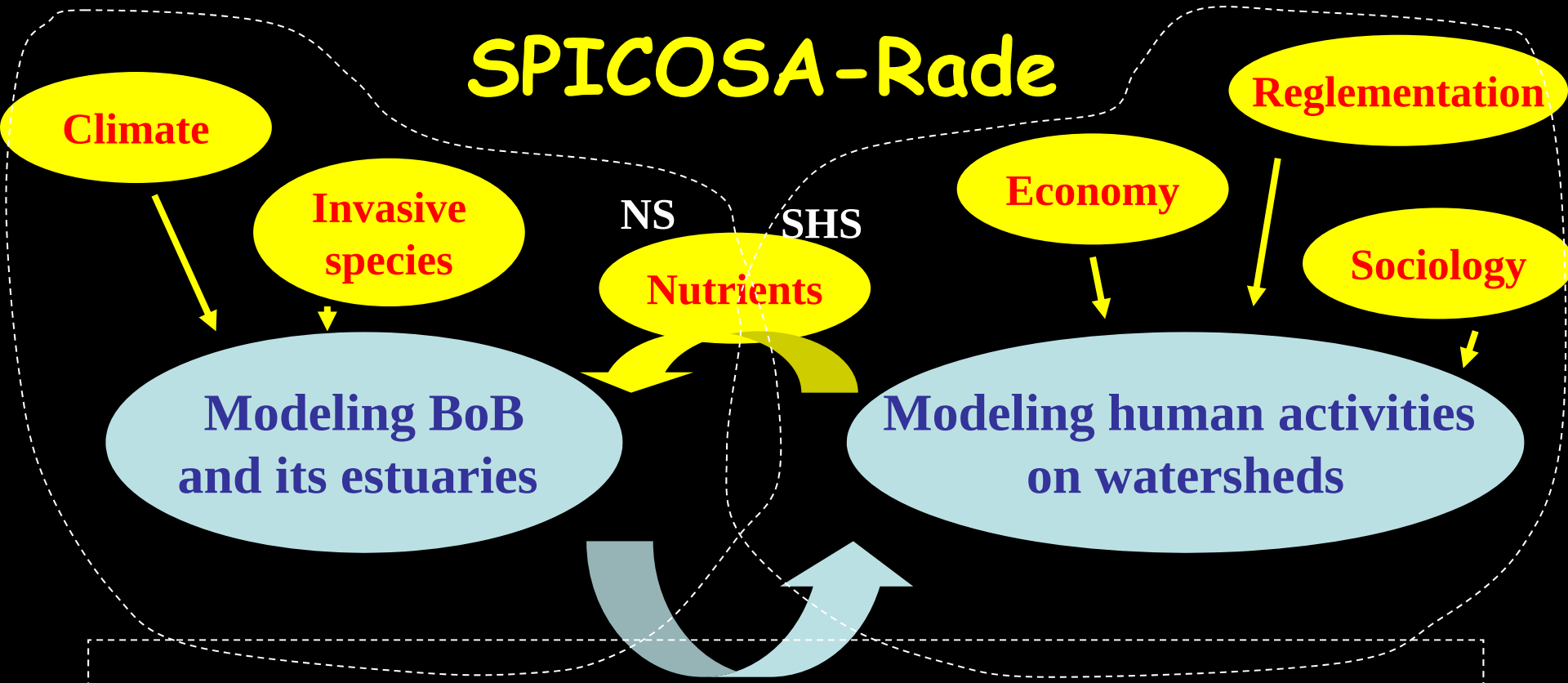
MOITEM-estuaires (EC2CO)



Objectives : to study the fate of river inputs (dissolved AND particulate) upon estuarine mixing

Methodology : seasonal surveys along Aulne and Elorn estuaries
emphasis on small and short time scales
production and degradation, water column and sediments

Collaborations : LEMAR (Si, OM), Chimie Marine (N), DYNECO (P), ECOBIO, LSCE, LGE



Systemic approach in the Bay of Brest

- Issue, system definition, system formulation…
- Co-construction of scenarios
- ESE Analyses of scénarios
- Decision tools

Science in Society, Society in Science

Merci à tous !

Thématiques scientifiques

Gestion Intégrée de la Zone Côtière