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Fisheries and Oceans Canada

Integrating macroalgae & wild bivalve populations to improve an ecosystem model

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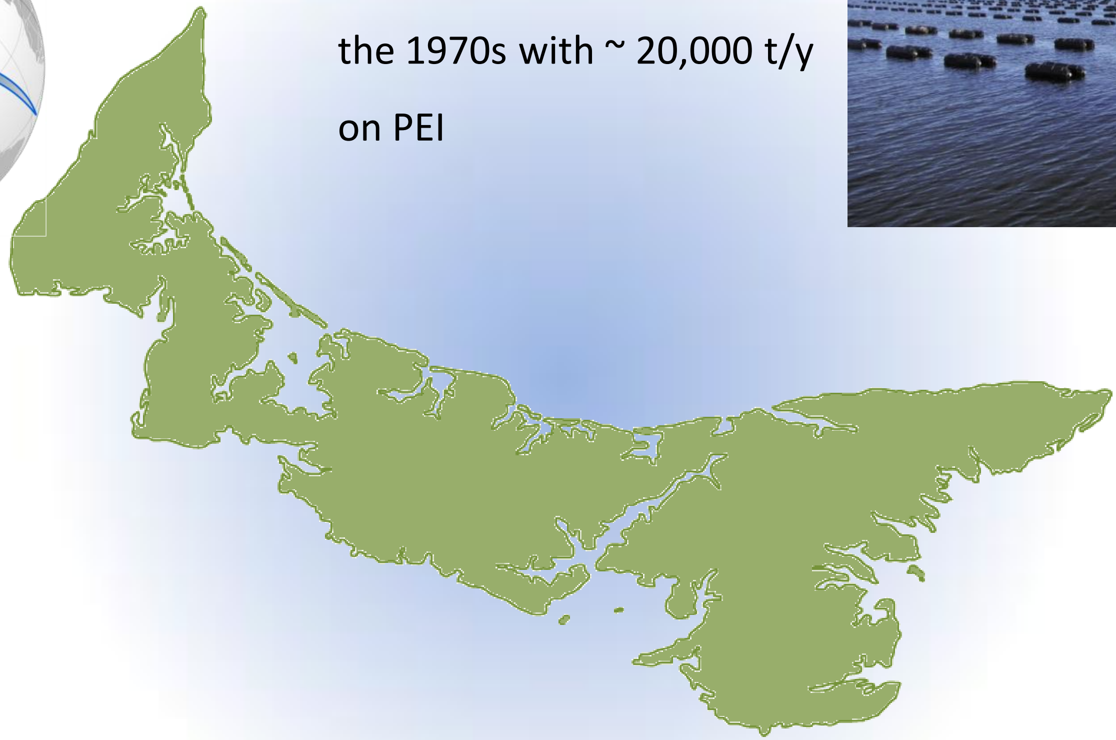
DEB2019 1-12 April 2019 / Brest (France)

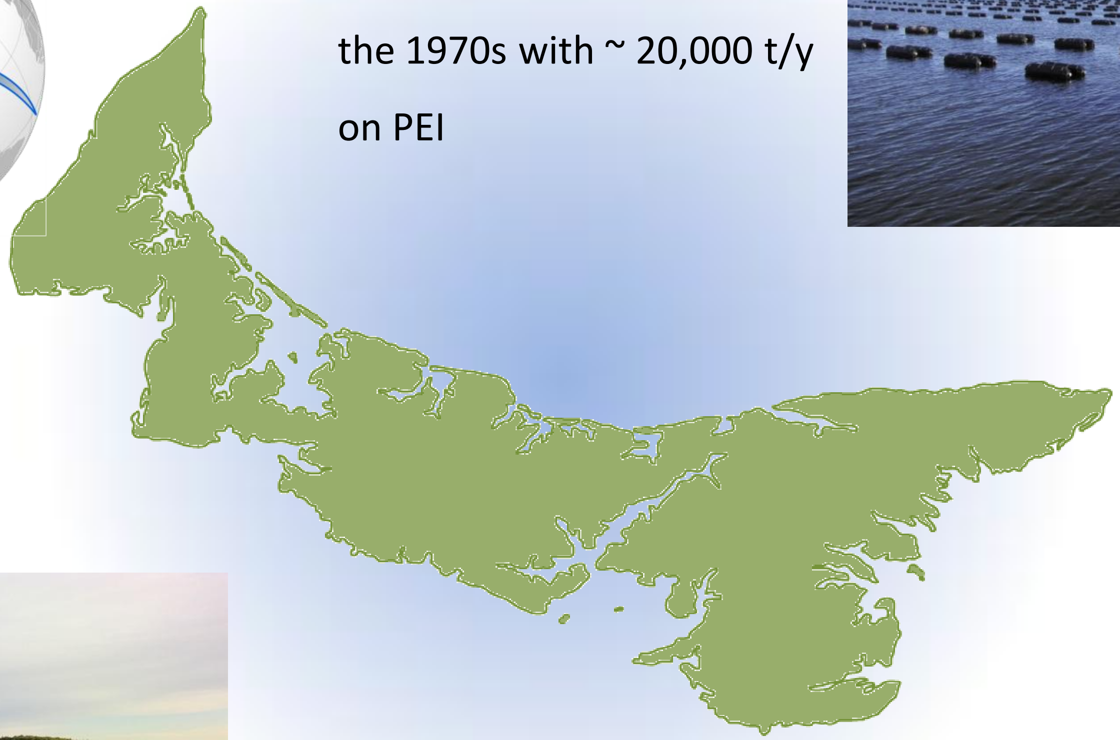
INTRODUCTION



<u>Aquaculture activities</u>

- Important industry since the 1970s with ~ 20,000 t/y on PEI

INTRODUCTION



Aquaculture activities

- Important industry since the 1970s with ~ 20,000 t/y on PEI

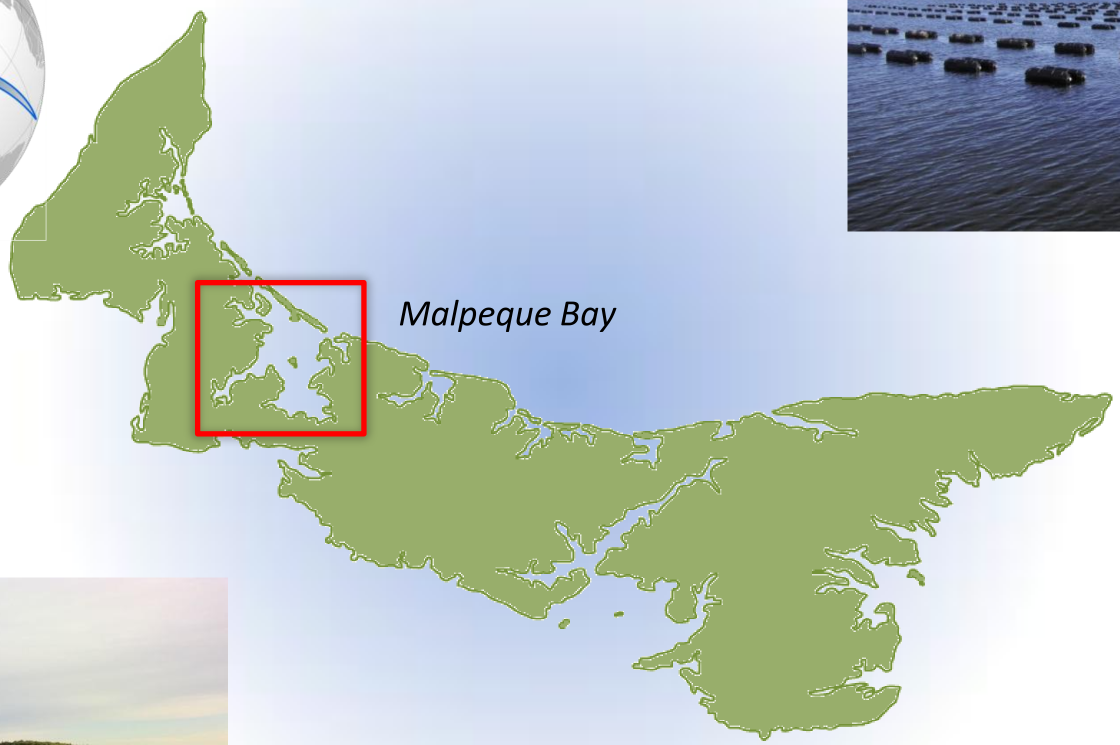
Agriculture

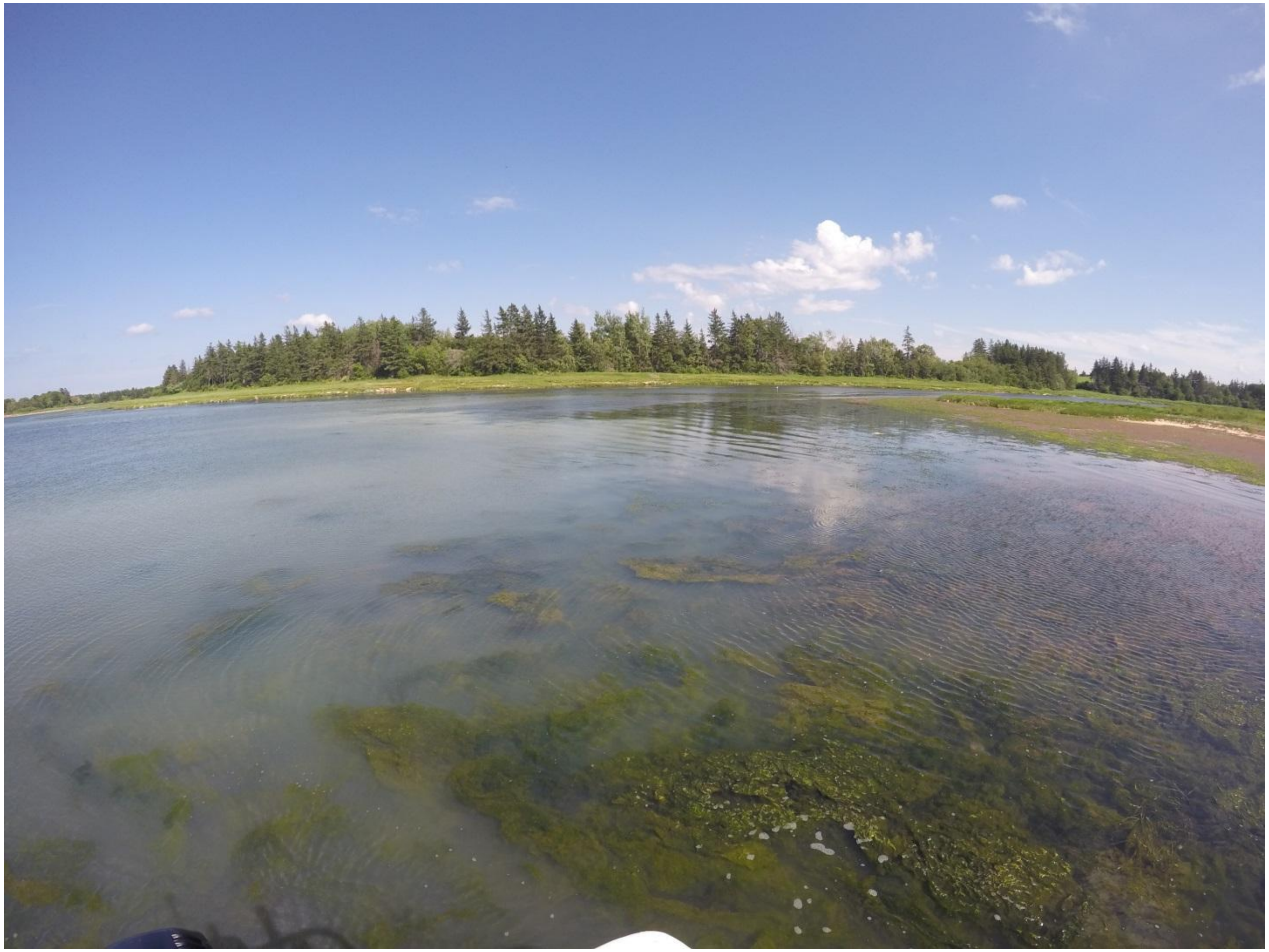
- Nutrient run-off from fertilizers (N and P)
- Contributes to coastal eutrophication (Shaw et al. 1998; Sharp et al. 2003)

INTRODUCTION

- Moratorium on further leasing in 1999
- Request for re-evaluation in 2007

INTRODUCTION

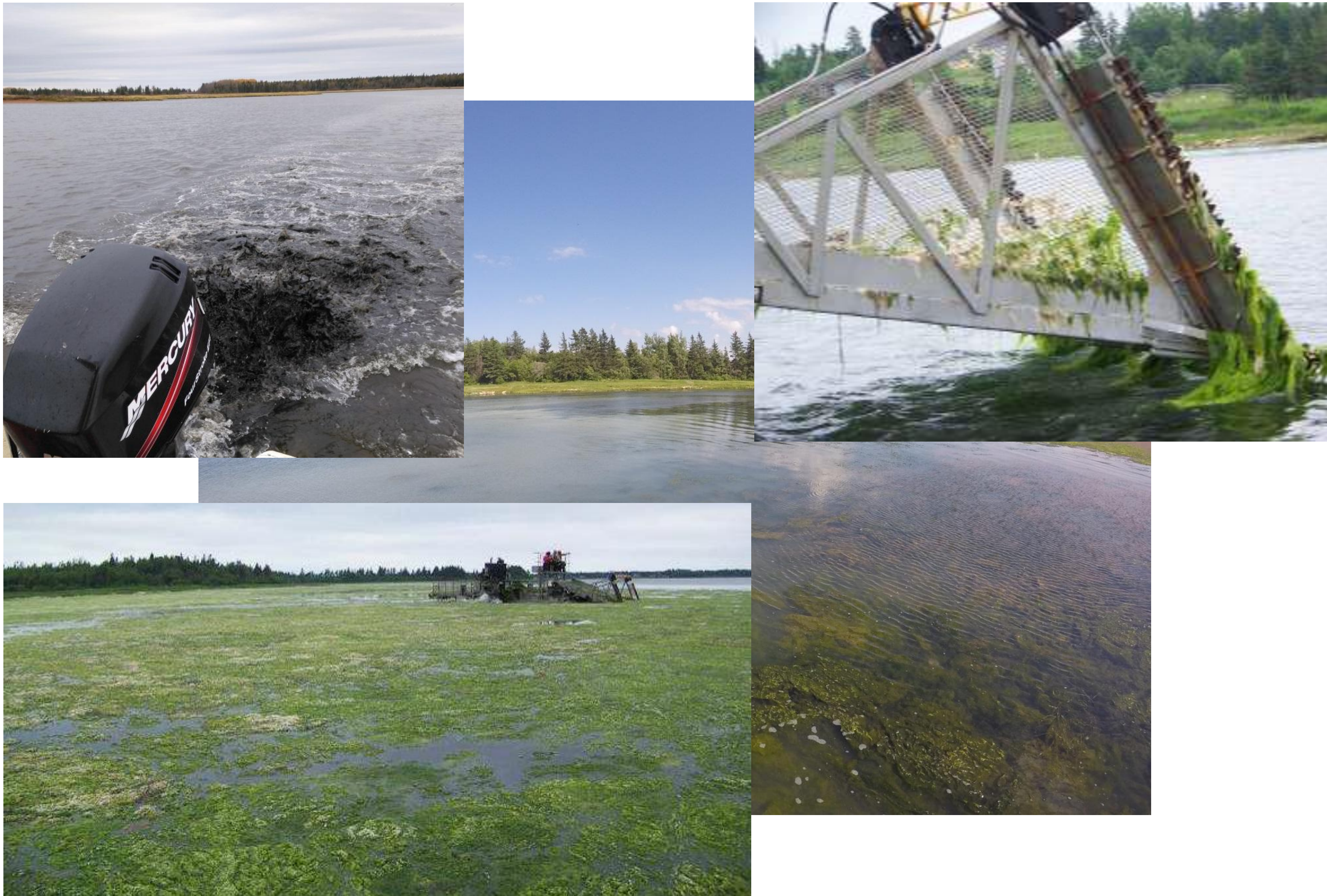




Sea lettuce – *Ulva lactuca*

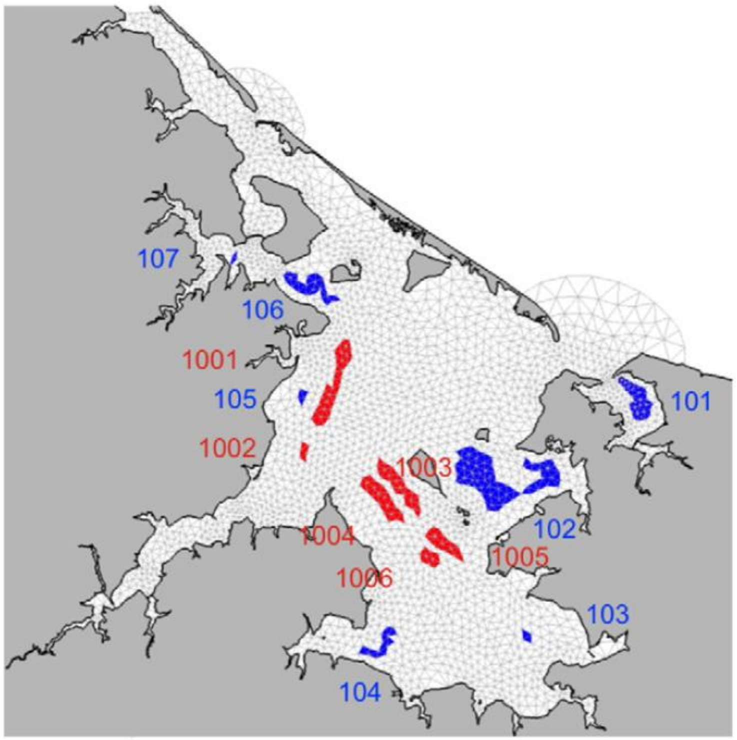
Sea lettuce – *Ulva lactuca*


MERCURY

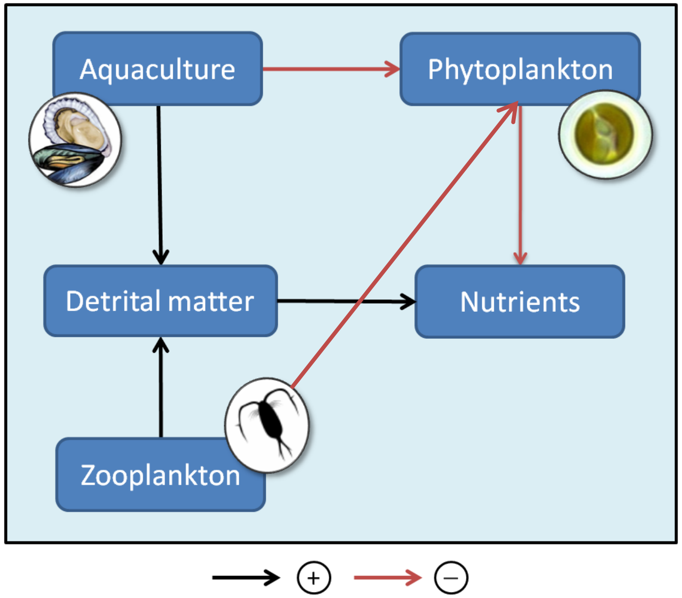

MERCURY

INTRODUCTION

- Marine spatial planning: projected expansion scenarios
  Ecosystem modeling (Carrying capacity)



Current and projected leases



INTRODUCTION

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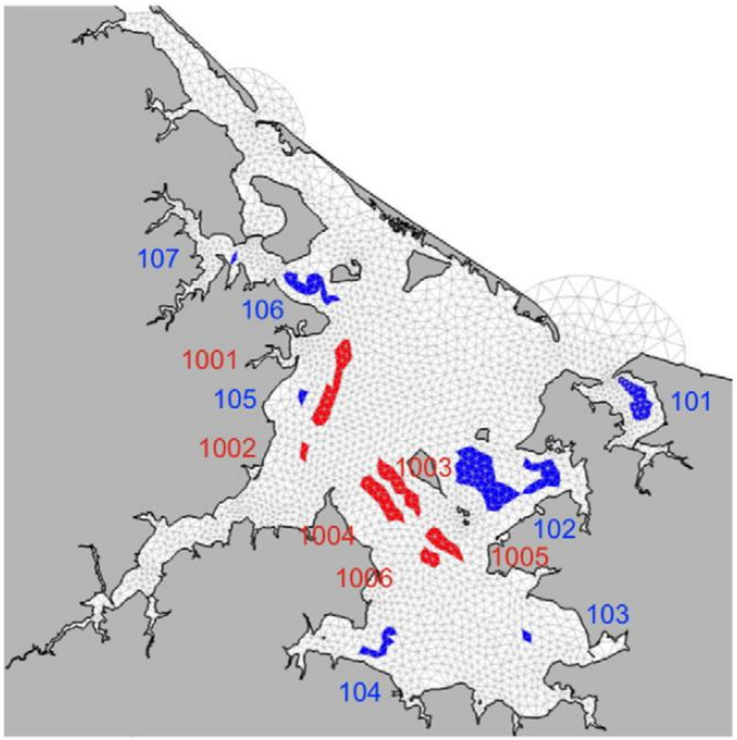

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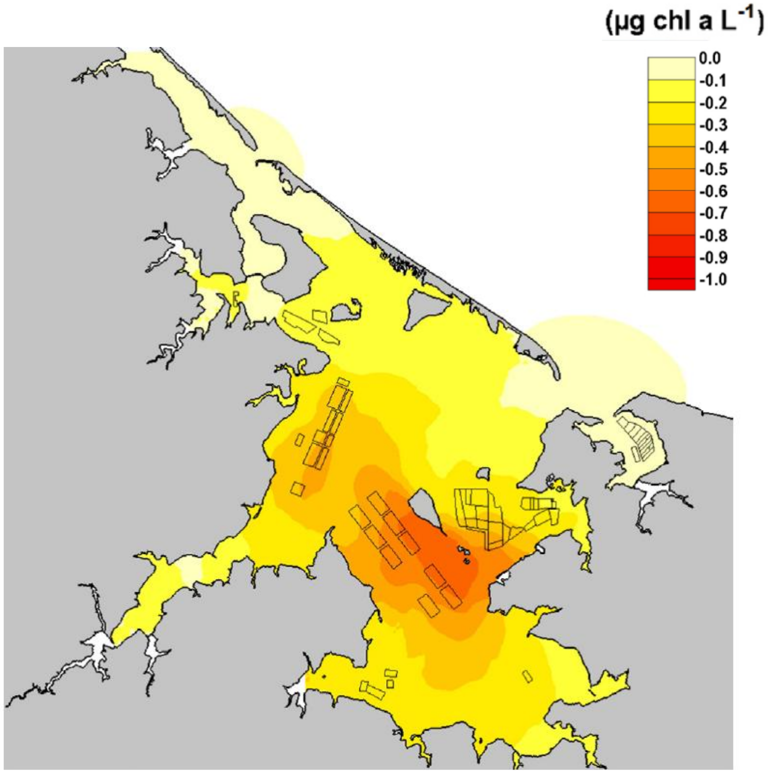
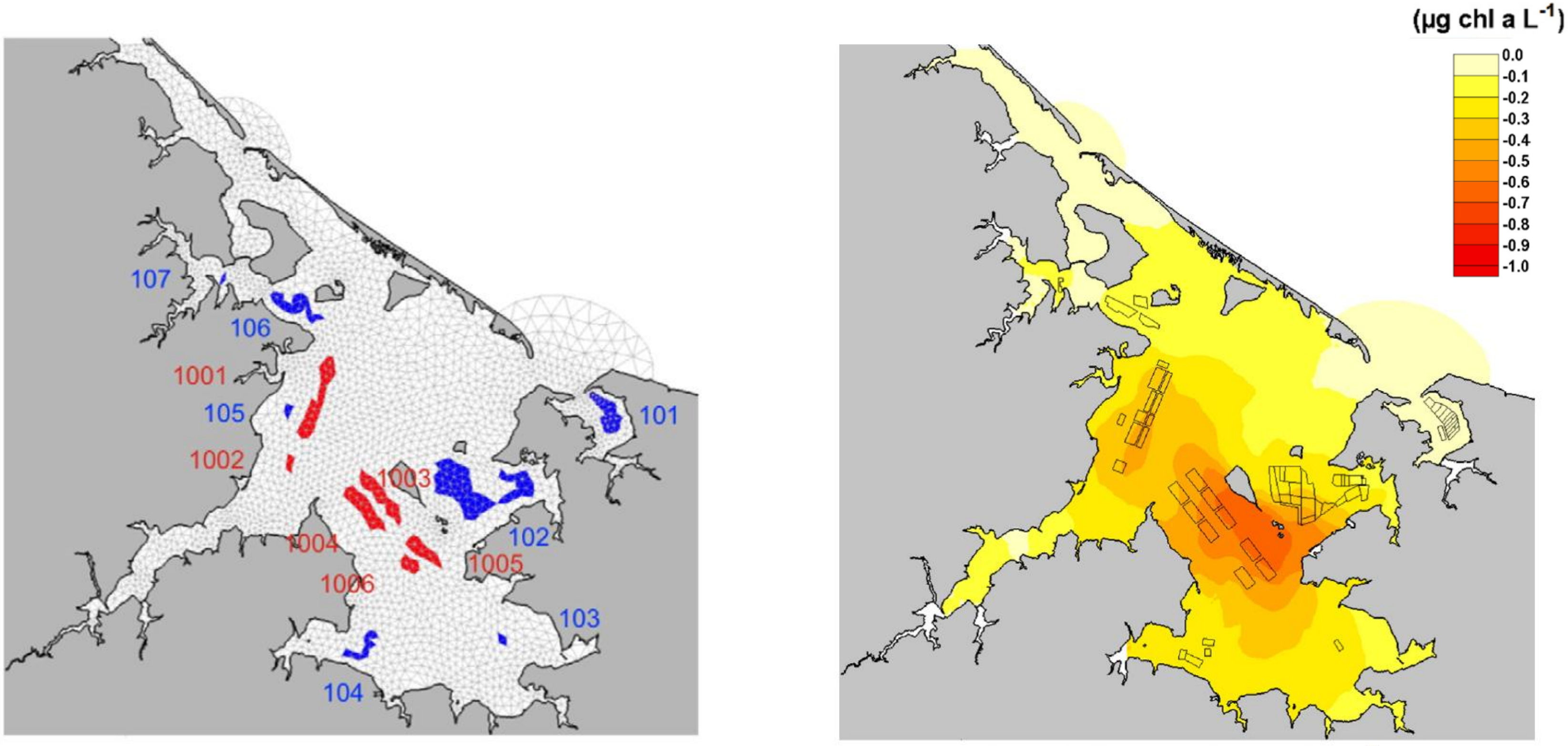


Change in phytoplankton

Filgueira et al. (2015)

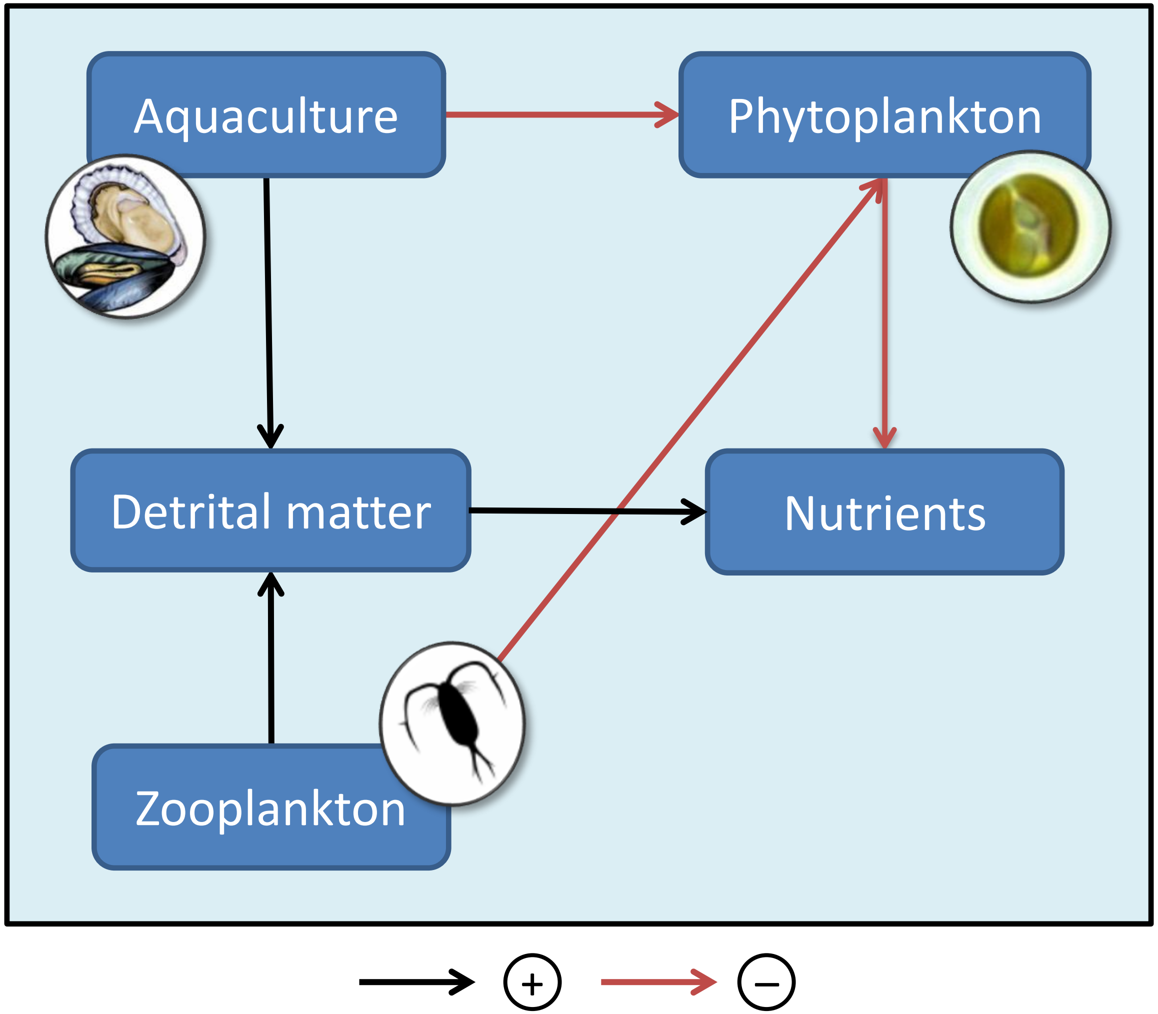
INTRODUCTION

- Marine spatial planning: projected expansion scenarios
  Ecosystem modeling (Carrying capacity)



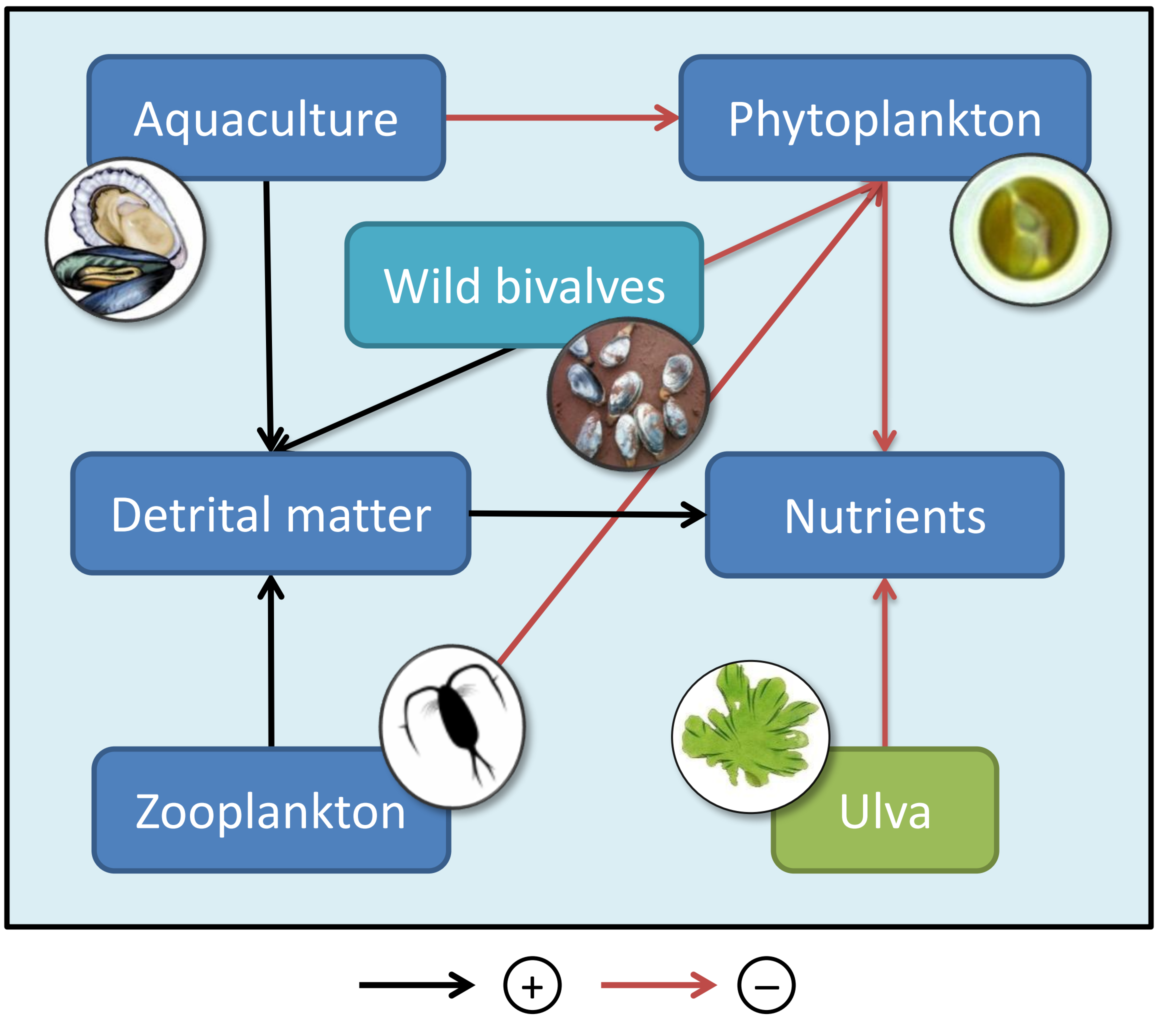
Can we improve model outputs by including other components of the ecosystem?

METHODS

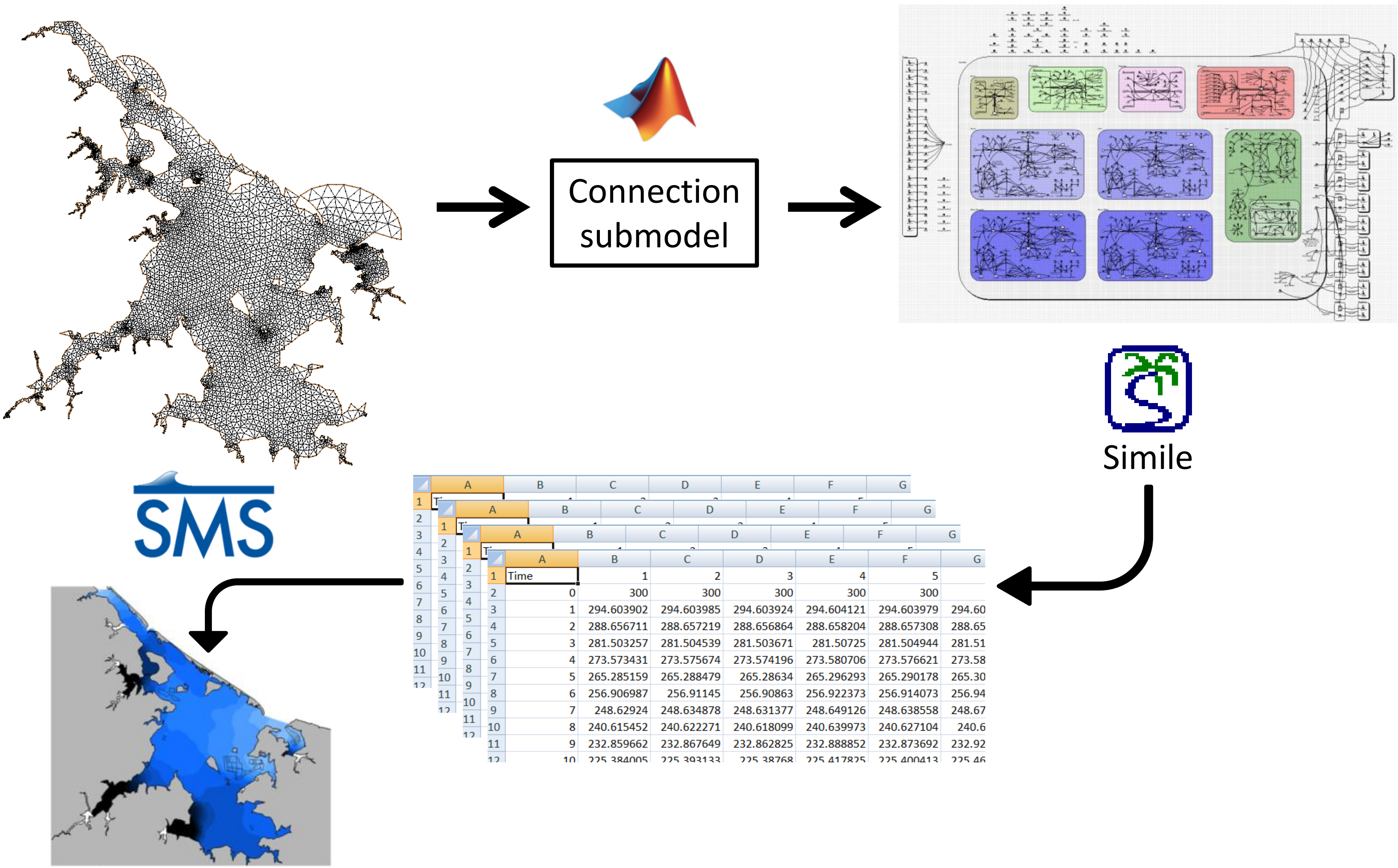


Aquaculture
Phytoplankton
Detrital matter
Nutrients
Zooplankton
+
−

METHODS


Aquaculture
Phytoplankton
Wild bivalves
Detrital matter
Nutrients
Zooplankton
Ulva
+
−

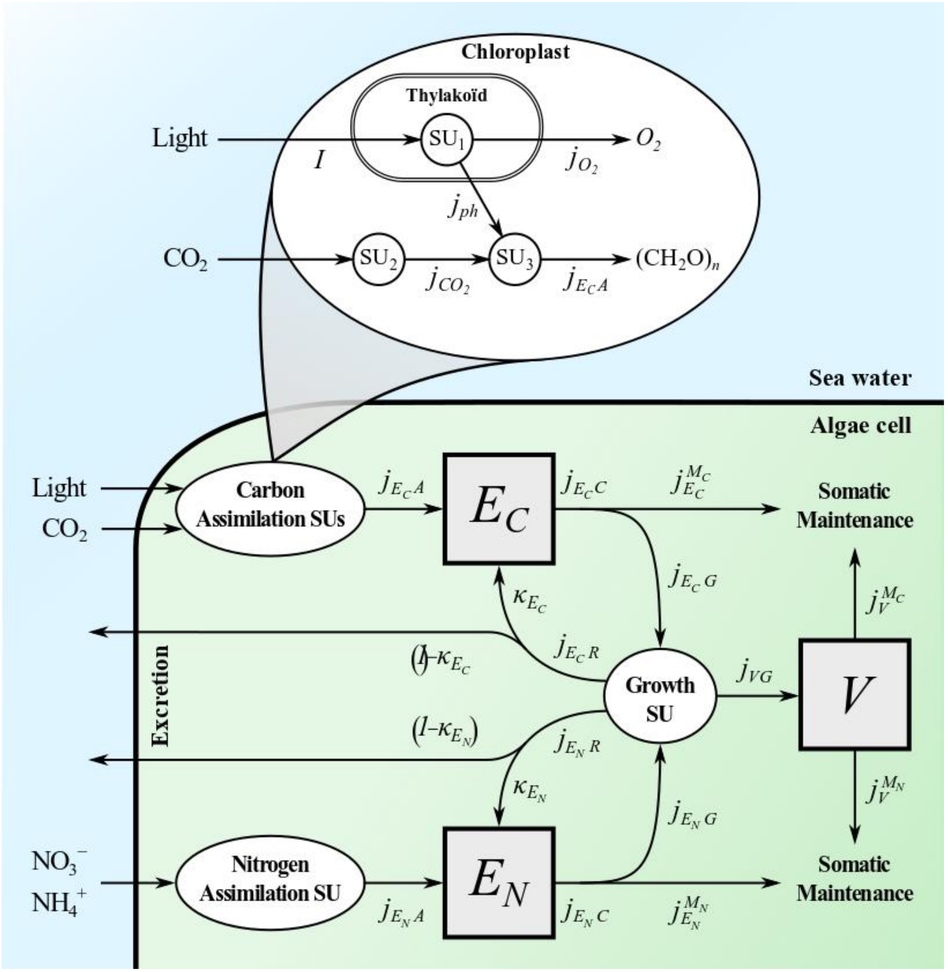
METHODS


Connection submodel
Simile
SMS
A B C D E F G
Time 1 2 3 4 5
0 300 300 300 300 300
1 294.603902 294.603985 294.603924 294.604121 294.603979 294.60
2 288.656711 288.657219 288.656864 288.658204 288.657308 288.65
3 281.503257 281.504539 281.503671 281.50725 281.504944 281.51
4 273.573431 273.575674 273.574196 273.580706 273.576621 273.58
5 265.285159 265.288479 265.28634 265.296293 265.290178 265.30
6 256.906987 256.91145 256.90863 256.922373 256.914073 256.94
7 248.62924 248.634878 248.631377 248.649126 248.638558 248.67
8 240.615452 240.622271 240.618099 240.639973 240.627104 240.6
9 232.859662 232.867649 232.862825 232.888852 232.873692 232.92

METHODS

DEB model with 2 reserves, adapted from a phytoplankton model

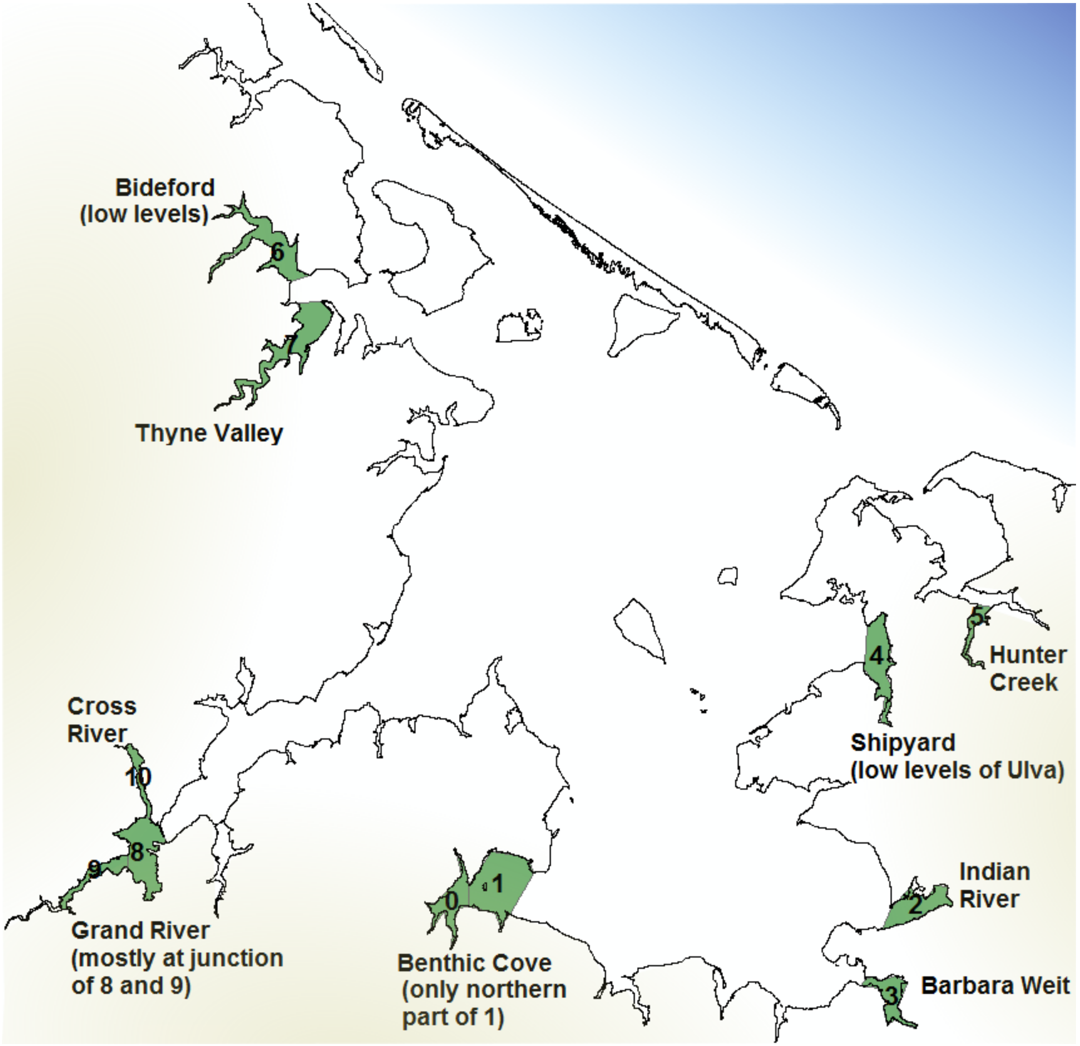
- 3 state variables (V, E_C, and E_N)
- SU dynamics :
    - Photosybthesis (C + light)
    - Growth (V1-morph)
- Shading module based on density
- Parameter calibration on literature data
- Model validation on field data



Lavaud et al. (in prep.)

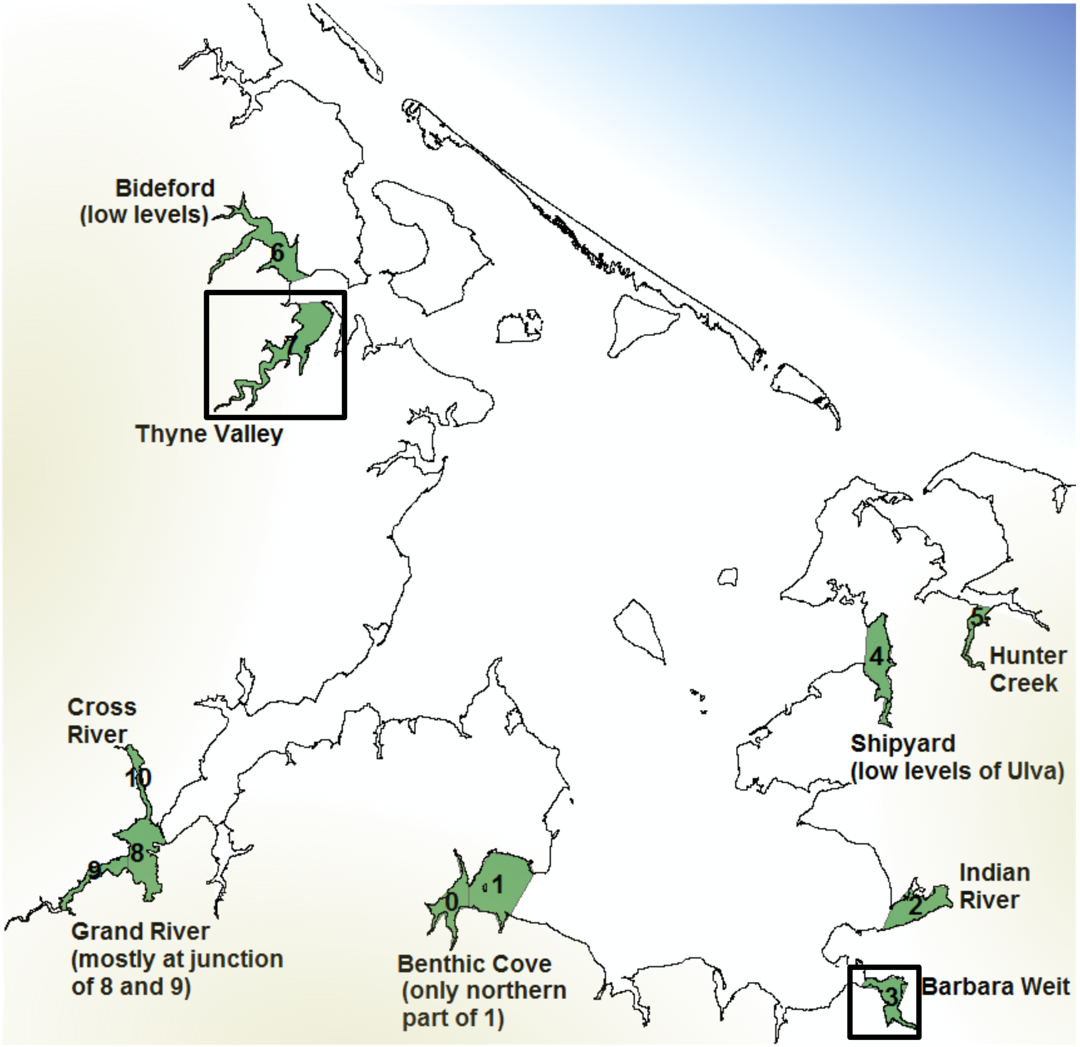
METHODS

- Field study
  - Spatial (2016)



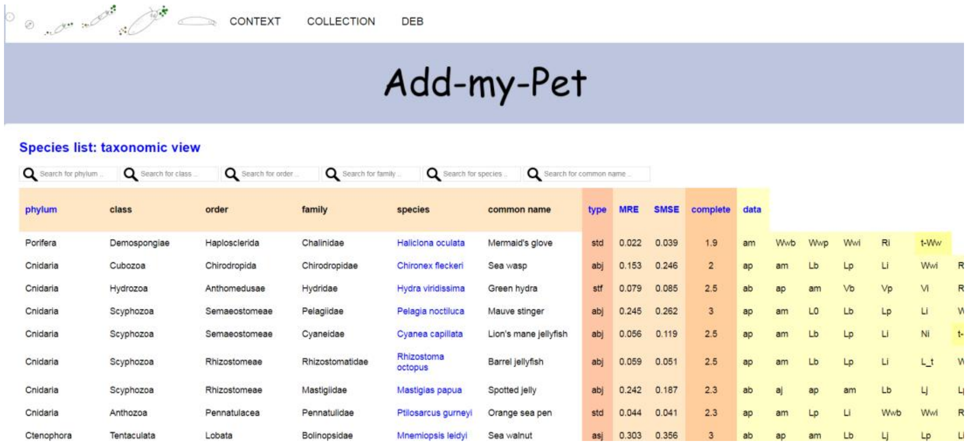
METHODS

- Field study
  - Spatial (2016)
  - Temporal (2017)



METHODS

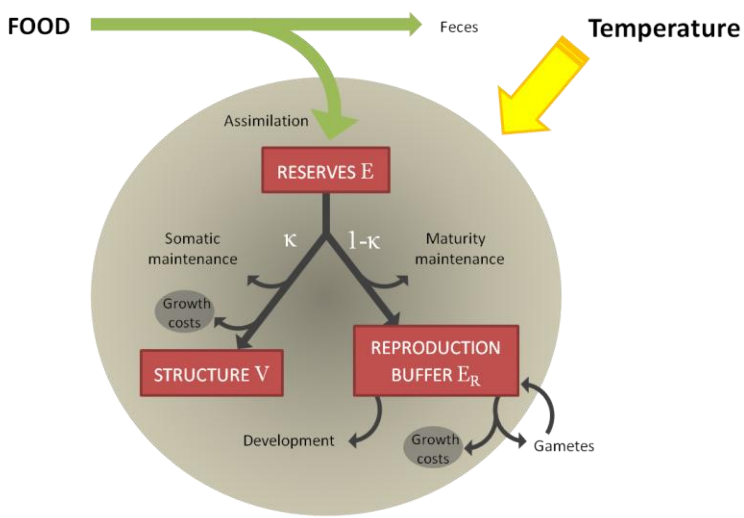
- Standard individual DEB models for wild bivalves



Species list: taxonomic view

Search for phylum ... | Search for class ... | Search for order ... | Search for family ... | Search for species ... | Search for common name ...

phylum	class	order	family	species	common name	type	MRE	SMSE	complete	data						
Porifera	Demospongiae	Haplosclerida	Chalinidae	Haliclona oculata	Mermaid's glove	std	0.022	0.039	1.9	am	Wwb	Wwp	Wwi	Ri	t-Ww	
Cnidaria	Cubozoa	Chirodropida	Chirodropidae	Chironex fleckeri	Sea wasp	abj	0.153	0.246	2	ap	am	Lb	Lp	Li	Wwi	R
Cnidaria	Hydrozoa	Anthomedusae	Hydridae	Hydra viridissima	Green hydra	stf	0.079	0.085	2.5	ab	ap	am	Vb	Vp	Vi	R
Cnidaria	Scyphozoa	Semaeostomeae	Pelagiidae	Pelagia noctiluca	Mauve stinger	abj	0.245	0.262	3	ap	am	L0	Lb	Lp	Li	W
Cnidaria	Scyphozoa	Semaeostomeae	Cyaneidae	Cyanea capillata	Lion's mane jellyfish	abj	0.056	0.119	2.5	ap	am	Lb	Lp	Li	Ni	t-
Cnidaria	Scyphozoa	Rhizostomeae	Rhizostomatidae	Rhizostoma octopus	Barrel jellyfish	abj	0.059	0.051	2.5	ap	am	Lb	Lp	Li	L_t	W
Cnidaria	Scyphozoa	Rhizostomeae	Mastigiidae	Mastigias papua	Spotted jelly	abj	0.242	0.187	2.3	ab	aj	ap	am	Lb	Lj	L
Cnidaria	Anthozoa	Pennatulacea	Pennatulidae	Ptilosarcus gurneyi	Orange sea pen	std	0.044	0.041	2.3	ap	am	Lp	Li	Wwb	Wwi	R
Ctenophora	Tentaculata	Lobata	Bolinopsidae	Mnemiopsis leidyi	Sea walnut	asj	0.303	0.356	3	ab	ap	am	Lb	Lj	Lp	Li



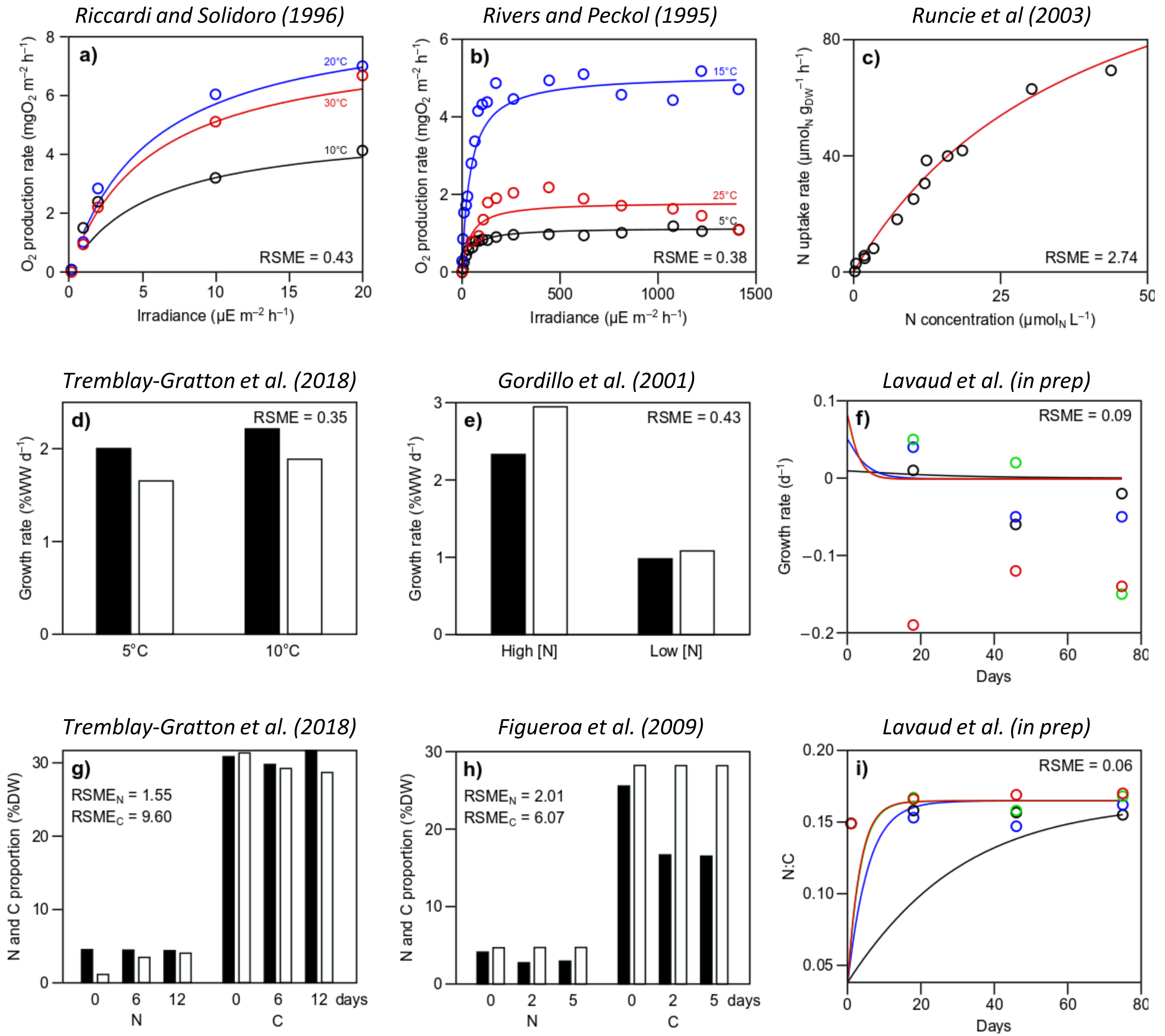
Softshell clam

Eastern oyster

RESULTS

RESULTS

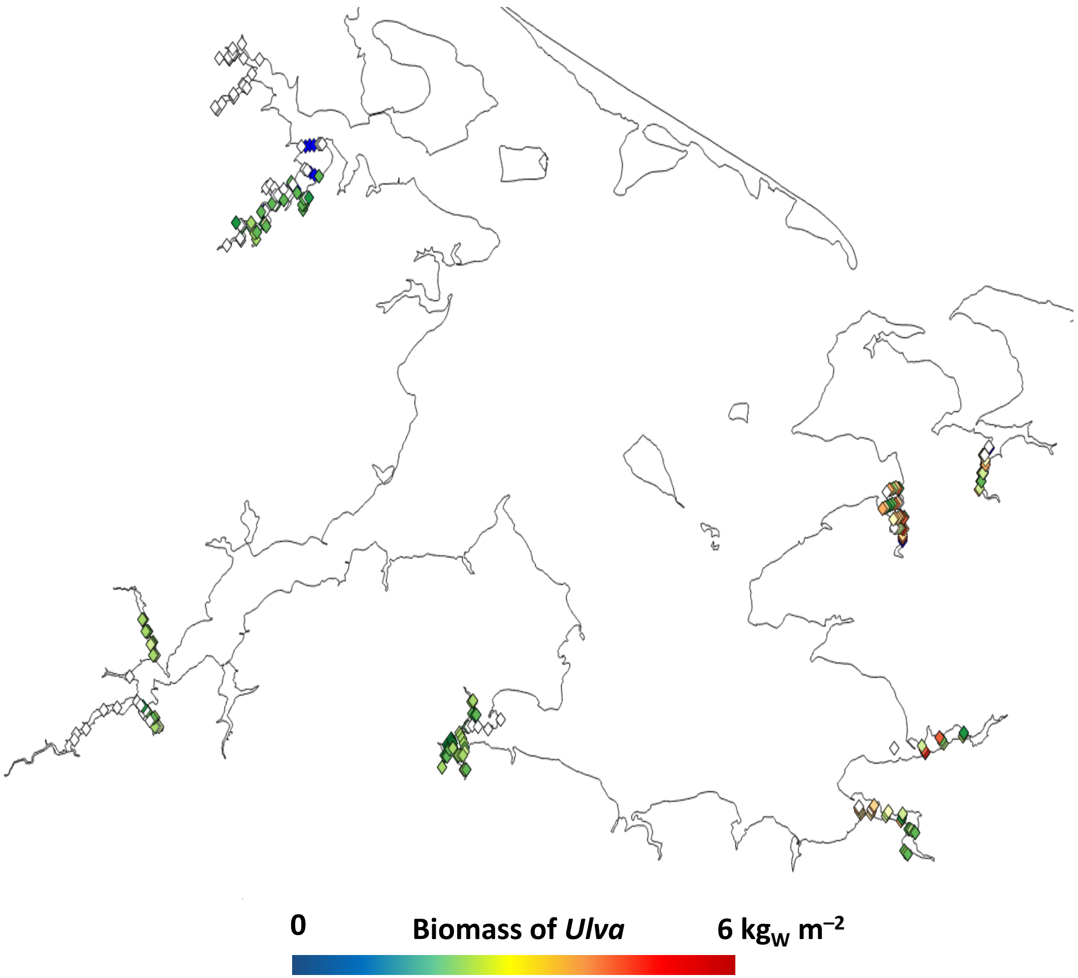
- Parameters calibration



Lavaud et al. (in prep)

RESULTS

- Spatial field study



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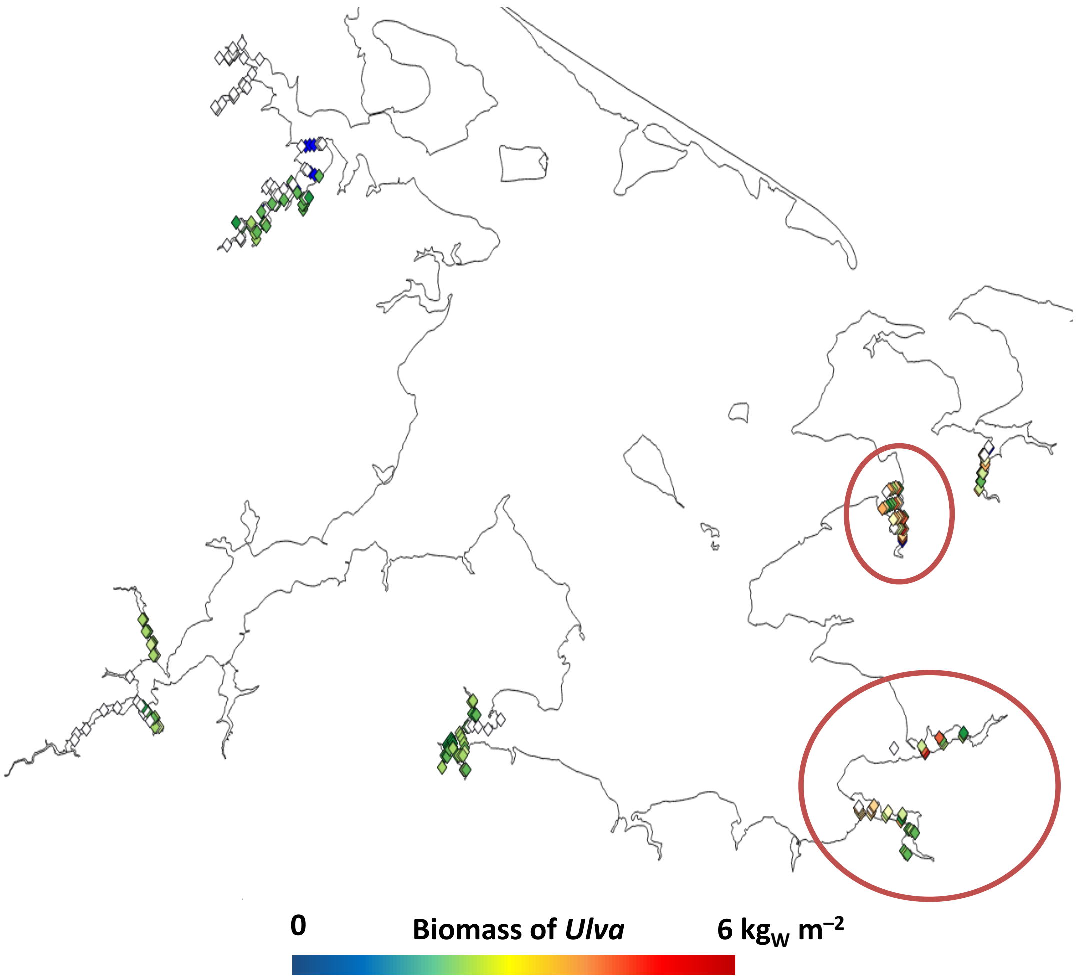

RESULTS

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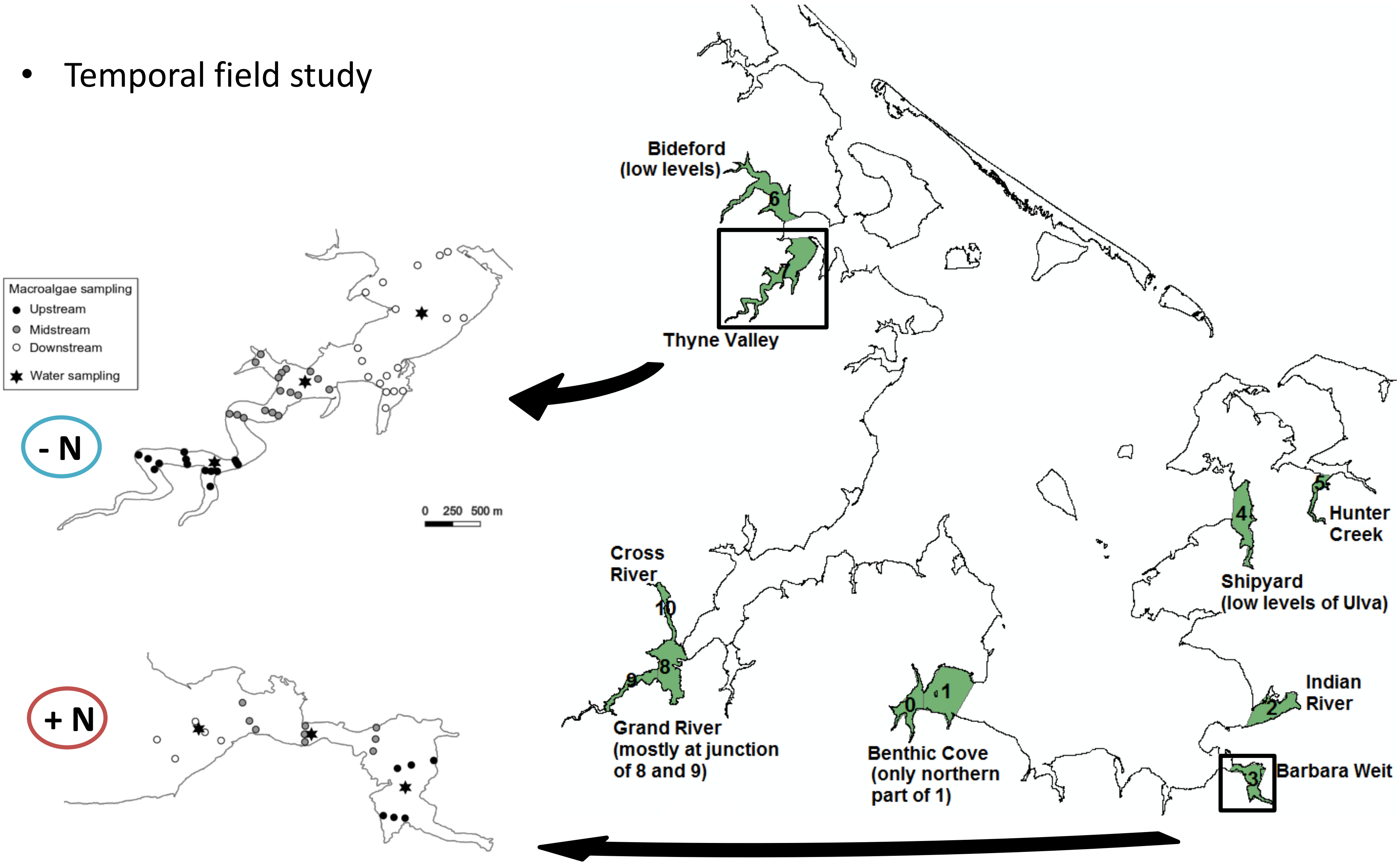

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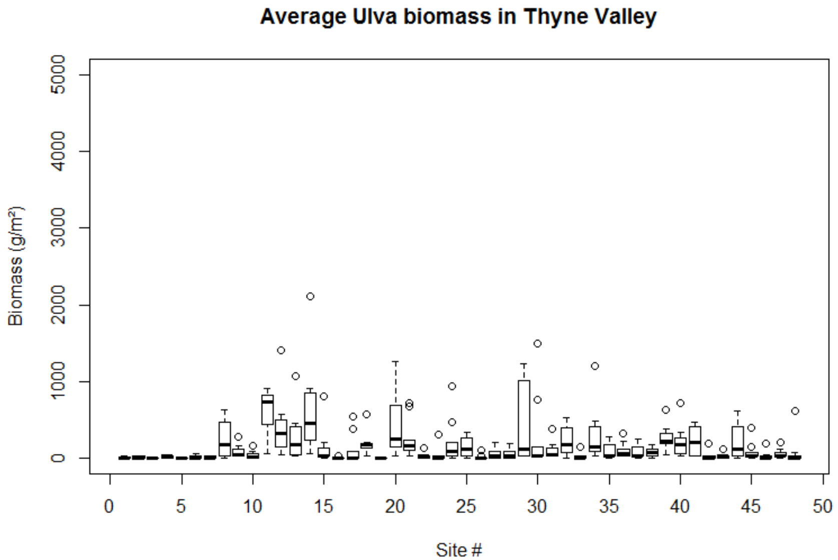
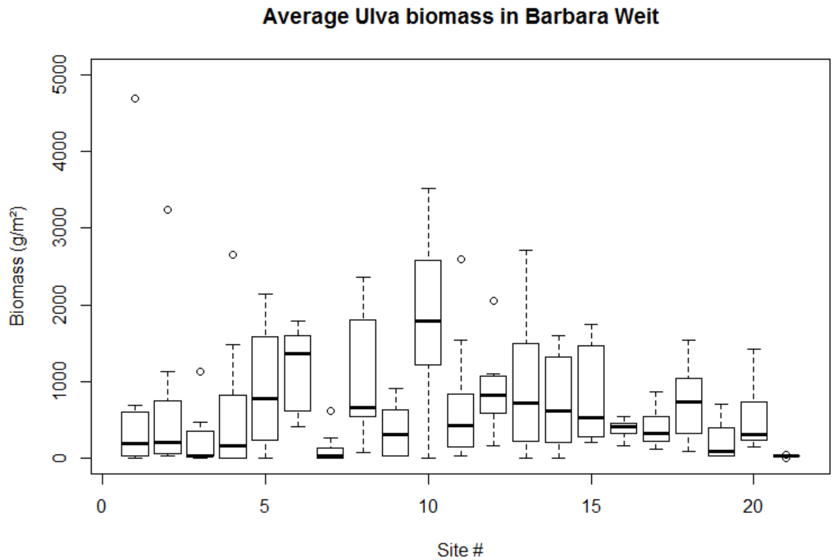
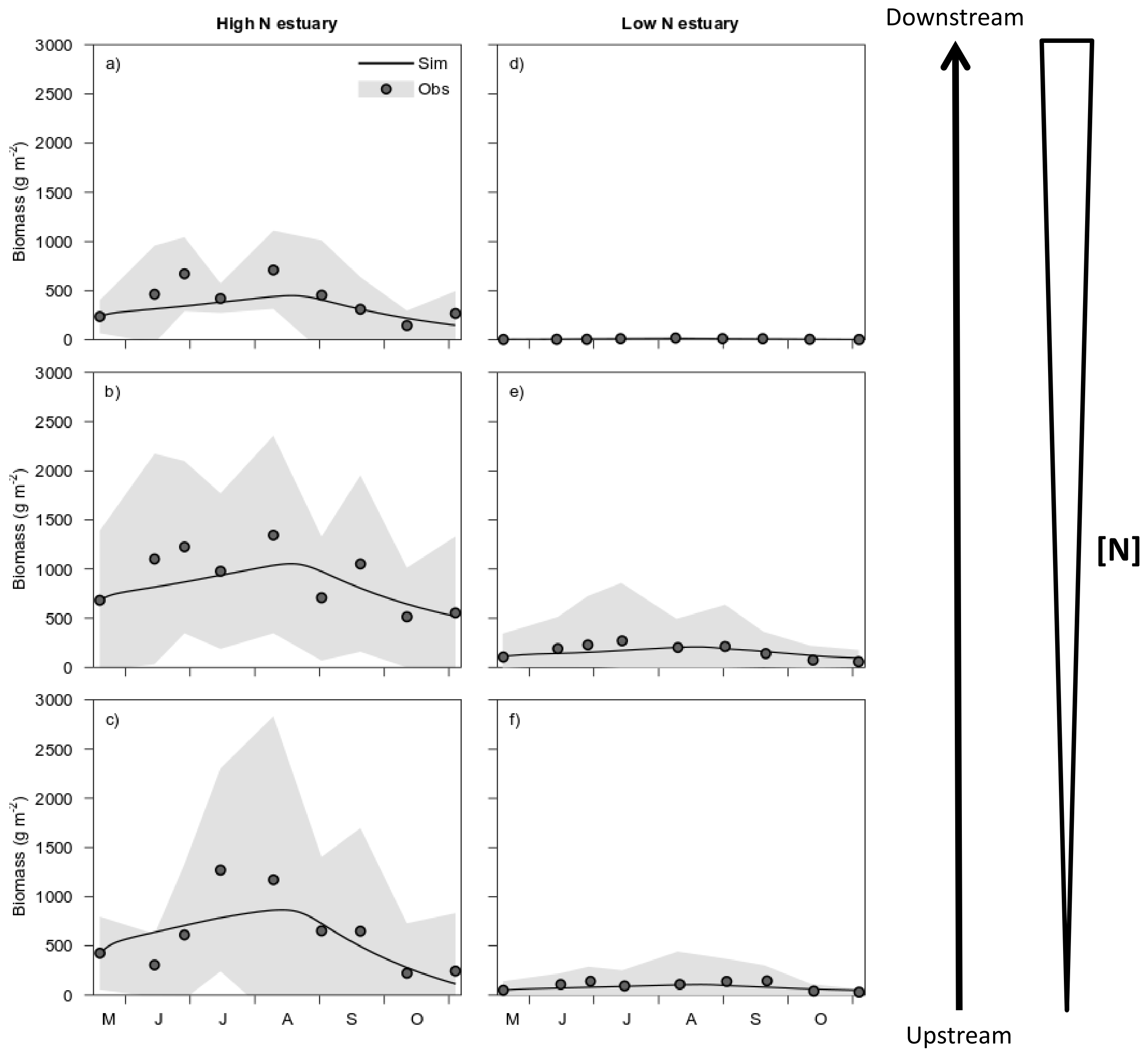




- Weak relationship with local nutrients concentrations: $R^2_{Nitrogen} = 0.40$, $R^2_{Phosphate} = 0.38$
- Strong spatial heterogeneity (limitation of sampling technique)
- Need to keep in mind the influence of wind, current, and the status of degradation (floating mats)

RESULTS

- Model validation



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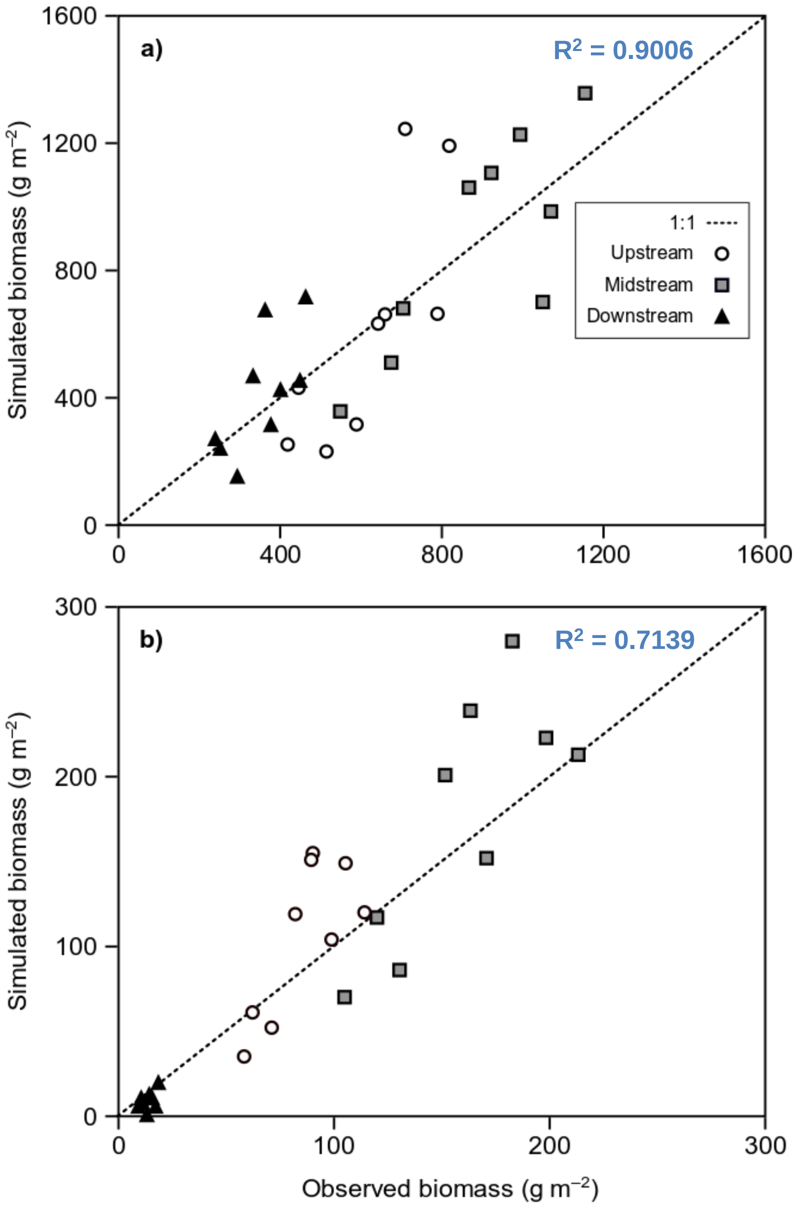
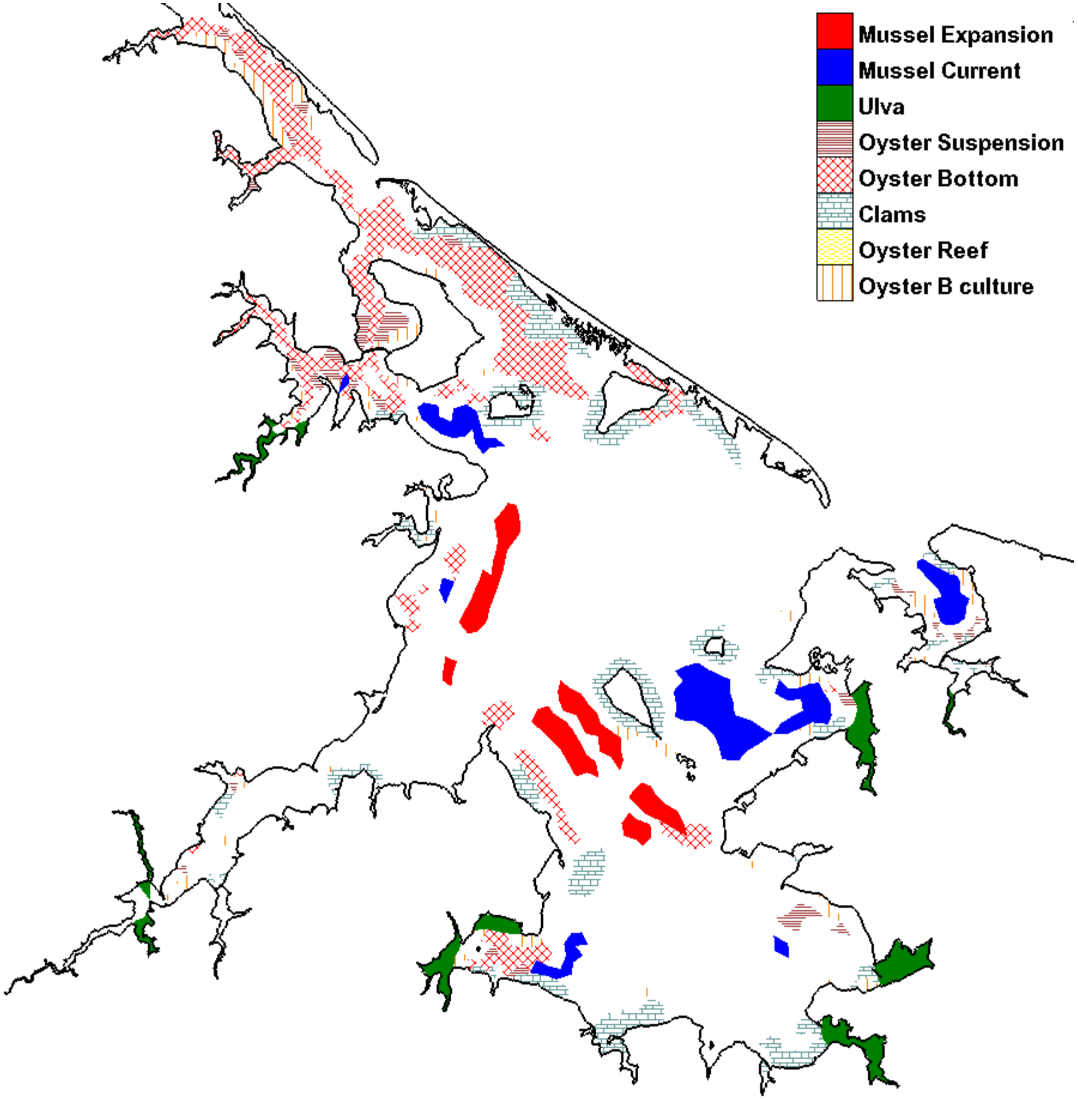


RESULTS

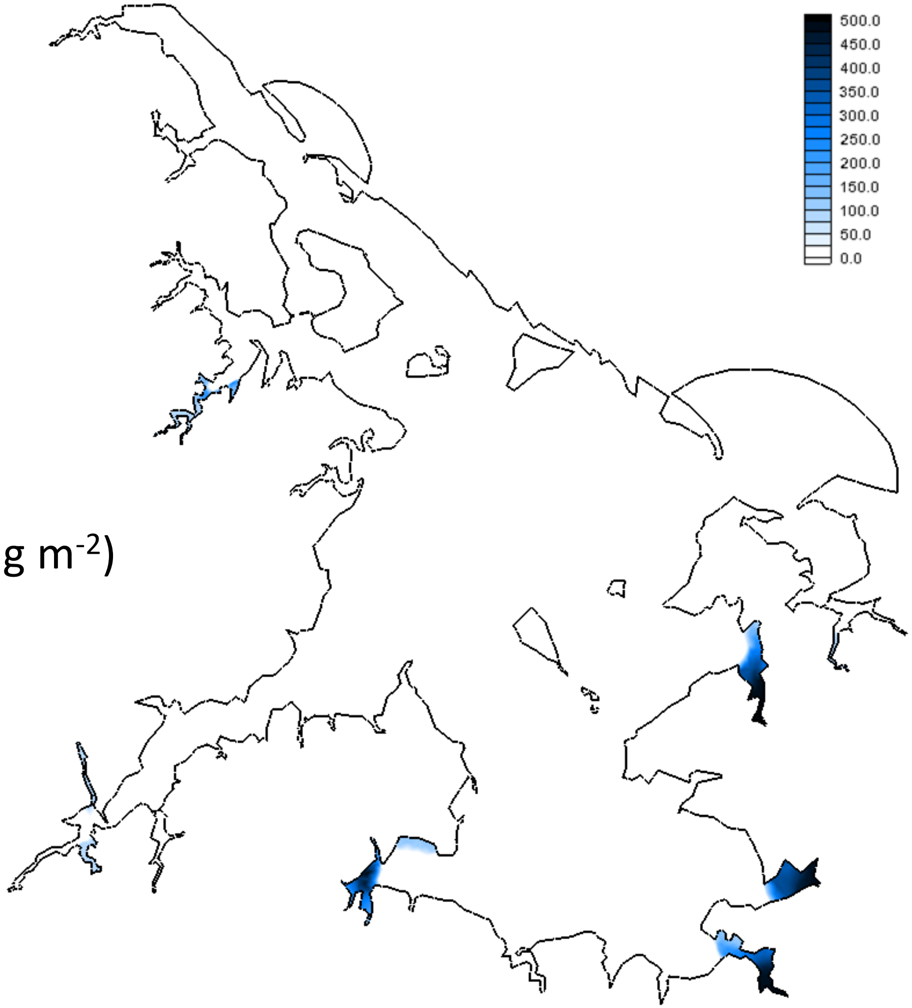
- Wild bivalve populations



RESULTS

- Ecosystem model simulations

Sea lettuce biomass (g m^{-2})



RESULTS

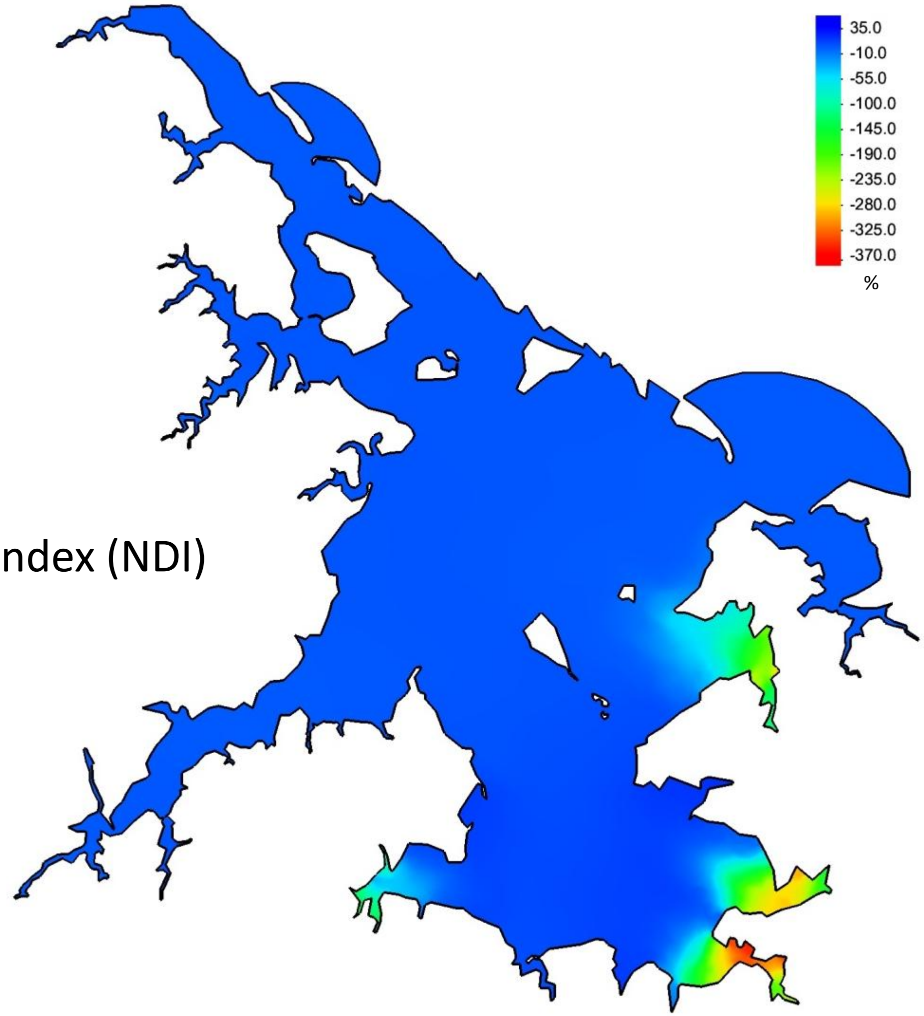
- Ecosystem model simulations

Sea lettuce biomass (g m^{-2})

RESULTS

- Ecosystem model simulations

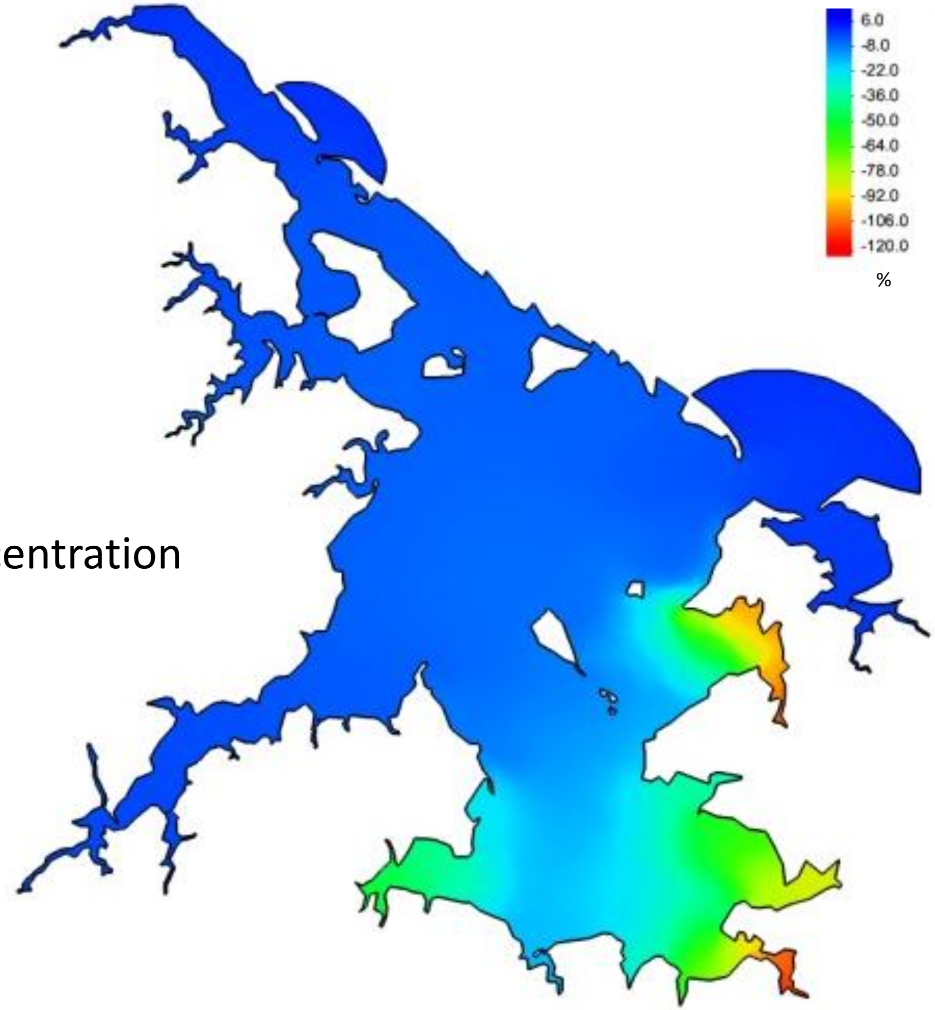
Nitrogen Depletion Index (NDI)



RESULTS

- Ecosystem model simulations

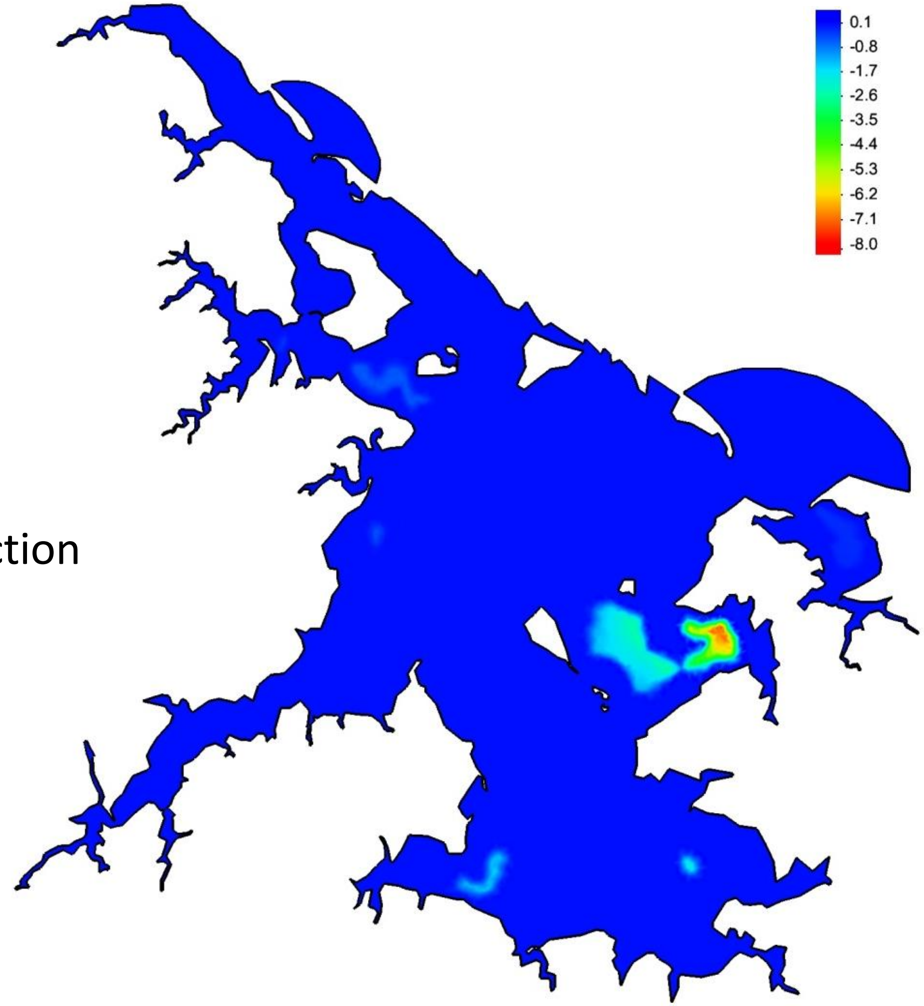
Phytoplankton concentration reduction



RESULTS

- Ecosystem model simulations

Mussel length reduction



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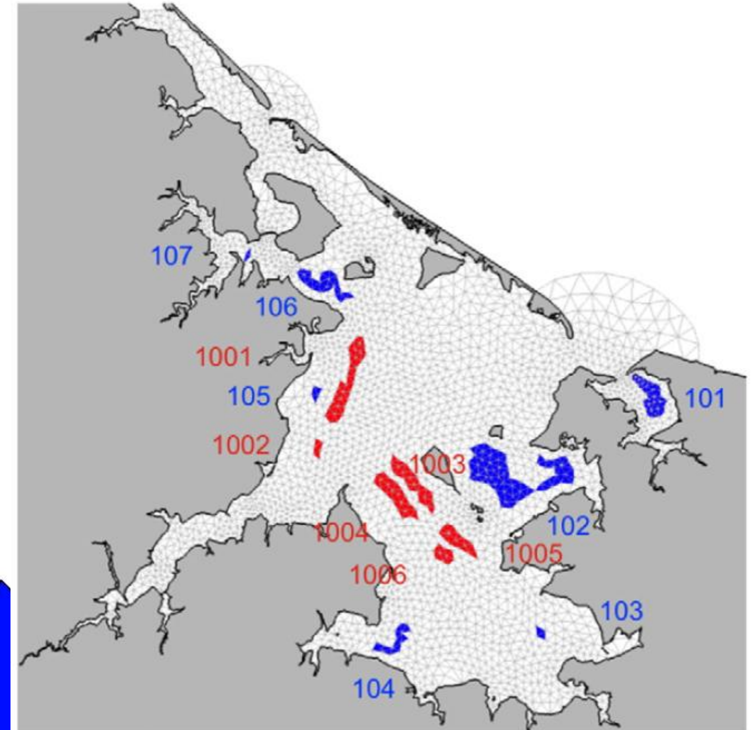

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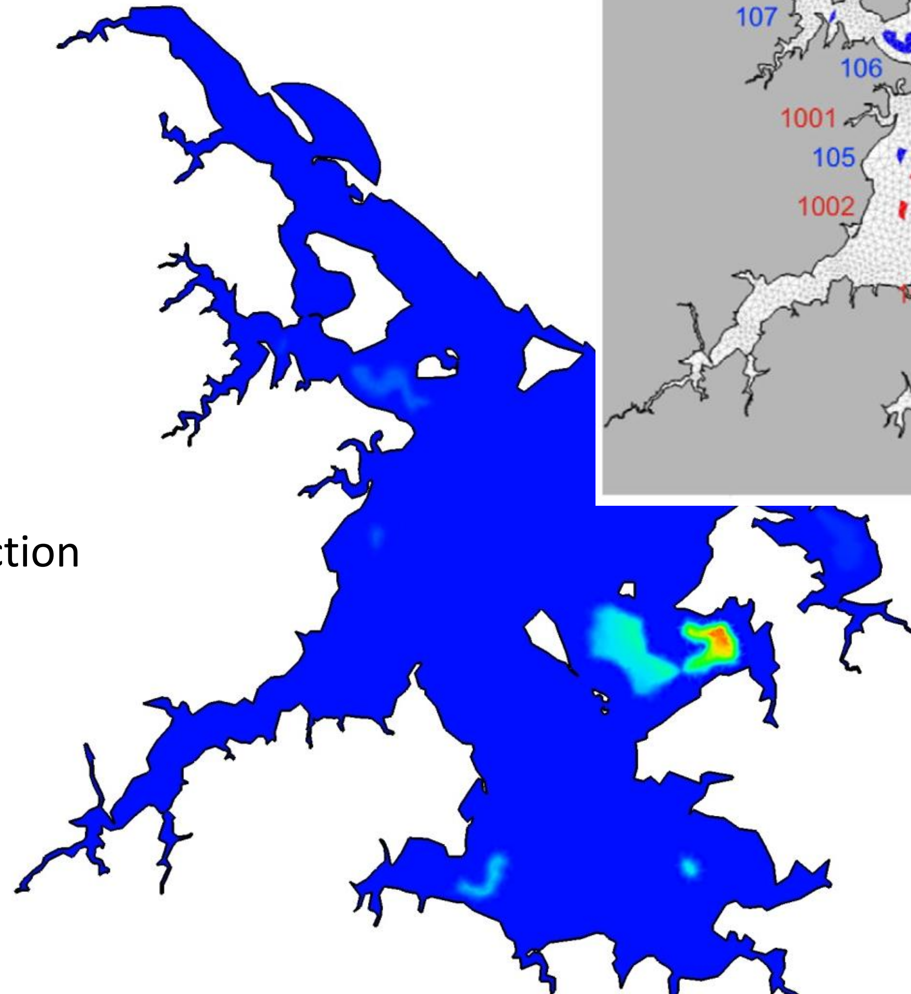

CONCLUSIONS

- High spatial variability of sea lettuce distribution. Temporal variability as well but the dynamics are similar in all systems.
- *Ulva* DEB model validated
- Check restored coherence with phytoplankton data with more observation
- Still working on the interpretation of potential impacts on wild bivalves populations

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PERSPECTIVES

- Test a more accurate/complex model including more nutrients, more detailed carbon assimilation (photoinhibition)
- Test the model in other locations (New Brunswick, Nova Scotia, …)
- Development of an identical model for sugar kelp in Rhode Island
- Application in Integrated multi-trophic aquaculture (IMTA)

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Thank you

NSERC CRSNG

Program for Aquaculture Regulatory Research

Dalhousie University

Laura Steeves, Leah Strople

François Villeneuve, Line McLaughlin

ULVA

Starvation experiment to estimate maintenance rates for each substrate (N and C)

- Negative growth rate
- Weight loss
- Respiration rate