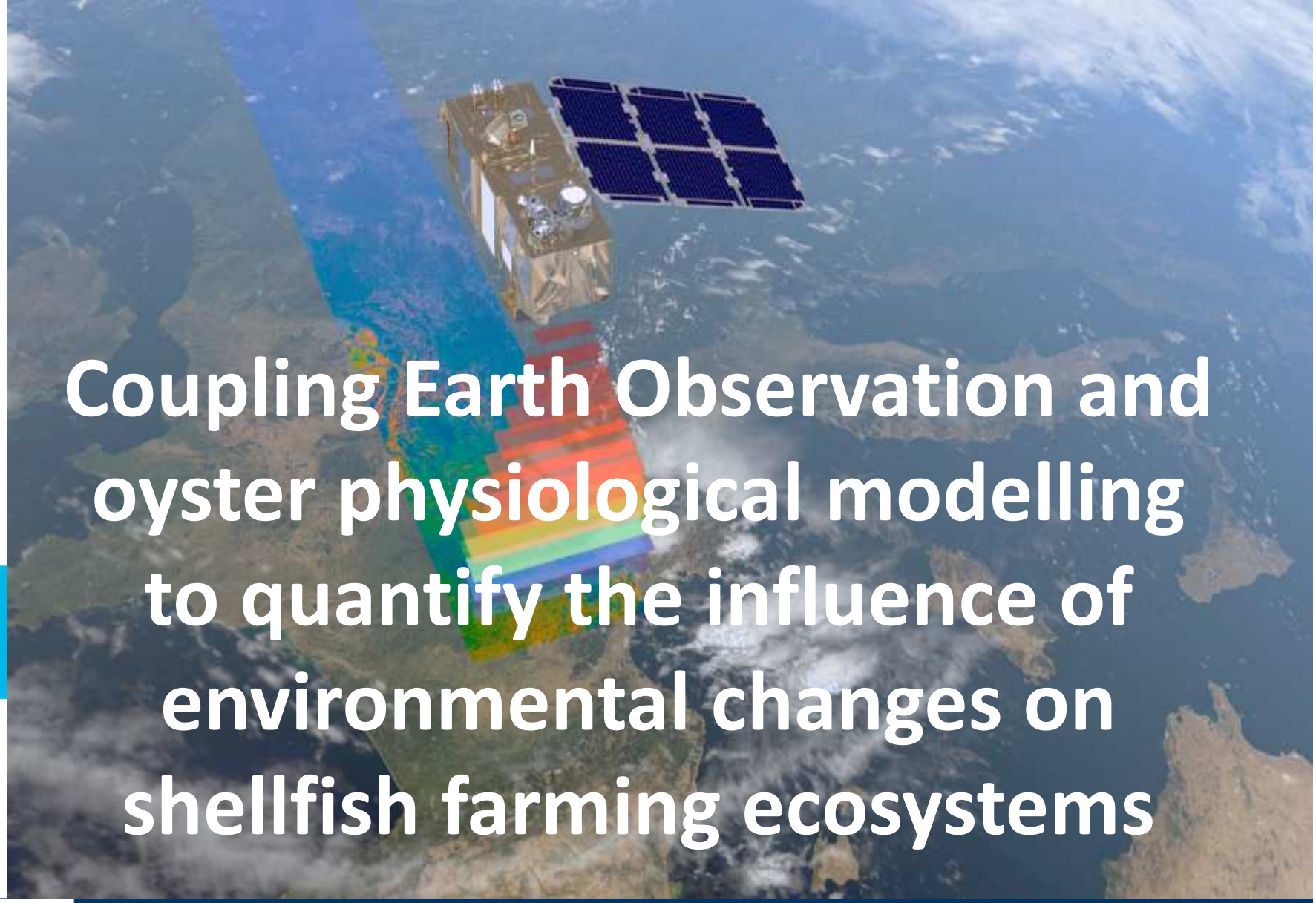

Coupling Earth Observation and oyster physiological modelling to quantify the influence of environmental changes on shellfish farming ecosystems

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Pierre Gernez, Mer Molécules Santé
Remote Sensing & Benthic Ecology
pierre.gernez@univ-nantes.fr

Coast Bordeaux 2017

Collaborators

Laurent Barillé

Yoann Thomas

Stéphane Pouvreau, Fabrice Pernet, Marianne Bruscia

David Doxaran

Phlippe Glize

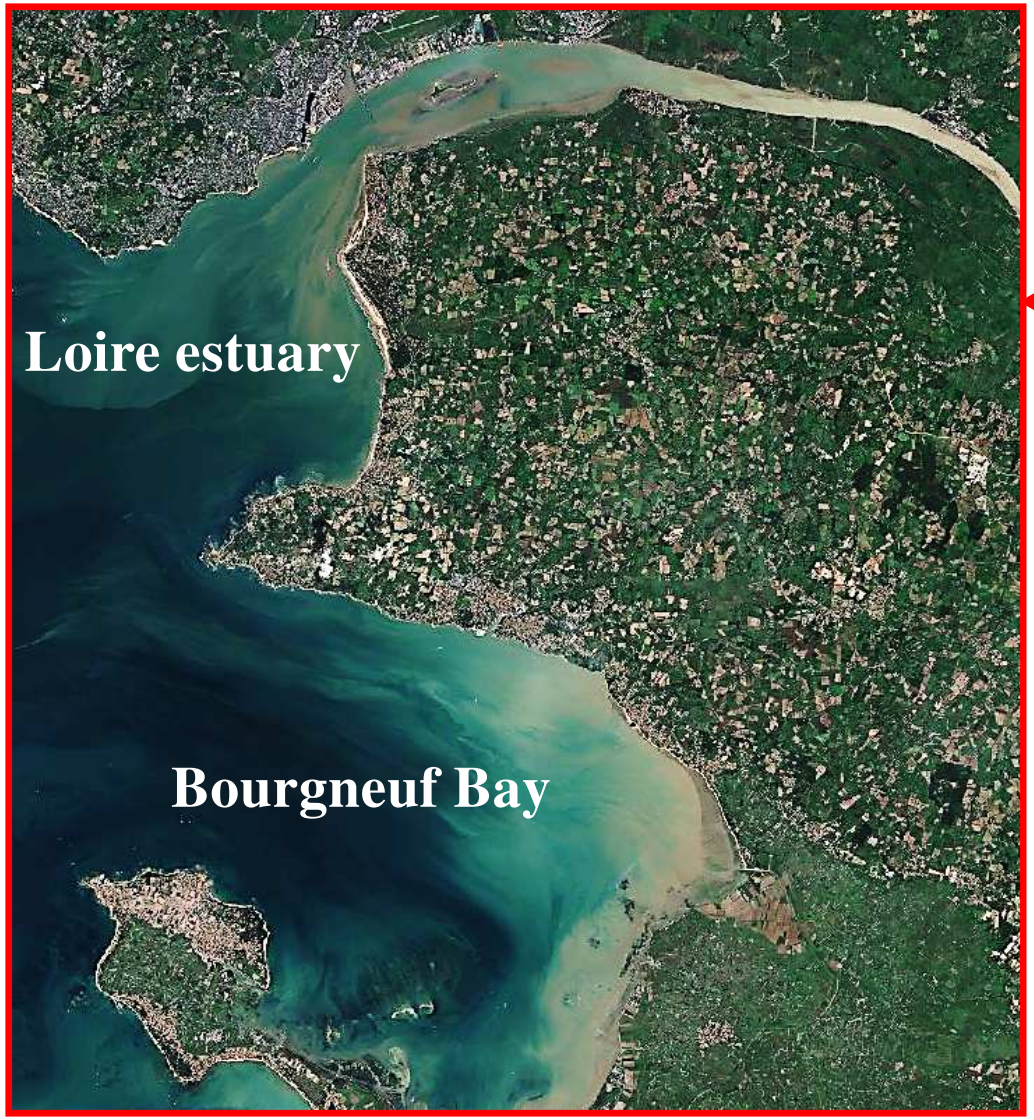
Satellite remote sensing for oyster-farming?

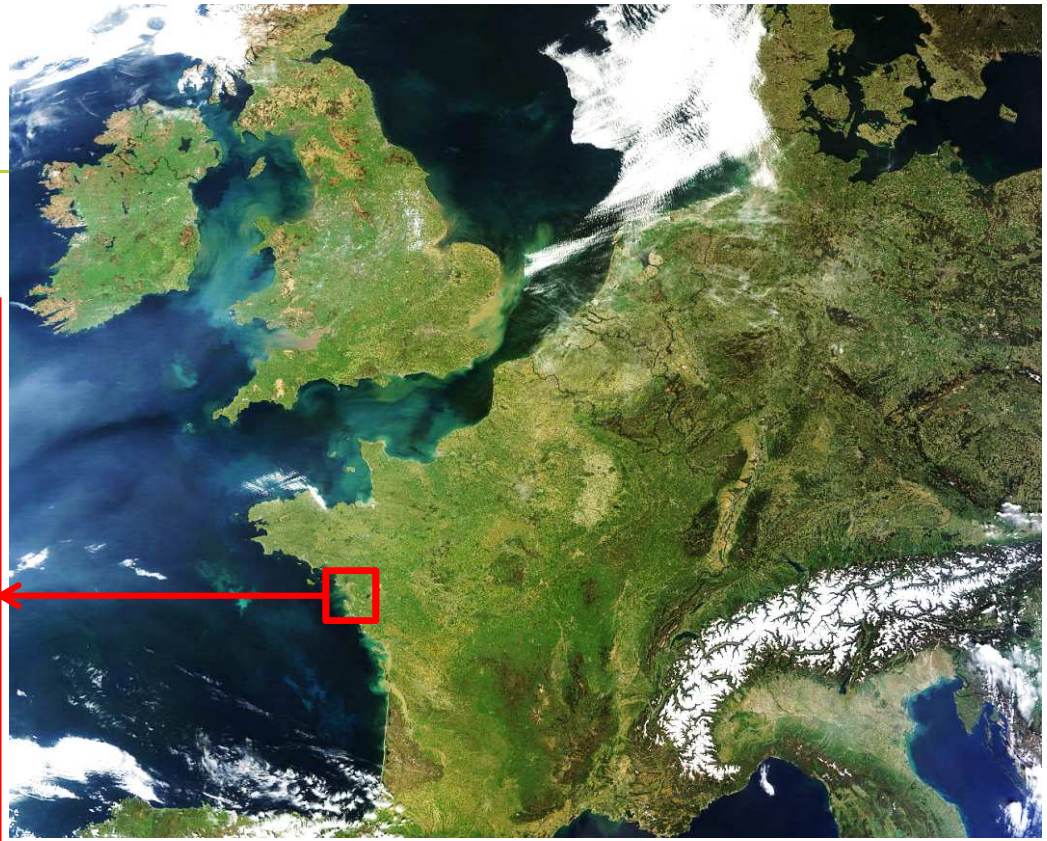
1) Influence of turbidity on oyster farming (Gernez et al., 2014, 2017)

2) *Site selection for offshore farming (not shown here, ask me for details)*

3) Influence of global change on shellfish ecosystems (Thomas et al., 2016)

Bourgneuf Bay





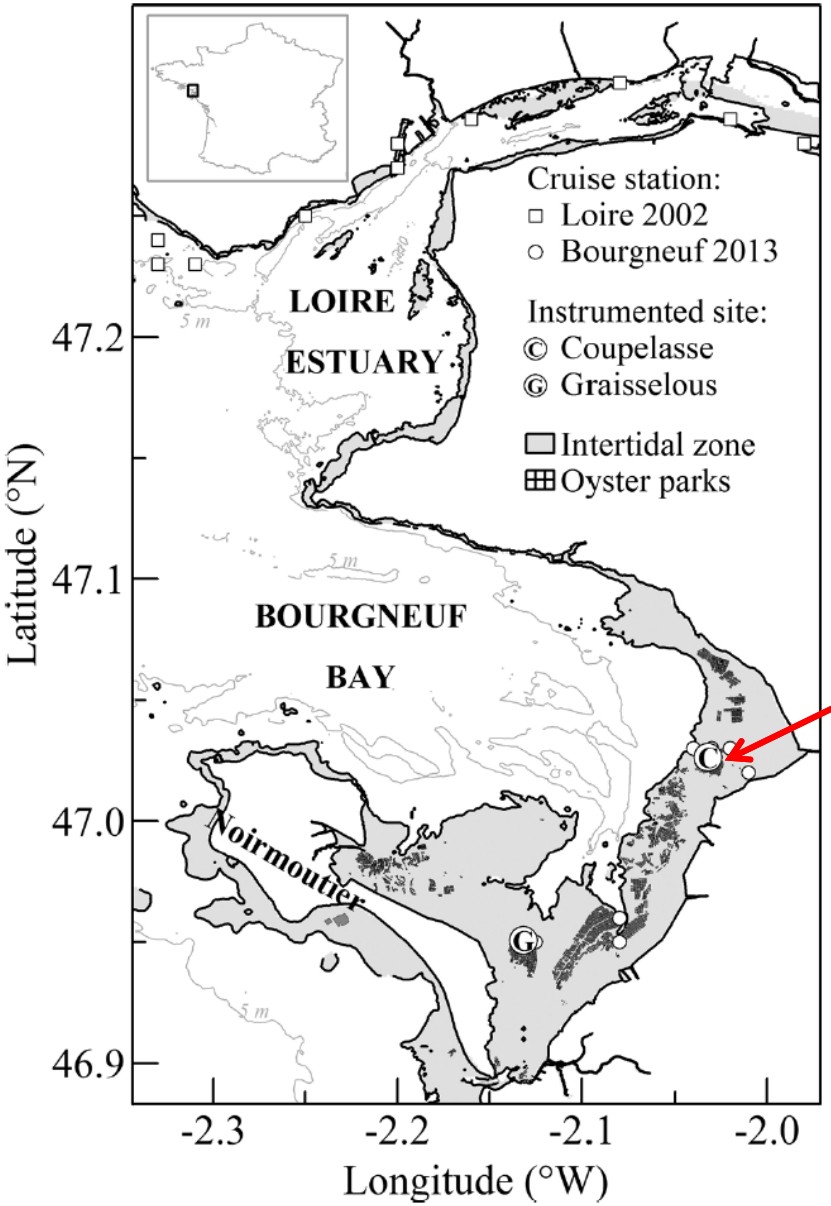
- Macrotidal bay (tidal range 6 m)
- Shallow bay (20 m)
- Soft-bottom (mudflats)

Oyster aquaculture: 5330 tons year^{-1}

- Traditional farming of *Crassostrea gigas*

- Recreational picking on wild reefs (*C. gigas*)
- Both on **intertidal zone**

Life in a turbid world (mudflats)



Too high turbidity impacts oysters

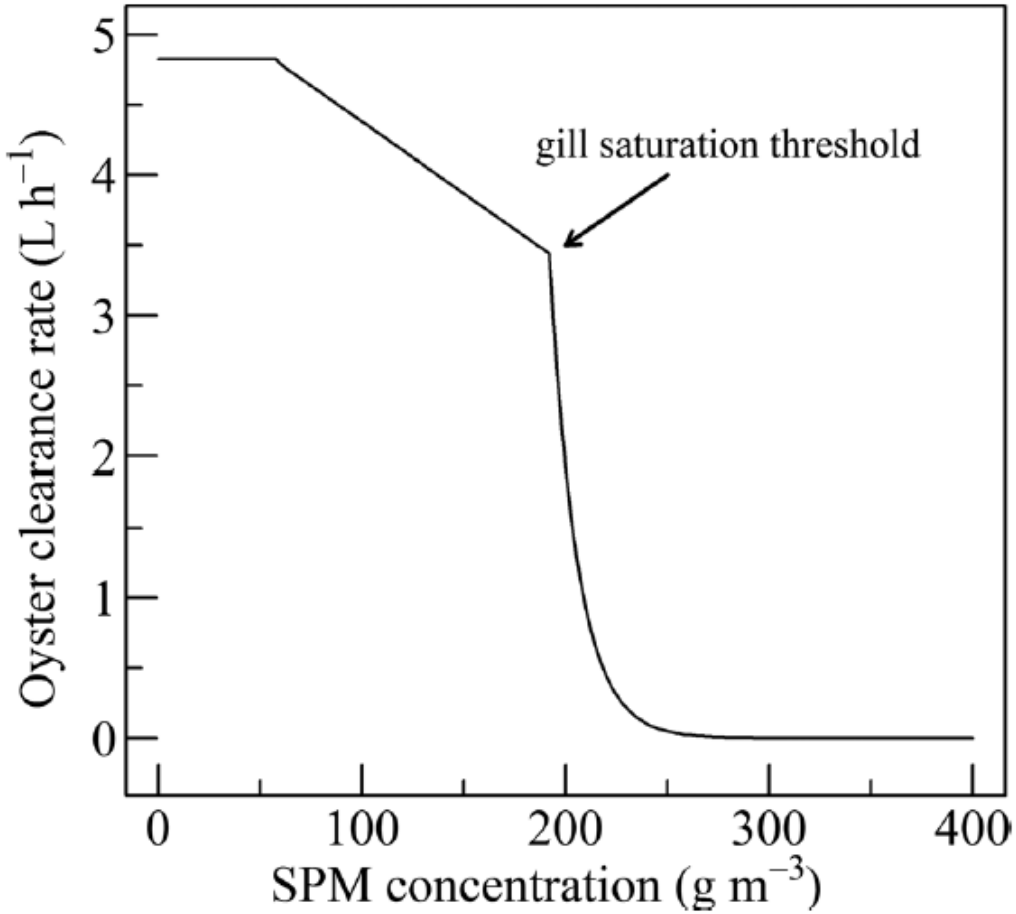
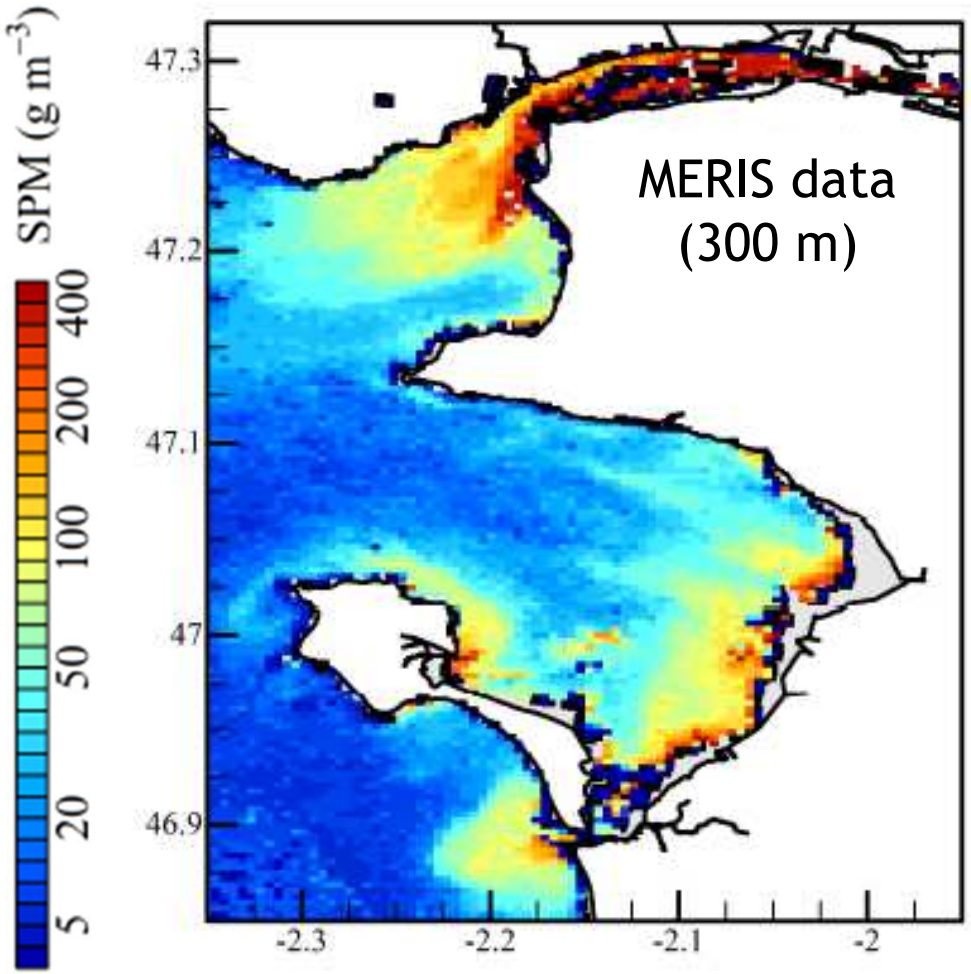


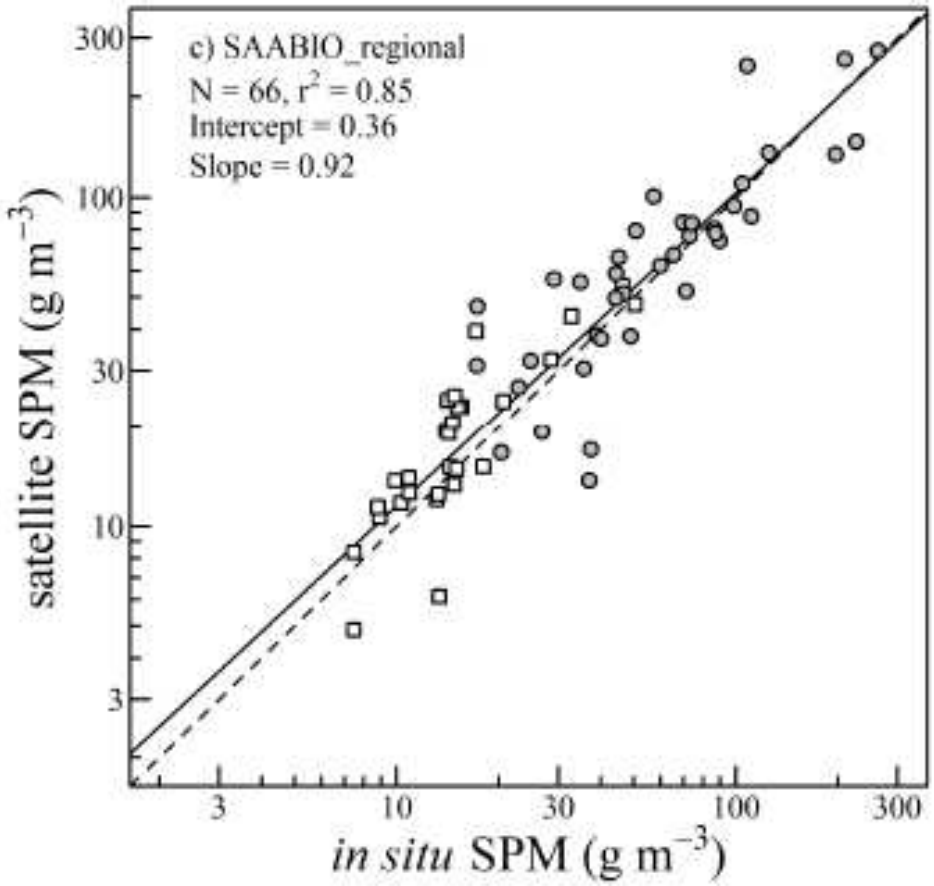
Figure 3. Modeled effect of suspended particulate matter (SPM) concentration on oyster clearance rate. The arrow at ~200 g m^{-3} shows the SPM concentration threshold at which oysters cannot filter anymore because of gill saturation (adapted from *Barillé et al.* [1997]).

Can we use satellite remote-sensing to map suspended particulate matter (SPM) and evaluate turbidity impact on oyster farms?

SPM remote sensing in Bourgneuf Bay



A dedicated algorithm was developed & validated



Gernez, Barillé, Lerouxel, Mazeran, Lucas, Doxaran (2014) Remote sensing of suspended particulate matter in turbid oyster farming ecosystems, J. Geophys. Res. Oceans, 119

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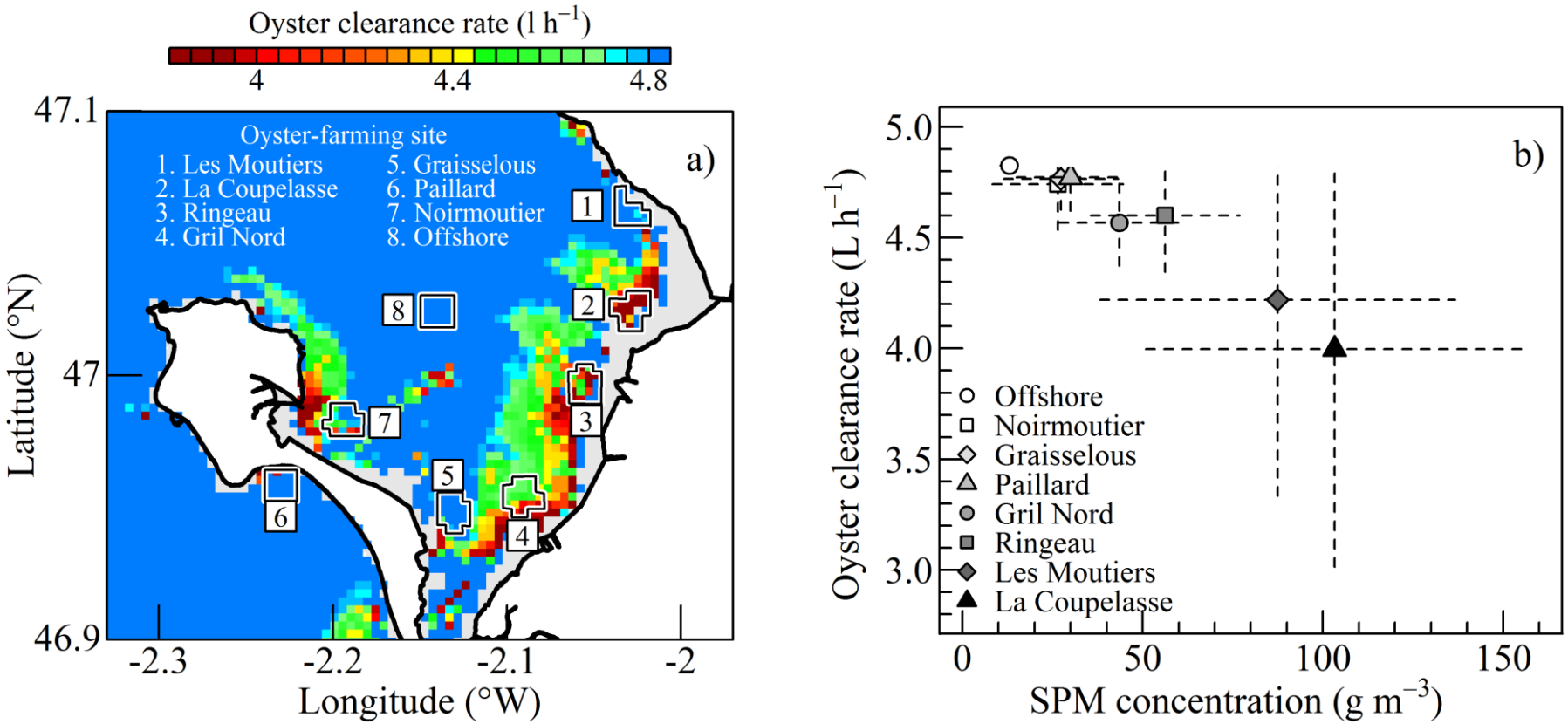
Virtual map of turbidity impact

- Averaged clearance rate computed using 2005-2006 MERIS data (300 m)



Gernez, Barillé, Lerouxel, Mazeran, Lucas, Doxaran (2014) Remote sensing of suspended particulate matter in turbid oyster farming ecosystems, J. Geophys. Res. Oceans, 119

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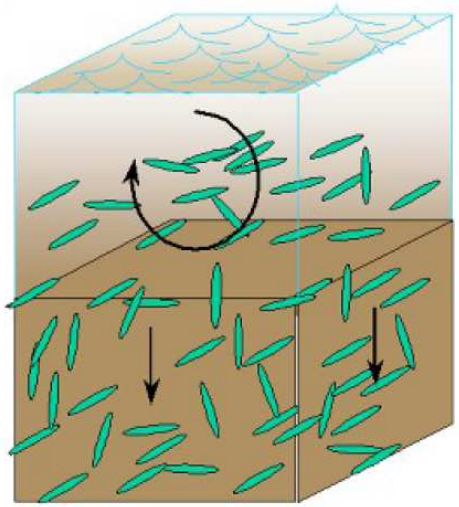
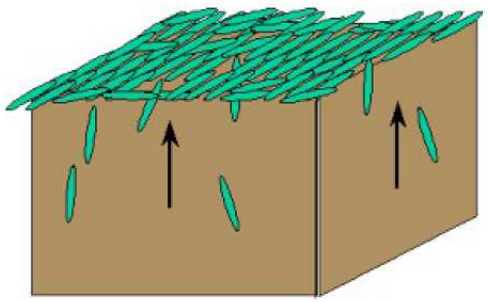
Can we go further than turbidity impact?

In-water chl *a* & benthic microalgae (BMA)

- BMA forms biofilms during low tide
- Resuspensded during flow & high tide
- Available food for oysters and other consumers



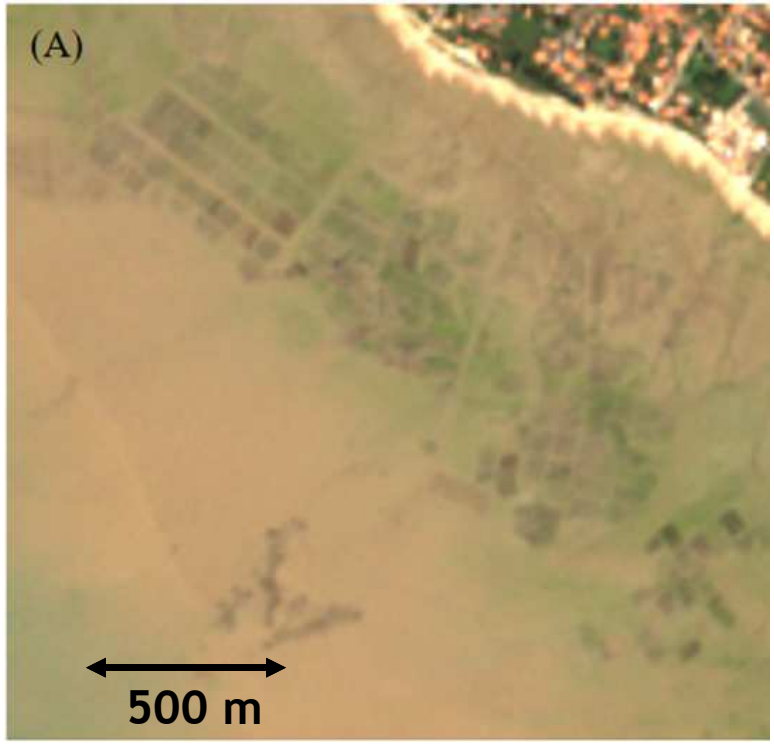
High tide

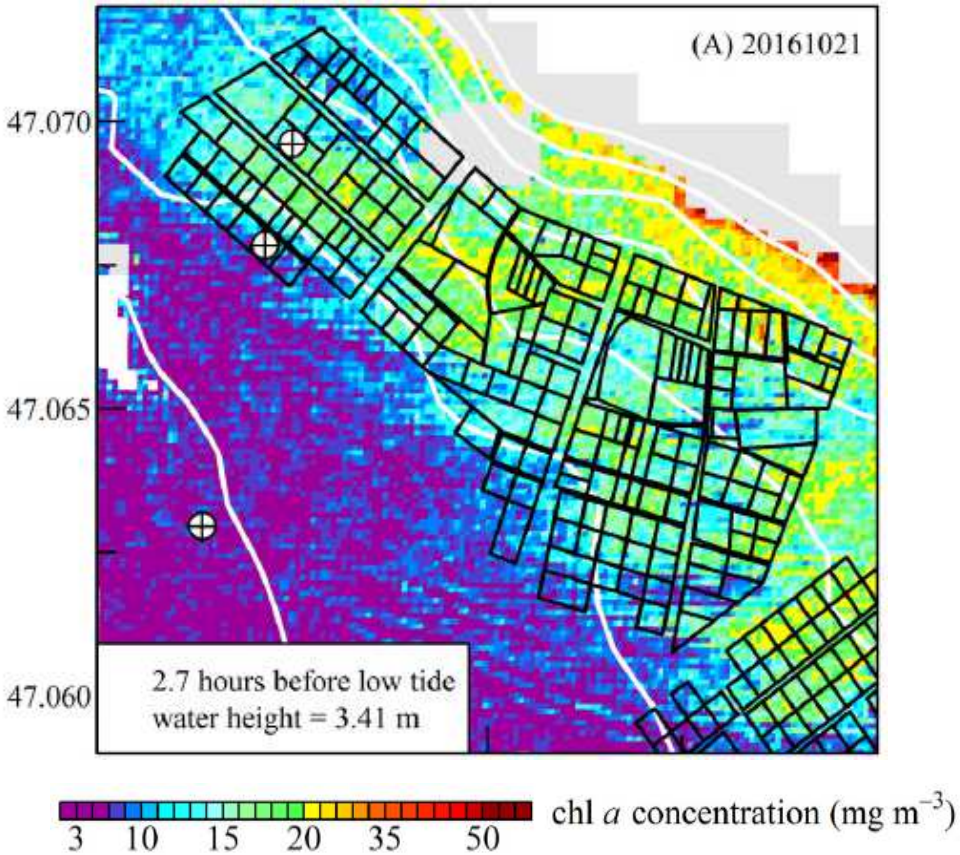


Low tide

Chlorophyll *a* remote sensing in Bourgneuf Bay

- Regional chl *a* algorithm applied to Sentinel2 data (20 m)



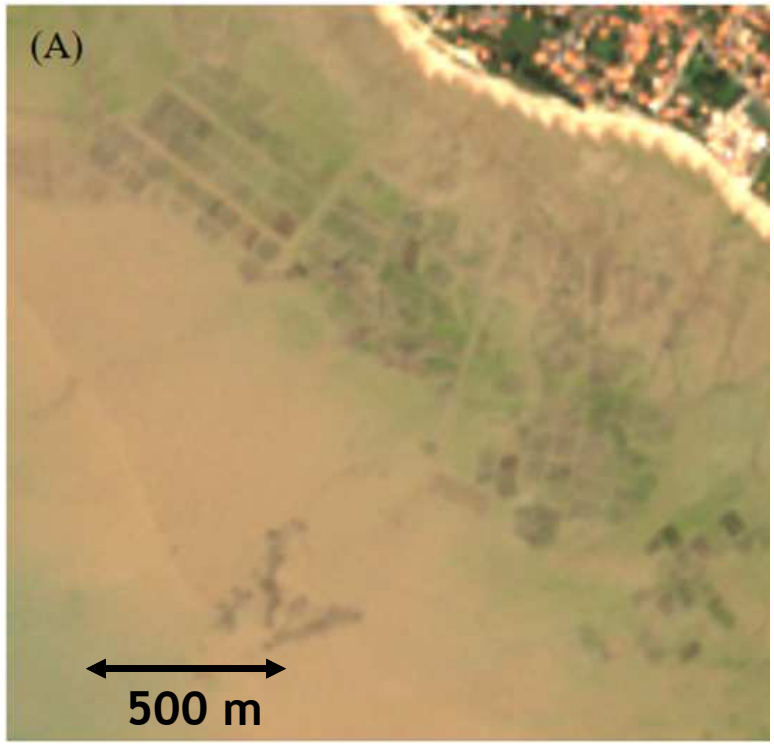


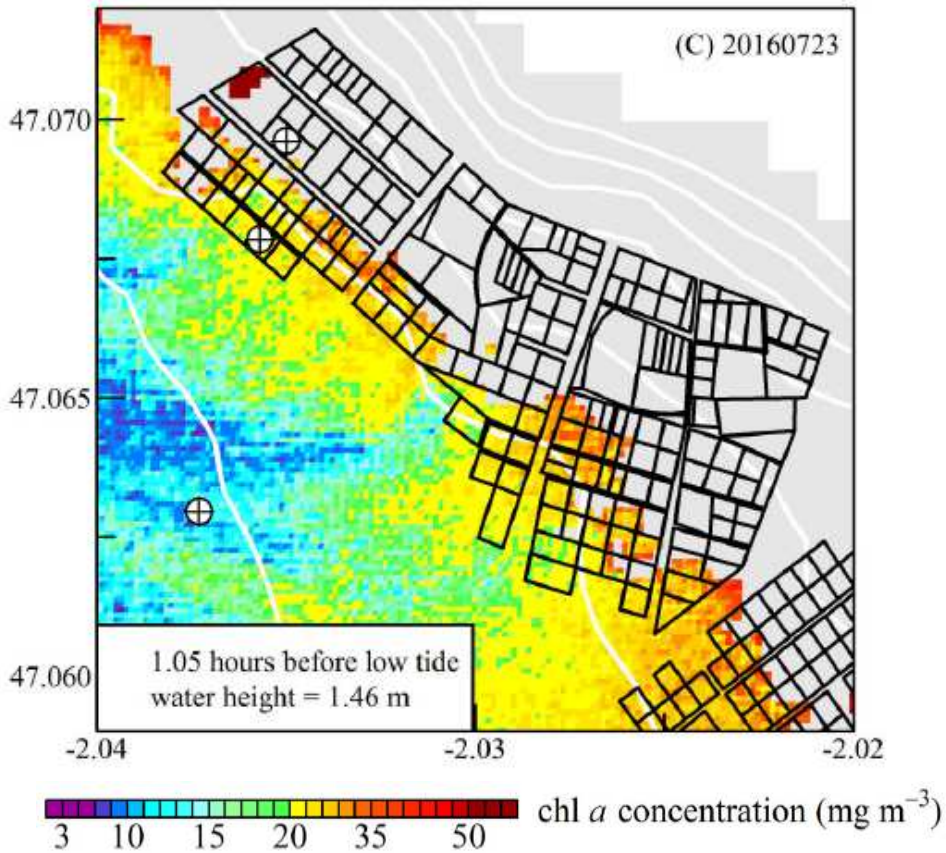
High tide

Gernez, Doxaran, Barillé L. (2017). Frontiers Marine Sci., 4: 137

Chlorophyll *a* remote sensing in Bourgneuf Bay

- Regional chl *a* algorithm applied to Sentinel2 data (20 m)





Low tide

Gernez, Doxaran, Barillé L. (2017). Frontiers Marine Sci., 4: 137

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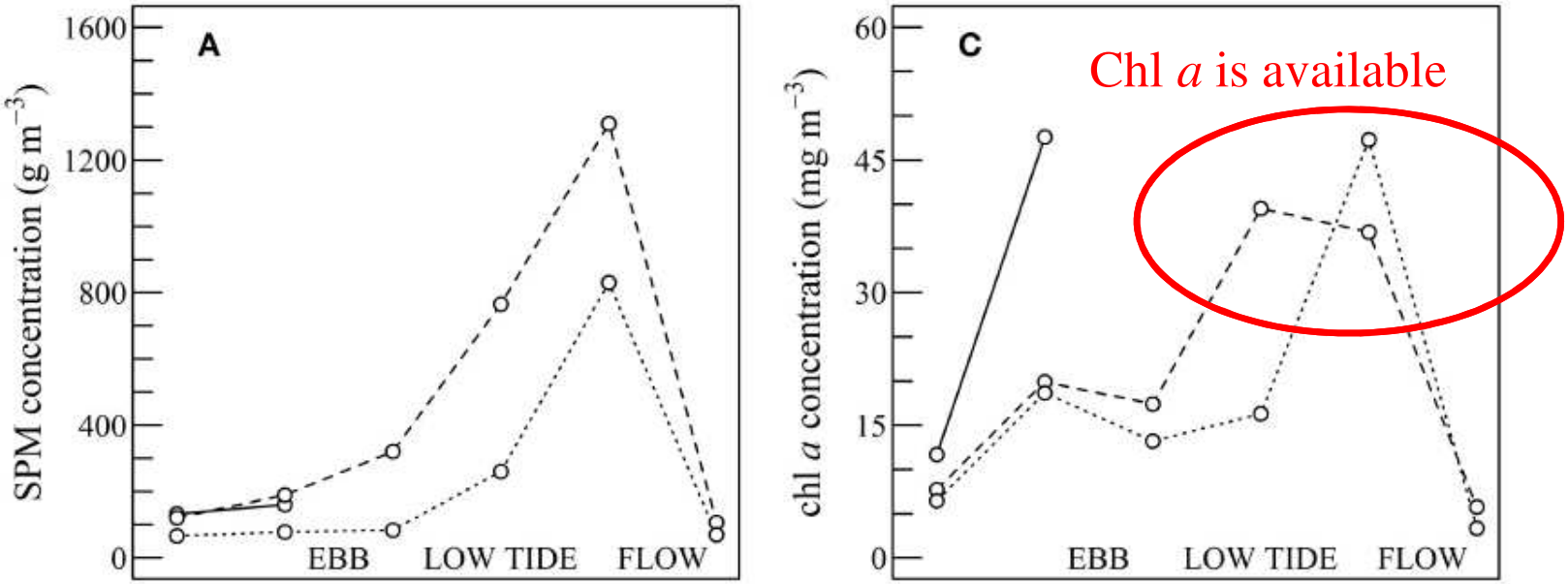
Chl *a* variability during tidal cycle



Gernez, Doxaran, Barillé L. (2017). Frontiers Marine Sci., 4: 137

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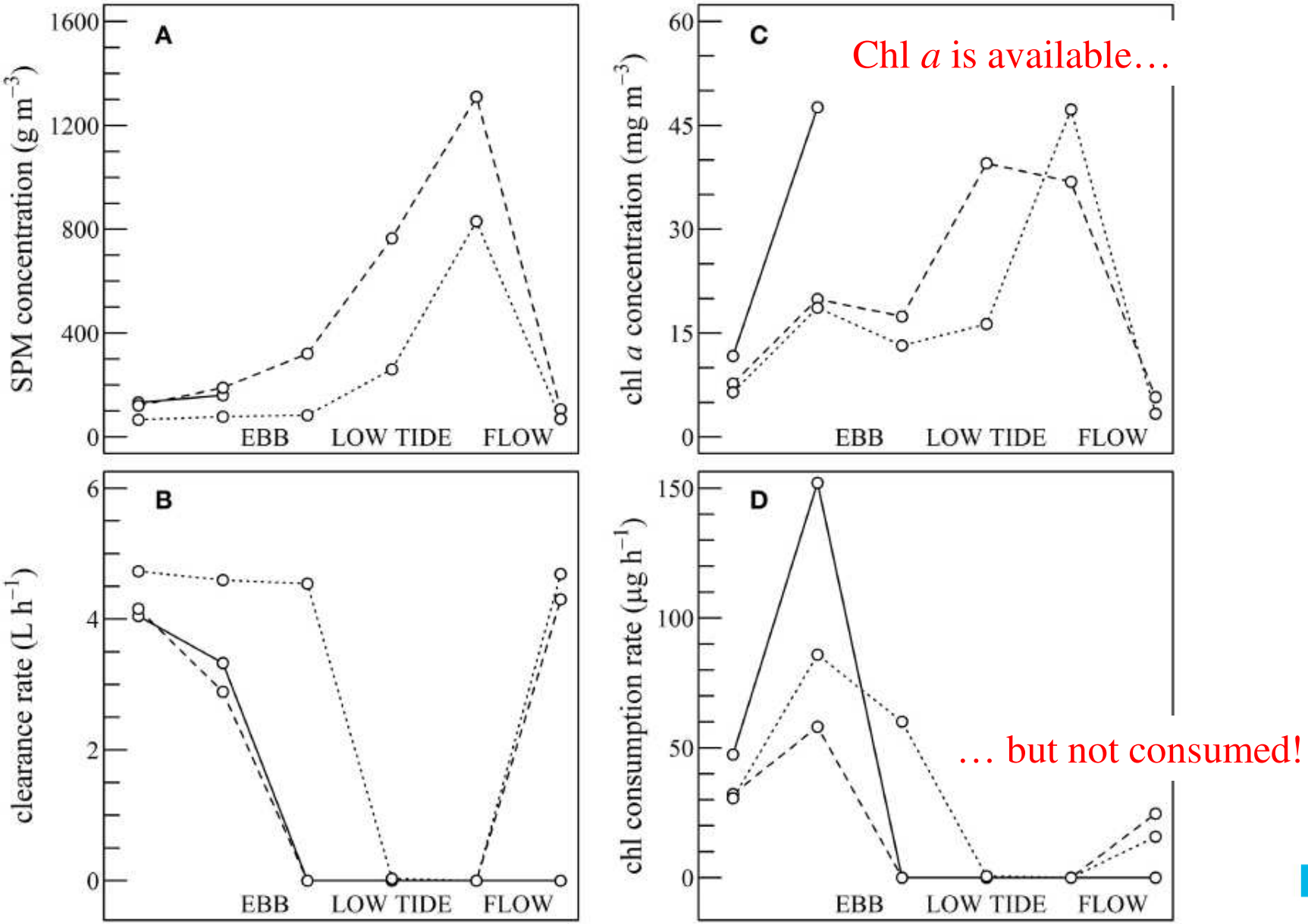
The « chocolate cake paradox »



Gernez, Doxaran, Barillé L. (2017). Frontiers Marine Sci., 4: 137

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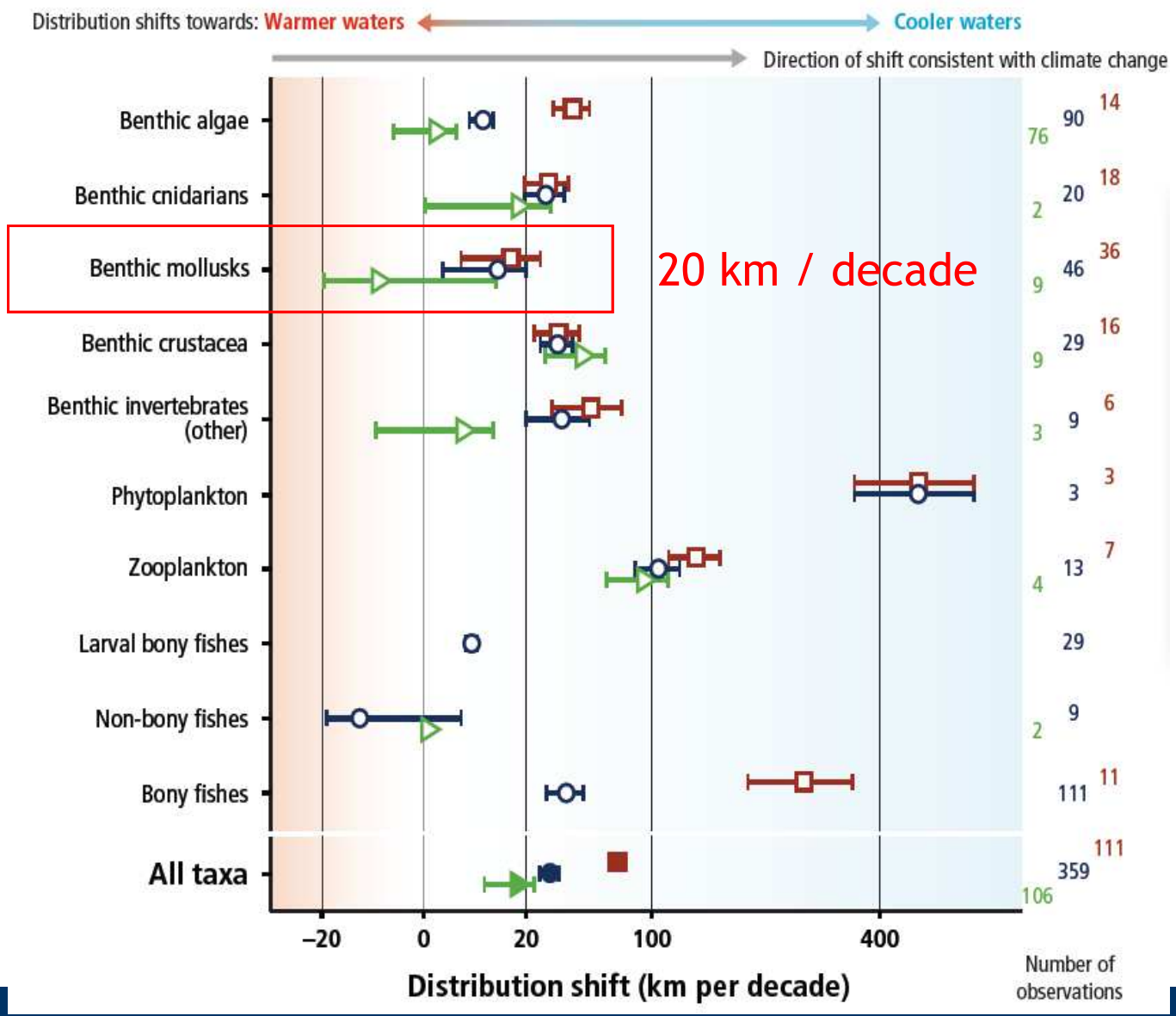
A few satellite maps were coupled with a few physiological responses, at the scale of an oyster farm

We then coupled 15-year satellite time-series with a full physiological model to assess effect of global change on *C. gigas* at European scale

Global change & poleward shift of marine species

- Poloczanska *et al.* (2013) & IPCC 2014



PACIFIC OYSTER: an invasive species?

- Unwanted beds in some places

Juist, Germany, 2007
A. Wehrmann
Senckenberg Research Institute
http://lms.seos-project.eu/

- Popular meal in others

OBJECTIVES

- Underpin effect of global change on Pacific oyster

- Quantify consequences in terms of
  - ✓ Growth
  - ✓ Reproductive effort
  - ✓ Geographical distribution

Journal of Biogeography (*J. Biogeogr.*) (2016) **43**, 568–579

ORIGINAL ARTICLE

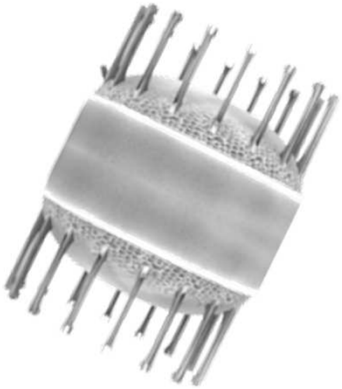
Global change and climate-driven invasion of the Pacific oyster (*Crassostrea gigas*) along European coasts: a bioenergetics modelling approach

Yoann Thomas[1]*, Stéphane Pouvreau[2], Marianne Alunno-Bruscia[2], Laurent Barillé[1], Francis Gohin[3], Philippe Bryère[4] and Pierre Gernez[1]

MATERIAL & METHODS

Satellite data
- SST
- SPM

In situ data
- Phytoplankton



Oyster model
- Growth rate
- Spawning date
- Repro. effort

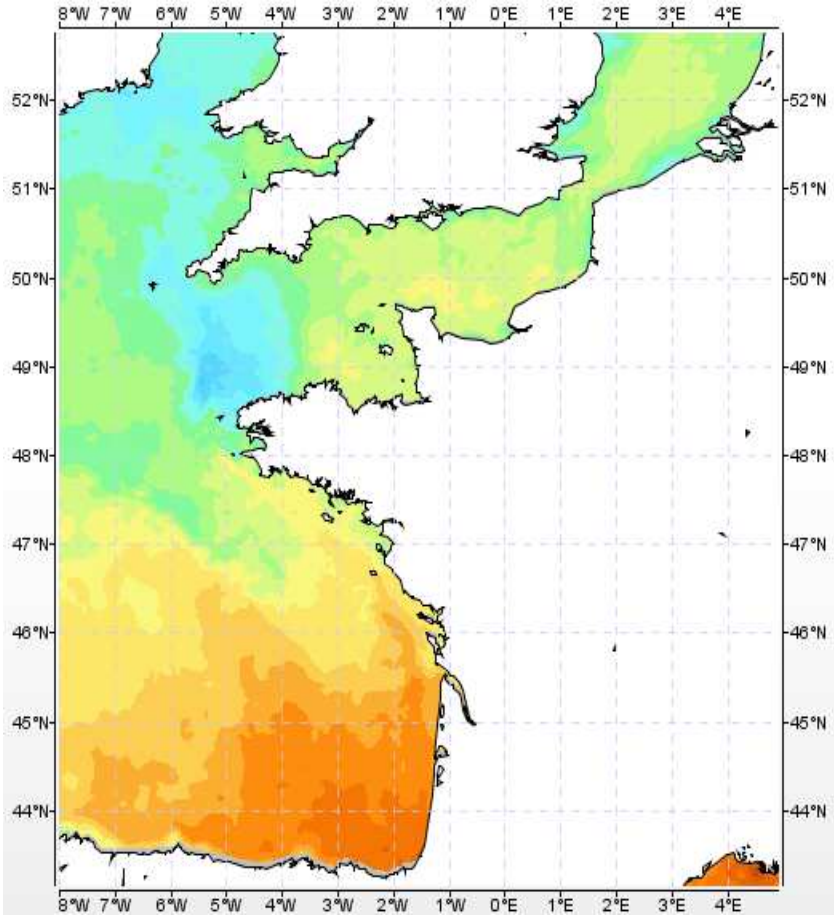
SATELLITE DATA: sea surface temperature (SST)

- **Daily SST data 1986-2013**

from Copernicus / MyOcean

1986-2009: AVHRR (Saulquin & Gohin 2010)

2009-2013: GHRSST (Dash *et al.* 2012)



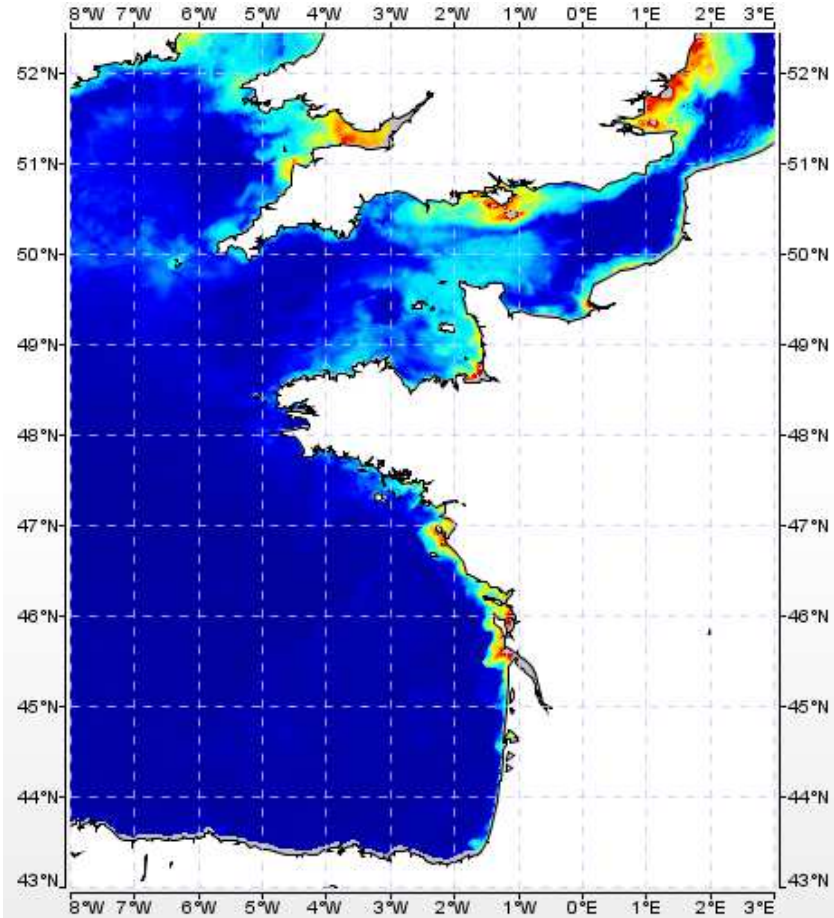
SATELLITE DATA: suspended particulate matter (SPM)

- **Daily SPM data 1998-2013**

SeaWiFS, MODIS & MERIS

Merged daily data (Saulquin et al., 2011)

OC5 algorithm (Gohin 2011)



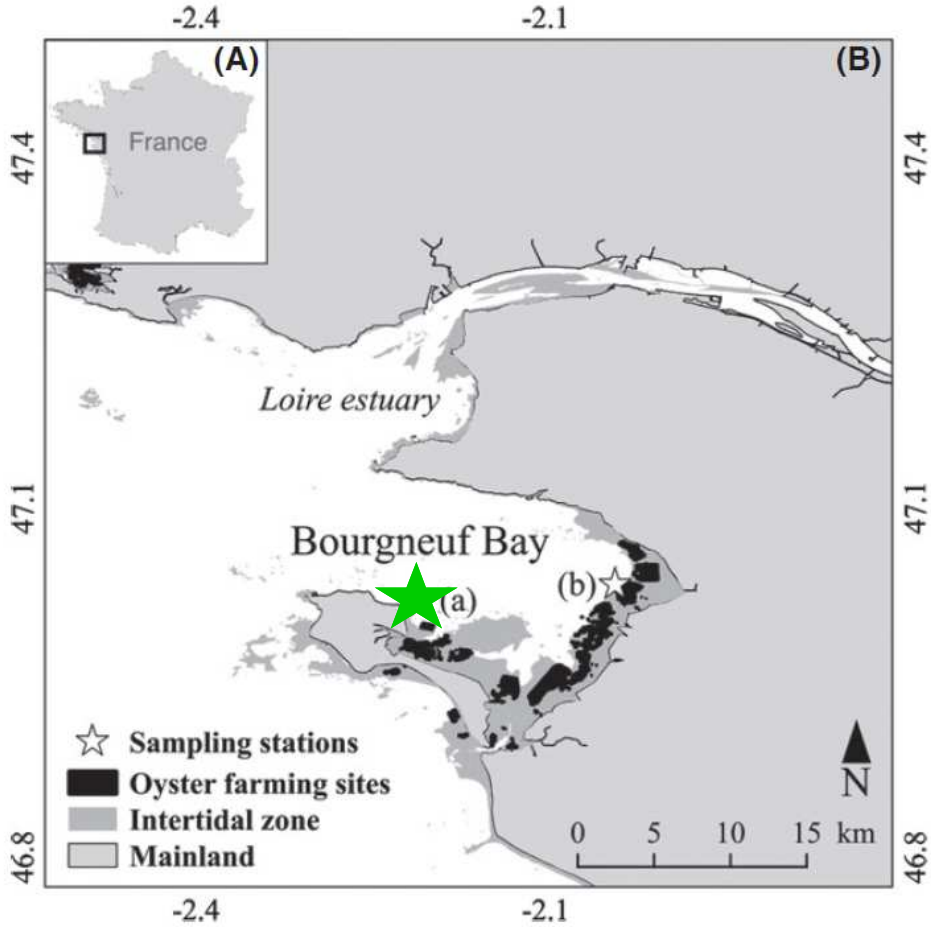
IN SITU DATA: phytoplankton

- **Monthly sampling 1998-2013**

Ifremer REPHY monitoring network

- ✓ Phytoplankton concentration
- ✓ Cell number
- ✓ Species identification

Lepidodinium *sp.* & Leptocylindrus *sp.* excluded



OYSTER MODEL: dynamic energy budget (DEB)

- **Ecophysiological model**

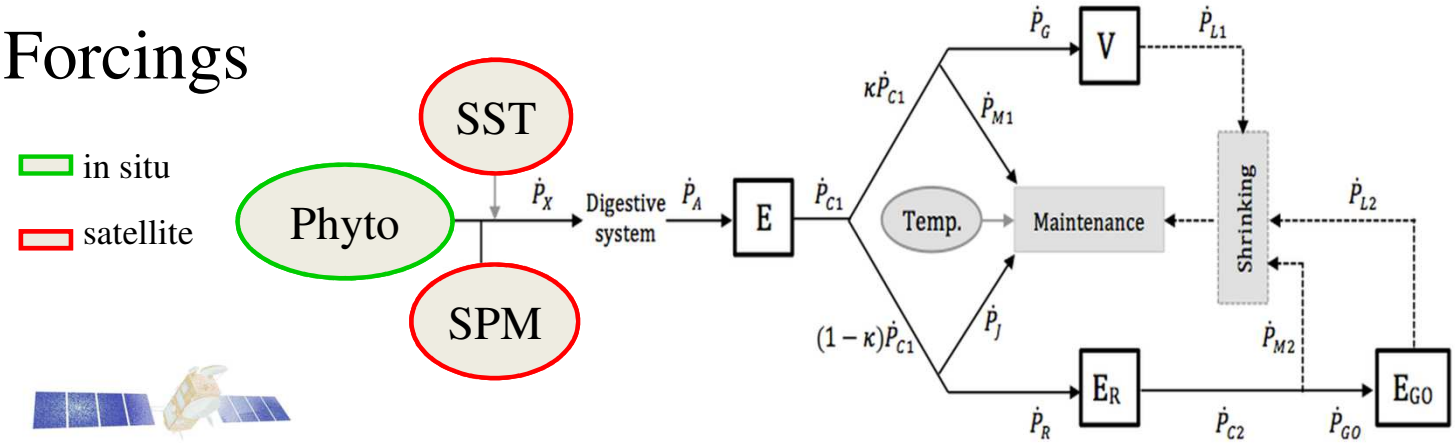
Oyster DEB model (Koijmann 2010, Pouvreau *et al.* 2006, Bernard *et al.* 2011)

…was improved:

✓ Individual-based model (IBM)

✓ Effect of too high SPM concentration on ingestion function

Forcings



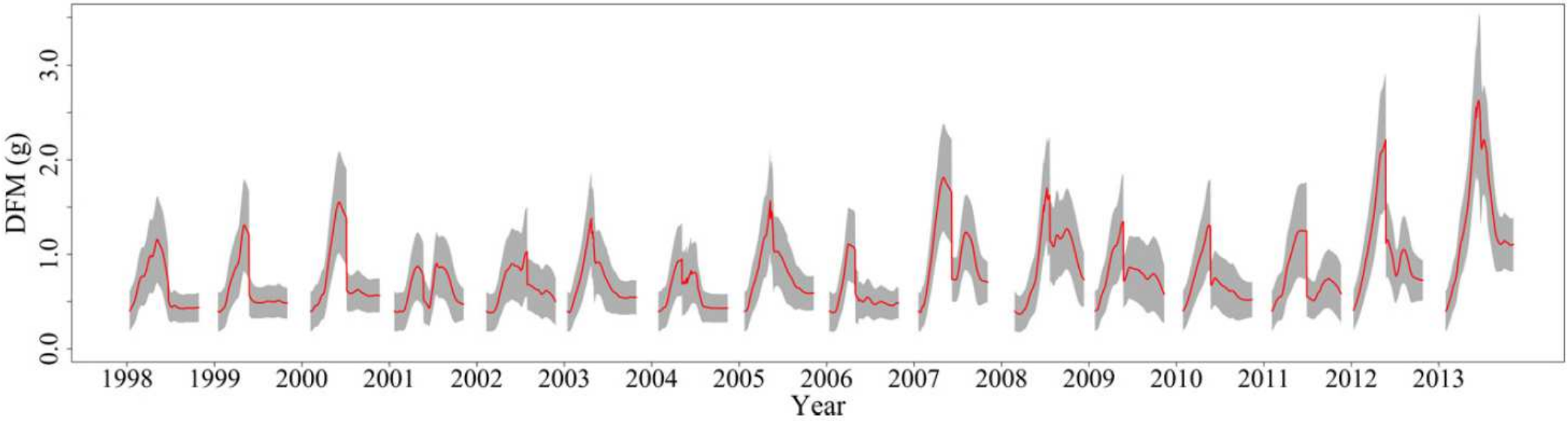
Reproduction *Structure*

Simulation output

- Dry flesh mass
- Length
- Oocyte number

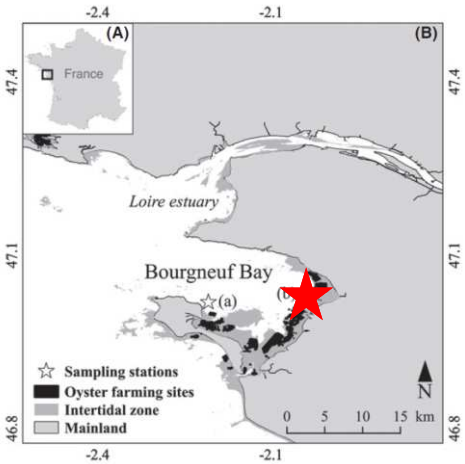
RESULTS

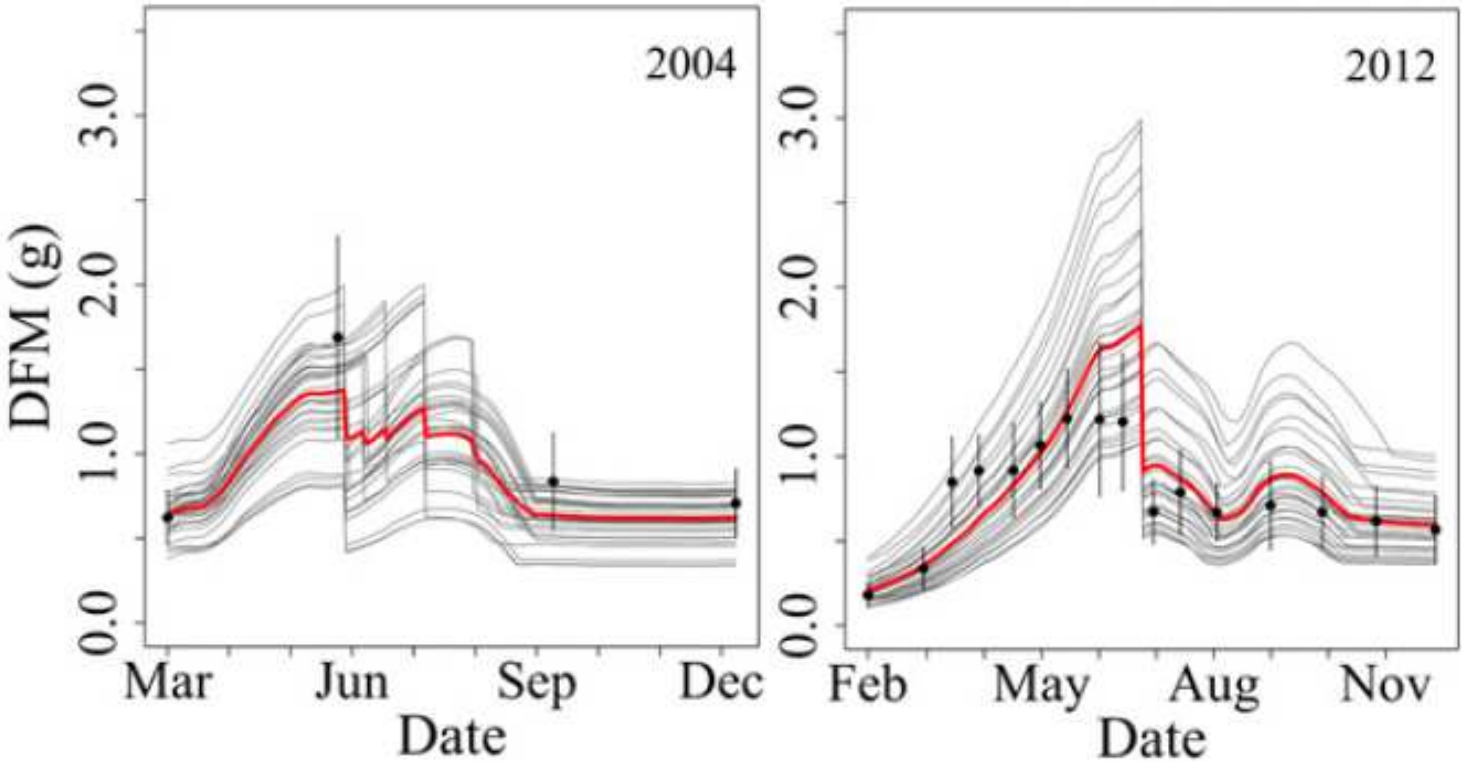
- **15-year time-series of simulated dry flesh mass (DFM)**



VALIDATION

- **Simulated *vs.* measured oyster growth**
  Ifremer RESCO monitoring network





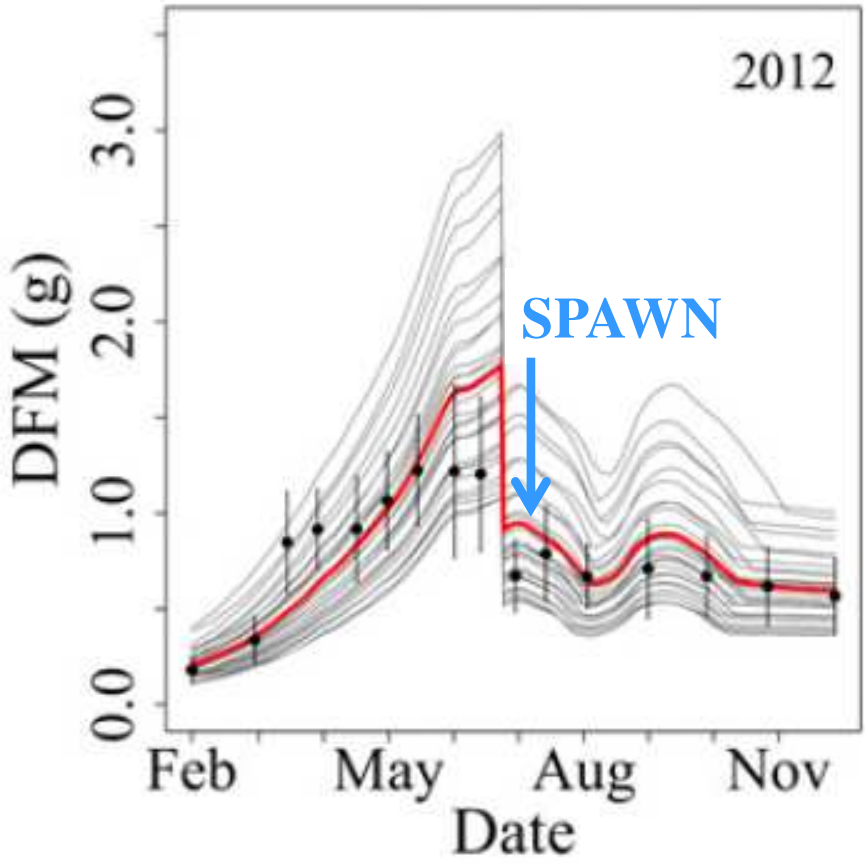
In situ oyster data

Simulation outputs

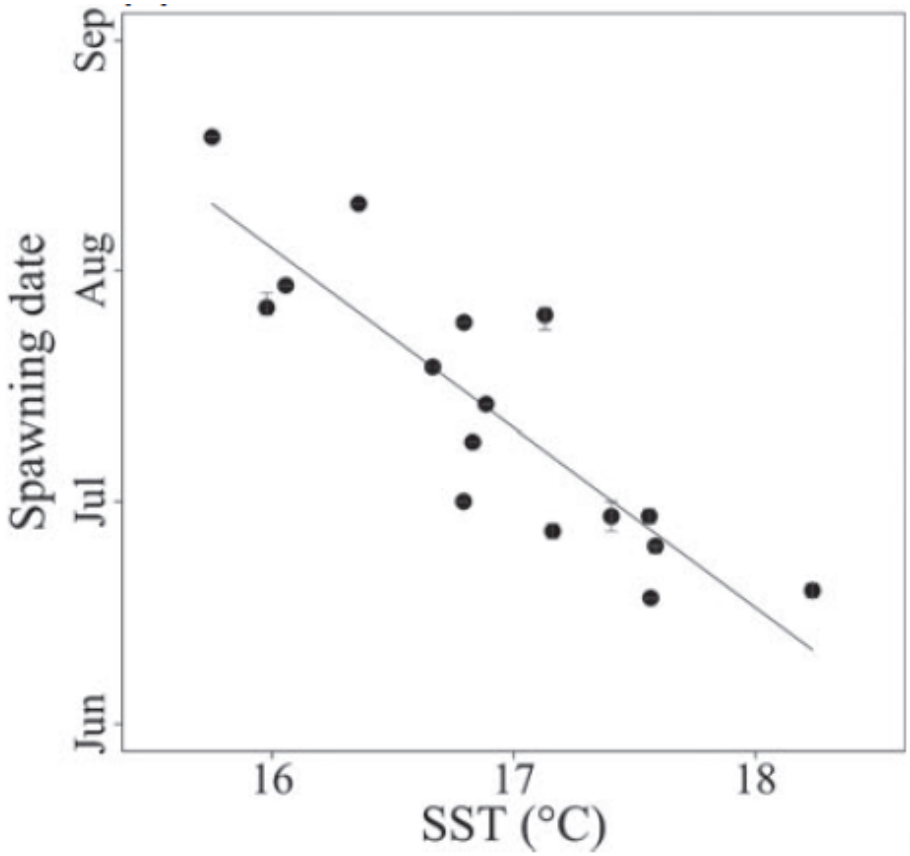
Individual trajectory

Mean

Spawning date was computed each year…

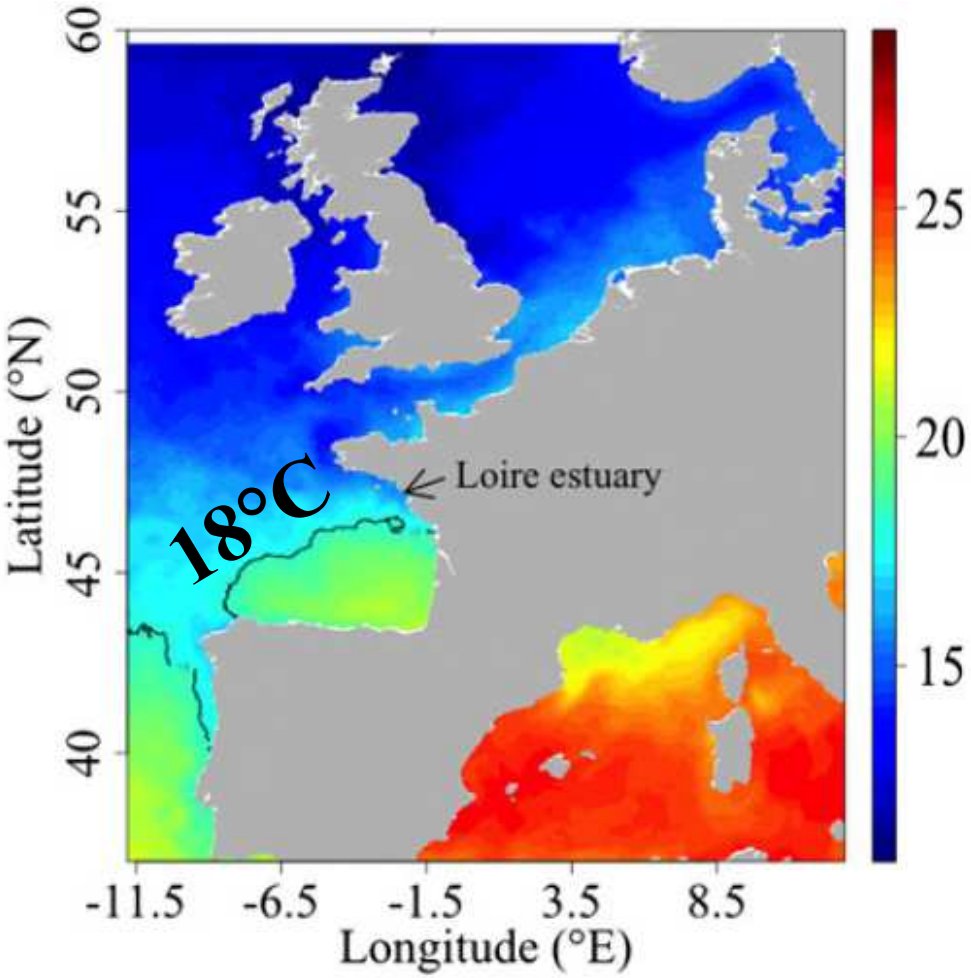


… and correlated with summer SST

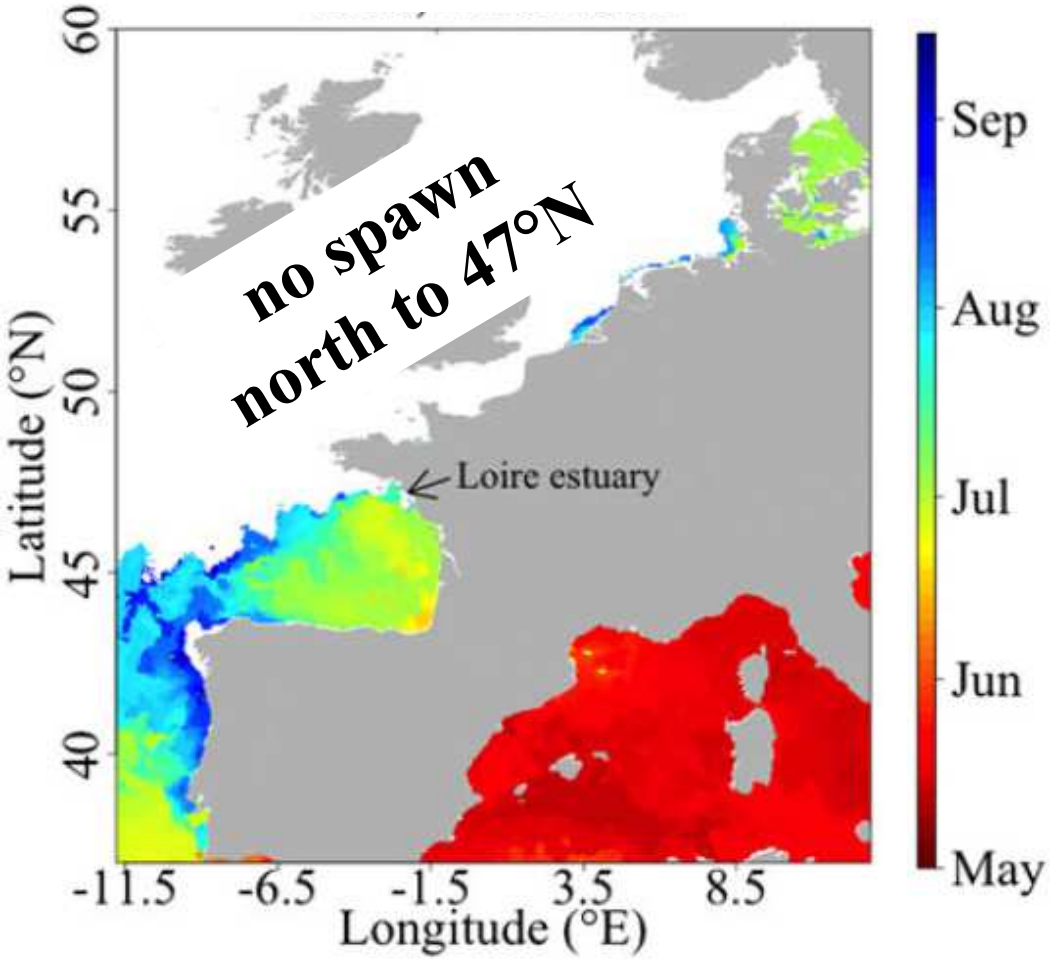


1986: cold summer

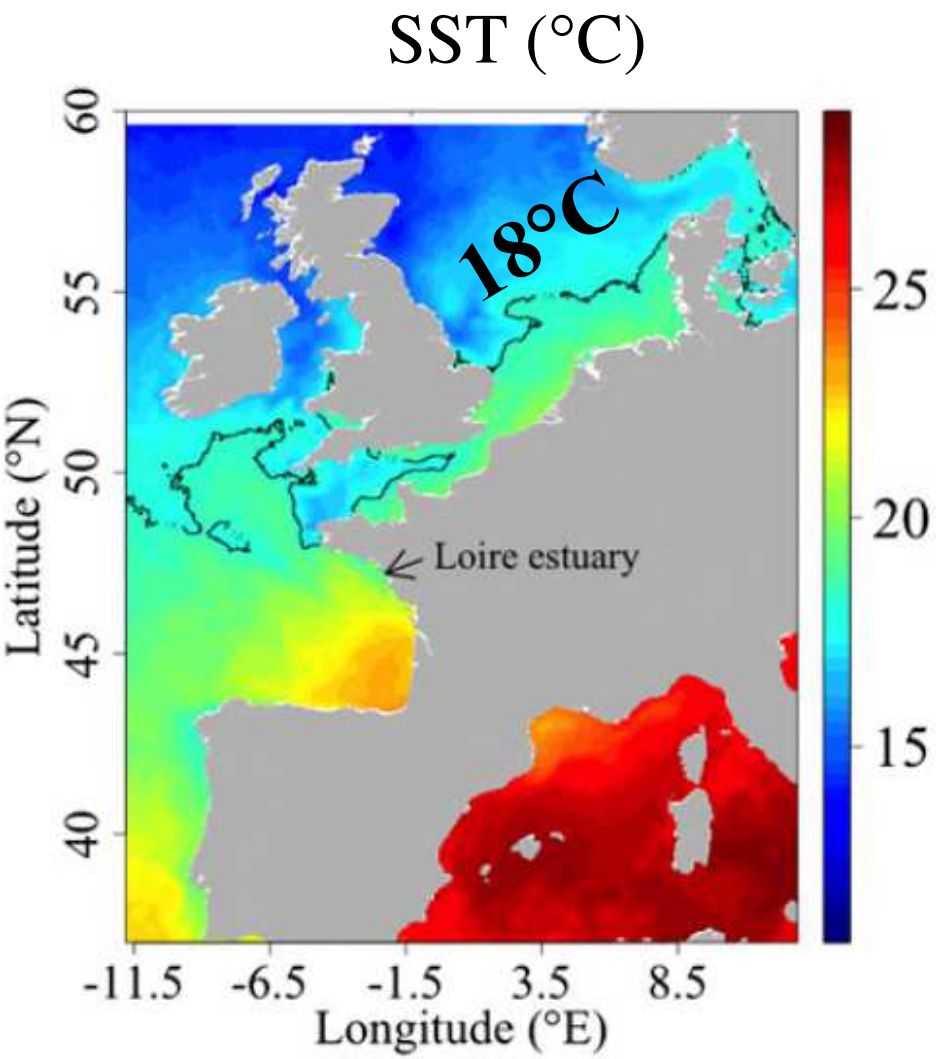
SST (°C)

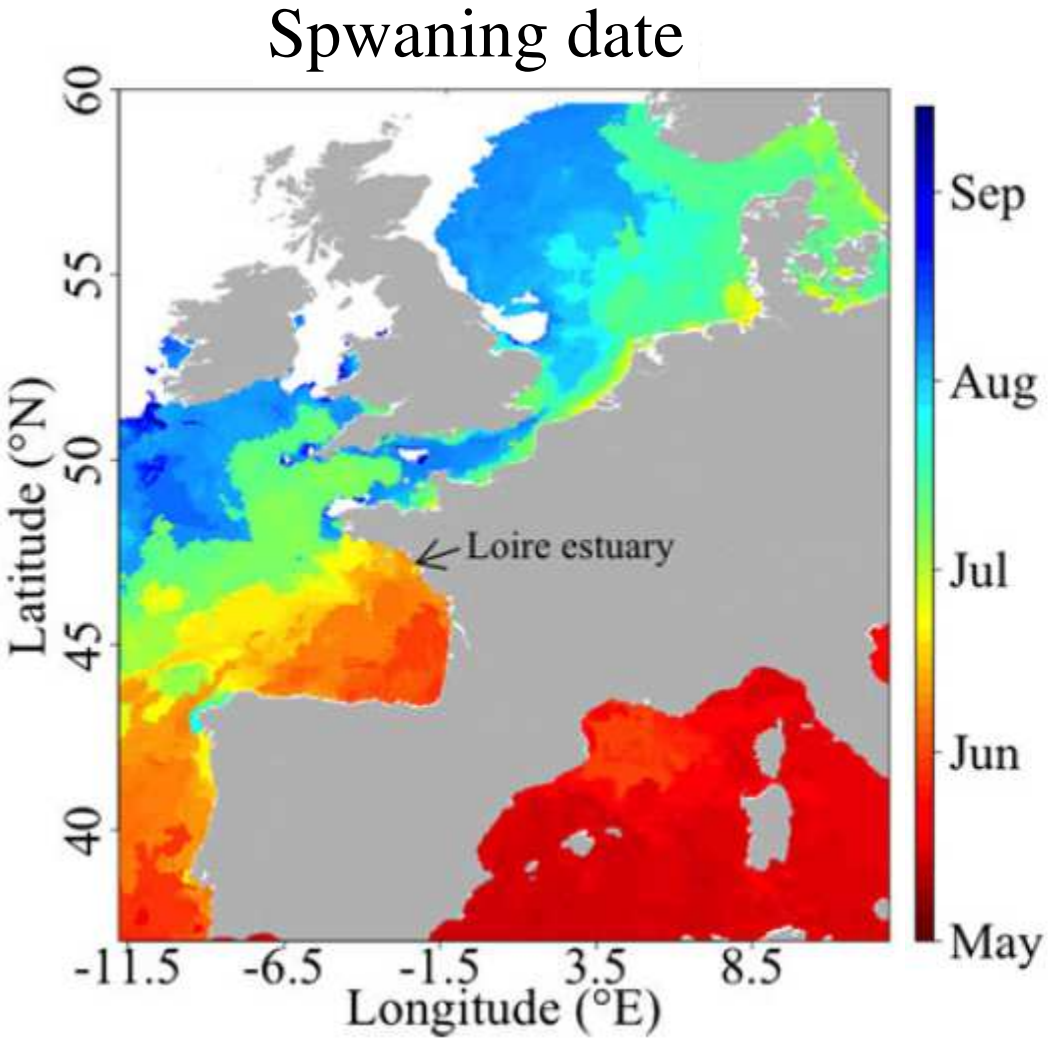


Spwaning date



2003 warm summer: shift from 47°N to 60°N





CONCLUSION

- **Earth Observation + oyster model**

  - ✓ a **generic approach** to study biogeographical responses of marine species to global change worldwide
  - ✓ a **practical tool** for coastal zone sustainable management
  - ✓ at **spatial-scales** from oyster-farm level to global scale

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Thank you !

- **TAPAS** http://tapas-h2020.eu/
Tools for Assessment and Planning of Aquaculture Sustainability

- **GIGAS-SAT** http://www.gigassat.org/
Adaptation of oyster farming ecosystems to global change

- **TURBO**
Turbidity of oyster farming ecosystems

- **HighROC** http://www.highroc.eu/
HIGH spatial and temporal Resolution Ocean Colour

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