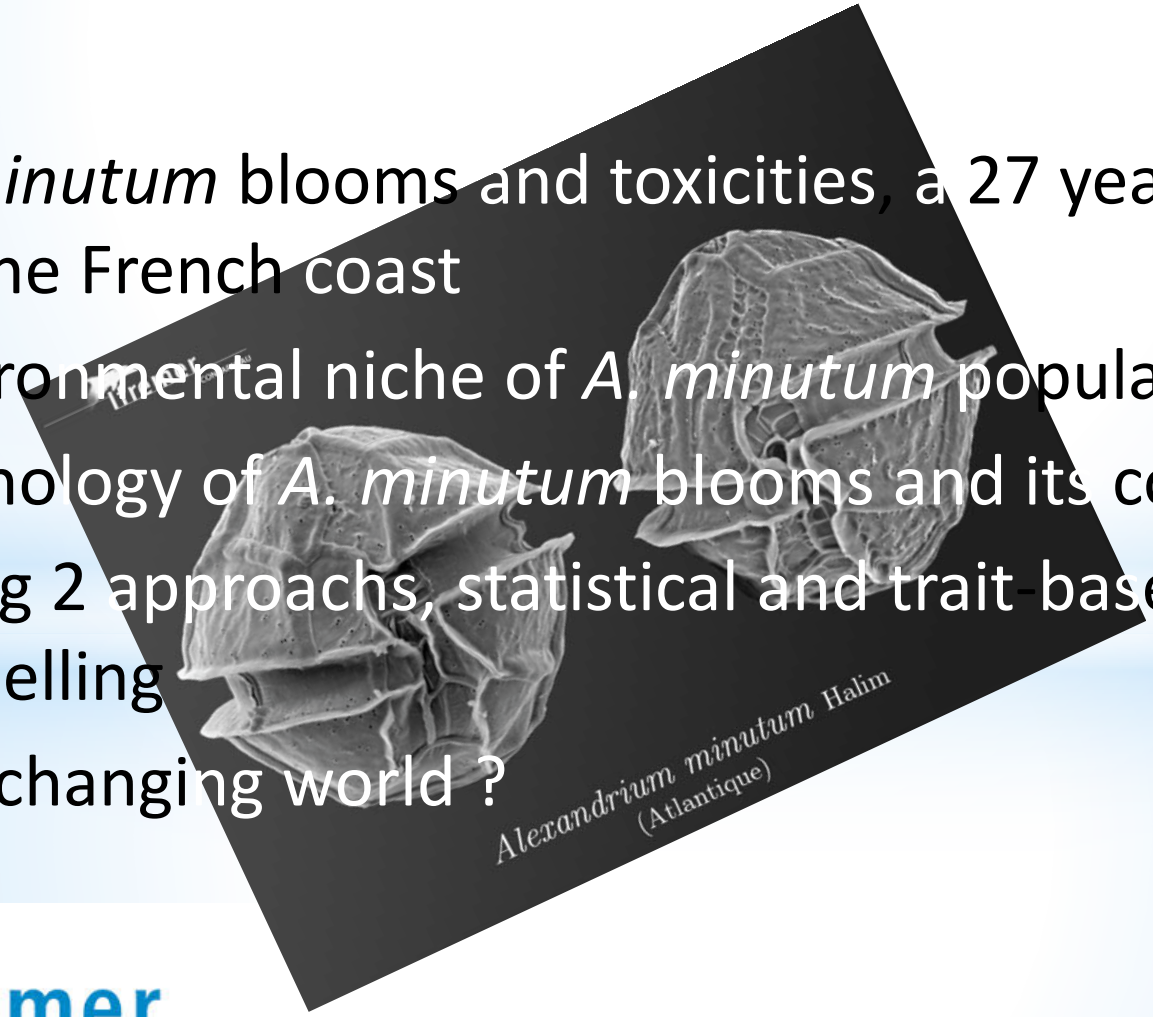
Toxic blooms phenology and abiotic controls in a changing world. The case of *Alexandrium minutum* in Britany (French coast).

Annie Chapelle, Carles Guallar-Morillo, Cédric Bacher, Martin Plus, Marc Sourisseau, Guillaume Le Gland, Valérie le Guennec, Laure Guillou



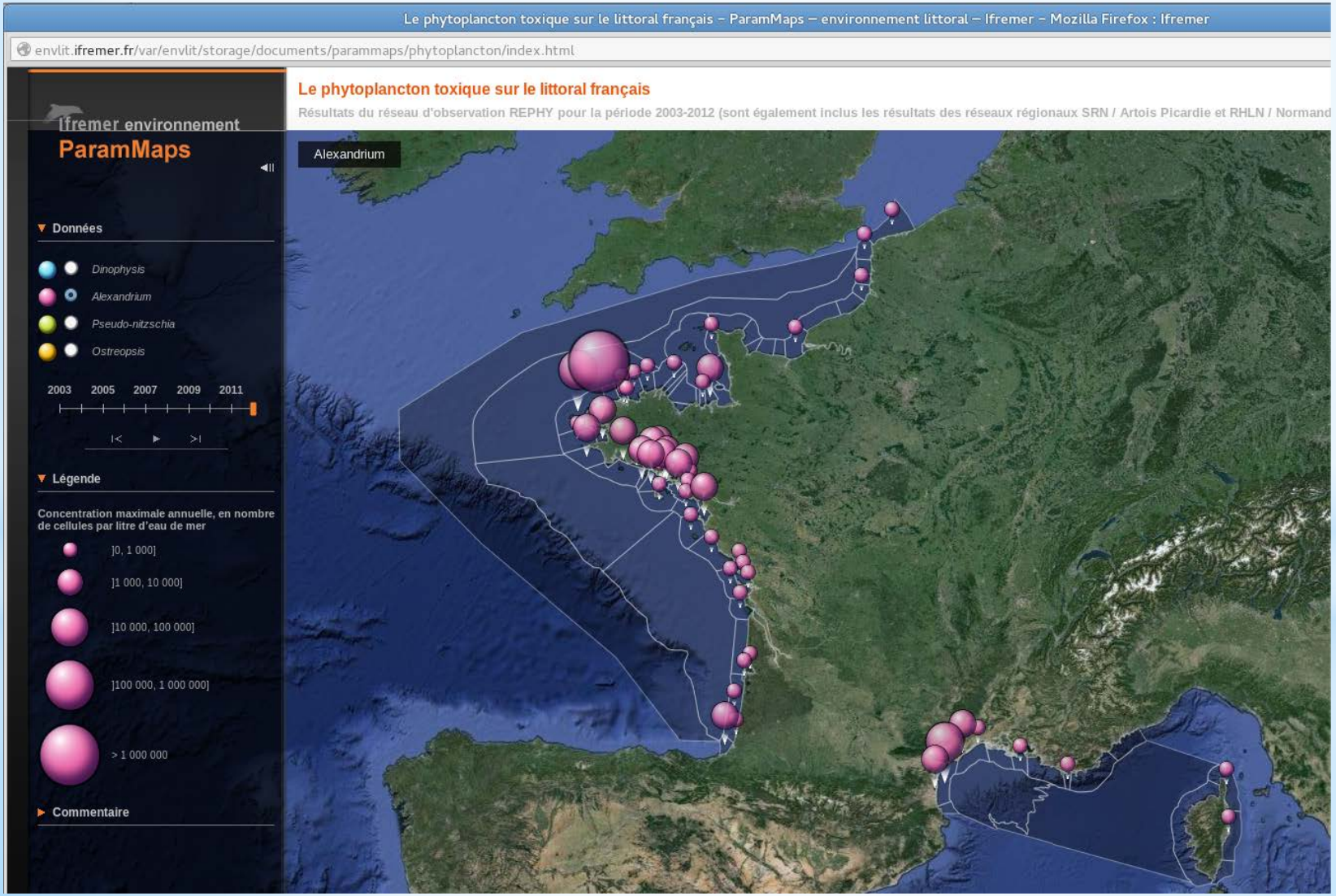
- *A. minutum* blooms and toxicities, a 27 years survey on the French coast
- Environmental niche of *A. minutum* populations
- Phenology of *A. minutum* blooms and its controls
- Using 2 approachs, statistical and trait-based modelling
- In a changing world ?

ifremer

agence de l'eau Loire-Bretagne

A. minutum blooms and toxicities, a 27 years survey on the French coast

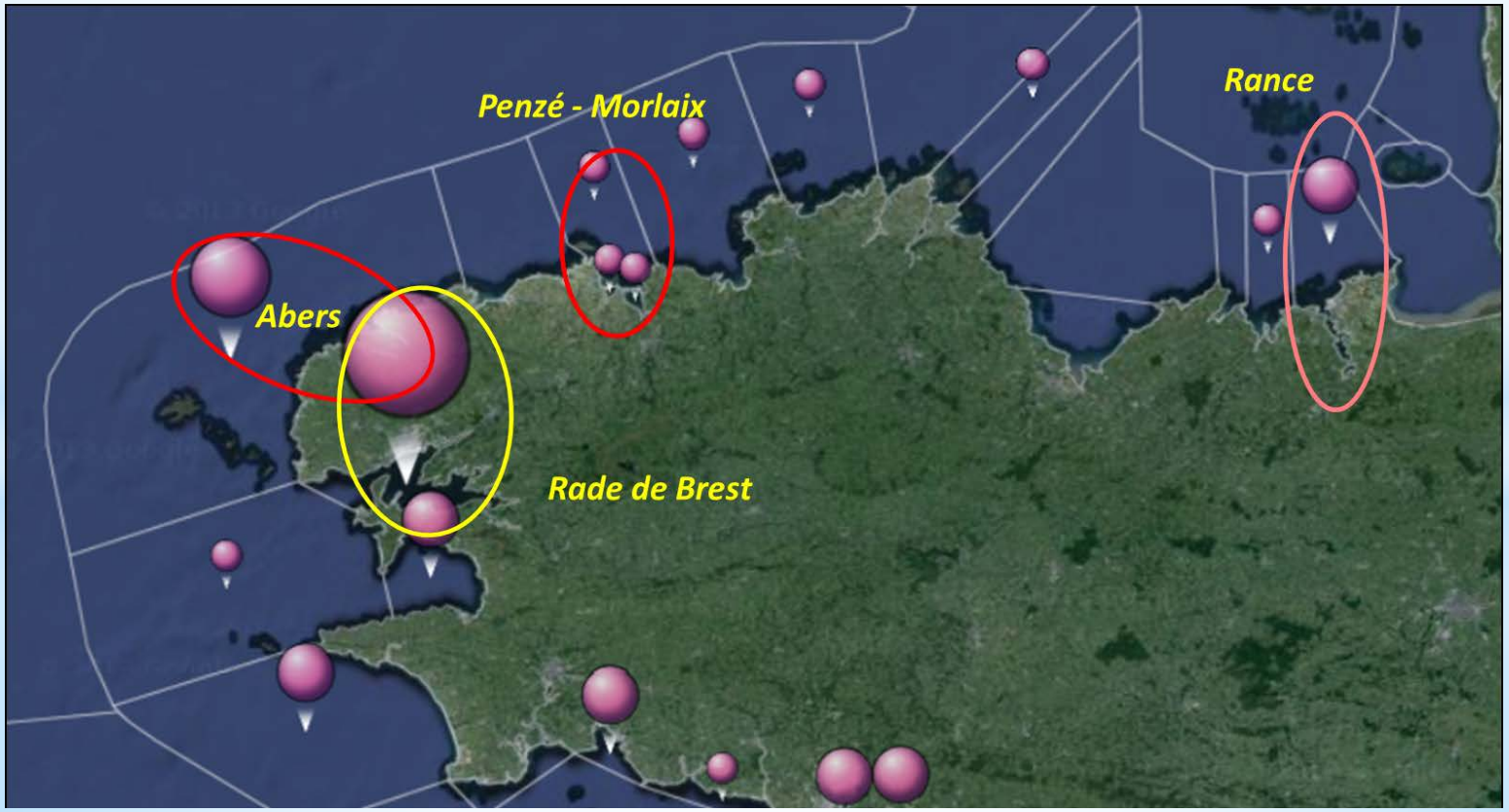
- First detection of *A. minutum* in 1988 (source Rephy)
- Present on the English Channel, Atlantic and Mediterranean French coast



A. minutum blooms and toxicities, a 27 years survey on the French coast

High blooms leading to toxicity only in Breton Estuaries. Maximum 44 M cell L^{-1} (source Rephy and Final, Paralex, Daoulex projects).

- Penzé, Morlaix, Abers (since 88)
- Rance (since 96)
- Rade de Brest (since 2010)



A. minutum blooms and toxicities, a 27 years survey on the French coast

- Niche analysis ●
- Phenology analysis ○
- Trait-based modelling ○

} Statistical studies : 1988 – 2014

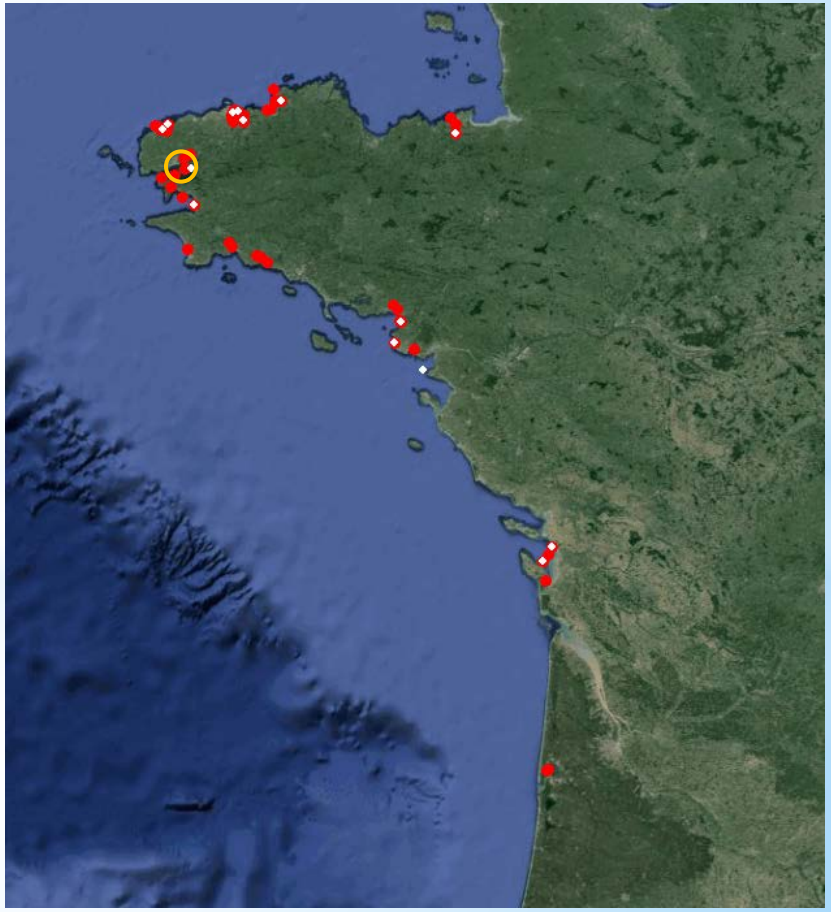
17 regions, 67 stations

Brest bay, 2012 - 2014

Environmental parameters

Chlorophyll	In situ, Satellite
Temperature	In situ, Satellite, Models
Salinity	In situ, Models
Turbidity	In situ
Oxygen	In situ
Suspended Particulate Matter	Satellite
Nutrients (N, P, Si)	In situ, Models
Irradiance	Satellite
Tide (coefficient and hight)	In situ, Models
River flow	In situ
Atmospheric pressure	In situ, Models
Wind (Direction, Speed)	In situ, Models
AMO, NAO	Climate index

Studied sites

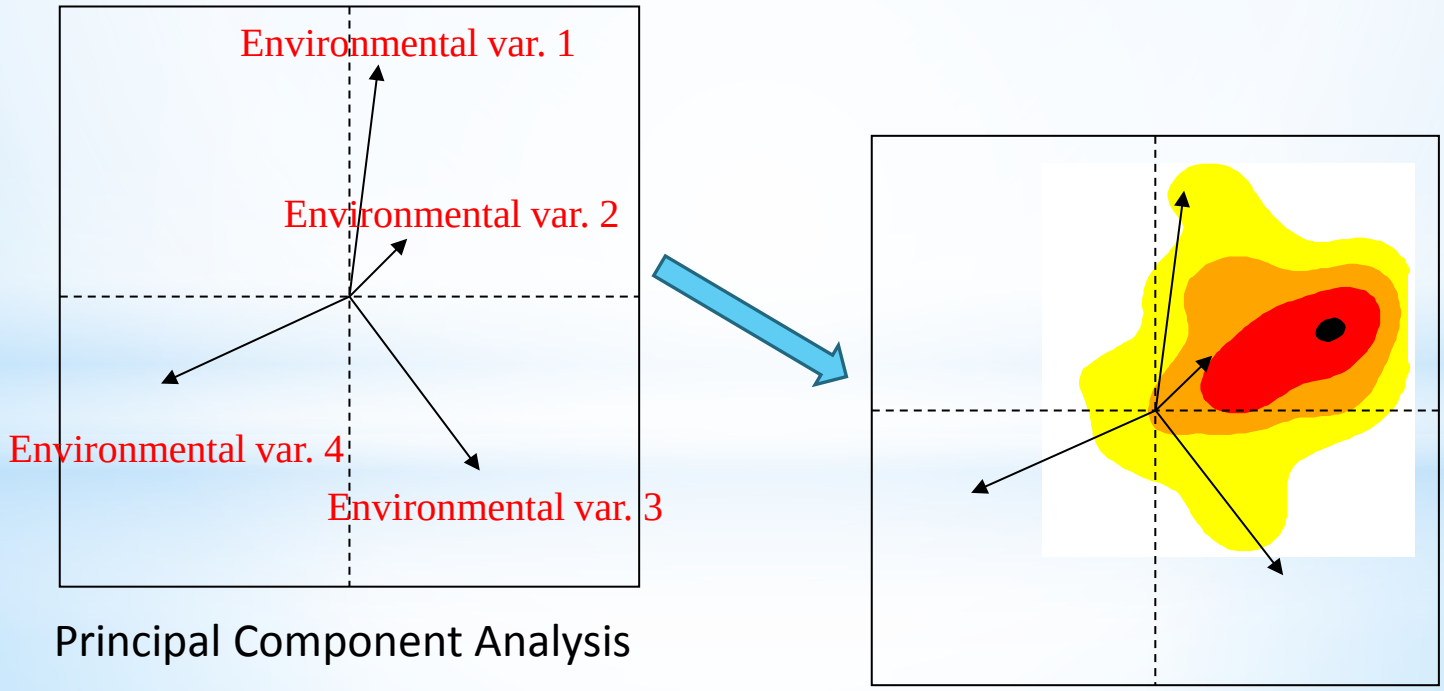


Environmental niche of *A. minutum* populations

- 'The *ecological niche* is the volume in the environmental space that permits a positive growth of the species' (Hutchinson 1957)
- Potential niche versus realised niche

Principal Component Analysis (Trait-base modelling)

- Define environmental space



Principal Component Analysis

(Broennimann et al. 2012)

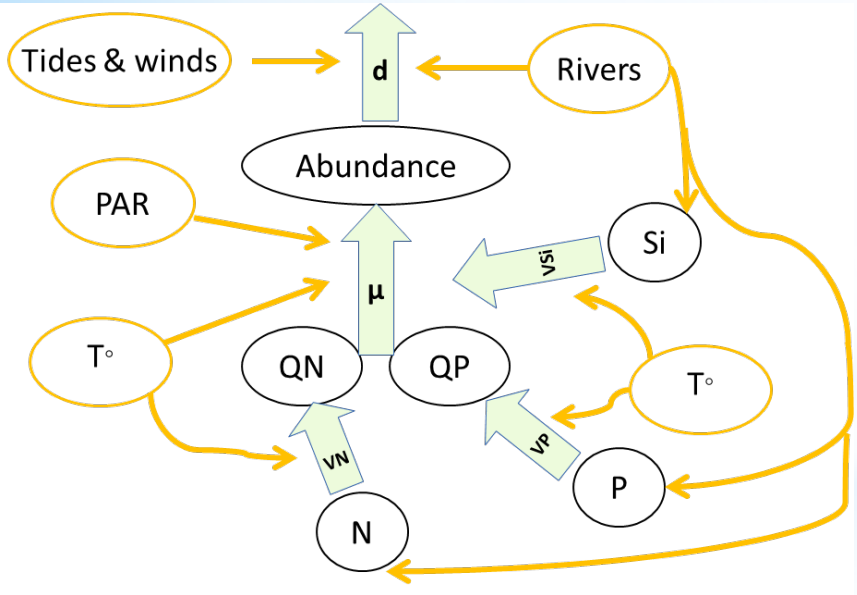
Kernel density function

Environmental niche of *A. minutum* populations

- 'The *ecological niche* is the volume in the environmental space that permits a positive growth of the species' (Hutchinson 1957)
- Potential niche versus realised niche

(Principal Component Analysis) **Trait-base modelling**

- **50 species + *A.minutum***

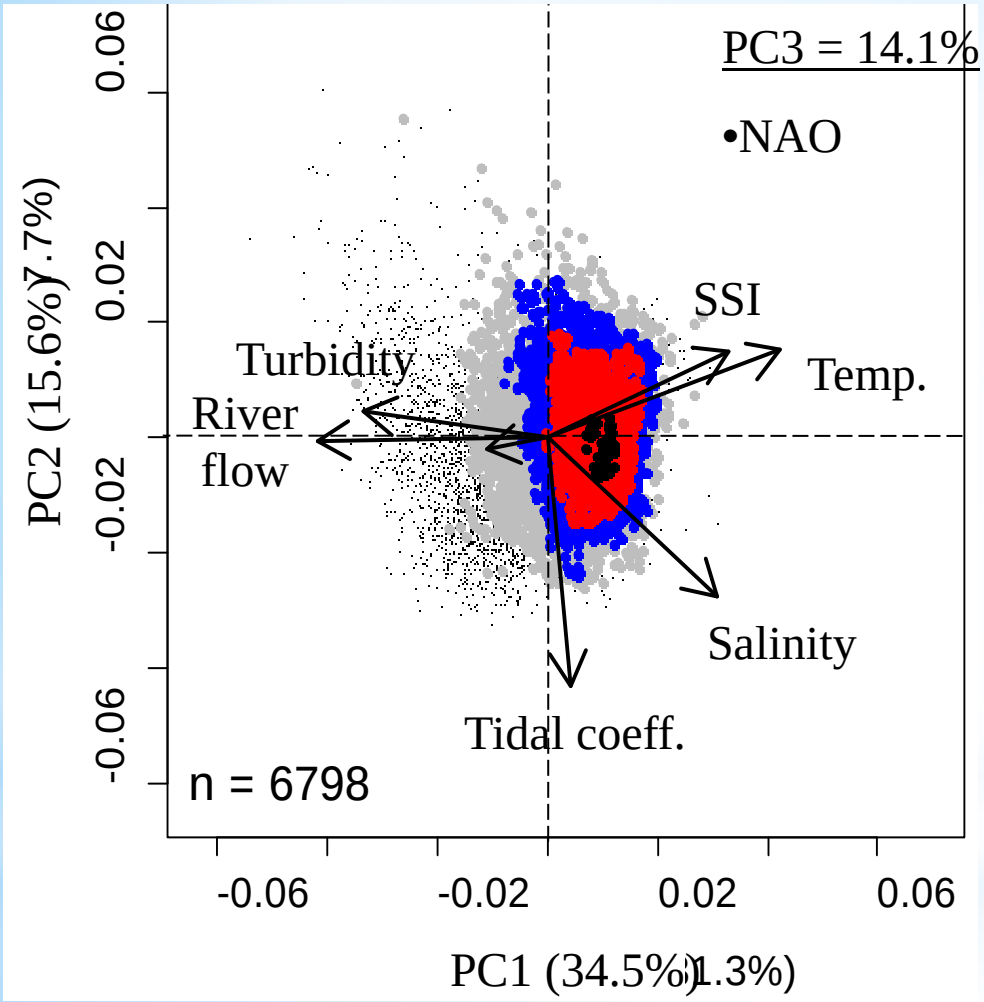


(Dutkiewicz & Follows, 2009)

Traits	Types of distributions
Diatom or Dinoflagellate	Random law (Binary reponse)
Size (1µm – 100µm)	Random and uniform law
Optimal temperature (10°C – 20°C)	Random and uniform law
Maximum growth rate	Eppley function (dependence in *Topt*)
Minimum Quota in Nitrogen, Phosphate and Silicium	Allometric law (Trade off with size)
Maximum Quota in Nitrogen, Phosphate and Silicium	Allometric law (Trade off with size)
Maximum Uptake rate in Nitrogen, Phosphate and Silicium	Allometric law (Trade off with size and optimal temperature)
Saturation coefficient in Nitrogen, Phosphate and Silicium	Allometric law (Trade off with size)
Optimal irradiance	Constant : 20 $W.m^{-2}$

Environmental niche of *A. minutum* populations

- **Principal Component Analysis**



Environmental variables	Minimum	Maximum	
Salinity	3.20	38.10	psu
Temperature	4.40	25.90	°C
Turbidity	0.08	120.00	NTU
Sea Surface Irradiance	8.9	416.5	$W \cdot m^{-2}$
Tidal coefficient	38.6	103.9	
North Atlantic Oscillation index	-1.654	1.658	

Contour probability mass

- 1
- 25
- 50
- 75

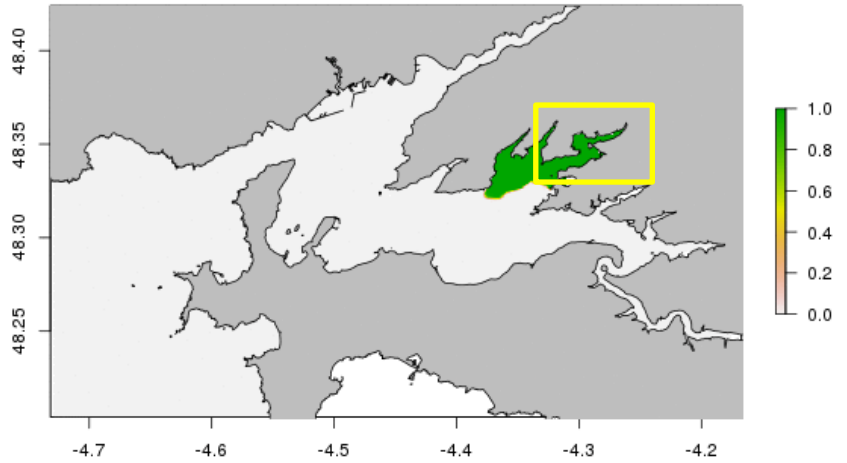
Realised niche : Warm temperatures, high irradiance, low river flow

Lower turbidity and higher salinities favourable

NAO and tides apparently no influence

Environmental niche of *A. minutum* populations

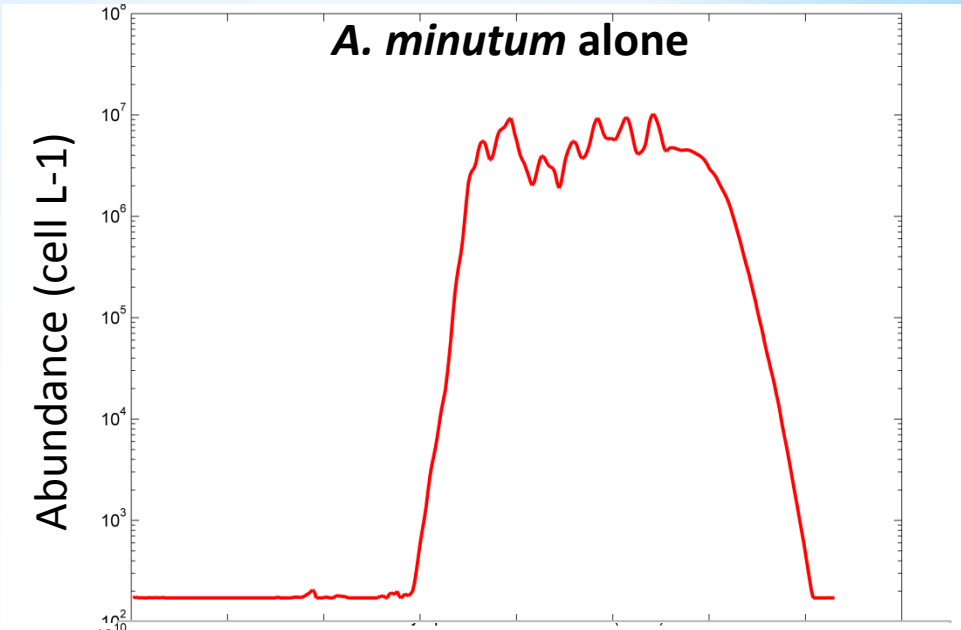
Trait-based numerical modelling

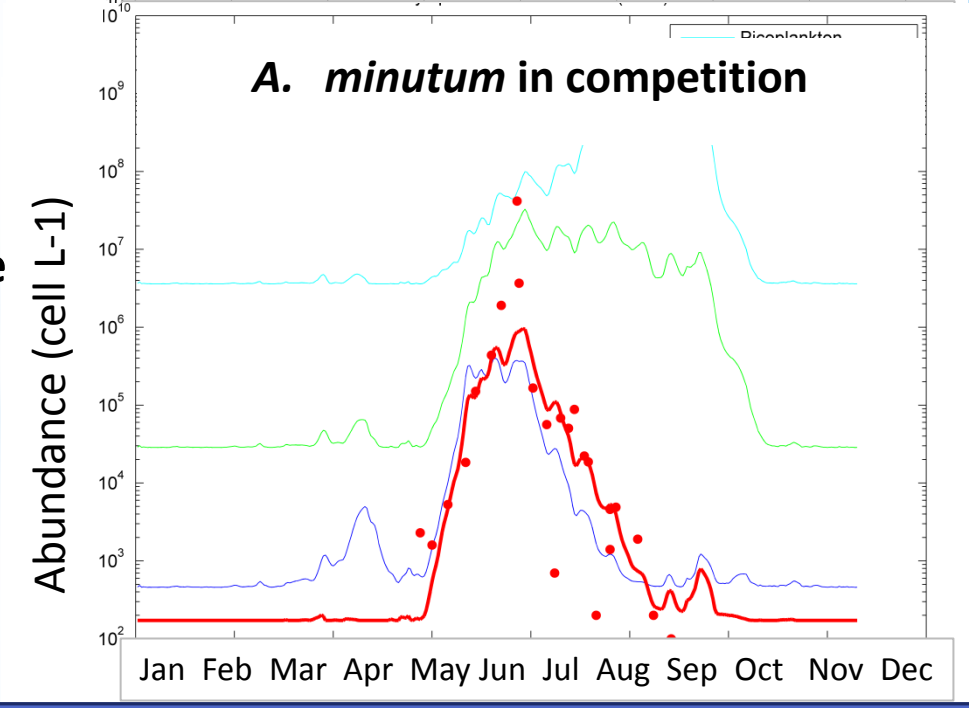


- ***A. minutum*** **alone → Potential niche**

- ***A. minutum*** **in competition → Realised niche**

	Model	Data
A. minutum		
Picoplancton		
Nanoplancton		
Microplancton		



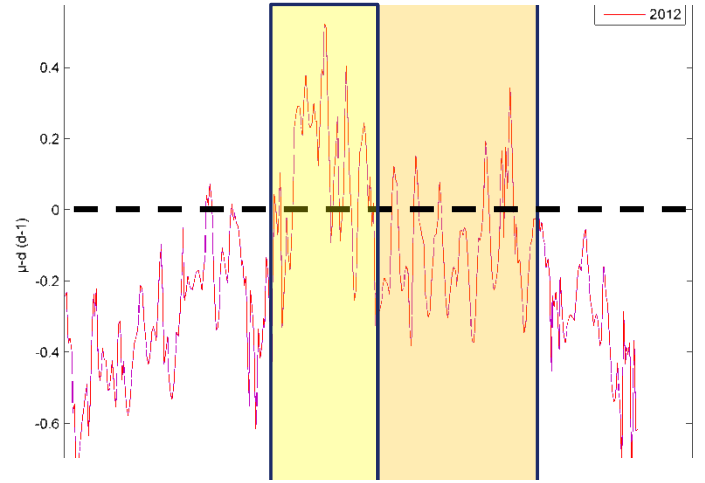


Potential niche : From May to October **Realised niche : From May to August**

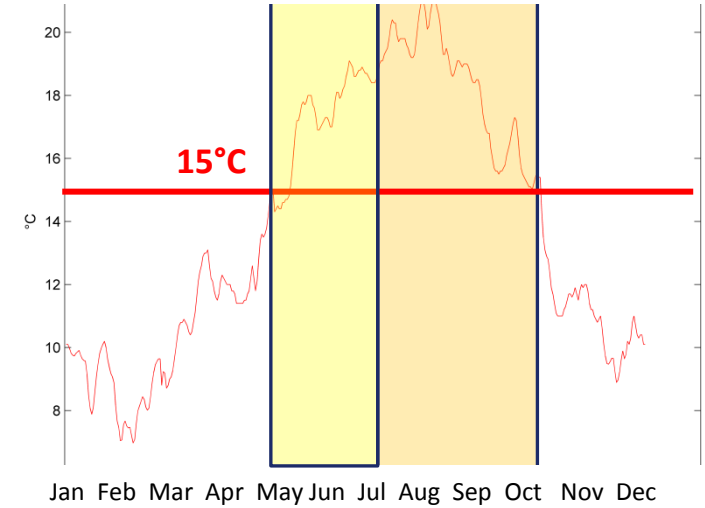
Environmental niche of *A. minutum* populations

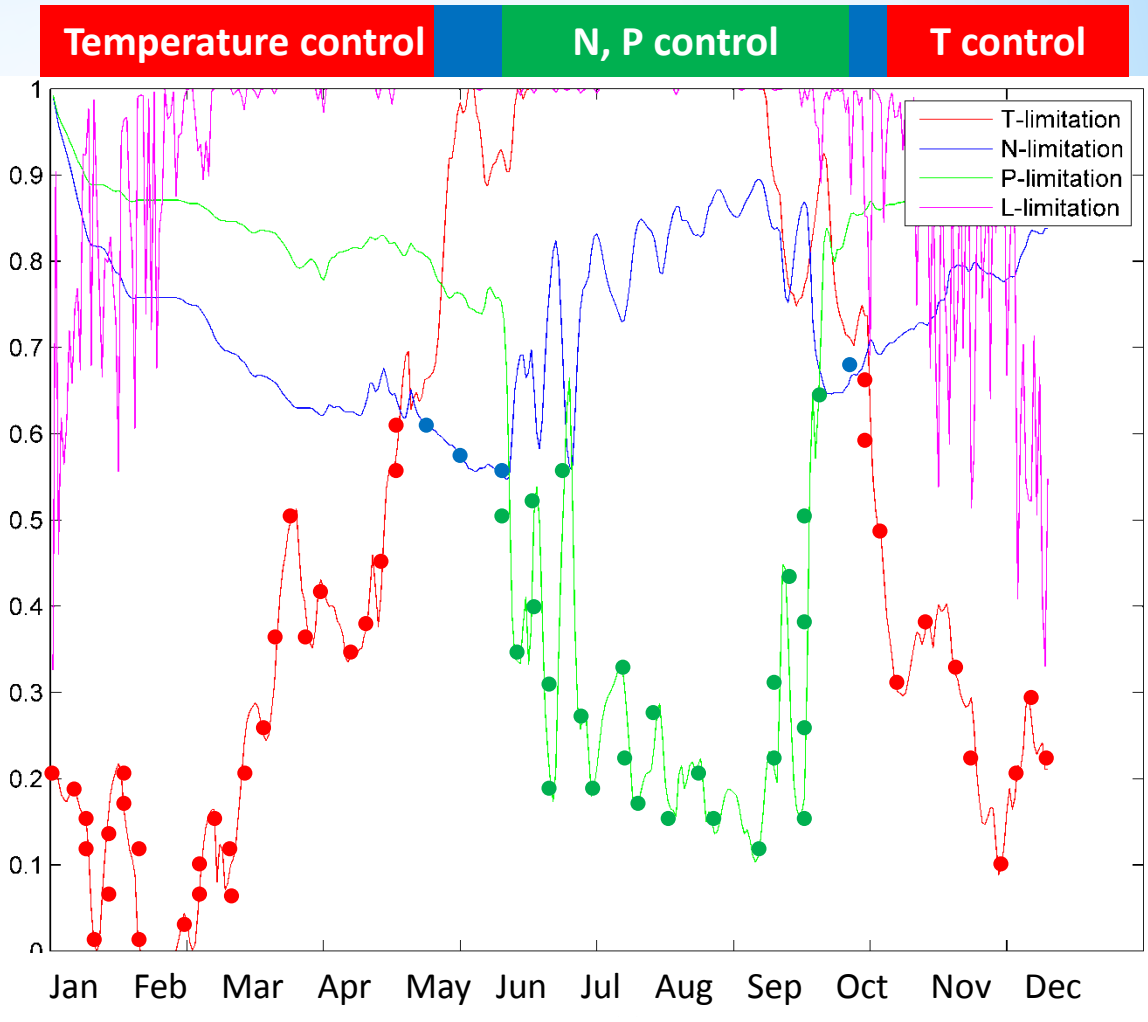
- **Trait-based numerical modelling** **Bloom possible when : μ > d**

dilution - growth **μ (T, I, Nut)** **d (tide, flow)**



temperature





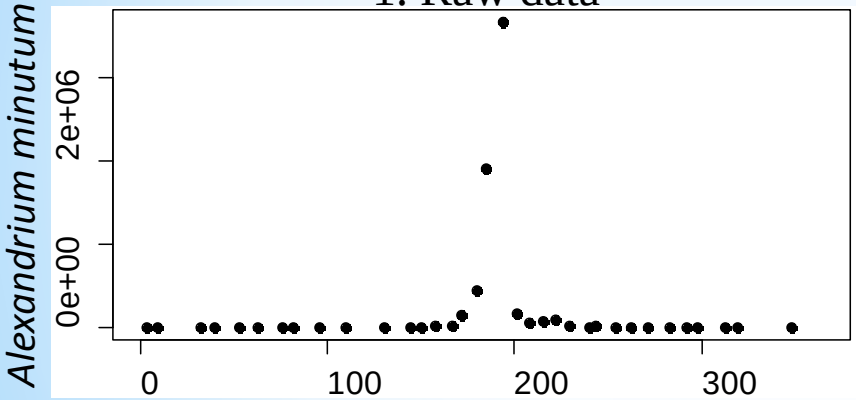
Potential niche : Dilution, Temperature. Temperature treshold : 15°C

Realised niche : Dilution, Temperature, Nutrients. Importance of competition for nutrients

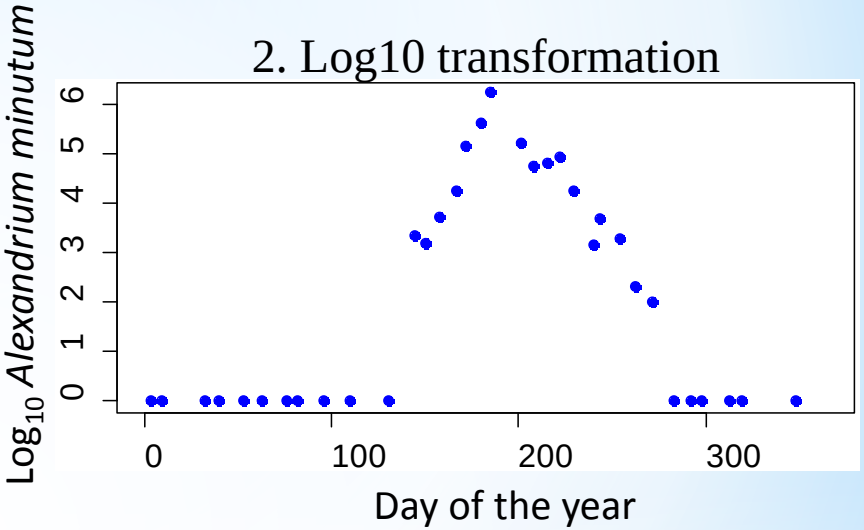
Phenology of *A. minutum* and its controls

'*Phenology*' characterise the life cycle phases or activities of plants and animals in their temporal occurrence throughout the year, especially in relation to climate and weather' (Lieth 1957, Vliet & de Groot 2004)

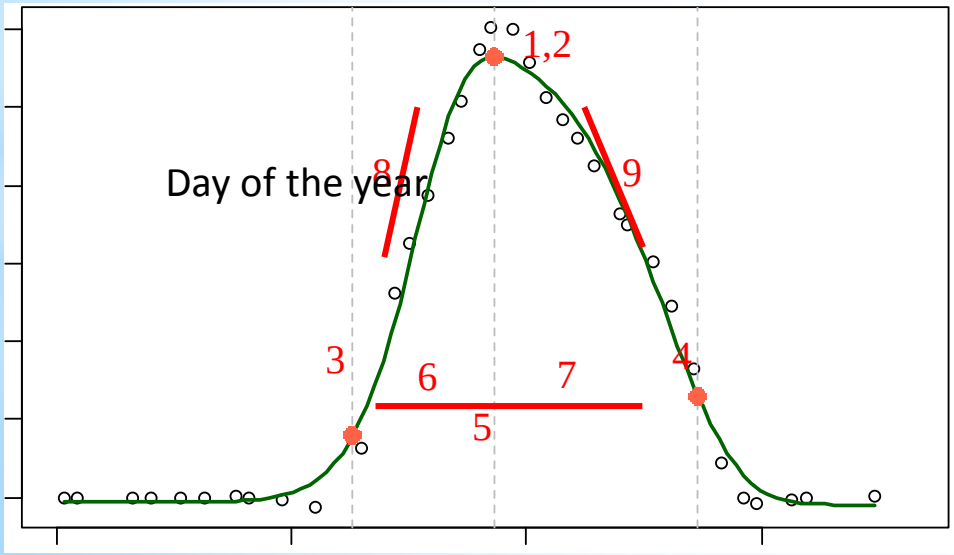
1. Raw data



2. Log10 transformation



3. Fit Weibull function

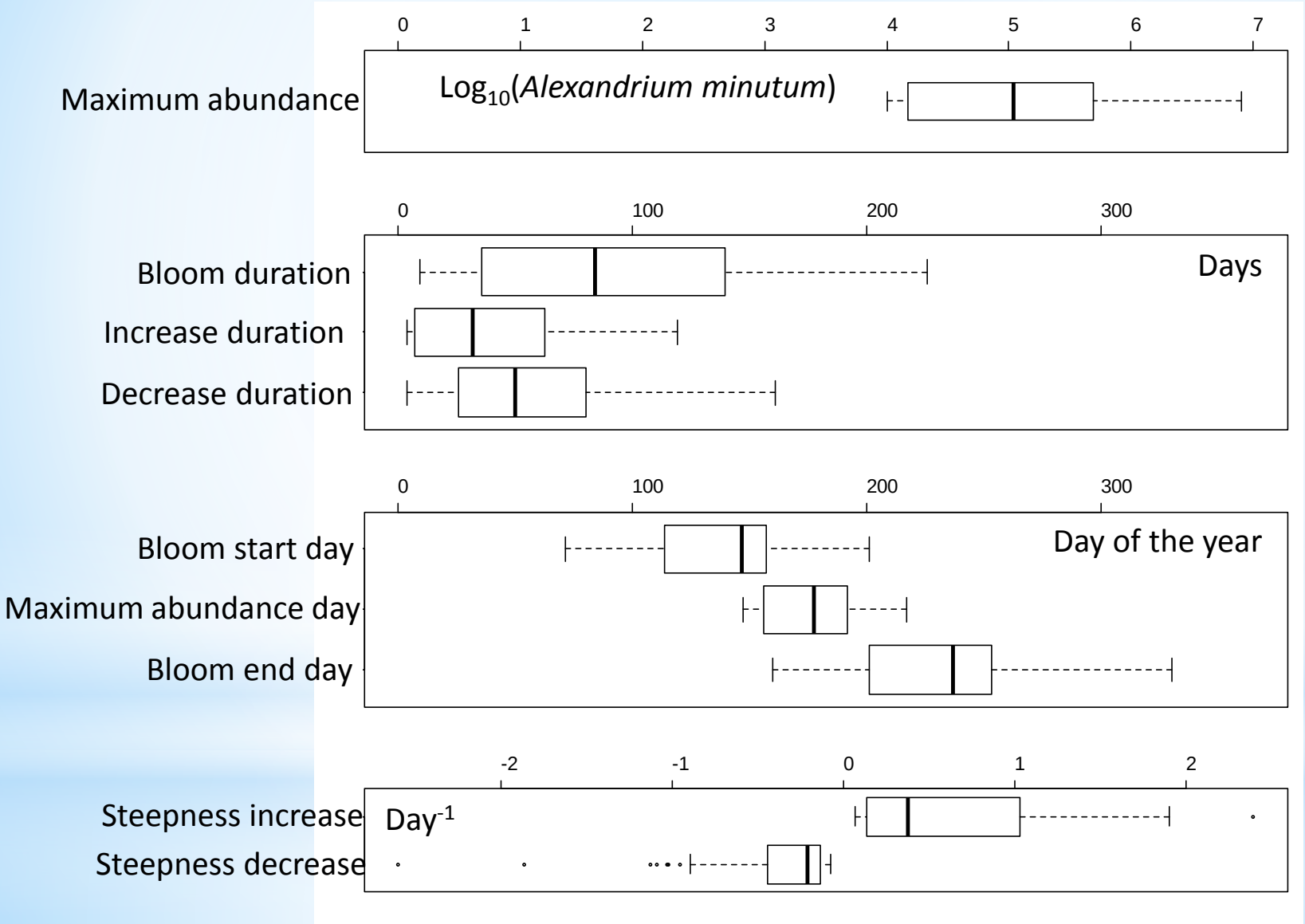


(Rolinski et al. 2007)

Define Phytoplankton bloom events

1 Max. abundance day
2 Max. abundance
3 Bloom start day
4 Bloom end day
5 Bloom length
6 Increase length
7 Decrease length
8 Steepness increase
9 Steepness decrease

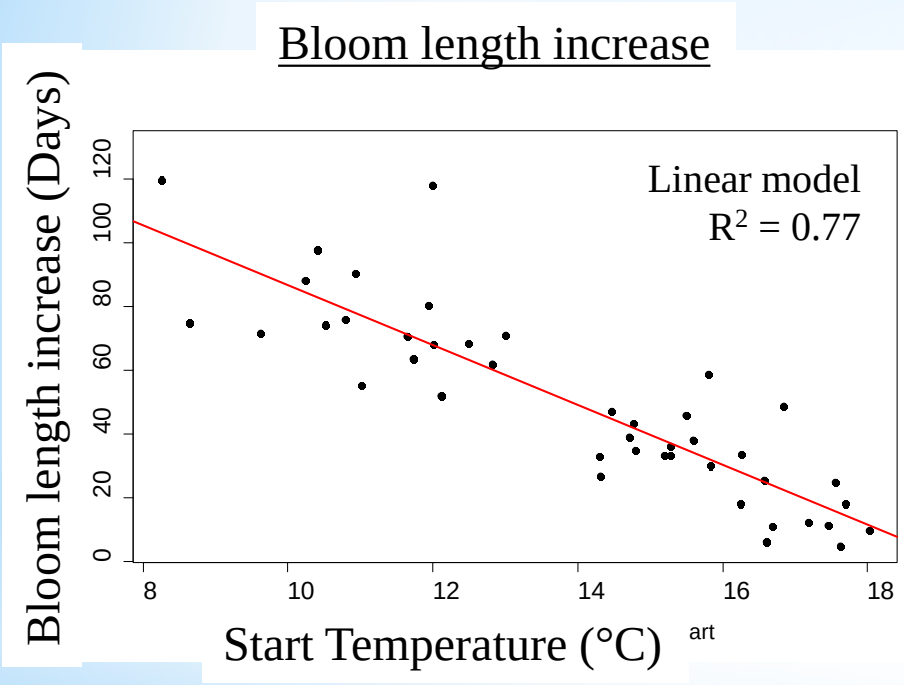
Phenology of *A. minutum* and its controls

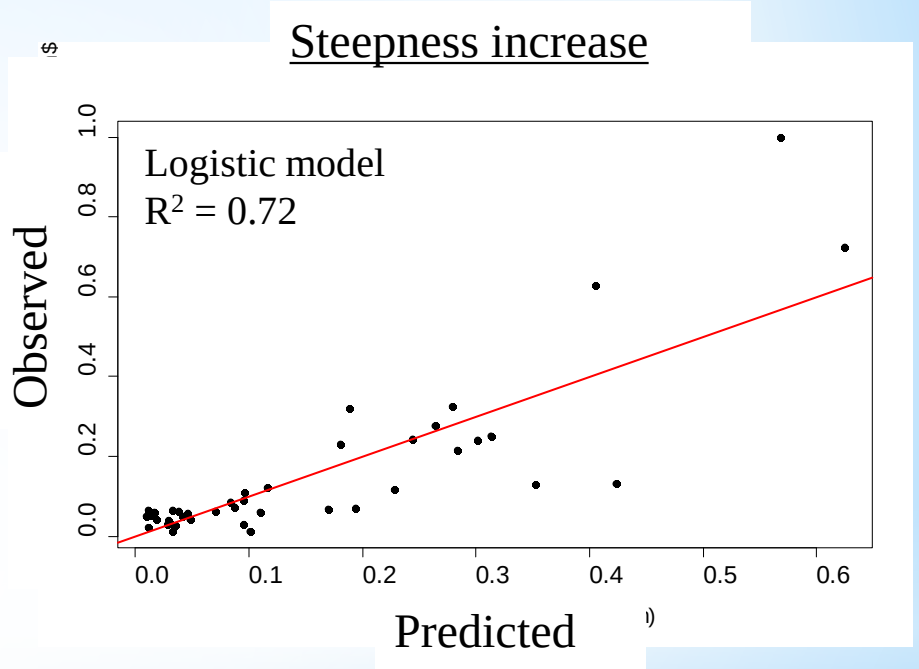


Weibull application to data (52 year-station time series)

Phenology of *A. minutum* and its controls

Stepwise regressions with environmental parameters





Temperature ← Factors → Temperature
Irradiance
Salinity (River flow?)

Temperature at the start of the bloom control growth rate (+), bloom length (-), bloom increase length (-), bloom lenght decrease (-).

Irradiance and Salinity also correlated but less.

Phenology of *A. minutum* and its controls

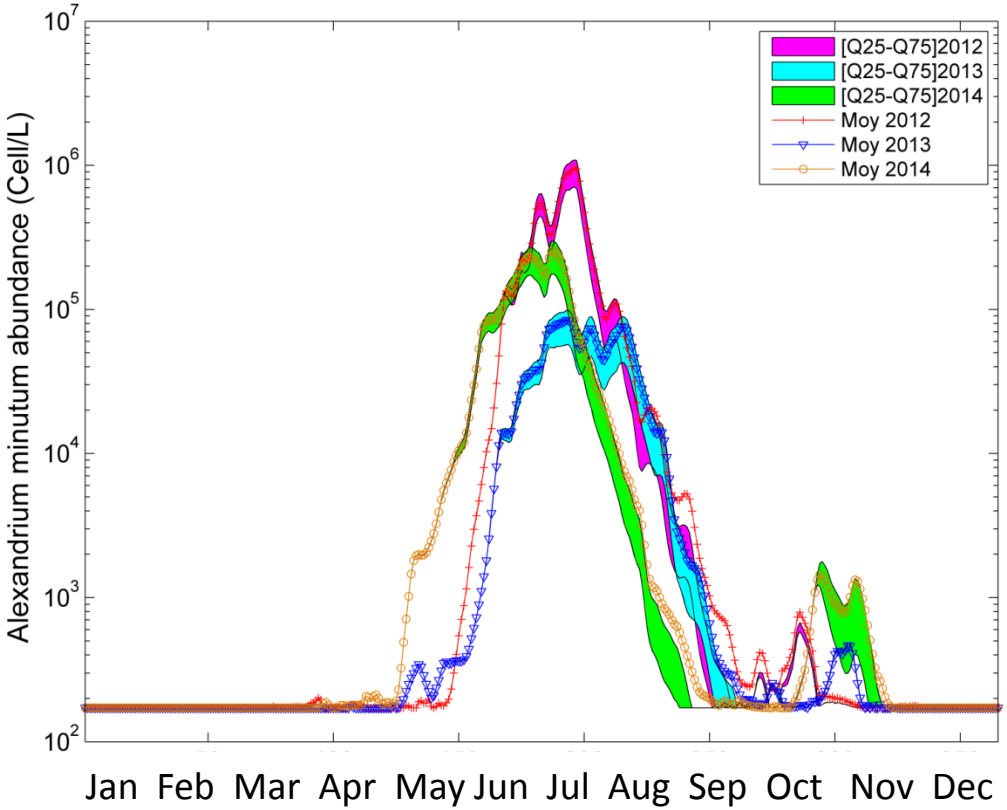
3 years modelling, Brest bay

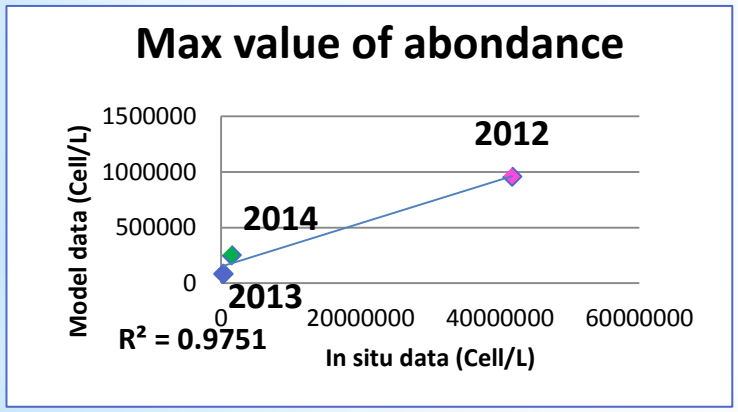
Abundance max : **2012** > 2014 > 2013

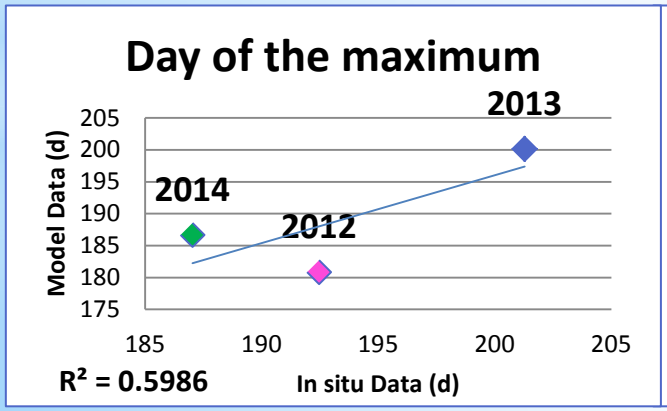
Day of the maximum: **2014** > 2012 >2013

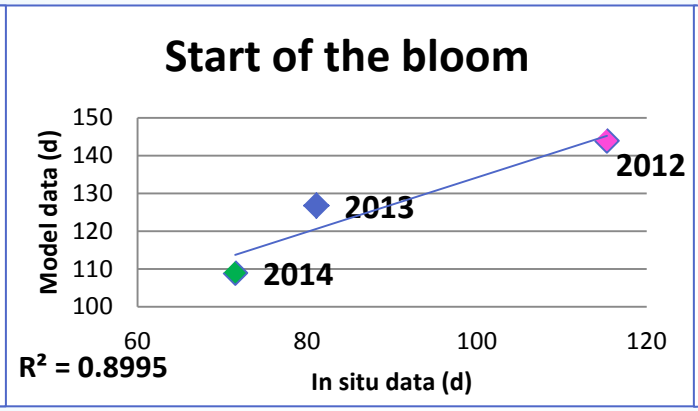
Start of the bloom : **2014** > 2013 > 2012

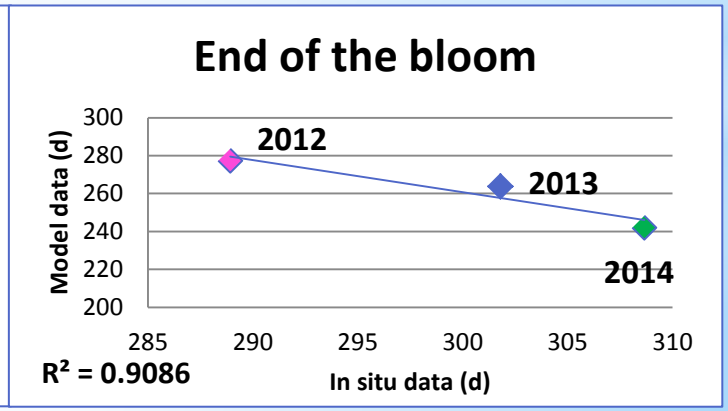
End of the bloom : model ≠ data





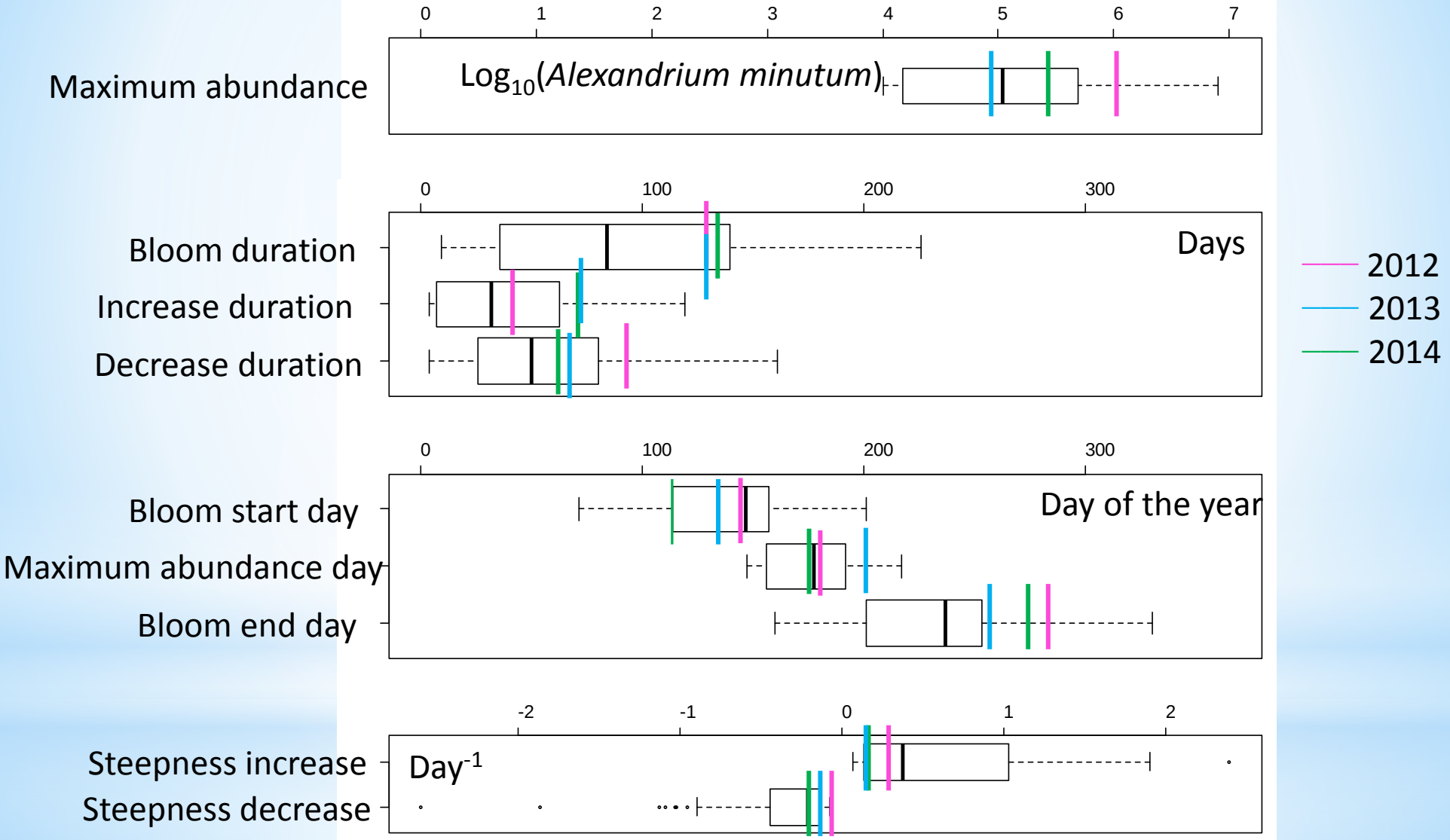






Phenology of *A. minutum* and its controls

Weibull application to data (52 year-station time series) + 3 years modelling

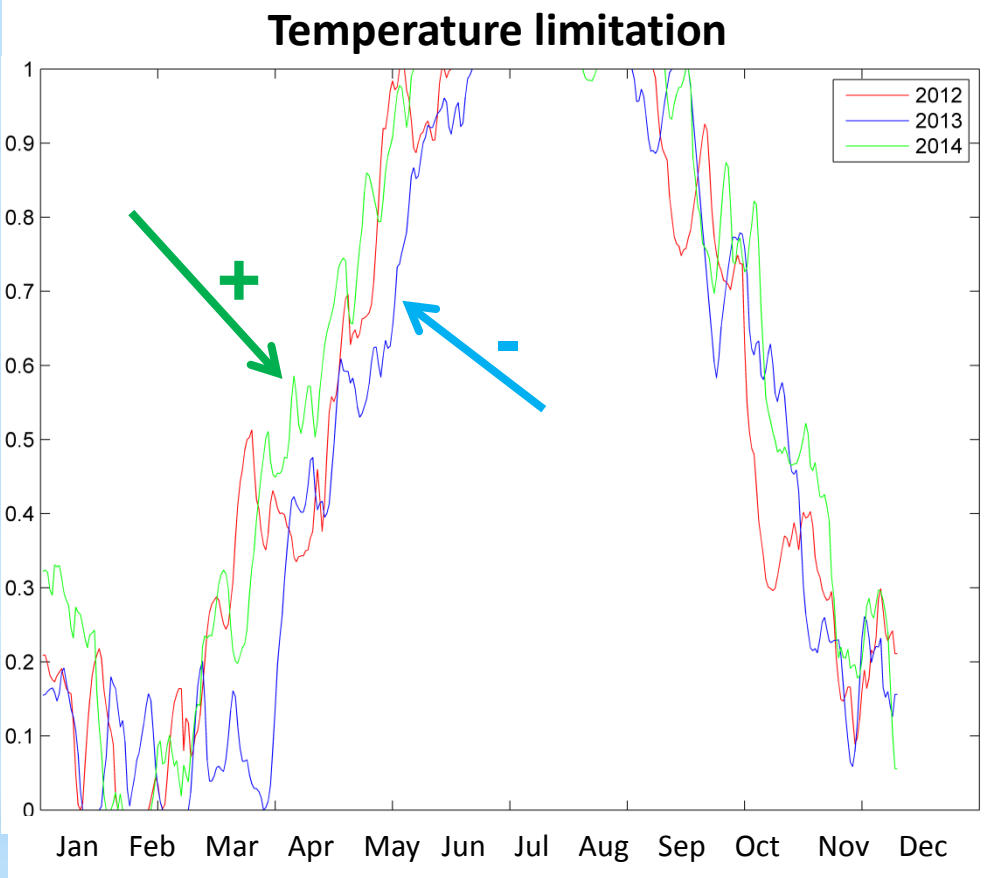


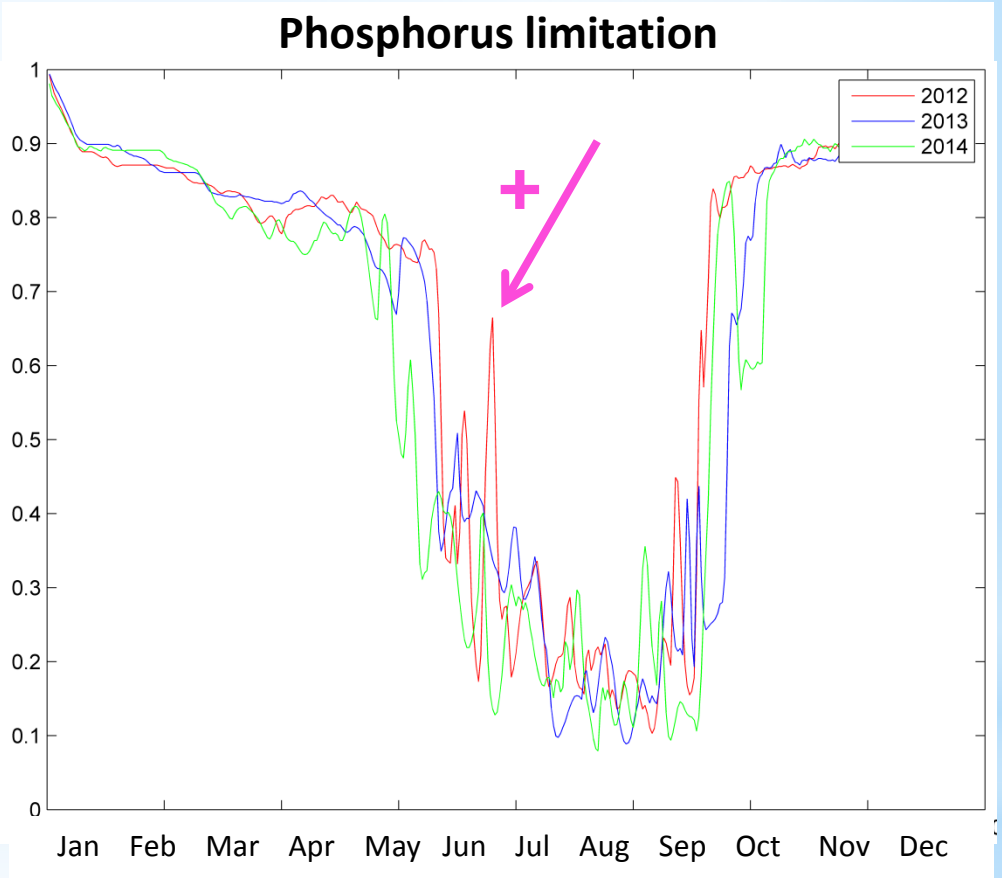
2012 is a very exceptional bloom in term of amplitude in the Brest bay

Blooms in Brest bay lasted more

Phenology of *A. minutum* and its controls

3 years modelling, Brest bay





Temperature controls the bloom initiation

Nutrients (P) control the bloom amplitude

Alexandrium minutum phenology and controls, in a changing world ? Perspectives

Abiotic controls

Biotic controls

Climatic changes

Human changes

Temperature

Tides

River flow

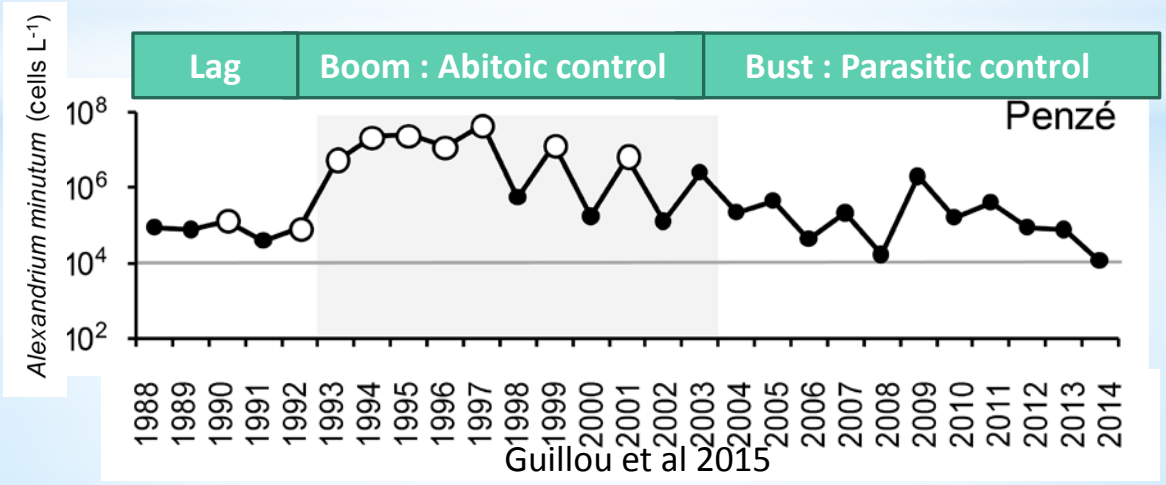
Nutrients

A. minutum

Predation Parasitism

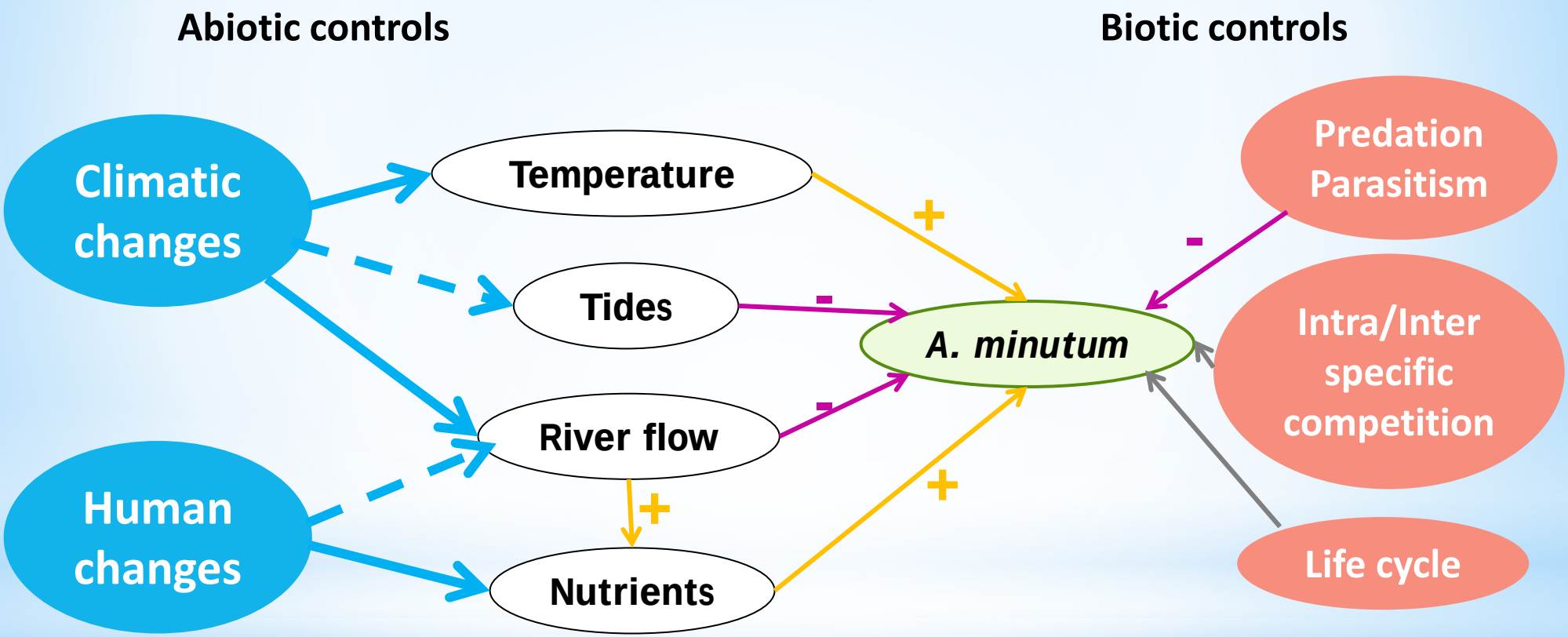
Intra/Inter specific competition

Life cycle



Guillou et al 2015

Alexandrium minutum phenology and abiotic controls, in a changing world ? Perspectives - Scenarios



Abiotic controls : need scenarios climatic and human changes

Biotic controls : our studies and collaborations


Thank you
Film Lann vraz (S. Daniellou)