Consequences of nutrient inputs on primary producers and monitoring strategies: A case study, the Bay of Seine - France

Pascal Claquin

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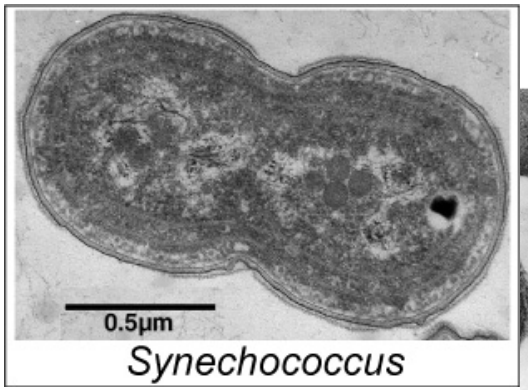
Primary producers

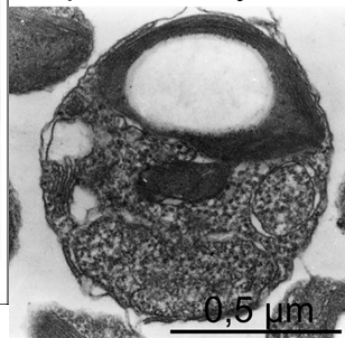
PHYTOPLANKTON

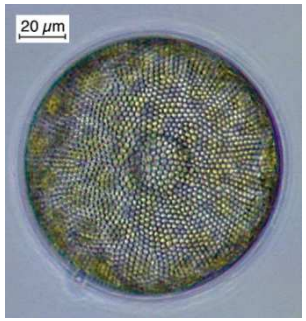
PHYTOBENTHOS



Synechococcus

Ostreococcus tauri
"pico"eucaryote

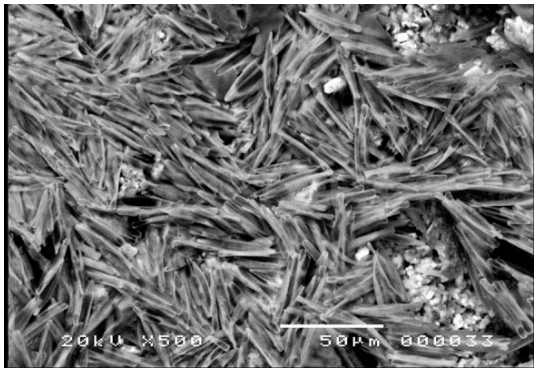




Eucaryotic microalgae
Cyanobacteria

Angiosperm

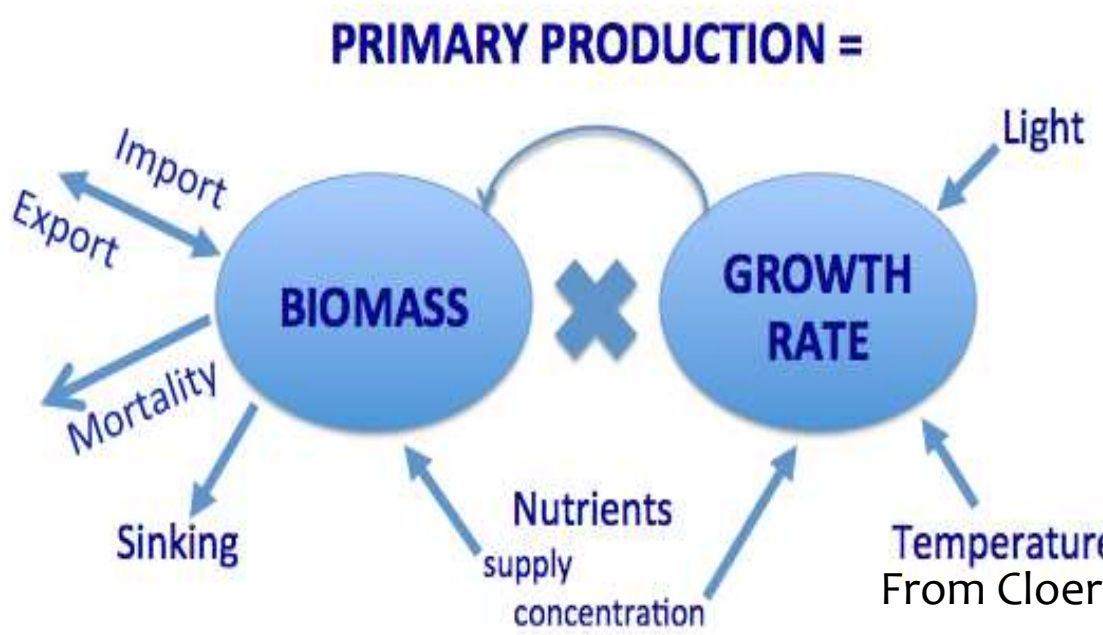
Macroalgae (G,B, R)



Microphytobenthos

Primary production

Primary production



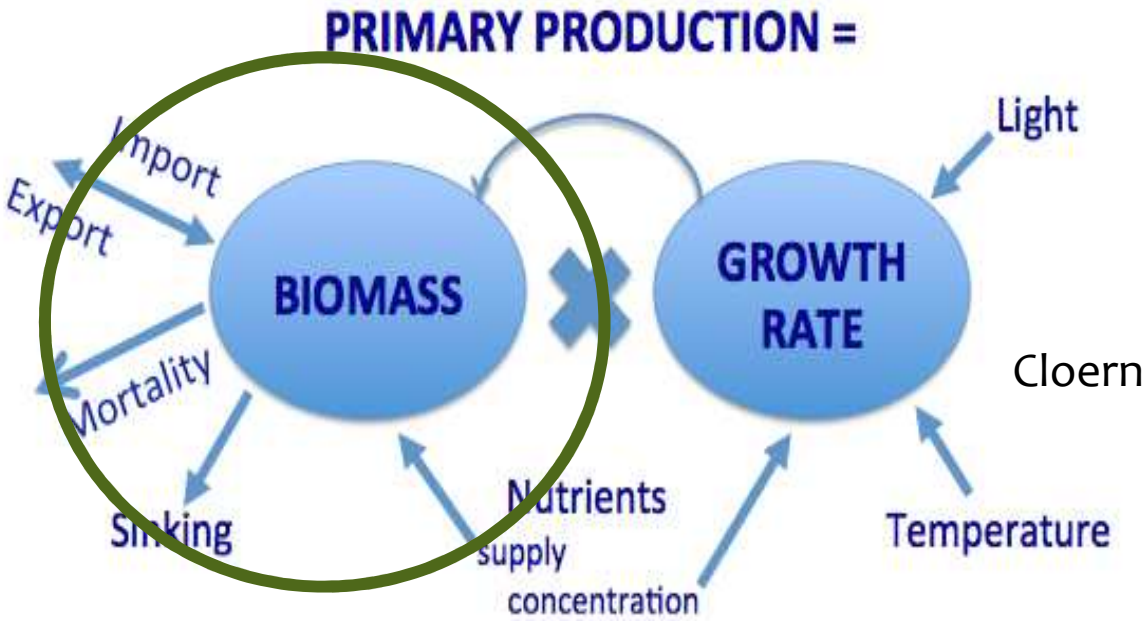
From Cloern et al (2014)

Biomass = Stock

Production = Carbon flux & Energy flux

* - Primary production is one of the main functions of marine ecosystems
* - But there are only few series of primary production measurements in comparison with biomass

In case of Eutrophication



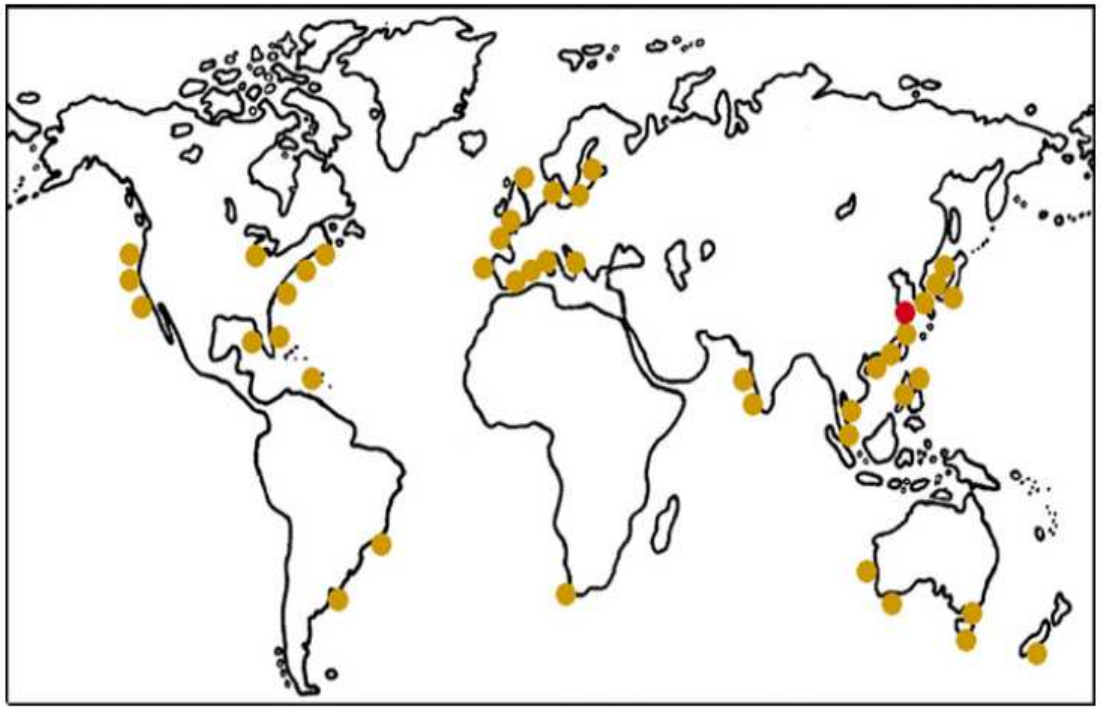
Cloern et al (2014)

There is an ACCUMULATION of BIOMASS
because of high growth rate and low export or high import….
which leads to a decrease of O2 and all the consequences on biogeochemistry, physiology, ecology, foodweb etc..

Biomass accumulation

* "Green tides" of opportunistic macroalgae

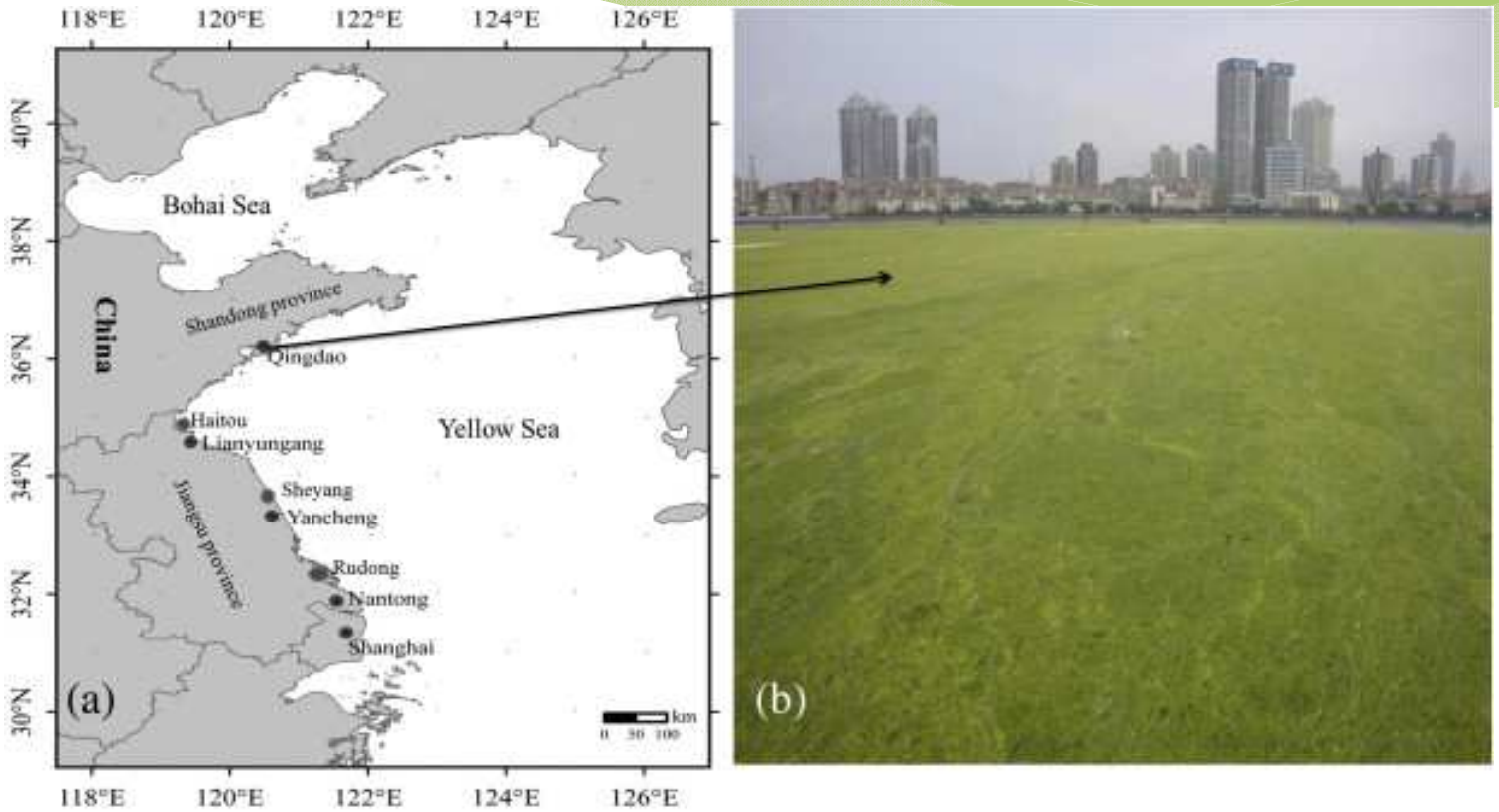
Fig. 1 Worldwide green tide distribution during the last three decades (only the most frequently attacked sites are included). The *red circle* marks the world's largest green tide, which occurred in the Yellow Sea, China, in both 2008 and 2009



Ye et al. (2011).

The largest green tide in Qingdao bay in 2009

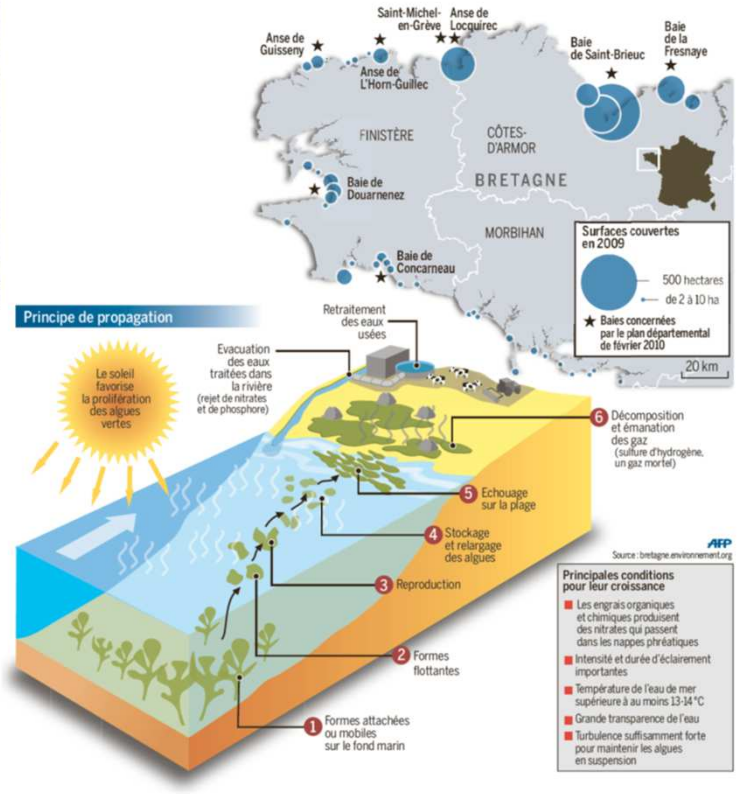
Biomass accumulation



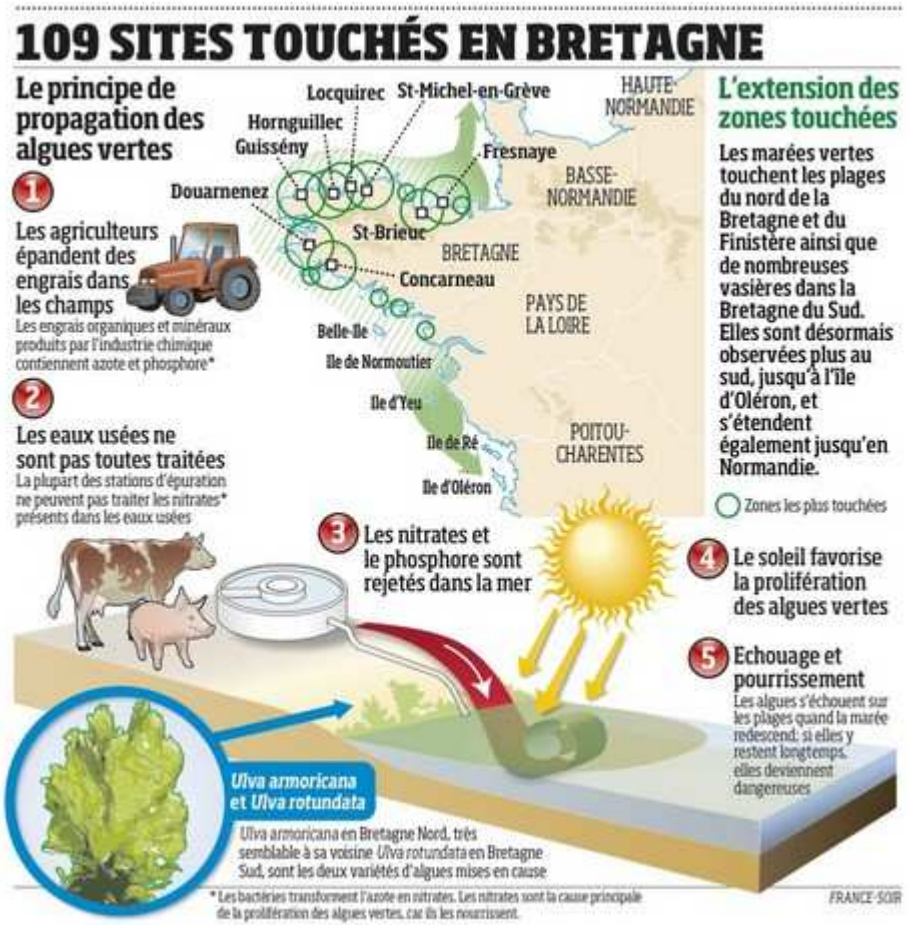
Liu et al 2013 *Ulva prolifera*

Massive seaweed beachings along shores

Massive seaweed beachings along Brittany coast (France)



Massive seaweed beachings along Brittany coast (France)



"Green tides" Type 1 : "Directly" related to Nitrogen inputs (associated with local hydrodynamism etc.)

Massive seaweed beachings along Brittany coast (France)

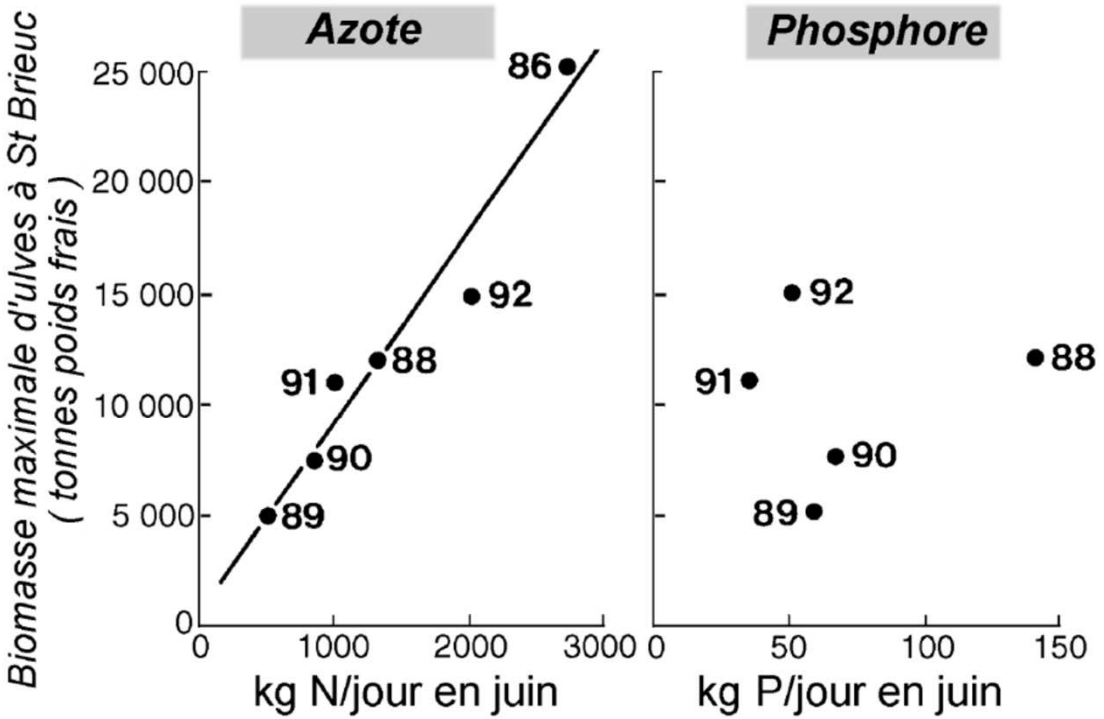


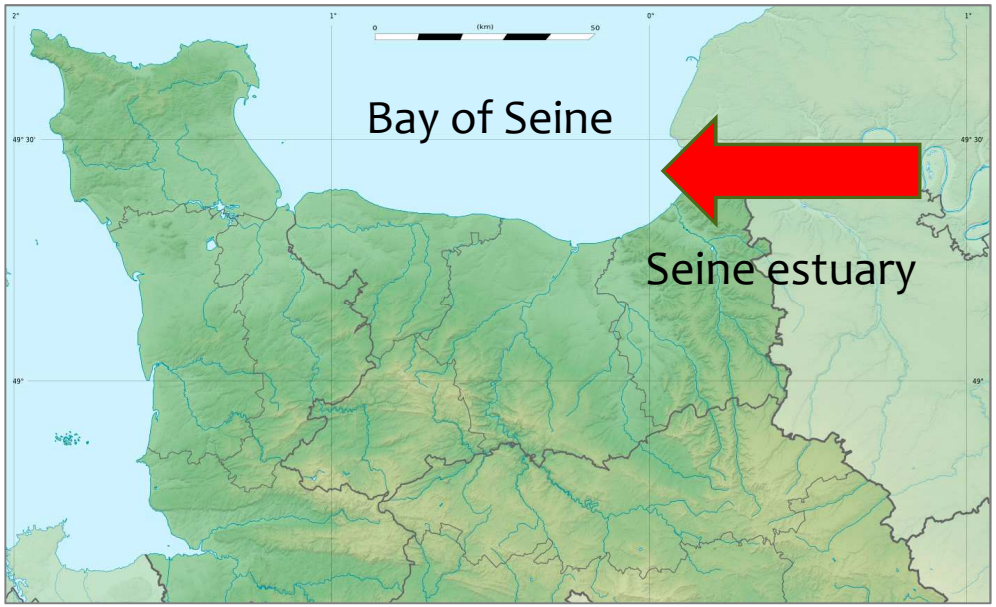
Figure 7. Relations empiriques entre les flux d'azote et de phosphore apportés par les rivières en juin dans le sud de la baie de Saint-Brieuc et le maximum annuel de biomasse atteint en juillet sur ce site. (Ménesguen et Piriou, 1995)

"Green tides" Type 1 : "Directly" related to Nitrogen inputs (associated with local hydrodynamism etc.)

Massive seaweed beachings along Normandy coast (France)

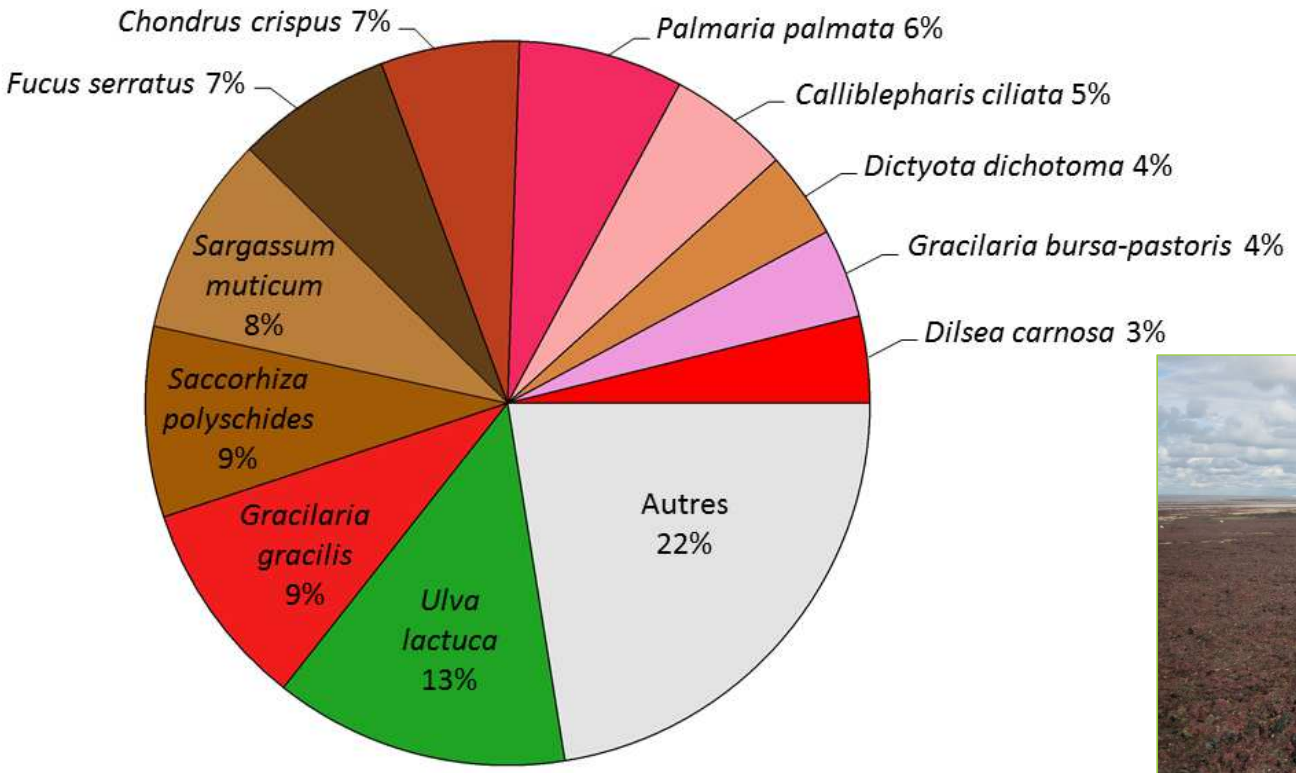
In the Bay of Seine

Massive seaweed beachings along Normandy coast (France)



PhD thesis of **Stéphanie Lemesle** (Supervisor : AM Rusig / I Mussio)

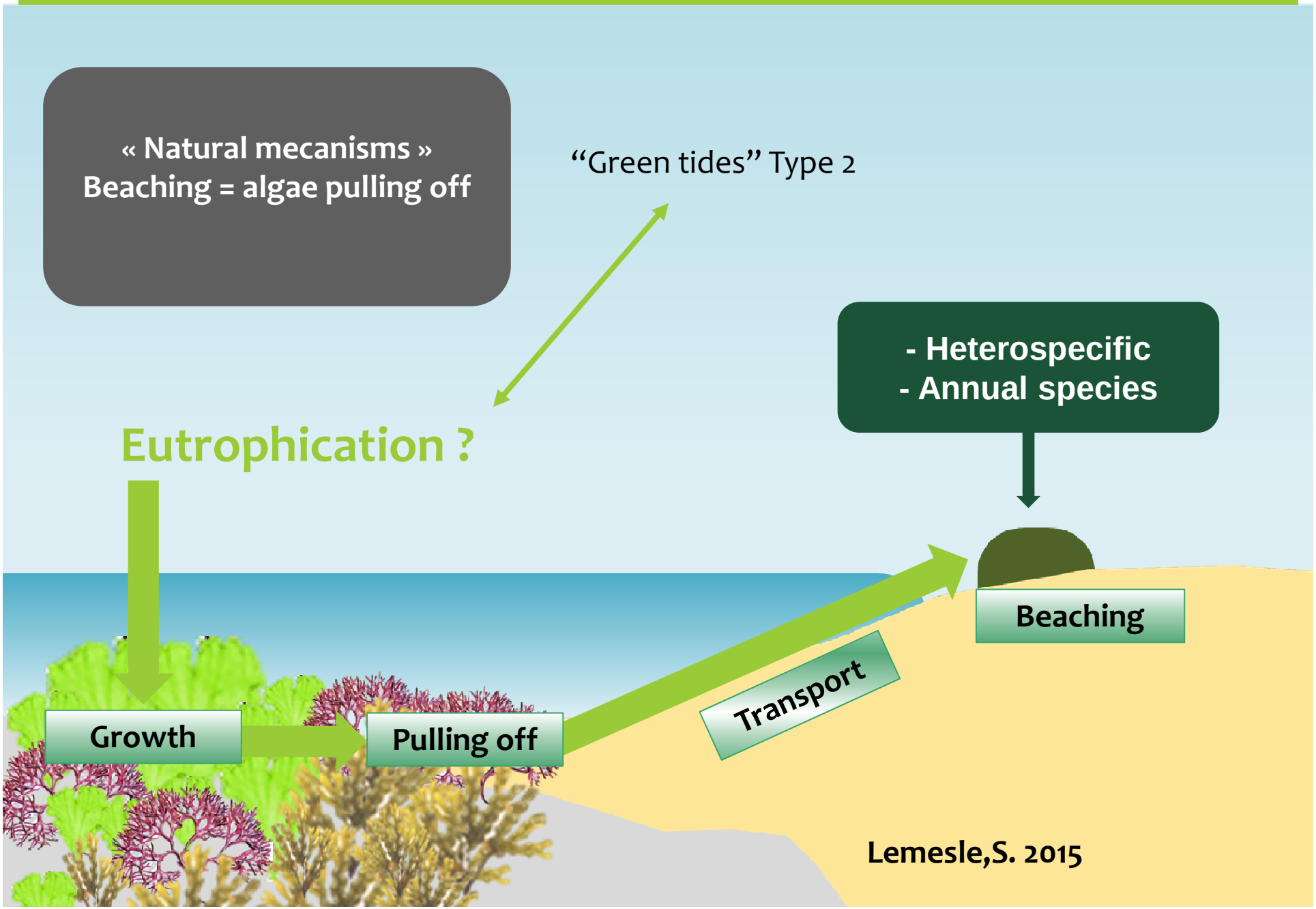
Massive seaweed beachings along Normandy coast (France)



Heterospecific beachings

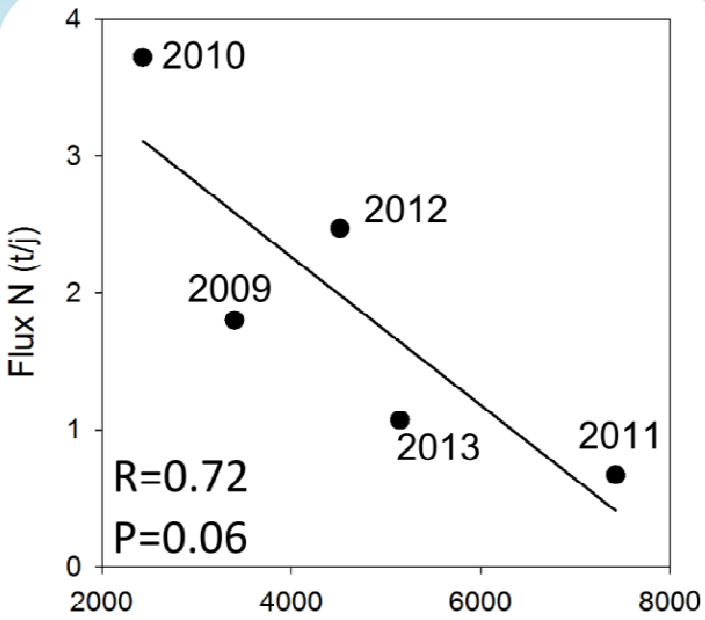
Lemesle,S. 2015

Massive seaweed beachings along Normandy coast (France)



Massive seaweed beachings along Normandy coast (France)

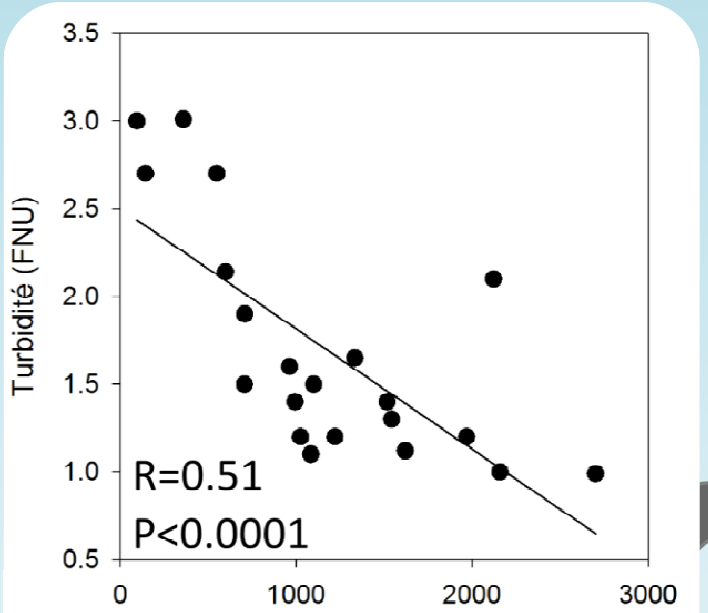
Spring N inputs



No direct relationship between Nitrogen input and beachings algae biomass

Lemesle,S. 2015

Massive seaweed beachings along Normandy coast (France)



Monthly accumulation of beachings algae biomass (t)

Origin of nutrients?

NH_4

NO_3

NH_4

PO_4

Turbidity = Light limitation of growth
Important beaching during summer

Nutrients inputs

Lemesle,S. 2015

Marine Pollution Bulletin 97 (2015) 241–254

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Impact of seaweed beachings on dynamics of $\delta^{15}N$ isotopic signatures in marine macroalgae

Stéphanie Lemesle [a,b], Isabelle Mussio [a,b,*], Anne-Marie Rusig [a,b], Florence Menet-Nédélec [c], Pascal Claquin [a,b]

Marine Pollution Bulletin xxx (2016) xxx–xxx

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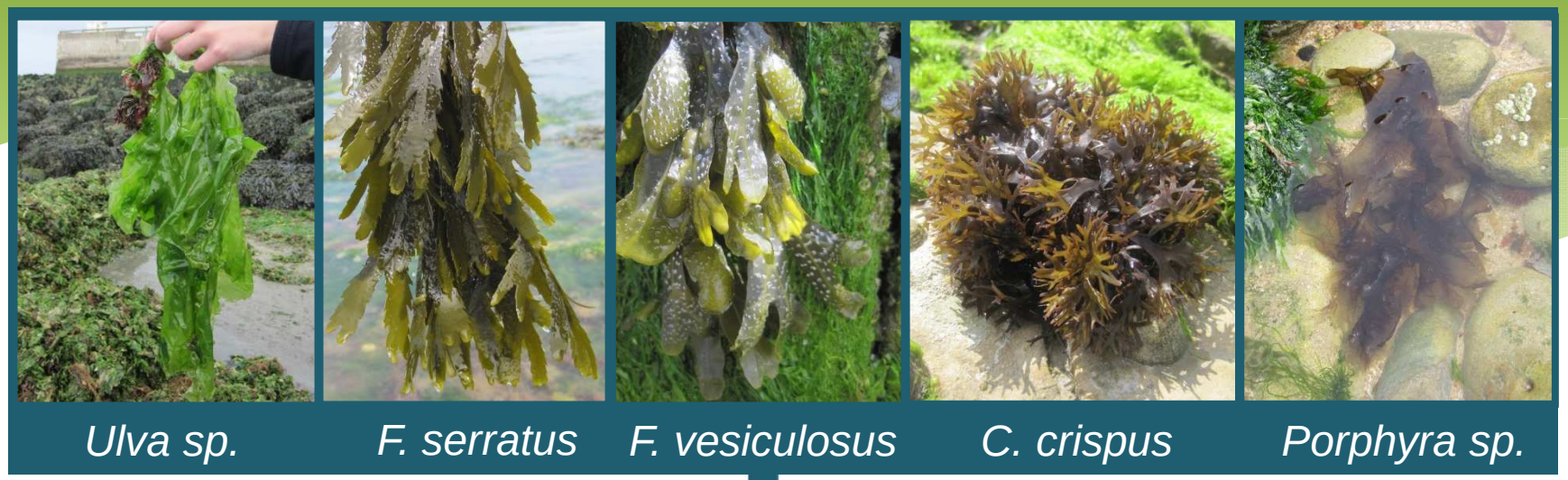
Dynamics of $\delta^{15}N$ isotopic signatures of different intertidal macroalgal species: Assessment of bioindicators of N sources in coastal areas

Stéphanie Lemesle, Alexandre Erraud, Isabelle Mussio *, Anne-Marie Rusig, Pascal Claquin



Ulva sp. *F. serratus* *F. vesiculosus* *C. crispus* *Porphyra sp.*

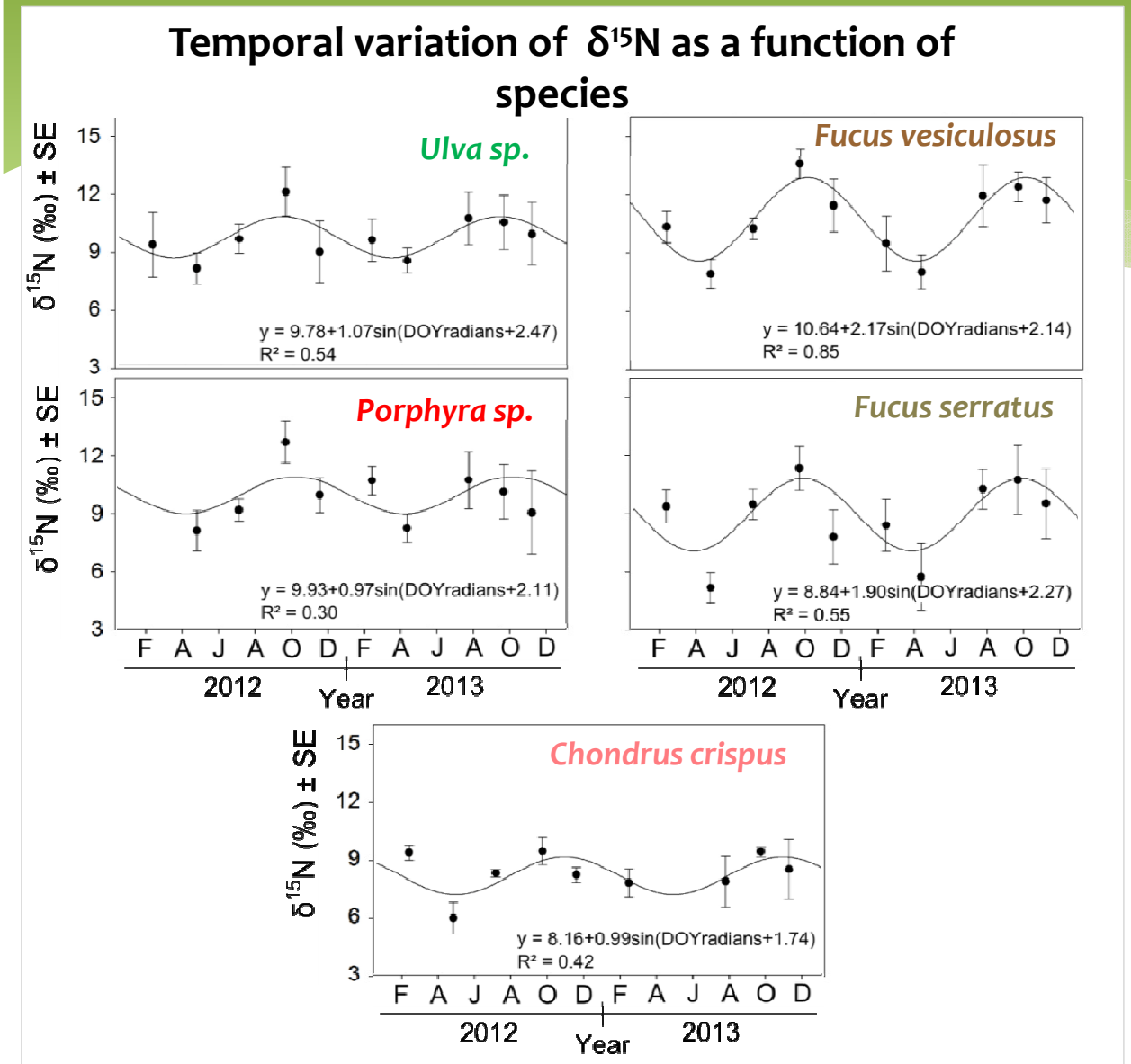
%N - %C – $\delta^{13}C$

$^{15}N/^{14}N$ - $\delta^{15}N$ (‰)

$\delta^{15}N$ algae ≈ $\delta^{15}N$ seawater

Lemesle,S. 2015

Temporal variation of $\delta^{15}N$ as a function of species

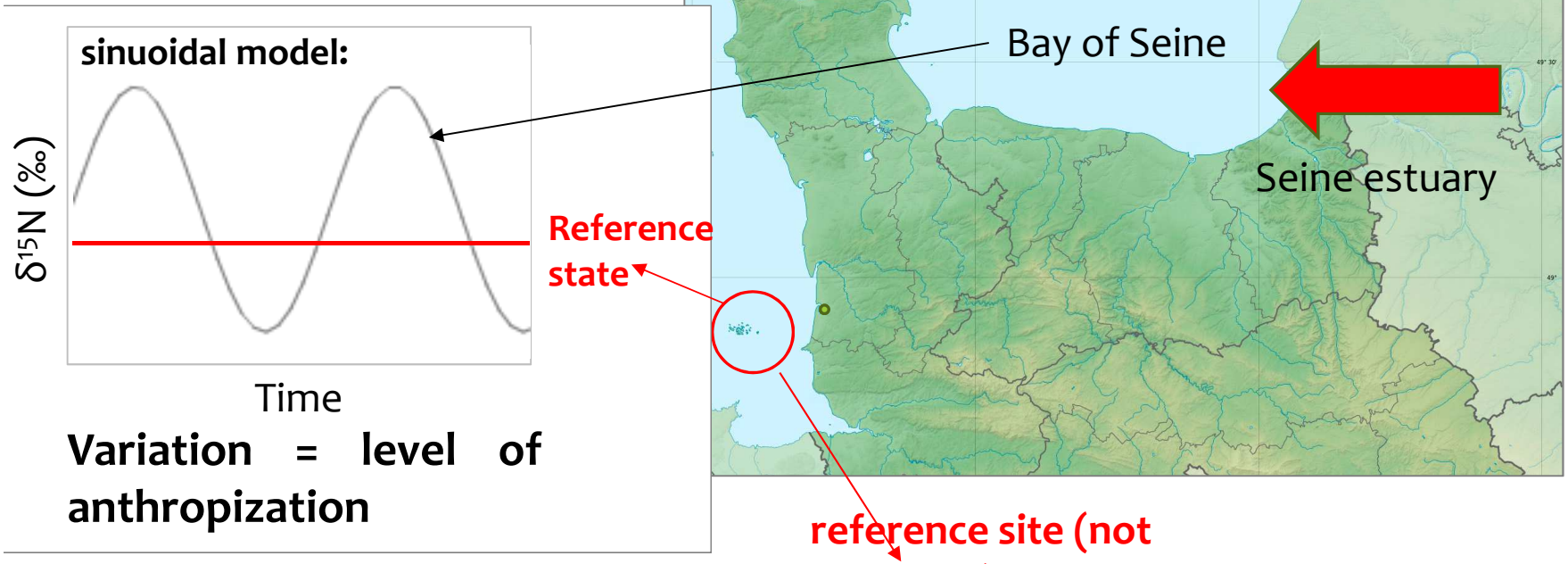


- Sinusoidal model

- Similar seasonal variation for all species

$\delta^{15}N$ from the reference site (not impacted) , Chausey Island : no temporal variation

Lemesle,S. 2015

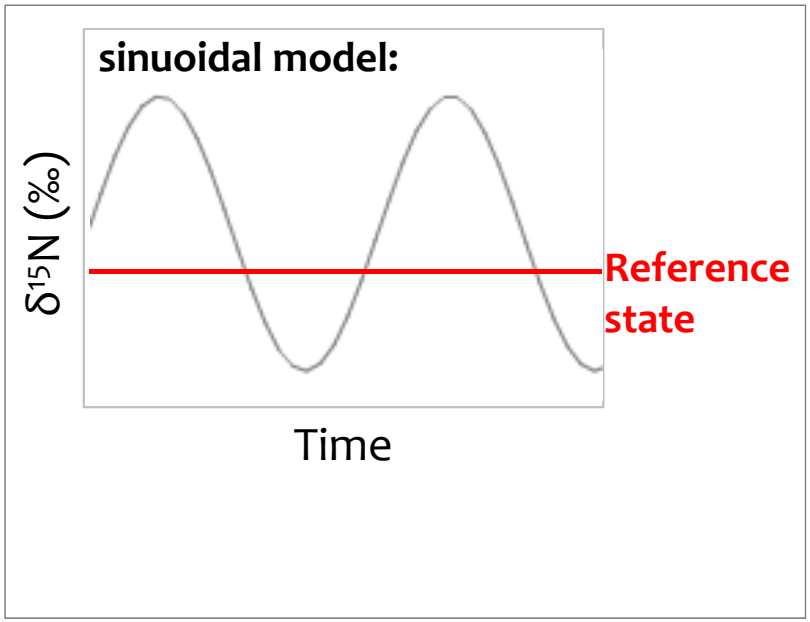


Lemesle,S. 2015

Seasonal trend of $\delta^{15}N$:

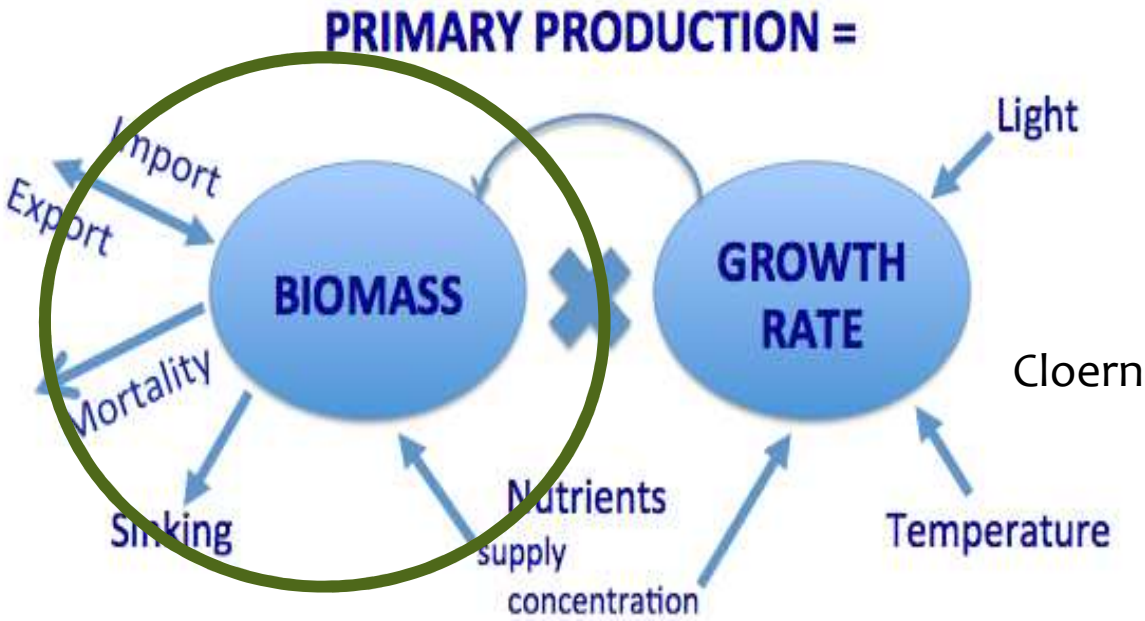
→ BIOINDICATOR of EUTROPHICATION

→ MONITORING



Lemesle,S. 2015

In case of Eutrophication



Cloern et al (2014)

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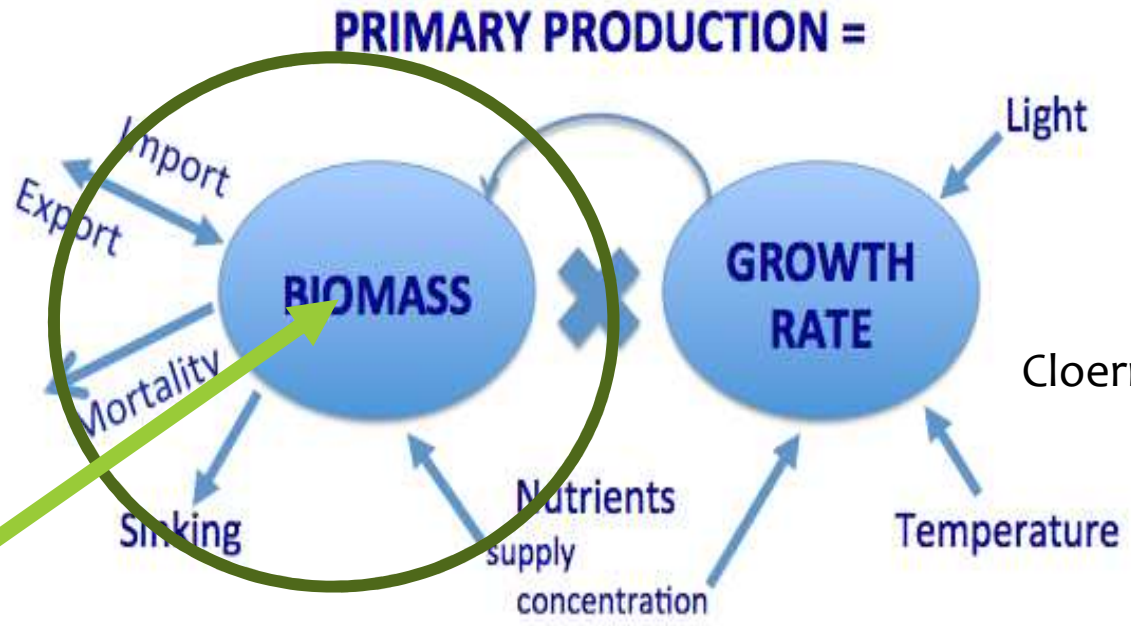
Because of high growth rate and low export or high import….
Which lead to a decrease of O2 and all the consequences on biogeochemistry, physiology, ecology etc..

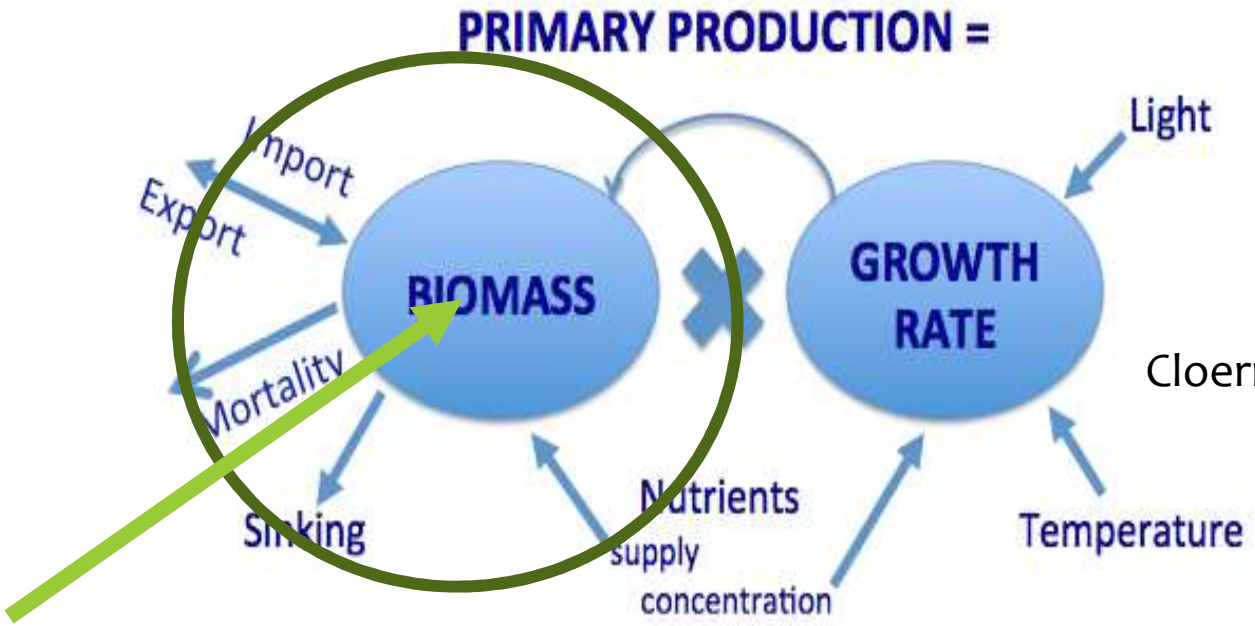
In case of Eutrophication



Cloern et al (2014)

BIODIVERSITY MODIFICATION

In case of Eutrophication



Cloern et al (2014)

BIODIVERSITY
MODIFICATION
Functional response traits

Ex: harmful algae
Phytoplankton species : toxin production

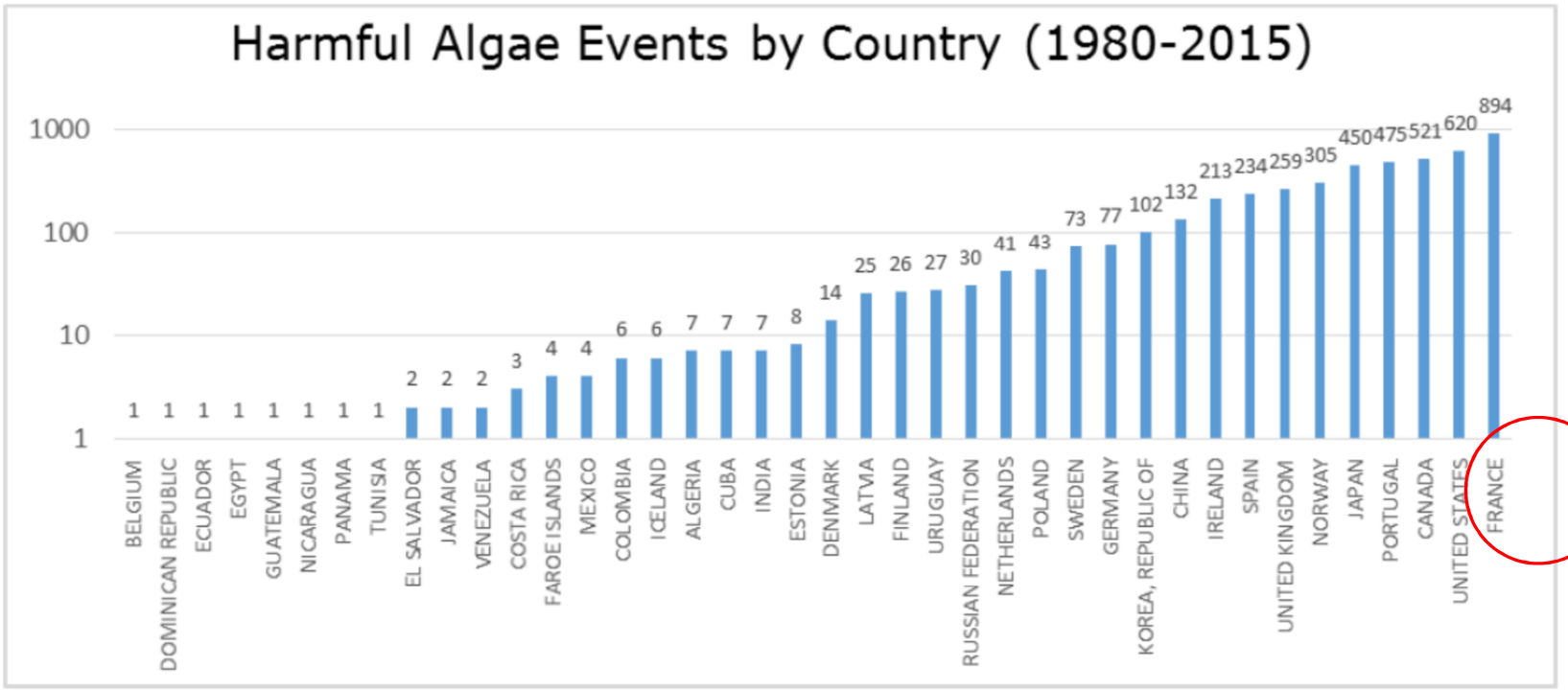


Figure 4: Total Number of Harmful Algae Events reported globally by single countries during the period 1980-2015 to the Harmful Algal Events Dataset (HAEDAT)

From Sanseverino et al 2016

France

Higher monitoring ?

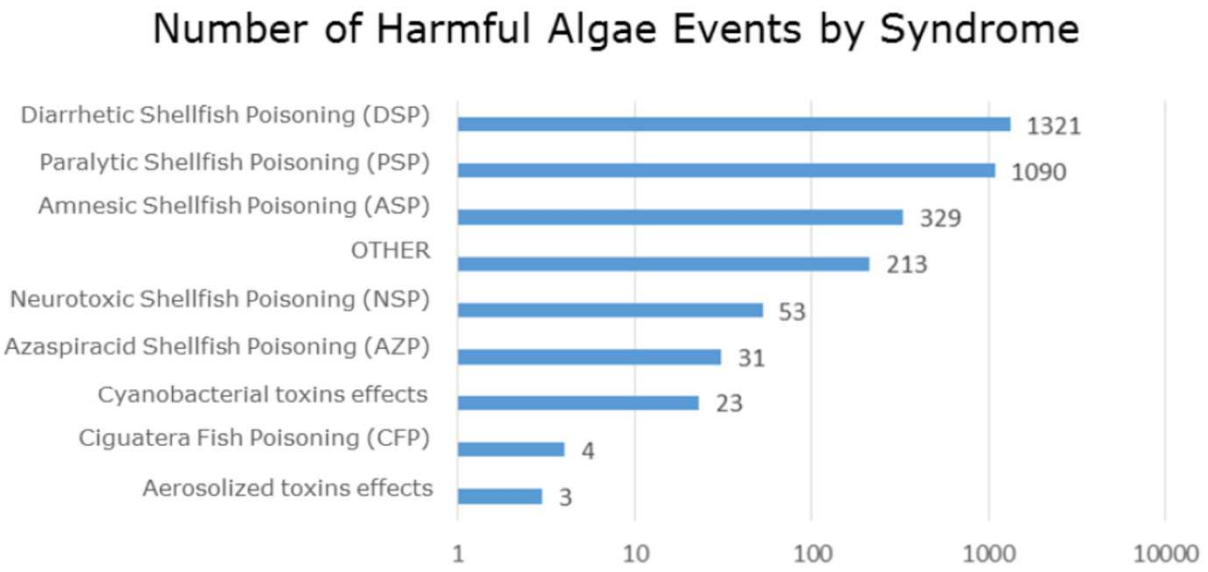
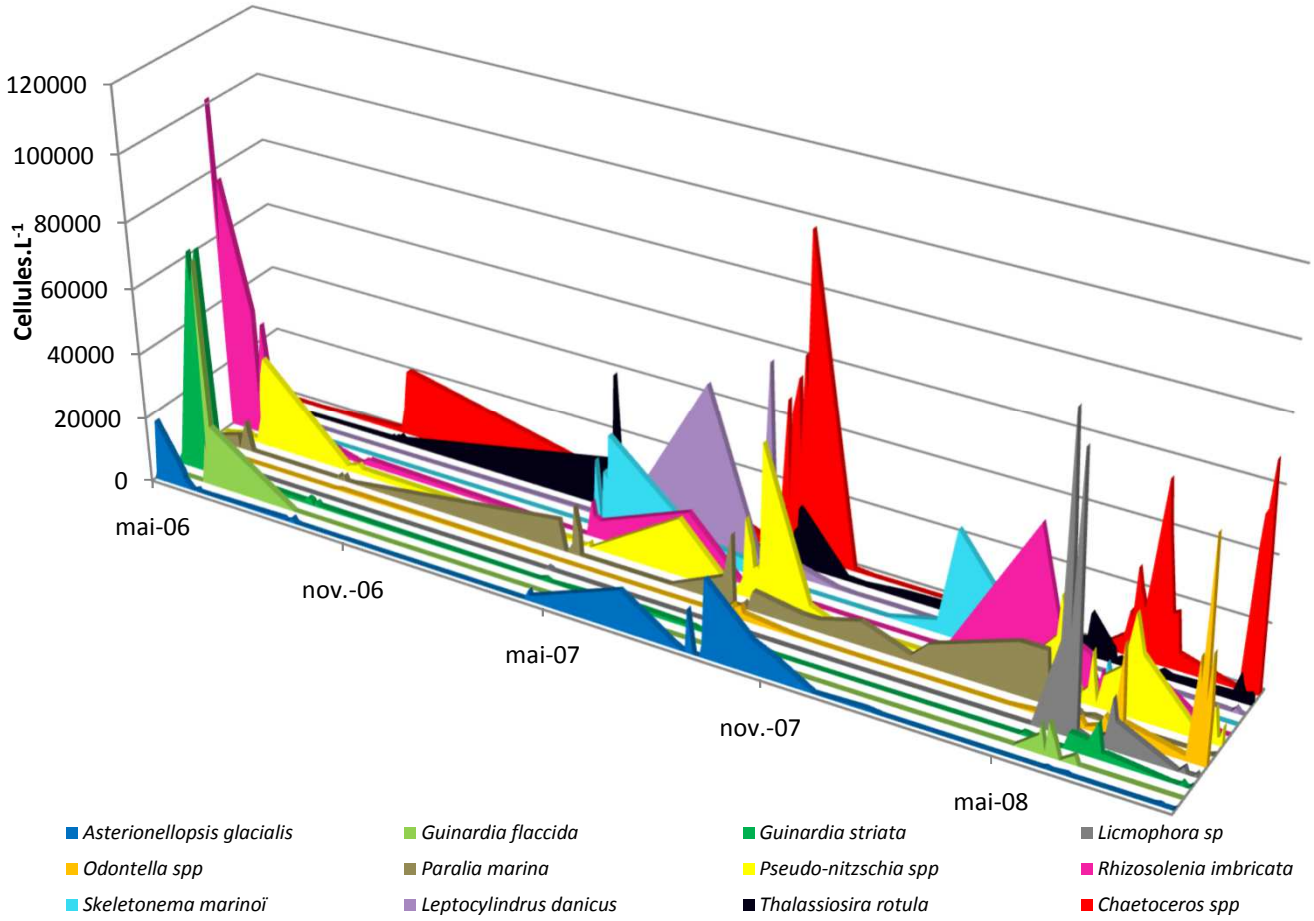


Figure 5: Total Number of Harmful Algae Events by syndrome reported globally during the period 1980-2015 to the Harmful Algal Events Dataset (HAEDAT)

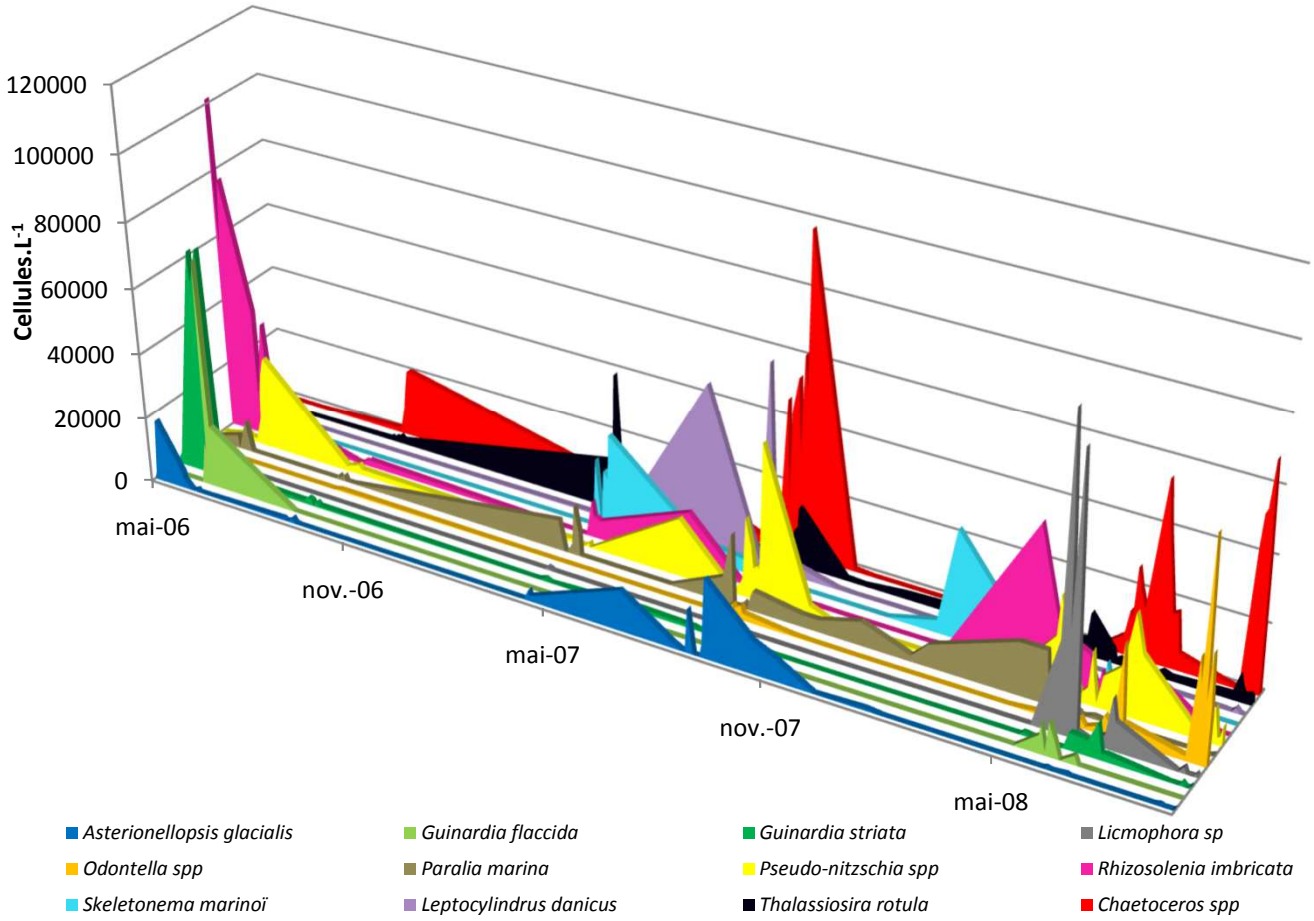
Mainly DSP, PSP, ASP

species succession



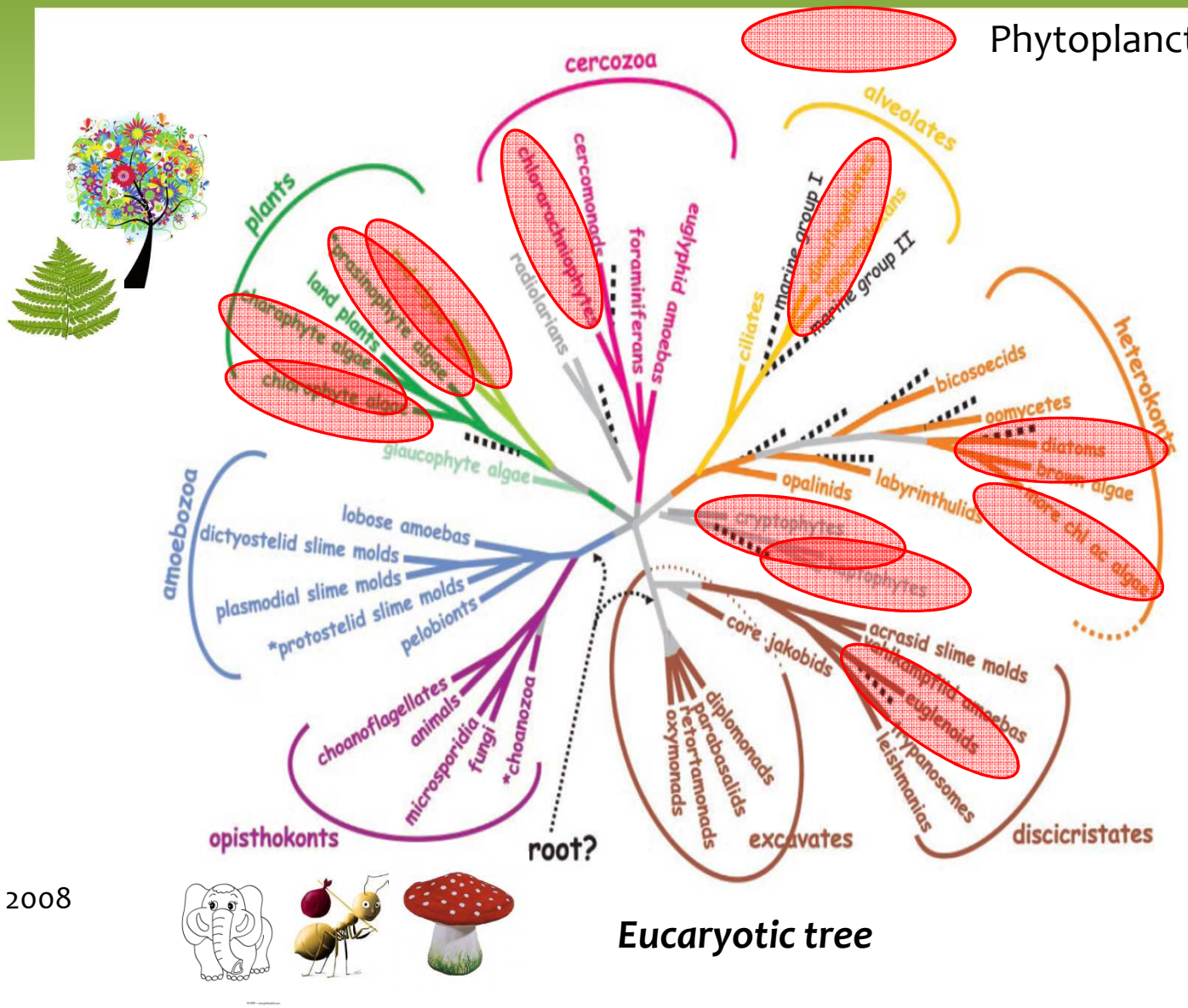
If you want to explain harmful algae events you have to understand species succession

species succession



Complex : many factors and high diversity of phytoplankton species

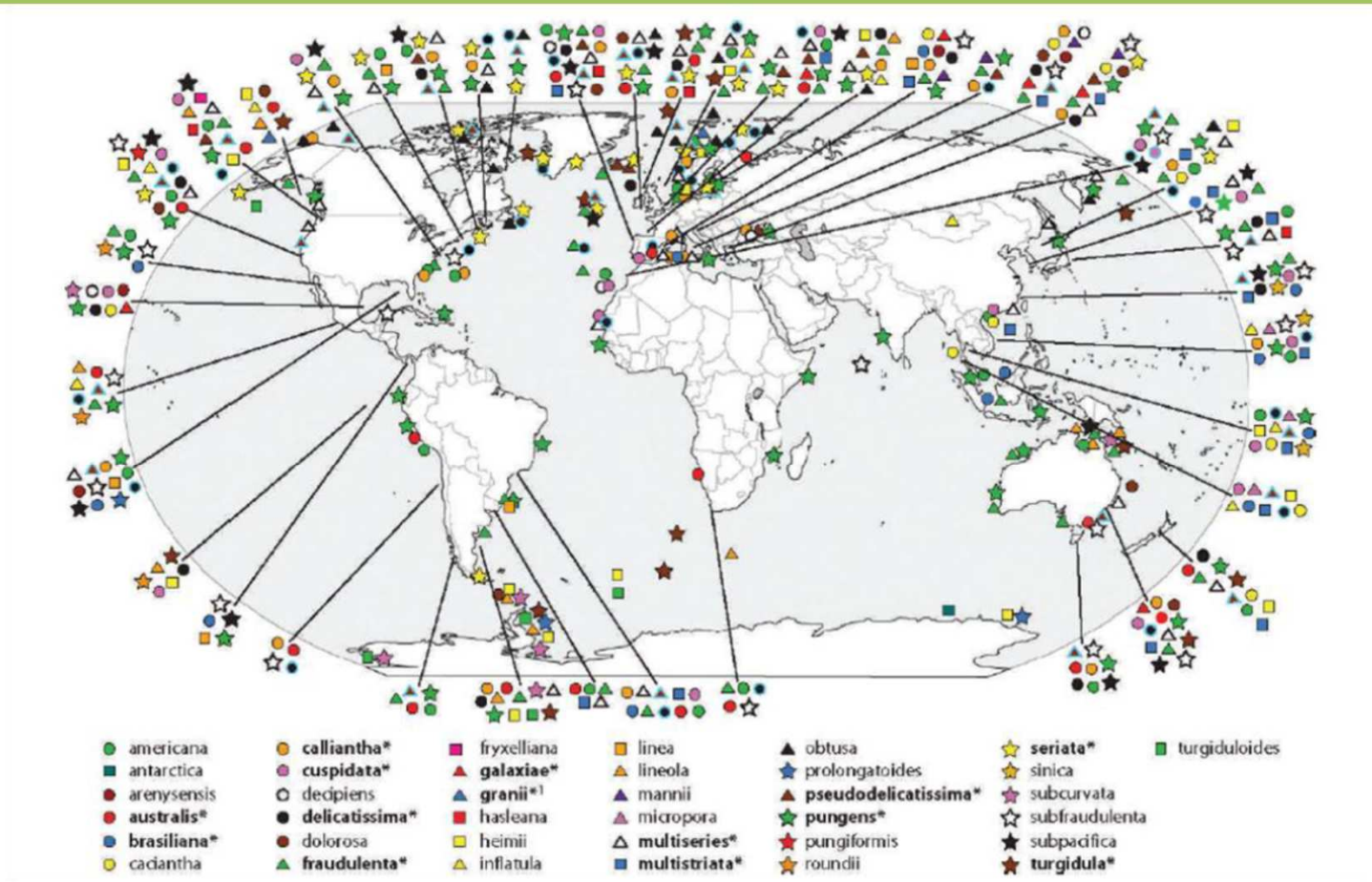
Phylogenic diversity of algae



Baldauf 2008

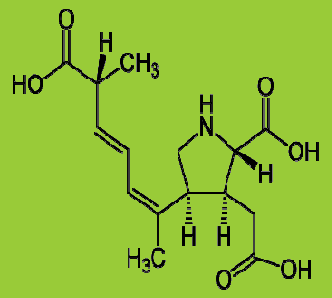
Eucaryotic tree

For example : *Pseudo-nitzschia*

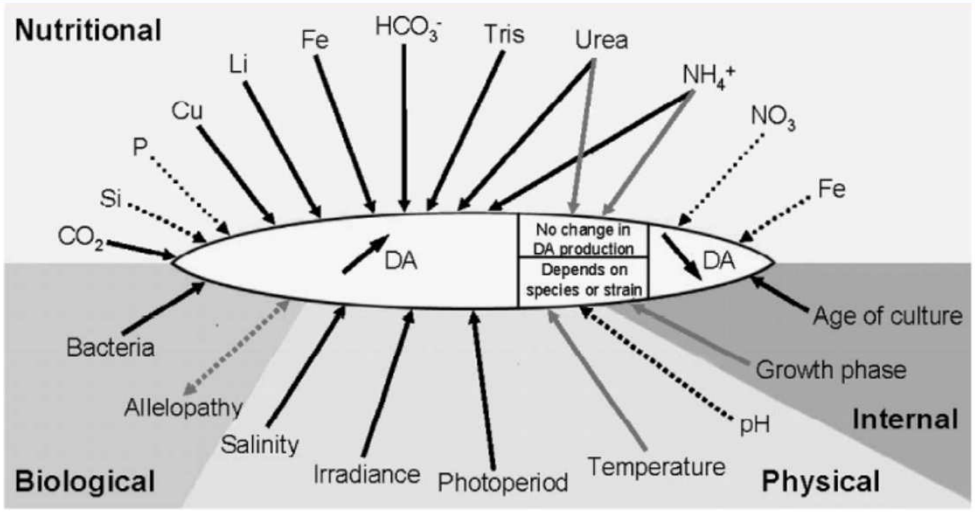


Lelong et al 2011

Some species of *Pseudo-nitzschia* produce domoic acid

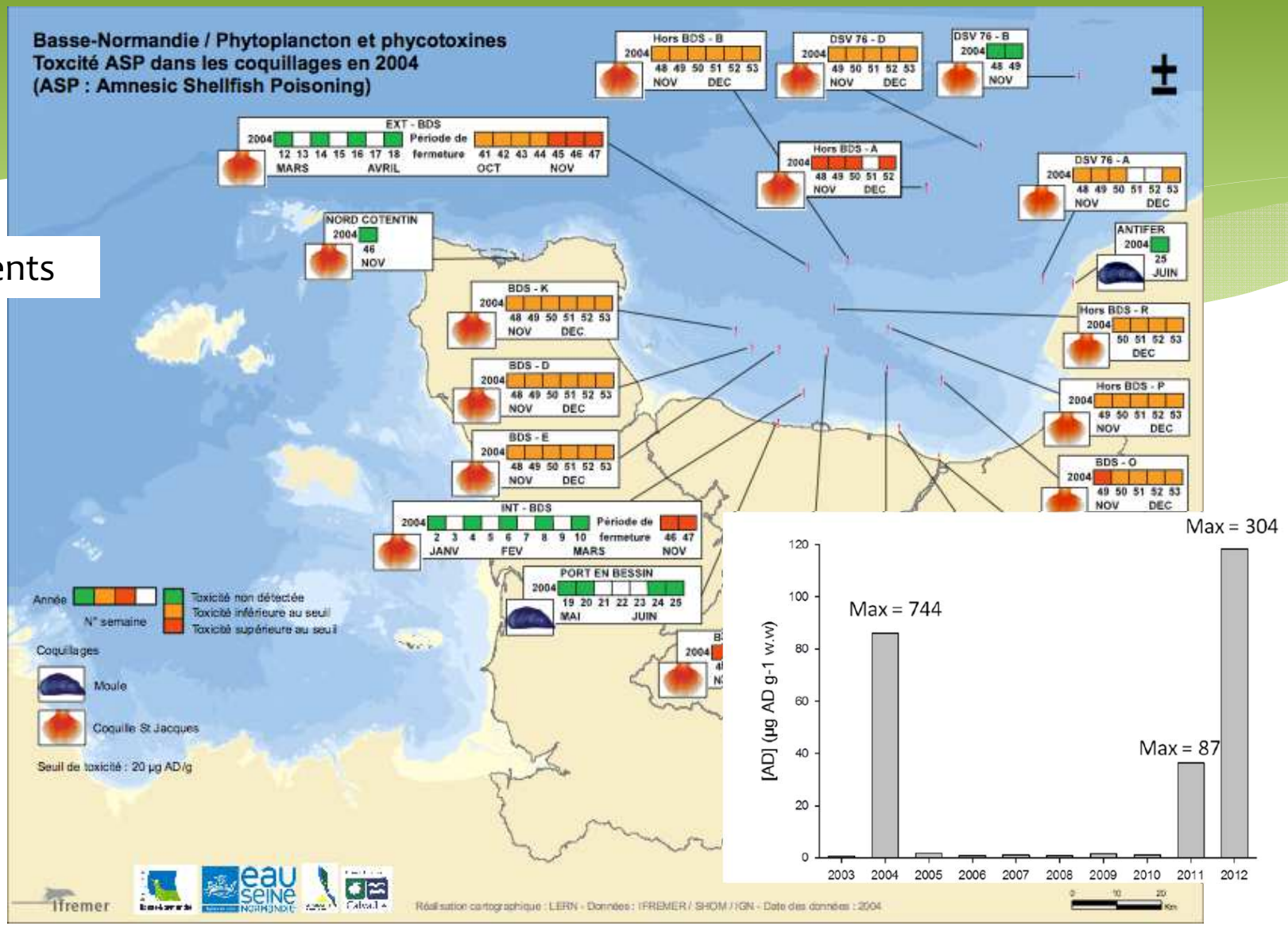


ASP (Amnesic Shellfish Poisoning)

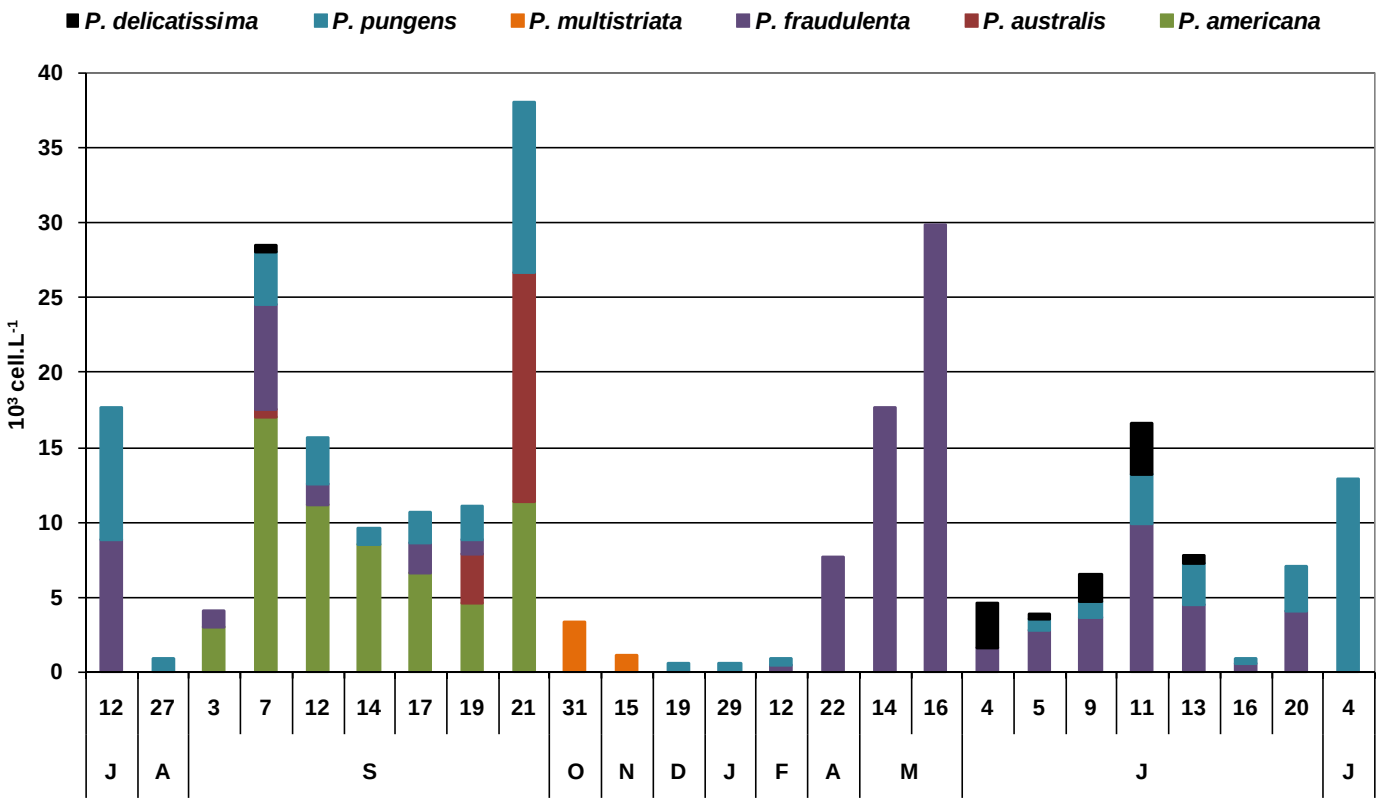


Factors studied and their impact on domoic acid production (review Lelong 2011)

ASP events

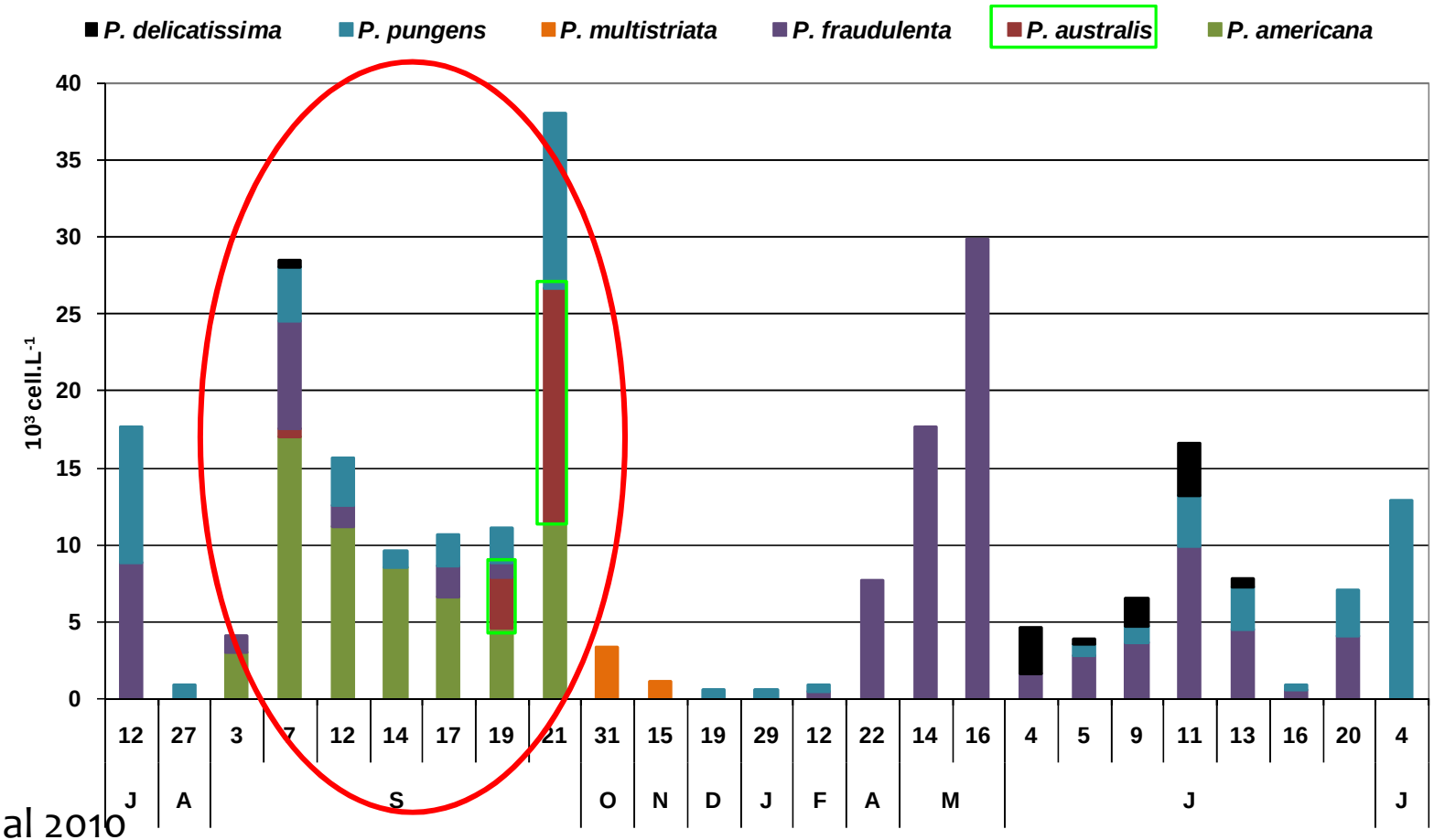


Contamination of King Scallop (*Pecten maximus*) – Main events 2004, 2011, 2012

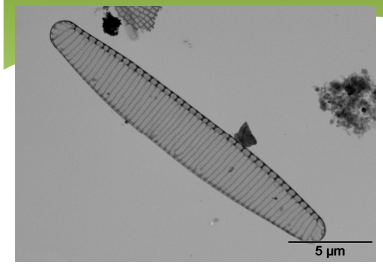


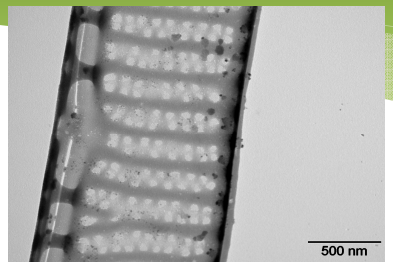
+ Survey of domoic acid concentration (>2,5 ng/L)

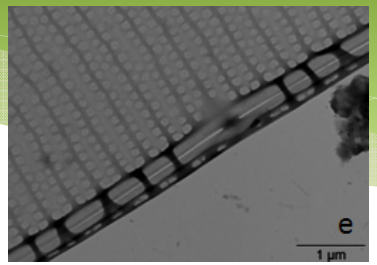
Klein et al 2010

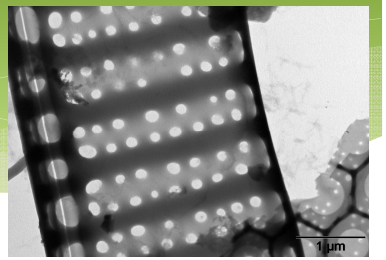


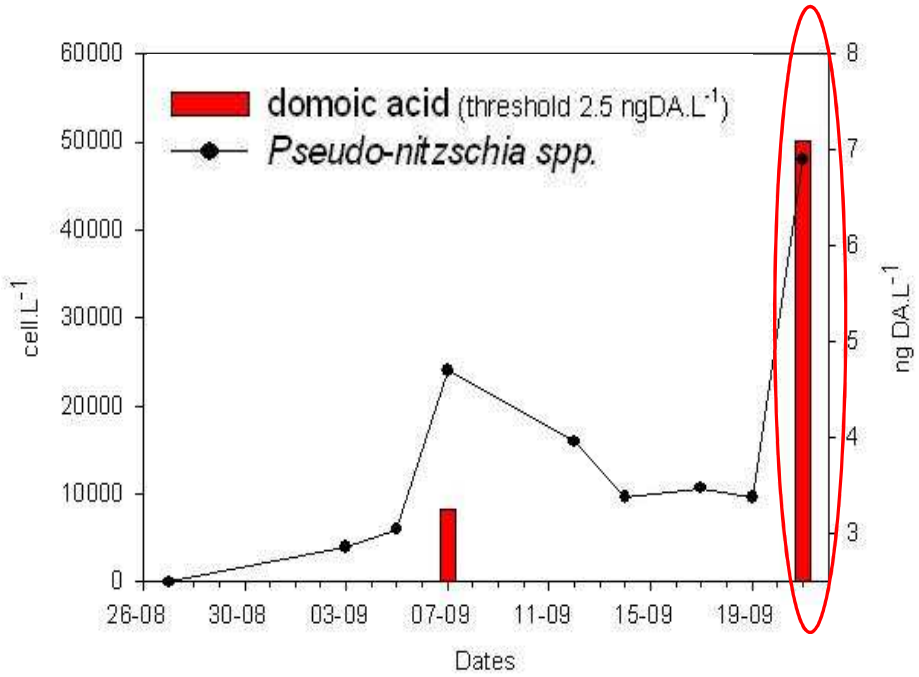
Klein et al 2010

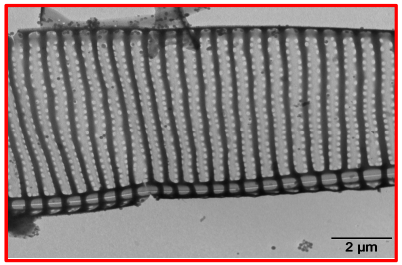






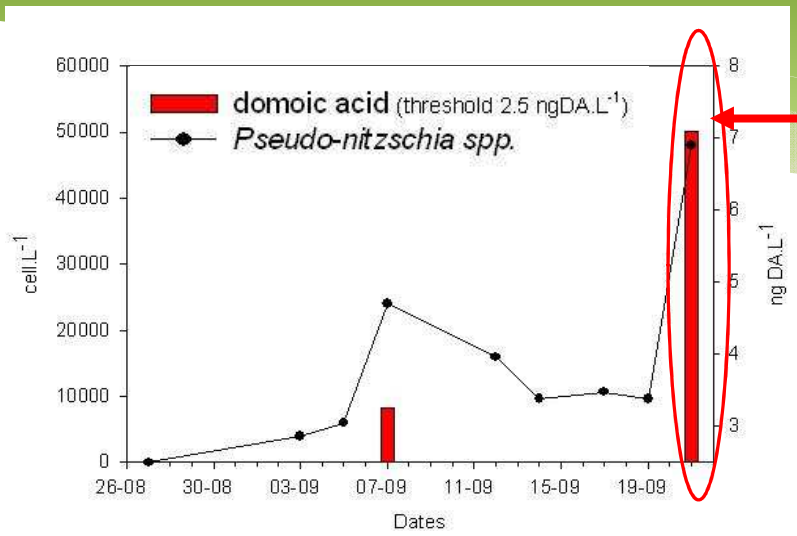




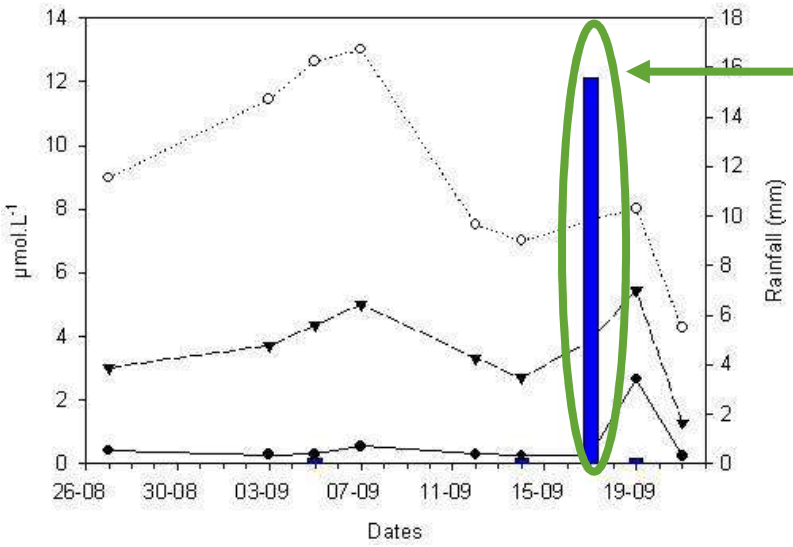


Klein et al 2010

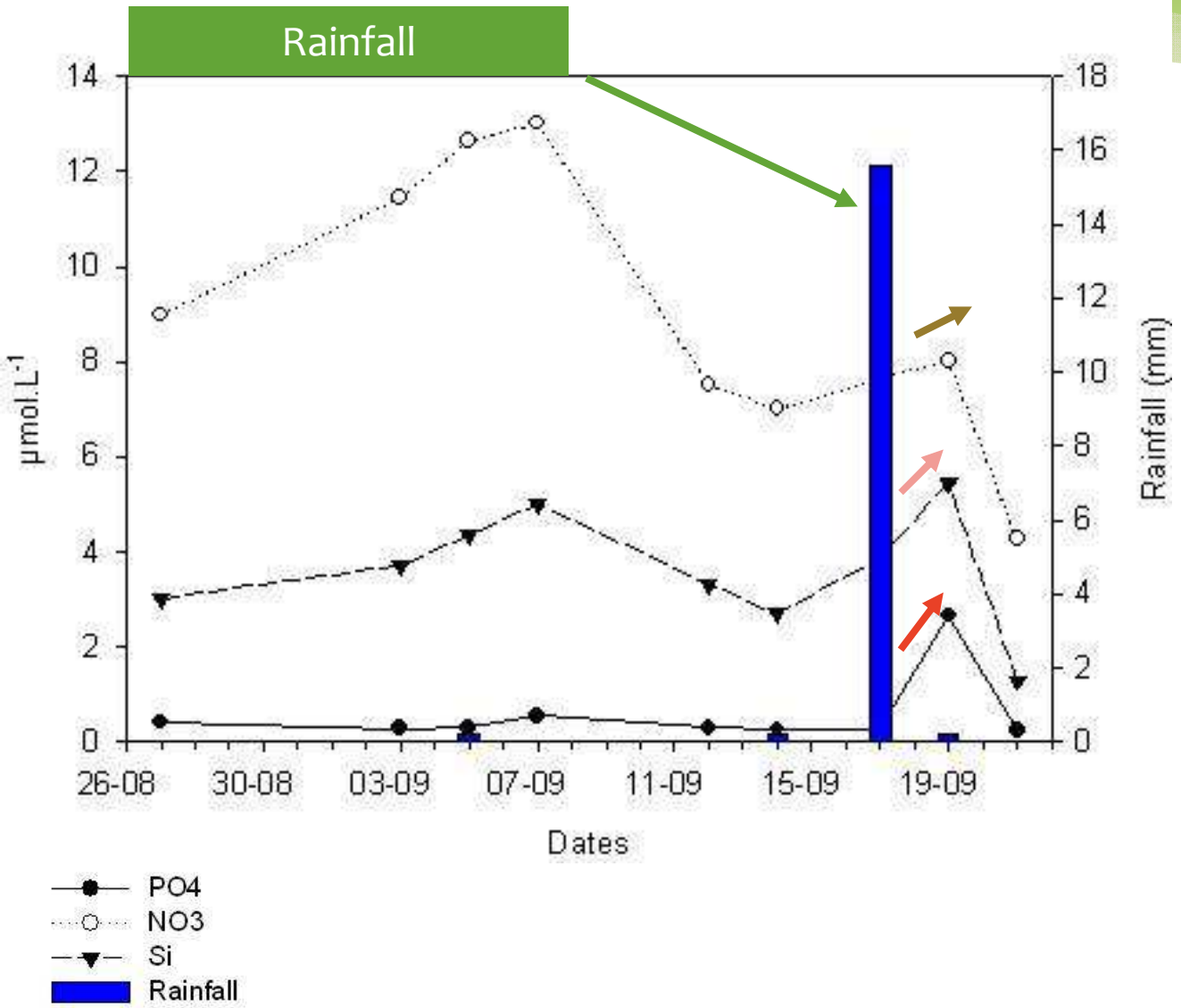
→ *P. australis* was probably responsible for domoic acid production



Domoic acid



Rainfall



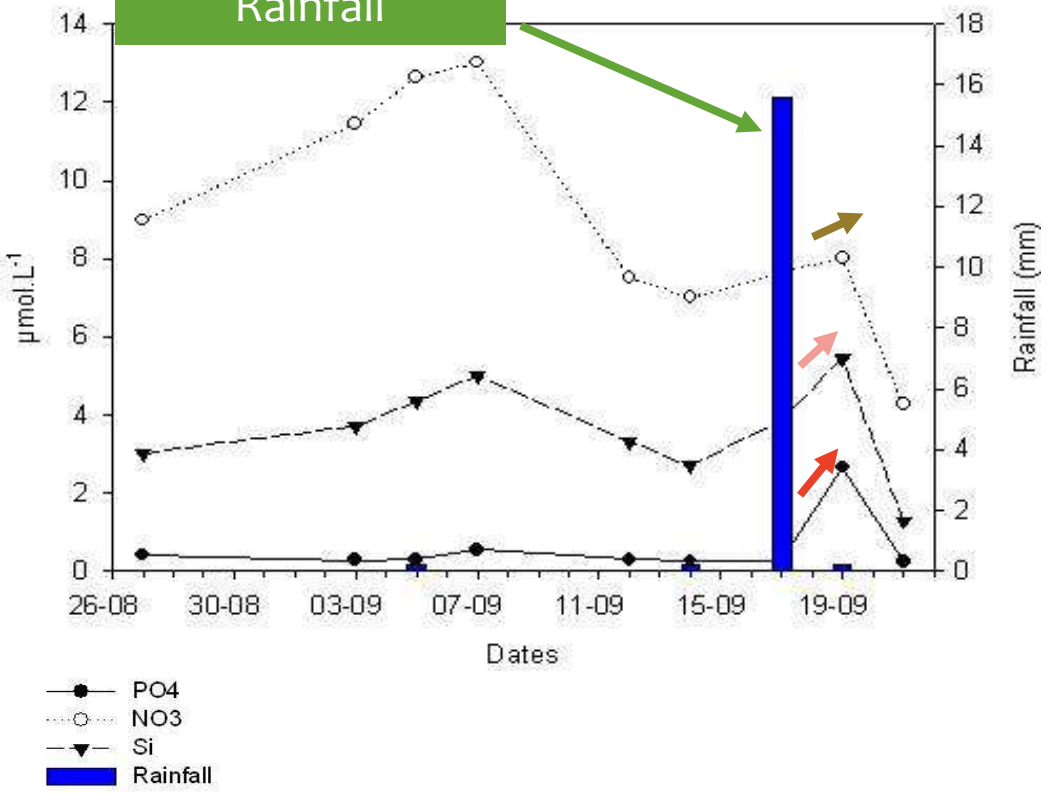
River inputs

N

Si

P

Rainfall



River inputs

N

Si

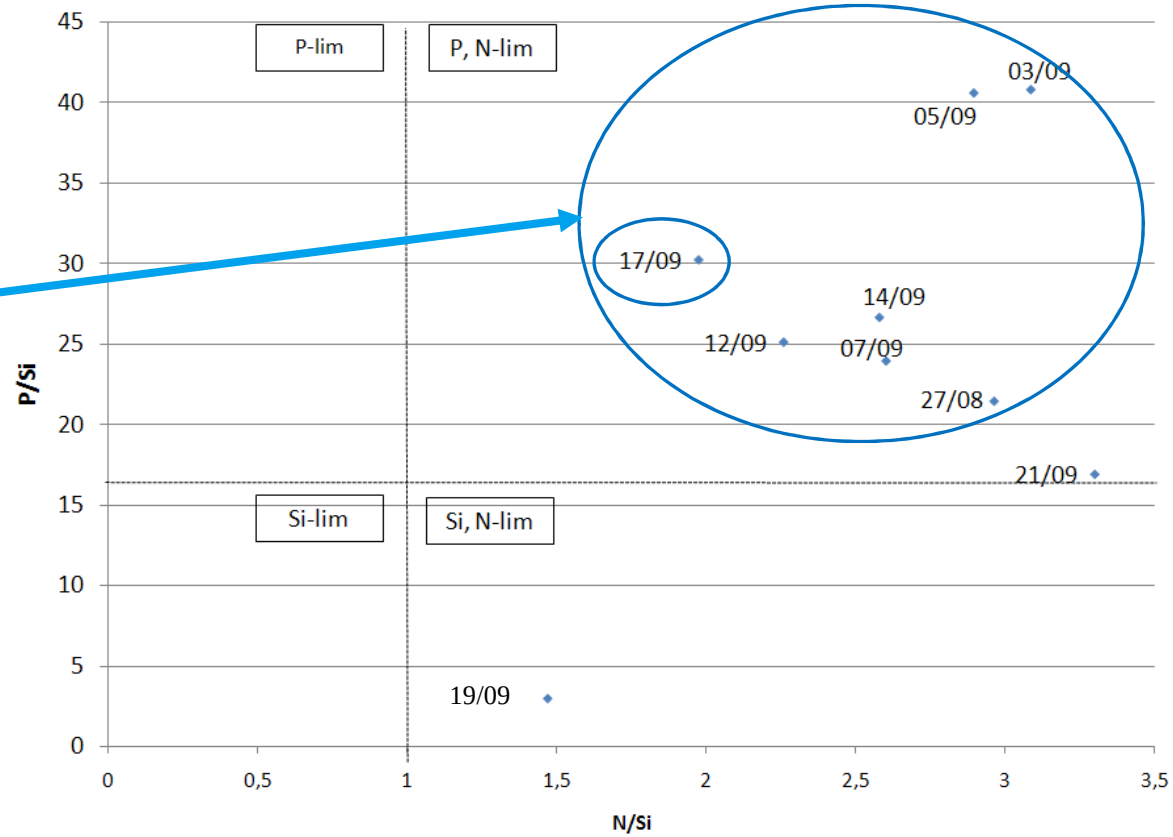
P

Variations of nutrient ratios (N/Si; P/Si; N/P)

Klein et al 2010

Variations of nutrient ratios (N/Si; P/Si; N/P)

Before rainfall



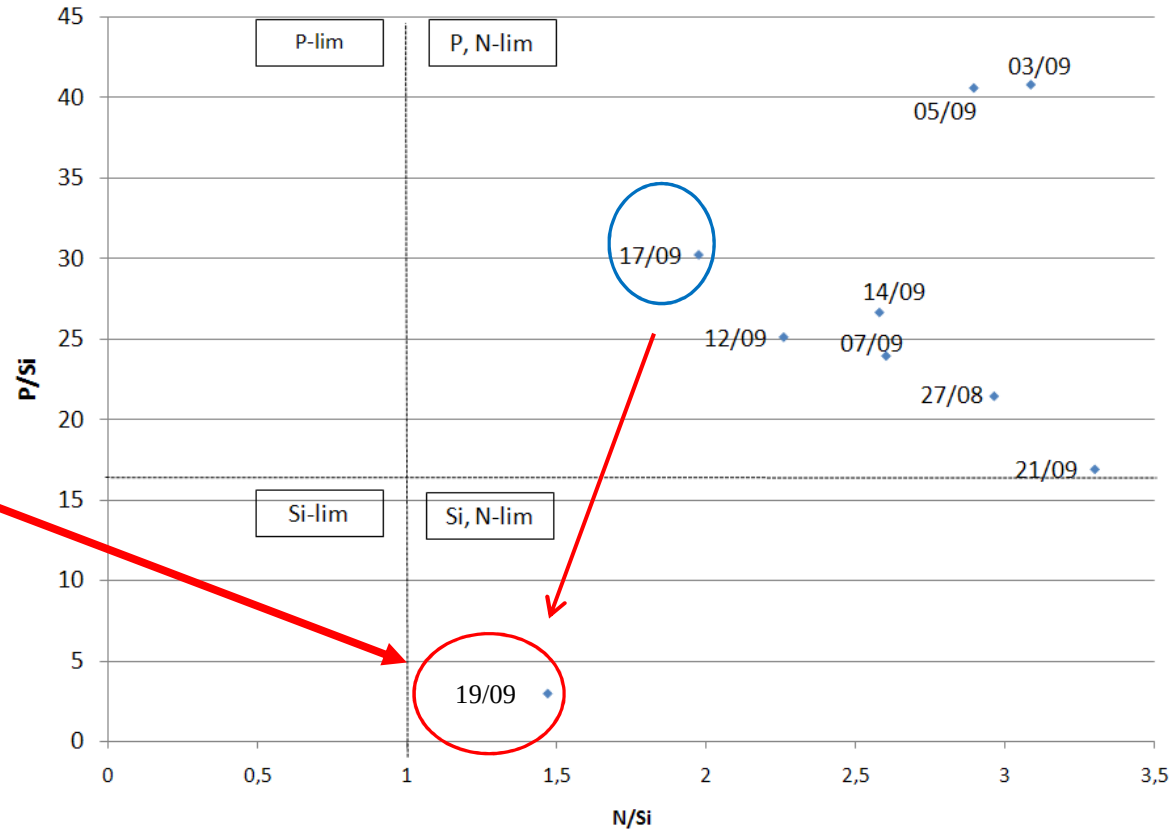
Trend = P limitation

Klein et al 2010

Klein et al 2010

Variations nutrient ratios (N/Si; P/Si; N/P)

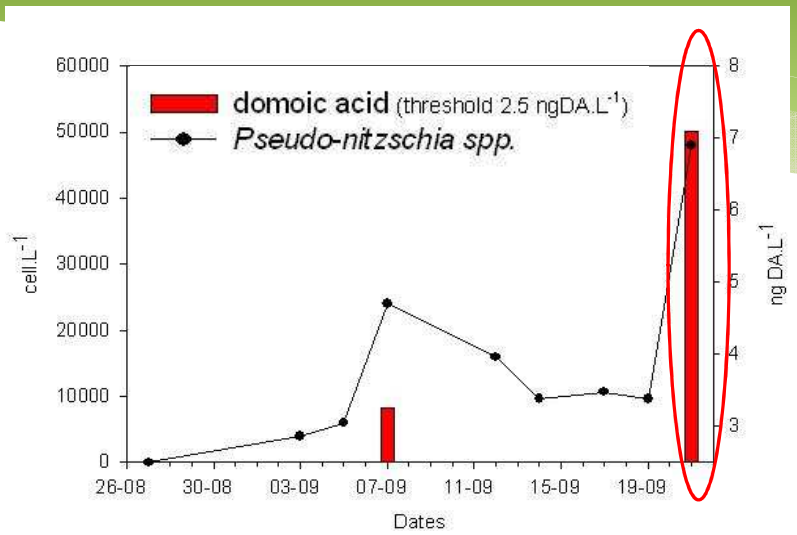
After rainfall



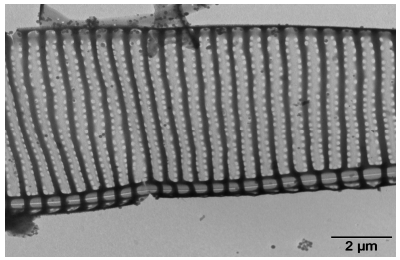
Trend: Silicate limitation

Limitation of silicates leads to production of domoic acid (Bates, 1998; Fehling *et al*, 2004)

Klein et al 2010



Domoic acid



P. australis

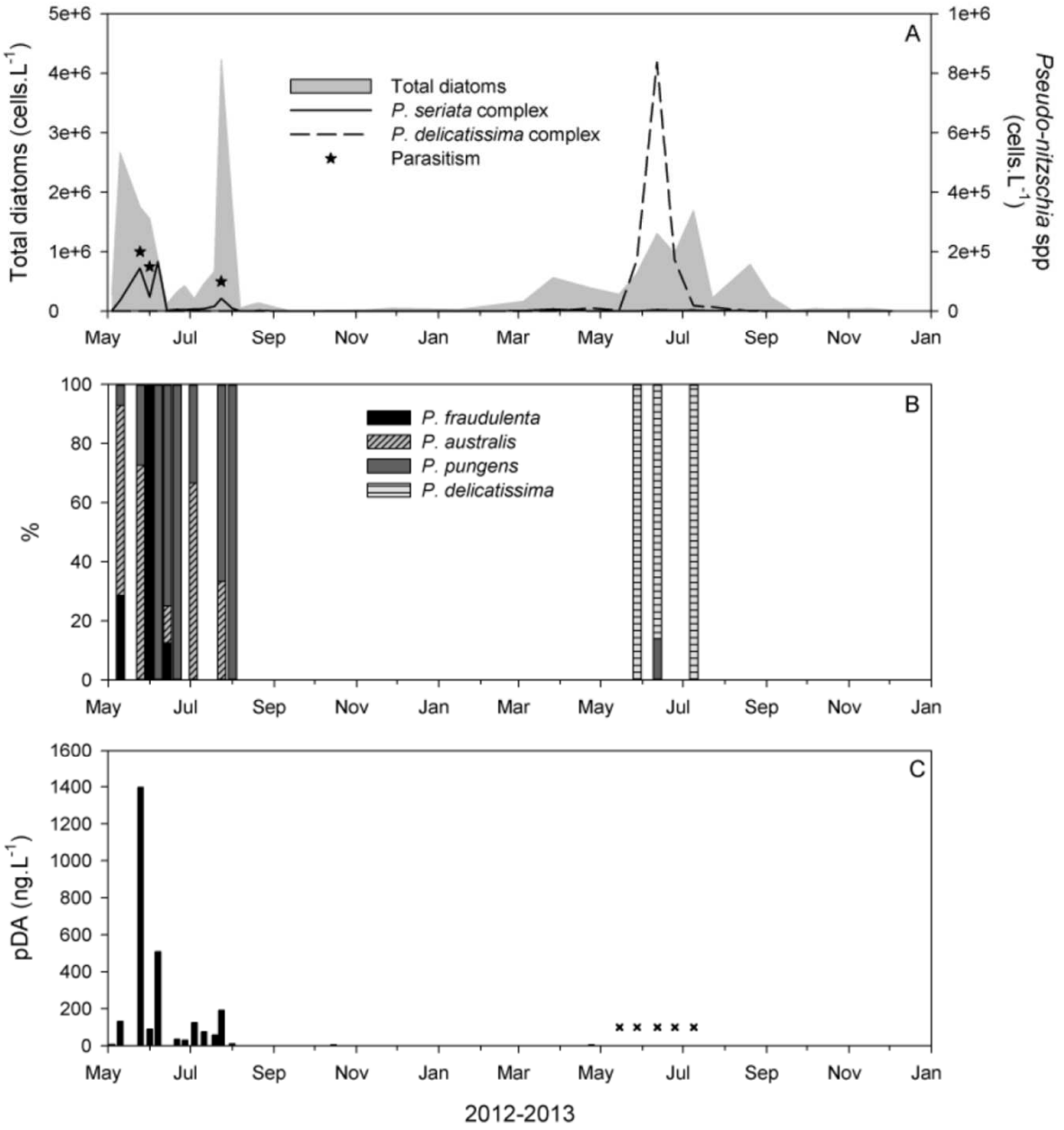
\+

Si Limitation

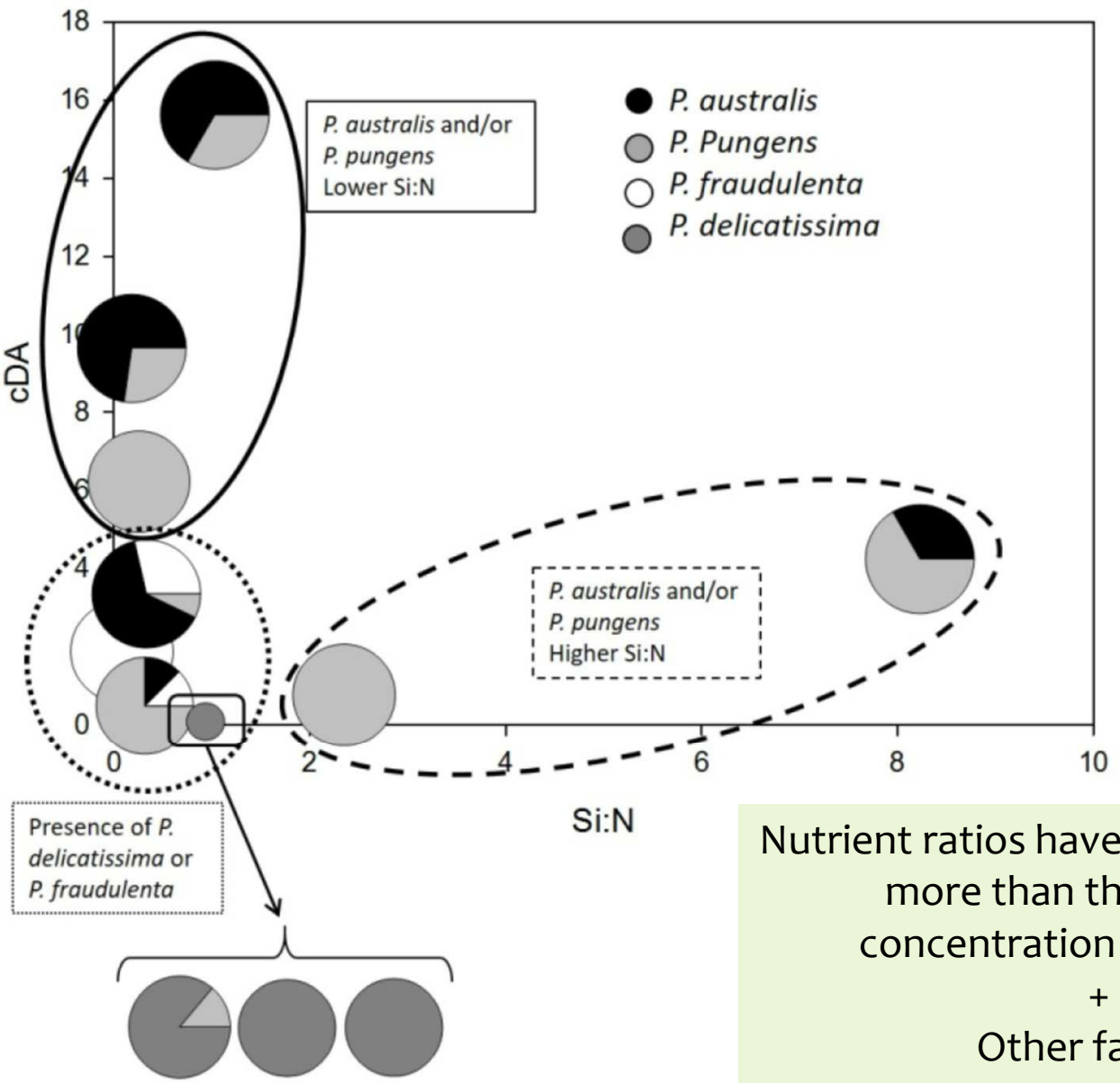
Even during a short period

This result was confirmed in another study in the bay of Seine (PhD thesis Maxine Thorel - Supervisor J. Fauchot & P. Claquin)

Thorel et al submitted



Thorel et al submitted



Nutrient ratios have to be considered more than the absolute concentration of nutrients

+

Other factors

= **For all phytoplankton species…**

* The effects of Eutrophication are complex because large parts of the effects **are not linearly** related to nutrient inputs.
* We need to continue to study **ecosystems functioning** by adapting the survey strategy to ecosystems, to the life cycle of the organisms and **go further than only biomass** and nutrient concentrations.

* **Production and biodiversity are the key words……**

High Frequency Measurements

* Smart buoy
  * Nutrients, Primary production, biomass etc at high frequency **at a proper order of magnitude as a function of the phytoplankton growth rate .**
  * **Development of measurements of diversity**

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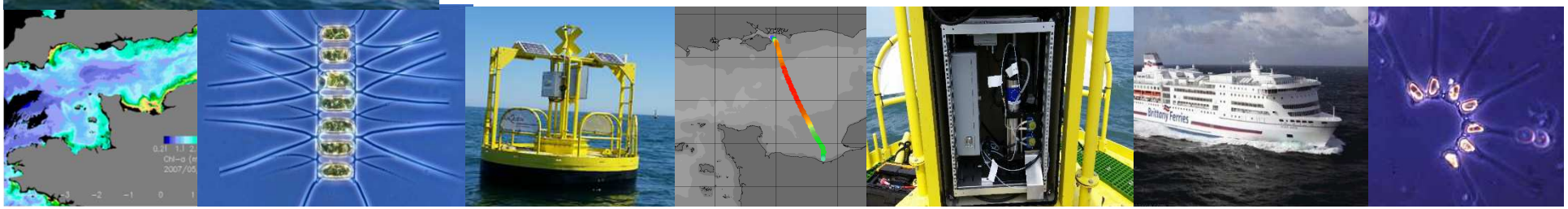
SMILE

Energy is provided by sun and **mainly by swell (waves)** (innovating system)



Thank you for your attention

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