Marine Pelagic Mucilage on the french basque coast area : causes, consequences and trends.

With funding :

© Marie-Noëlle de Casamajor

Local context : observations of fishermen

- Brief historical background…
  - ➢ present at least since late 70's
  - ➢ formerly spring phenomenon
  - ➢ ↑ abundance and frequency since early 2000
  - ➢ ↑ long-lasting through year (march to november)
  - ➢ Mostly as flocs

- Fisheries & economical consequences
  - ➢ decreasing yields
  - ➢ health and safety concerns
  - ➢ tourism impacts ?

- Many questions…
  - ➢ Composition ? origin ? dynamics ?
  - ➢ *Environmental conditions driving such outbreaks*
  - ➢ *Main planktonic assemblages & processes involved*

Local context : observations of fishermen

- Sometimes other forms apparition ??

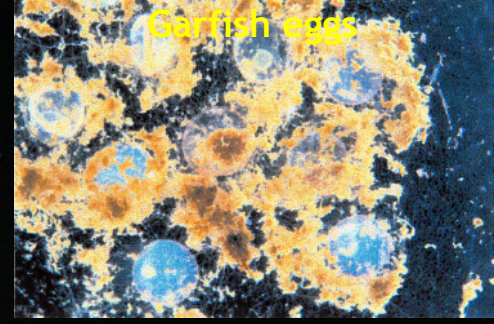
- Linked with other coastal phenomenom ?

Marie-Noëlle de Casamajor

Preliminary studies

- **2001 : Ifremer**
  - ➢ One day sampling 23/05/2001 on fish lines and plancton net 60 µm
  - ➢ « Not a sign of an unbalanced ecosystem »
- **2006 : LAPHY**
  - ➢ 2 days sampling 24 and 26/05/2006 on fish lines and nets
  - ➢ Aggregates of various origins trapped species in an organic matrix
- **2010 : IMA - CIDPMEM 64-40 partnership**
  - ➢ Fishermen survey (location and period)
  - ➢ Weekly sampling from 11 april to 27 october
  - ➢ Coastal pelagic aggregates containig a wide variety of organisms
- **2012 : IMA – CIDPMEM 64-40 partnership**
  - ➢ Fishermen survey (location and period)
  - ➢ International literature review
  - ➢ Preparation of the 2013-2015 research program
- **2013-2017 : Research program**

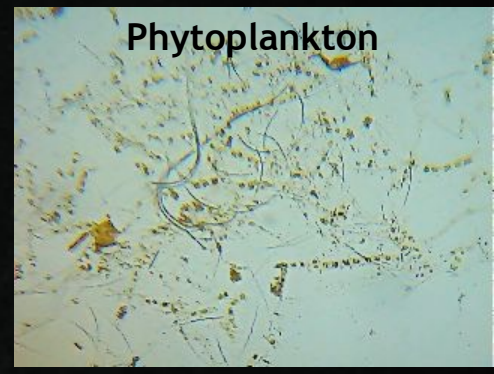

Hydrozoa


Garfish eggs

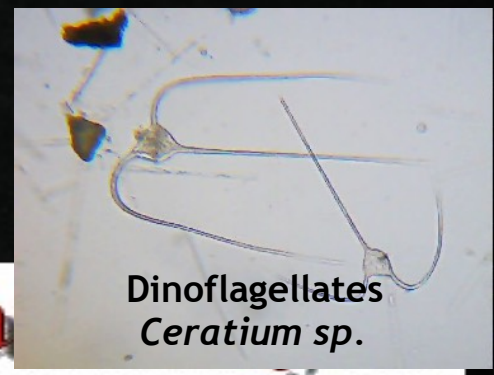

Appendicularia


Zooplankton


Anchovy eggs

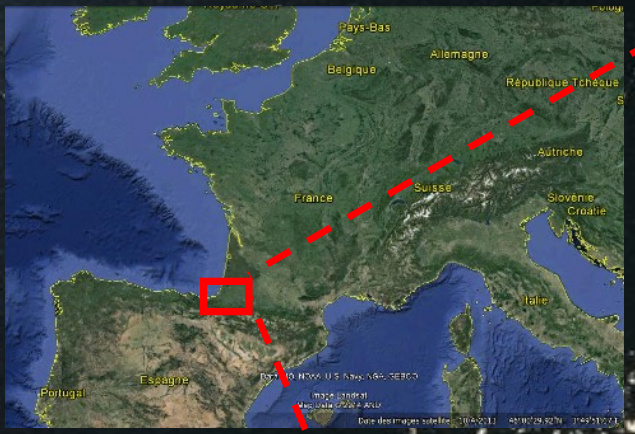

Phytoplankton

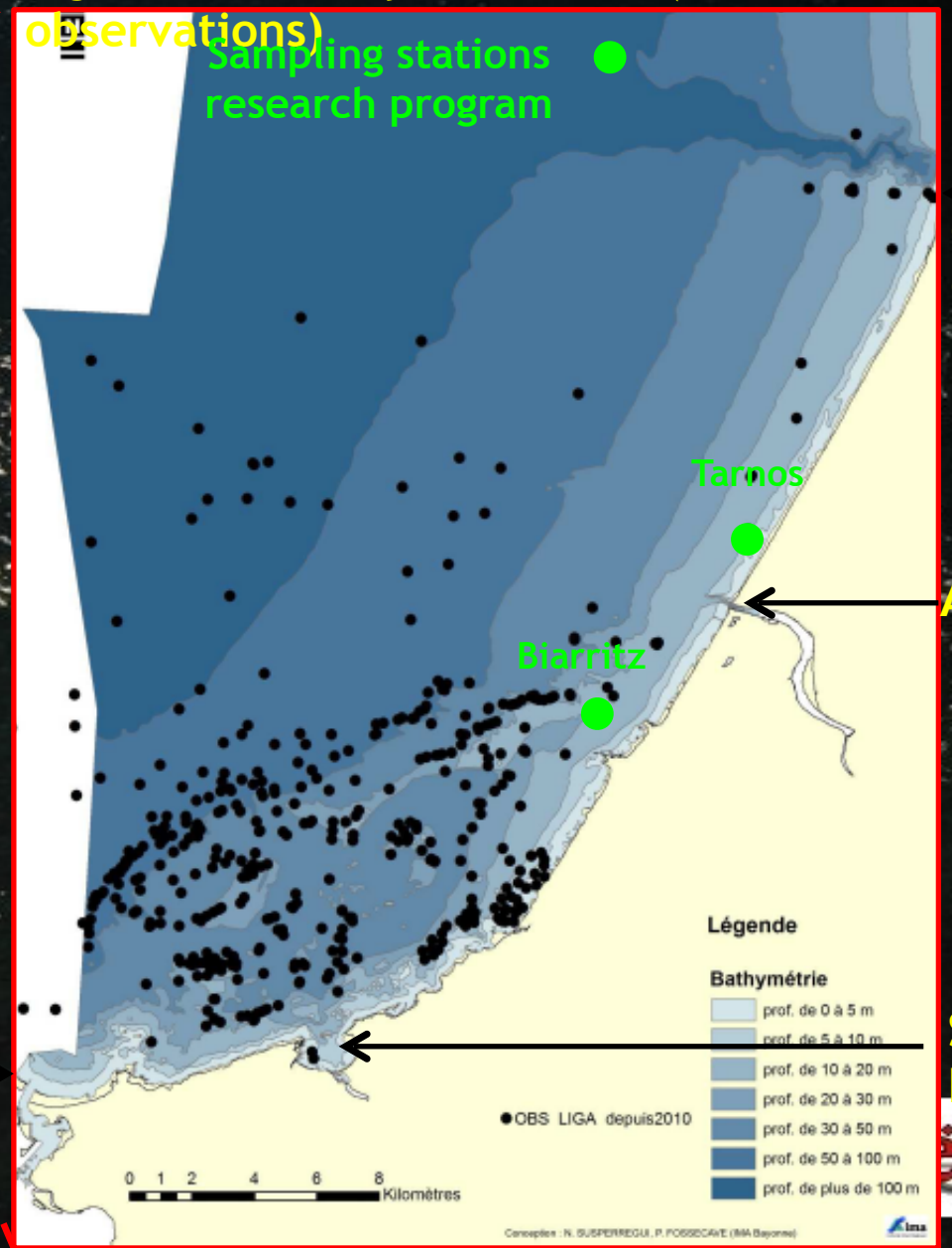

Diatoms
Chaetoceros sp.


Dinoflagellates
Ceratium sp.

Partnership IMA-CIDPMEM 64-40 : location

Liga's location by fishermen (2010 - 2012 = 1054 observations)





Capbreton Canyon

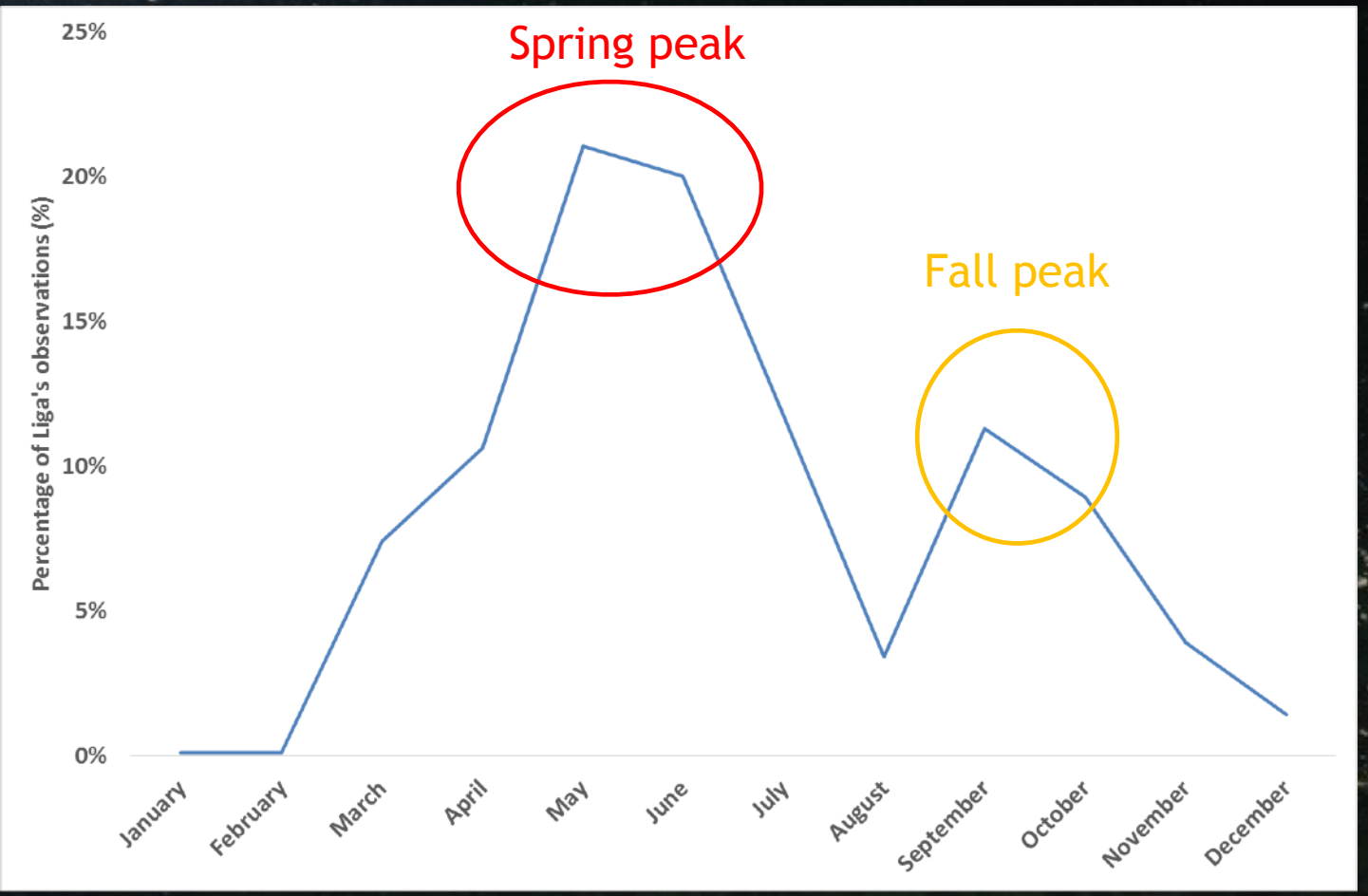
Adour River

Saint Jean de Luz Bay

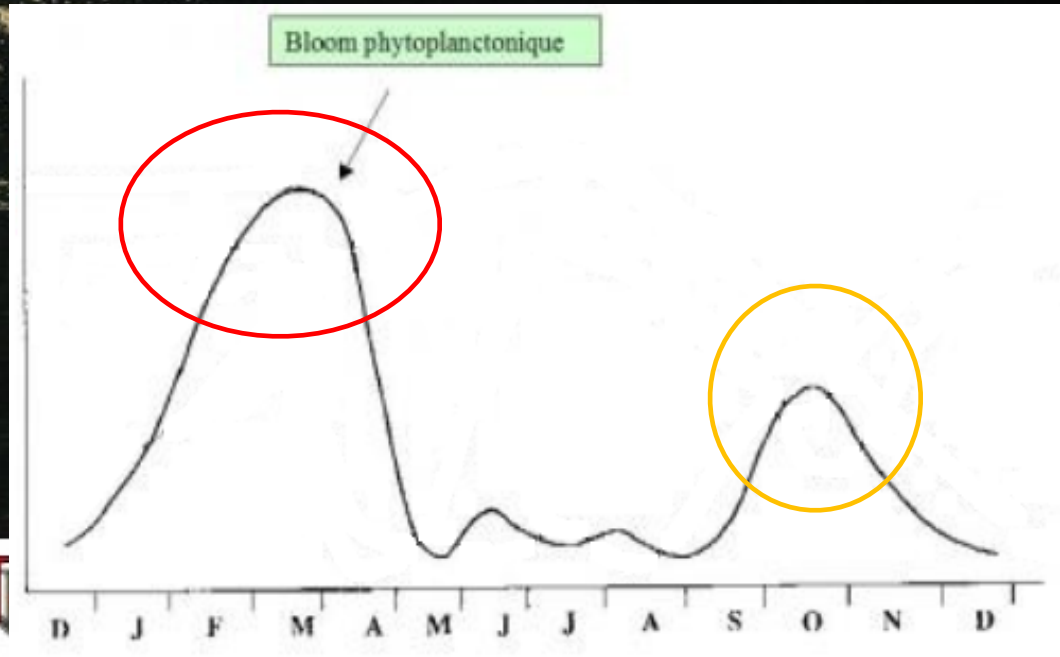
Spain border

ëlle de Casamajor

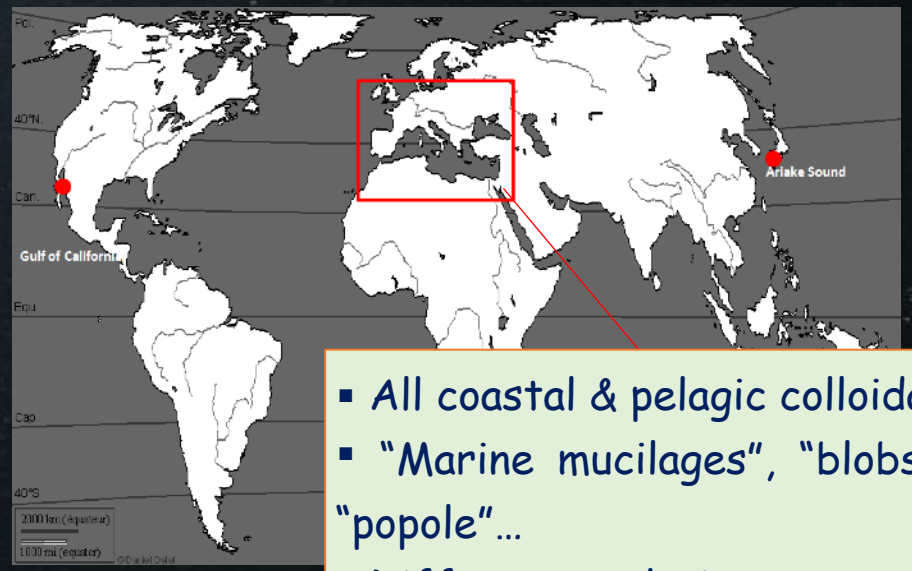
Partnership IMA-CIDPMEM 64-40 : appearance period



Linked with annual phytoplanktonic dynamics ?

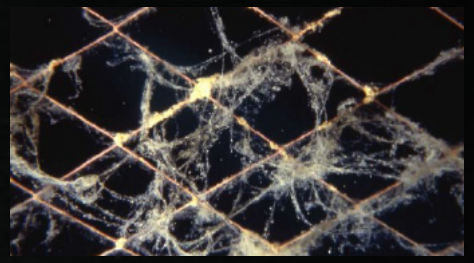


Literature review : International background



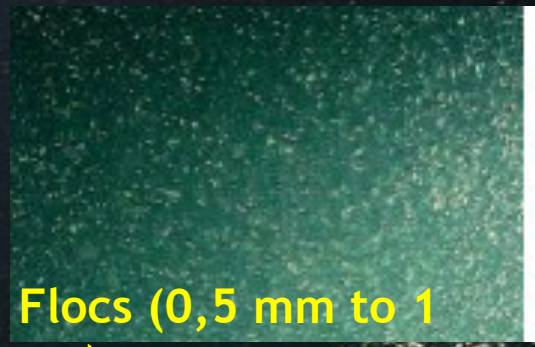
Alldredge et Cracker 1995
Fukao et al. 2009
Mackenzie et al. 2002
Schiapareli et al. 2007

- All coastal & pelagic colloidal aggregates
- "Marine mucilages", "blobs", "mare sporco", "glitsa", "Nuta" or "popole"…
- Different evolution stages covering 100s of km
  - ✓ as temporary ecosystems
  - ✓ holding large biodiversity of micro-organisms (diatoms, dinoflagellates, protozoans, bacteria, zooplankton), organics, minerals, contaminants…)

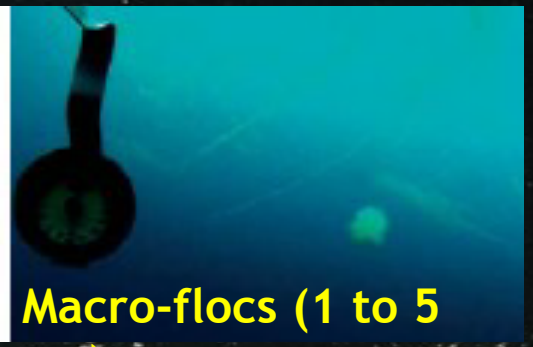


Agencia catal
Tufek
Balki
Nikolai
Innamo
Giani et al., 2005
Degobbis et al., 1999
Mecozzi et al., 2001
Rinaldi et al., 1995
…

Literature review : different forms of mucilage



Flocs (0,5 mm to 1 cm)



Macro-flocs (1 to 5 cm)

Stringers (2 to 20 cm)

Ribbons (20 cm to 1 m)

Youngest form

Cobweb (various meters)

Clouds (various meters)

Oldest form

Pelagic forms

Hydroclimatic conditions (Wave, wind, hydrodynamism...)
Biological diversity

Sedimentation

False bottom

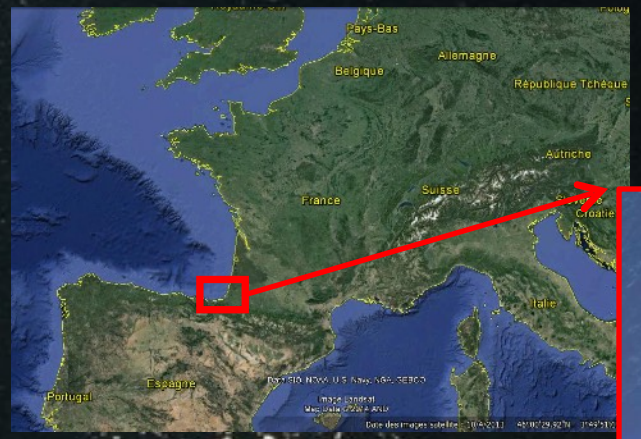
Blanket

Surface lift

Surface creamy layer

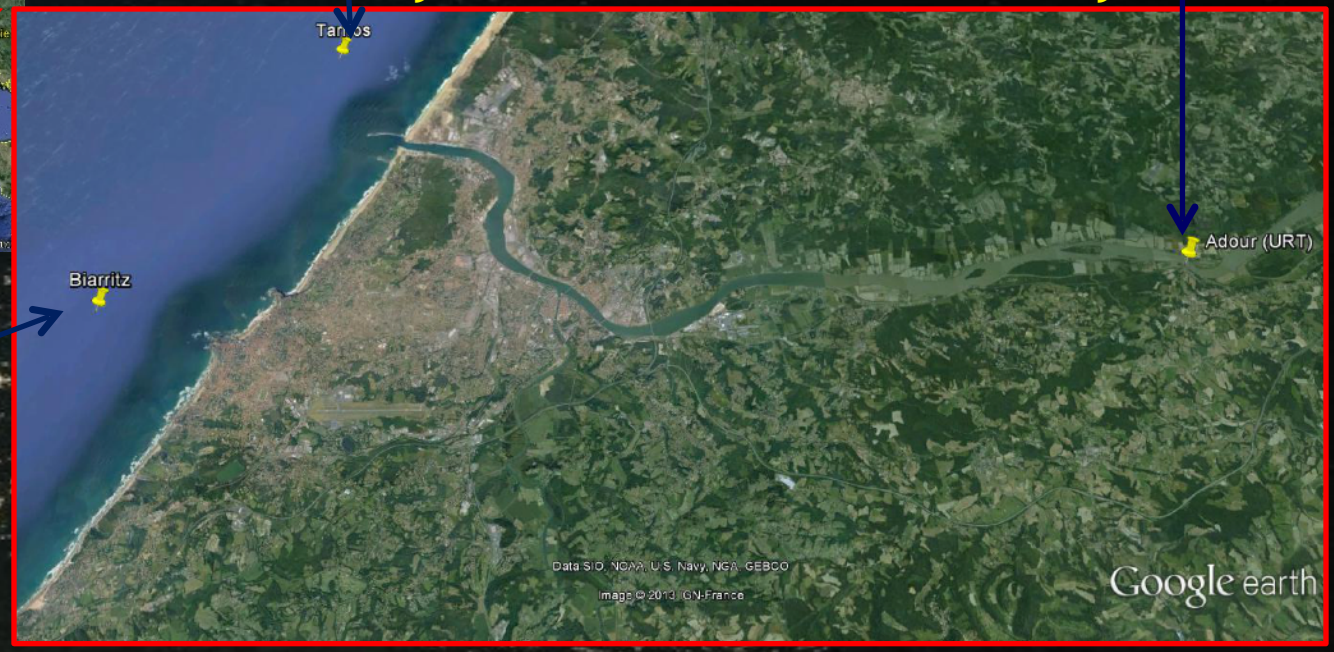
Surface gelatinous layer

Research program 2013-2017 : sampling strategy



Tarnos Coastal station
Day , High tide + 2, monthly

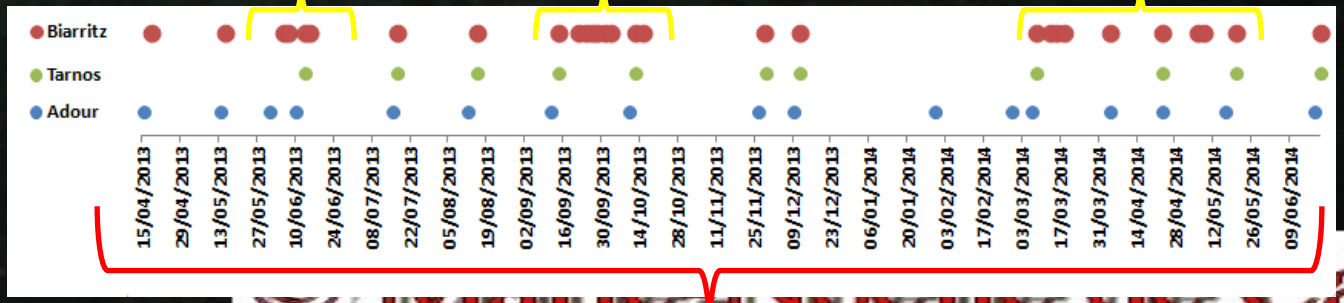
Adour Continental inputs
Day -1, Low tide, monthly



Biarritz Coastal station
Day , High tide, monthly and intensive

- 2 frequencies

Intensive in Biarritz = Mechanism of formation



Monthly at the 3 stations = Seasonal dynamic

Research program 2013-2017 : Sampling strategy

Biogeochemical background
(nutrients, pigment, POM, DOM)

Physicochemical background
(CTD Profiles)

Hydroclimatic background
(Adour river flow, Swell, wind, solar irradiance, …)

Surrounding water

MUCILAGE

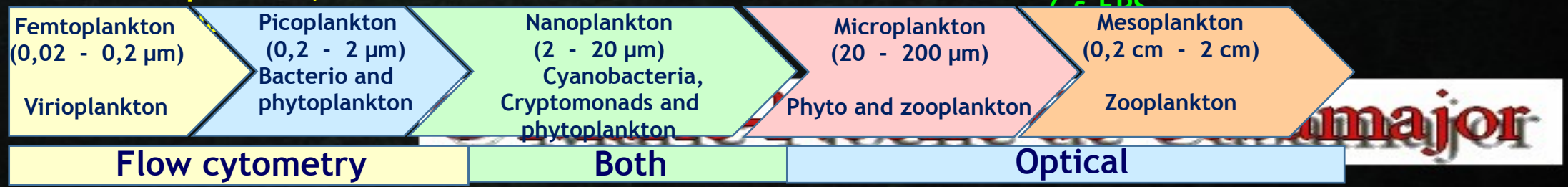
Diversity

- Flow cytometry
  - ✓Viruses,
  - ✓Heterotrophic prokariotes
  - ✓Autotrophic pico-nanoplankton
  - ✓ Cyano bacteria
- Optical microscopy
  - ✓Nanoplankton,
  - ✓Microphytoplankton,
  - ✓ Microzooplankton,

Biological processes

- Primary production
  - ✓Primary production,
  - ✓ Nutrient Bioassays

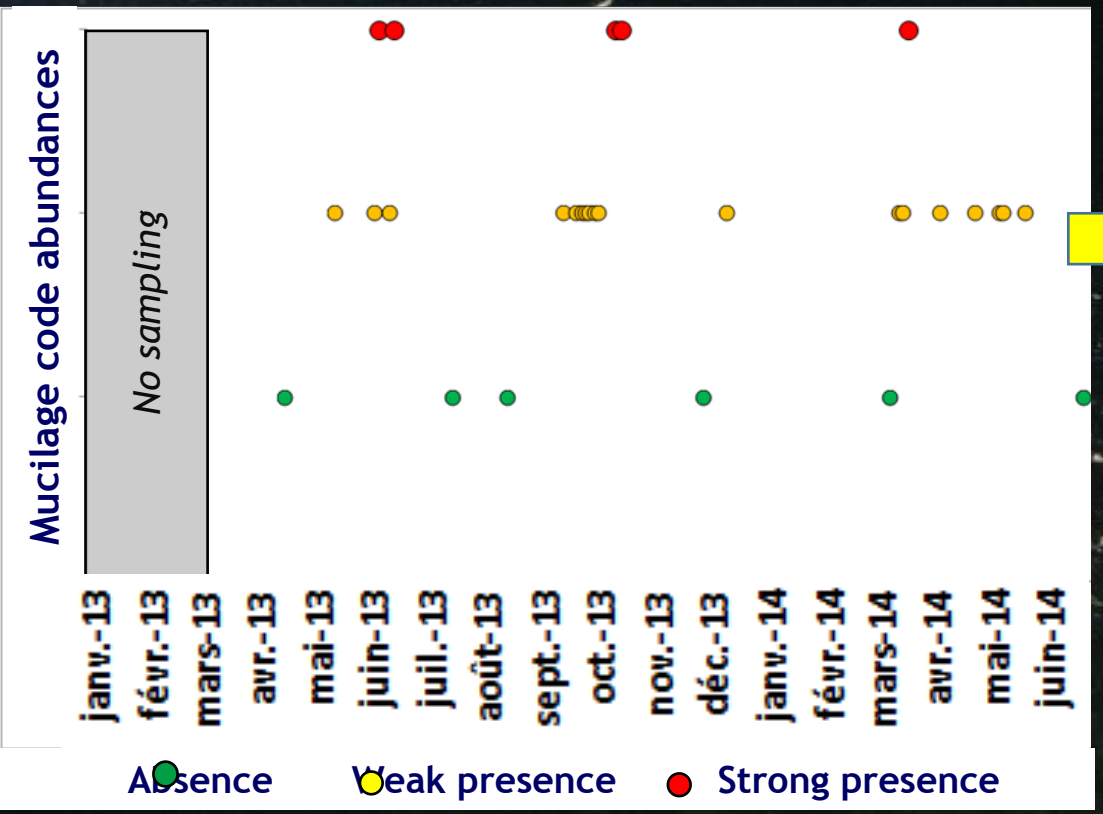
- Exudation processes
  - ✓TEP,
  - ✓ EPS

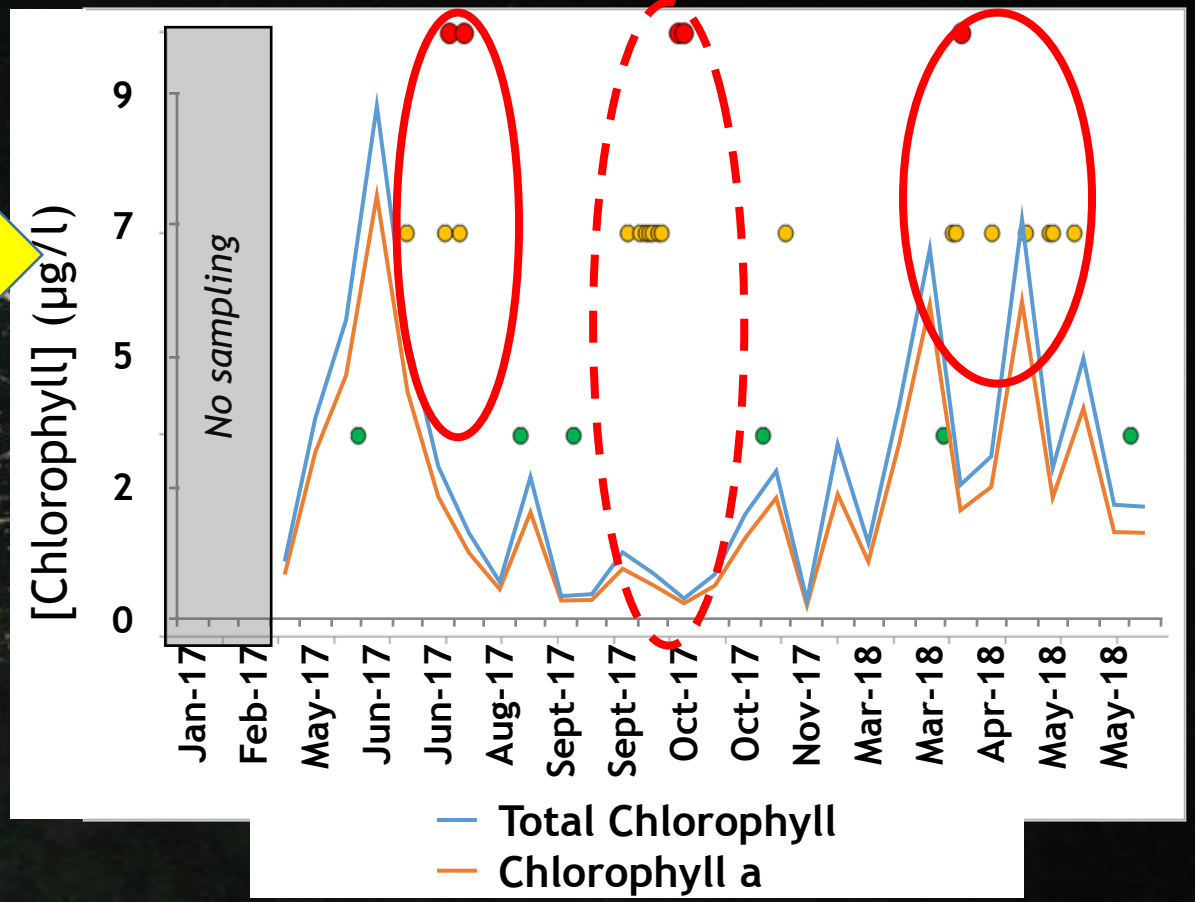


Processes : Primary production

Is there a link between mucilage occurrence and phytoplankton biomass ?

ong presence : June 2013 , October 2013, March 2014

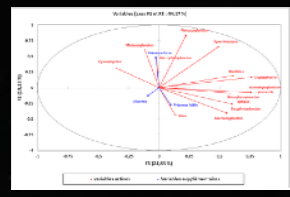




Mucilage occurrence positively correlated with chlo *a* (p value KW test = 0,035) chlo tot (p value test KW= 0,038)

↳ Positive correlation between mucilage appearance and phytoplankton production

Planktonic assemblages in relation to mucilage ?



1. Which functional groups and size classes are associated to mucilage occurrence ?

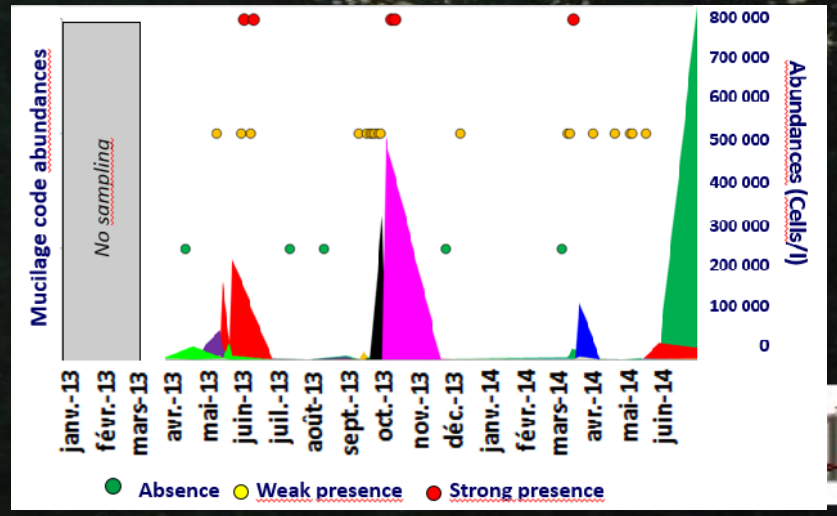
- Strong presence positively correlated with seasonal **microphytoplankton** abundances (p value KW test = 0,017)
- Absence negatively correlated with seasonal abundance of *Synechococcus sp.* cyanobacteria (p value KW test = 0,006)

2. Which microphytoplankton group is associated to mucilage events ?

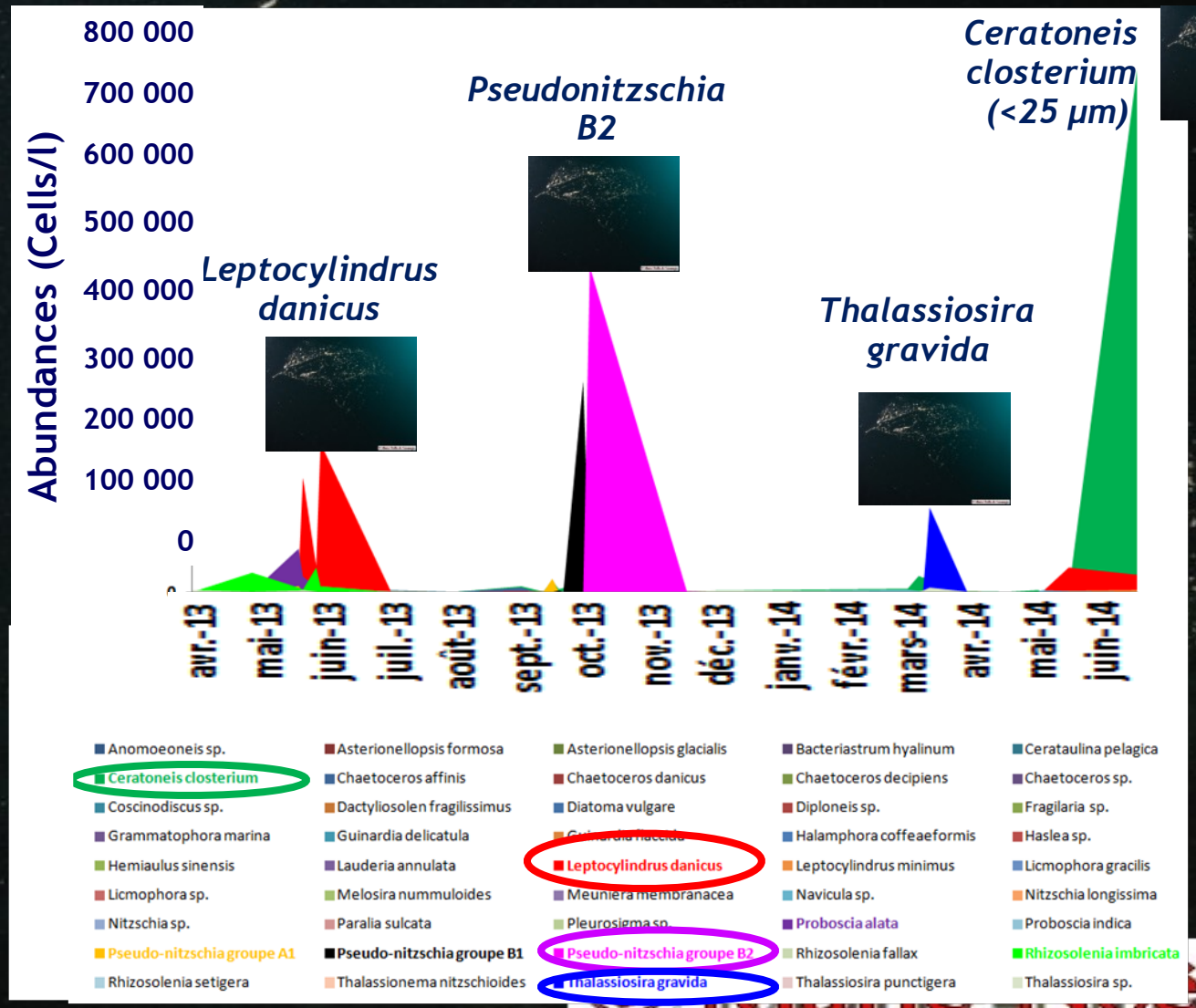
- Strong presence positively correlated with seasonal **diatoms** abundances (p value KW test = 0,001)

3. Which diatom species are associated to mucilage events ?

- 99 microphytoplankton taxa identified : Diatoms (46), Dinoflagellates (47)



Planktonic assemblages in relation to mucilage ?



- Diatoms abundances increase with mucilage strong presence
- Different dominant species depending on season

↳ Positive correlation between mucilage strong presence and diatoms abundances

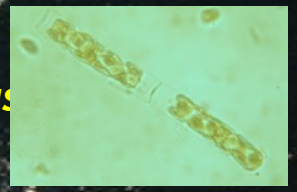
Planktonic assemblages in relation to mucilage ?

4. Which diatom species are involved in mucilage formation ?

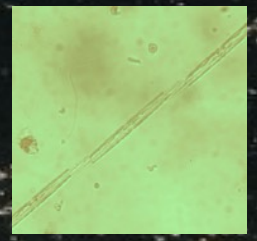
- Sorting Abundance/PERMANOVA/INDVAL → Indicator species of strong presence of mucilages

7 DIATOMS

Leptocylindrus danicus
IV=0,879 (p-value=0,01)



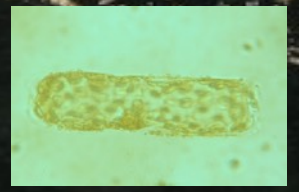
Pseudo-nitzschia B2 group
IV=0,599 (p-value=0,01)



Navicula spp.
IV=0,584 (p-value=0,03)

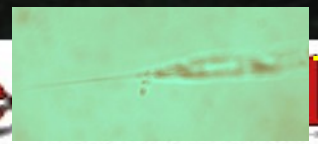
Guinardia delicatula
IV=0,526 (p-value=0,04)

Guinardia flaccida
IV=0,635 (p-value=0,01)



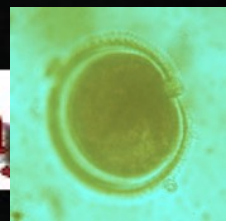
Leptocylindrus minimus
IV=0,582 (p-value=0,03)

Rhizosolenia setigera
IV=0,393 (p-value=0,03)



1 DINOFLAGELLATE

→ ***Protoperidinium oceanicum***

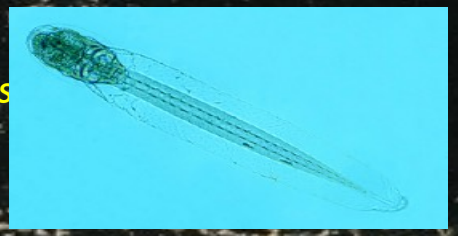


Planktonic assemblages in relation to mucilage ?

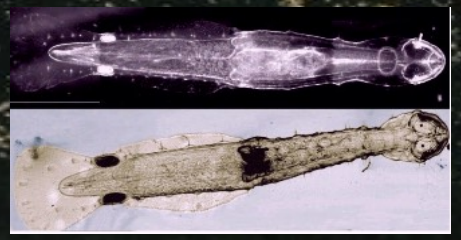
5. Which mesozooplankton indicator species of mucilage strong presence ?

➢ ***Siphonophora Diphiidae***
IV= 0,678 (p-value=0,002) -> Cnidarians

➢ ***Oikopleura sp.***
IV= 0,638 (p-value=0,01) => Appendicularians



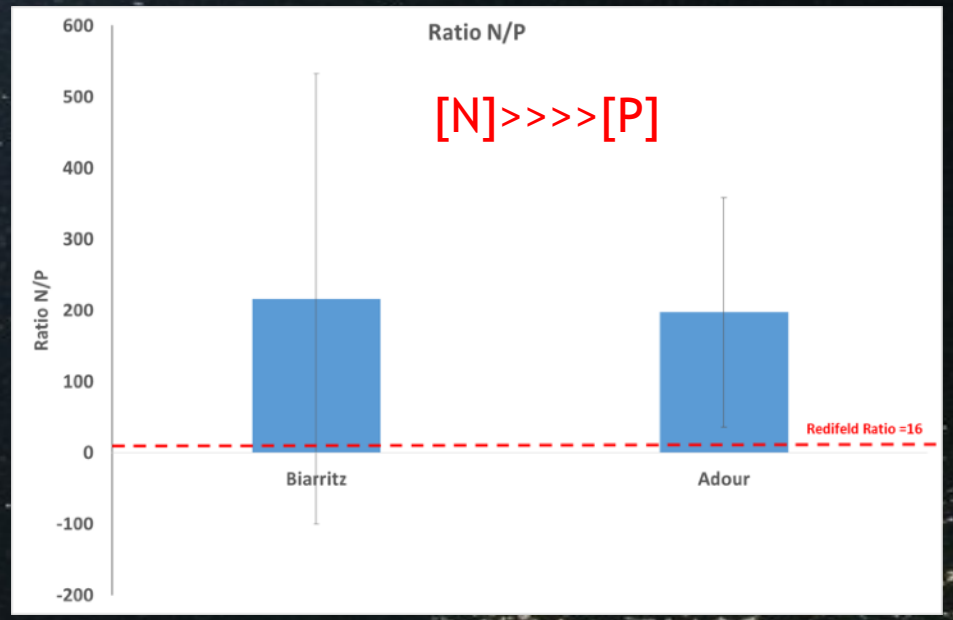
➢ ***Sagitta sp.***
IV= 0,603 (p-value=0,06) => Chaetognaths

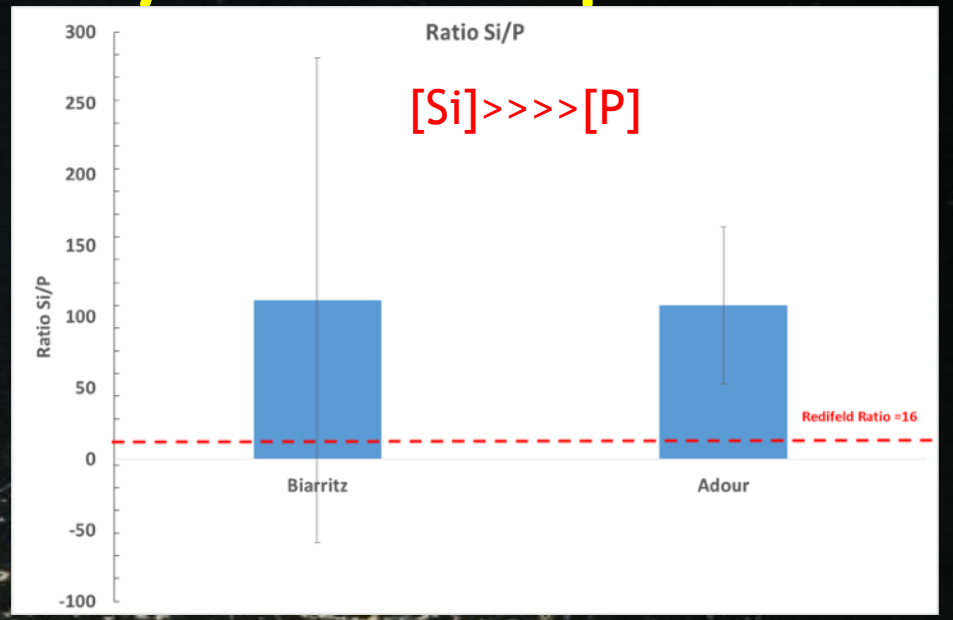


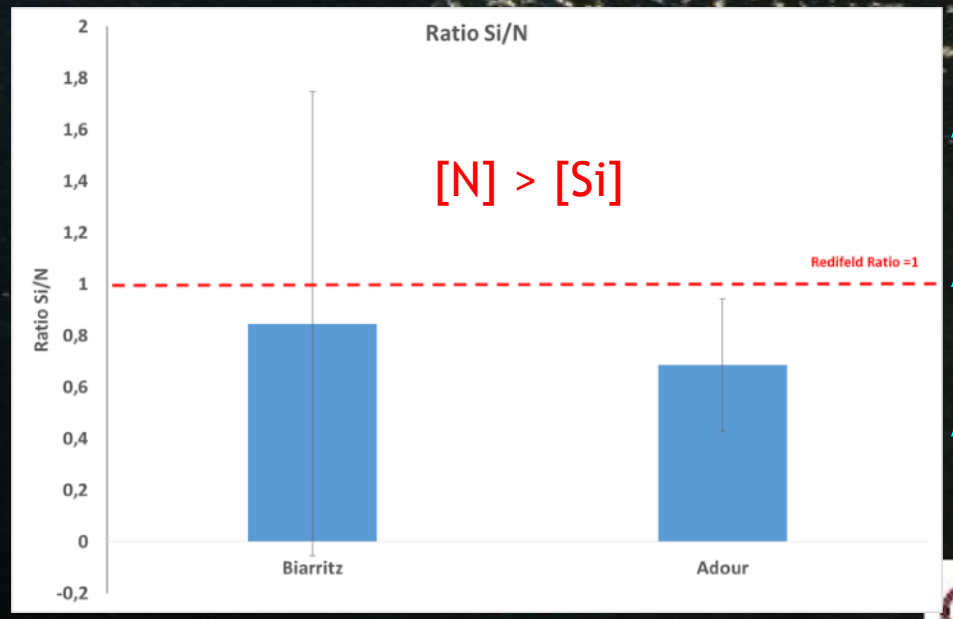
Gelatinous species
Link with climate change ?

➢ ***Oncaea sp.***
IV= 0,588 (p-value=0,05) => Copepods

Unbalanced ecosystem ? Trophic conditions





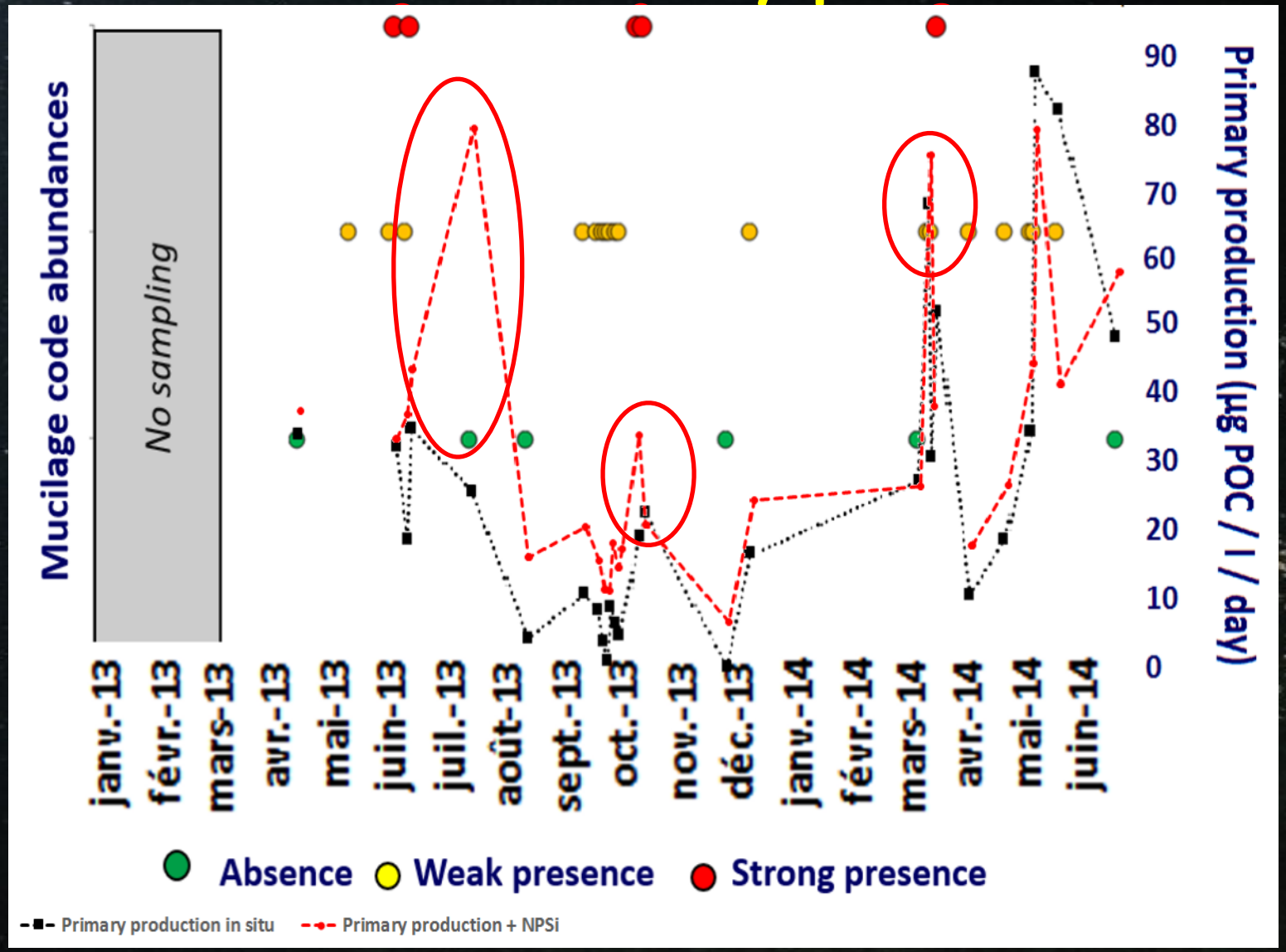


Ä Unbalanced nutritive conditions

Ä Limitation of primary production

Ä Limiting nutrient P > Si > N

Processes ? Primary production controlled by nutrients



↳ PP positively correlated with strong mucilage presence

↳ Nutrient limitation of Primary production

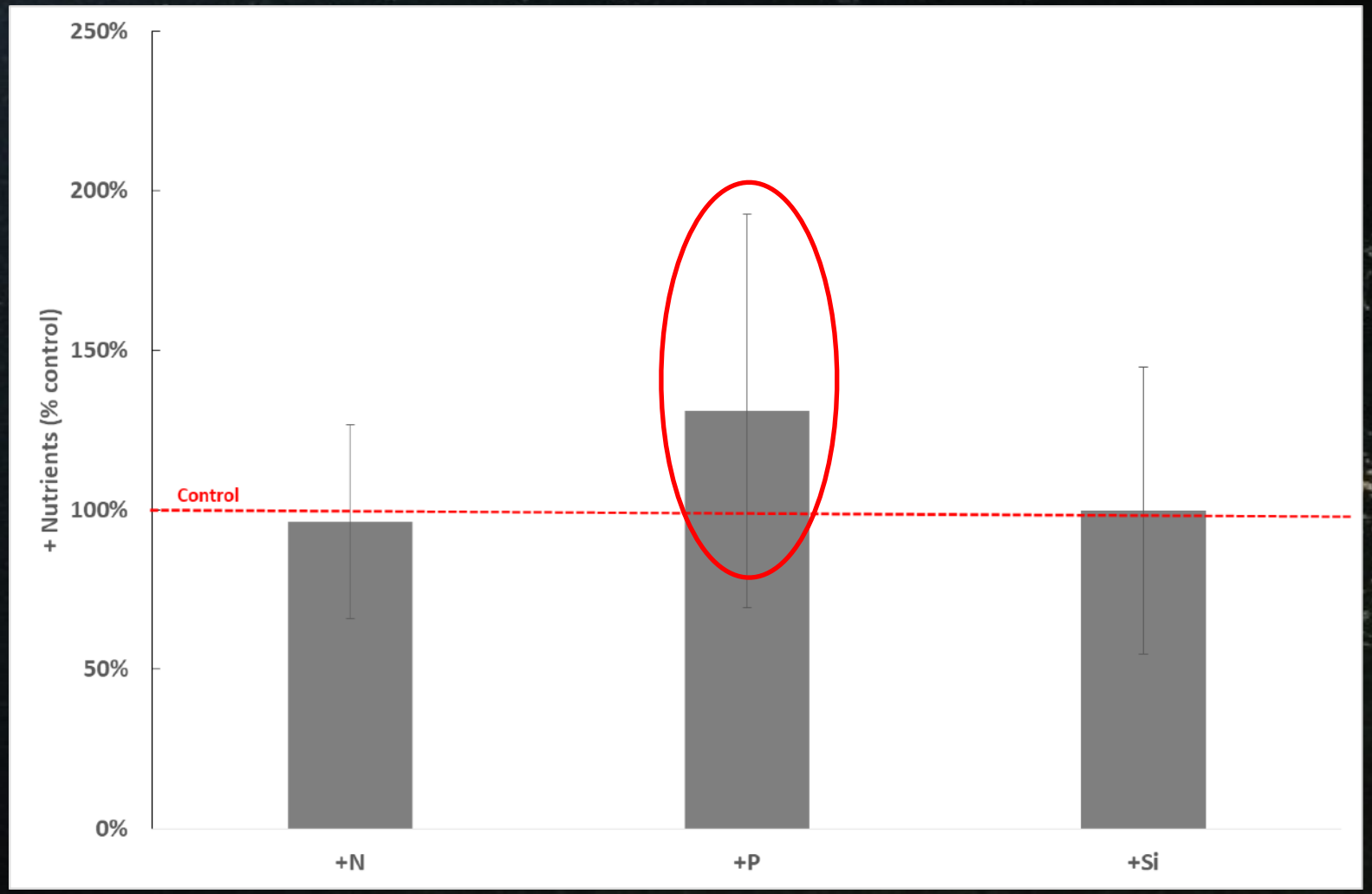
June- july 2013

October 2013

March 2014

Which nutrient is controlling primary production ?

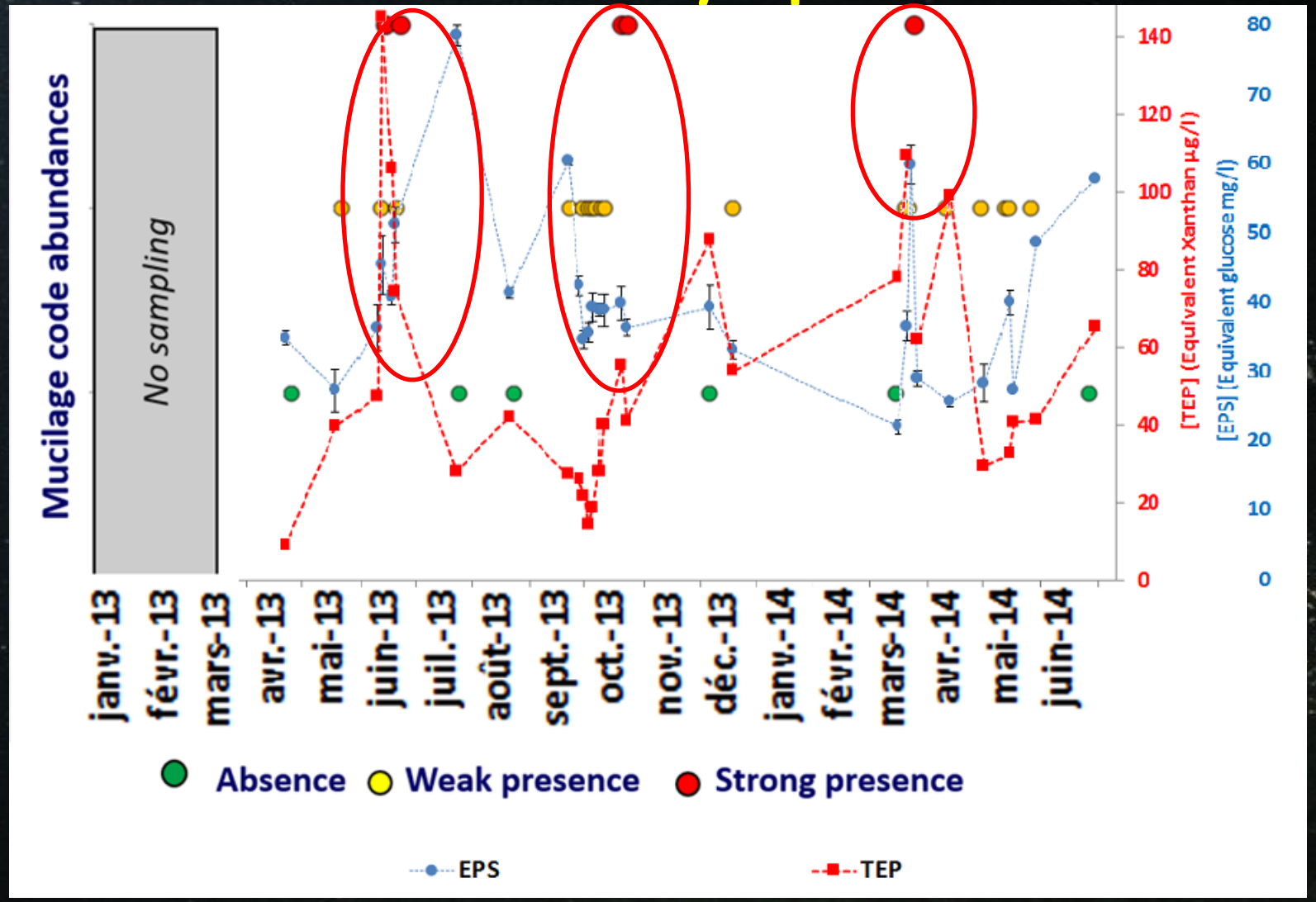
Processes ? Primary production controlled by nutrients



- No N limitation of primary production
- No Si limitation of primary production
- P limitation of primary production in
  - June- july 2013
  - October 2013
  - March 2014

- P concetrations controls primary production (p value Pearson = 0,0011)

Phytoplankton exudation ?



↳ ↑ EPS before ↑ TEP

↳ EPS positively correlated with P limitation of primary production (p value Pearson test = 0,042)

↳ TEP positively correlated with strong mucilage presence (p value Pearson test = 0,013), microphytoplankton (p value Pearson test = 0,038) and diatoms abundances (p value Pearson test =0,037)

↳ P limitation of primary production → EPS exudation → Agregation on TEP → mucilage appearance

CONCEPTUAL MODEL of MPM

Solar irradiance
Air and water temperature
High N/P ratio

P limitation of primary production

Production

Phytoplanktonic biomass (Chlo) and diversity (Diatoms, EPS producers…)

Nutritive stress

Exudation

Extra-cellular polysaccharidic substances (EPS)

Microfibrils

Colloidal aggregate

Aggregation/Disentegration

Wind direction
Coastal currentology (gyre)

Coastal front (River mouth)
Pycnocline (River discharge)
Currentology
Swell
Wind speed

Dispersion and residence time

Dispersion and residence time

Dispersion and residence time

Pelagic mucilage

Aggregation/Disentegration

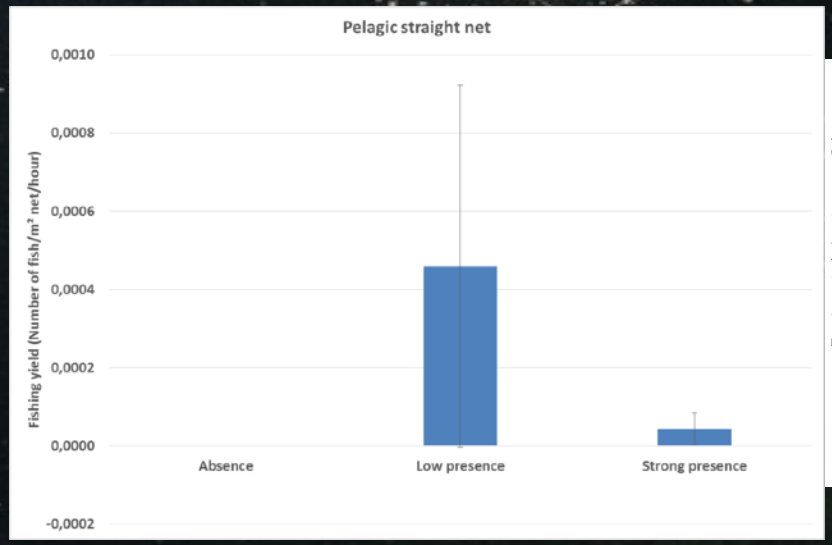
Transparent exopolymeric particles (TEP)

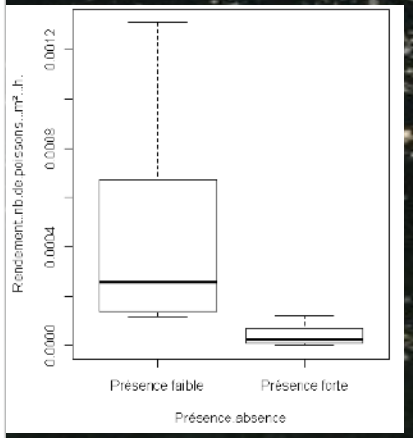
major

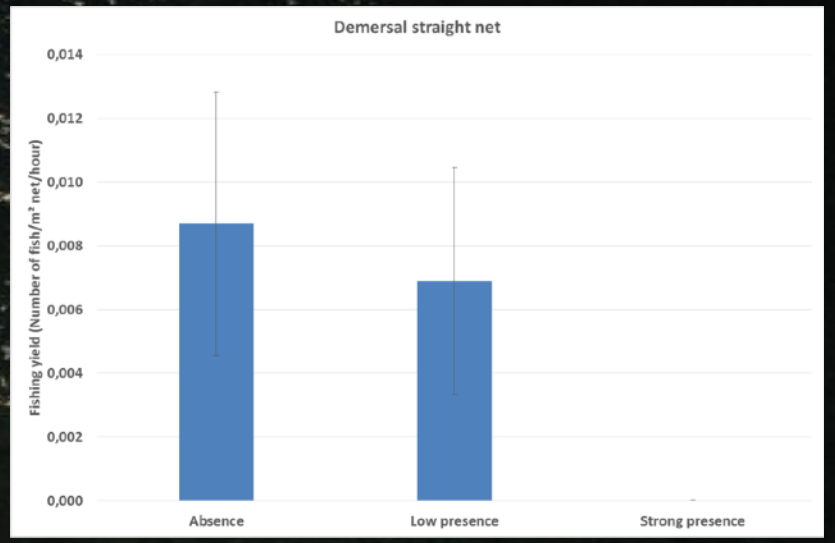
Impact on fisheries : yield

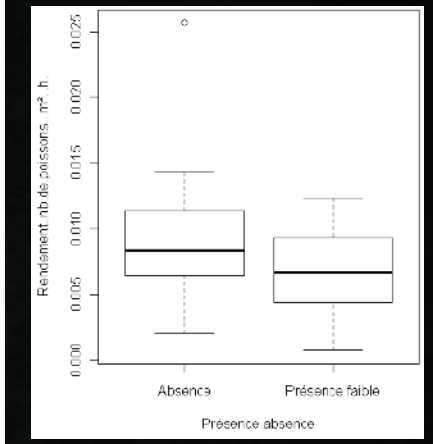
- Sampling of 27 pelagic and 60 demersal straight net from April to october
- Recording
  - ➢ net characteristics : lenght, height, mesh, duration, all catches (commercial and non commercial)
  - ➢ Mucilage presence : absence, low presence, strong presence

- Calculation of fishing yields in number of individuals per net area and hours of immersion







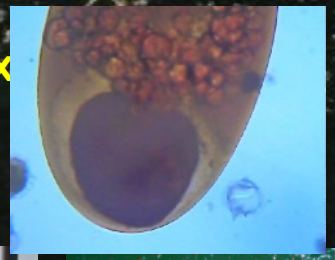


- Significative decrease of pelagic straight net yields between low and strong mucilage presence (p value Wilcoxon test = 0,0003)

- No significative decrease of demersal straight net between absence and low presence (p value wilcoxon test = 0,5)

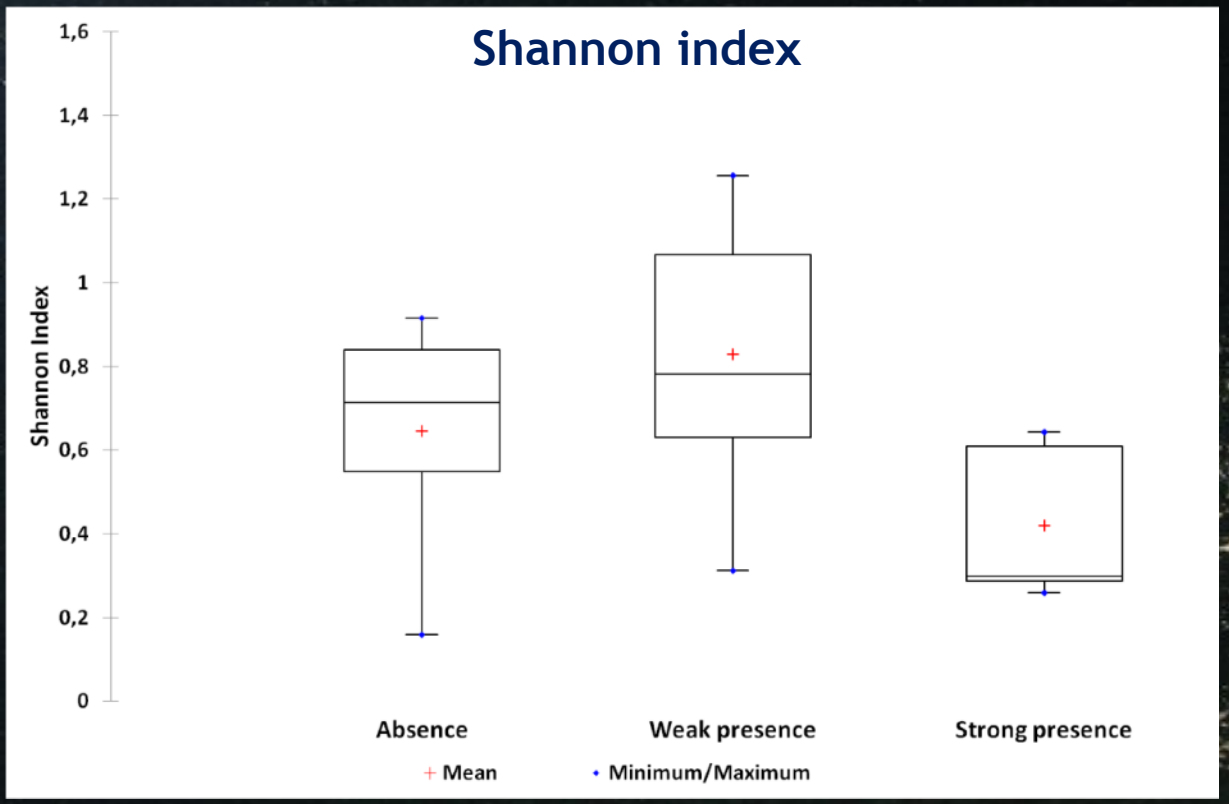
Other impact on fisheries

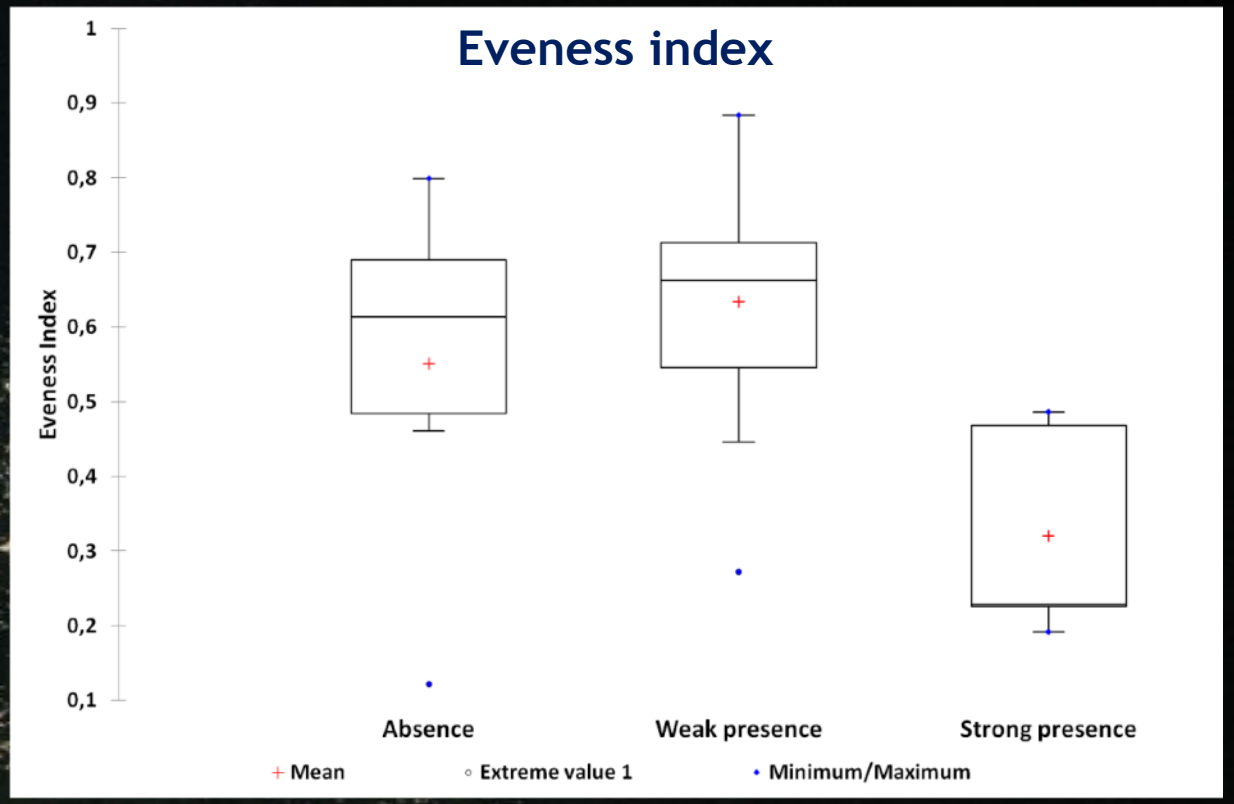
- Degradation of working and hygienic conditions
- Dermatological irritations : Itching, burns, urticaria
- Reduction of exploitable fishing areas
- Impact on species of fishery interest
  - ➢ Bonito (*Sarda sarda*) : Gill clogging
  - ➢ Small pelagic species (Anchovy, sardine…) : mucilage found in stomach con
  - ➢ Many eggs and larvae trapped into mucous matrix



ajor

Impact on microphytoplankton biodiversity





- During strong presence mucilage period
  - ➢ Significant decrease of diversity (↓ Shannon Index, p value KW test = 0,025)
  - ➢ Significant increase of dominance (↓ Eveness Index, p value KW test = 0,018)

Other impacts in Adriatic

- Tourism : - 60 % of tourist arrivals in Rimini in 1991 (Becheri, 1991)

- Fishing :
  - ➢ Loss of nets (Inamorati, 1995)
  - ➢ Stoppage of fishing activity (Calvo, 1995)
  - ➢ Financial compensation by EU (29 M€) (Ecopharm, 2003)

- Species of fishing interest
  - ➢ Change on the spawning region of anchovy (Kraus & Supic, 2011 ; Regner, 1996 ; Dulcic, 1997)
  - ➢ Drop on survival of larval stages and adult fishes (Regner, 1996)
  - ➢ Drop on hatching success rate of pelagic fish eggs (Rinaldi, 1995)
  - ➢ Settling to the bottom, death of bivalve mollusca and affect crustaceans, eggs and larvae of bottom dwelling fish species Rinaldi, 1995)

- On the marine ecosystem
  - Modification of the Carbone cycle (Leppard, 1995)
  - Negative effect on benthic ecosystems sucha as oxygen deficiency, mass mortalities, sponge necrosis and other benthic organisms and trophic disruption (Precali et al., 2005; Rinaldi et al., 1995 ; Schiaparelli et al., 2007; Giuliani et al., 2005; Metaxatos et al., 2003).








Retrospective study

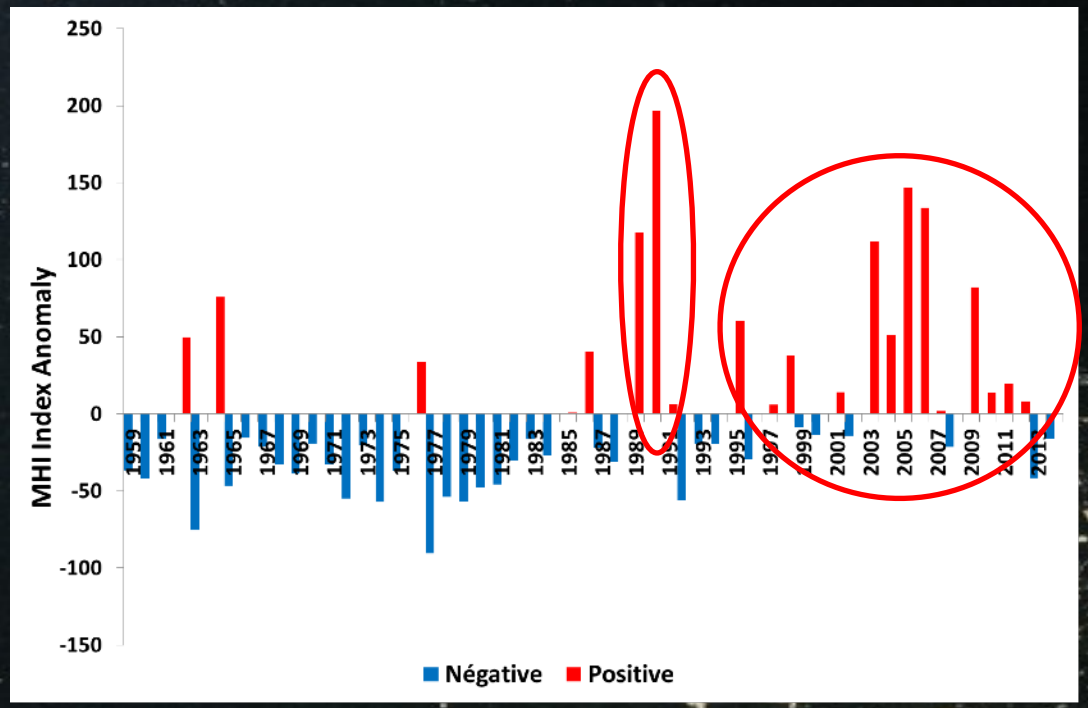
1. Data collection and analysis
   - ✓ Meteorological station of MeteoFrance in Biarritz
     - Daily mean air temperature (1956-2014), daily maximum wind speed and direction (1973-2014)
   - ✓ Riverine inputs of Adour river
     - Daily discharges (1956-2014) and monthly nitrogen and phosphorus concentrations in Urt (1976-2013)
   - ✓ Coastal water bodies
     - Daily swell : Anglet data buoy (2009-2014) (CEREMA/IVS) and replay of climatic conditions by numerical simulations (SIMAR - Puerto del estado) (1958-2009) (IVS)
     - Monthly temperature, salinity, nutrients and chlorophyll in Sea surface in St Jean de Luz (1976-1979) and (2007-2014)
2. daily Mucilage Hydroclimatic Index (MHI) creation, composite index based on

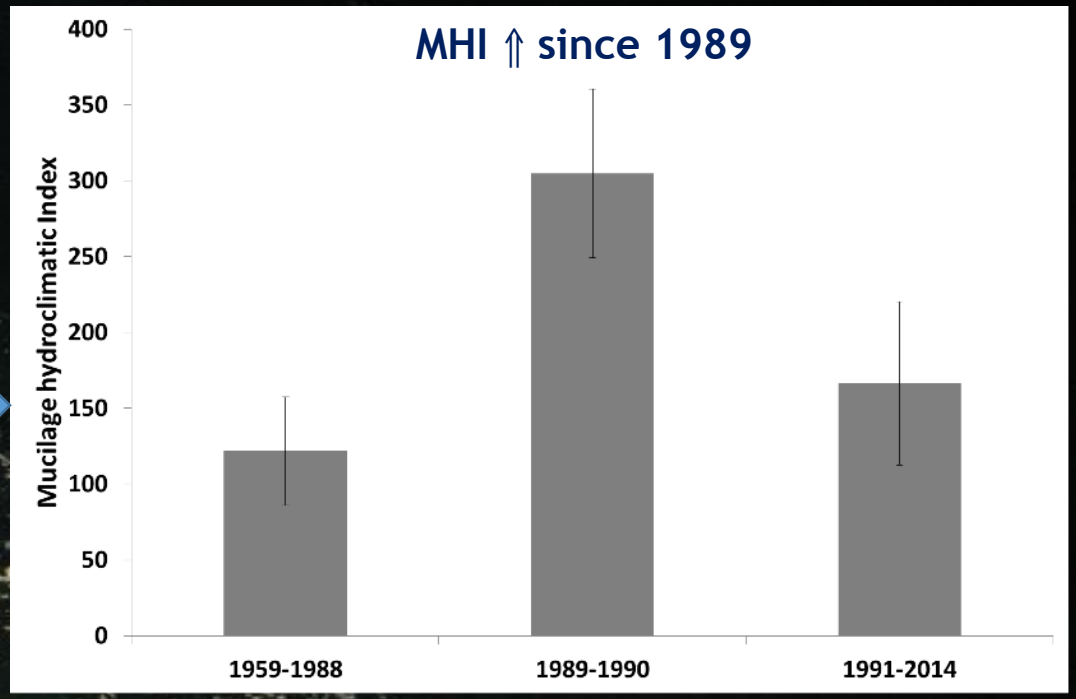
MHI = (Solar irradiance * Air max temperature) / (Adour river discharge*Swell)

High value MHI = Anticyclonic condition + calm sea + moderate Adour discharge
Low value MHI = Low pressure conditions + rough sea + high Adour discharge

3. Statistical processes
   - ✓ Continuous time series : Anomalies of each parameters = graphical descriptive approach and Hubert segmentation test (Krhonostat) = significant changes in time series
   - ✓ Discret time series
     - Boxplot (XL Stat) = graphical descriptive approachKruskall Wallis test (Xl Stat) = significant differences (5% significance level)

1959 - ACTUAL Mucilage hydroclimatic Index





The evolution of abiotic parameters driving mucilage formation may promote their increasing abundance and residence time recorded by fishermen since the early 2000s

Phosphorus ↓ Nitrogen → Silicon ↑ ⇒ N/P & Si/P ratios ↑ (unbalanced nutrient supply) ⇒ ↑ Phytoplankton

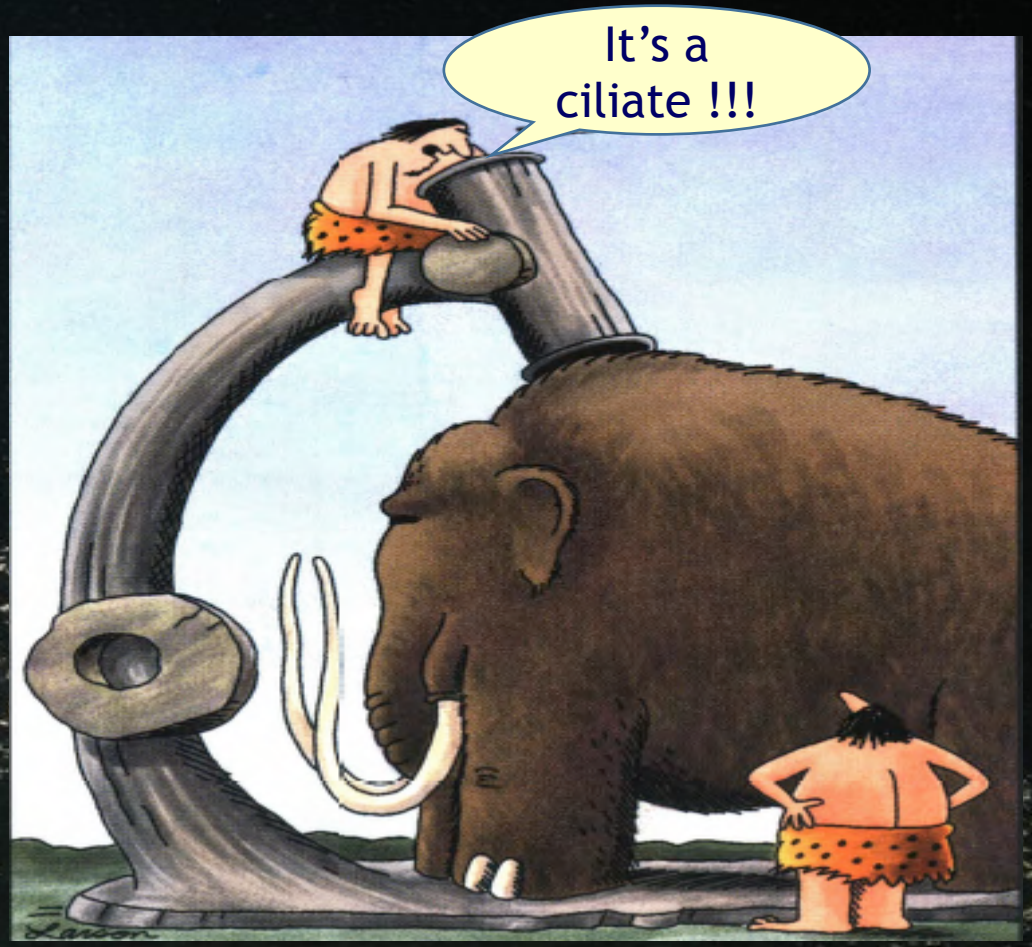
Exudation

Air temperature ↑ ⇒ Sea Surface temperature ↑
River discharge ↓ ⇒ Sea surface salinity ↑

Wind speed ↓ ⇒ Swell ↓ ⇒ hydrodynamism–

Pycnocline formation ↑ ⇒ Accumulation/ aggregation ↑

residence time ↑



Thanks for your attention !

Nicolas SUSPERREGUI - CIDPMEM 64-40

n.susperregui@cidpmem6440.fr