Sedimentary ancient DNA (sedaDNA) reveal shifts in marine protist communities after World War II and agricultural pollution

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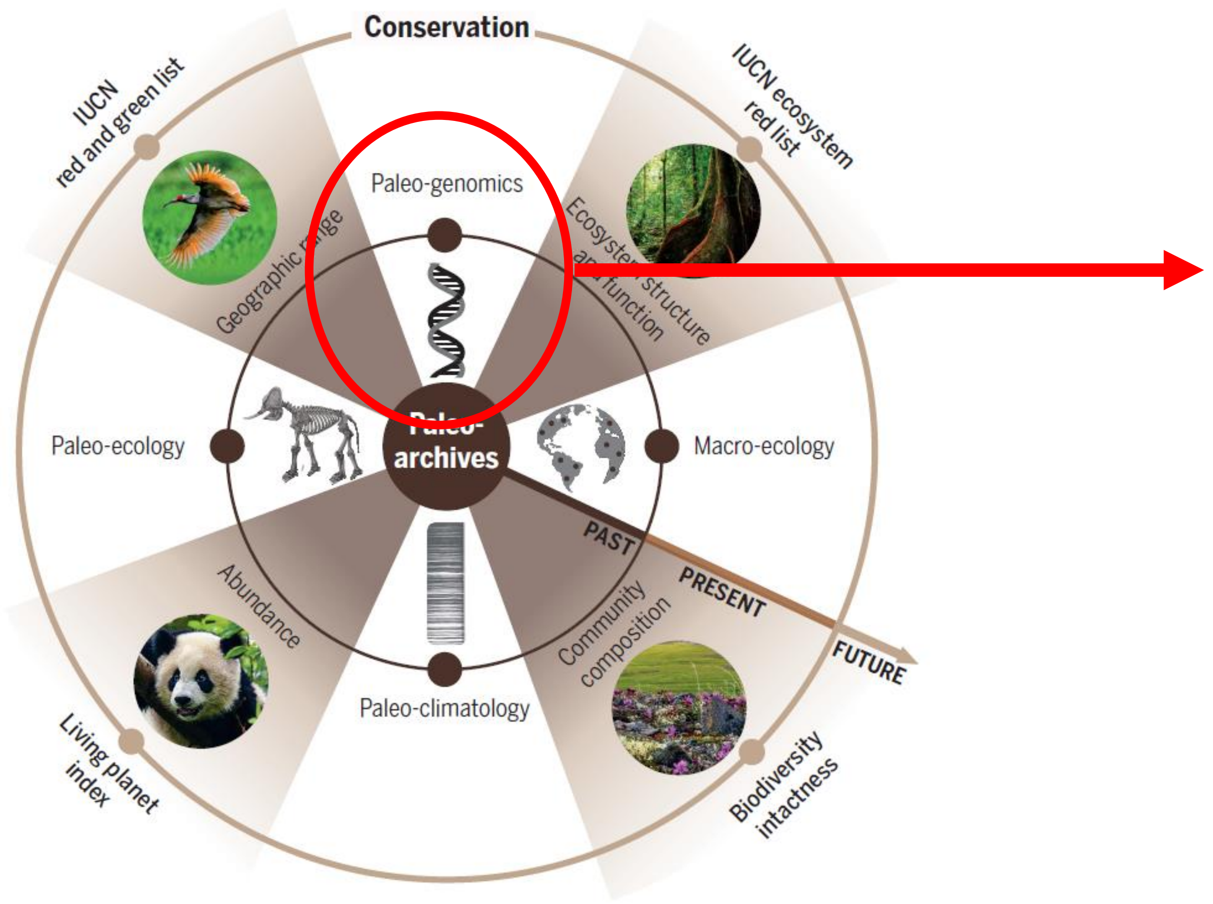
ESTIVAL ROOCH 14-15 Octobre 2021

Paleo-archives: a source of information for understanding ecosystems variations



Using paleo-archives to safeguard biodiversity under climate
Fordham et al. 2020 Science

Sedimentary ancient DNA

A tool for reconstructing the biodiversity of past biological communities and their shifts in relation to environmental changes.

Plankton Paleogenetics

Ancient Plankton DNA can be preserved in sediments of up to the Pleistocene (~ 125 000 years)

Geobiology

Geobiology (2011), 9, 377–393 DOI: 10.1111/j.1472-4669.2011.00290.x

Preservation potential of ancient plankton DNA in Pleistocene marine sediments

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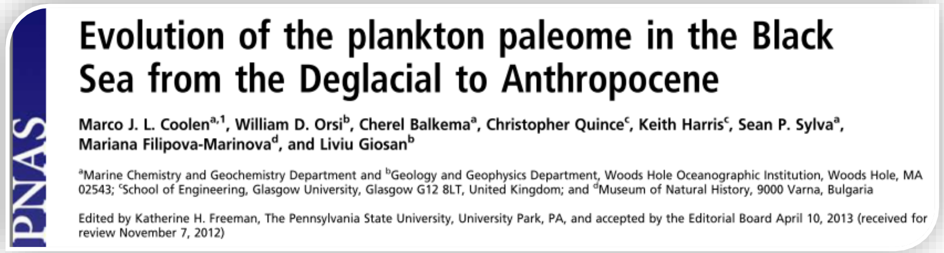
Plankton communities dynamics have been reconstructed and liked to environmental changes



PNAS

Evolution of the plankton paleome in the Black Sea from the Deglacial to Anthropocene

Marco J. L. Coolen[a,1], William D. Orsi[b], Cherel Balkema[a], Christopher Quince[c], Keith Harris[c], Sean P. Sylva[a], Mariana Filipova-Marinova[d], and Liviu Giosan[b]

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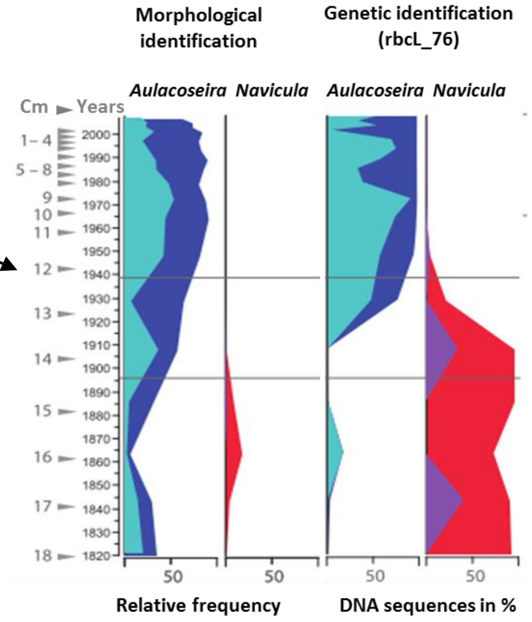
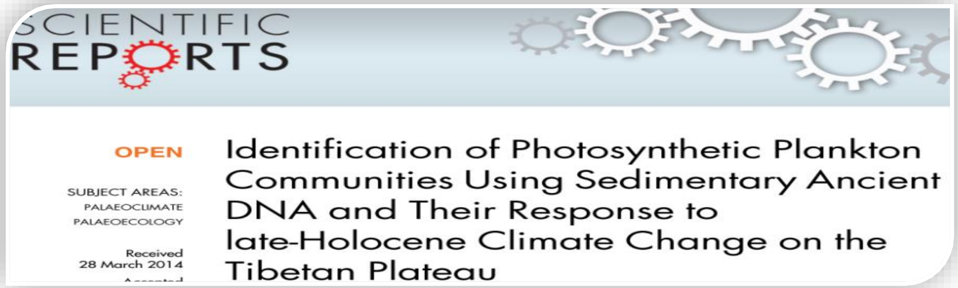
Edited by Katherine H. Freeman, The Pennsylvania State University, University Park, PA, and accepted by the Editorial Board April 10, 2013 (received for review November 7, 2012)

Shift in diatoms community around 1940





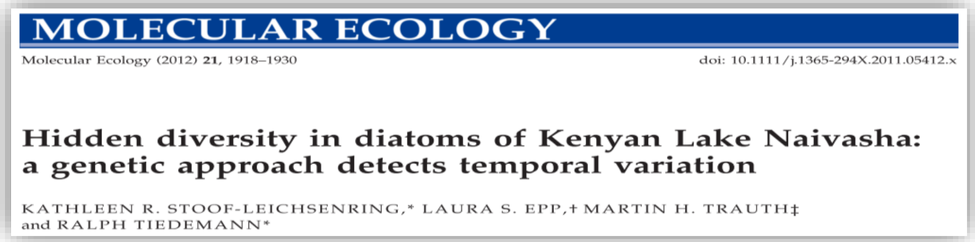
SCIENTIFIC REPORTS

OPEN

SUBJECT AREAS:
PALAEOCLIMATE
PALAEOECOLOGY

Received
28 March 2014

Identification of Photosynthetic Plankton Communities Using Sedimentary Ancient DNA and Their Response to late-Holocene Climate Change on the Tibetan Plateau



MOLECULAR ECOLOGY

Molecular Ecology (2012) 21, 1918–1930 doi: 10.1111/j.1365-294X.2011.05412.x

Hidden diversity in diatoms of Kenyan Lake Naivasha: a genetic approach detects temporal variation

KATHLEEN R. STOOF-LEICHSENRING,* LAURA S. EPP,† MARTIN H. TRAUTH‡ and RALPH TIEDEMANN*

Target ecosystems in paleogenetics

Typical deep ocean, permafrost, ice, fjörds, lakes

What about coastal ecosystems?

Objectif :
Use the potential of paleoecological approach to reconstruct environmental changes of the coastal ecosystem

The Bay of Brest (France)

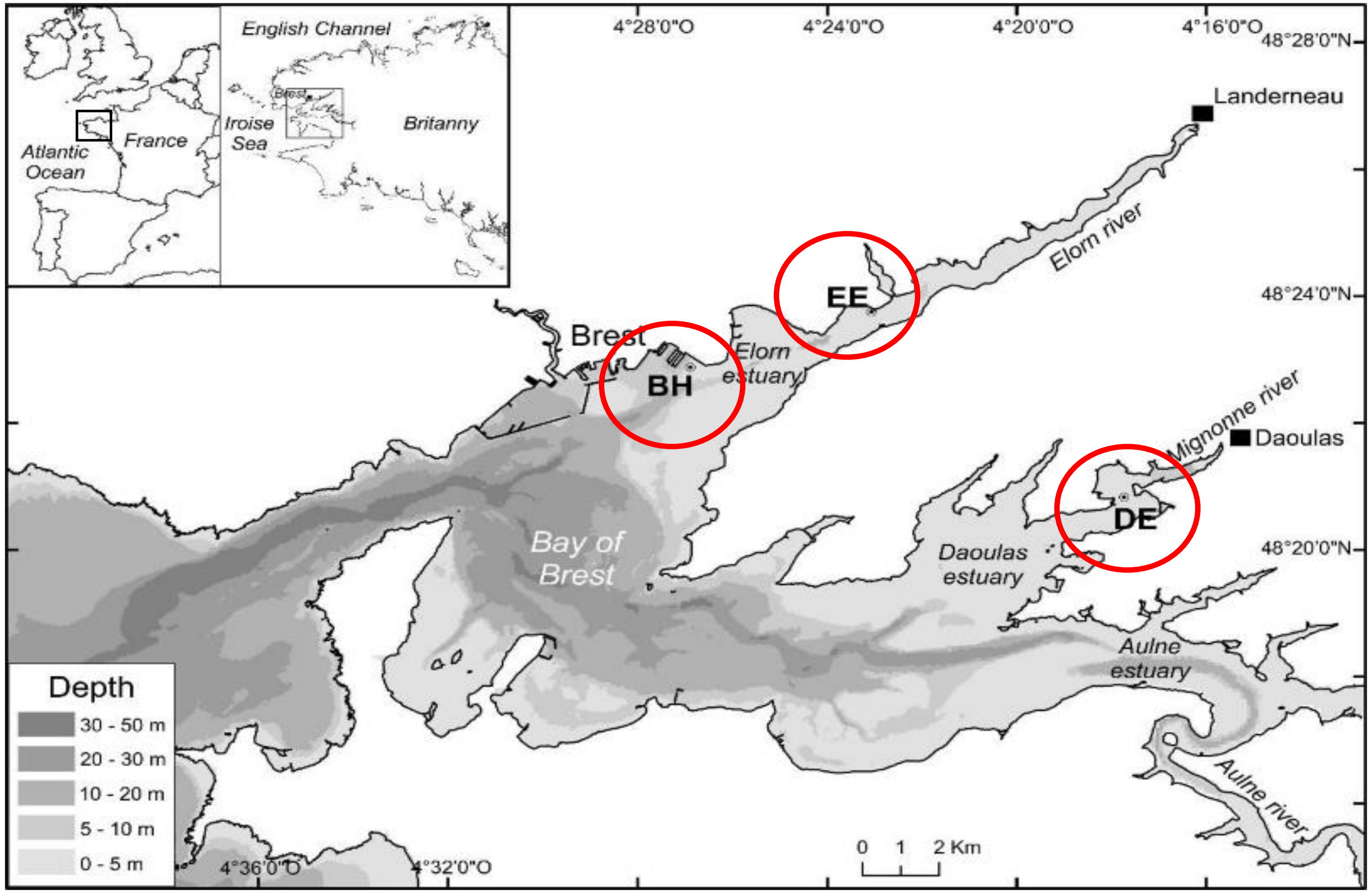
- 17th -18th centuries: naval town during the industrial développement

- 1940- 1944 : World War II (pollution of army activity, navy traffic, bombing)

- Since 1950 : intense agricultural development (eutrophication)

- Since 1990: control of eutrophication

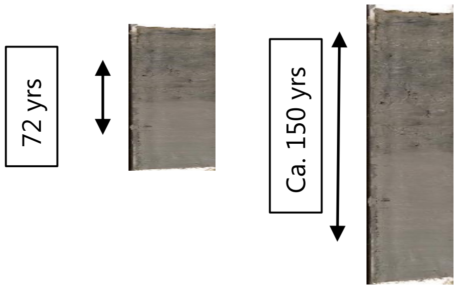
Sediment core sampling strategy

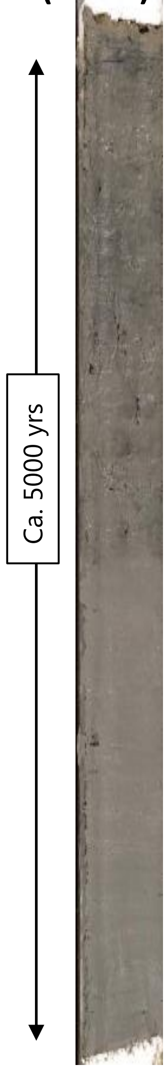


Core validation:

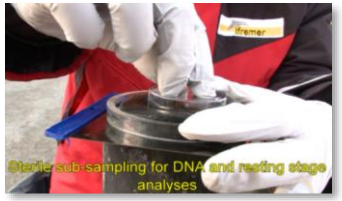
- Sedimentation and bioturbation rates (short half-life radionucleotides)
- Sediment dating (^{210}Pb, ^{137}Cs, ^{14}C analyses)
- Sediment permeability [H_20]
- granulometry

EE (0.4 m) DE (0.7 m) BH (3.4 m)

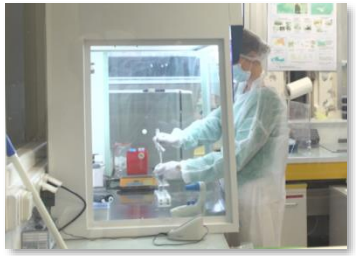




Sediment core collection by scuba divers or core sampler



Slice into 1 cm-layers and collection of the inner part of layer



DNA extraction in dedicated clean lab

Protist *sed*aDNA nature and its potential use as proxy for ecosystem variation

➔ *sed*aDNA degradation (= fragmentation)

Muddy sediments allow a better preservation of the *sed*aDNA that can be analyzed with a good taxonomic resolution (ca. 400 bp marker gene, V4 18 rDNA)

(Capo et al. *Mol. Ecol.,* 2016)

➔ sedimentary ancient DNA (*sed*aDNA) characterization :

*sed*aDNA mostly correspond to intracellular DNA, protected in cell restring stages

(Siano et al. *Current Biology*, 2021)

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(Siano et al. *Current Biology*, 2021)

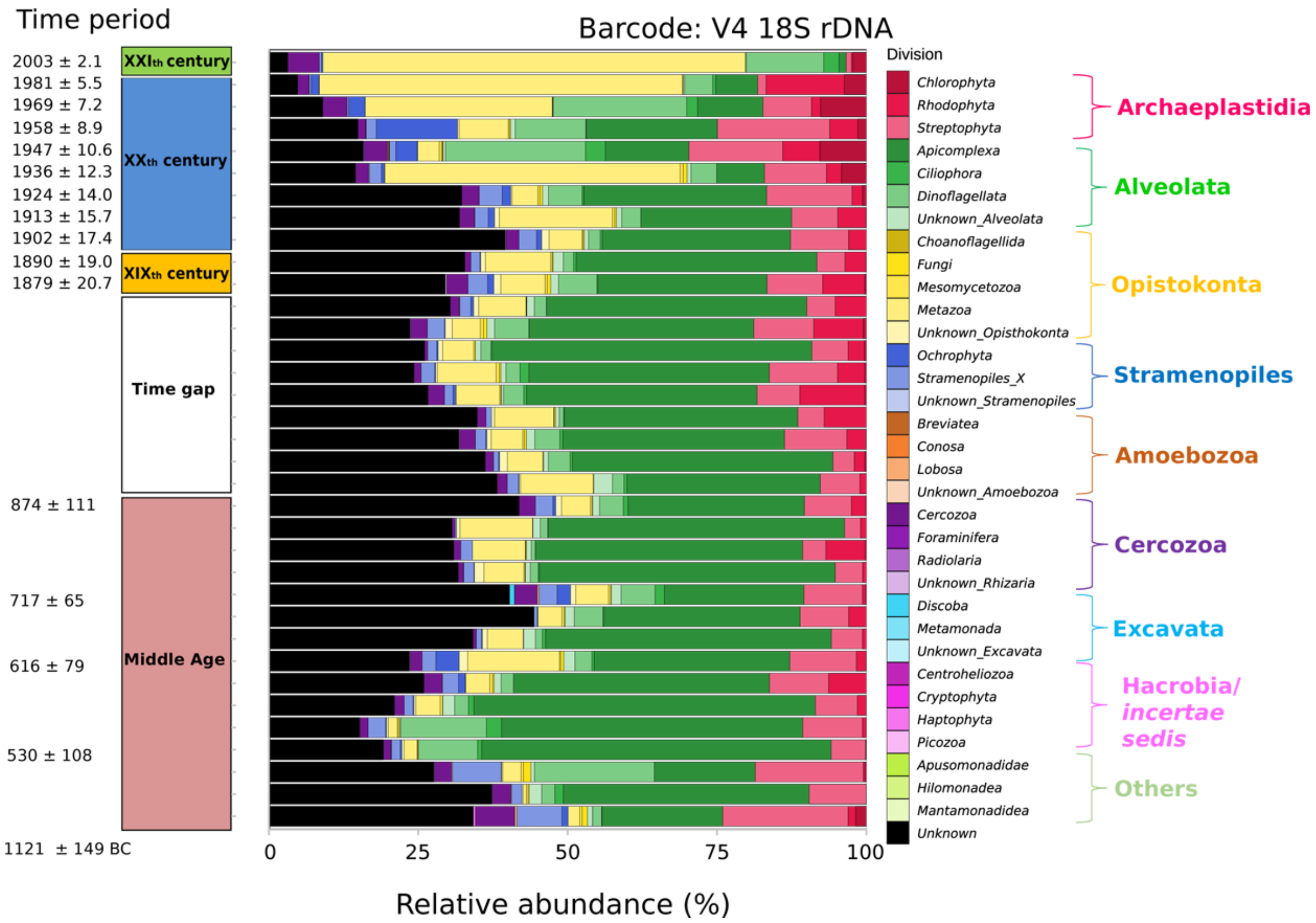
➔ *sed*aDNA as a proxy of protist community shifts in relation to anthropogenic pressures

Can *sed*aDNA contribute to the evaluation of coastal ecosystems resilience?

Metacommunity vs. pollutant (heavy metals, PCBs) analyses

(Siano et al. *Current Biology*, 2021)

*seda*DNA : protist diversity

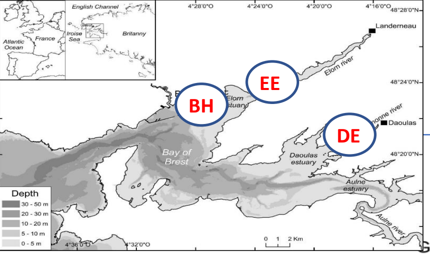


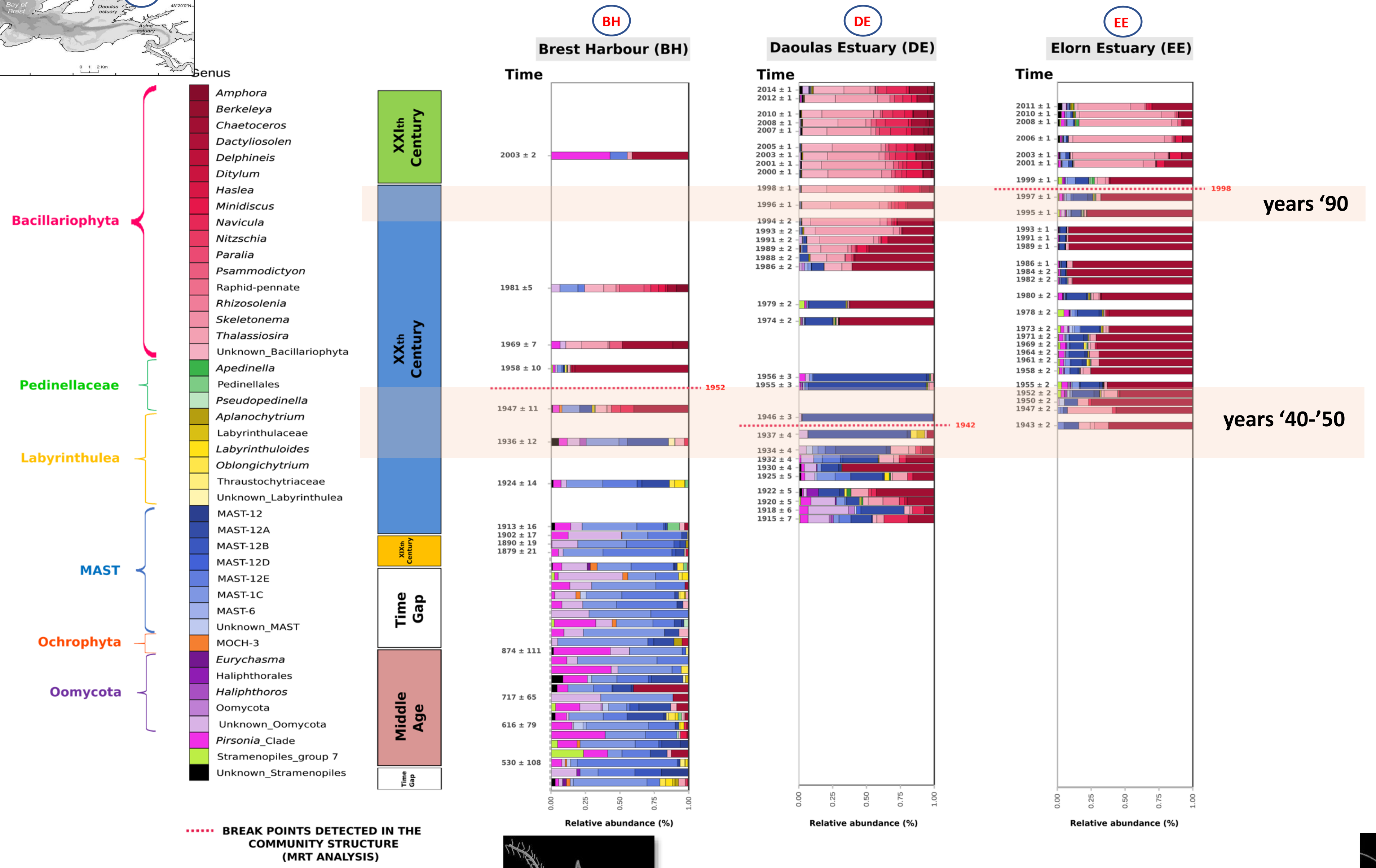
Siano et al. *Current Biology* 2021

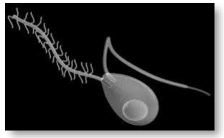
Gregarines (metazoans parasites) very abundant

➔ **Common pattern with terrestrial protist sediment communities**

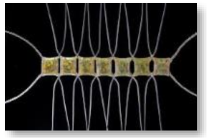
Protist community changes: Stramenopiles



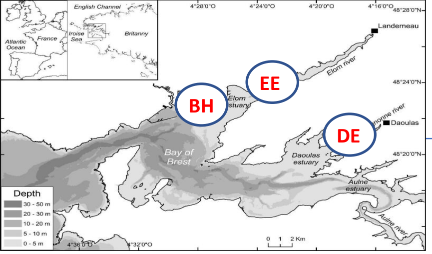




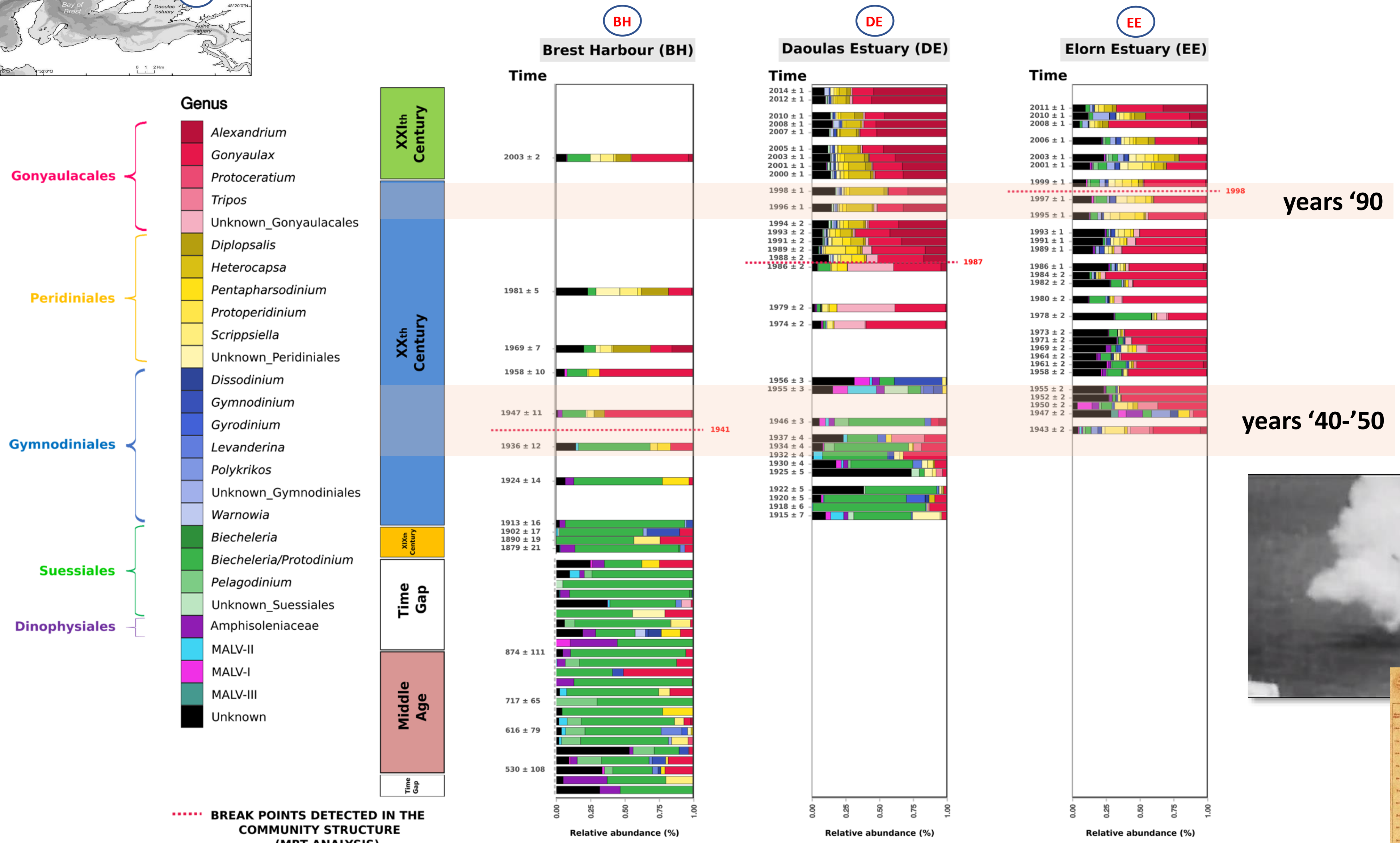
Marine Stramenopiles (MASTs) ➔ Diatoms



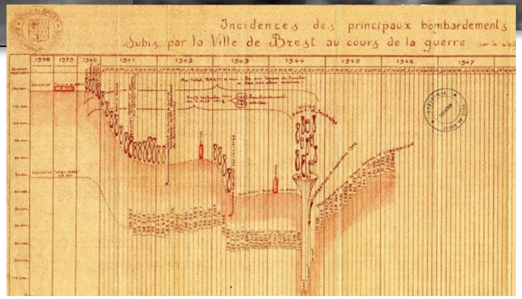
Siano et al. *Current Biology* 2021

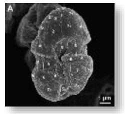


Protist community changes: Dinoflagellates



BREAK POINTS DETECTED IN THE COMMUNITY STRUCTURE (MRT ANALYSIS)



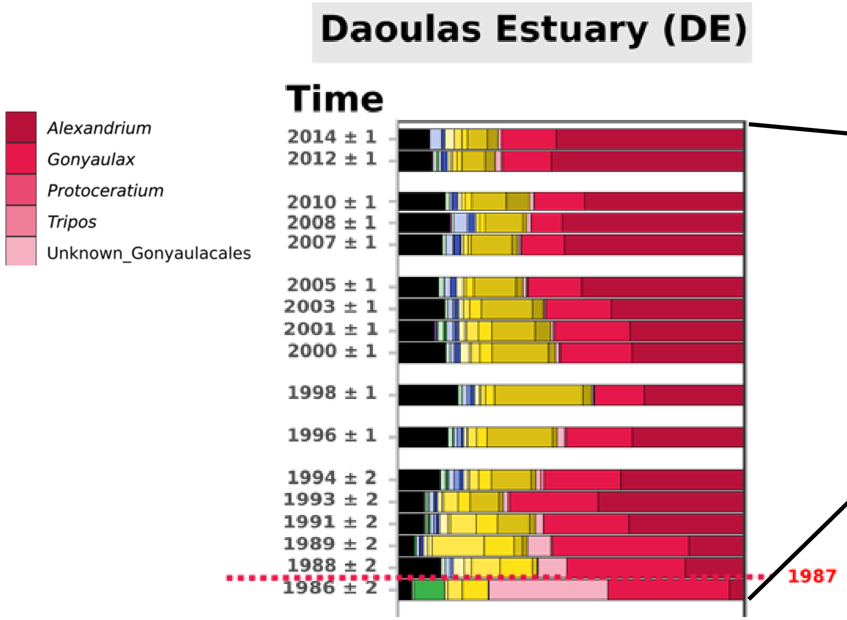


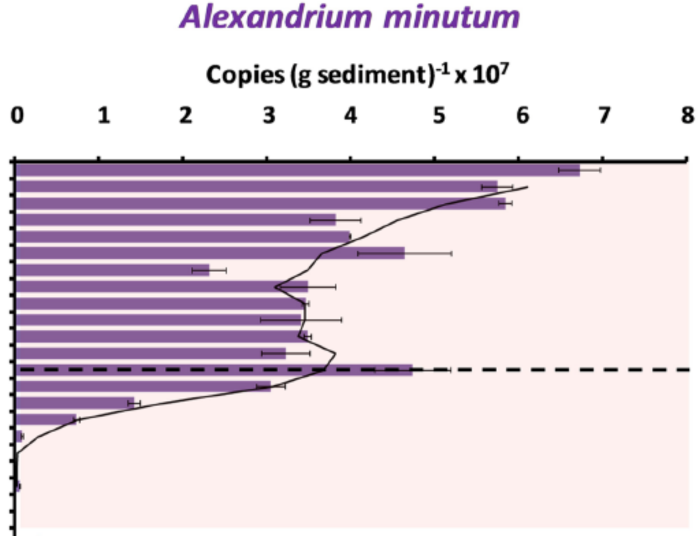
Order Suessiales ➔ Order Gonyaulacales

Historical documents of Brest archive municipality

Siano et al. *Current Biology* 2021

Dinoflagellate genera shifts



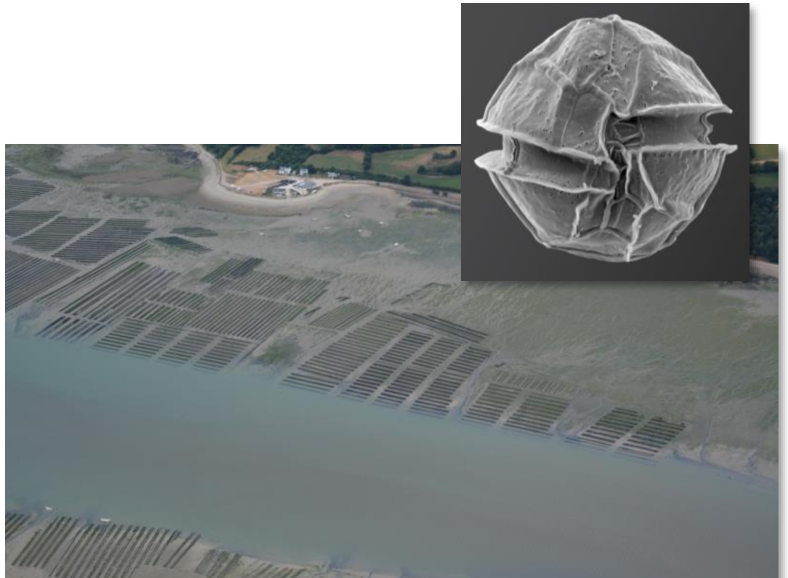


Siano et al 2021
Metabarcoding analyses

Klouch et al 2016
qPCR analyses

1873 ± 6

Recrudescence of blooms of the toxic dinoflagellate *Alexandrium minutum*

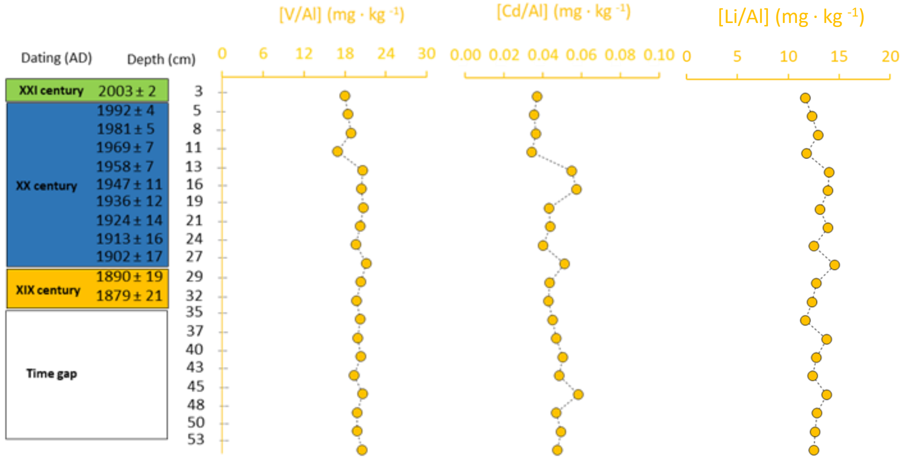


Bloom of *A. minutum* in the Morlaix Bay (North Brittany) (Summer 2015)

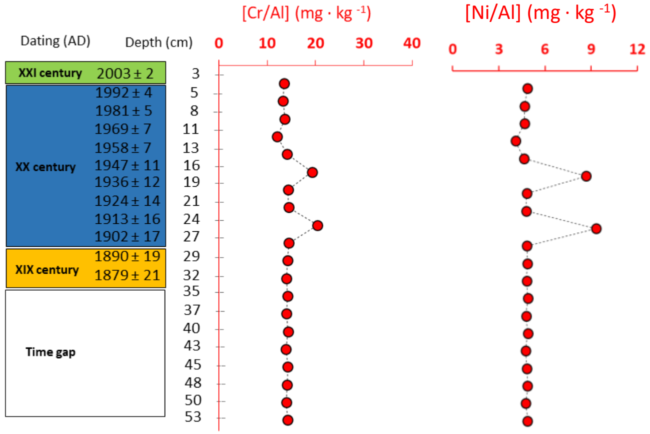
Heavy metal contaminations

Three heavy metal profile groups and Enrichment Factor Calculation (EF)

Groupe 1



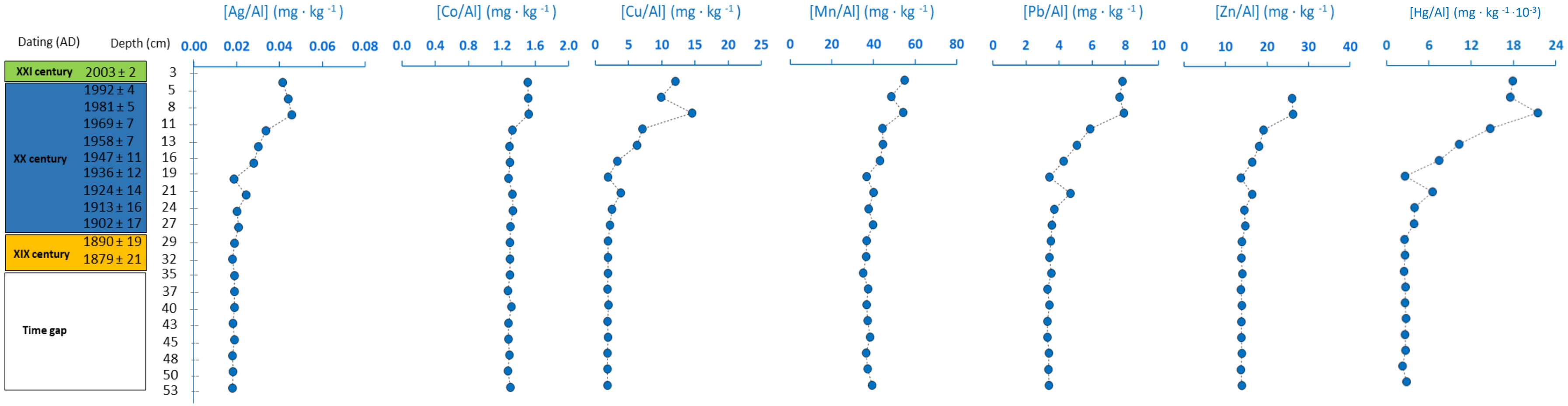
Groupe 2



EF: 2.0

➔ antropogenic impact

Groupe 3

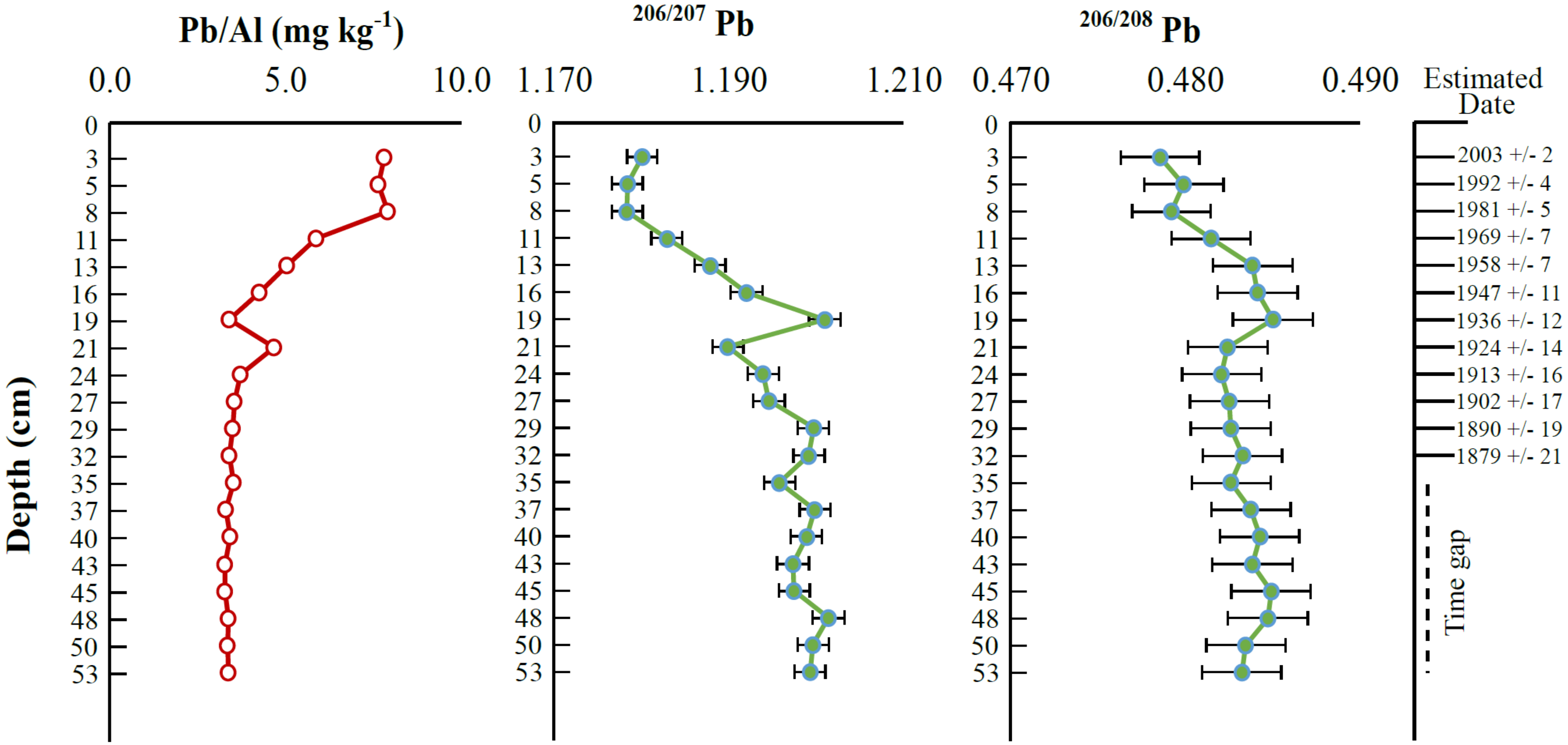


EF: 1.9-9.5

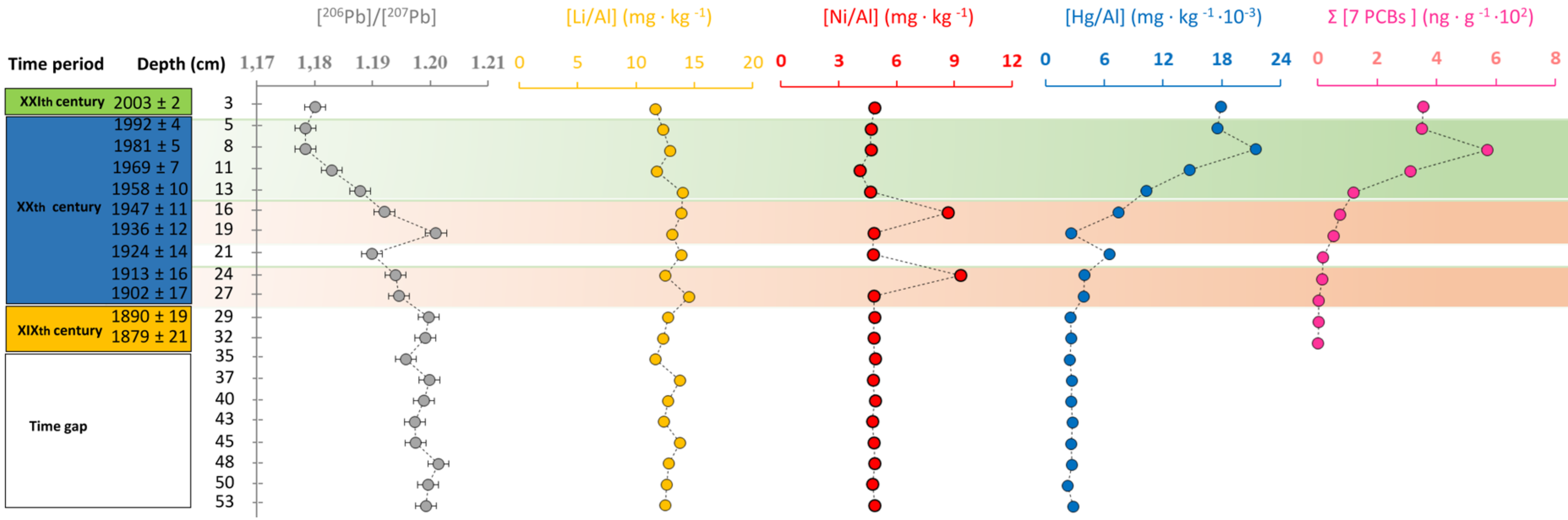
➔ Moderate to strong anthropogenic impact

Zn < Pb < Ag < Cu < Hg

Heavy metal contaminations



Reconstruction of historical pollutions



Signatures of chronic contaminations of agricultural origin

➔ Corroboration of palynological data cf. Lambert et al. 2017

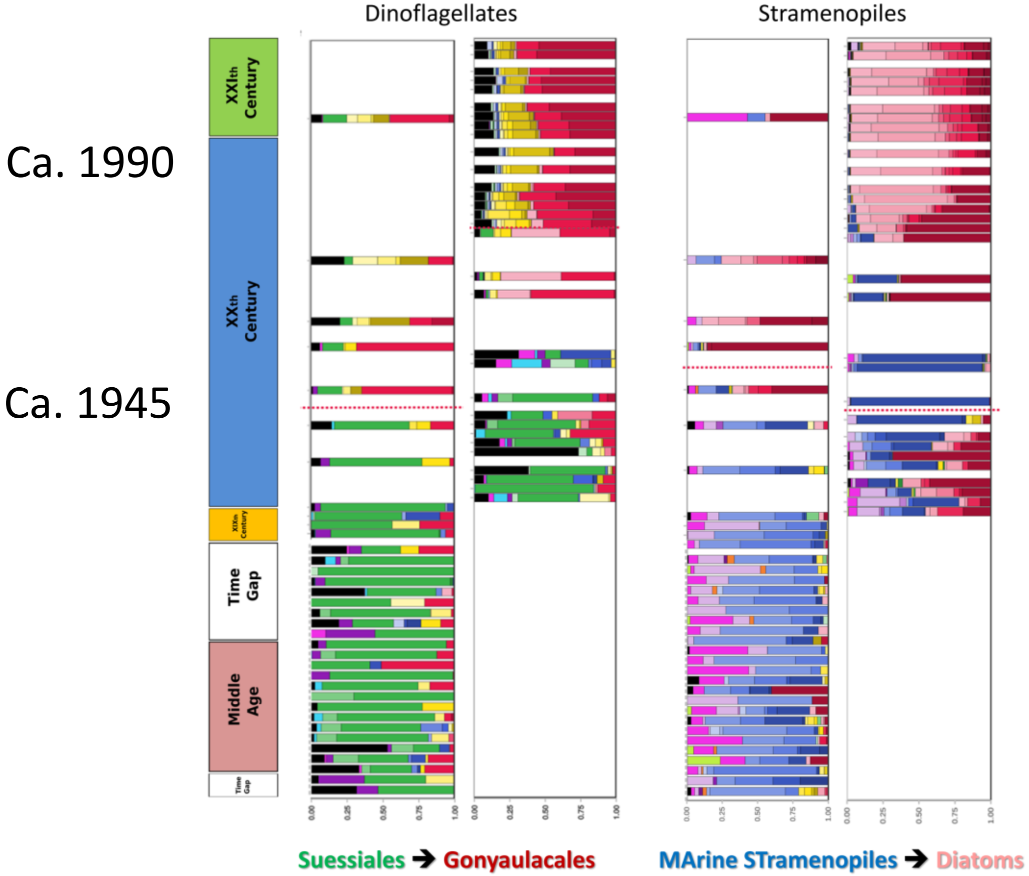
Ni and Cr contaminations

➔ Similar to contaminations observed in sediments of 1945 at Pearl Harbour (Aswhood & Olsen 1988)

➔ Cumulation of occasional (extreme event) and chronic chemical contamination

Conclusions

Microbiological shifts



Contamination

Human impacts

Coastal plankton communities affected by an anthropogenic perturbations
were not able to recover their initial (pre industrial) state,
questioning about the **resilience and stability** capacities of marine coastal areas impacted by humans

Thanks for your attention

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Collaborators:

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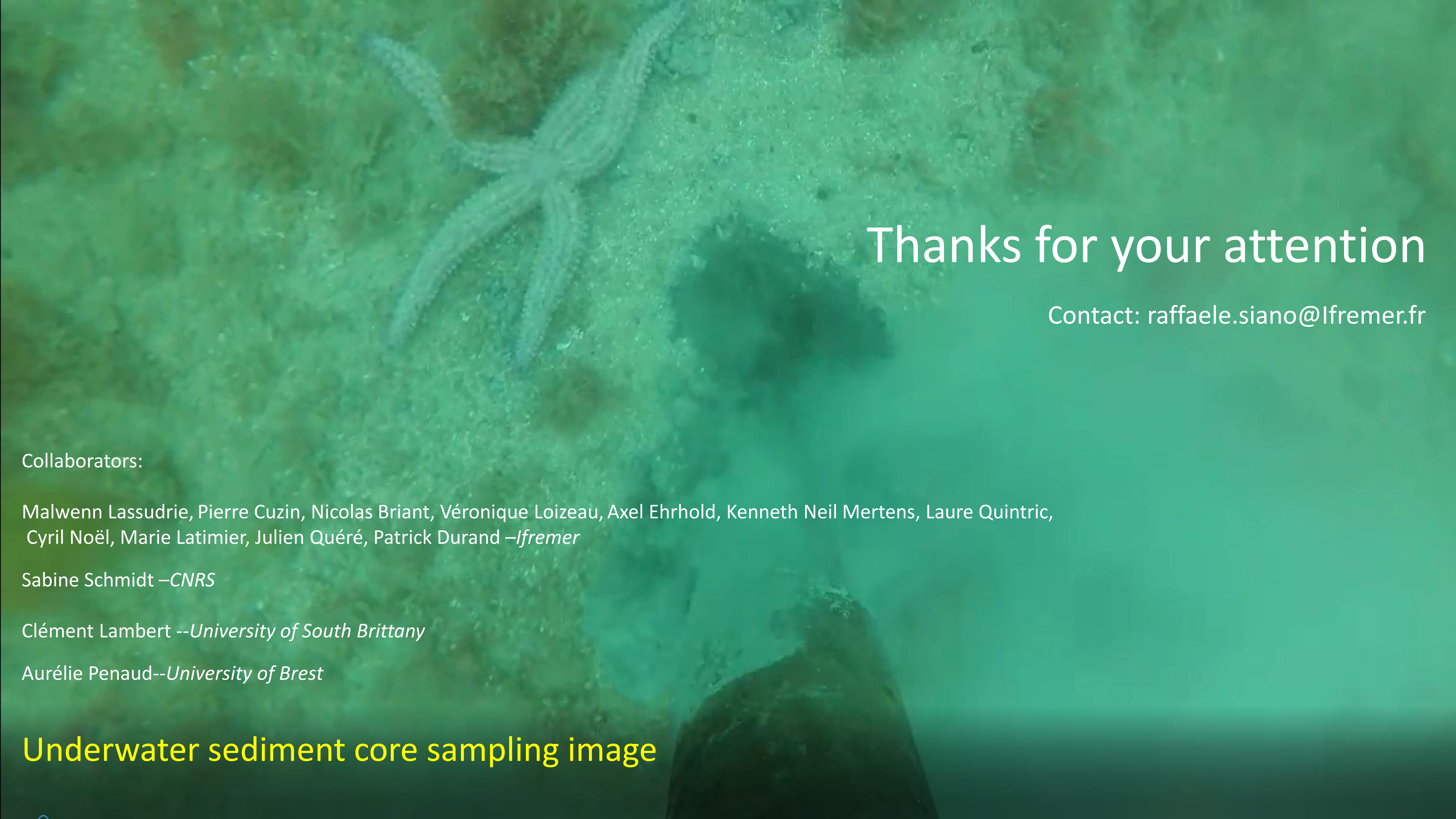
Sabine Schmidt –*CNRS*

Clément Lambert --*University of South Brittany*

Aurélie Penaud--*University of Brest*



Underwater sediment core sampling image