What do oyster shells tell us about paleoclimatology?

Damien Huyghe, Marc de Rafelis, Laurent Emmanuel, Loïc Marlot, Franck Lartaud

The Problem

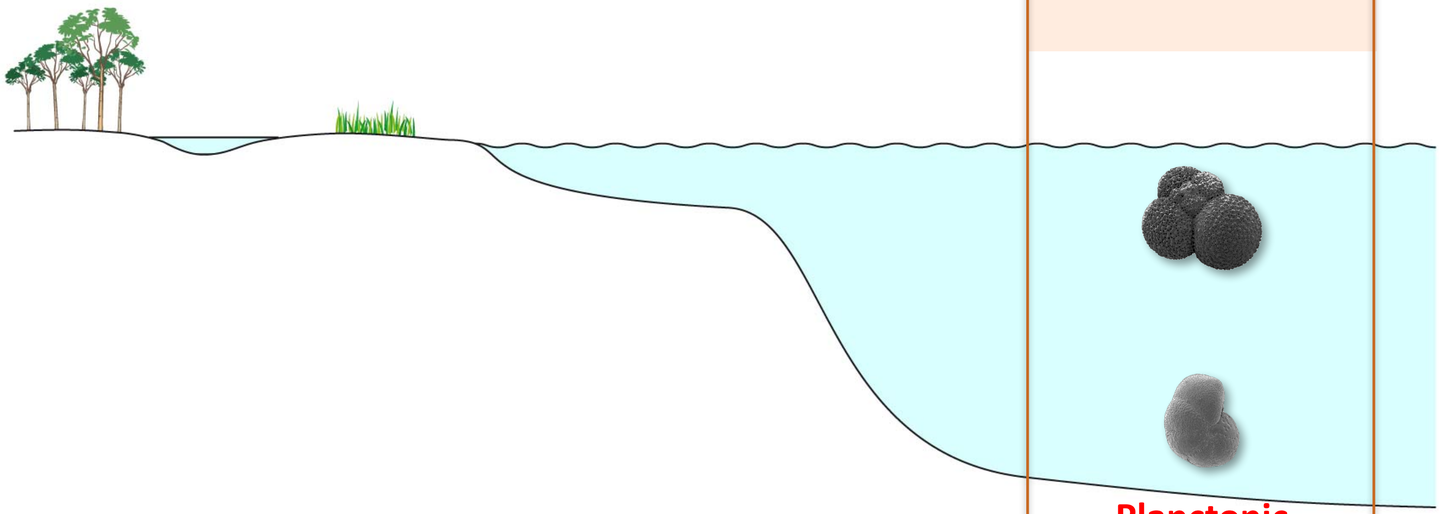
Stable isotope geochemistry

- $\delta^{18}O$ des carbonates

$\delta^{18}O_{CaCO3} = f (\delta^{18}O_{water} \& T_{water})$

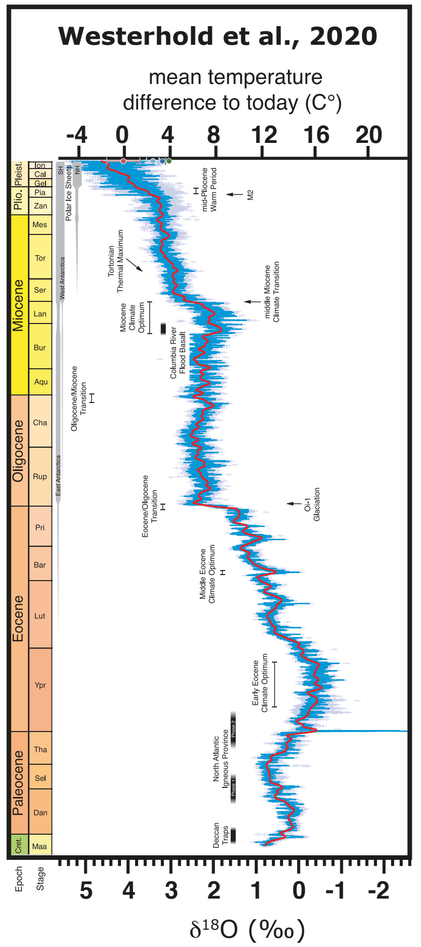
Measured *Unknown*

$$\delta^{18}O_{CaCO3} = \left(\frac{(\ ^{18}O/^{16}O\ )\ ech}{(\ ^{18}O/^{16}O\ )\ std} \right) - 1 \quad \times 1000$$



Marine environment

Planctonic & benthic foraminifera

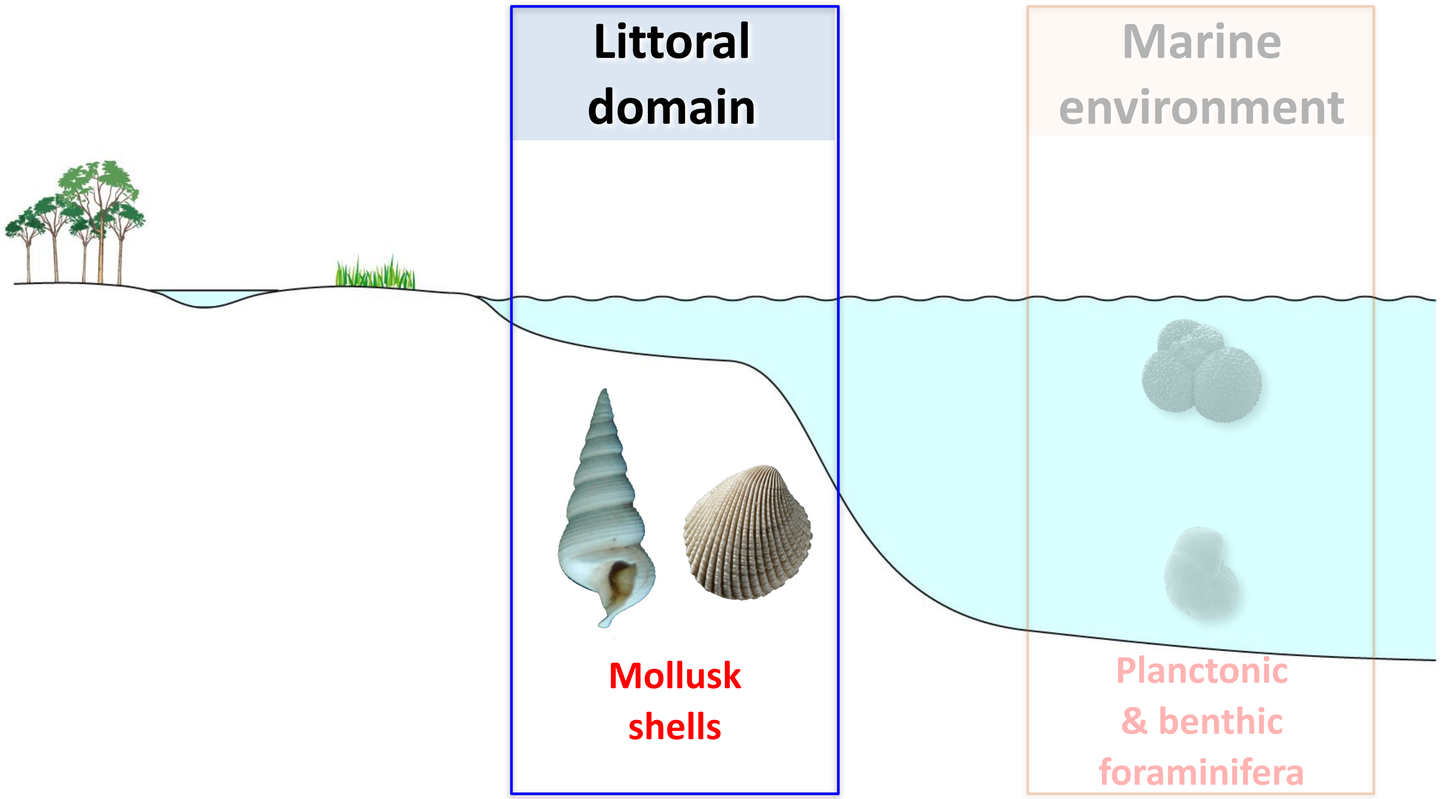


The Problem

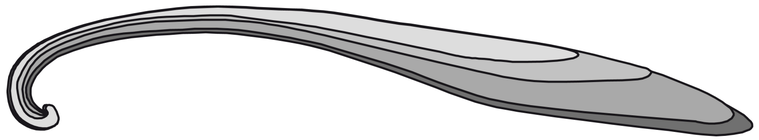
Paleoclimatic data from shallow water environments

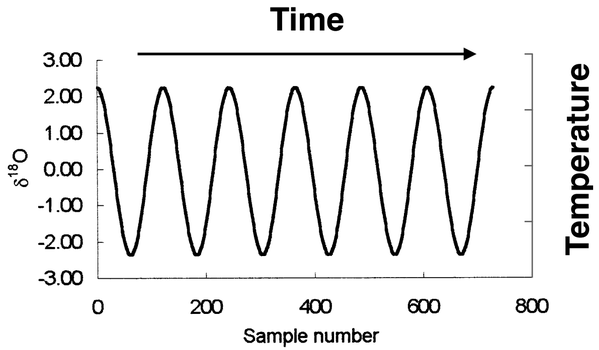
- More sensitive to **low amplitude climatic variations**
- Access to **seasonal temperature variations**

Continuous recording of the **seasonal temperature** variations



Mollusks





Goodwin et al., 2003

The Problem

Paleoclimatic data from shallow water environments

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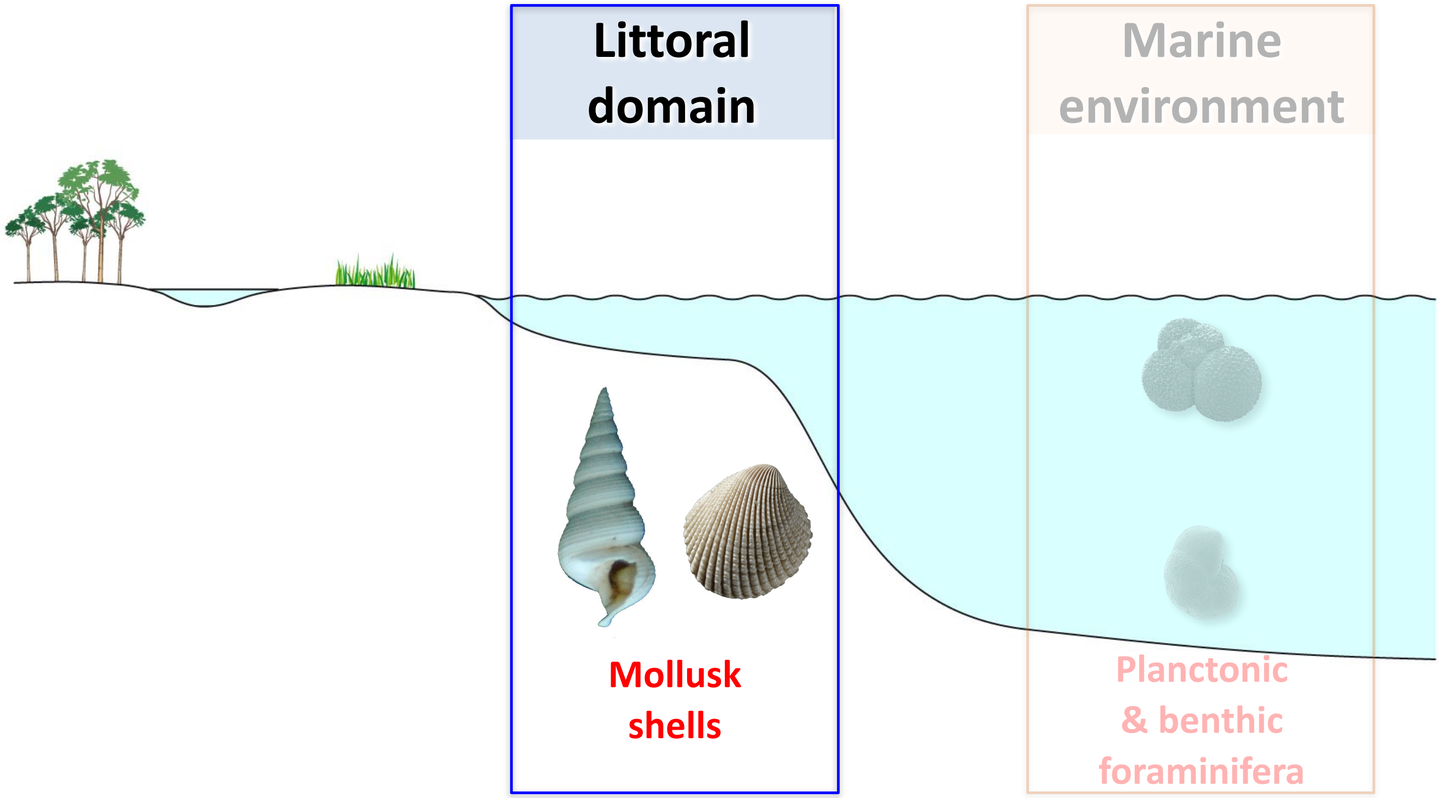
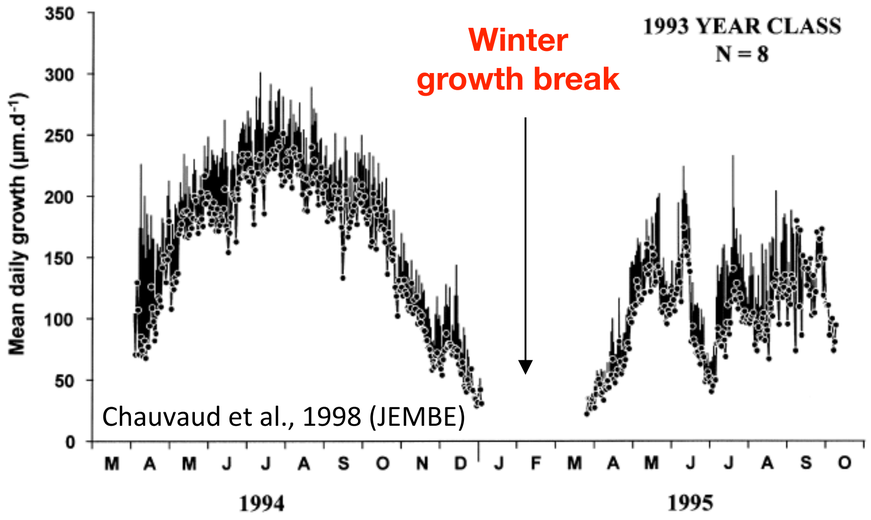
- Access to **seasonal temperature variations**



Winter growth break

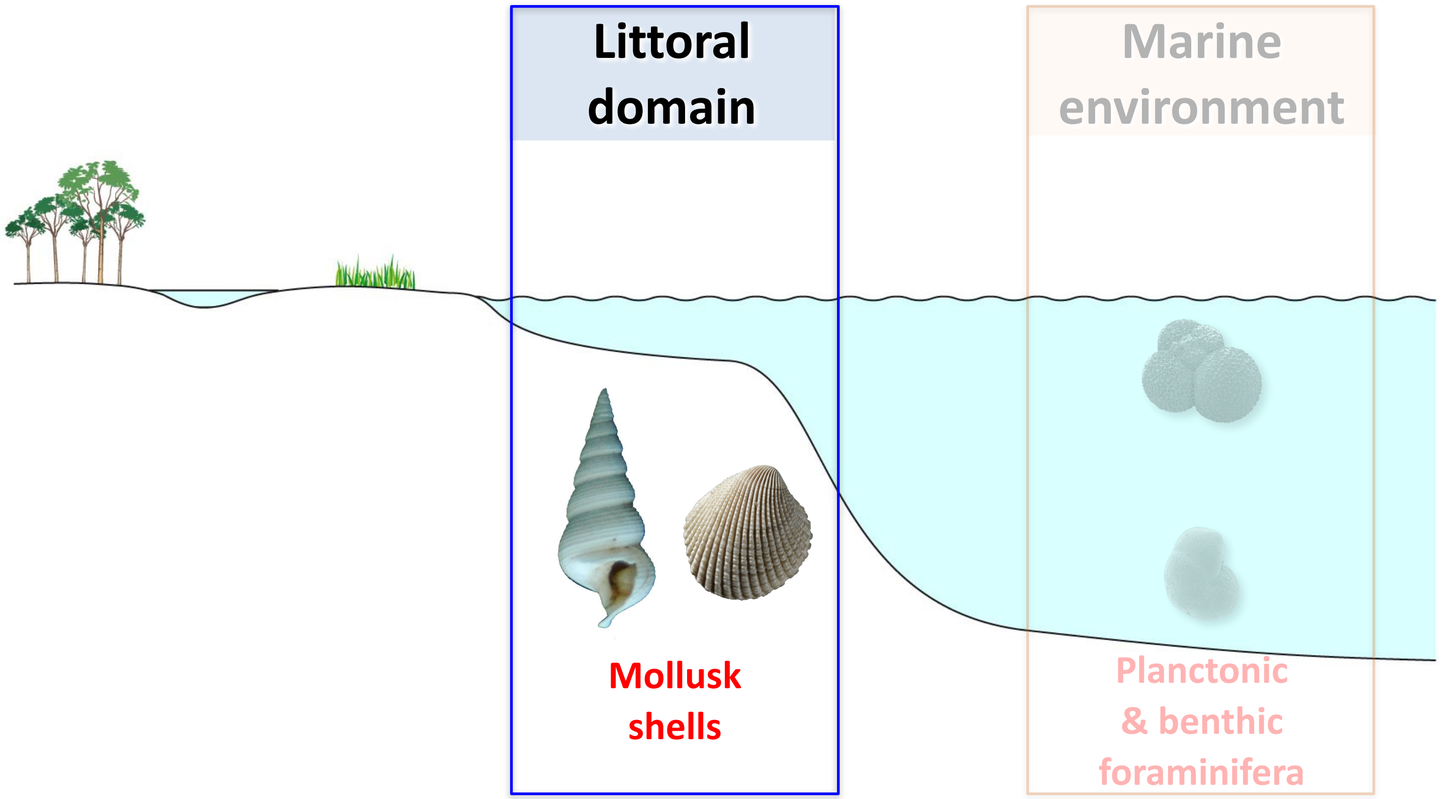


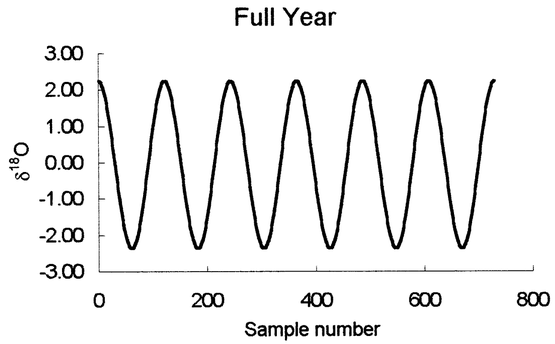
The Problem

Paleoclimatic data from shallow water environments

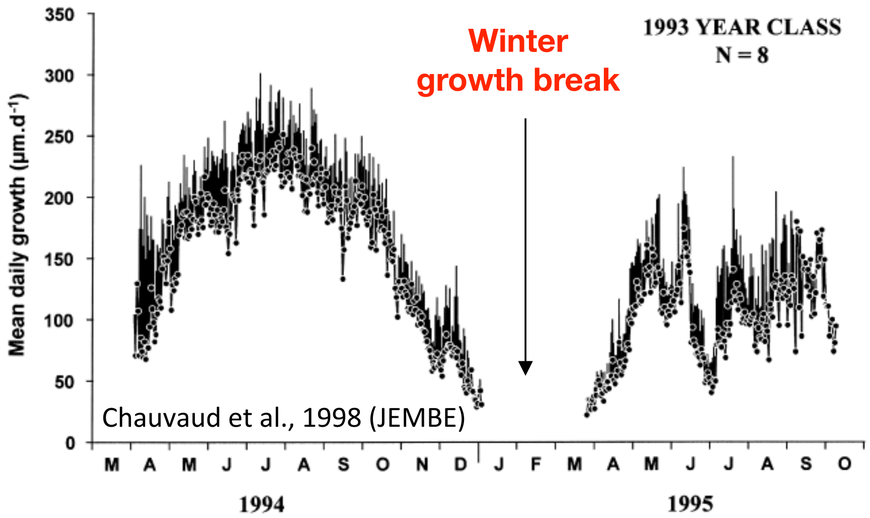
- More sensitive to l**ow amplitude climatic variations**
- Access to **seasonal temperature variations**

What do mollusc shells really record?





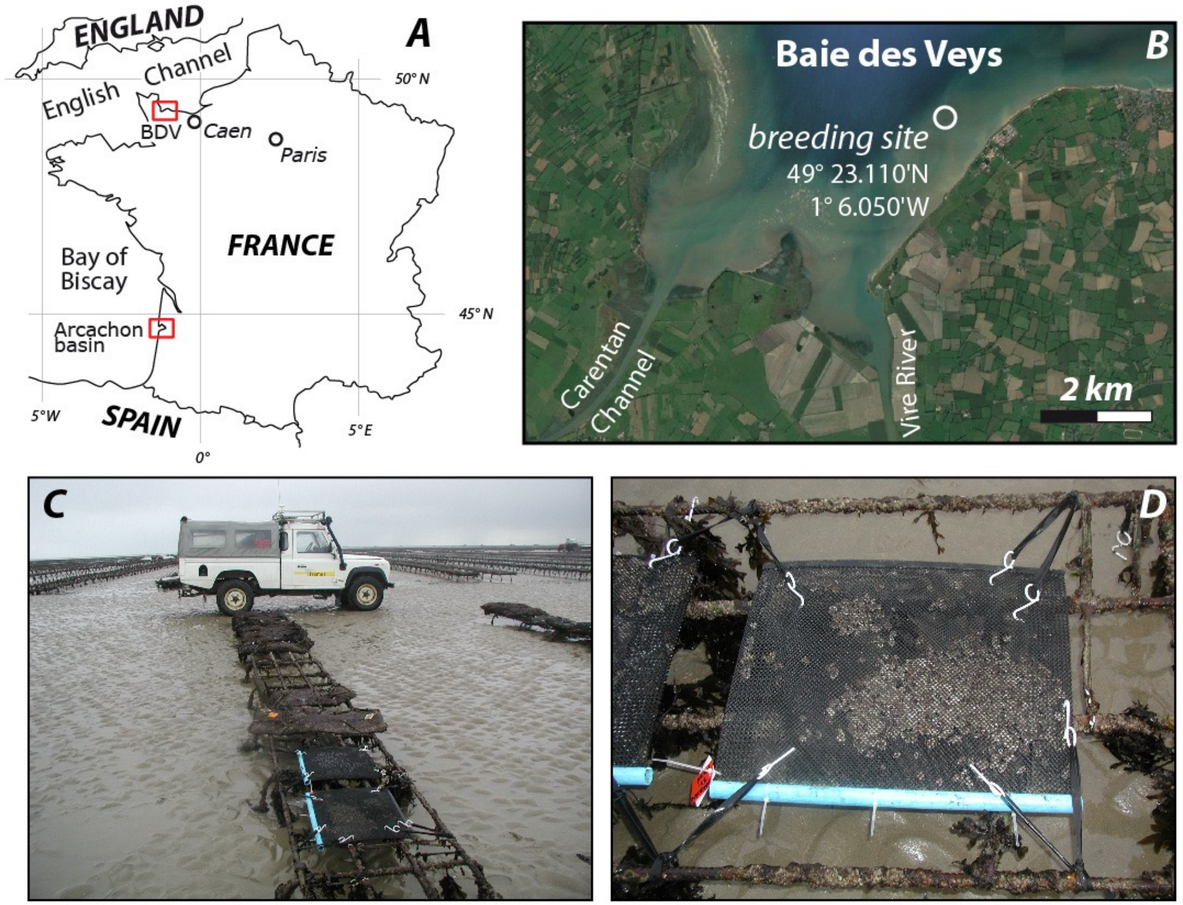
Goodwin et al., 2003



Chauvaud et al., 1998 (JEMBE)

Modern calibration

- **Oyster shells** bred in a farming site in Normandy

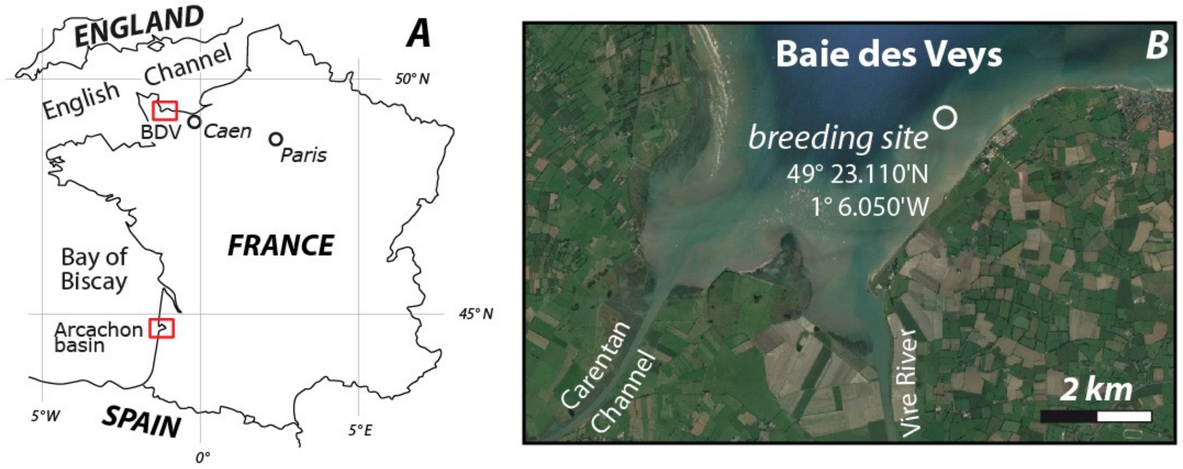


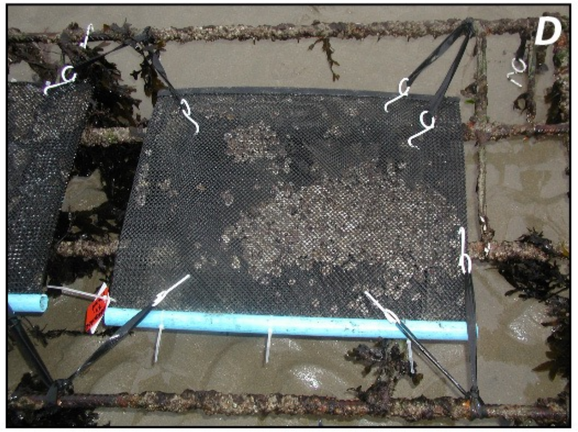
Maganalla gigas

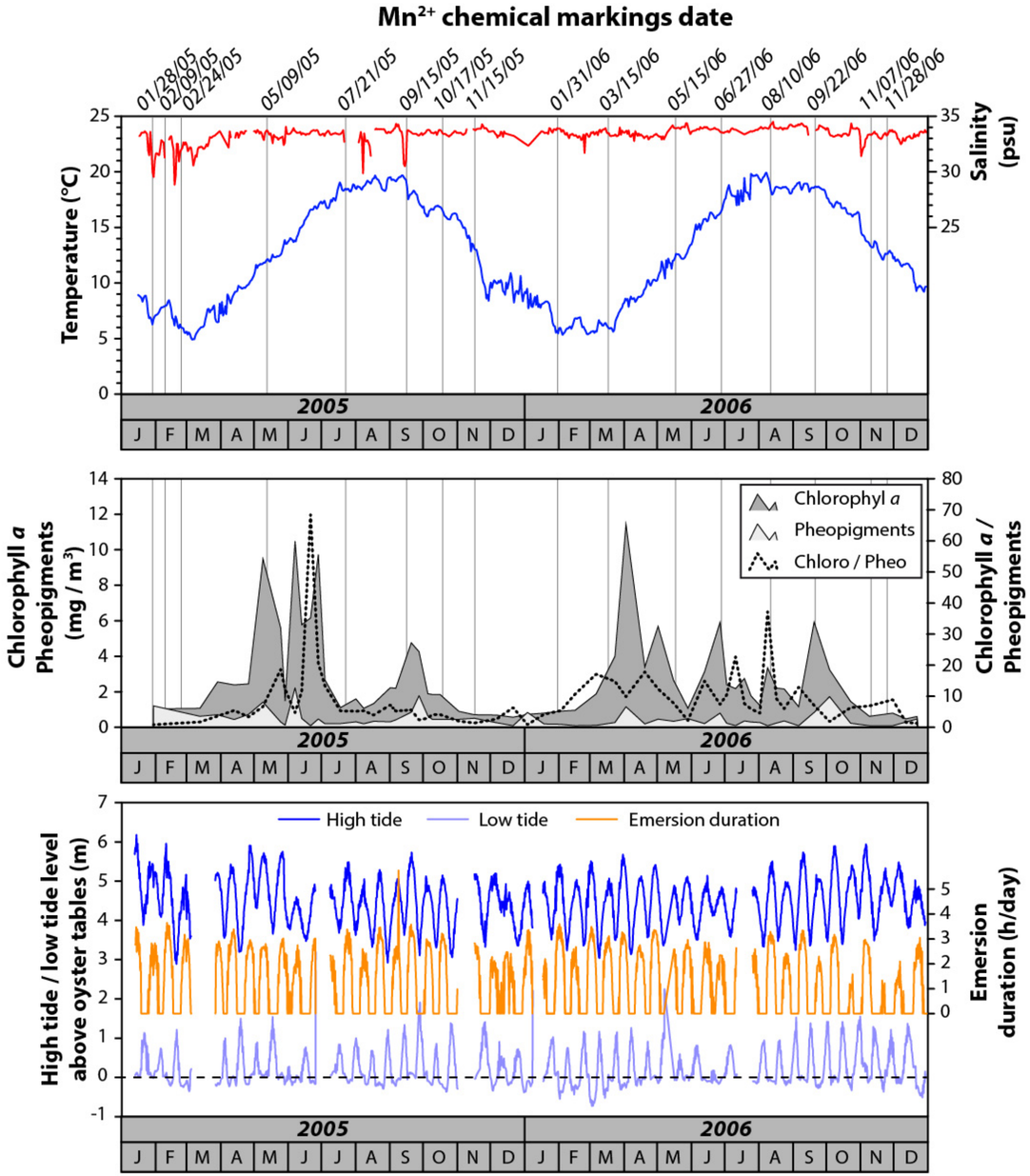
Huyghe et al., 2019, Marine Biology

Modern calibration

- **Oyster shells** bred in a farming site in Normandy
- High resolution recording of the **environmental parameters**



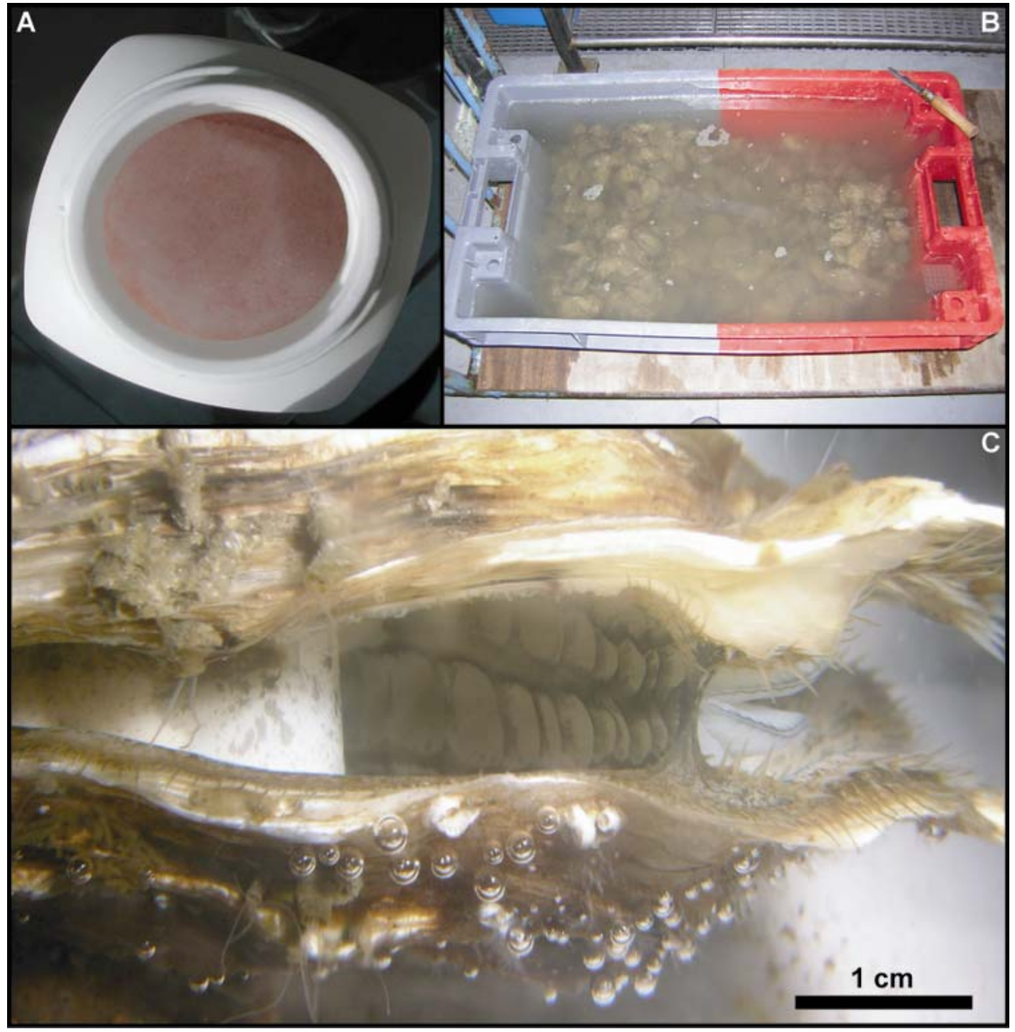




Huyghe et al., 2019, Marine Biology

Calibration sur le récent

Several in-vivo **Mn^{2+} chemical marking** of the shells



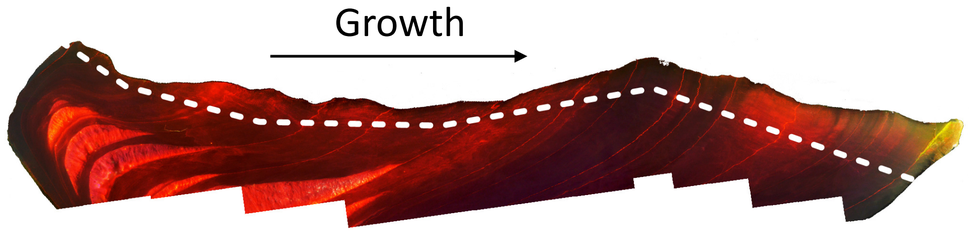
Lartaud et al., 2010, GML

Date	Historique	Marquages
août-04	Arcachon	
28/01/05	Marais	OK
01/02/05	BDV	
09/02/05	BDV	OK
24/02/05	BDV	OK
09/05/05	BDV	OK
21/07/05	BDV	OK
15/09/05	BDV	OK
17/10/05	BDV	OK
15/11/05	BDV	OK
31/01/06	BDV	OK
15/03/06	BDV	OK
15/05/06	BDV	OK
27/06/06	BDV	OK
10/08/06	BDV	OK
22/09/06	BDV	OK
07/11/06	BDV	OK
28/11/06	BDV	

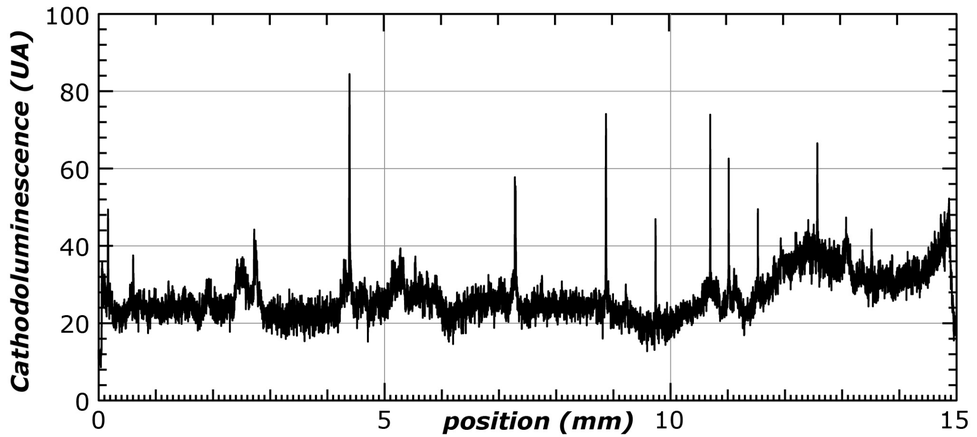
15 markings in 2 years

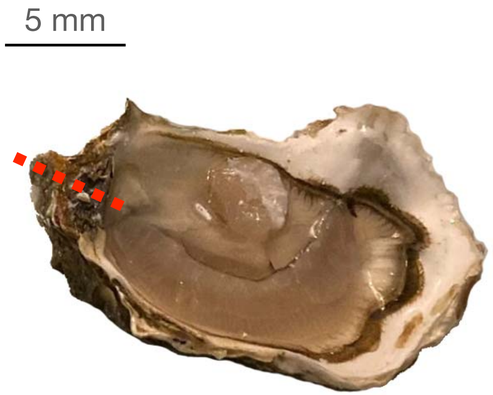
Modern calibration

Observation under
cathodoluminescence



Revelation of the **Mn^{2+}**
Chemical markings





Huyghe et al., 2019, Marine Biology

Modern calibration

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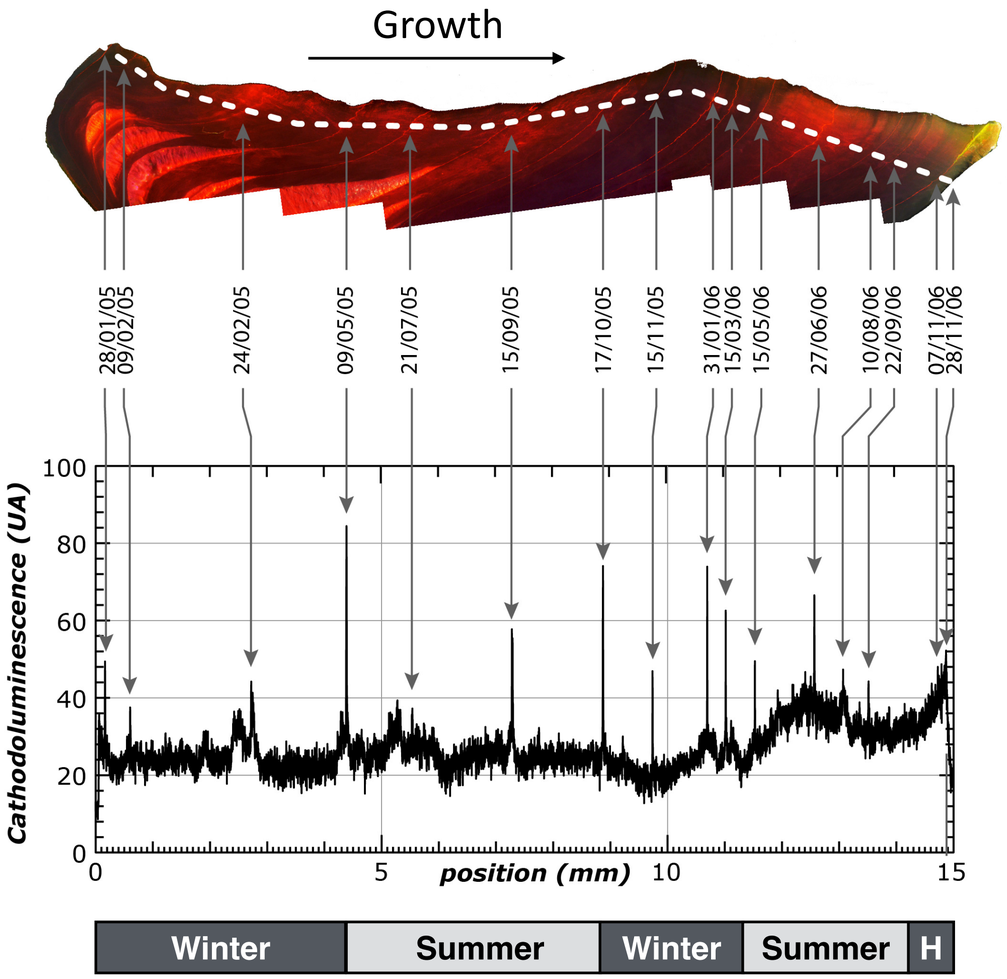
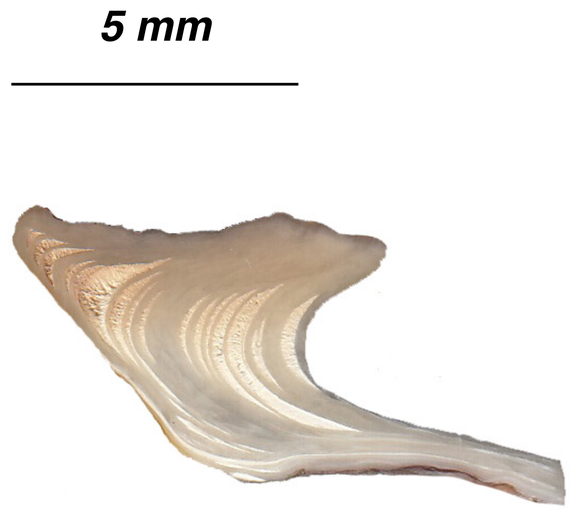
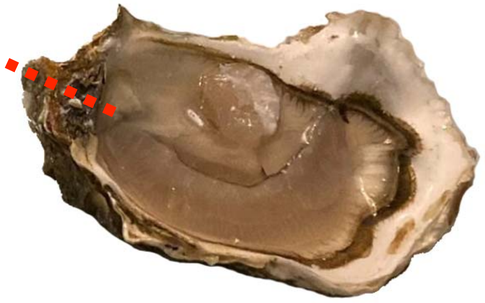


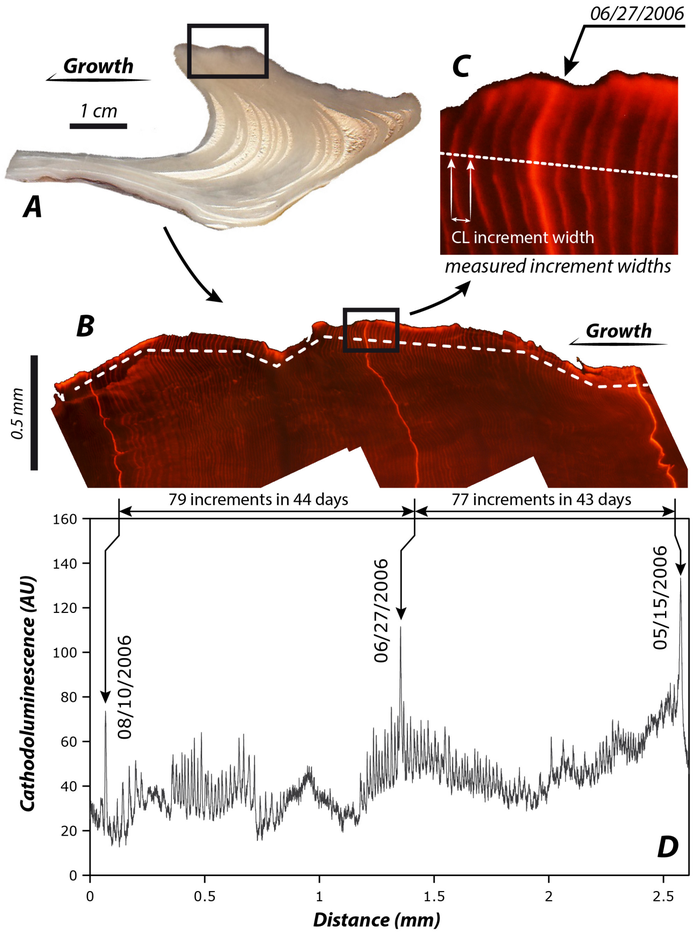
Huyghe et al., 2019, Marine Biology





Sclerochronology

- **Rythmicity** and **controlling** parameters of oyster shell growth



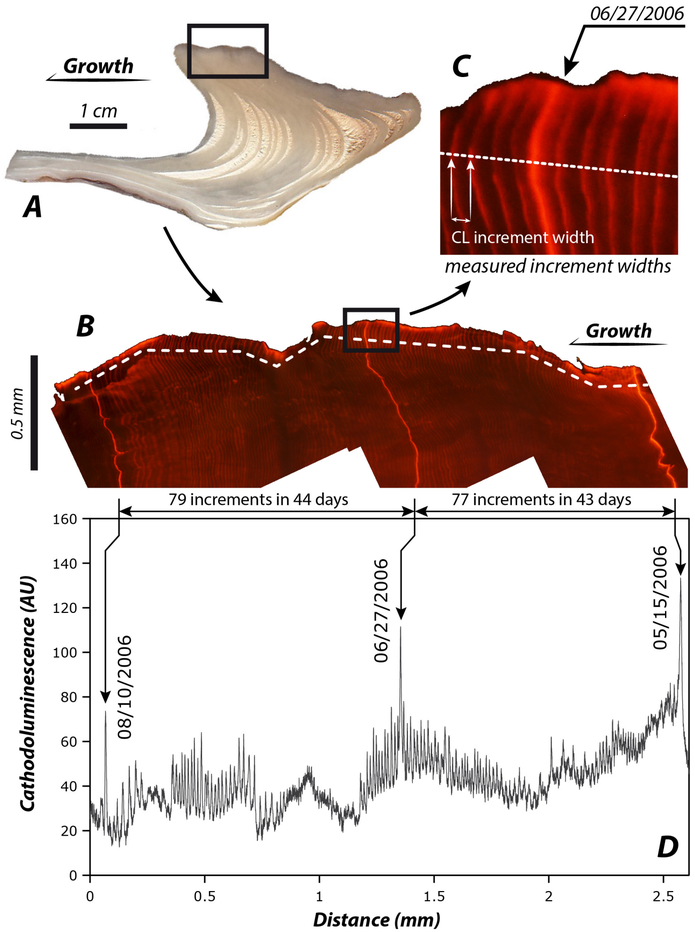
2 increments / day

Short-term ⟶ **tidal**

Huyghe et al., 2019, Marine Biology

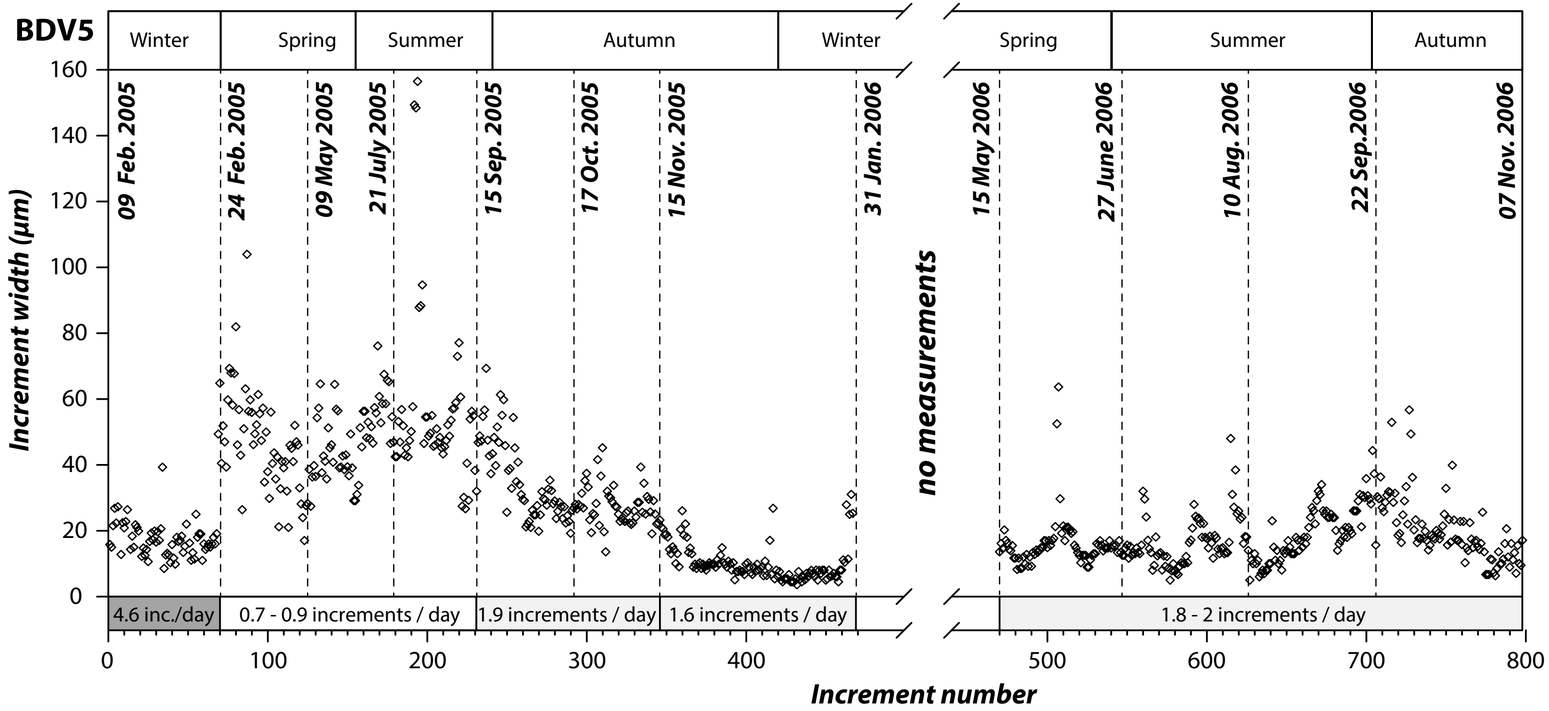
Sclerochronology

- **Rythmicity** and **controlling** parameters of oyster shell growth



2 increments / day

Short-term ⟶ **tidal**



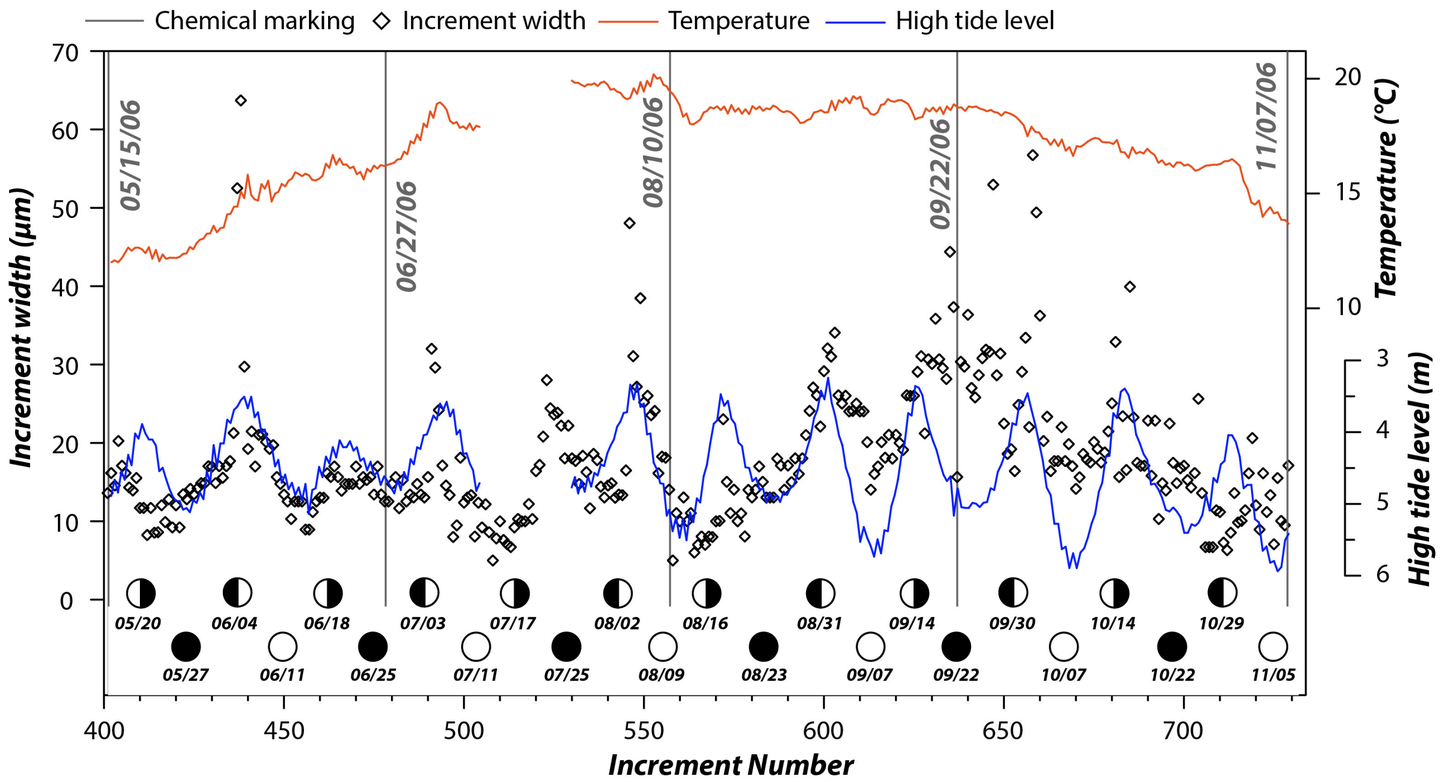
Huyghe et al., 2019, Marine Biology

Sclerochronology

- **Rythmicity** and **controlling** parameters of oyster shell growth

Periodic fluctuation of increment width

Medium-term ⟶ **Lunar**

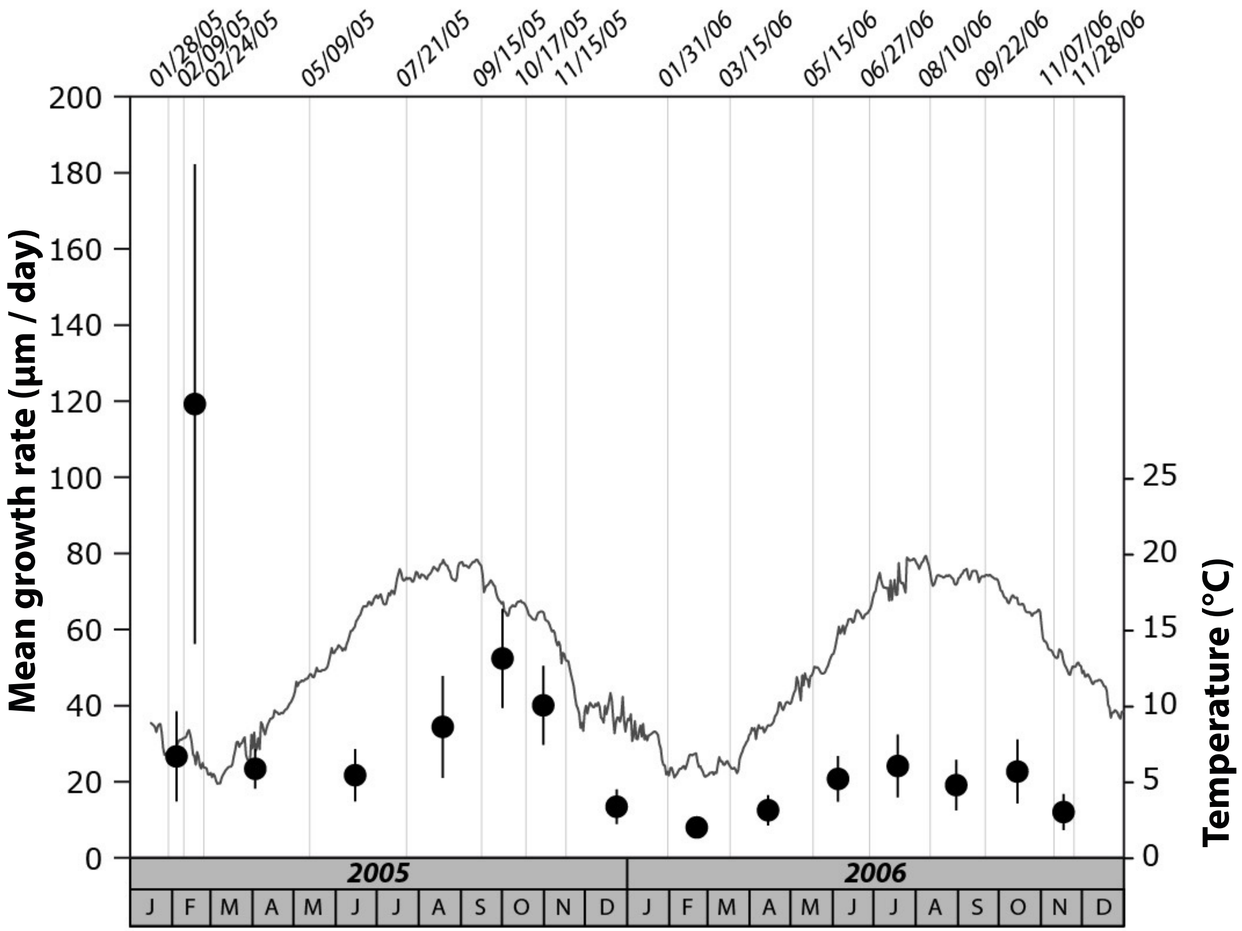


Huyghe et al., 2019, Marine Biology

Sclerochronology

- **Rythmicity** and **controlling** parameters of oyster shell growth

long-term → **temperature**



Huyghe et al., 2019, Marine Biology

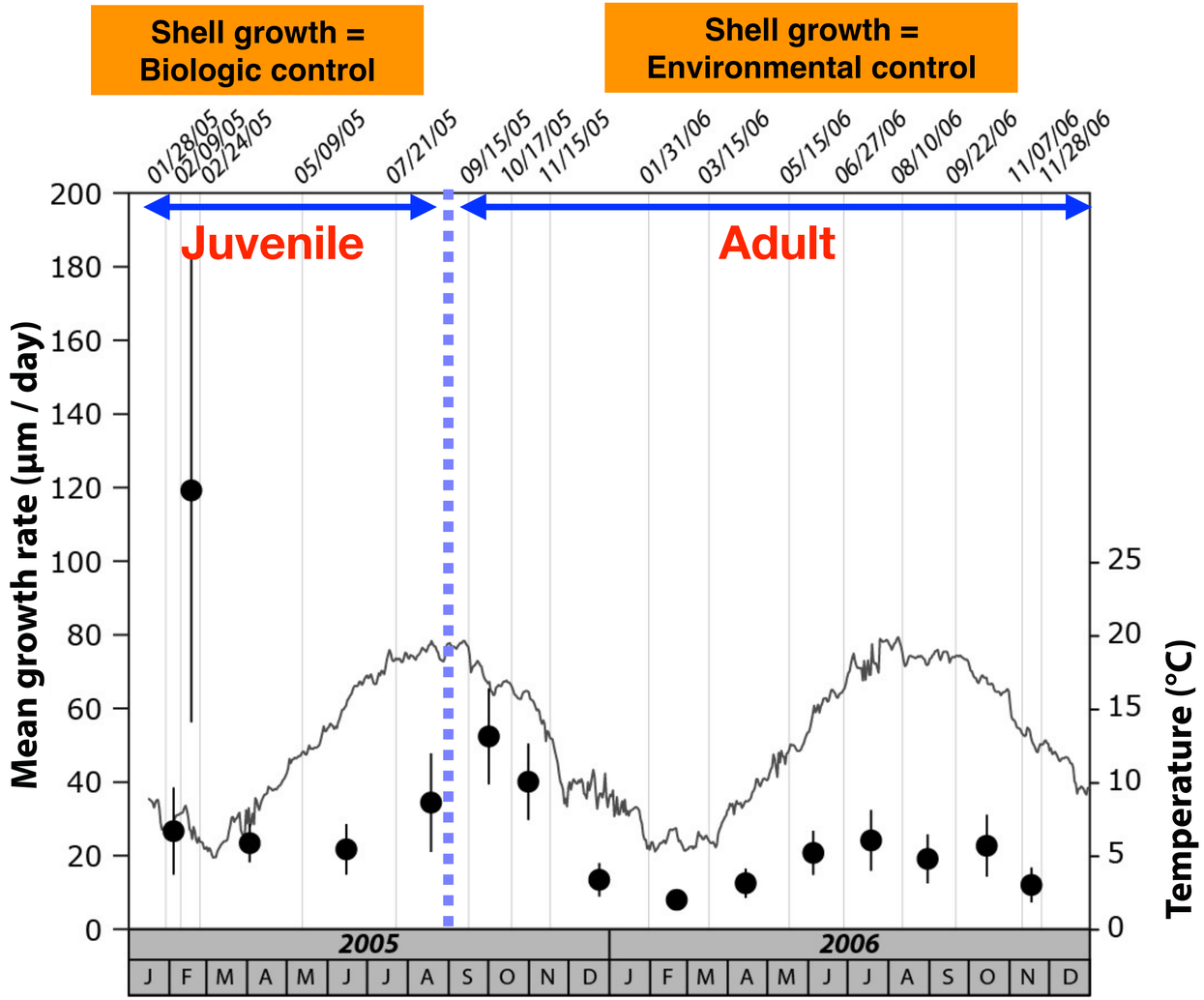
Sclerochronology

- **Rythmicity** and **controlling** parameters of oyster shell growth

long-term → **temperature**

Medium-term → **lunar**

Short-term → **tidal**



Huyghe et al., 2019, Marine Biology

Huyghe et al., 2019, Marine Biology

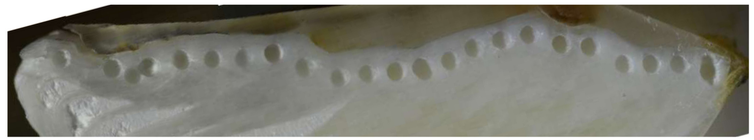
- **Implications for temperature reconstruction**

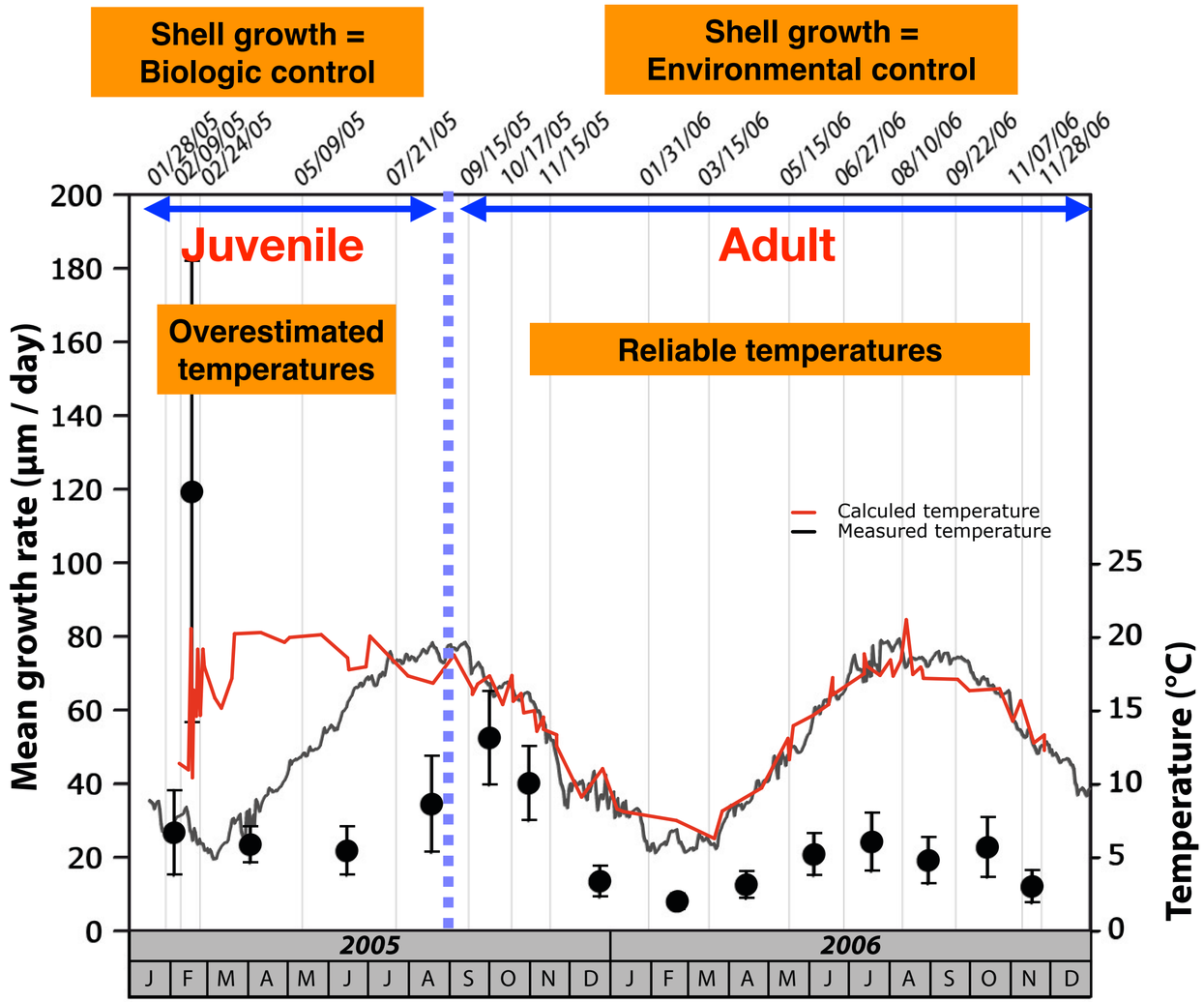
Stable isotopes data

✓ Reliable temperatures calculated for **adults**

✗ Overstimated températures for the **juvenile** part

→ **Kinetic and biologic control on the isotopic composition of oyster shells**





Huyghe et al., 2020, ECSS

- **Uncertainty : $\delta^{18}O_w$ unknown in the past**

- **$\delta^{18}O$ of the carbonates**

$\delta^{18}O_{CaCO3}$ = f ($\delta^{18}O_{water}$ & T_{water})

measured *unknown*

- **Δ_{47} of the carbonates**

Δ_{47} = f (T_{water})

measured *unknown*

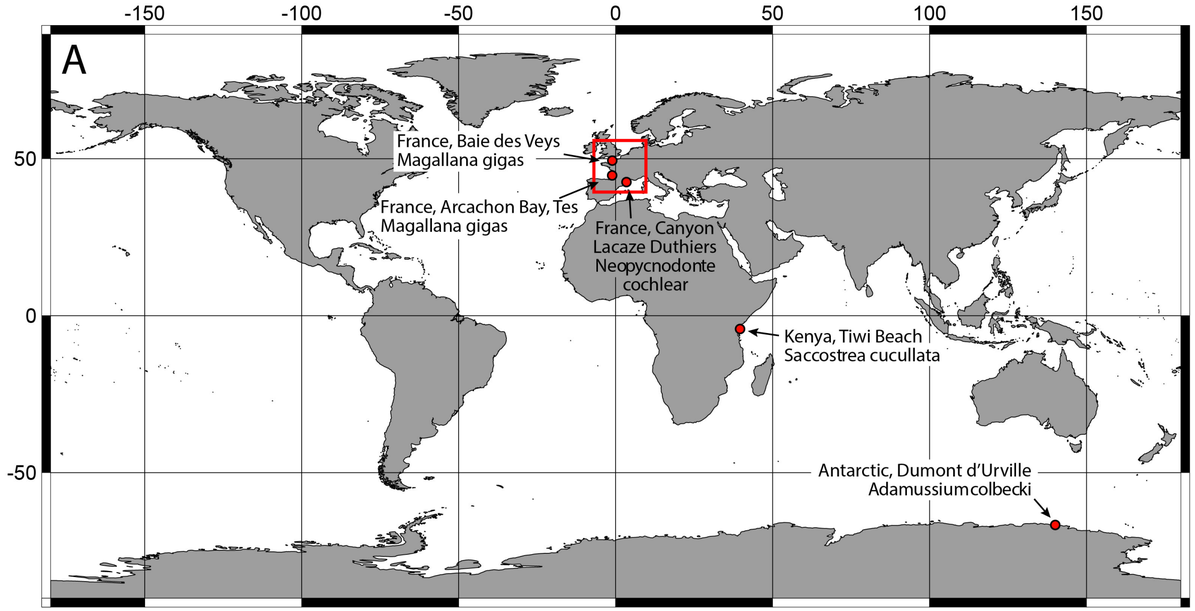
Magallana gigas

Cubitostrea plicata

Ostrea bellovacina

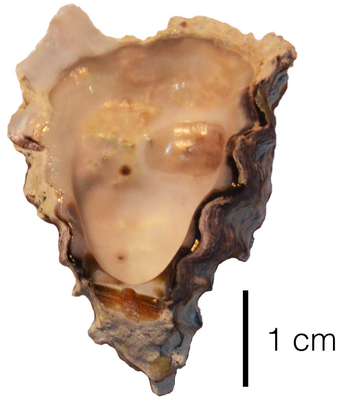
Geochemistry: the Δ_{47}

Neopycnodonte cochlear



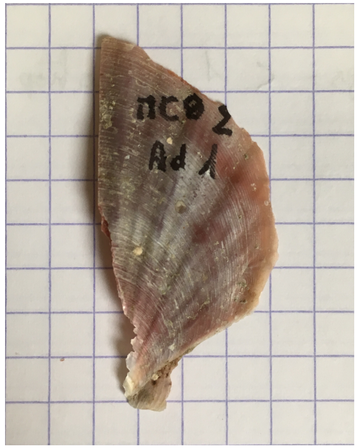
Huyghe et al., 2022, GCA

Saccostrea cucullata



MAT : 26.8 +/- 0.85°C

Adamussium colbecki

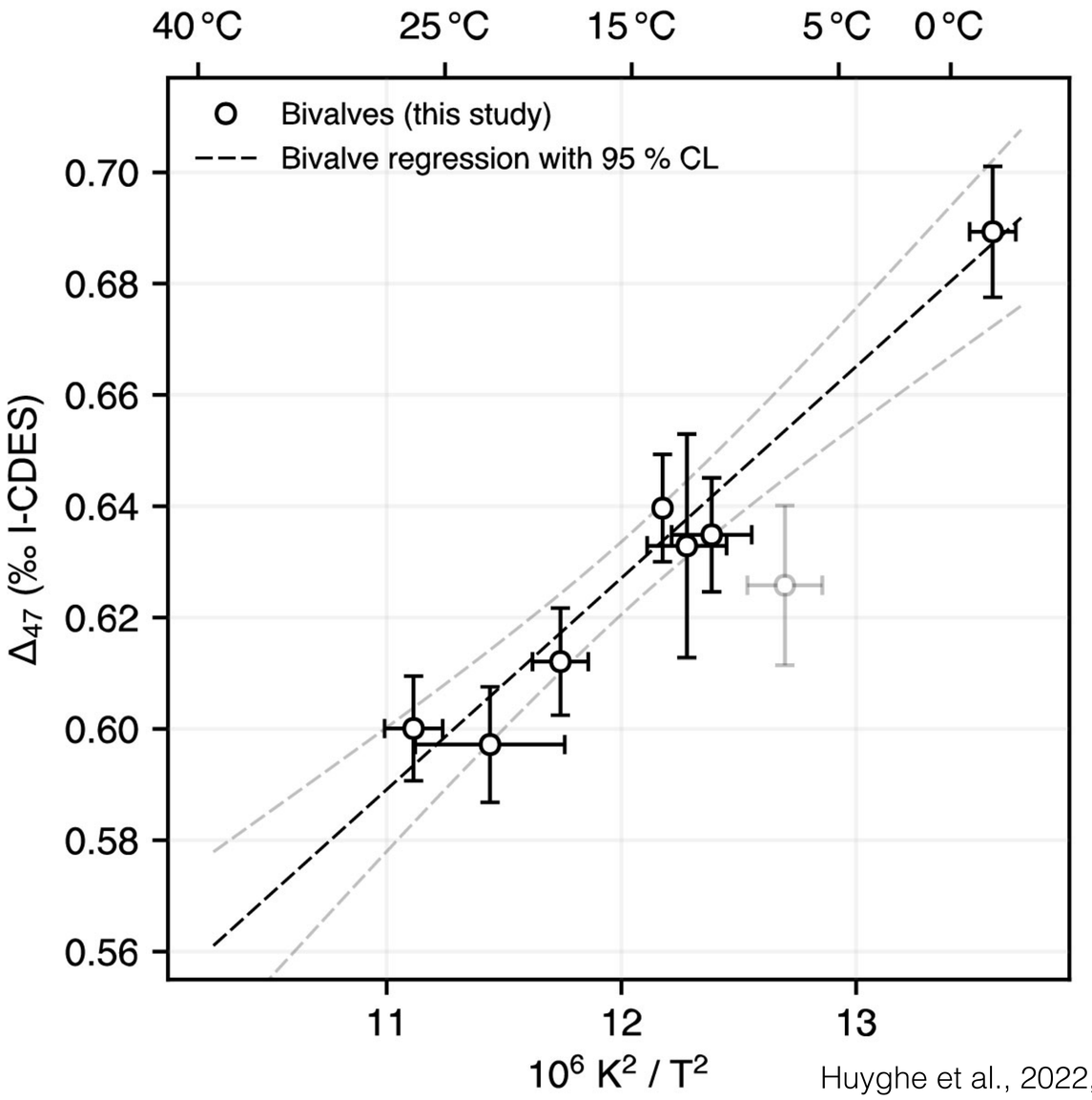


MAT : -1.7 +/- 0.5°C

Magallana gigas

Arcachon	Normandie
Mean summer temperature : 22,5 ± 2.1°C	Température estivale moyenne mesurée : 18.7 ± 0.2°C
Température hivernale moyenne mesurée : 7.4 ± 1.3 °C	Température hivernale moyenne mesurée : 8 ± 0.4 °C

Geochemistry: the Δ_{47}



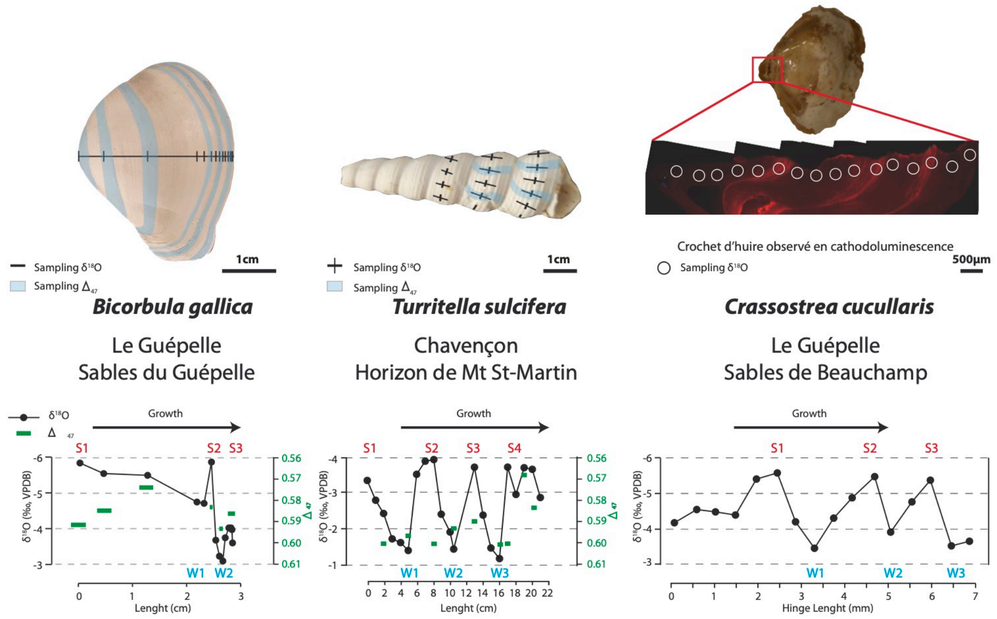
Huyghe et al., 2022, GCA

✓ Good correlation **Δ_{47} / Temperature**

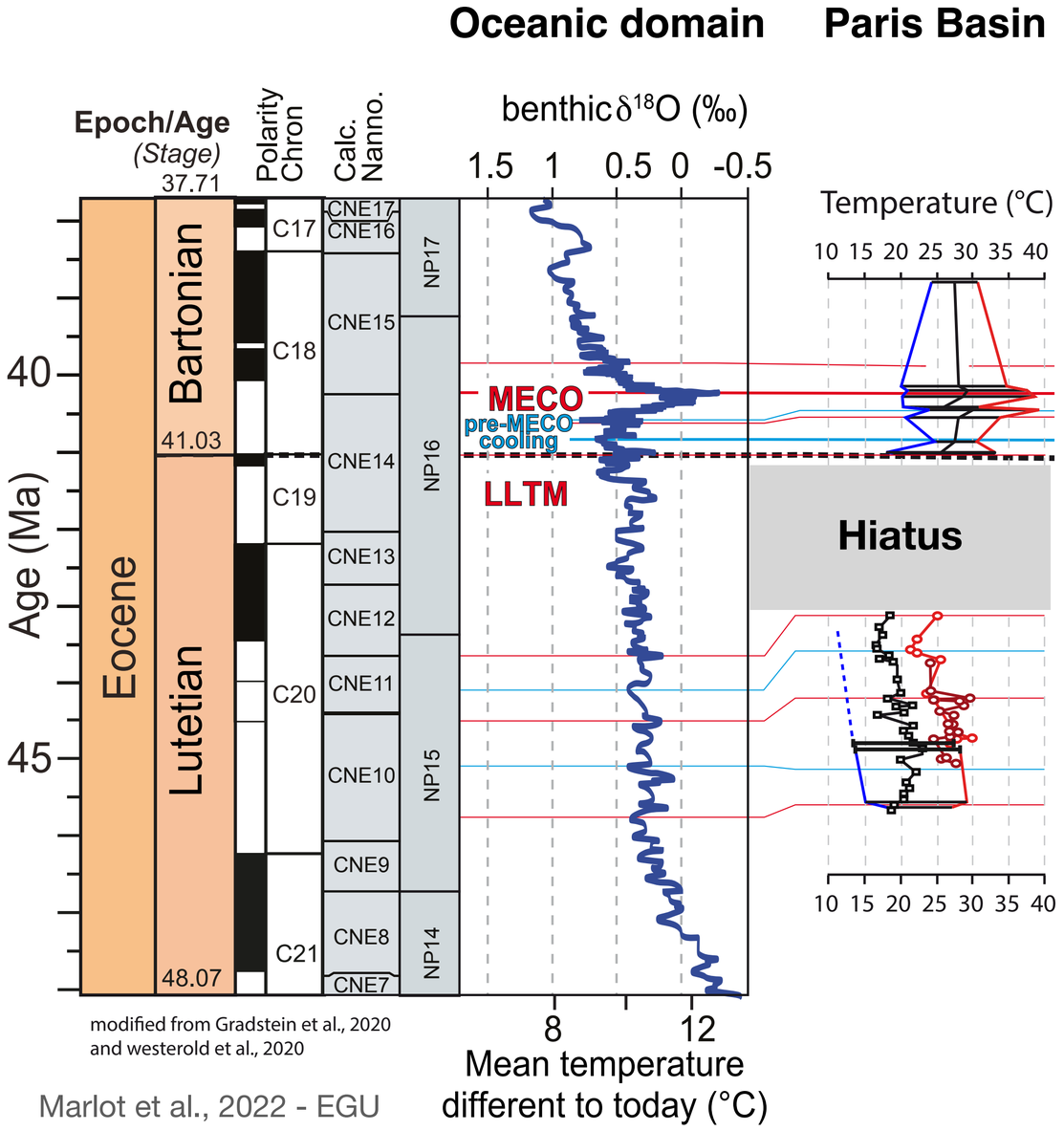
✓ **Seasonal scale** calibration

✗ Juvenile part → **Isotopic fractionation**

Application to the past : the Bartonian of the Paris Basin



- Summer temperature **~ 37 °C**
- Winter temperature **~ 20 °C**
- Increase of the **seasonal gradient of temperature**



Marlot et al., 2022 - EGU

Conclusions

- Oyster shells growth obeys to: **- Tidal** cycles
  - Lunar
  - Seasonal

- Oyster mineralize their shell **all along the year**

- **Seasonal variations of temperature** can be reconstructed from **$\delta^{18}O$** and **Δ_{47}** measurements of oyster shells

- The **juvenile phase** follows biological control factors inducing **isotopic fractionation**