Can physiological biomarkers provide new insights to understand growth variations in the European sardine?

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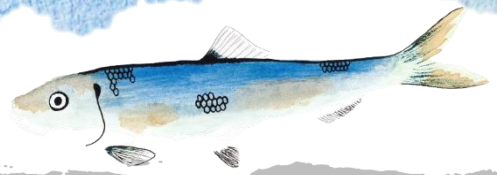
Small Pelagic Fish Symposium, May 2026

Réjane Janon

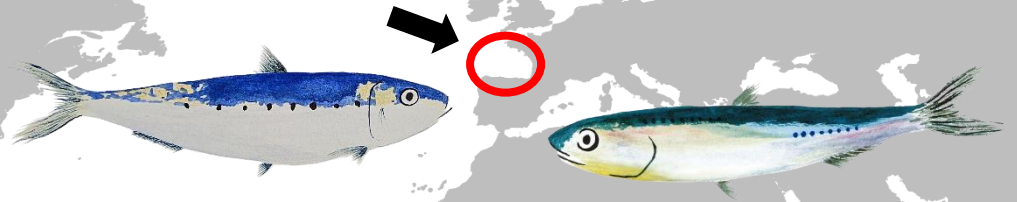
Decline in size-at-age in several small pelagic fish populations



Pacific herring (*Hay, 2019*)
-15% in 25 years

Atlantic mackerel (*Olafsdottir, 2016*)
-10% in 11 years

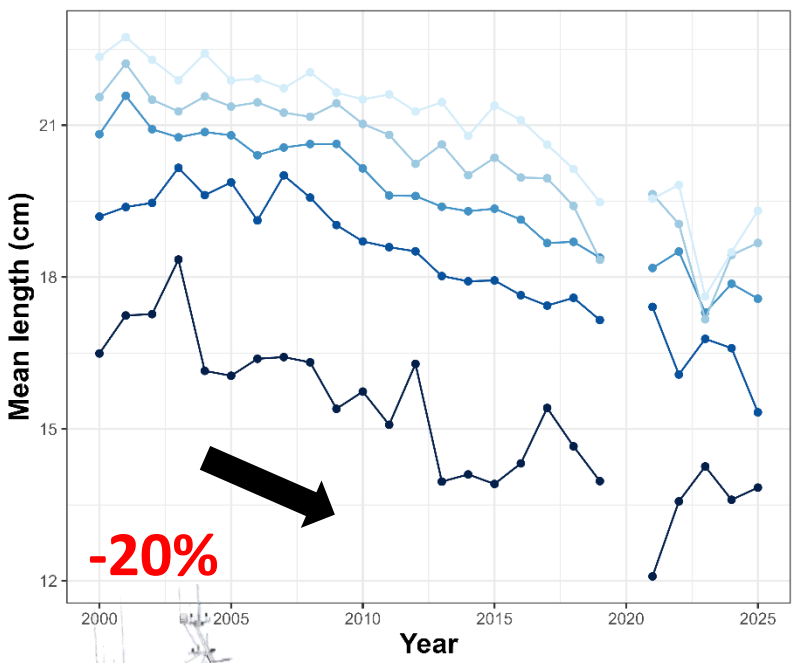
Chub mackerel (*Kamimura, 2021*)
-20% in 10 years

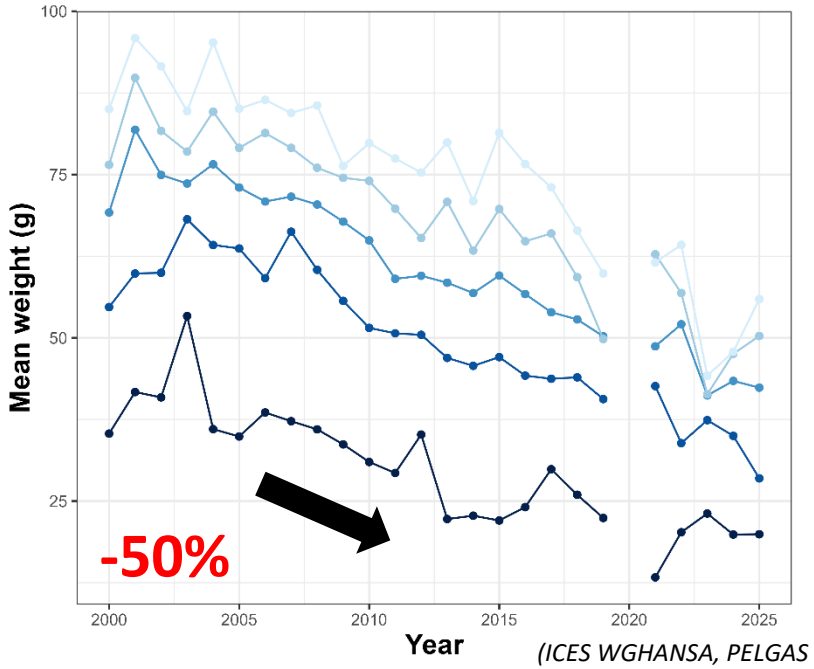


Sardine and Anchovy (*Doray, 2018; Saraux, 2019; Albo-Puigserver, 2021*)
Sardine -30% in 8 years

Anchovy (*Canales, 2018*)
-2 cm in 15 years

Sardine size-at-age declines in the Bay of Biscay

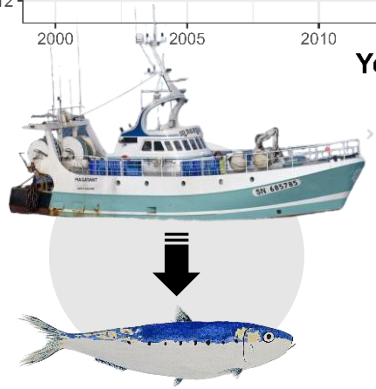




Age
1
2
3
4
5

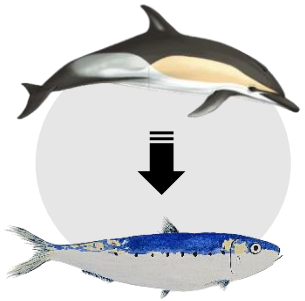
(ICES WGHANSA, PELGAS survey)

Why?



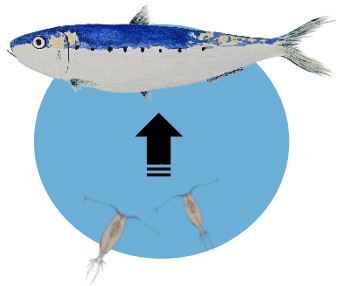
Fisheries-induced selection

Moderate fishing pressure and sardine's **size declines** started **before** F increase *(Boëns, 2023)*



Top-down control

No sign of **increased** predator **abundance** and **rejected in other areas** *(Saraux, 2019)*



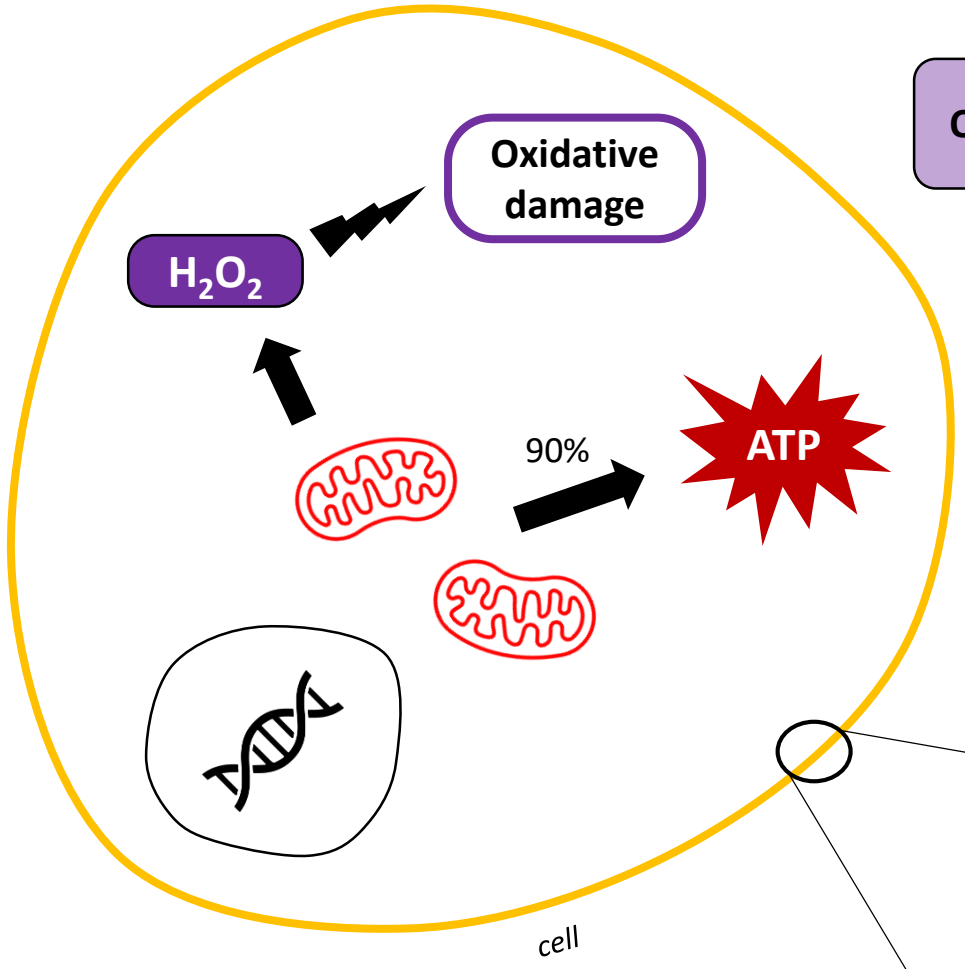
Bottom-up control

Decline in **zooplankton** mean **size** suggesting lower food quality *(Menu, 2023; Grandrémy, 2023)*

How?

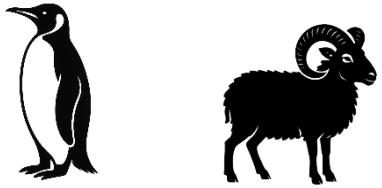
What **physiological mechanisms** can **link environmental** variability with **changes** in **size-at-age**?

Objective: Which physiological traits are associated with size-at-age variations in sardine?



Oxidative damage

+



(Geiger, 2012; Christensen, 2016; Smith, 2016)

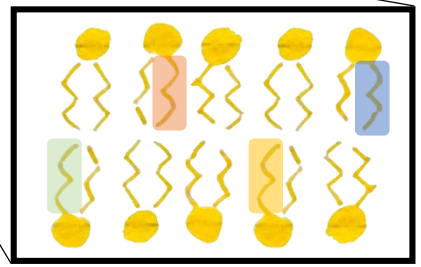
Mitochondrial efficiency

+

(Salin, 2019; Thoral, 2021; Dawson, 2022)

G R O W T H

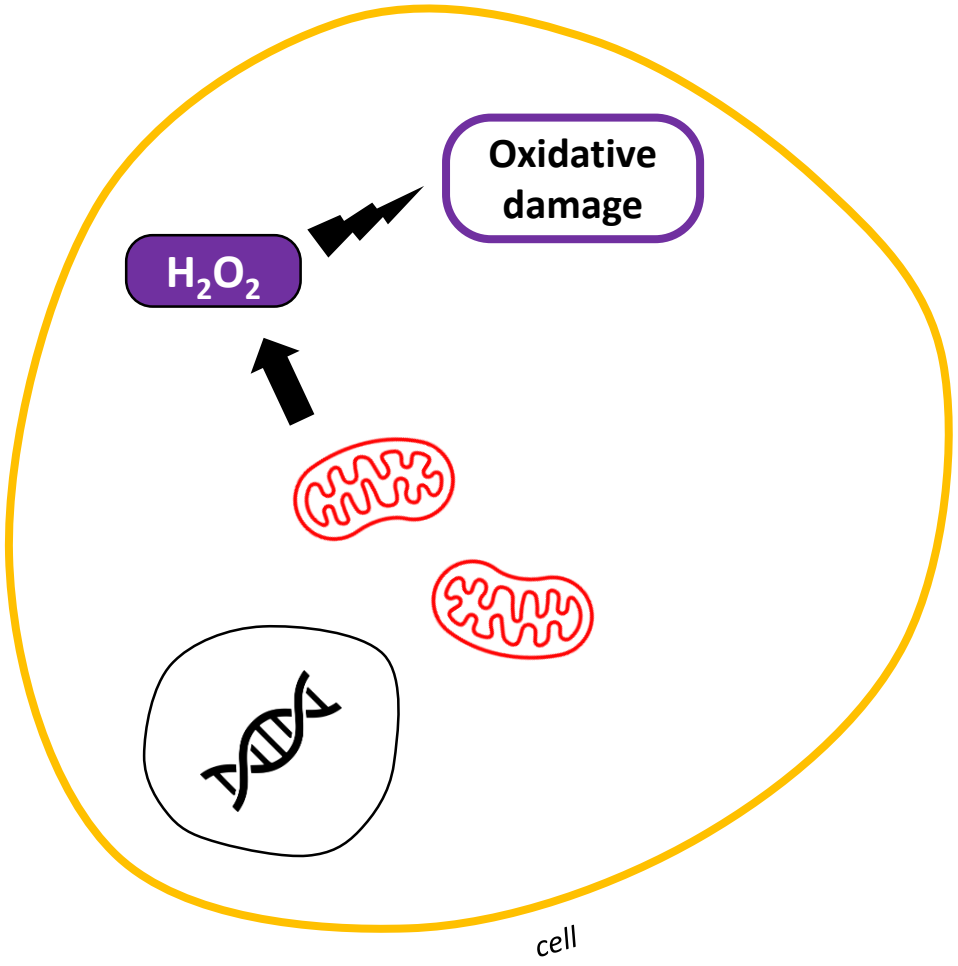
+



Membrane fatty acid composition

(Mathieu-Resuge, 2024; Bertrand, 2024; Péron, 2025)

Does larger sardines accumulate more oxidative damage?



Oxidative damage

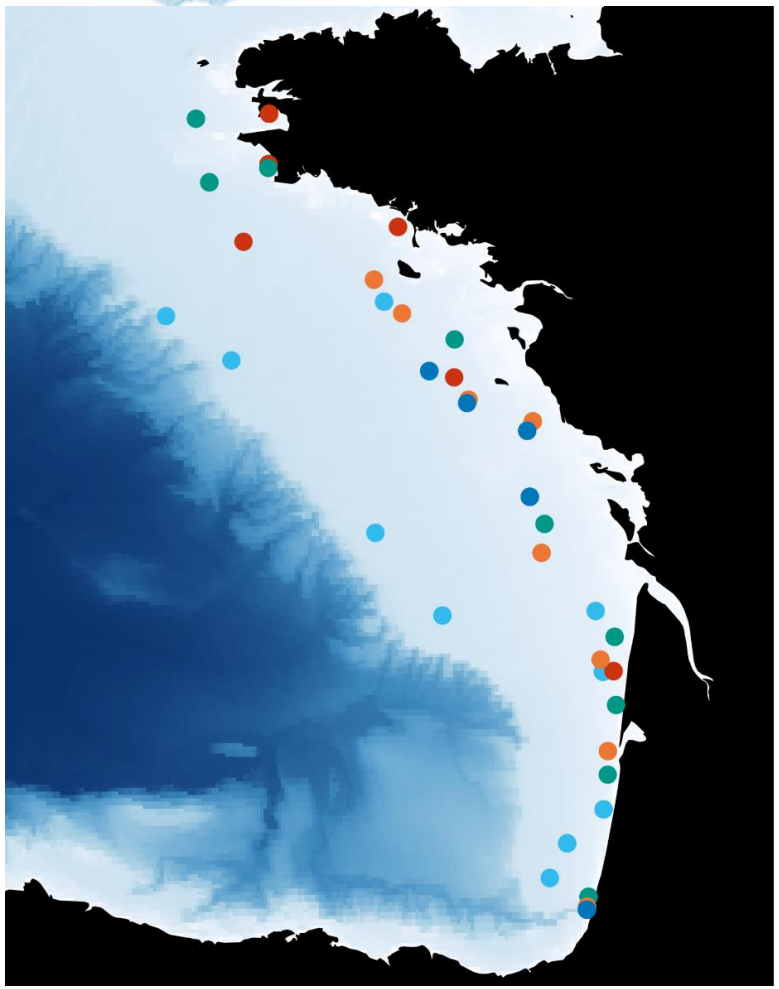
?

+

Oxidative damage < Oxidative damage + Oxidative damage

Size–at–age

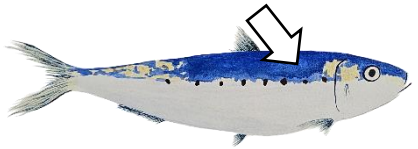
Does larger sardines accumulate more oxidative damage?

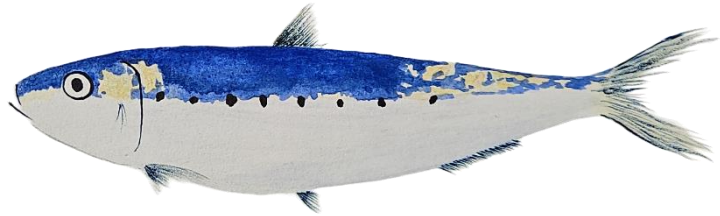


Survey

- EVHOE 2020
- EVHOE 2021
- PELGAS 2021
- PELGAS 2022
- PELGAS 2023

1-yr-old



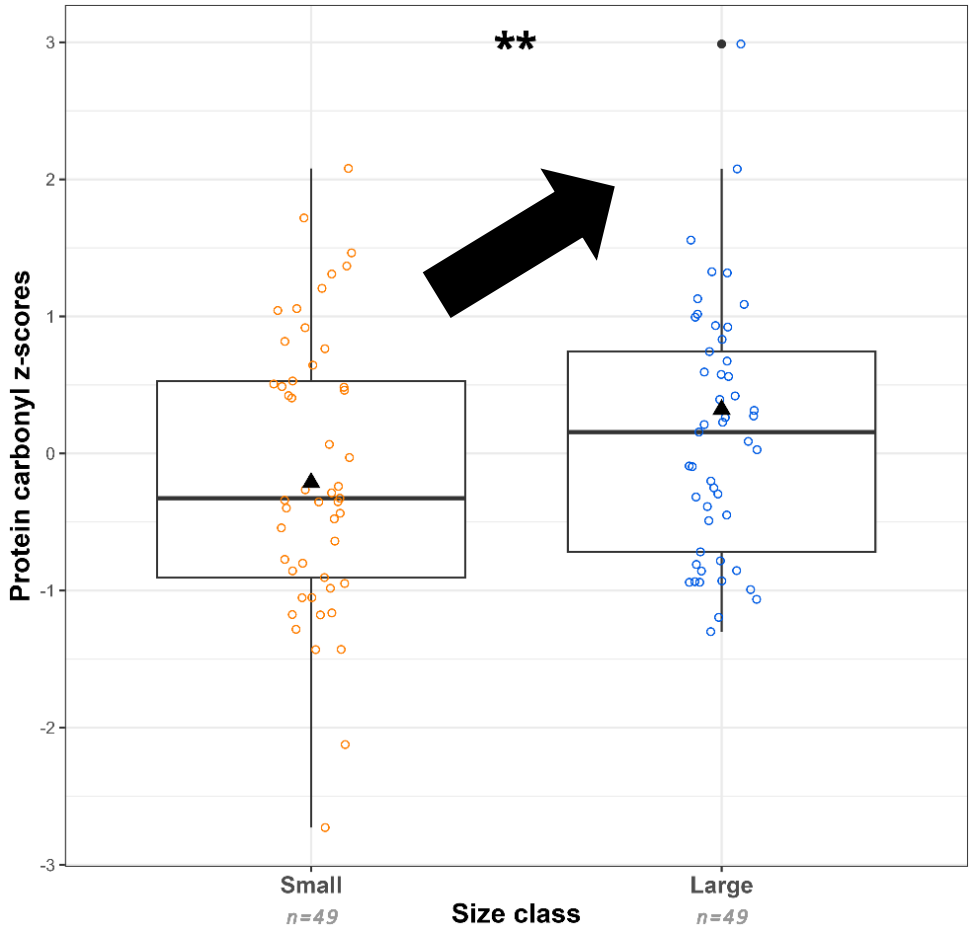


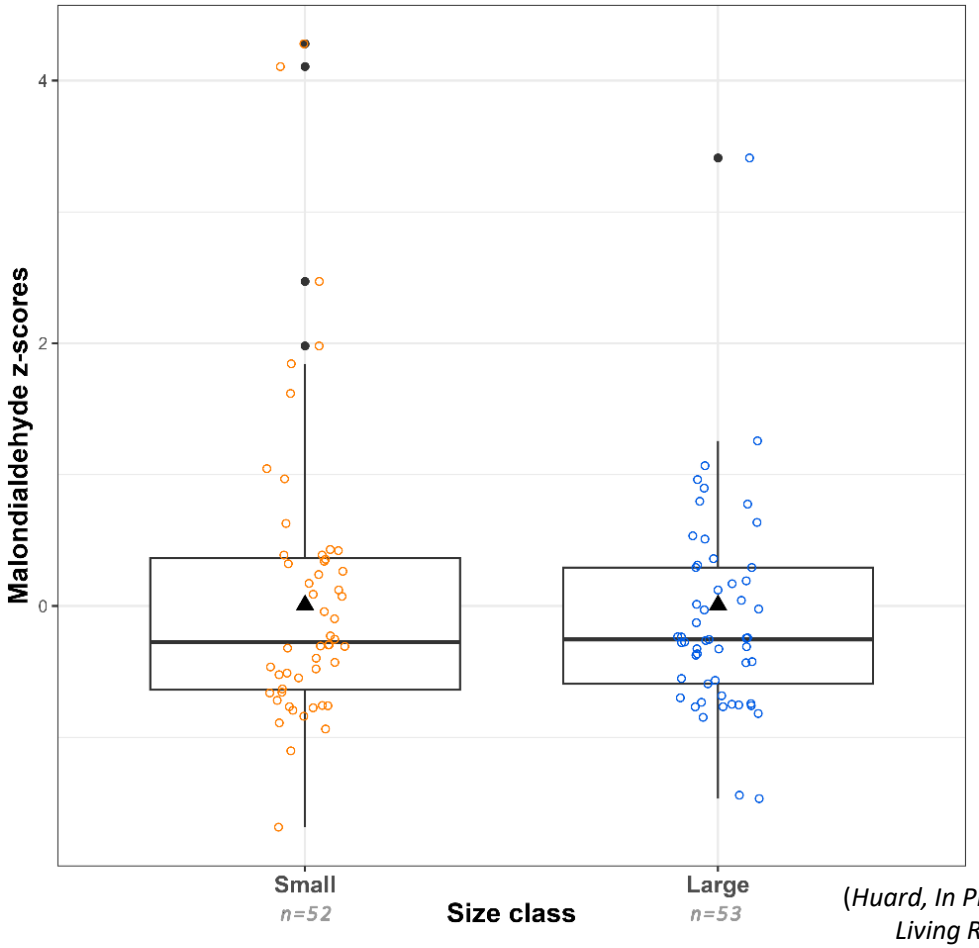
‘Small’ ‘Large’

Protein carbonyl *Malondialdehyde*

Oxidative damage assays

Larger sardines have higher levels of protein carbonyl



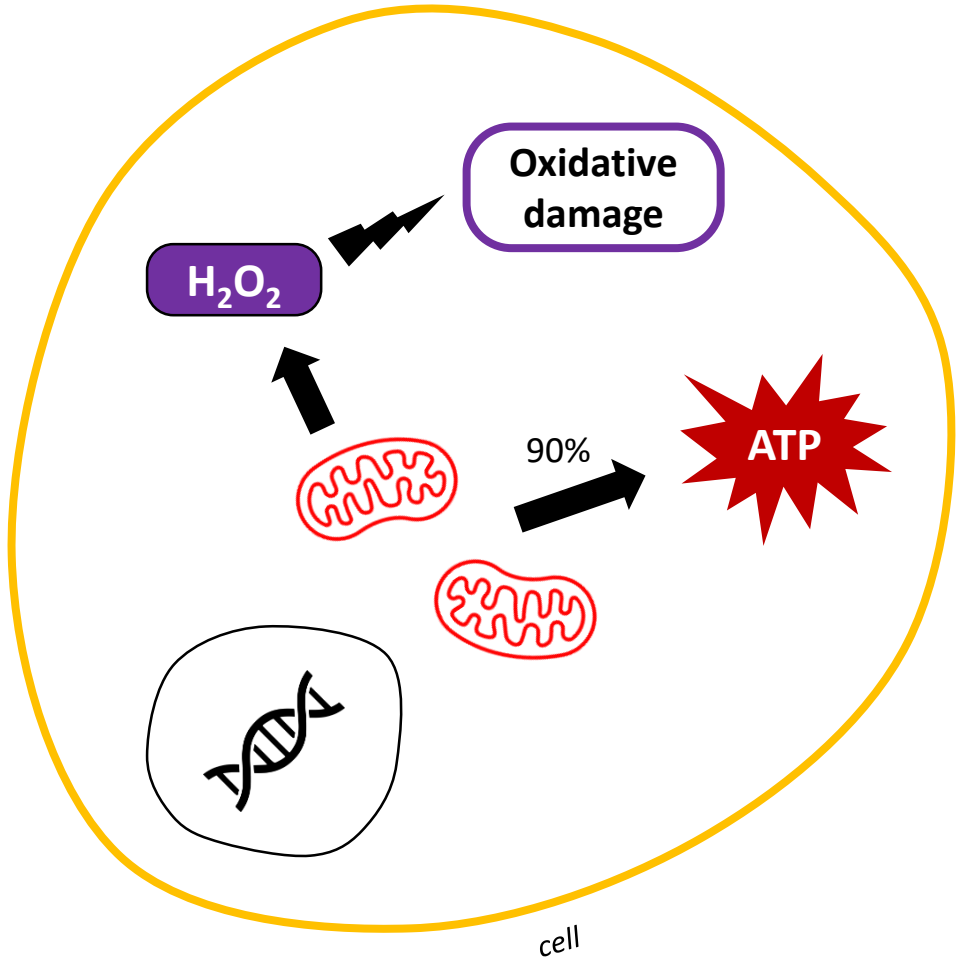


(*Huard, In Press in Aquatic Living Resources*)

→ **Higher** levels of **protein carbonyl** in **larger individuals**

→ **No difference** in **malondialdehyde** content between **size** classes

Does larger sardines have more efficient mitochondria?



Oxidative damage

Protein carbonyl < Protein carbonyl, Protein carbonyl, Protein carbonyl

\+

Mitochondrial efficiency → ? → Size-at-age

\+

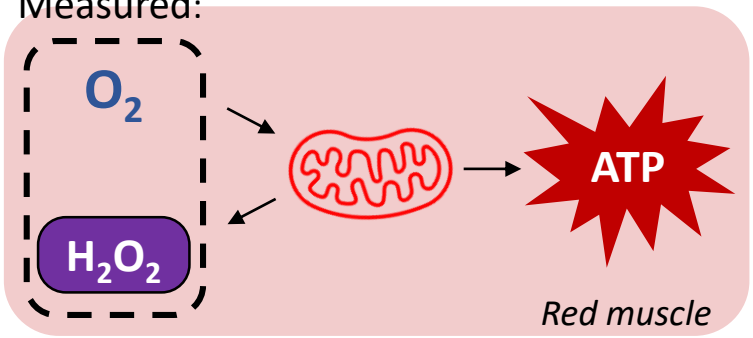
Efficiency < Efficiency, Efficiency, Efficiency

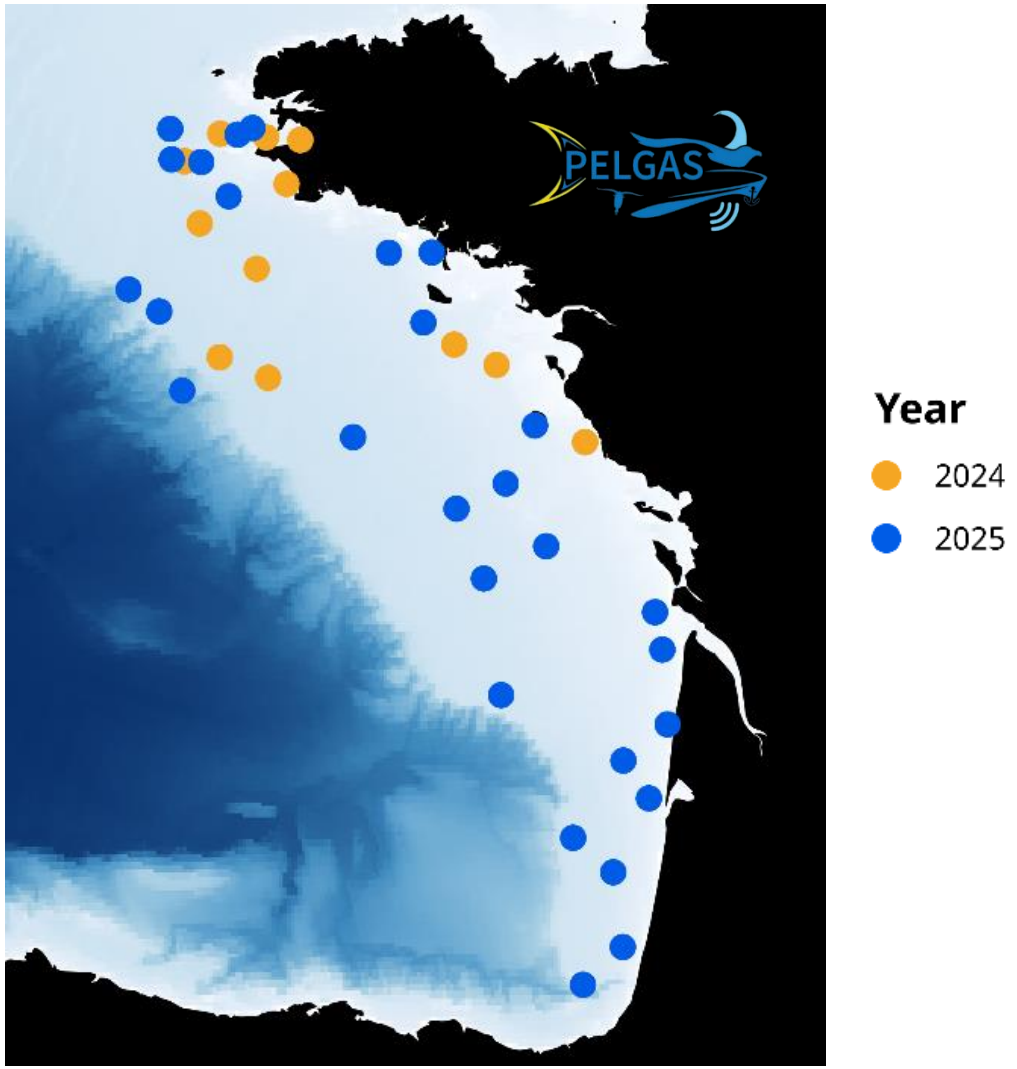
H_2O_2 < H_2O_2, H_2O_2, H_2O_2

Does larger sardines have more efficient mitochondria?

1st assessment of mitochondrial traits in a wild SPF

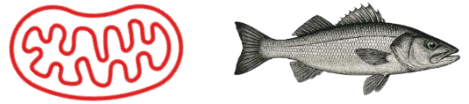
Measured:

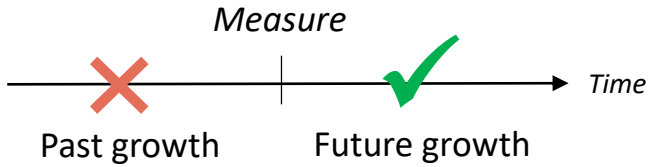




Smaller sardines have more efficient mitochondria

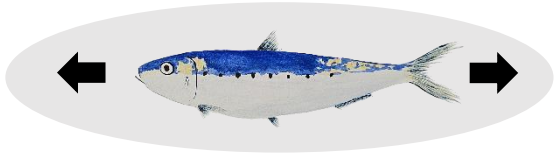
→ **Smaller sardines** mitochondria invest **more O_2 into ATP synthesis**





(Quéméneur, 2022)

Mitochondrial plasticity → upcoming needs

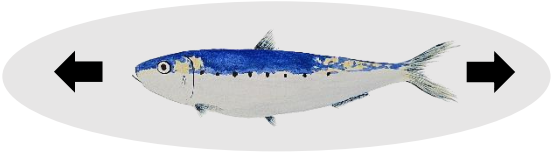


Compensatory growth

Smaller sardines have more efficient mitochondria which release more H_2O_2

→ **Smaller sardines** mitochondria invest **more O_2 into ATP synthesis**

Mitochondrial plasticity → upcoming needs

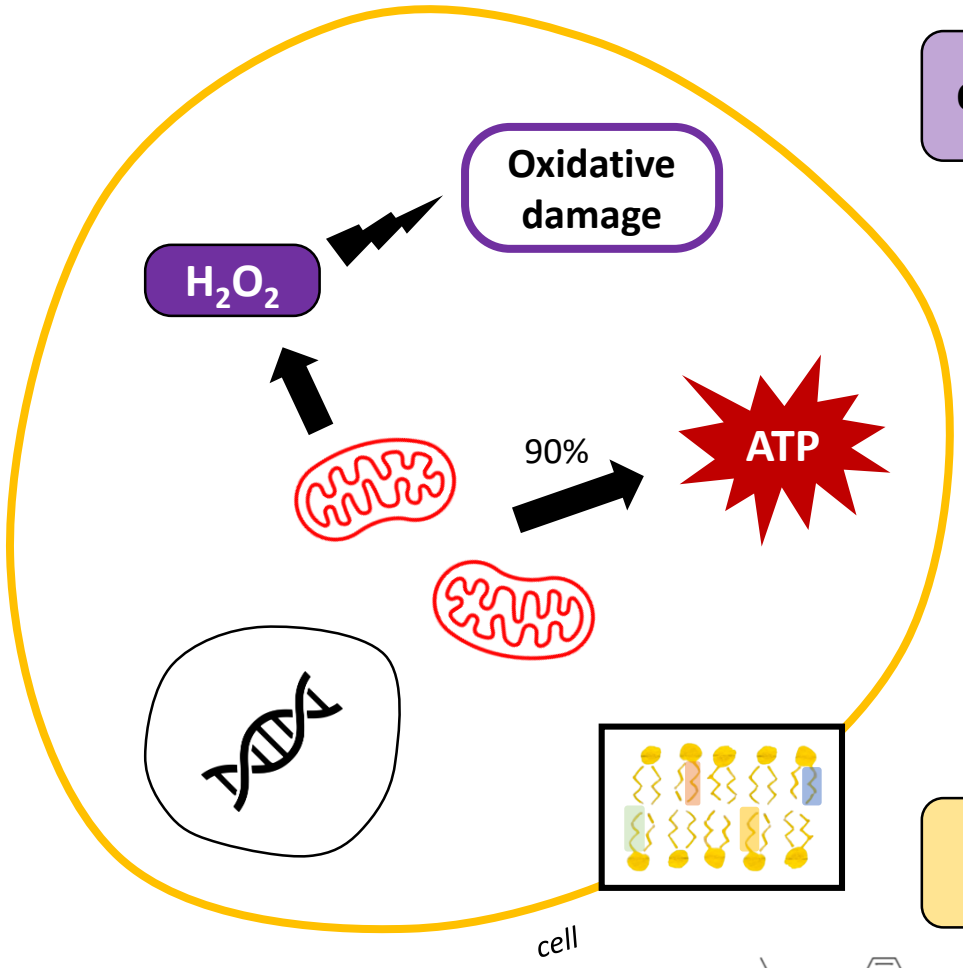


Compensatory growth

→ **Smaller sardines** mitochondria release **more H_2O_2**

→ The **strength** of the **relationships varies with year**

Is membrane fatty acid composition associated with sardines' size-at-age?



Oxidative damage

Mitochondrial efficiency

Membrane fatty acid composition

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?

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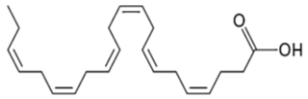
S i z e – a t – a g e

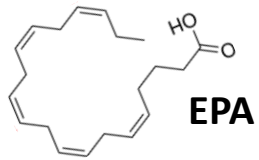
Protein carbonyl < Protein carbonyl, Protein carbonyl, Protein carbonyl

Efficiency, Efficiency, Efficiency > Efficiency

H_2O_2, H_2O_2, H_2O_2 > H_2O_2



DHA = Docosahexaenoic acid

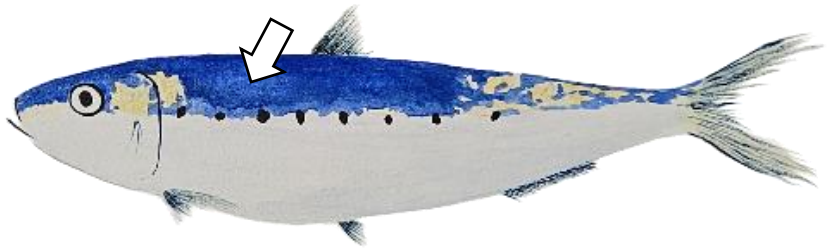


EPA = Eicosapentaenoic acid

Is membrane fatty acid composition associated with sardines' size-at-age?

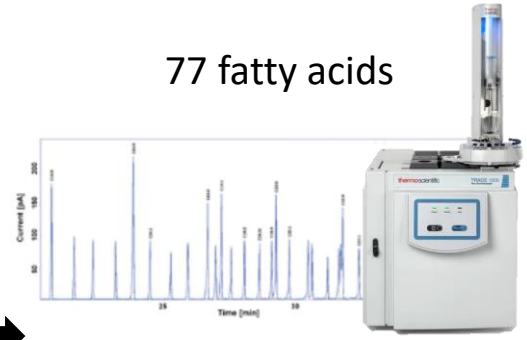
1- and 2-yrs-old

White muscle



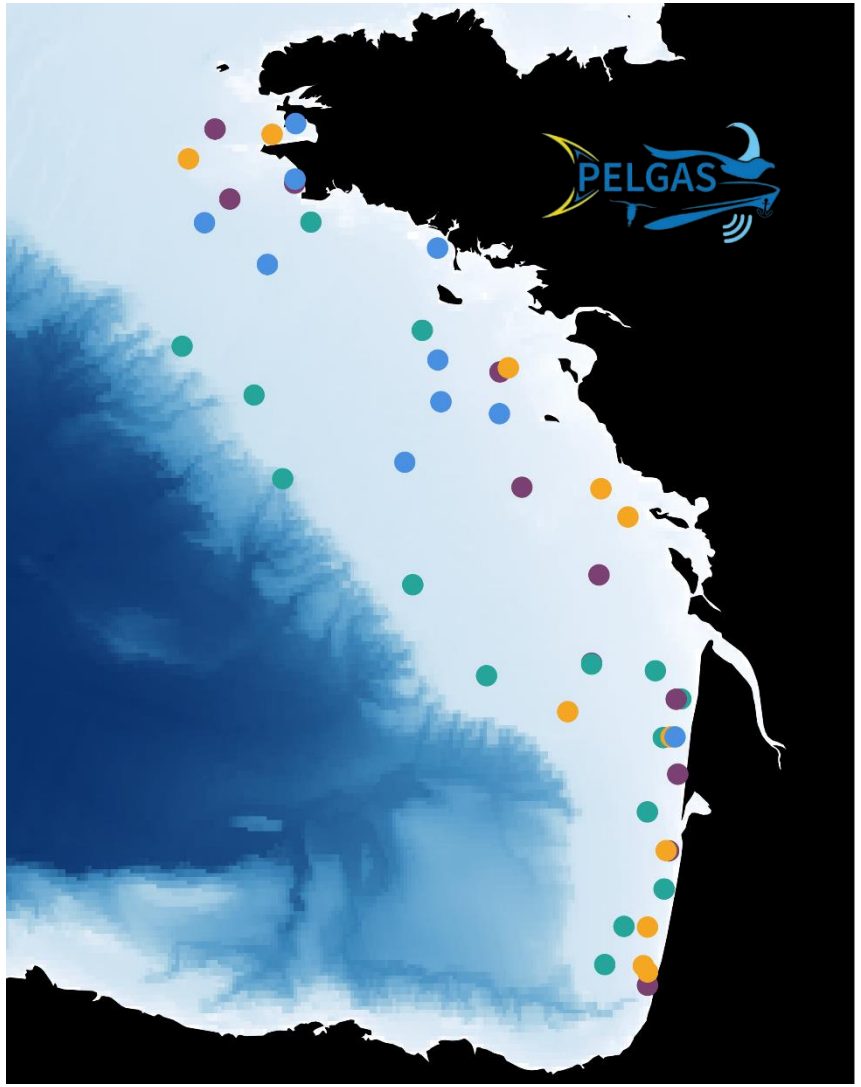
Separation of reserve and **membrane lipids** on silica microcolums

77 fatty acids



→ PCA on fatty acid composition

→ Extracted first two components



Membrane fatty acid composition is associated with sardines' size-at-age across years

DHA negatively associated with **PC1**

Food quality

DHA

DHA

→ **Smaller sardines** had **higher proportion** of **DHA** in their membrane

→ Consistent across ages but **strength varies across years**

Negative relationship between **DHA** and **growth rate** appear **only** in conditions of DHA **deficient diet** (*Bertrand, 2024*)

Membrane fatty acid composition is associated with sardines' size-at-age across years

EPA positively associated with **PC2**

50% immature

spawning

EPA → **Reproduction**

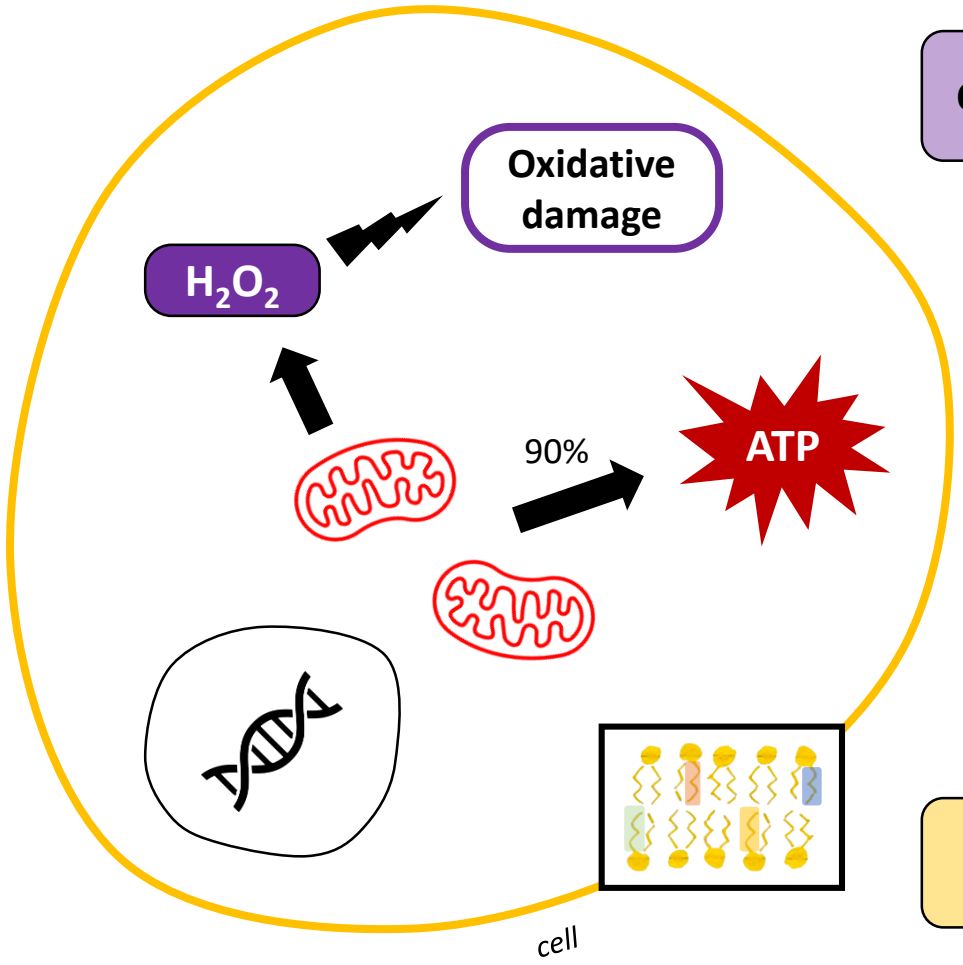
(*Garrido, 2007; Yasuda, 2021; Vila-Belmonte, 2025*)

EPA

→ **Larger sardines** had **higher proportion** of **EPA** in their membrane

→ **Strength** varies across years and **ages**

Physiological traits are associated with size-at-age variations in sardine



Oxidative damage

Mitochondrial efficiency

Membrane fatty acid composition

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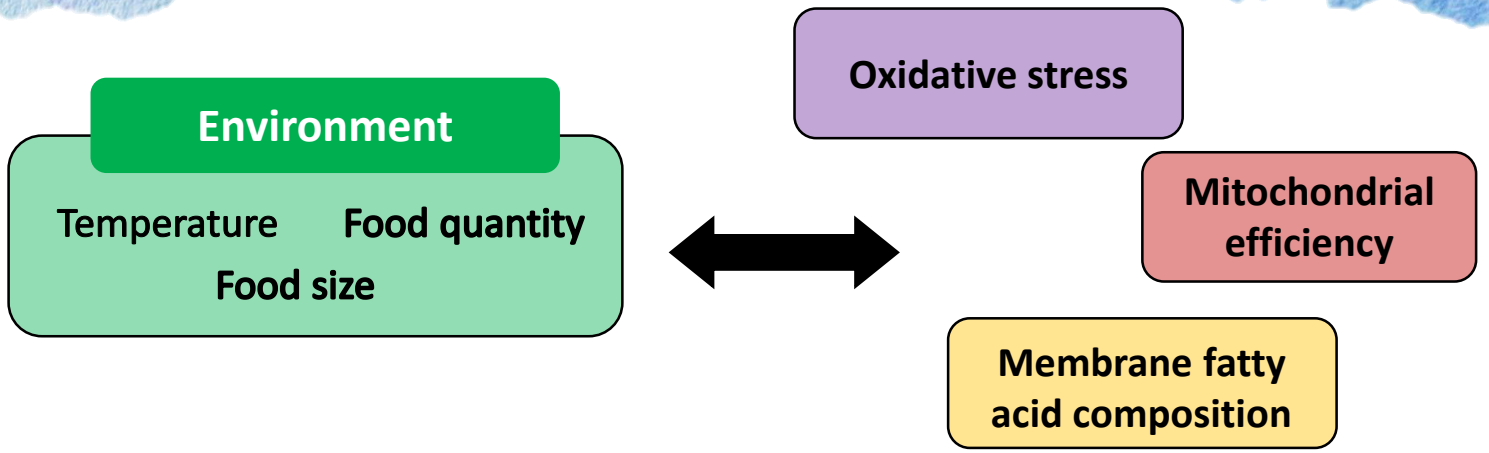
\+

Size–at–age

What's next?



→ **Spatial** and **temporal variations** in physiological traits

THANKS !

Co-authors

Pablo Brosset

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Karine Salin

Fany Sardenne

Philippe Soudant

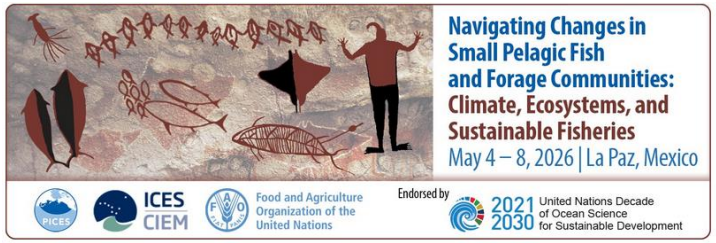
Christophe Lebigre

Funding my venue

ICES CIEM

Ifremer

Organisers of the symposium



Looking for a postdoc position for 2027…

Feel free to contact me

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