Session 3

Understanding growth and survival declines in small pelagic fish: A multi-approach study in the Bay of Biscay and Gulf of Lions

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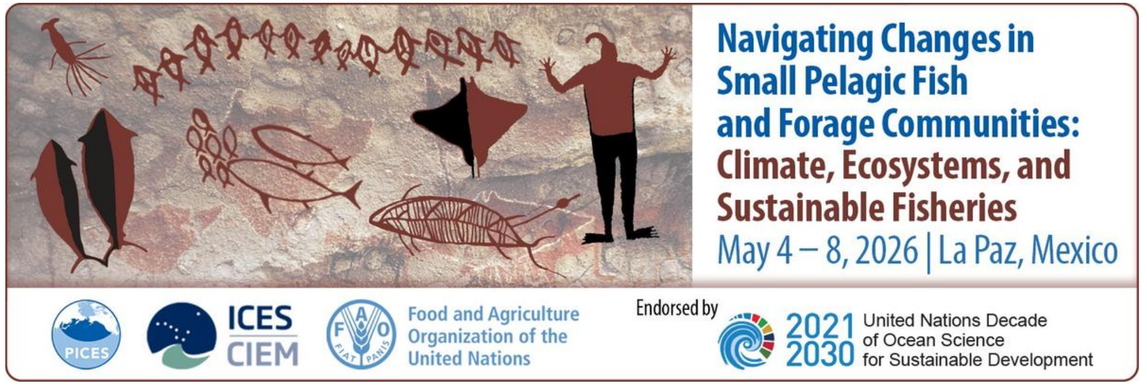
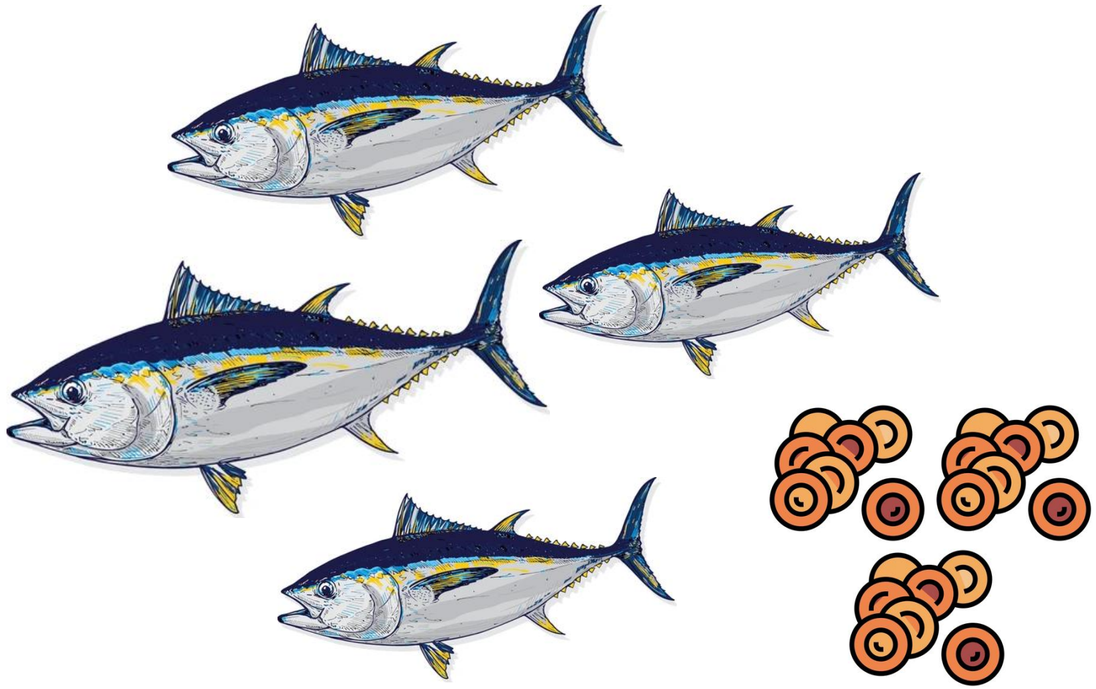
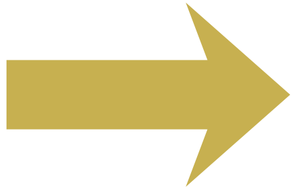
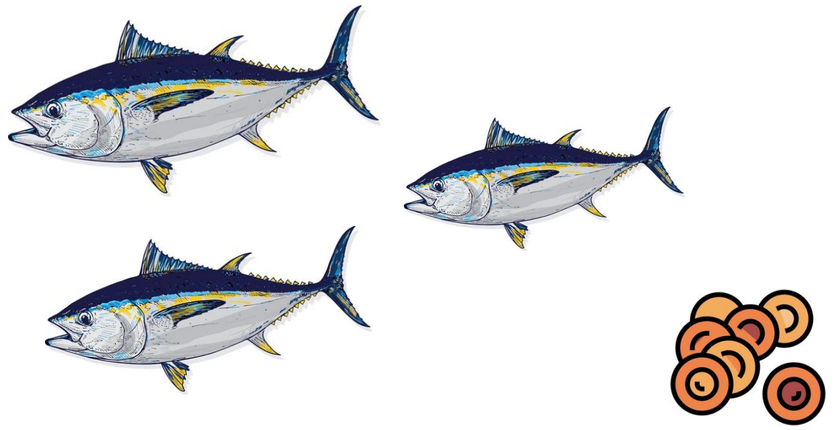


Fish life history traits, climate change, and fishing pressure







Growth: reduced with temperature and with lower primary productivity

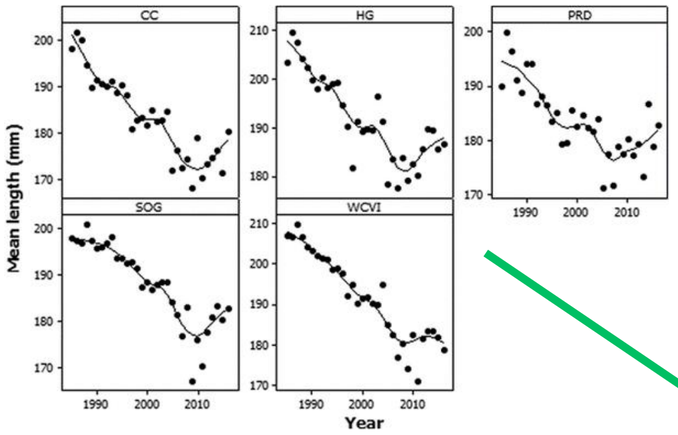
Survival: reduced population renewal

Reproduction: Spawning timing and area
Larval development rate and survival

Small pelagic size is declining worldwide

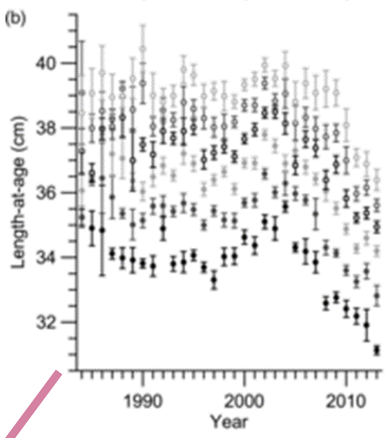
Pacific herring (Northeast Pacific)

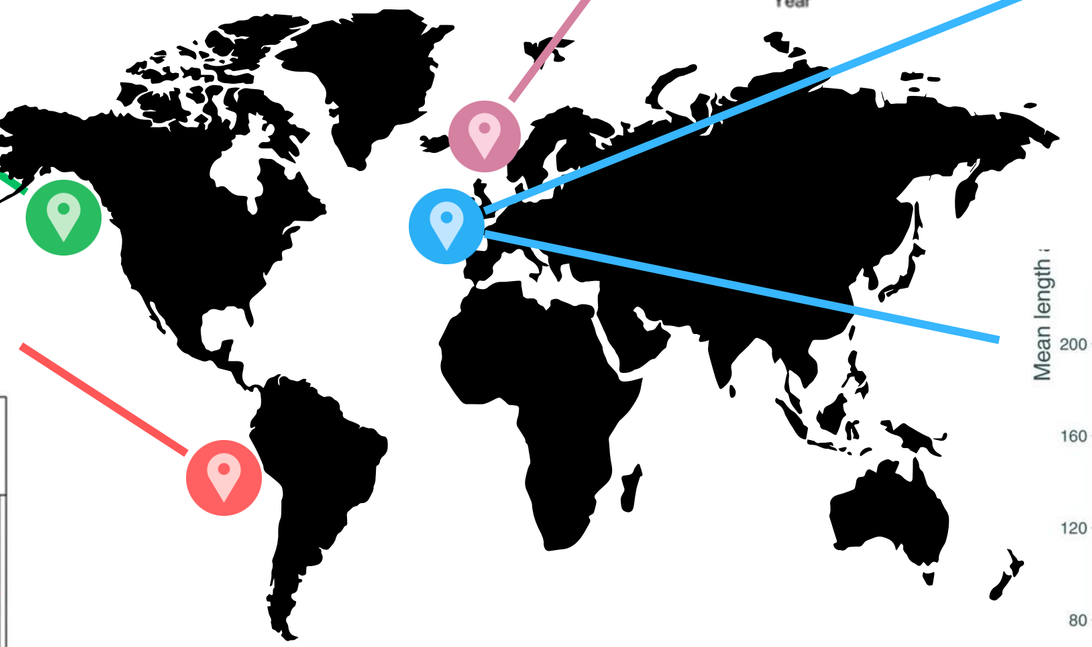
Hay et al., (2019)

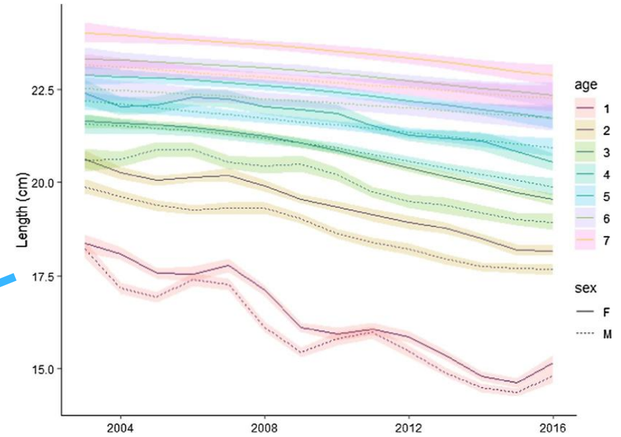


Atlantic mackerel (North sea)

Olafsdottir et al., (2016)





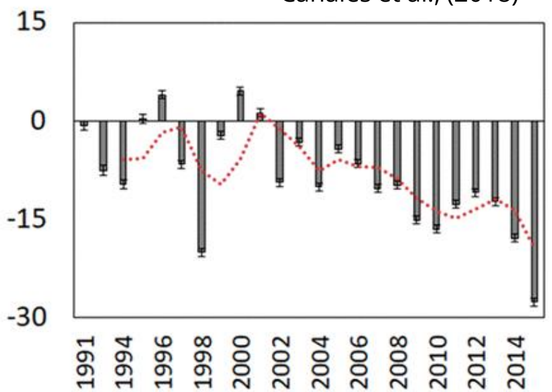


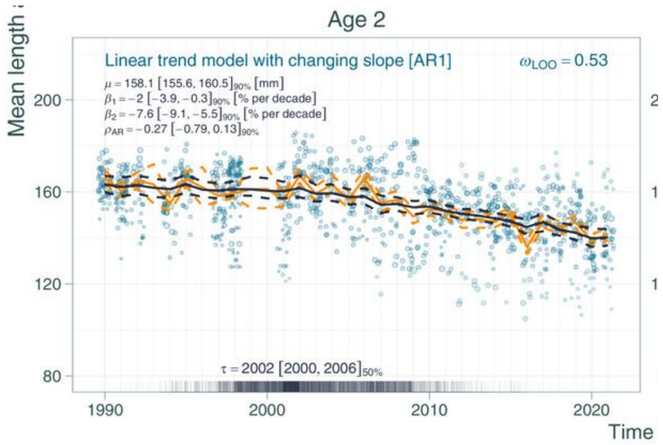
European sardine (Bay of Biscay)

Véron et al., (2020)

Anchovy (*E. ringens*, Southeast Pacific)

Canales et al., (2018)





Anchovy (*E. encrasicolus*, Bay of Biscay)

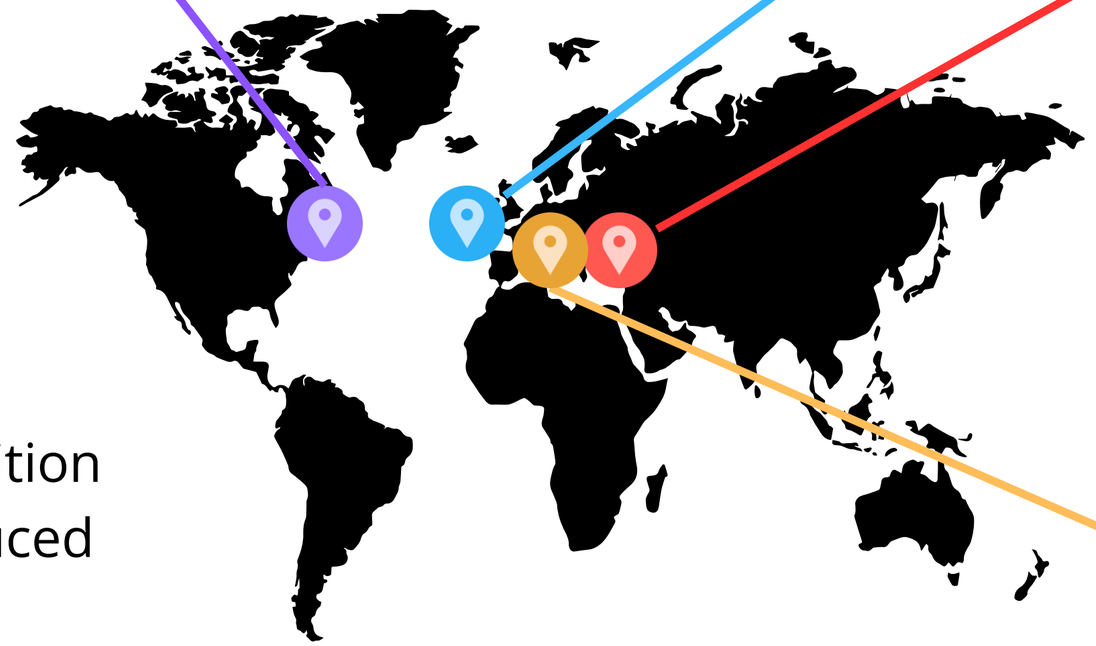
Taboada et al., (2024)

Small pelagics body condition is declining worldwide

Northeast Atlantic
(*E. encrasicolus*, *S. pilchardus*)
Gernez et al., (2025)

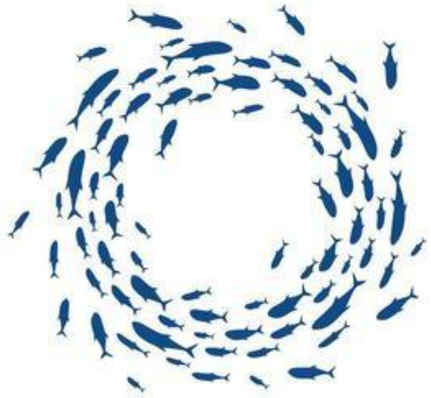
Northwest Atlantic
(Atlantic mackerel))
Plourde et al., (2015)

Black sea anchovy
Gücü et al., (2018)



NW Mediterreanean sea
(*E. encrasicolus*, *S. pilchardus*))
Brosset et al., (2017)

These changes in body condition can be accompanied by reduced adult survival.



1. *What environmental drivers influence changes in small pelagic fish population structure and life-history traits?*
2. *What physiological mechanisms underlie the observed changes in growth and body condition?*

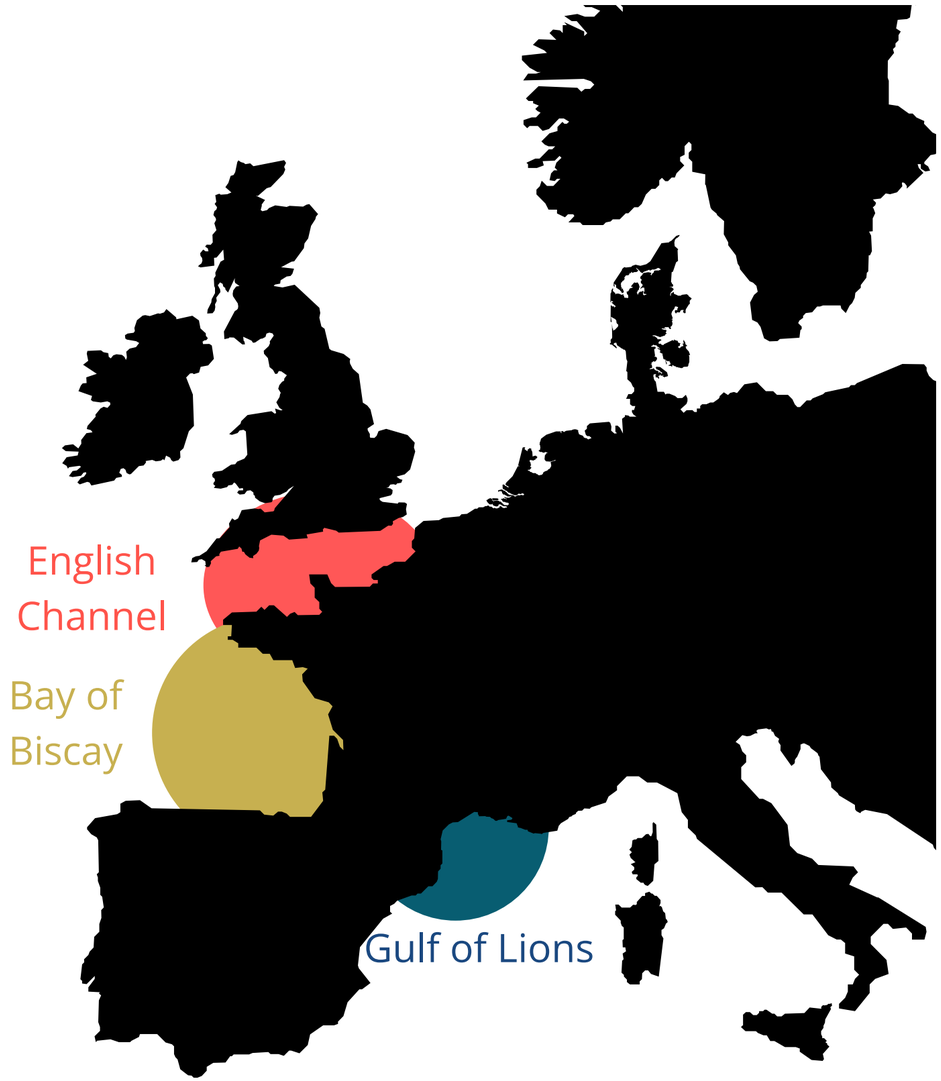
Focus on different areas in French waters

2.

Small pelagic fish demographic and biological changes

2.1 Demographic and biological changes on SPF

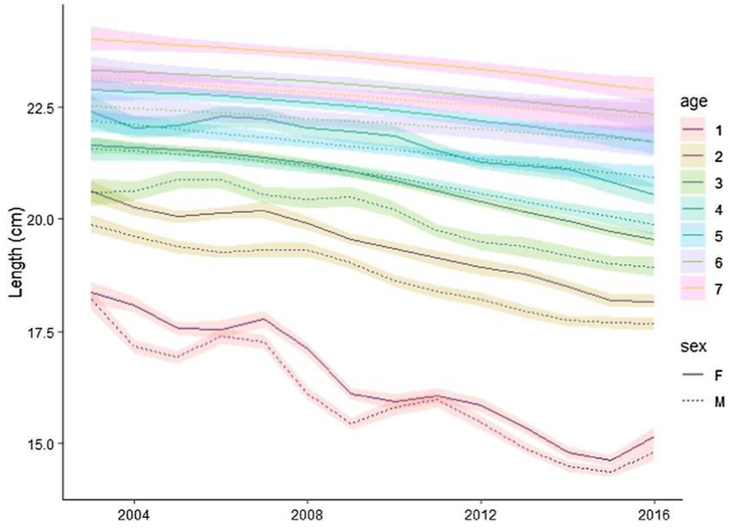
Three contrasted areas along a latitudinal gradient



2.1 Demographic and biological changes on SPF

Bay of Biscay

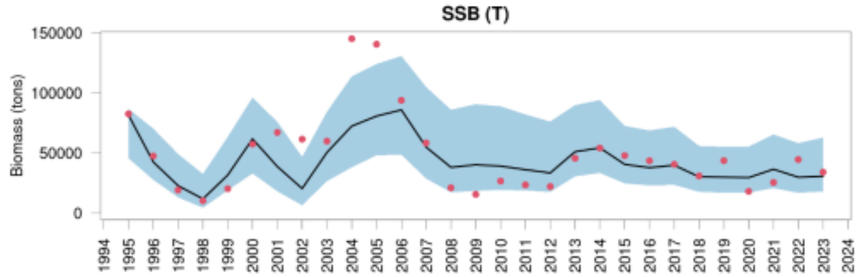
Length (cm)



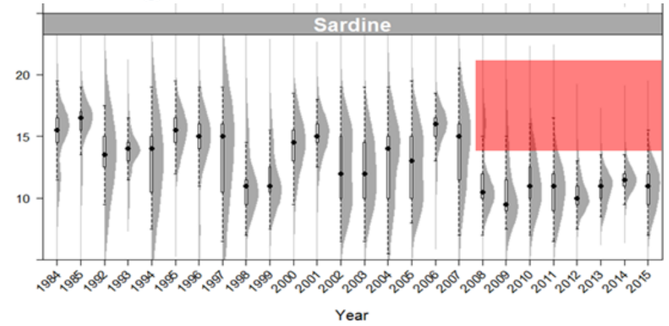
Veron et al., 2020

Saraux et al., 2019

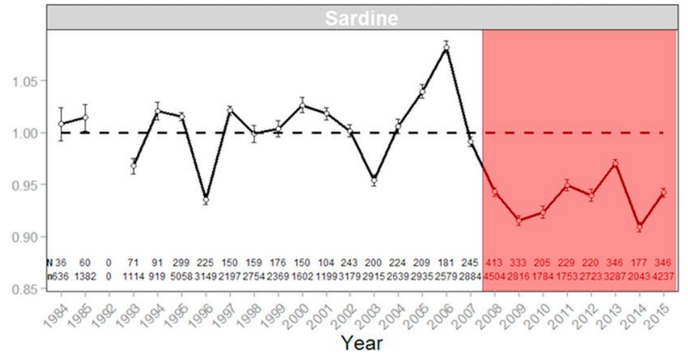
Gulf of Lions



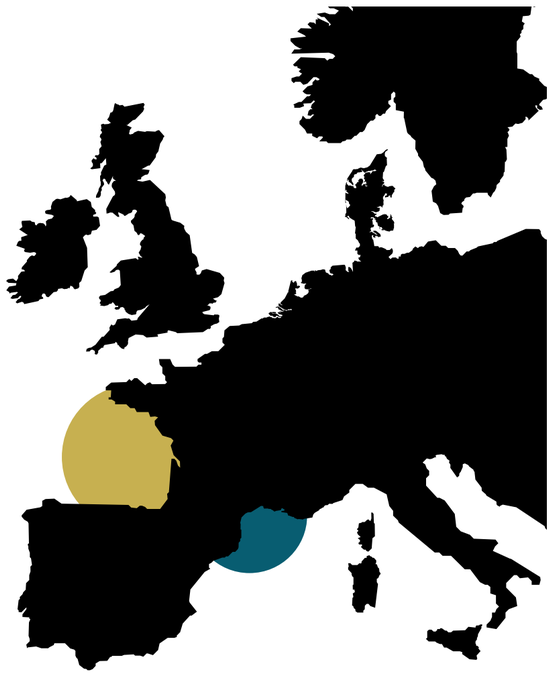
Length (cm)



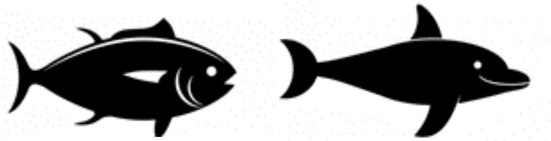
Body condition



2.2 Drivers of demographic and biological changes on SPF



PREDATORS (**TOP-DOWN**)



Predation by tuna & marine mammals

Fishing pressure

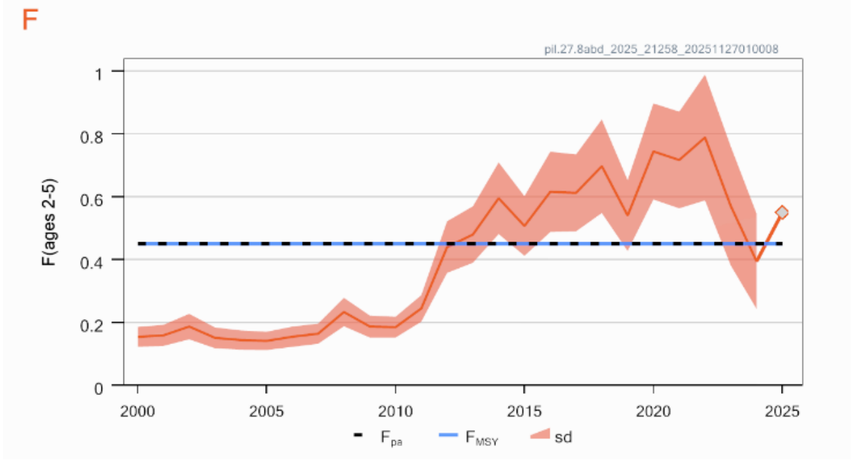
SMALL PELAGICS

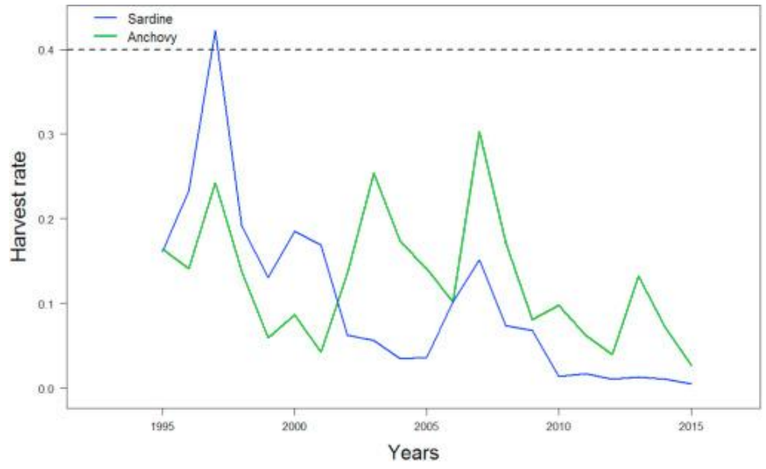
Population characteristics (size, age, condition…)

PREYS (**BOTTOM-UP**)

Plankton effect

2.2 Drivers of demographic and biological changes on SPF





Bay of Biscay fishing mortality and Gulf of Lions harvest rates of sardine and anchovy. Dashed line indicates the reference point.

PREDATORS
(**TOP-DOWN**)

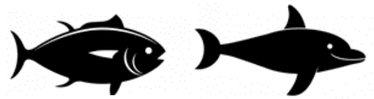
Fishing pressure

Population characteristics (size, age, condition…)

Low fishing pressure amid SPF population shifts

2.2 Drivers of demographic and biological changes on SPF

PREDATORS
(**TOP-DOWN**)



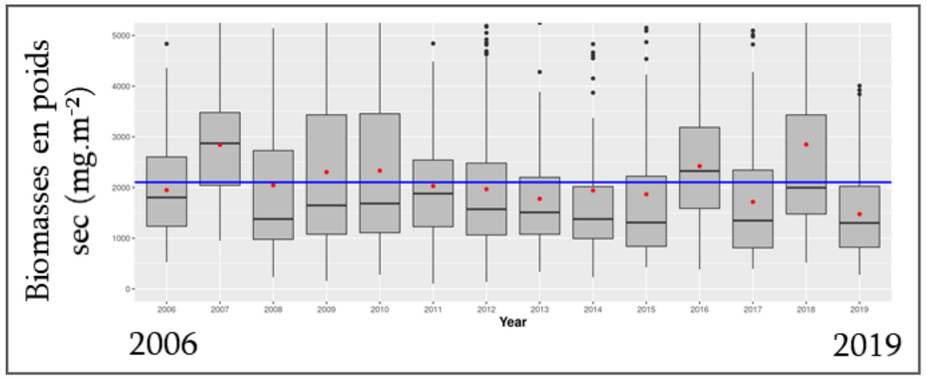
Predation by tuna &
marine mammals

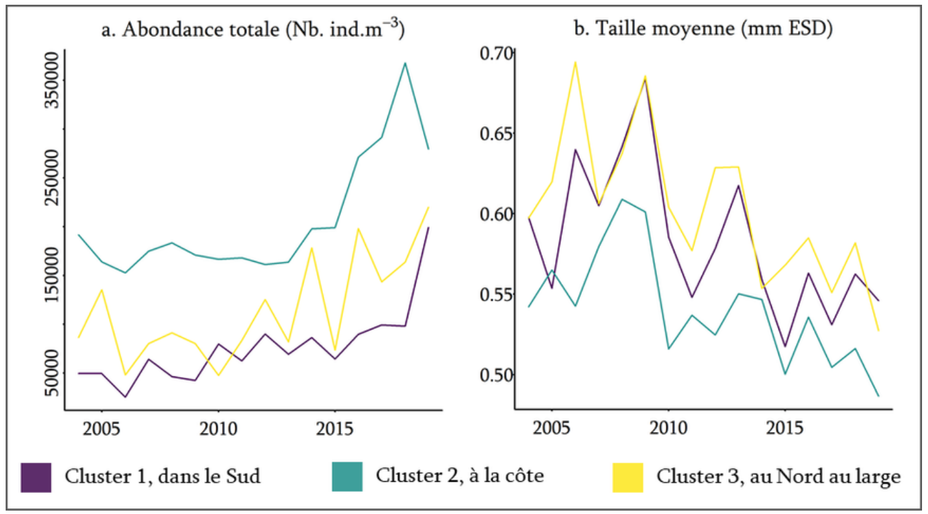
Population characteristics (size, age, condition…)

DEB modeling estimates that ingestion by tuna and marine mammals accounts for **less than 2% of total sardine biomass, with no size selectivity when predating sardines.**

Van Beveren et al., 2017

2.2 Drivers of demographic and biological changes on SPF





Apparent stability in zooplankton biomass masks **increasing abundance and declining body size**

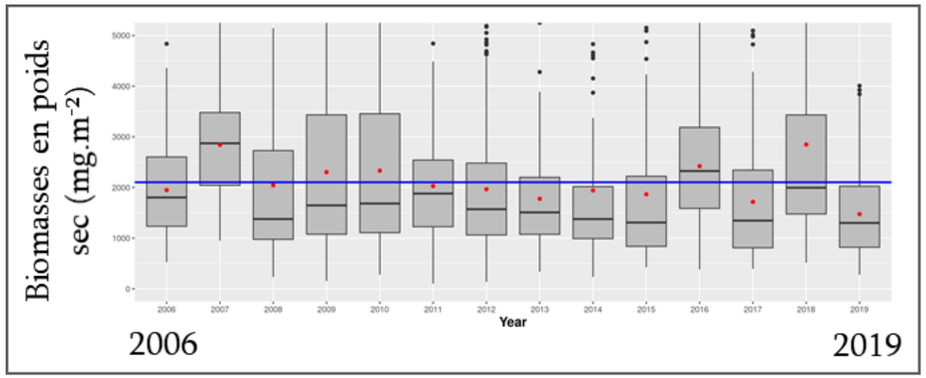
Grandremy et al., 2023

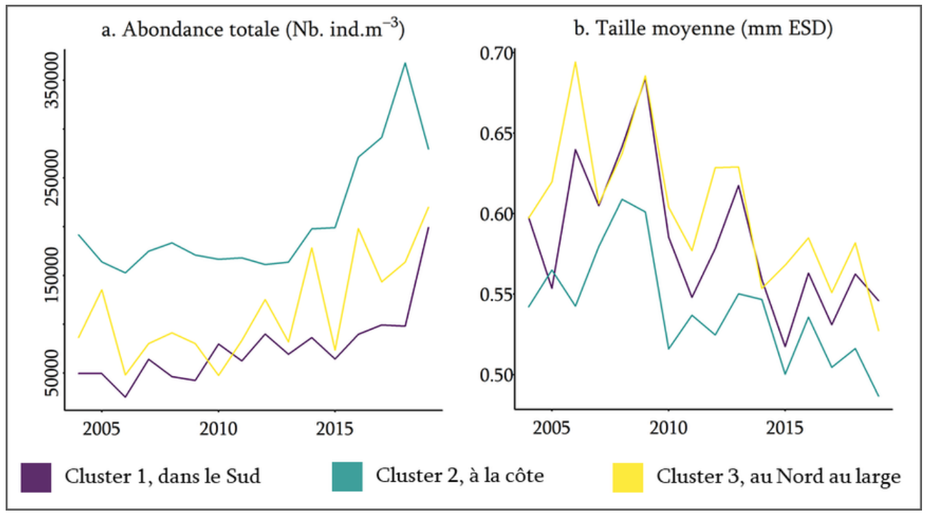
Population characteristics (size, age, condition…)

Plankton effect

PREYS (**BOTTOM-UP**)

2.2 Drivers of demographic and biological changes on SPF





Smaller zooplankton is associated with lower food quality and higher feeding costs for sardines, reducing their energy intake and potentially explaining declines in growth and body condition.

Population characteristics (size, age, condition…)

Plankton effect

PREYS
(**BOTTOM-UP**)

2.2 Drivers of demographic and biological changes on SPF

Decline in size, overmortality of older and larger individuals

Scientific bottleneck:

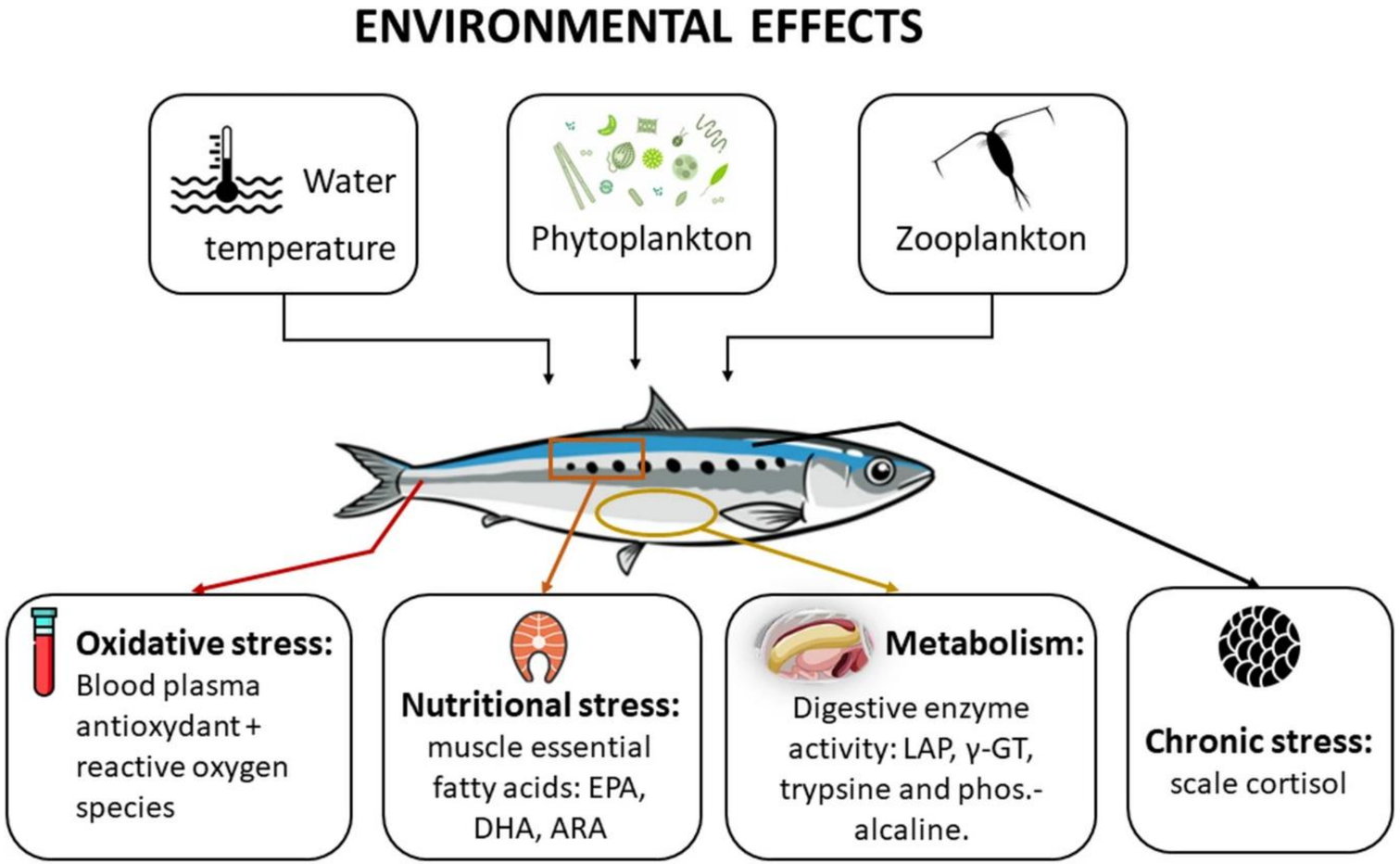
What are the underlying mechanisms driving changes in SPF?

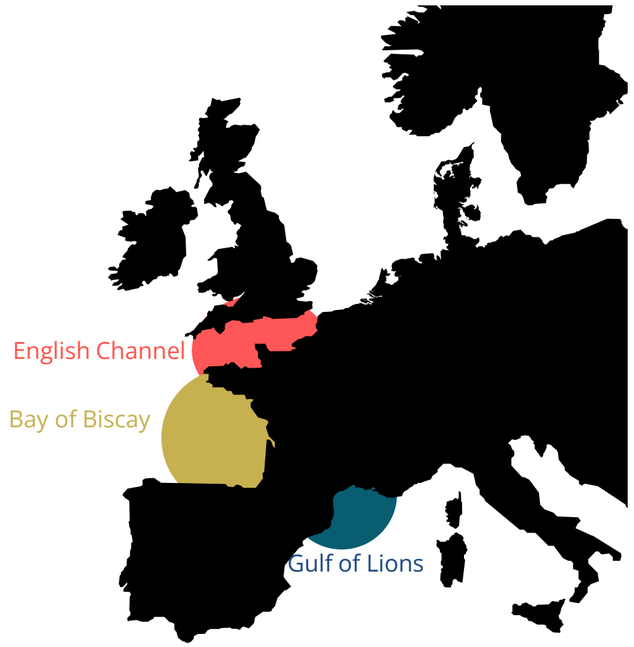
Environmental effects

3.

Investigating underlying mechanisms through an ecophysiological approach

3. An ecophysiological approch



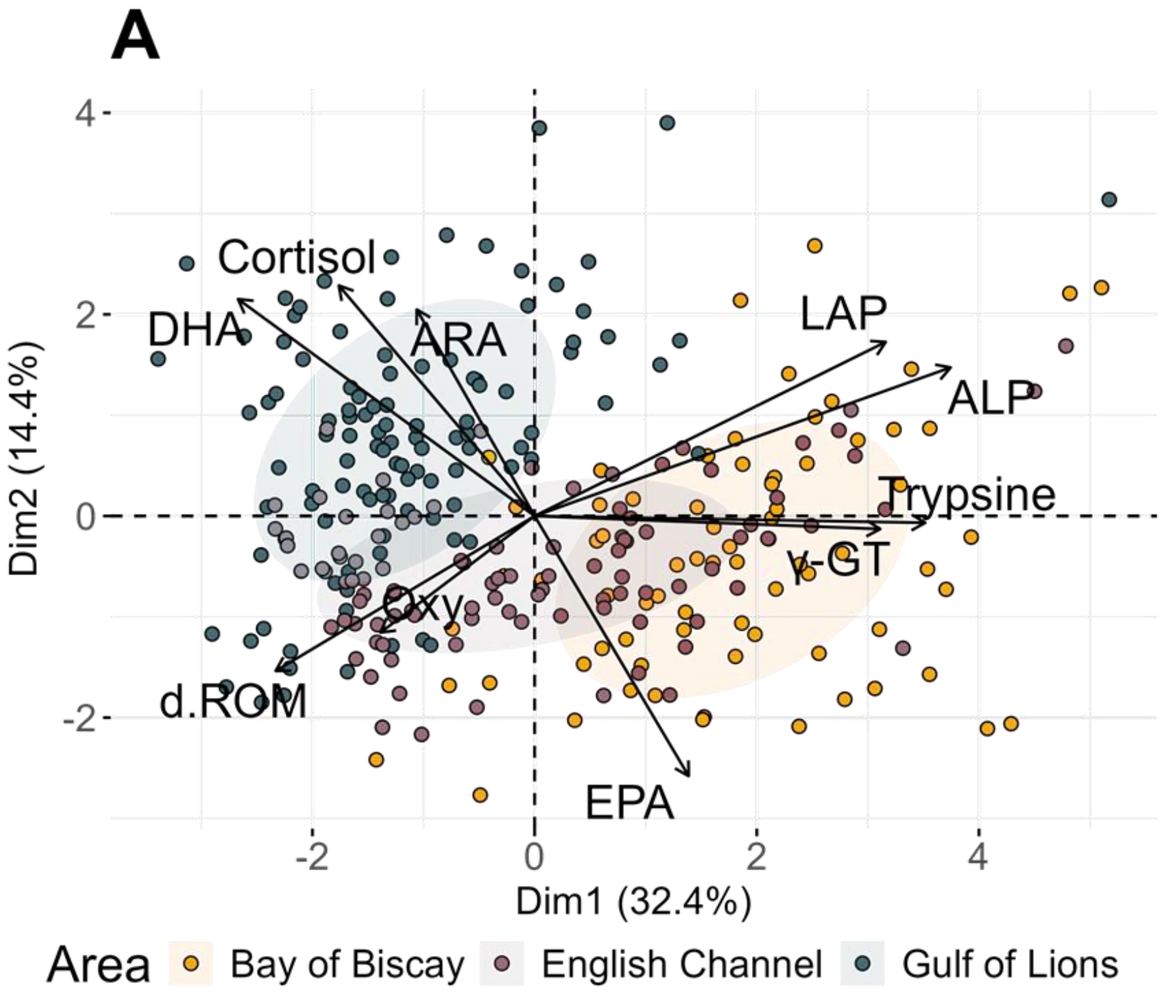


300 sardines in total (~100 by area)

Decline in size, overmortality of older and larger individuals

3. An ecophysiological approch

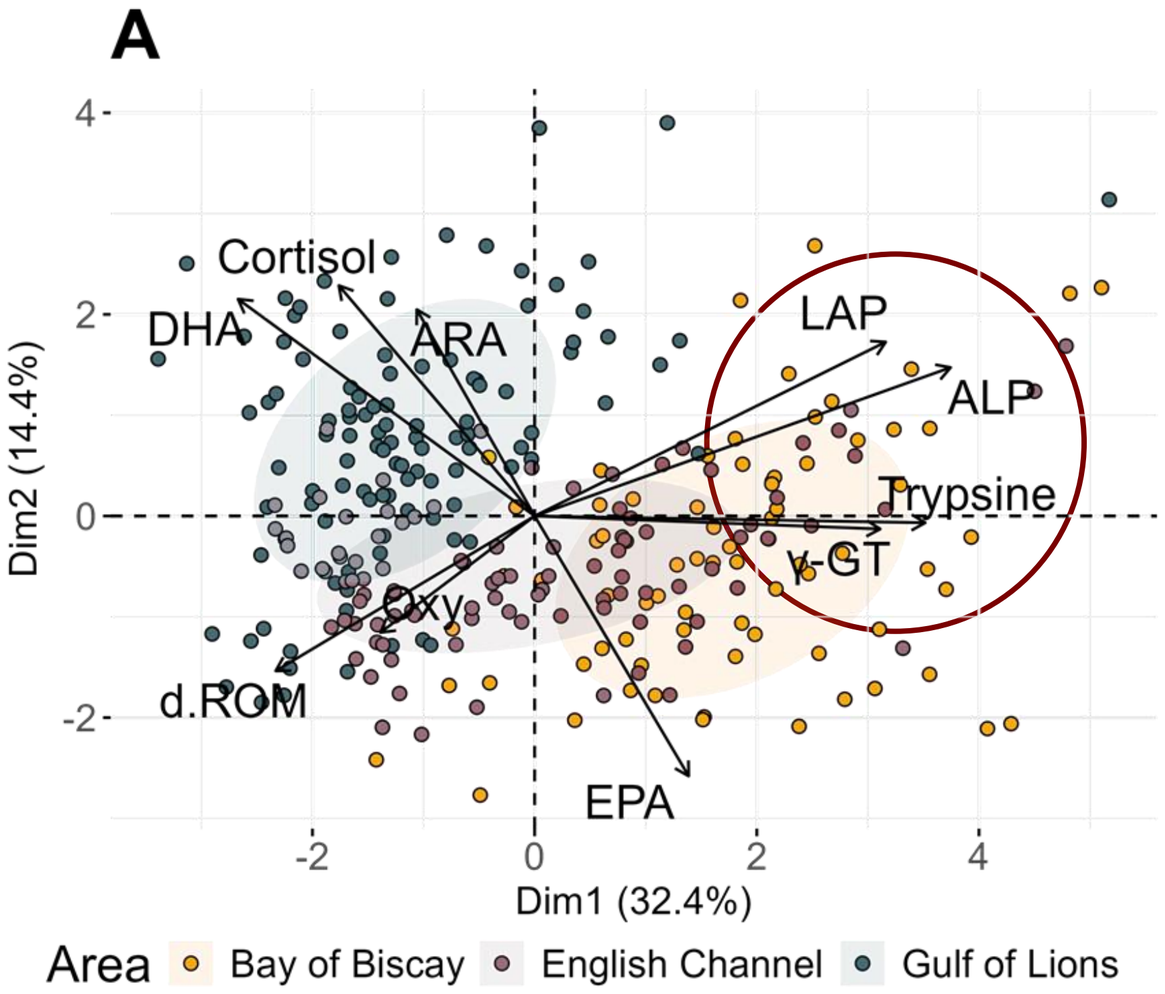
First step to summarize physiological variables with a PCA



3. An ecophysiological approch

First step to summarize physiological variables with a PCA

PC1 → Better metabolism

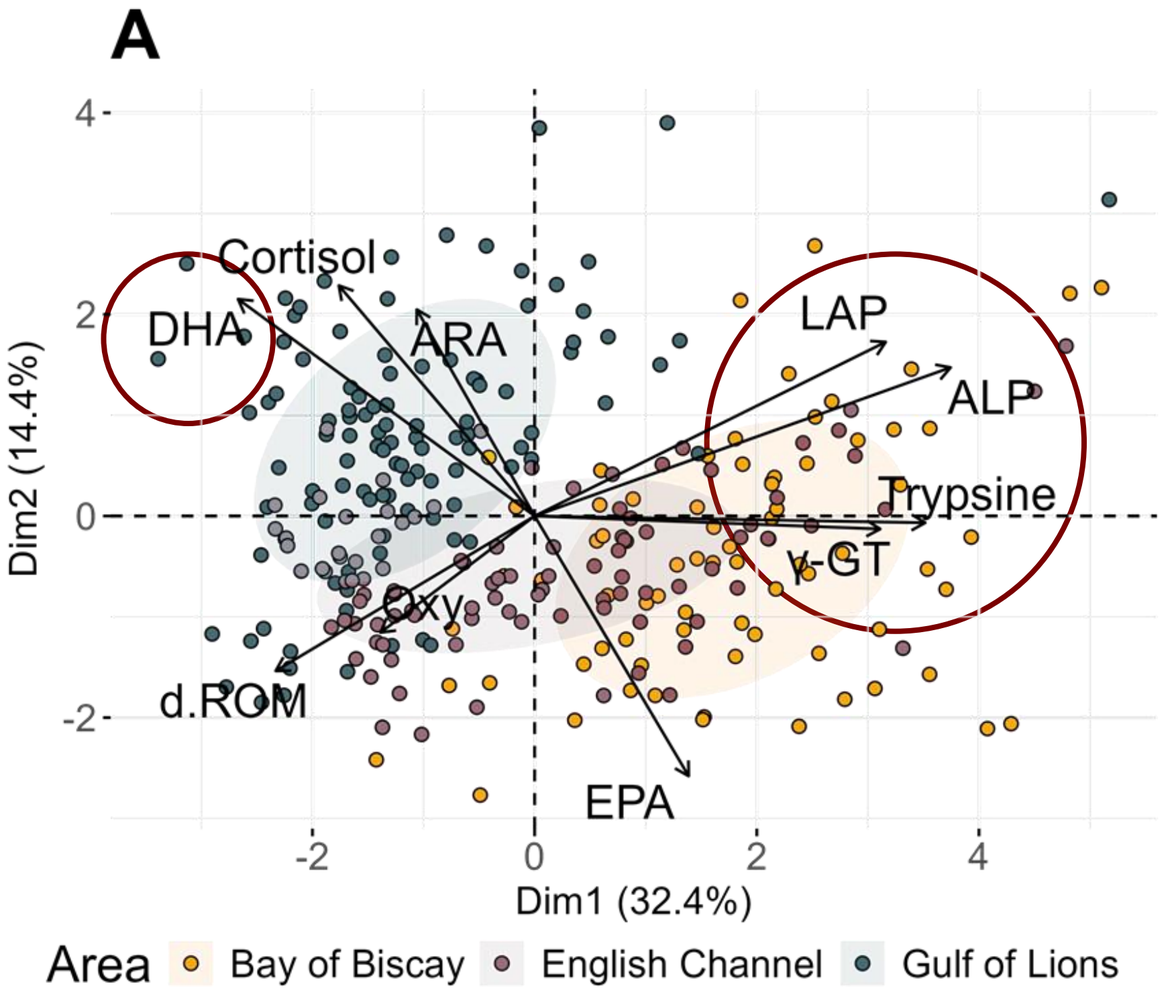


3. An ecophysiological approch

First step to summarize physiological variables with a PCA

PC1

Better metabolism
Less nutritional stress

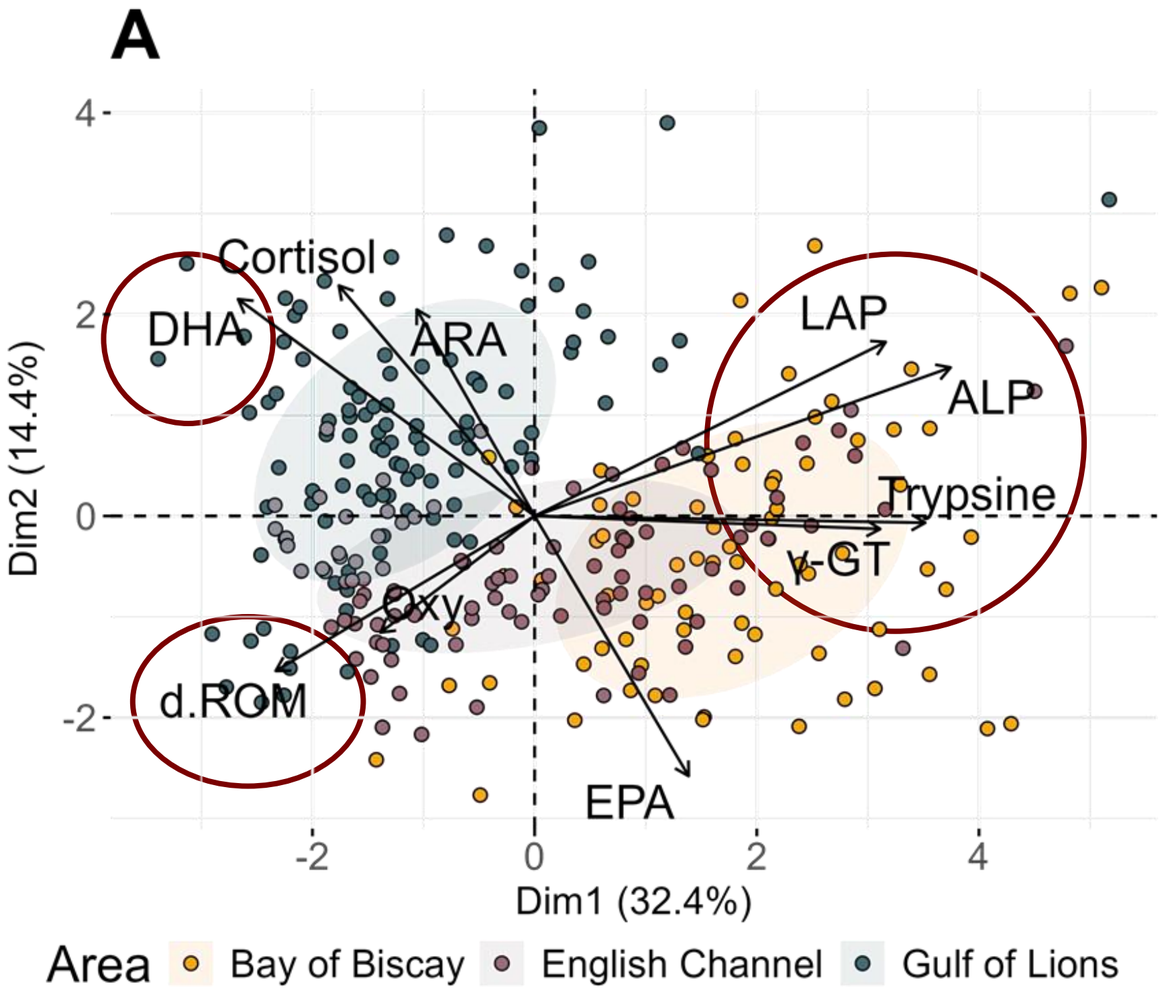


3. An ecophysiological approch

First step to summarize physiological variables with a PCA

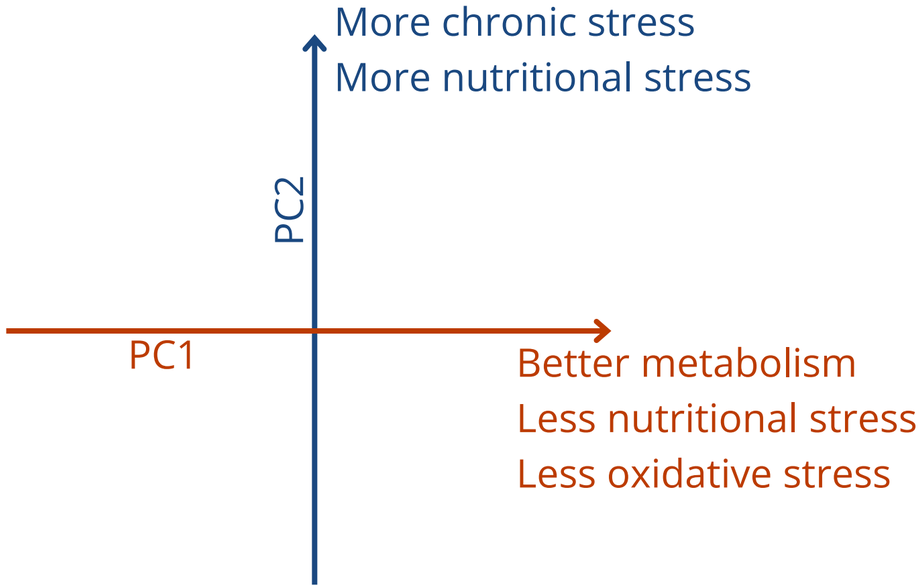
PC1

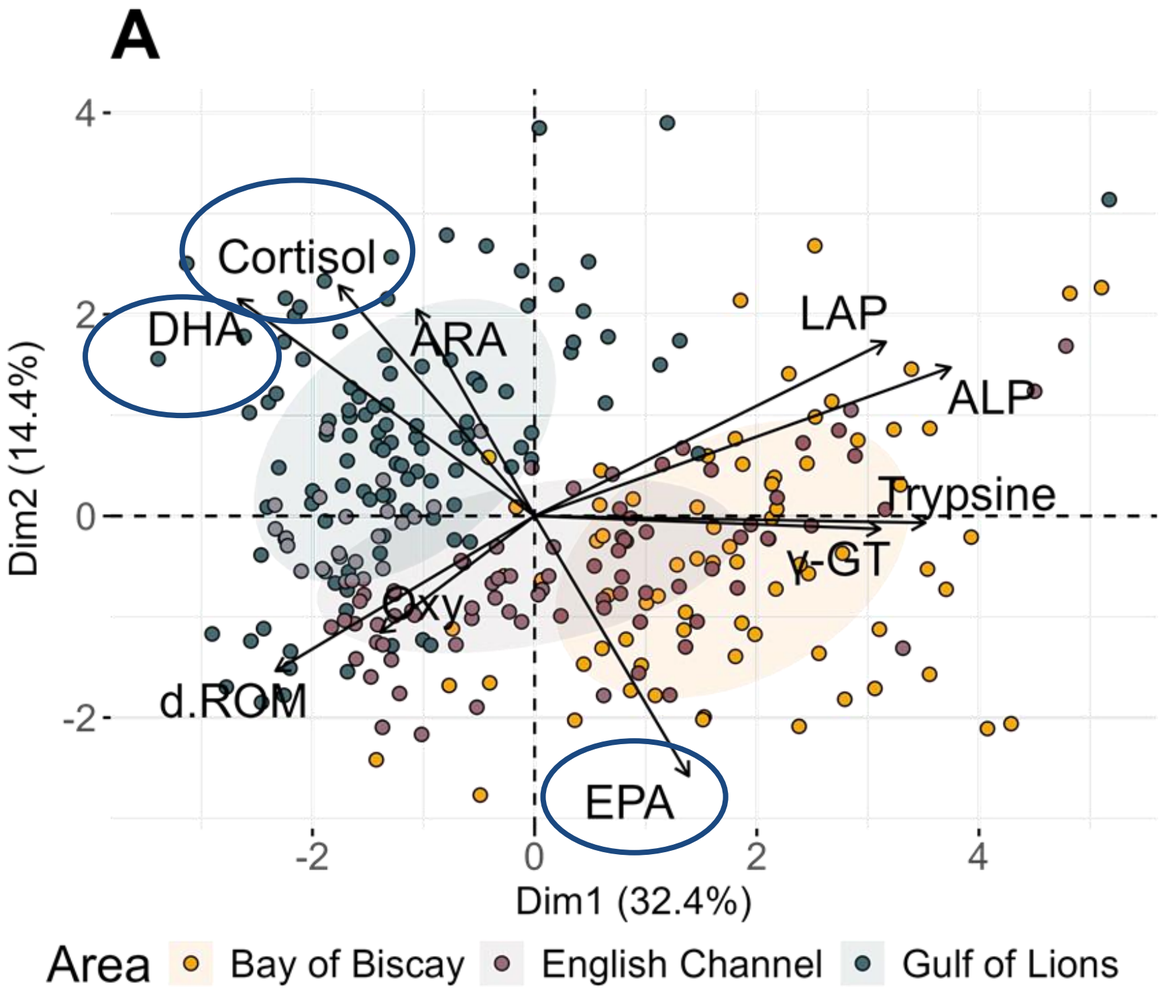
Better metabolism
Less nutritional stress
Less oxidative stress



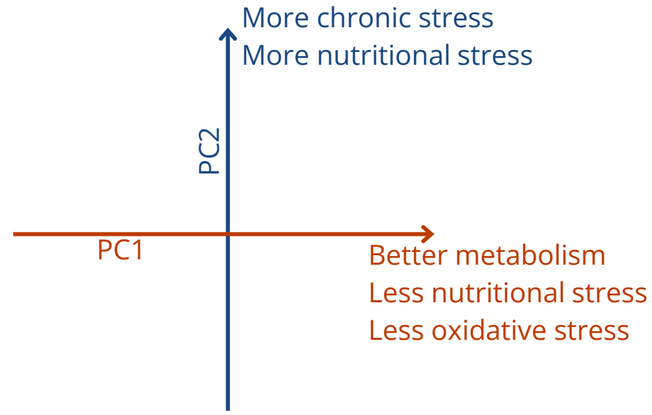
3. An ecophysiological approch

First step to summarize physiological variables with a PCA





3. An ecophysiological approch



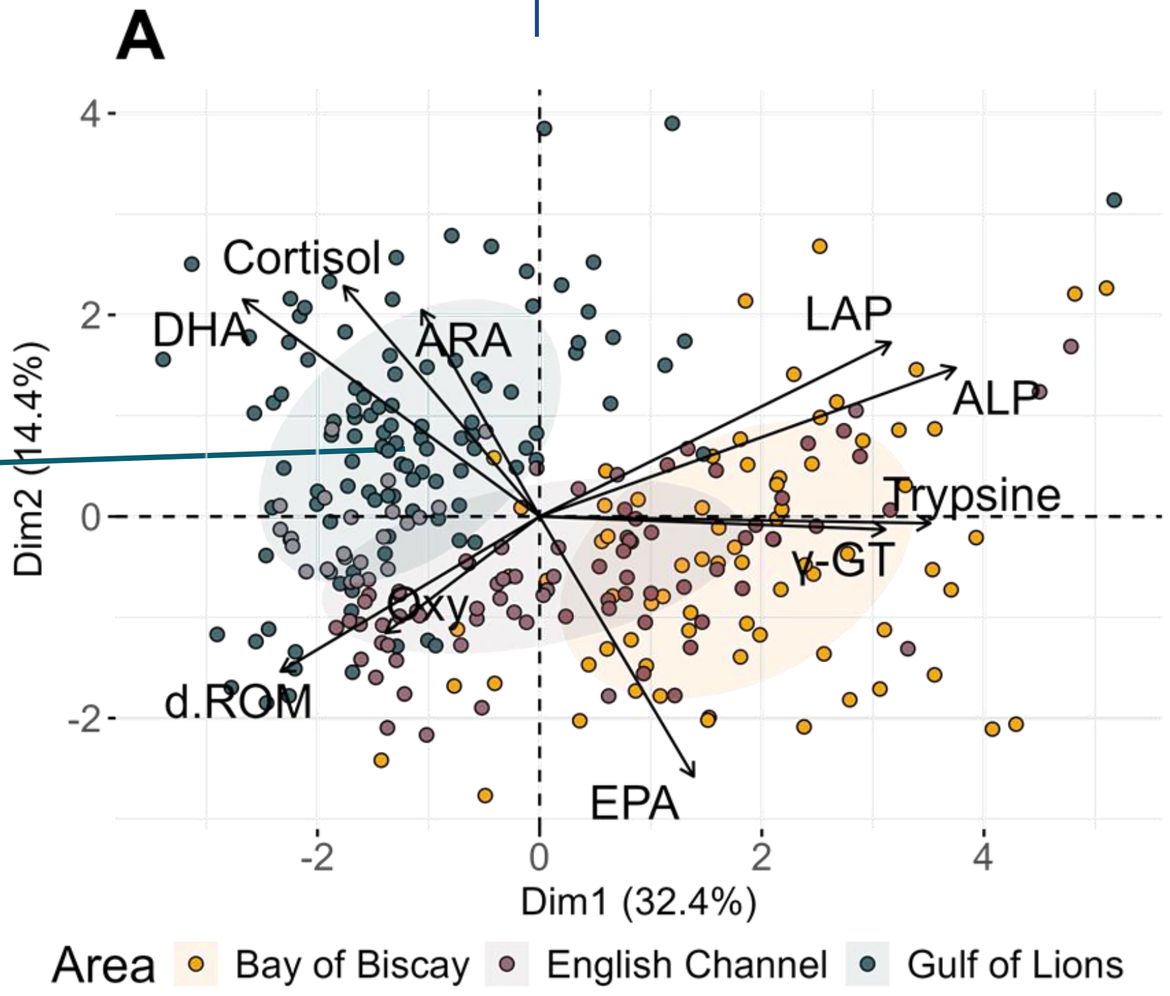
Gulf of Lions

Sardines are in a **poorer physiological state**

Potential mechanisms at play

Cortisol reduce energy intake
=> Reduced growth?

Nutritional stress alters celular functionning and weaken immune response
=> reduced growth and survival?



3. An ecophysiological approch

Gulf of Lions

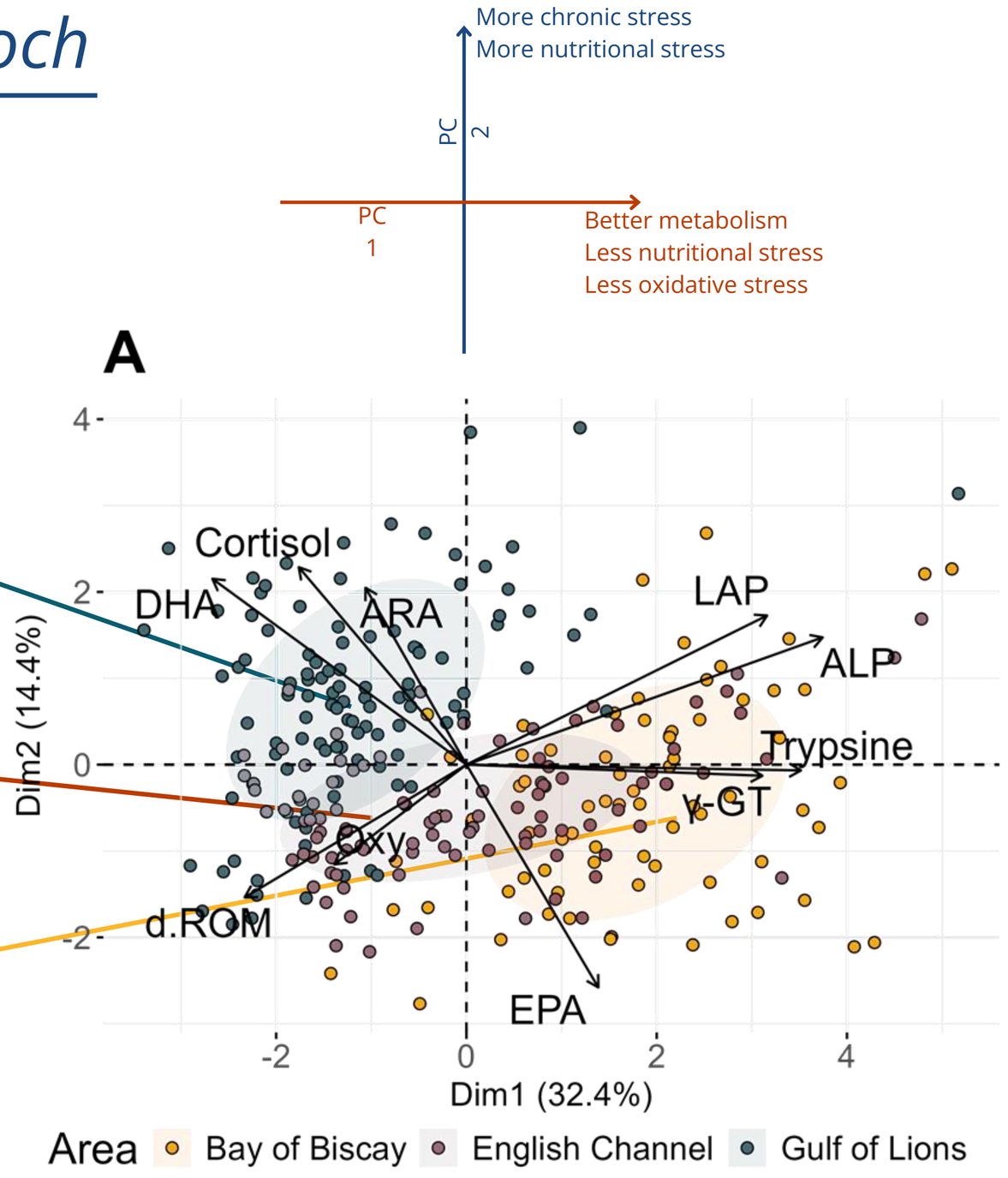
Sardines are in a poorer physiological state

English Channel

Sardines in an intermediate physiological state

Bay of Biscay

Sardines seem to be in a better physiological state



3. An ecophysiological approch

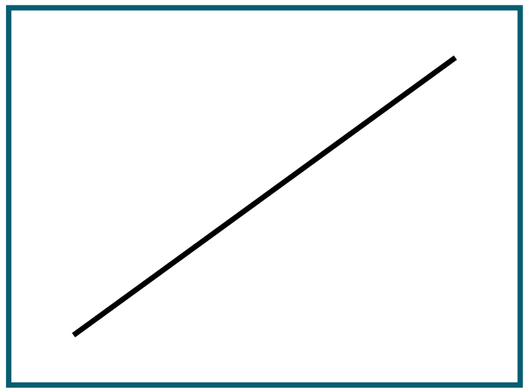
Better metabolism
Less nutritional stress
Less oxidative stress

PC1

More chronic stress
More nutritional stress

PC2

Gulf of Lions



Water column T°

Gulf of Lions

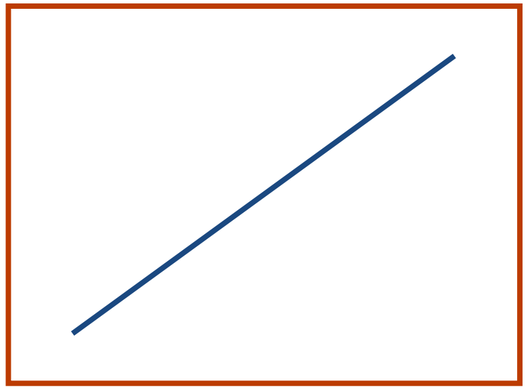
Physiological variability seems to depend mainly on water temperature

3. An ecophysiological approch

Better metabolism
Less nutritional stress
Less oxidative stress

PC1

English Channel



Zooplankton

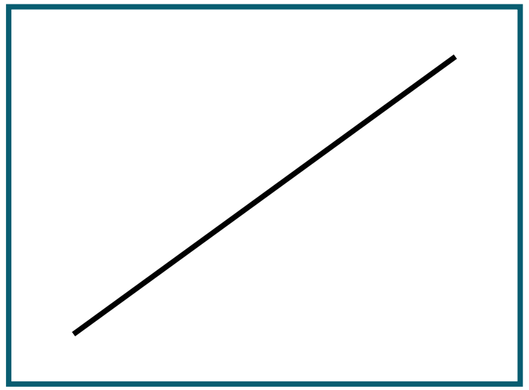
English Channel

Physiological variability seems to depend mainly on food quantity

More chronic stress
More nutritional stress

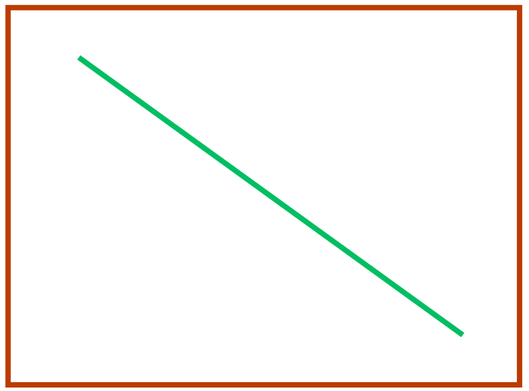
PC2

Gulf of Lions



Water column T°

English Channel



Phytoplankton

Gulf of Lions

Physiological variability seems to depend mainly on water temperature

3. An ecophysiological approch

Sardine physiological variables showed clear responses to environmental variability. The next step is to link this physiological variability to size-at-age and adult overmortality.

For further details, please refer to Raphaëlle’s presentation tomorrow morning, which will examine mitochondrial performance, oxidative stress, and fatty acid composition in relation to sardine size-at-age.

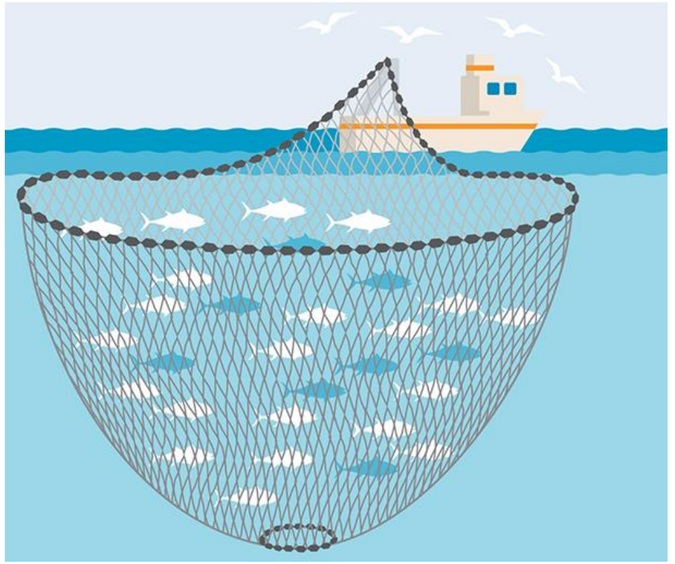
4.

Broader consequences beyond SPF populations

4.2 Impacts on socio-ecological systems and market dynamics

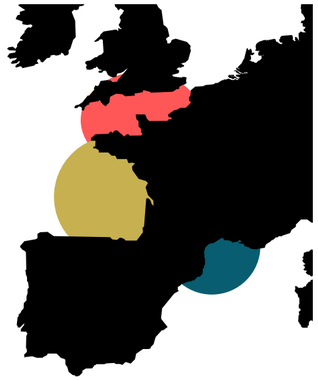
DEFiPEL

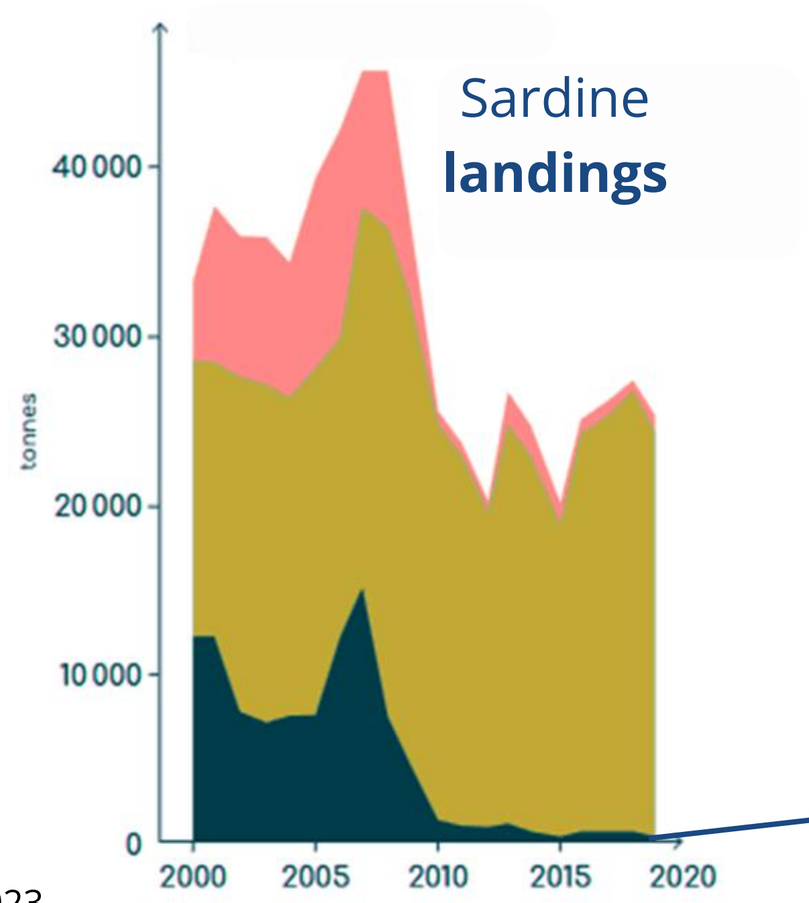
Development of an integrated management approach for the small pelagic sector



4.2 Impacts on socio-ecological systems and market dynamics

Impacts on **fishing activity**



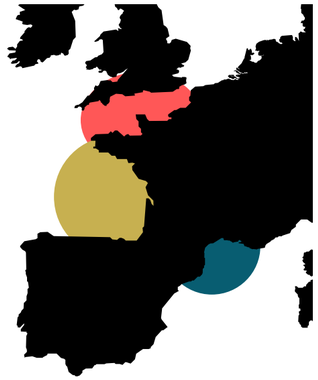


In the gulf of Lions, sardines are too small and lean. No economic values. Landings today = landings 1950s

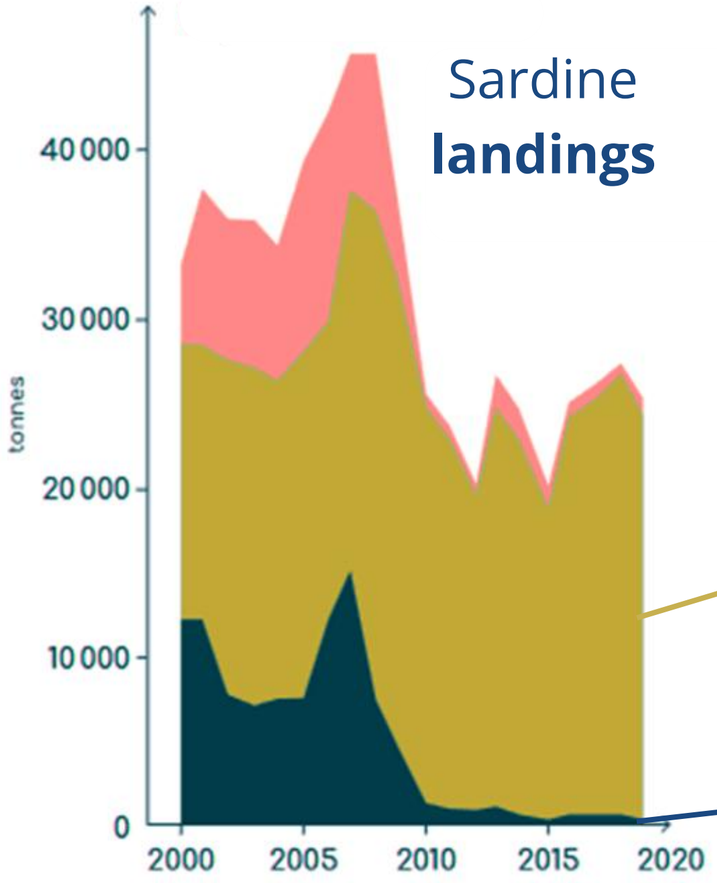
DEFIPEL, 2023

4.2 Impacts on socio-ecological systems and market dynamics

Impacts on **fishing activity**



Sardine
landings

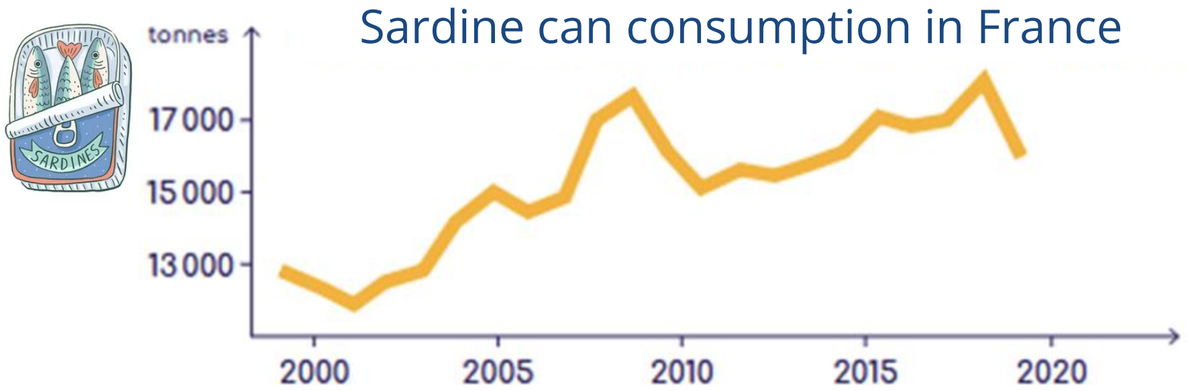


Sardine fishing in the Bay of Biscay has progressively intensified, but over what period will this persist?

In the gulf of Lions, sardines are too small and lean. No economic values. Landings today = landings 1950s

4.2 Impacts on socio-ecological systems and market dynamics

Impacts on **market** dynamics

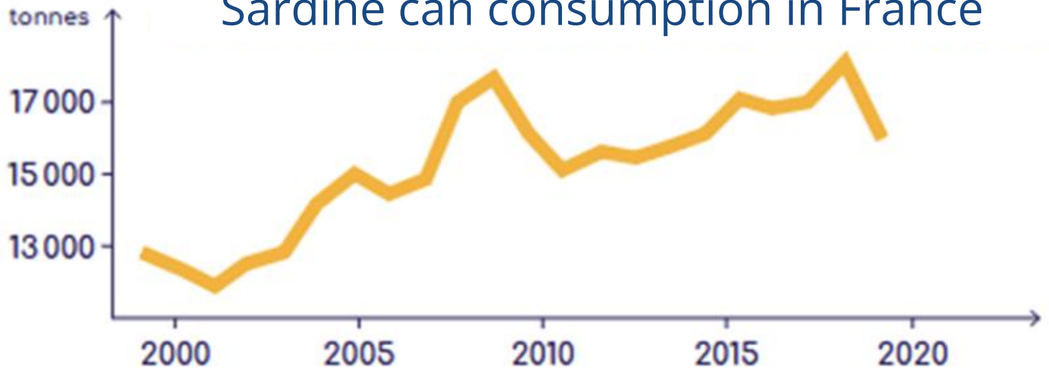


Canned sardine consumption is increasing in France, as it remains an affordable product with a positive nutritional image (rich in omega-3).
However, the French sardine fishing fleet is unable to meet this growing demand, partly due to smaller and leaner sardines.

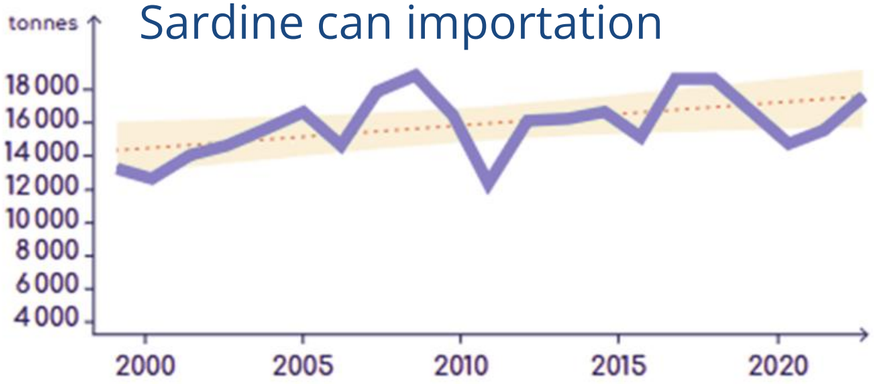
4.2 Impacts on socio-ecological systems and market dynamics

Impacts on **market** dynamics

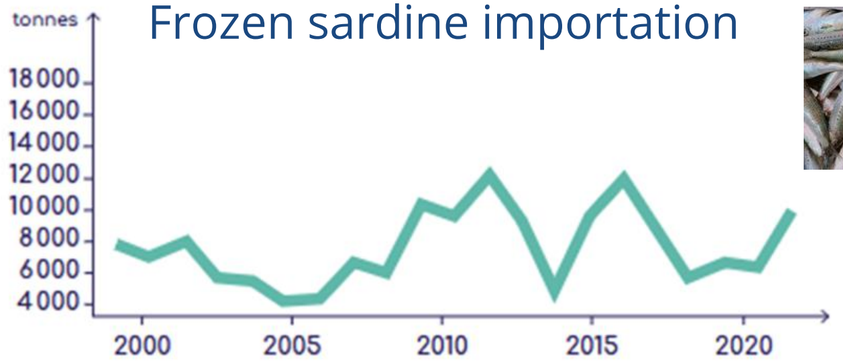
Sardine can consumption in France



Sardine can importation



Frozen sardine importation



Sardine can importation (Morocco, Croatia or Portugal)

Frozen sardine imports for the French canning industry

DEFIPEL, 2023

5.

Advancing SPF life history variation studies: future researches

Future directions

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Planque et al., 2026

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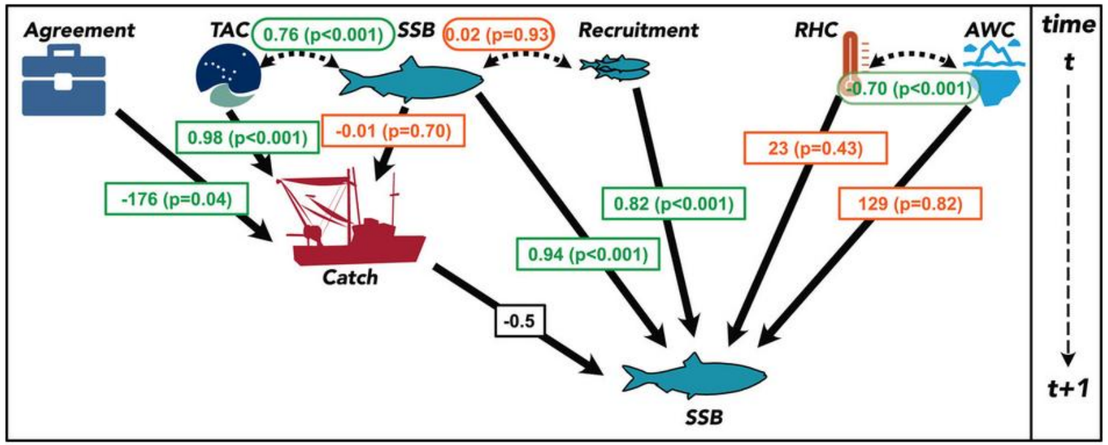
- **Move beyond assessing the resilience of SPF populations in isolation.**

Future studies should forecast the entire socio-ecosystem as a whole, with fish population trajectories under different climate change scenarios, fishing management strategies, and industry transformation pathways.



Planque et al., 2026

Thanks for your attention!

Ifremer

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