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A multi-indicators approach to better characterise littoral pelagic diversity

Eric Goberville
Julien Richirt and Benoit Sautour

Objectives of the talk

- (1) to estimate the **effectiveness** of common diversity indicators to “resume” coastal ecosystems changes
- (2) to investigate the effectiveness of a **multivariate approach** applied on diversity indicators
- (3) to study whether **large-scale hydro-climatic indices** are efficient to characterise diversity changes at a local scale
- (4) to introduce the development of a **niche-based indicator** applied on copepods species

What is the challenge?

Data from monitoring programmes are accumulating

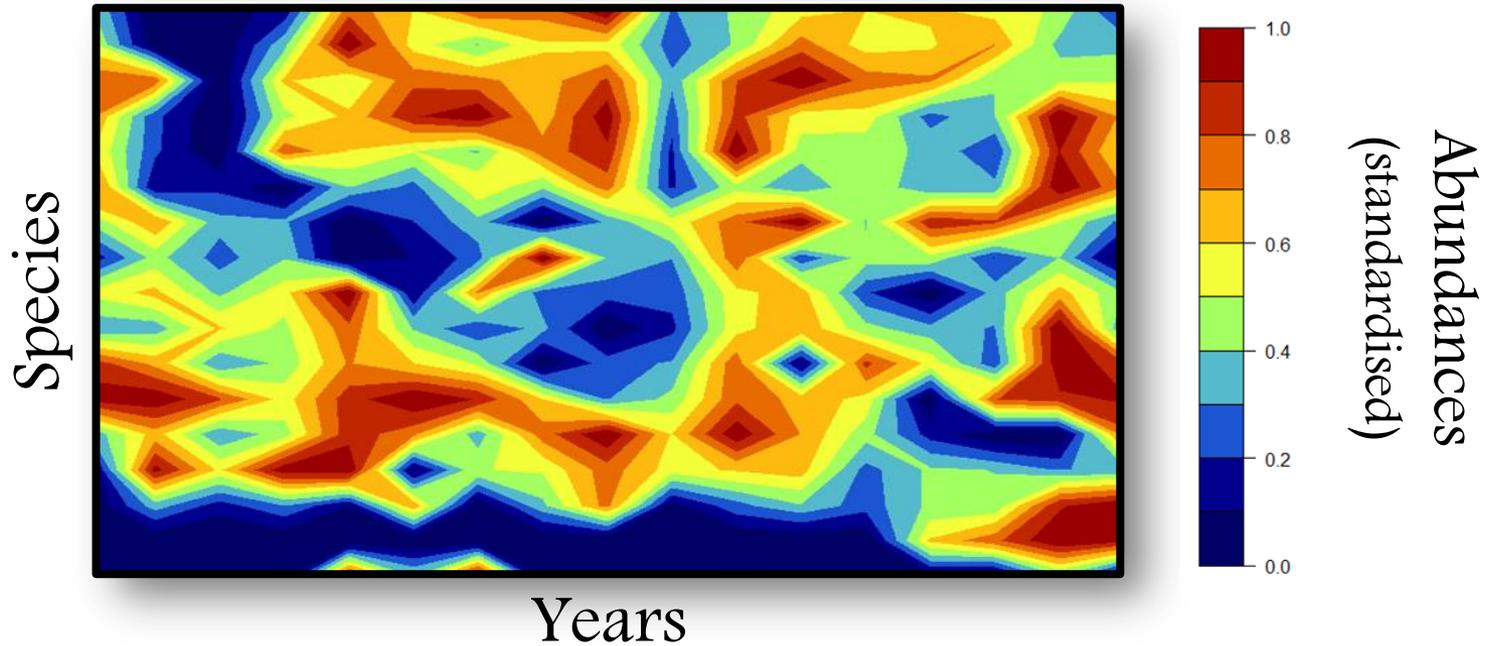
but

- estimating biodiversity patterns
- evaluating consequences of biodiversity changes

remains a

SCIENTIFIC CONUNDRUM

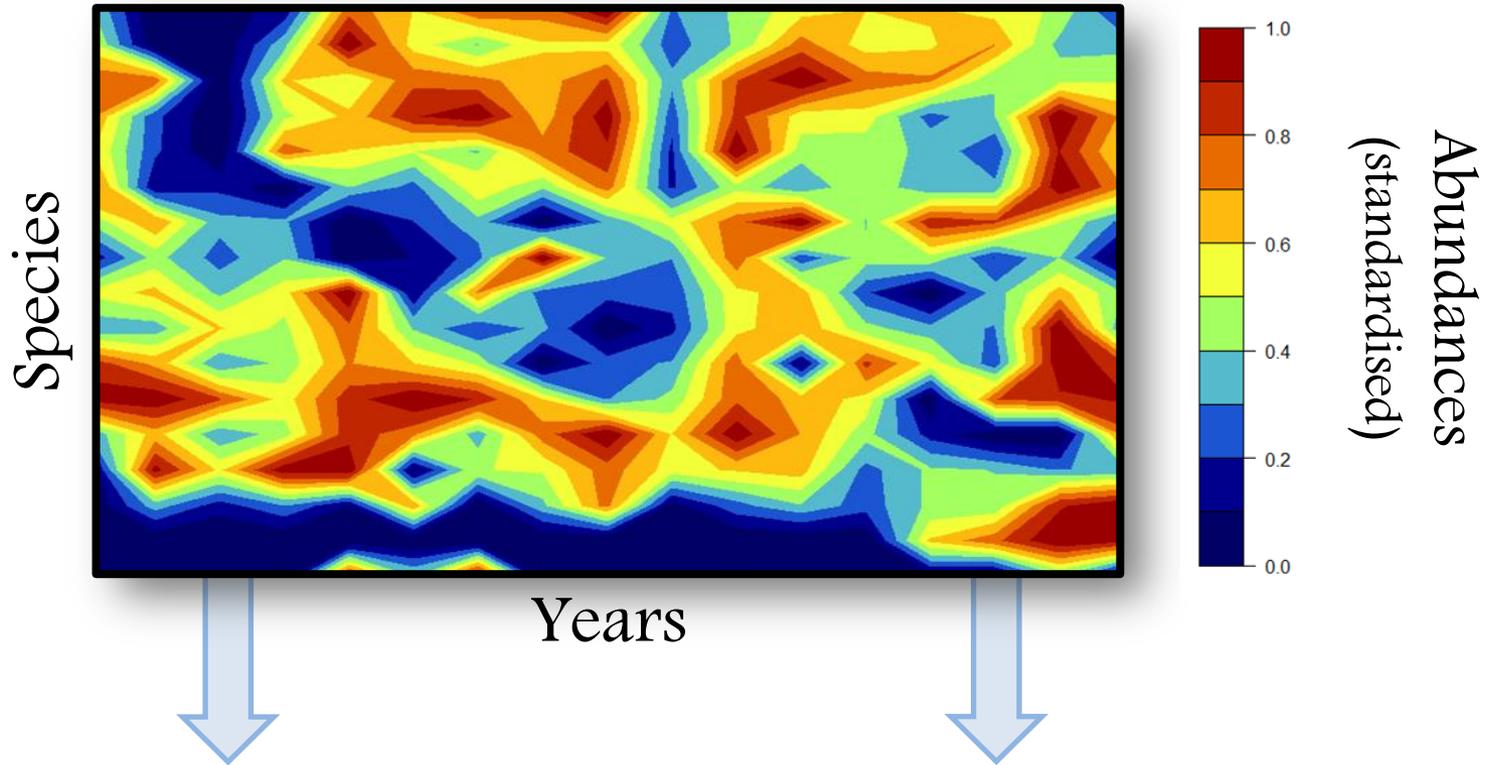
What is the challenge?



Example:

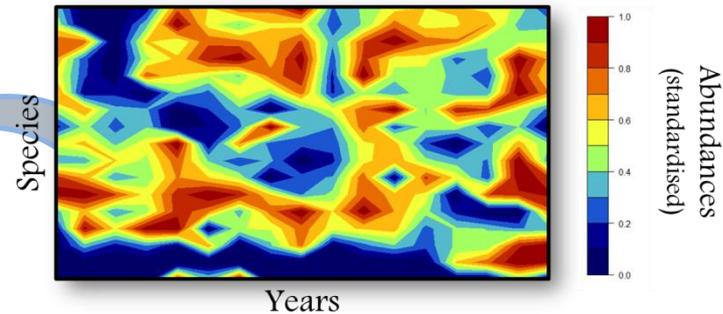
15 years of sampling, 1 site, 17 species

What is the challenge?



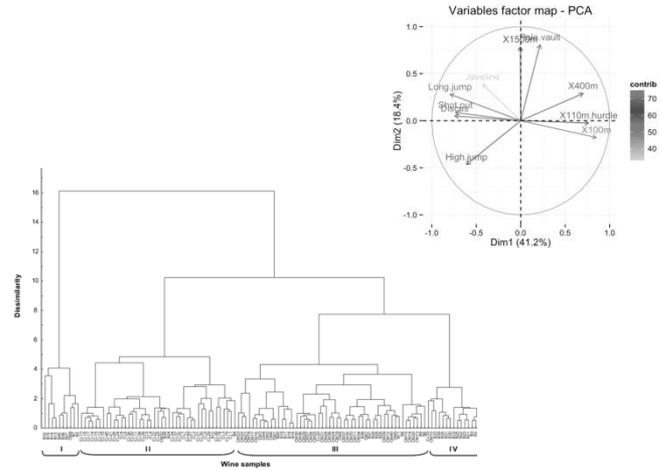
**How to summarise the structure of ecosystems?
How to detect changes?**

How to address the issue?

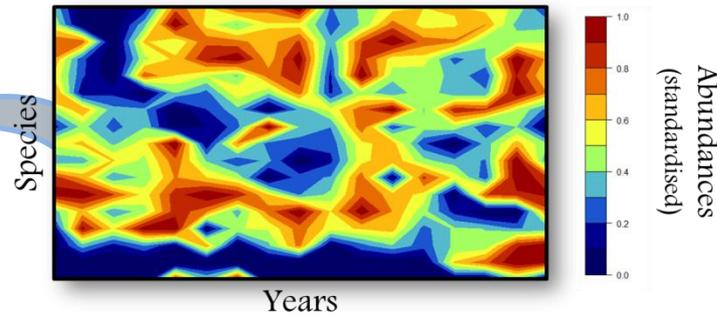


Using multivariate procedures

(i.e. principal component analysis,
non-metric multidimensional
scaling, clustering...)

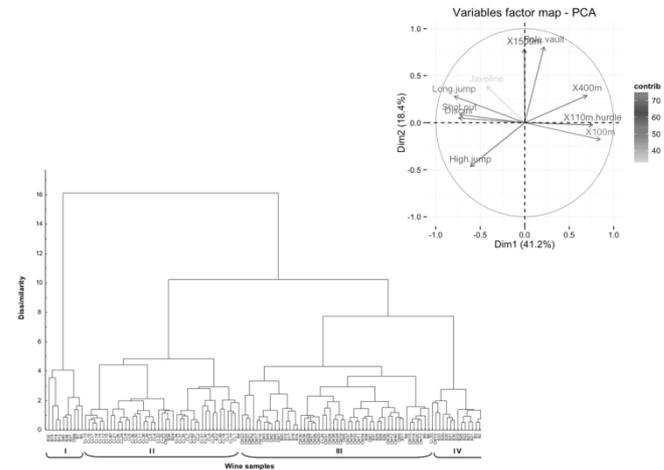


How to address the issue?



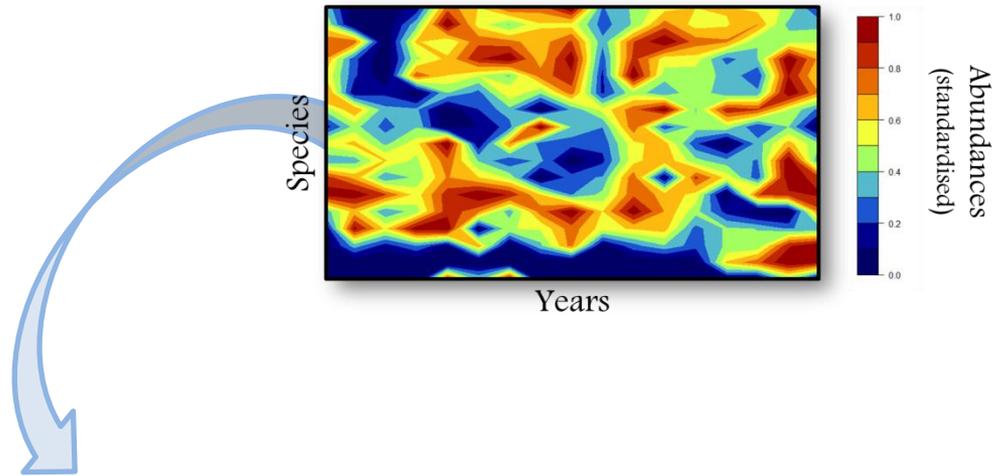
Using multivariate procedures

(i.e. principal component analysis, non-metric multidimensional scaling, clustering...)



➤ come with their own rules and assumptions that may make analysis complex and difficult to interpret

How to address the issue?



Using diversity indicators

(i.e. Species richness, Shannon, Simpson, Berger–Parker, Odum, Pielou, Margalef, McIntosh, Jaccard index and its components...)

**and far from being
exhaustive!!**

$$D = \sum_{i=1}^S \frac{n_i(n_i - 1)}{N(N - 1)}$$

$$H' = \sum_{i=1}^S (p_i)(\ln p_i)$$

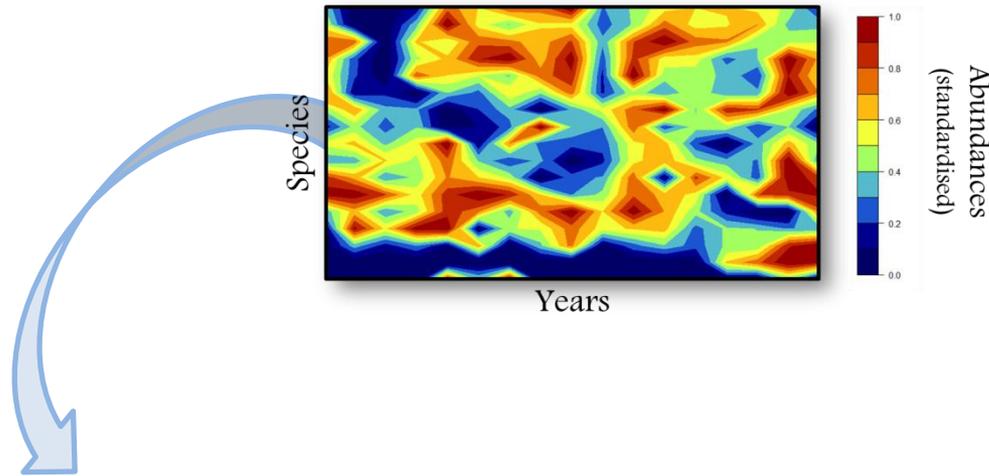
...

What is a good indicator?

An indicator should have the following characteristics:

- Policy relevant and meaningful
- Biodiversity relevant
- Scientifically sound and methodologically well founded
- Easy to understand
- Based on affordable monitoring, available and routinely collected data
- Amenable to modelling of cause-effect relationships
- Good spatial and temporal coverage of data
- Applicable at a national scale
- Aggregation possible at a range of scales
- Sensitive to change
-

How to address the issue?



Using diversity indicators

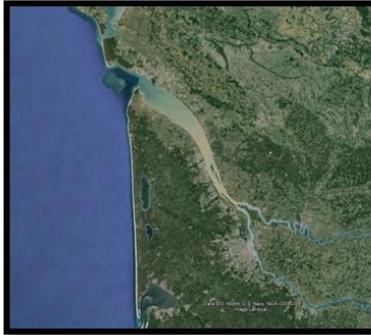
(i.e. Species richness, Shannon, Simpson, Berger–Parker, Odum, Pielou, Margalef, McIntosh, Jaccard index and its components...)

➤ Which indicator should we choose to “resume” ecosystem state?

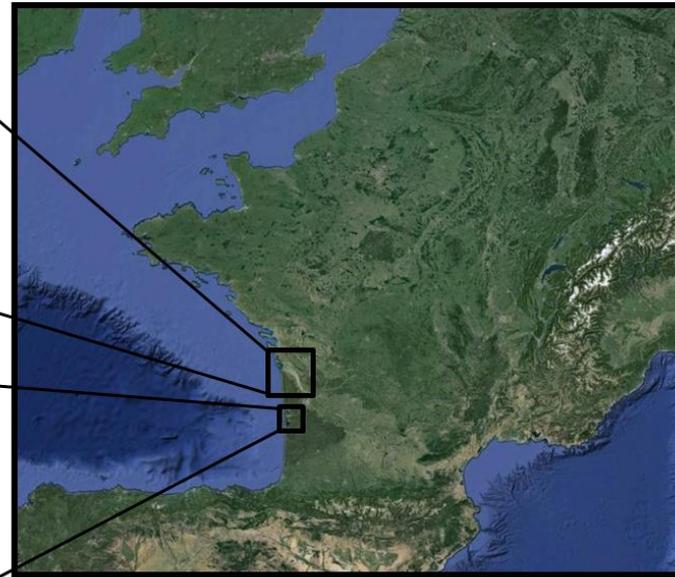


Location of the studied sites

Gironde estuary



Western Europe



Arcachon Bay



- Two ecosystems geographically adjacent but highly contrasted (a semi-enclosed bay *vs* an estuary)

Biological data

Focus on copepod species

- ✓ Dominant members of the zooplankton
- ✓ Prominent role in the dynamic and stability of ecosystems
 - ✓ Integrate rapidly environmental signals

Biological data

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SOMLIT programme

Using data from 1998 to 2014



Arcachon

17 species



Gironde

17 species

13 species are present in both ecosystems

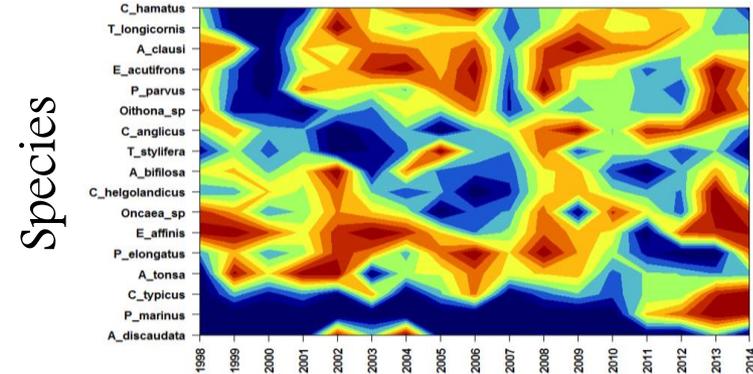
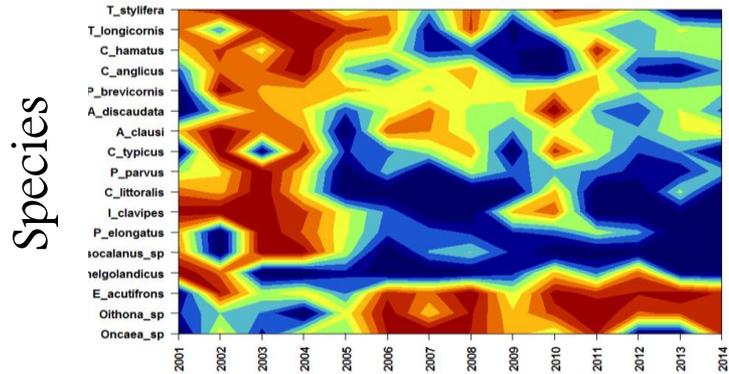
Year-to-year changes in copepod assemblages



Arcachon



Gironde



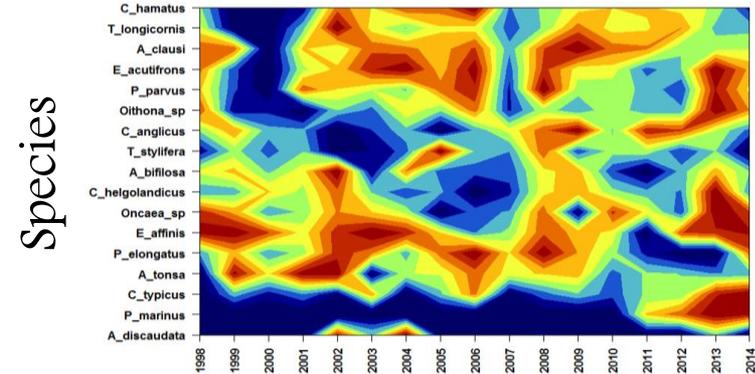
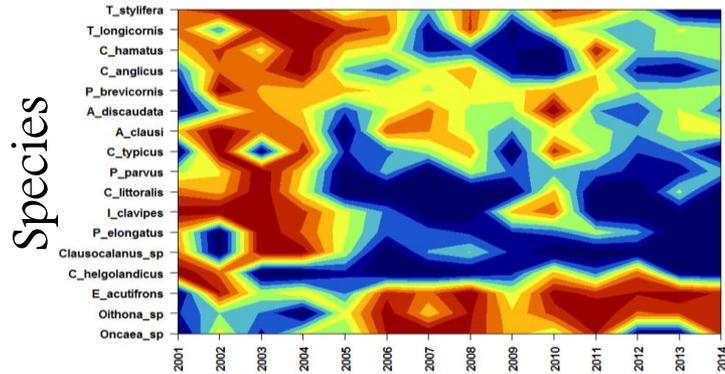
Year-to-year changes in copepod assemblages



Arcachon



Gironde



Year-to-year changes

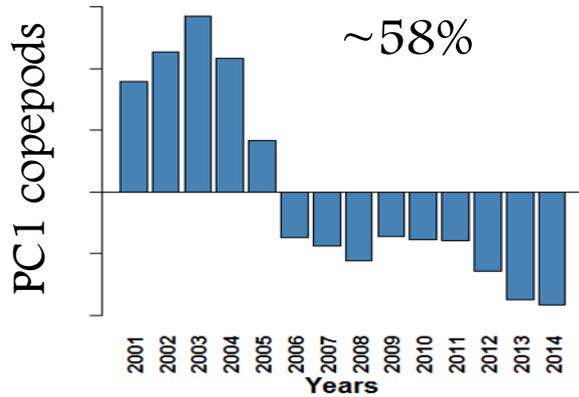


Standardised principal component analysis

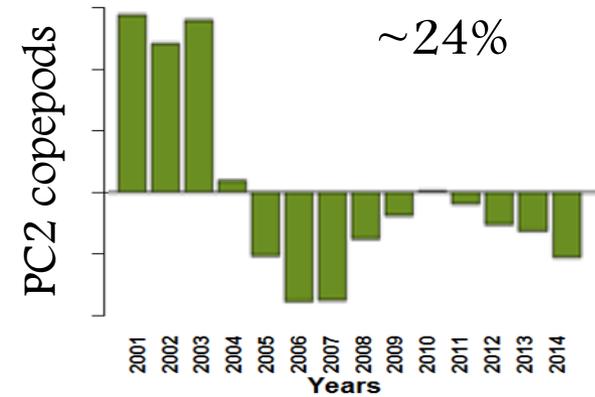
Year-to-year changes in copepod assemblages



Arcachon



Gironde



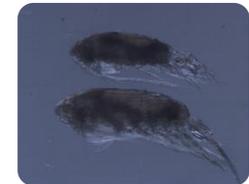
P. parvus



Oithona sp.



T. longicornis



A. discaudata

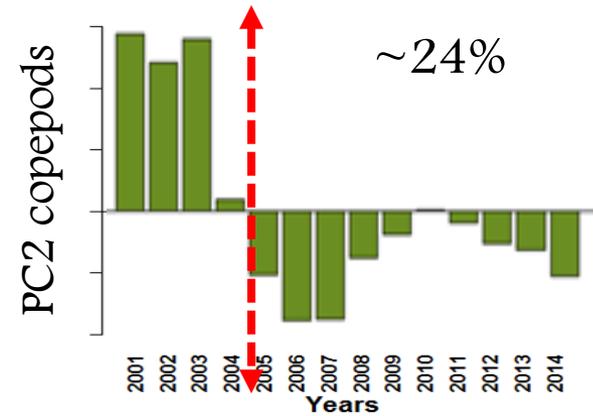
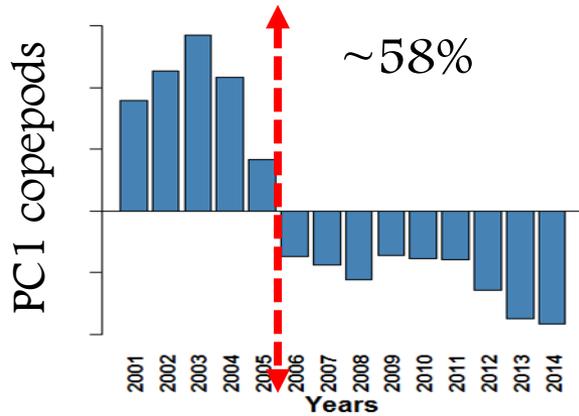
Year-to-year changes in copepod assemblages



Arcachon



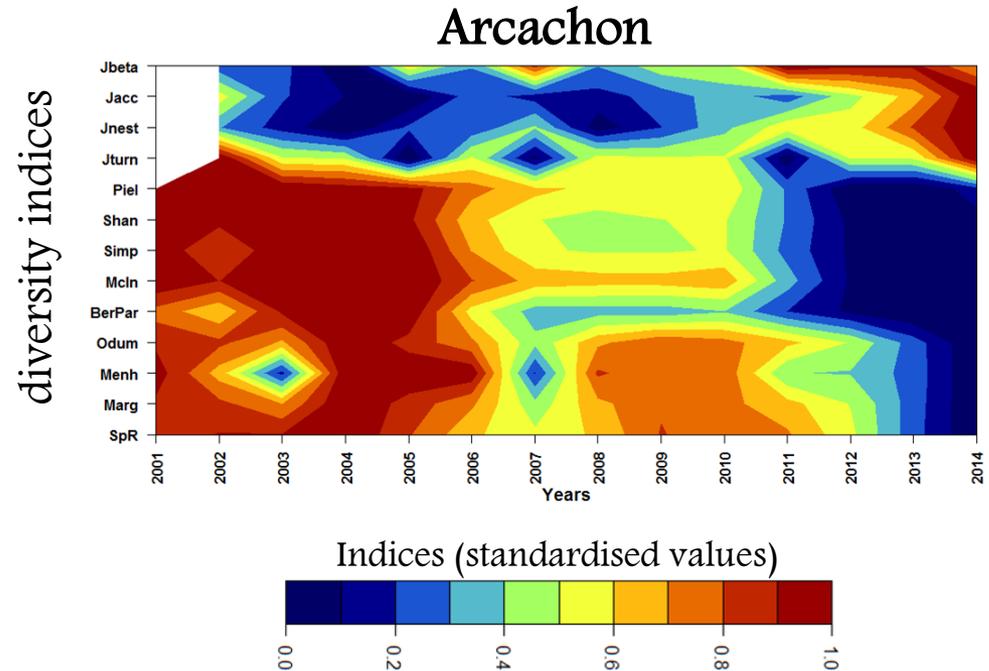
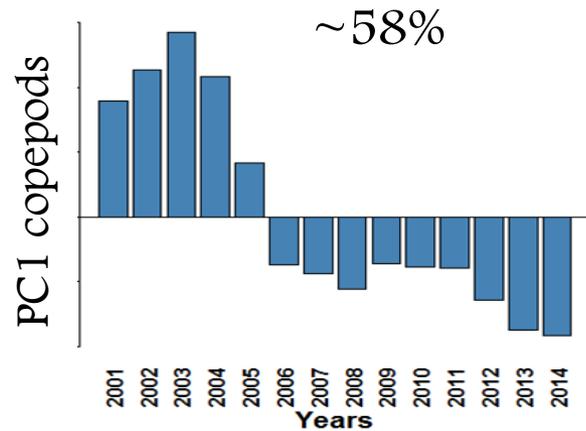
Gironde



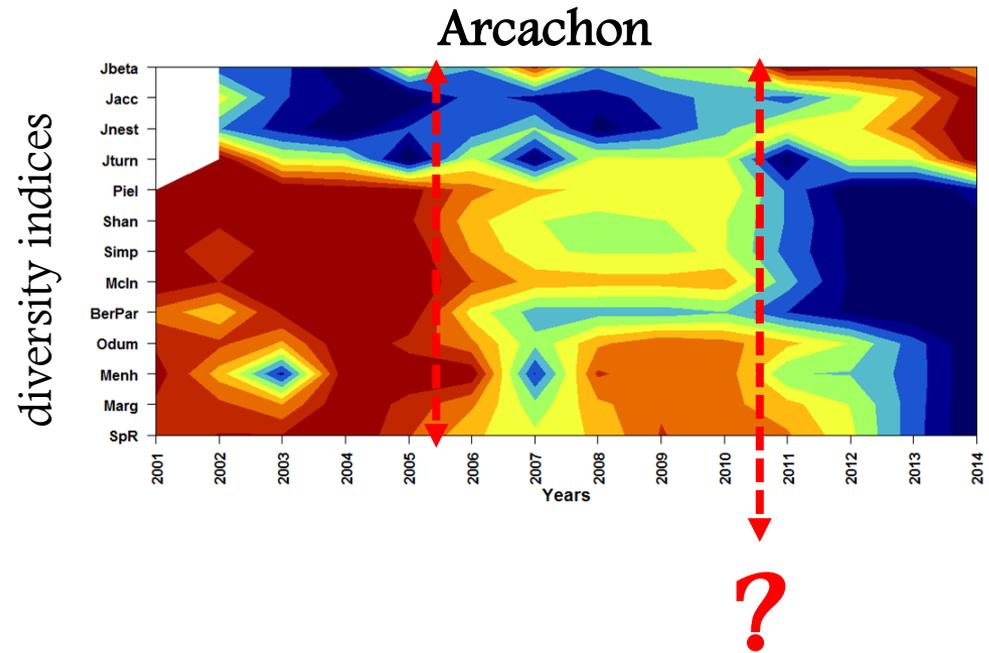
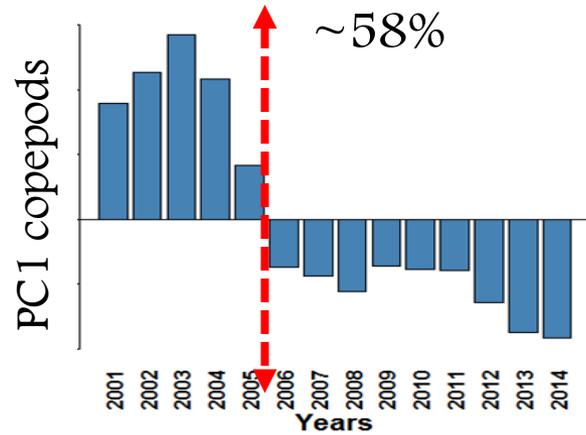
Change in copepod assemblages detected circa 2005

Effectiveness of common diversity indicators

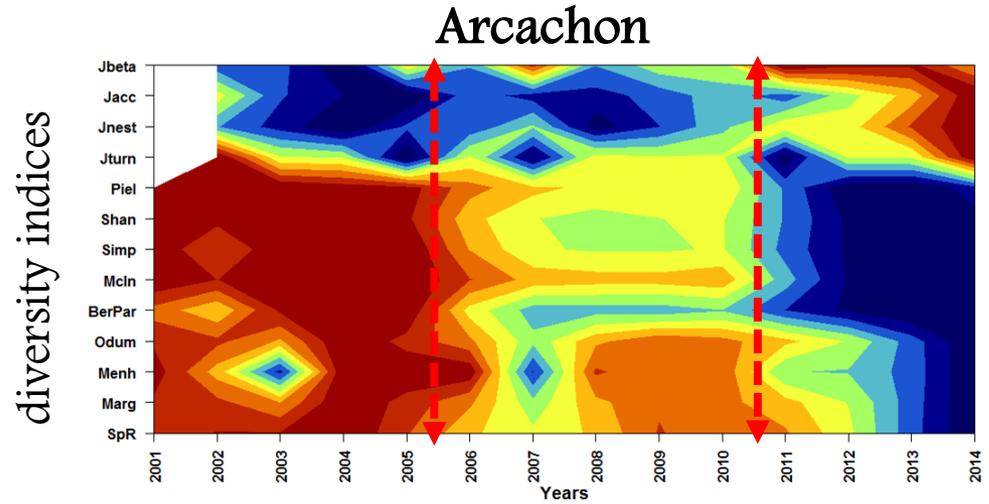
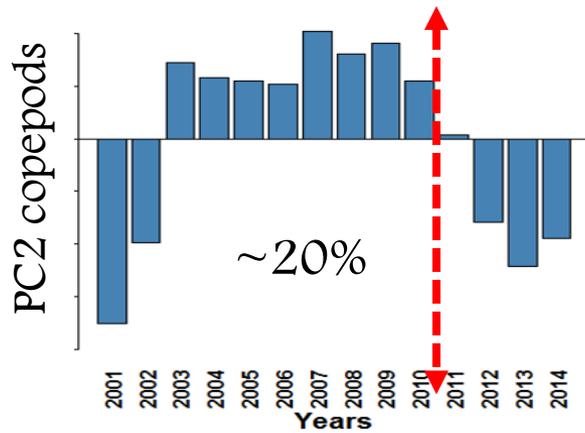
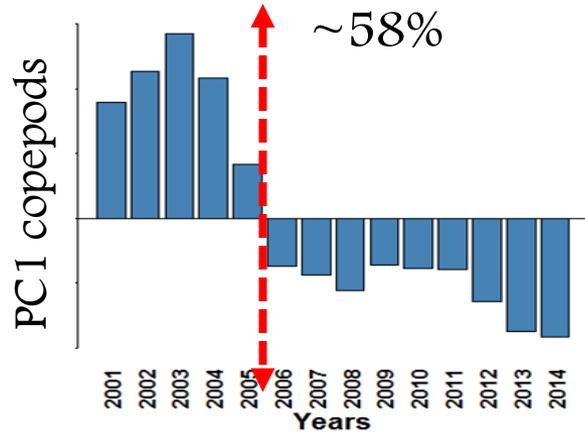
Calculation of 13 common diversity indicators and comparison with year-to-year changes extracted by PCA



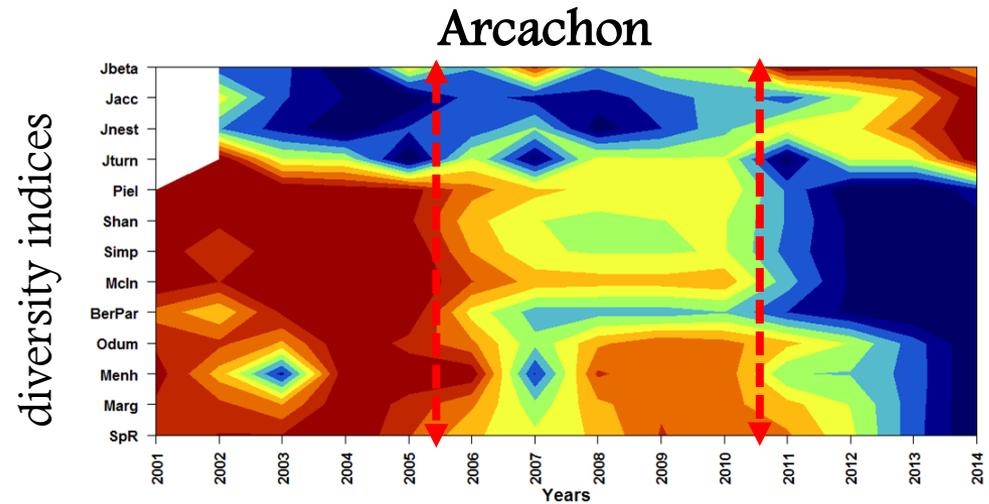
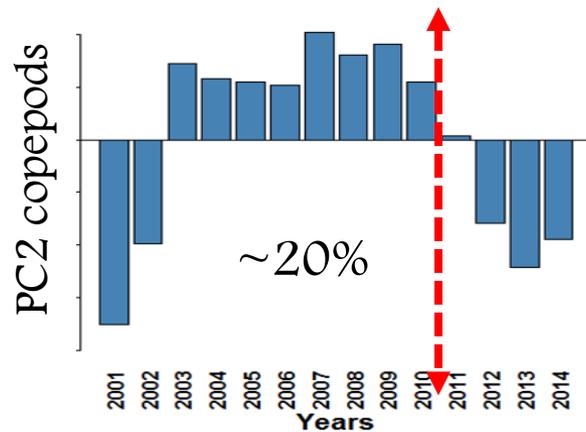
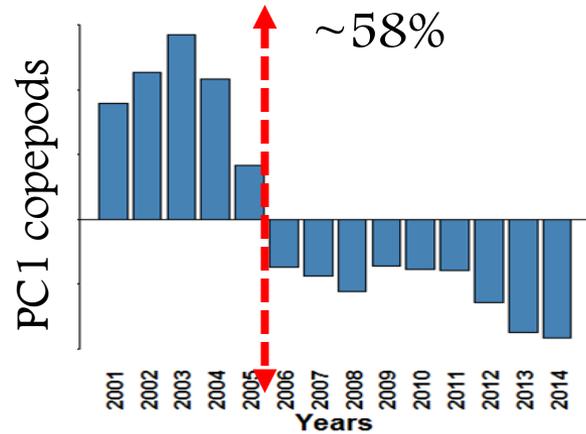
Effectiveness of common diversity indicators



Effectiveness of common diversity indicators

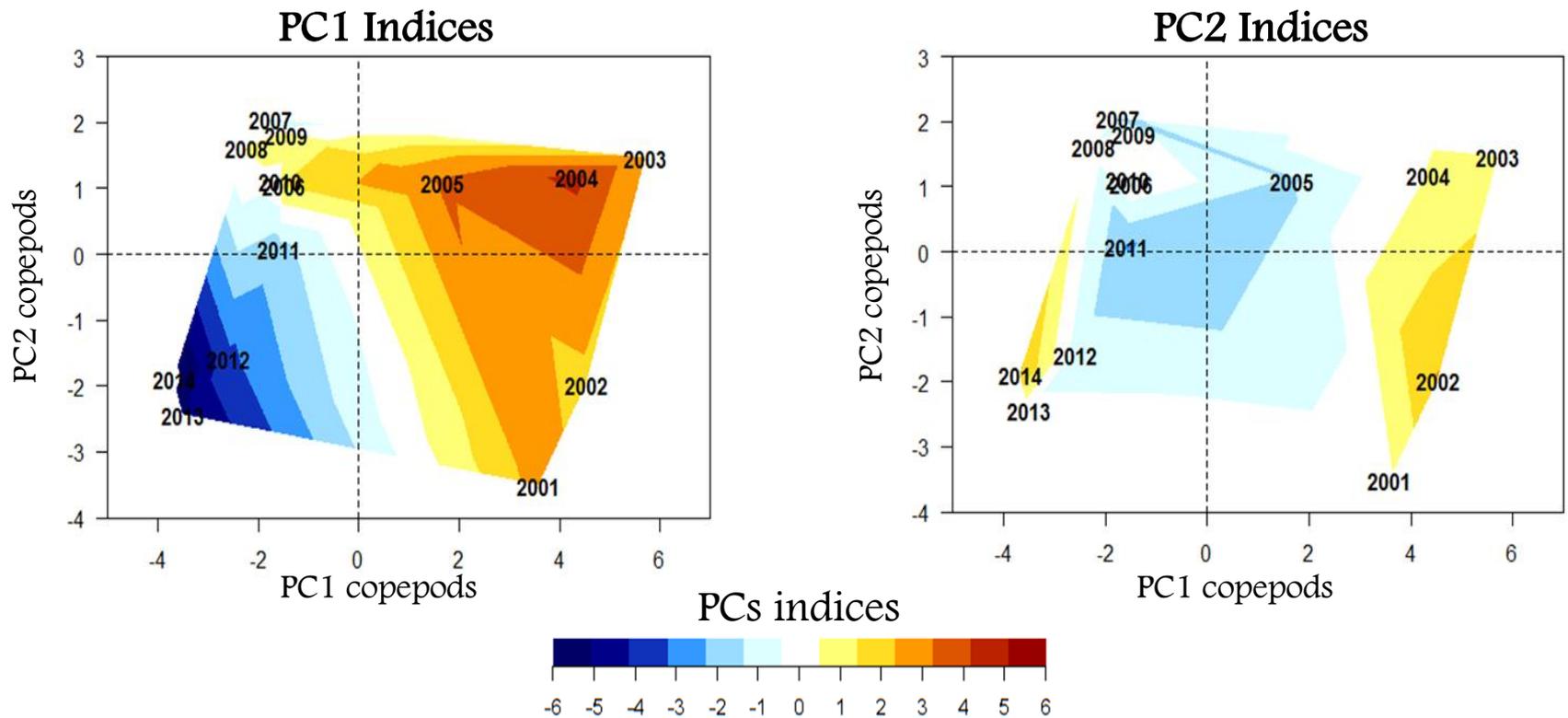


Effectiveness of common diversity indicators

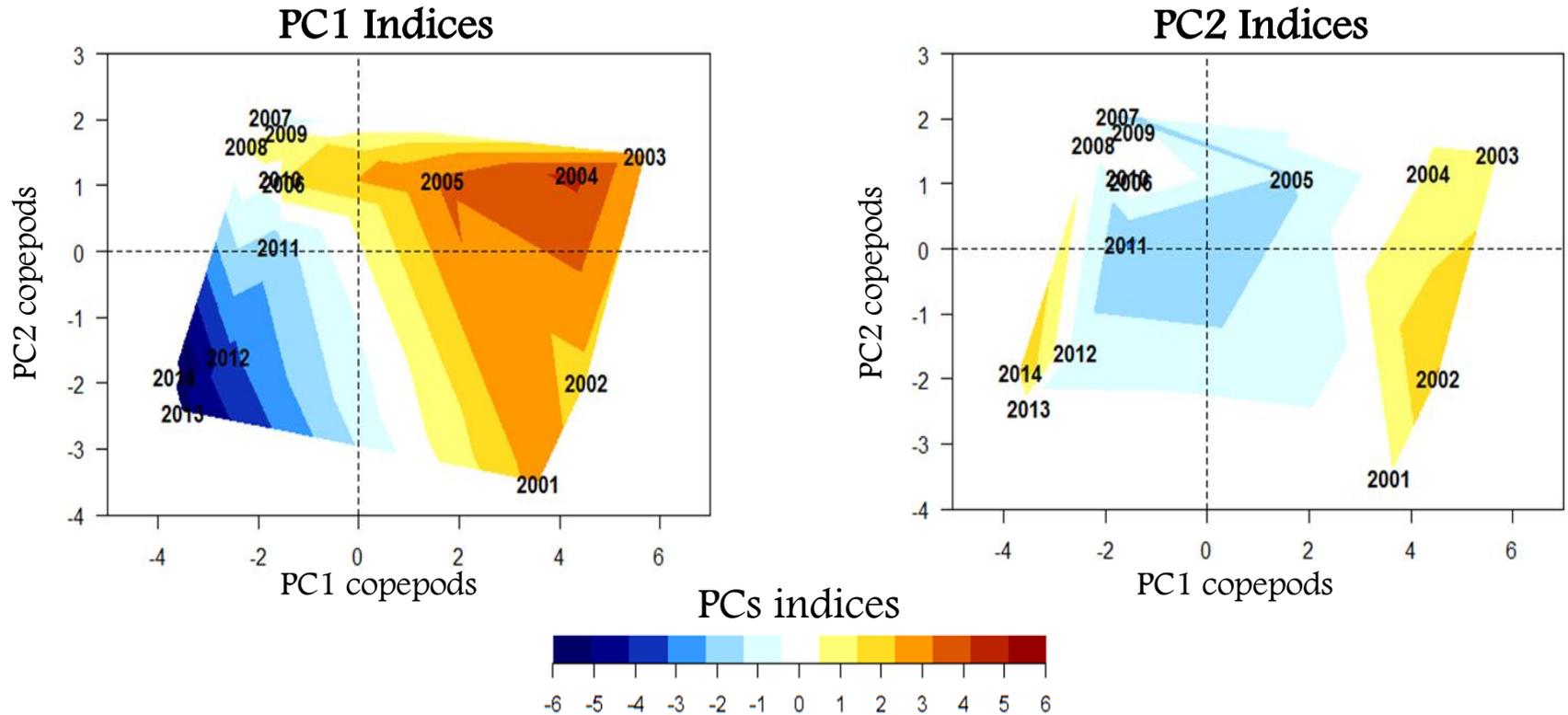


Diversity indices are relevant to characterise year-to-year changes in copepod assemblages

Effectiveness of common diversity indicators



Effectiveness of common diversity indicators



The two approaches highlight 3 periods with distinct diversity “characteristics”

Transition periods in 2005/2006 and 2011/2012

Influence of large-scale indices?

EAP

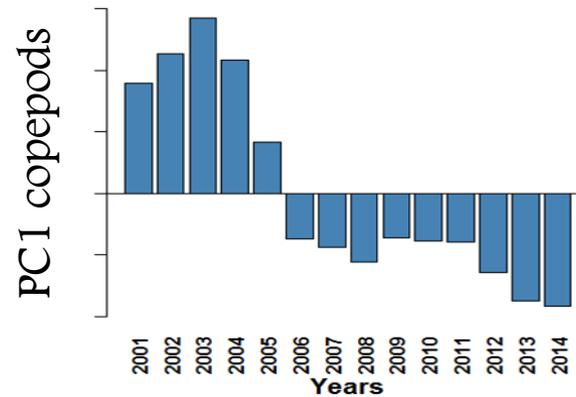
NAO

NHT

AO



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No direct influence of large-scale indices

EAP

$r = -0.11$
 $p = 0.66$

NAO

$r = 0.38$
 $p = 0.21$

NHT

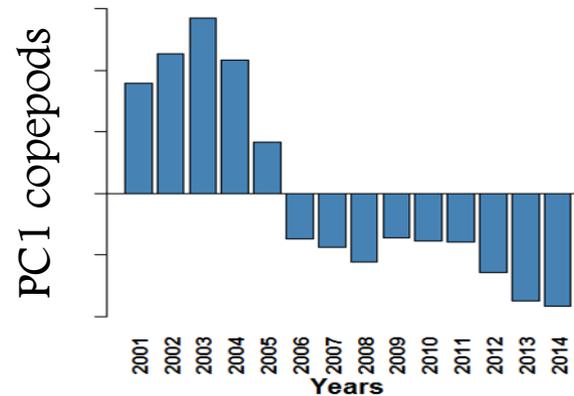
$r = -0.34$
 $p = 0.26$

AO

$r = 0.20$
 $p = 0.51$

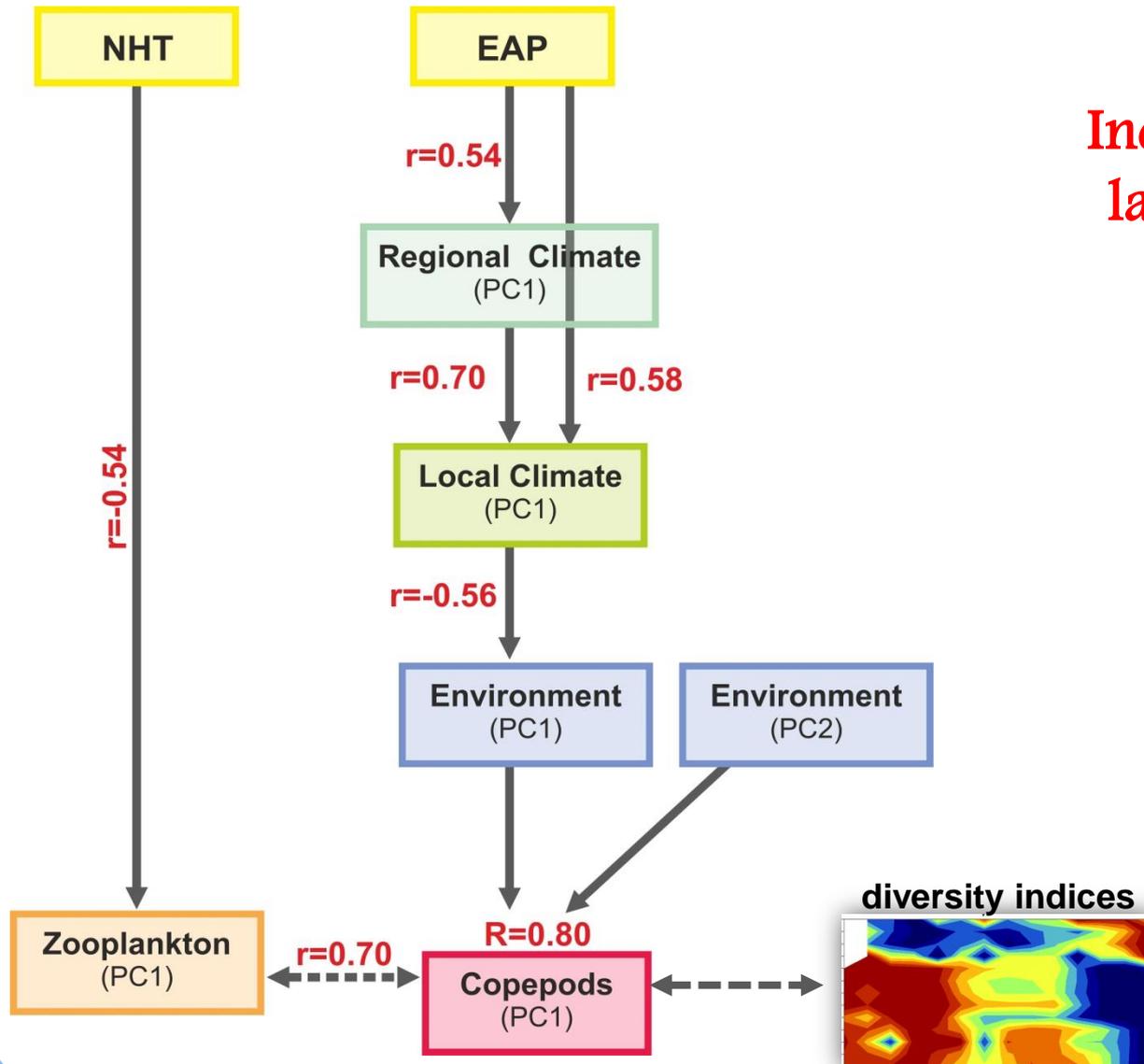


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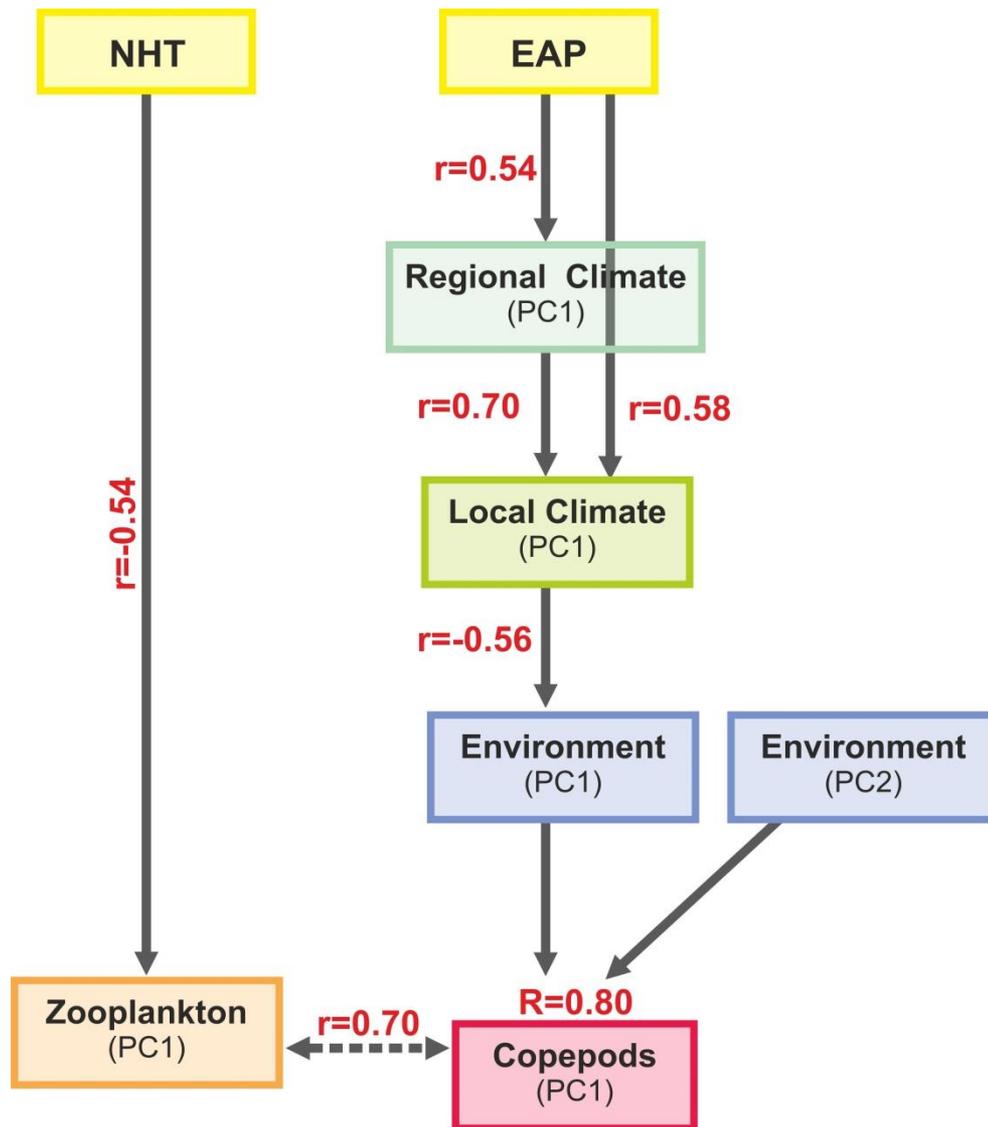
No direct influence
of large-scale indices
on changes in
copepod assemblages

But an indirect influence: a “cascade effect”

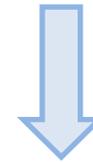


Indirect influence of large-scale indices

But an indirect influence: a “cascade effect”

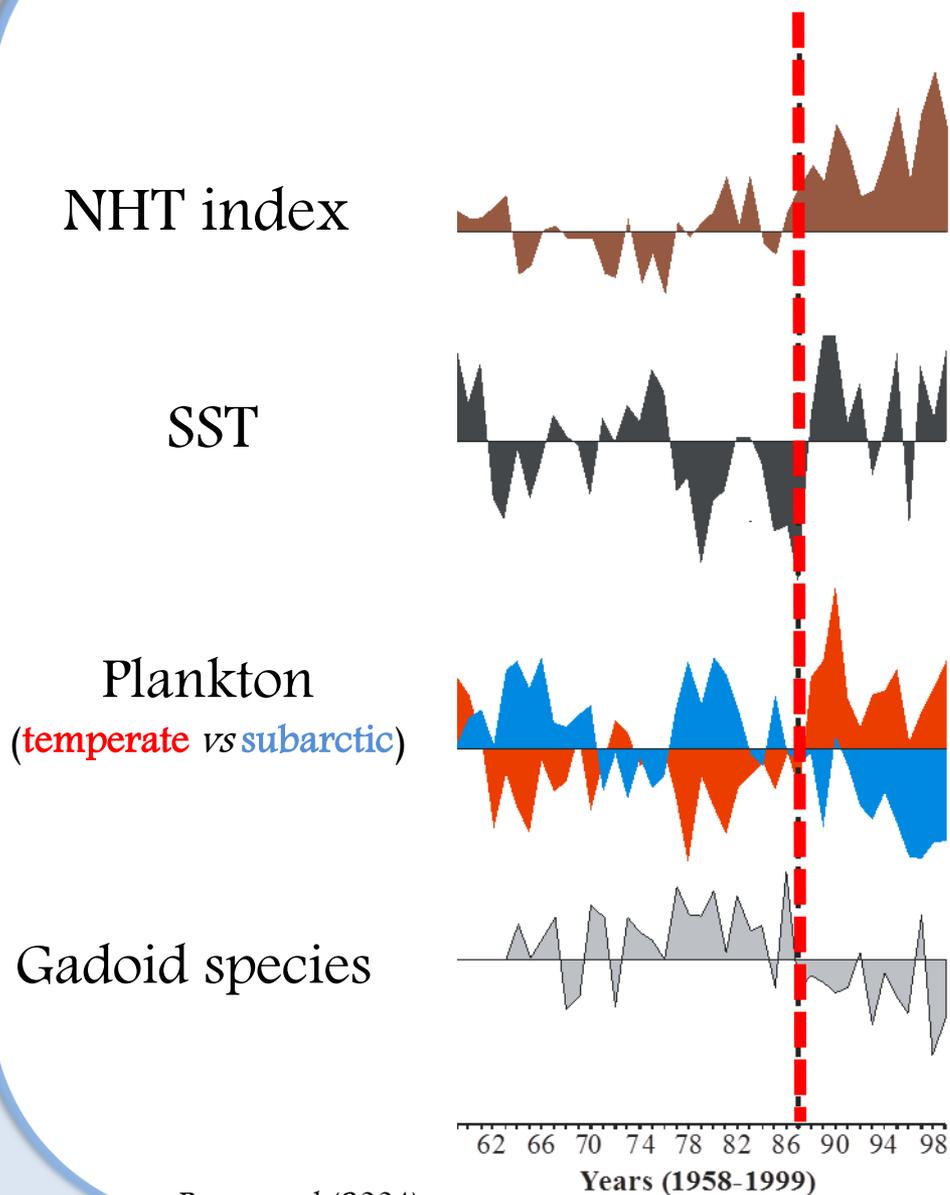


Indirect influence of large-scale indices

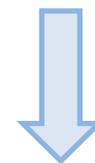


At local scale, diversity indices are more effective than large-scale indices to detect changes in copepod assemblages

In the North Sea



Strong influence of a large-scale index (NHT anomalies) on copepod assemblages



Detecting the influence of large-scale indices might be dependent of the spatial and temporal scale of the study

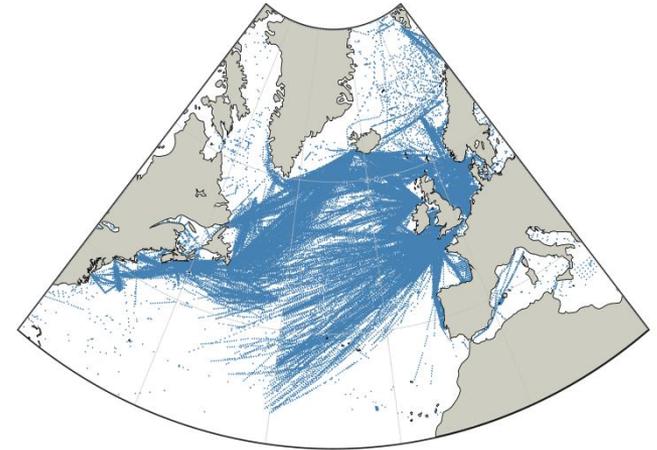
Adaptation of a thermal niche-based indicator

(deVictor, 2008)

Birds are tracking climate warming, but not fast enough

Vincent Devictor^{1,2}, Romain Julliard¹, Denis Couvet¹ and Frédéric Jiguet²

- Calculating monthly **STI** for ~80 copepod species (based on observations at the scale of the North Atlantic; **mainly CPR data**)
- Identifying copepods **assemblages**
- Calculating **CTI** for each assemblage
- **Testing the relevance** of CTIs
 - (i) at large and local scales
 - (ii) at different temporal scales
 - (iii) *vs* other diversity indices

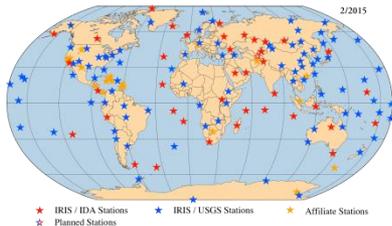


Concluding remarks

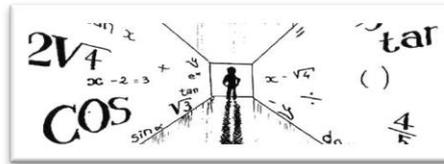
If climate change continues to rates projected by the IPCC, ecosystems and their biodiversity will suffer profound alterations...

IT IS THEREFORE CRUCIAL

to encourage
(and finance)
monitoring programmes



to elaborate
statistical tools
and indicators



to identify to
species-level



to better evaluate and manage ecosystems health

Special thanks to:

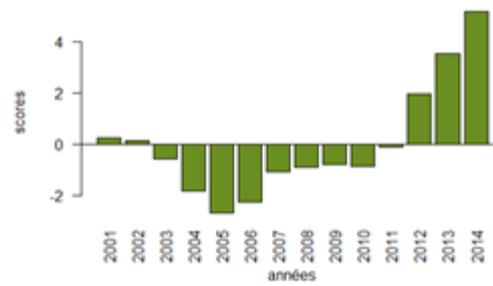
The Region Nord – Pas-de-Calais
for financial support

The SOMLIT and CPR teams
for providing biological and environmental data

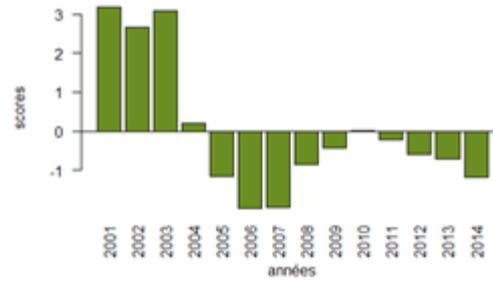
The scientific steering and local organizing committee,
the conveners of this workshop and all participants

And, of course, my colleagues...

c) PC1 : 36.9%



d) PC2 : 23.4%



e) PC3 : 19.1%

