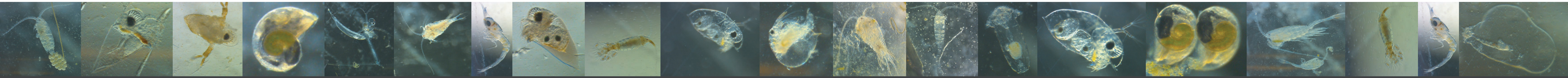


# Validating the performance of zooplankton as ecological state indicator - a European comparison

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## Why zooplankton as indicator?

Zooplankton is the main link between phytoplankton and zooplanktivorous fish and can be even used to forecast fisheries status. Also, zooplankton species are

- (1) highly sensitive to environmental changes
- (2) rapidly reproducing organisms with wide dispersal ability,
- (3) transfer environmental signals over short time scales, and
- (4) ubiquitous in the ocean

## What is a good indicator?

- meaningful and grounded in research
- simple to measure and cost-effective
- **sensitive** to environmental changes
- **robust** (predictable over time)
- **specific** to pressures
- **not redundant**
- **applicable** across wide set of systems

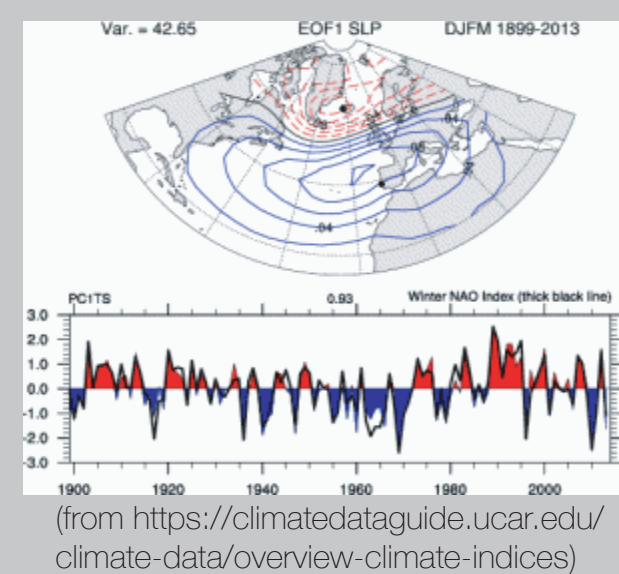
These performance criteria relate to the quality of the data and sampling design!

Most work related to the implementation of marine management strategies focuses more on defining and setting reference and target levels and less on testing for the indicators' performance.

## Tested zooplankton indicators

- ① **Diversity-based:**
  - Species Richness
  - Shannon Index
  - Pielou's Evenness
- ② **Stock-based:**
  - Total Abundance
  - Total Biomass
- ③ **Trait-based:**
  - Mean size
- ④ **Compositional:**
  - Taxa abundances

## Climatic & interacting pressure variables



### Large-scale climate indices:

- North Atlantic Oscillation (NAO)
- Arctic Oscillation (AO)
- Atlantic Multi-decadal Oscillation (AMO)

### Regional-scale climate pattern:

- Summer sea surface temperature (Temp)
- Summer sea surface salinity (Sal)
- Winter deepwater salinity (Sal<sub>deep</sub>) (only Baltic)

### Interacting pressures:

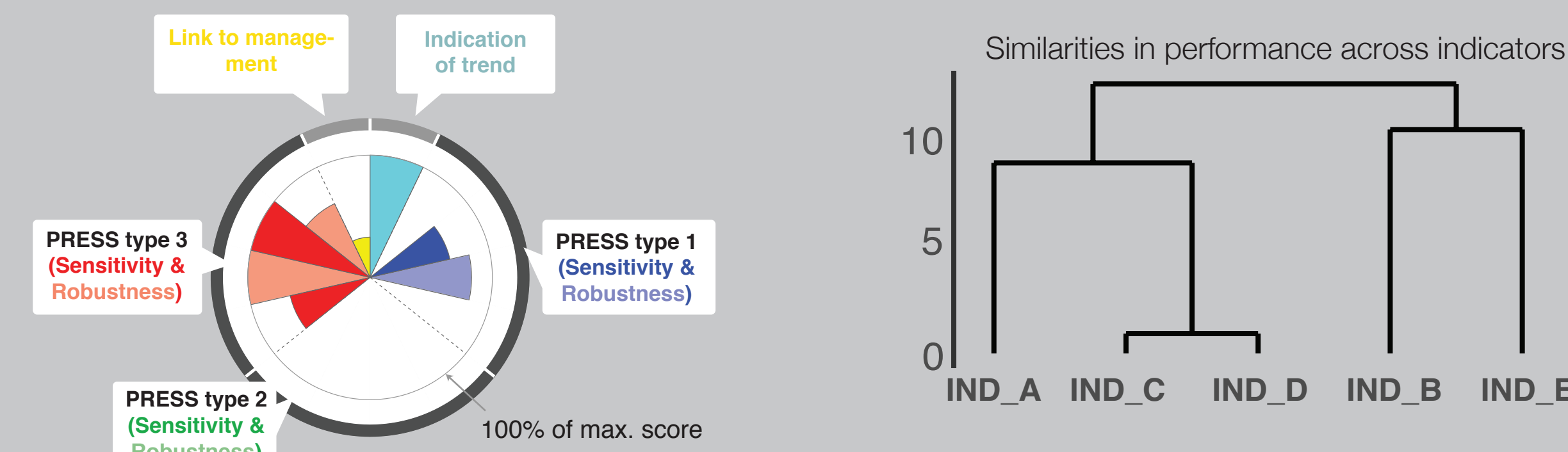
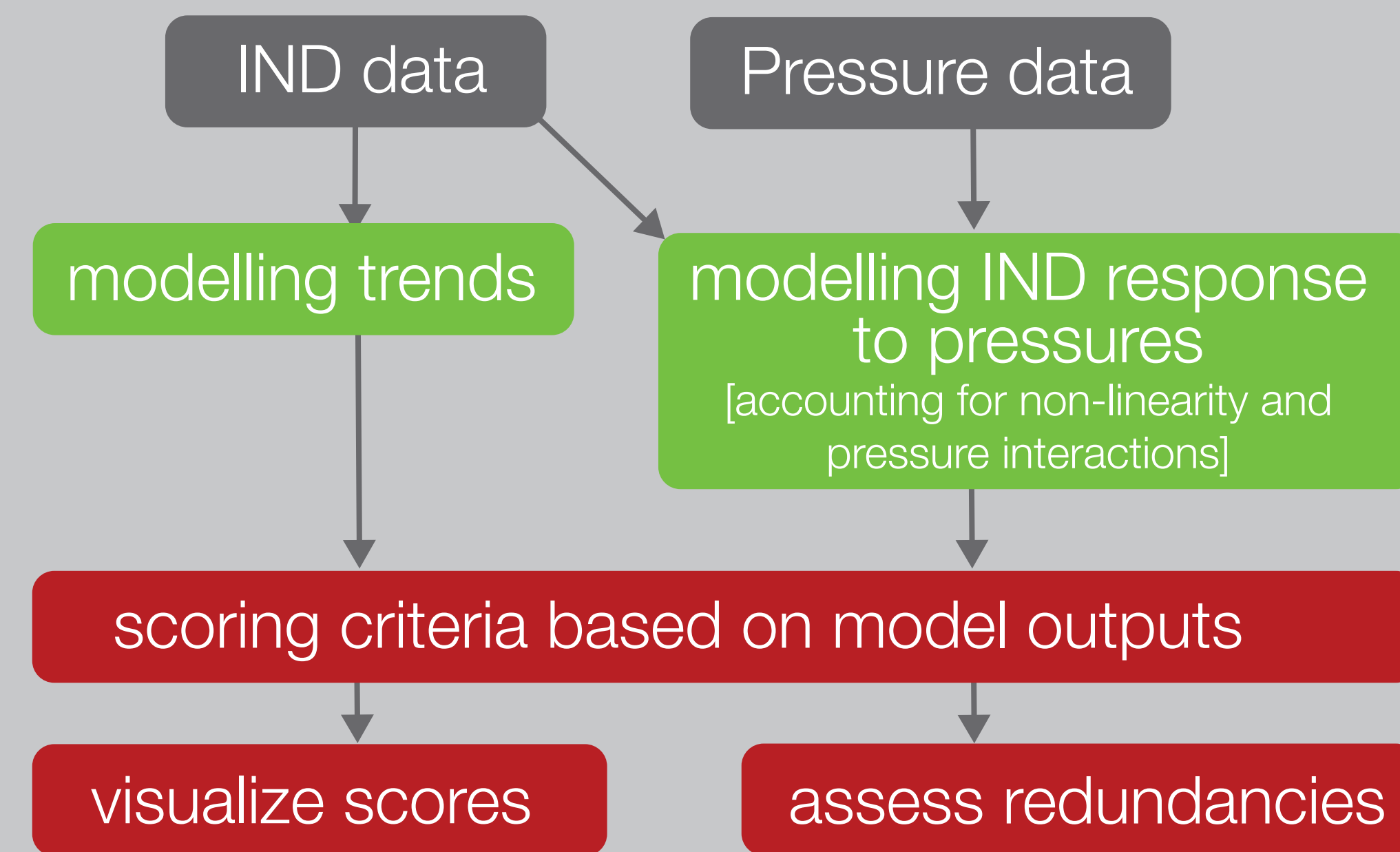
- planktivorous fish catch
- nutrient concentrations (only Baltic)



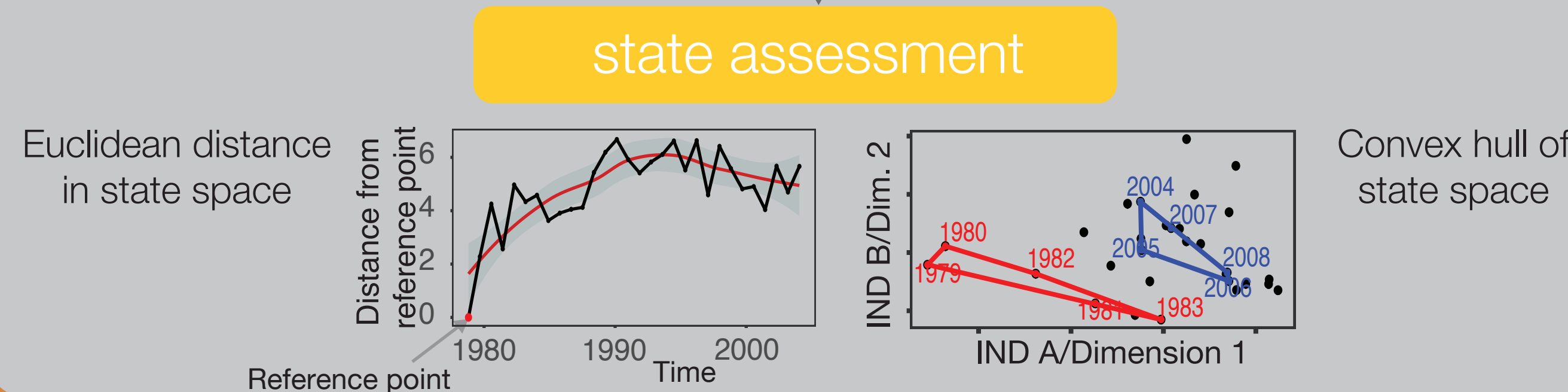
## A new R package for testing INDicators

INDperform is a toolbox that implements the **quantitative framework** for selecting and validating indicators **described in Otto et al. (2018)**. The package **provides functions to test and score indicators** as well as **to assess the ecosystem status**, including a demo dataset of food web indicators and pressure variables. It features the following advantages

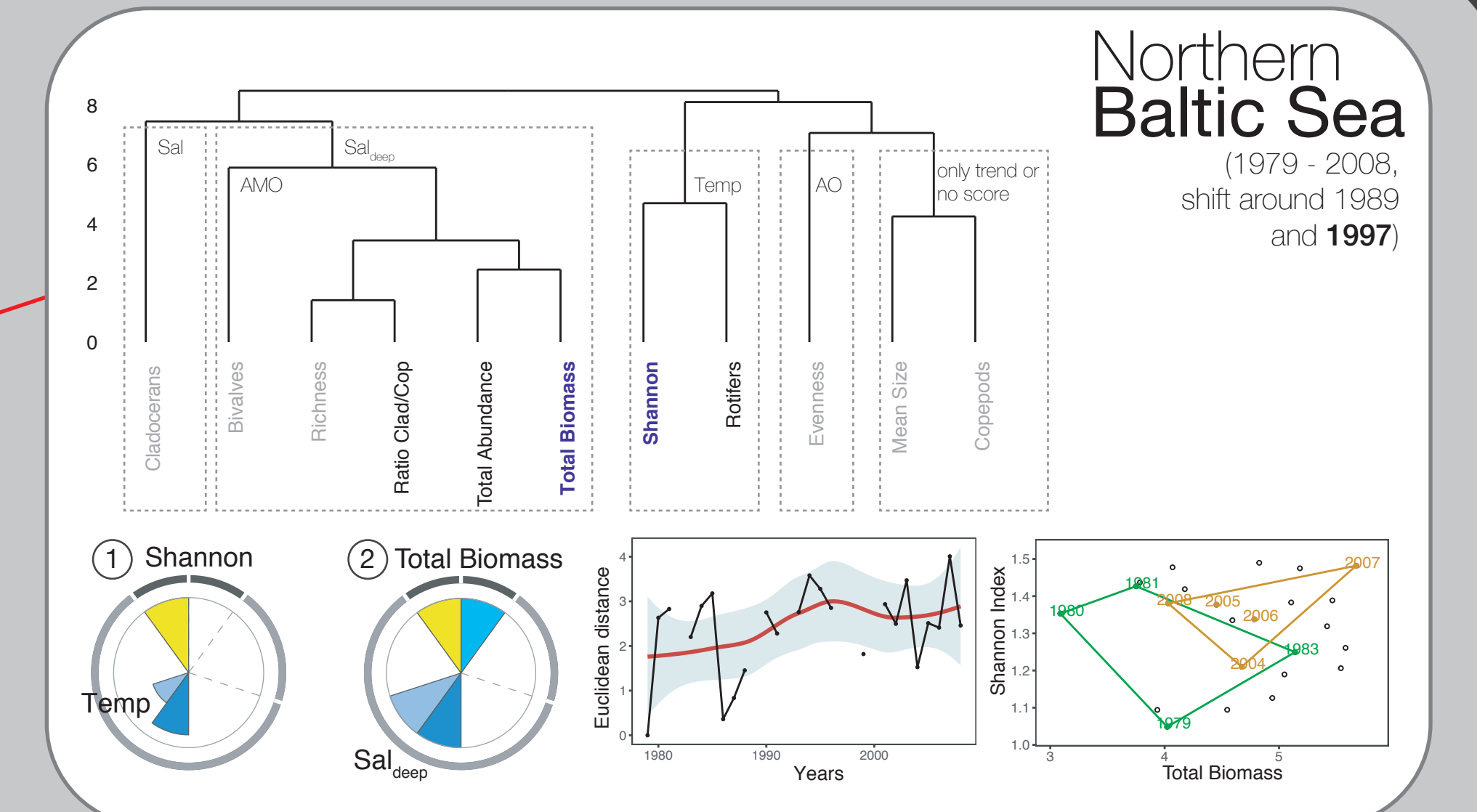
- **simple** implementation of the framework,
- **many** indicators can be **tested within minutes**
- criteria and scoring scheme can be **easily adjusted**
- analysis splits into **train and test data** - allows for testing **robustness after regime shifts**



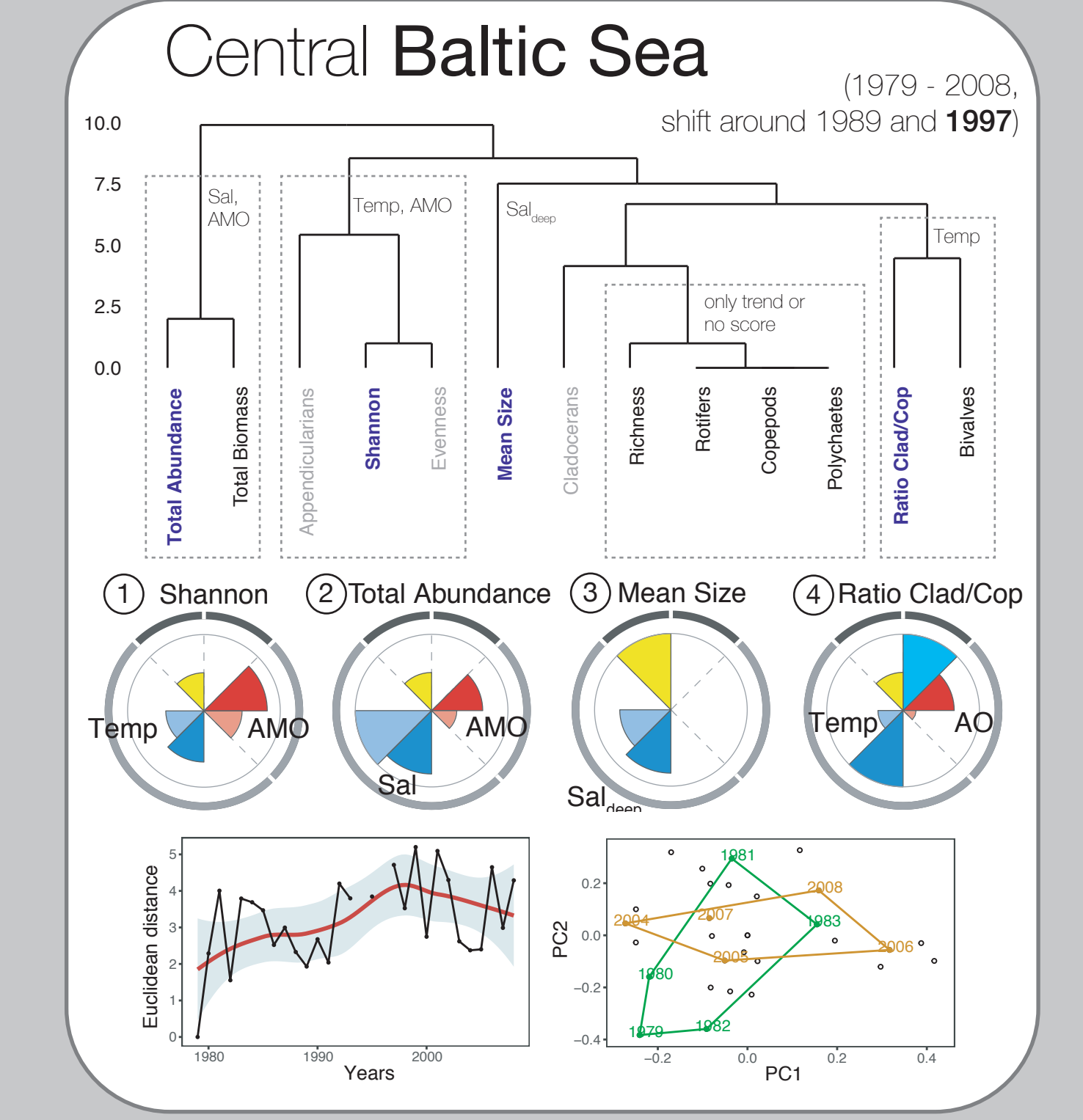
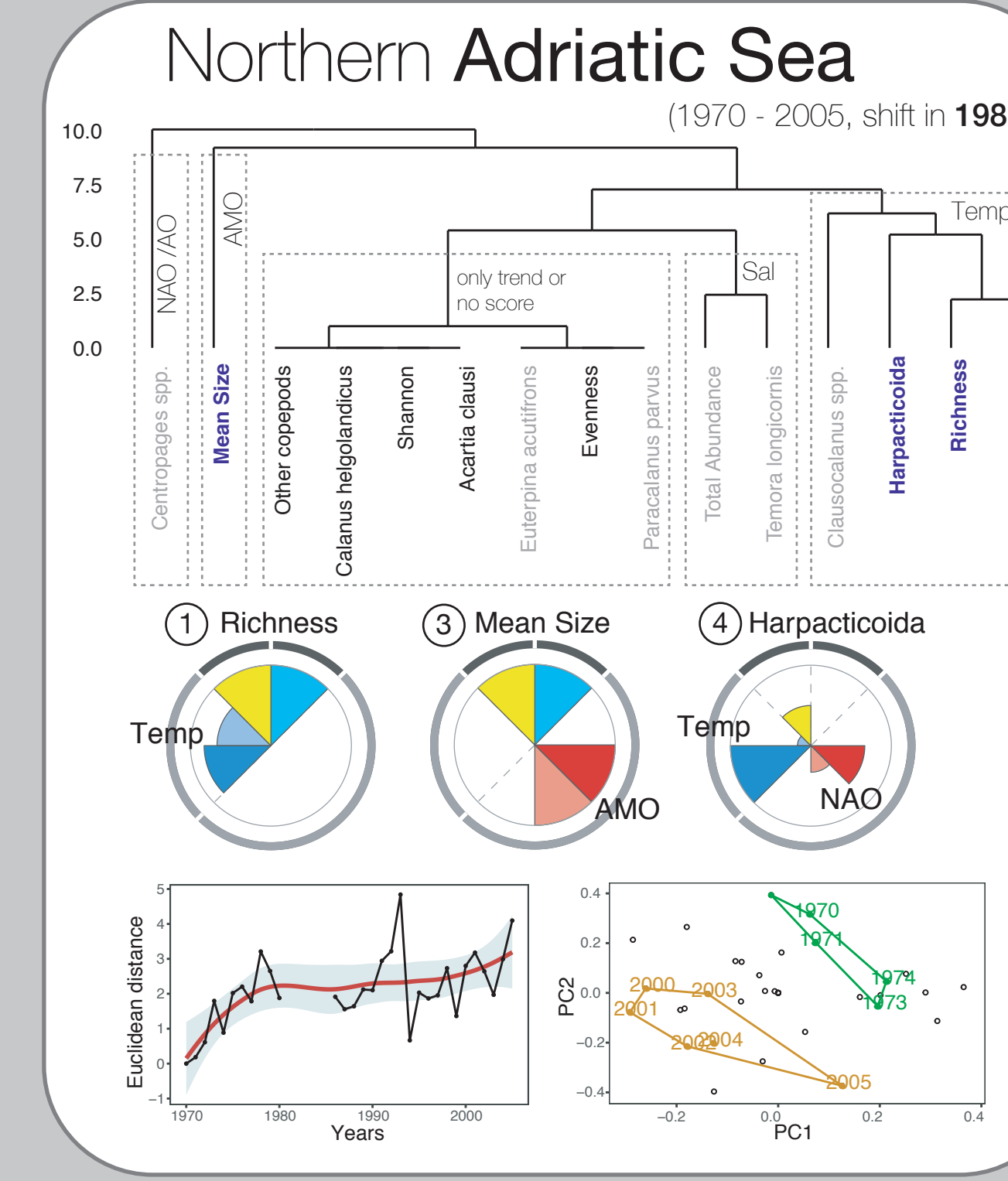
Selection of best performing and complementary IND suite



## European comparison



Blue indicators in dendrogram: most robust indicators (even when assigning training data randomly instead of using the post-shift period)



## Summary

- **Only few indicators** show a **good and consistent performance** with respect to climatic changes.
- No universal IND, however **diversity-based** indicator types **performed well** in all three systems.
- Both **large-scale** and **regional-scale** climate pattern affected indicators.
- Climate **interacted** stronger with **nutrient concentration** than fishing pressure.
- Particularly in the **Adriatic Sea** final indicator suite **deviates** greatly from earlier period.

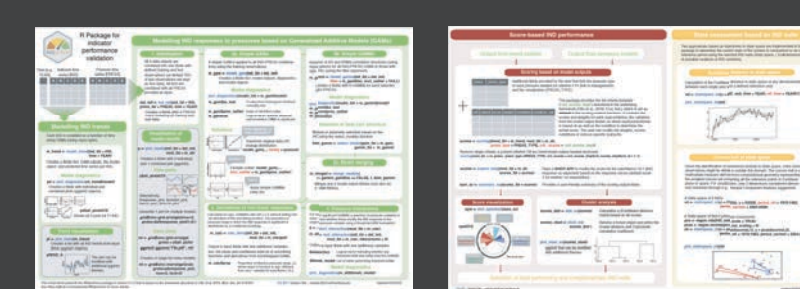


Data sources: SYKE, IOW, NOAA, ICES database, FAO, Baltic Environment Database, IE.U. Copernicus Marine Service Information

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grab a cheatsheet

[www.github.com/saskiaotto/cheatsheets](https://www.github.com/saskiaotto/cheatsheets)



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