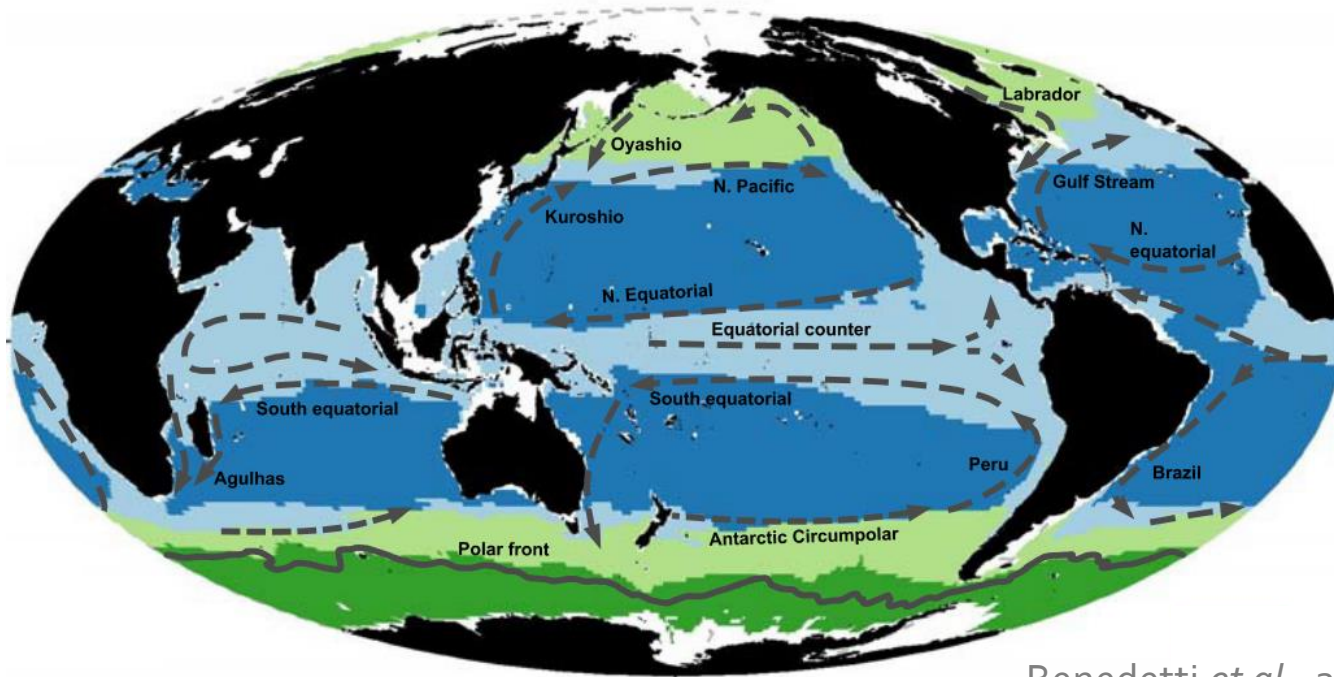# How do the ecological traits of North Atlantic copepod communities shape their distribution?
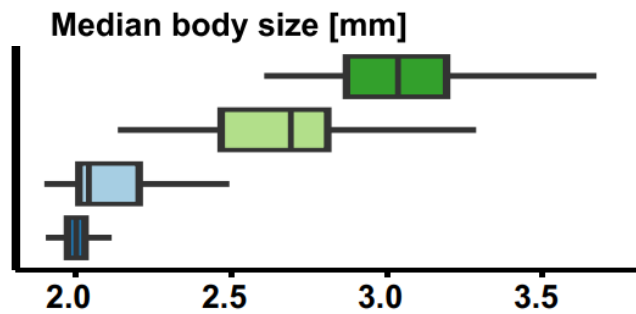
Marion Vilain

Frédéric Olivier, Eric Goberville & Dorothée Vincent

Image : *Metridia lucens* ©Anaïs Royer

7th International Zooplankton Production Symposium

Benedetti *et al.*, 2023

Median body size [mm]

Diel vertical migration (DVM)

⟶ Impacts community dynamics

trophic interactions

biological carbon pump

Copepod ecological **traits**

⟶ Influence life functions

⬇
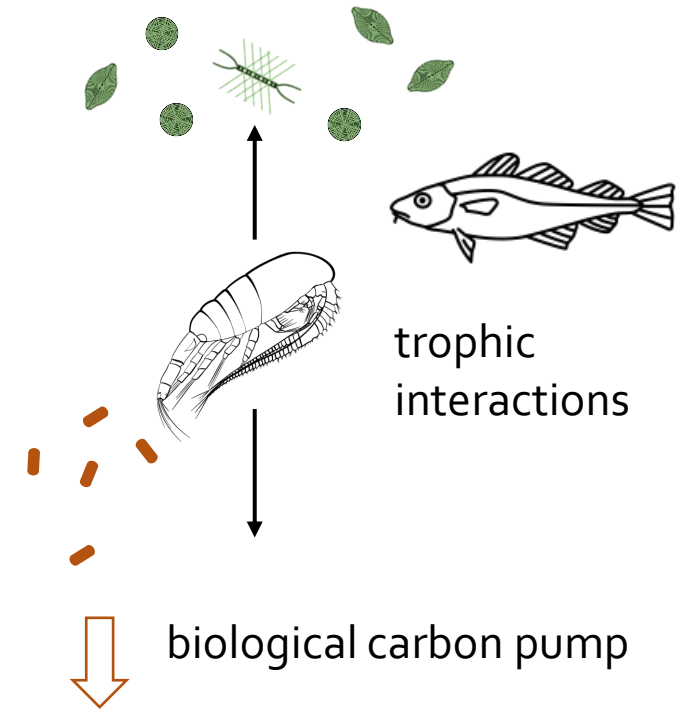
distribution

⇨ **How can DVM shapes copepod communities distribution at macroscale ?**

Continuous Plankton Recorder Survey data

Marine Biological Association

Selection: copepod abundances
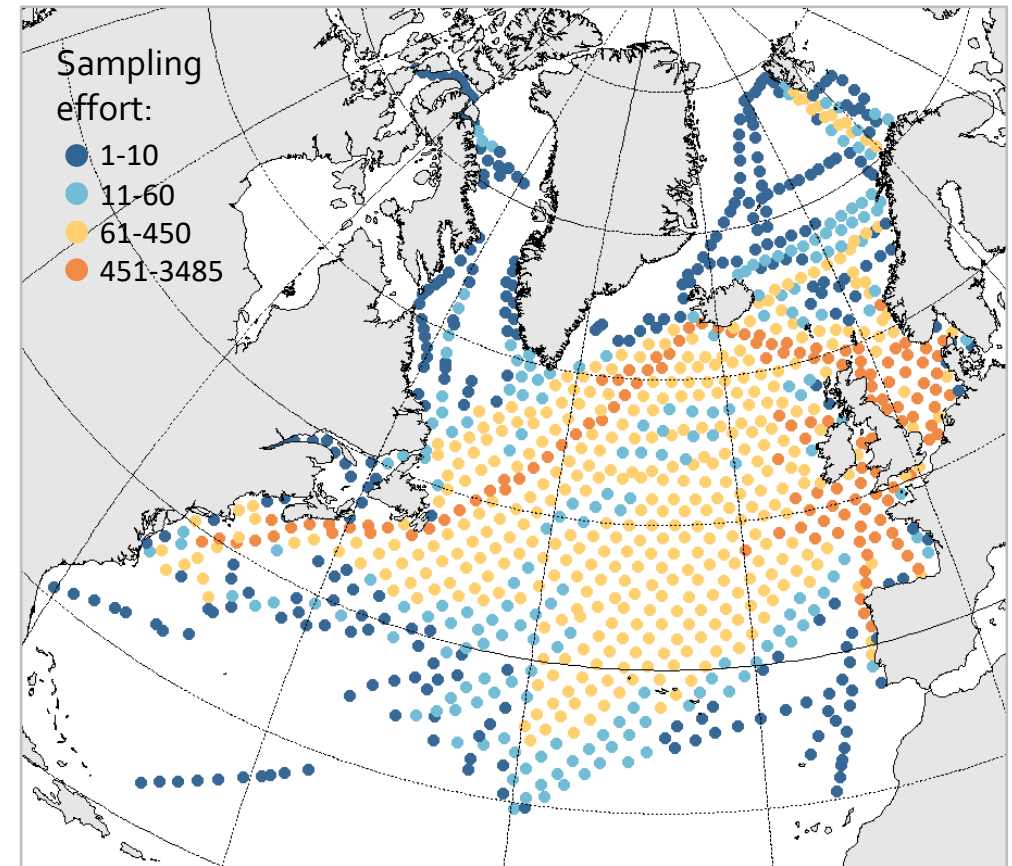
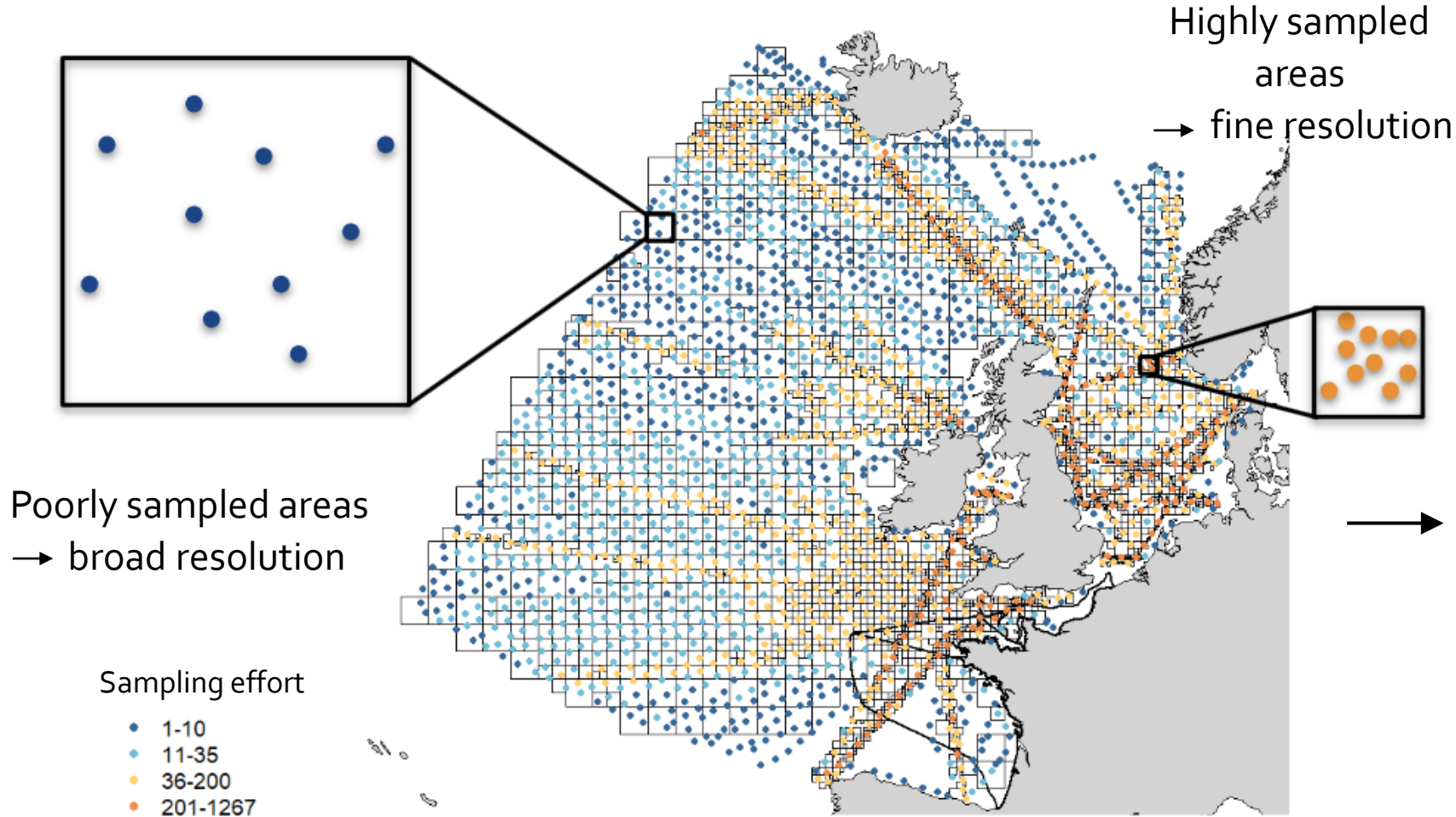Location: North Atlantic

Period: 1966-2021

Sampling depth : ~ 10 m
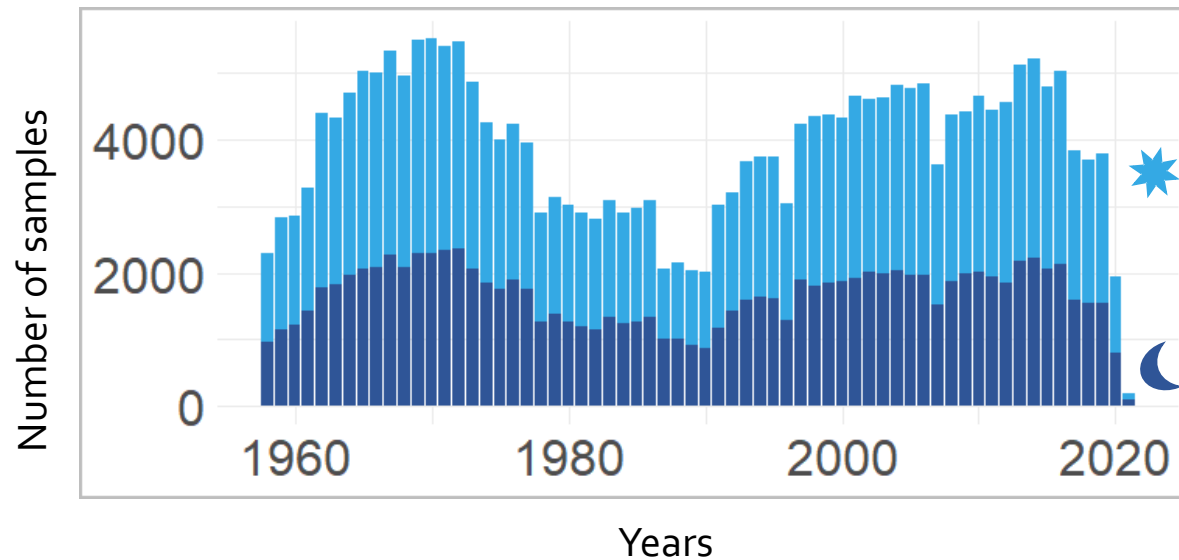
Day/night limit: solar elevation = -6°

Sampling effort ~ CPR routes

# How to manage CPR irregular sampling effort ?

Quadtree approach

Highly sampled areas
→ fine resolution

Poorly sampled areas
→ broad resolution

Sampling effort
- 1-10
- 11-35
- 36-200
- 201-1267

Geographical cell	Species	Abundance
Cell 1	*Sp A*	1
Cell 1	*Sp B*	2
Cell 2	*Sp A*	5
Cell 2	*Sp B*	1
Cell 3	*Sp B*	2
Cell 3	*Sp C*	5

Calculation of
$mean(log_{10}(abundance + 1))$
by resampling

Defining bioregions while preserving species identity: network clustering

Geographical cell	Species	Abundance
Cell 1	*Sp A*	1
Cell 1	*Sp B*	2
Cell 2	*Sp A*	5
Cell 2	*Sp B*	1
Cell 3	*Sp B*	2
Cell 3	*Sp C*	5
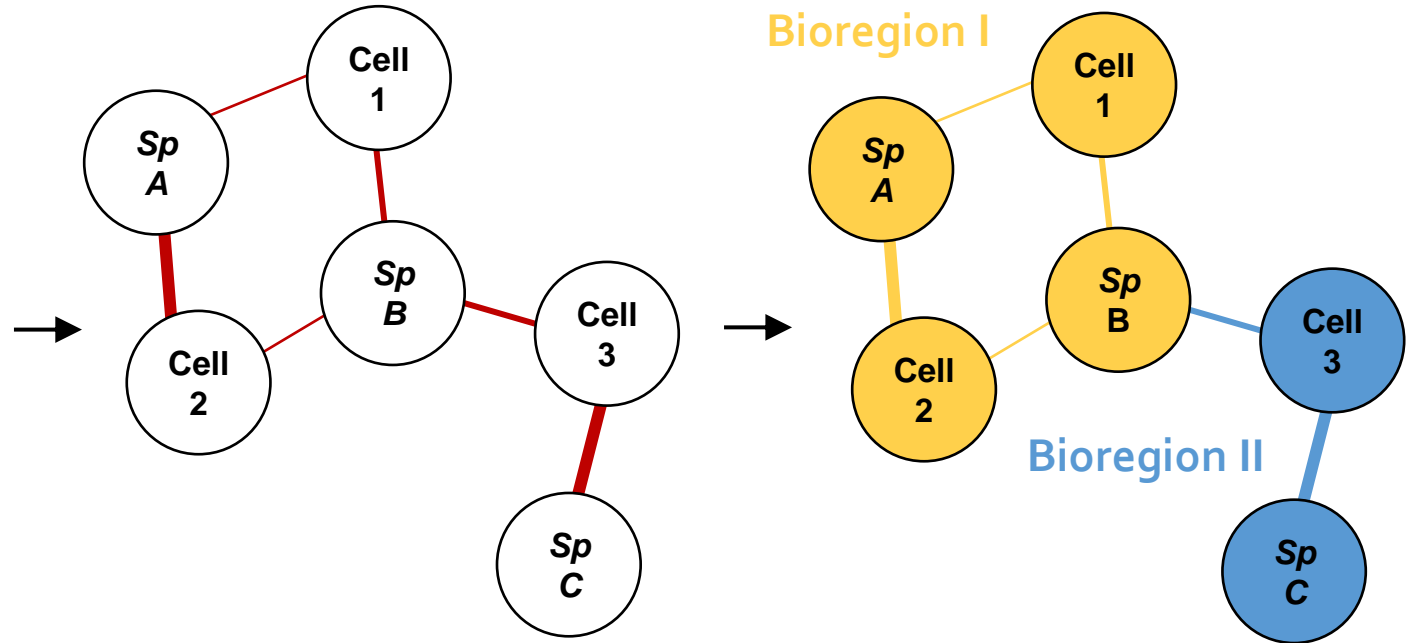
Calculation of mean($\log_{10}$(abundance + 1)) by resampling

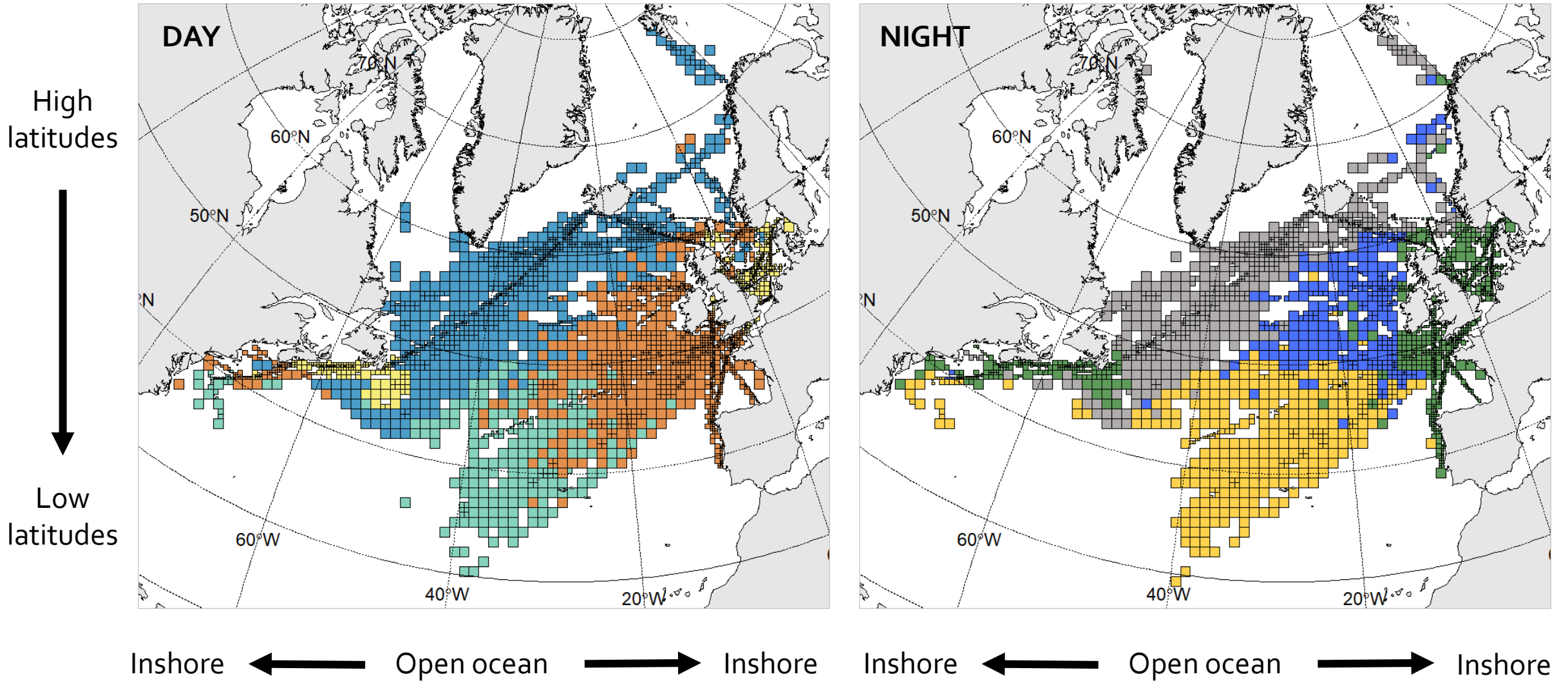Geographical cells – species network weighted by abundance

Identification of bioregions by network clustering

Rosvall & Bergstrom, 2008
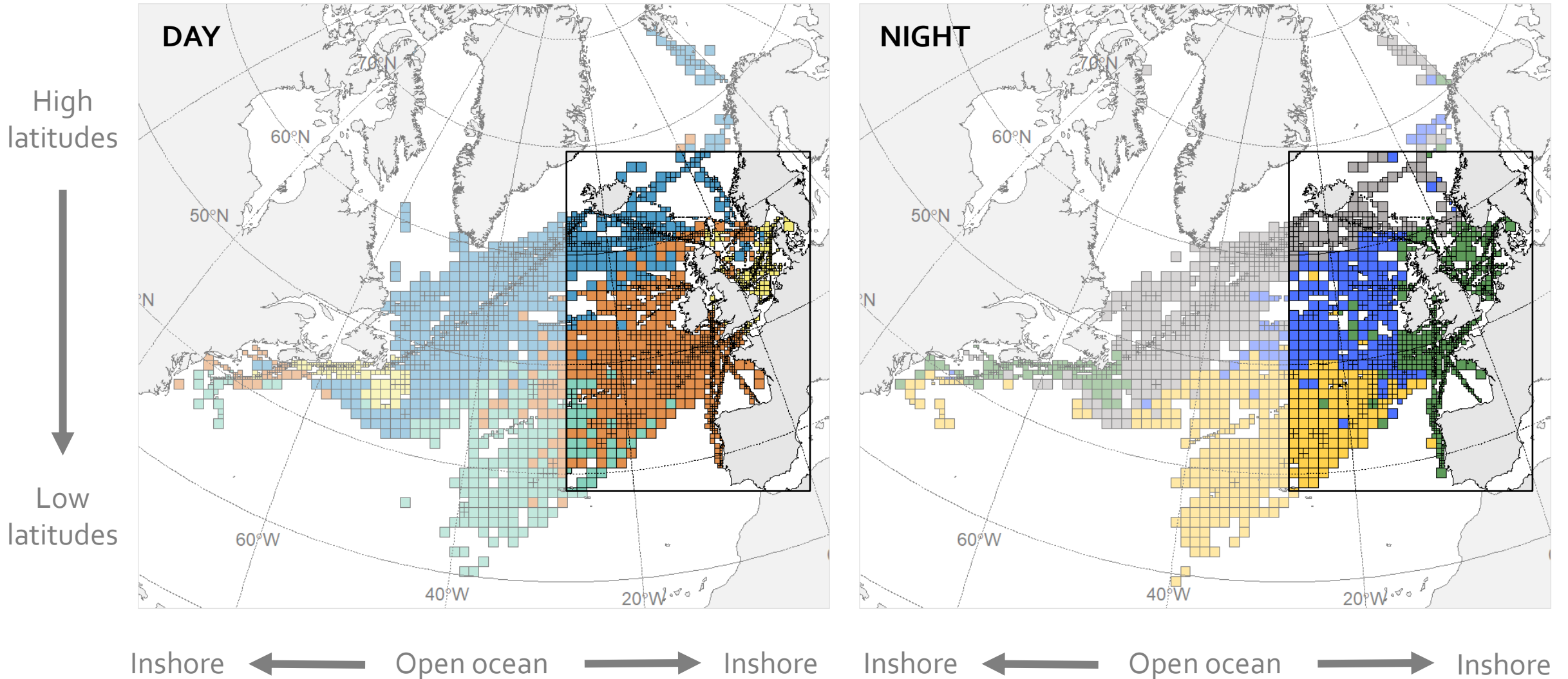Leroy *et al.*, 2019

North Atlantic copepod-based partitions 1966-2021

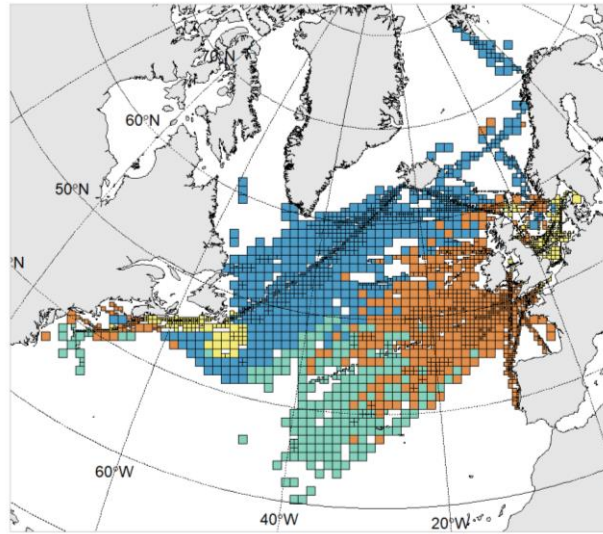Two main gradients driving day and night bioregions

High latitudes

Low latitudes

DAY

NIGHT

Inshore ← Open ocean → Inshore

Inshore ← Open ocean → Inshore

North Atlantic copepod-based partitions 1966-2021

Some contrasted patterns
between day and night

DAY

NIGHT

High latitudes

Low latitudes
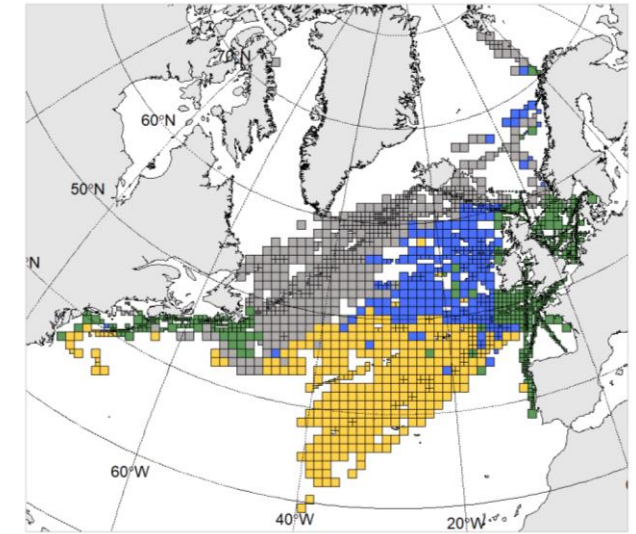
Inshore ⟵ Open ocean ⟶ Inshore

Inshore ⟵ Open ocean ⟶ Inshore
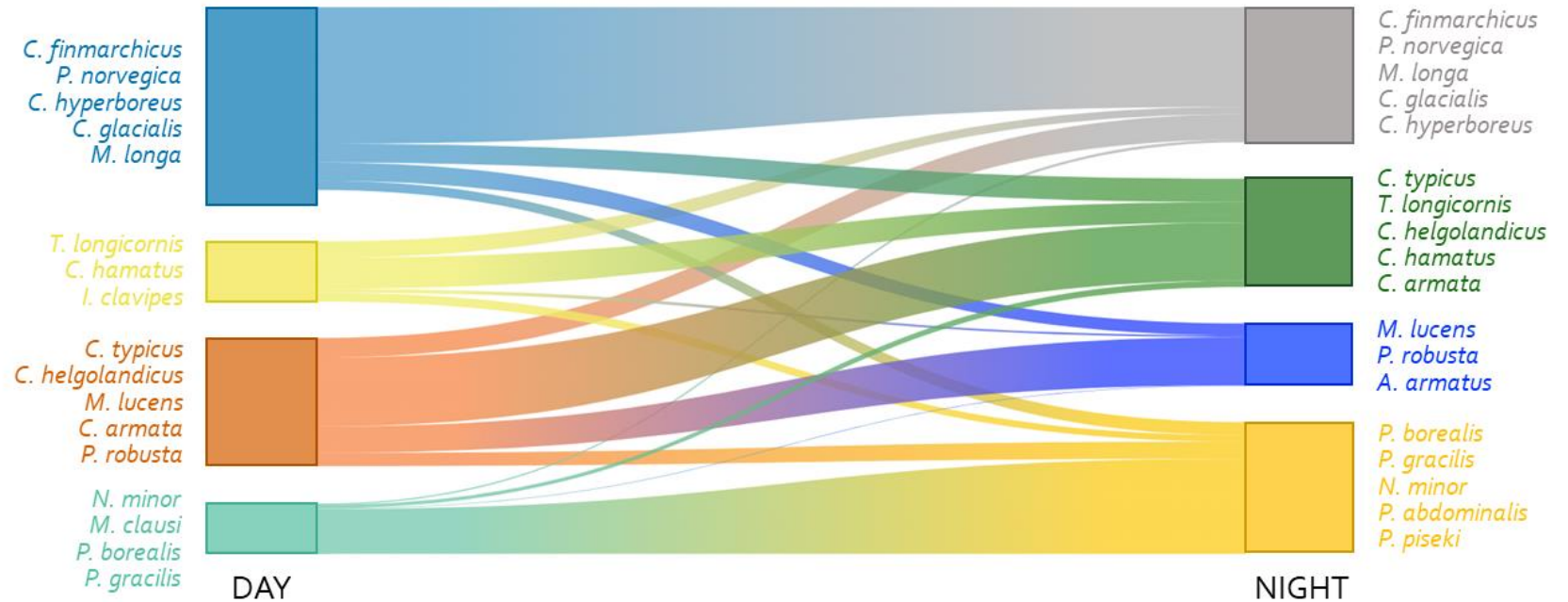
Diffuse boundaries & transition zones
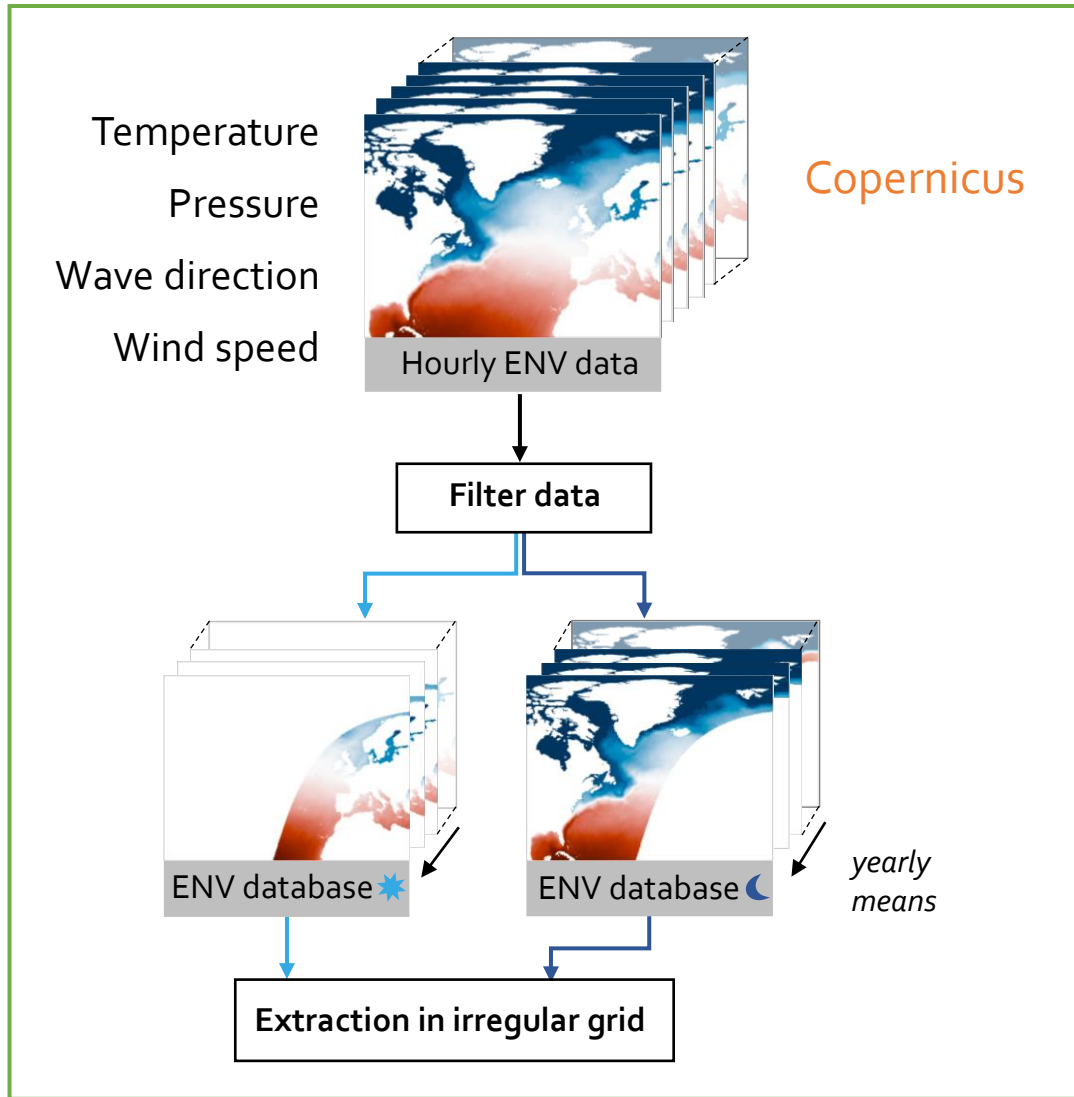
Dynamic partitions
with transition zones

DVM

Species & geographical
cells exchanges
between day and night

DAY

NIGHT

C. finmarchicus
P. norvegica
C. hyperboreus
C. glacialis
M. longa

T. longicornis
C. hamatus
I. clavipes

C. typicus
C. helgolandicus
M. lucens
C. armata
P. robusta

N. minor
M. clausi
P. borealis
P. gracilis

C. finmarchicus
P. norvegica
M. longa
C. glacialis
C. hyperboreus

C. typicus
T. longicornis
C. helgolandicus
C. hamatus
C. armata

M. lucens
P. robusta
A. armatus

P. borealis
P. gracilis
N. minor
P. abdominalis
P. piseki

Vilain *et al.* (in prep)

8

Bioregions environmental characteristics

Temperature
Pressure
Wave direction
Wind speed

Hourly ENV data

Copernicus

Filter data

ENV database ☀   ENV database ☽

yearly means

Extraction in irregular grid

Diatoms
Dinoflagellates
Fish larvae
Invertebrate larvae

CPR data

Day/night separation

4000
2000
0
1960   1980   2000   2020

Regularisation in irr. grid
Bootstrap
Mean per cell

ENVIRONMENT – PHYTOPLANKTON – MEROPLANKTON
DATASET

Bioregions environmental characteristics
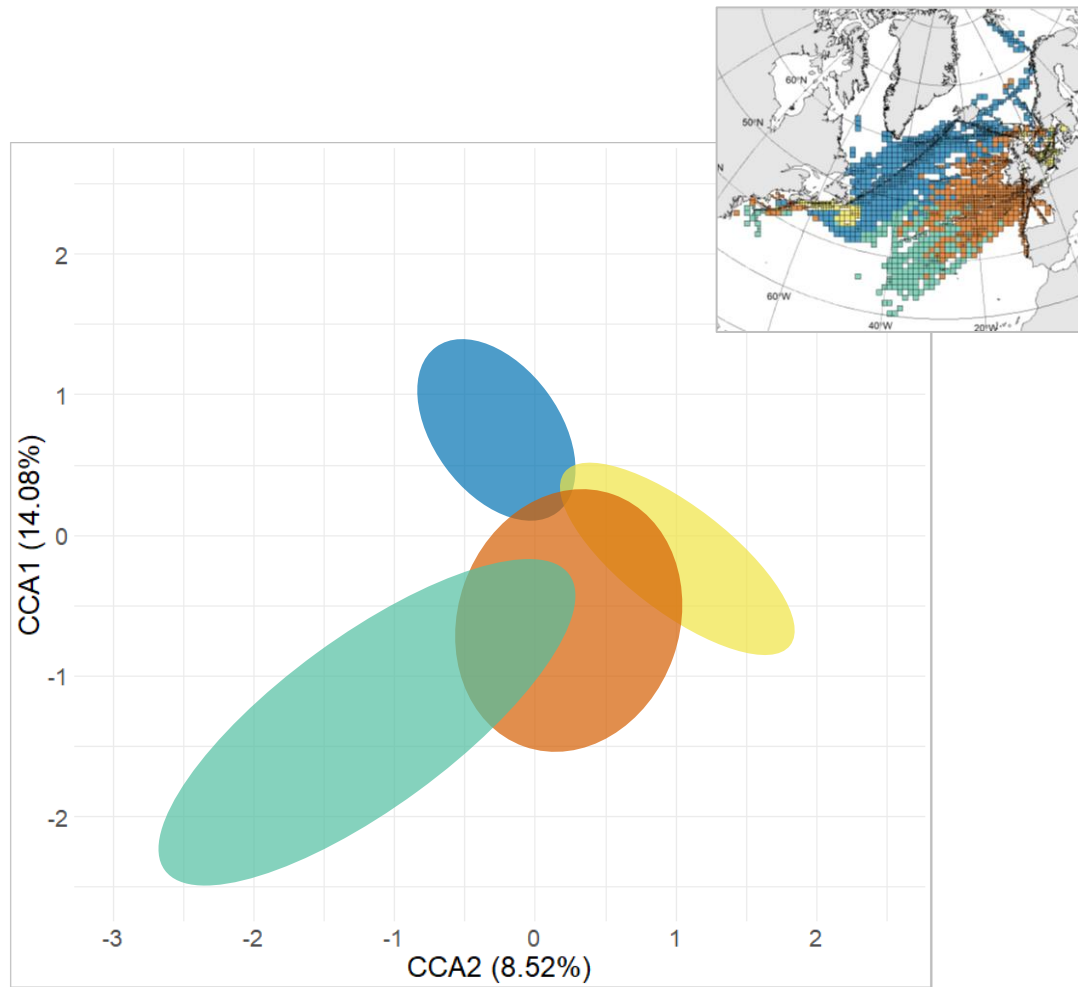
23%
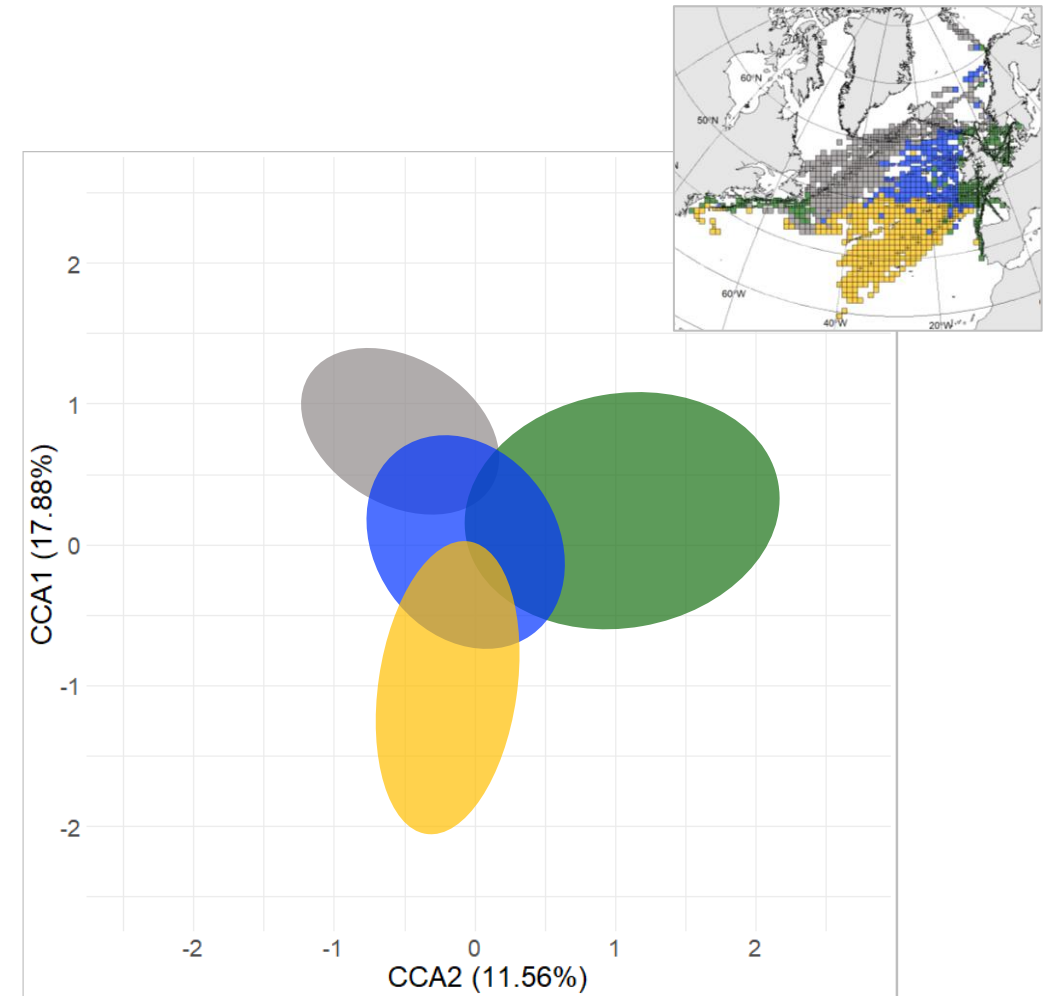
29%

Bioregions environmental characteristics

High latitudes
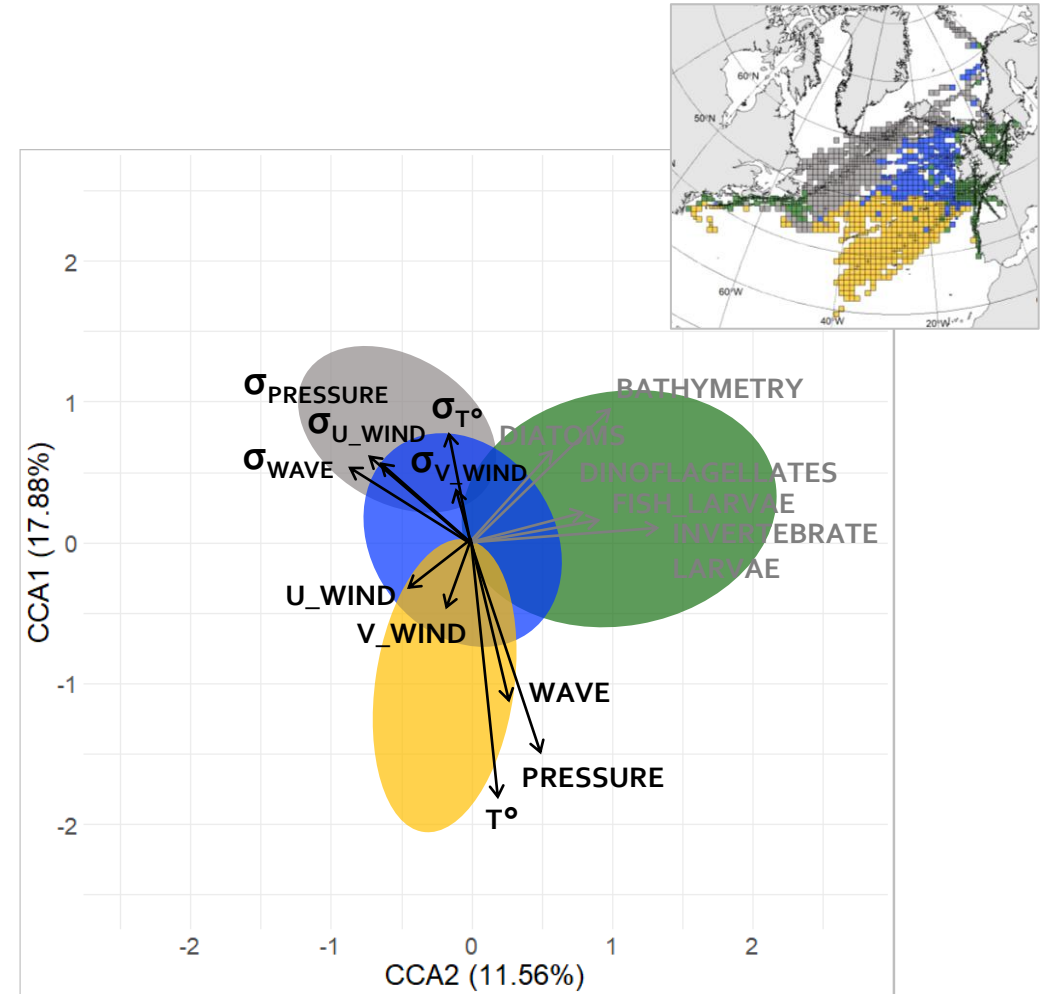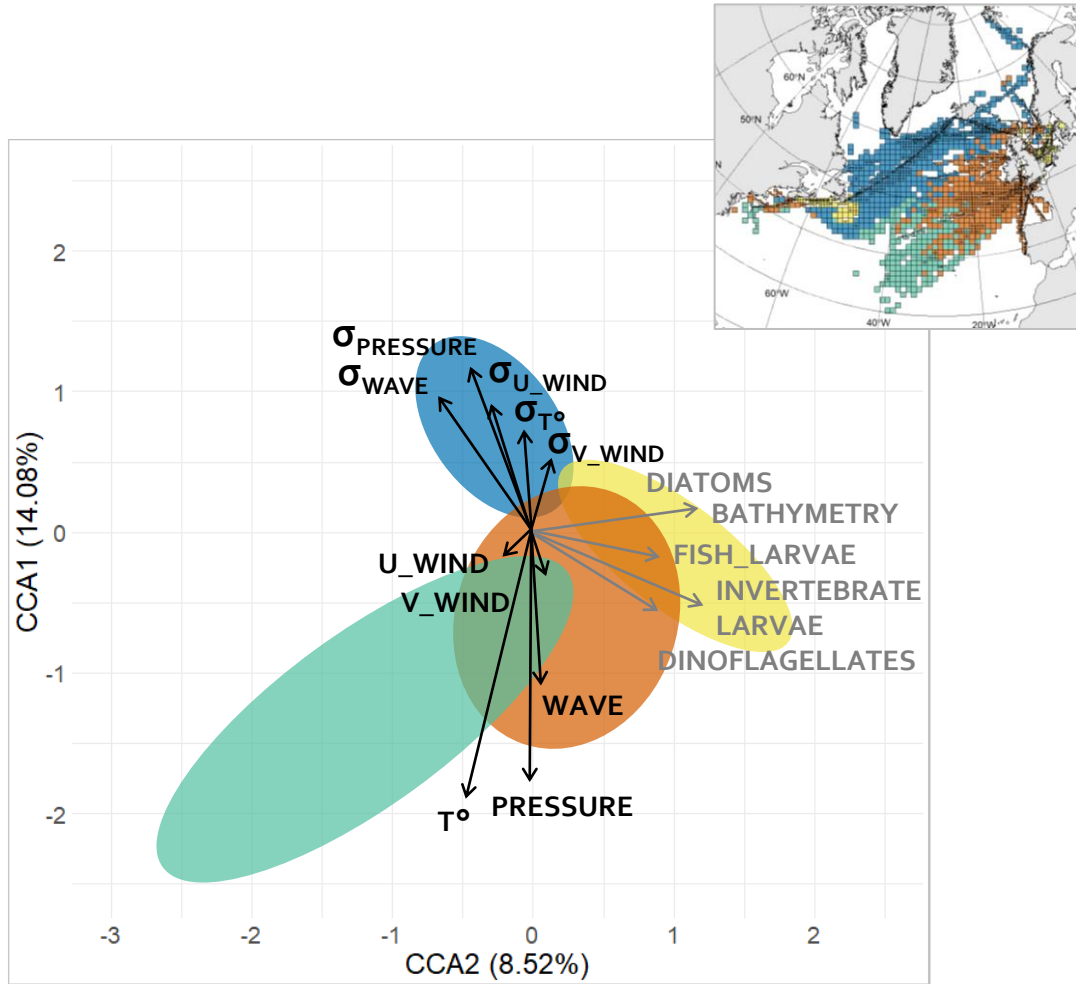
Temperature

Low latitudes
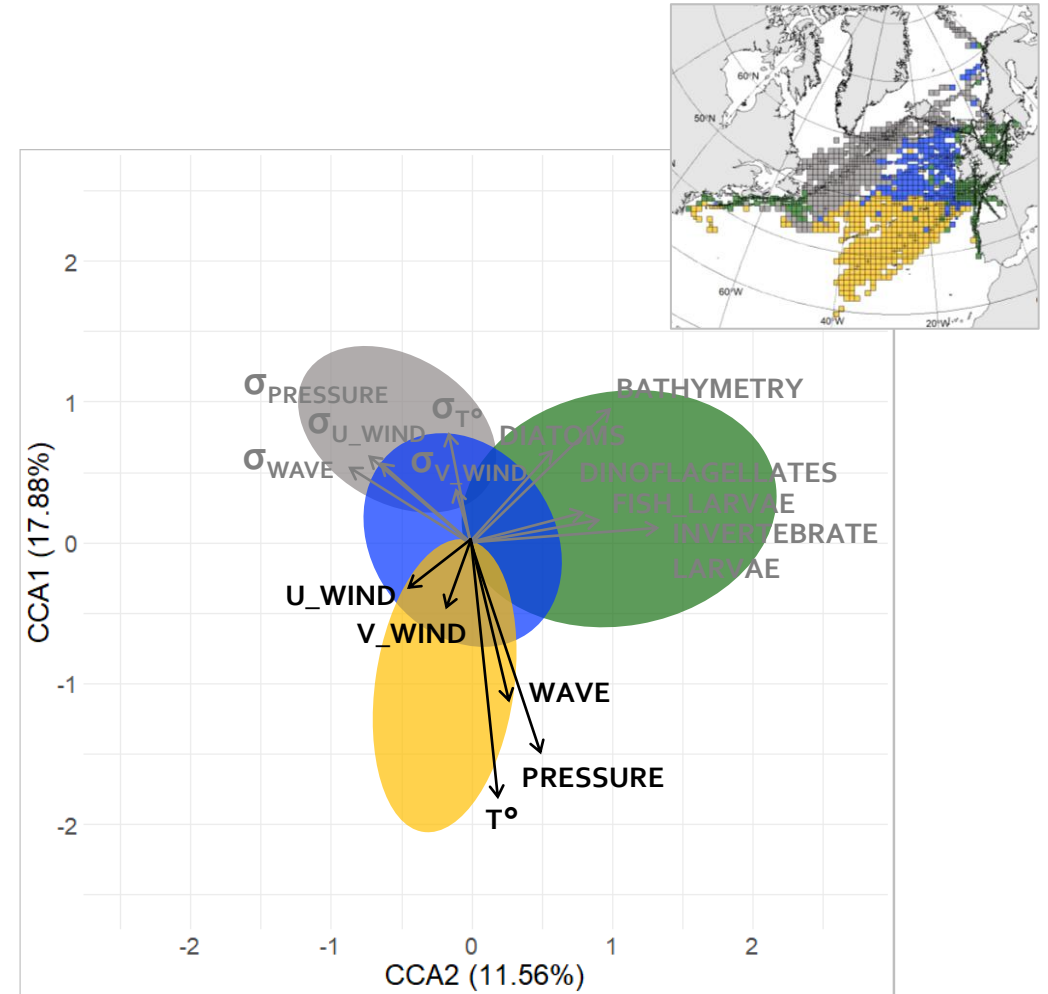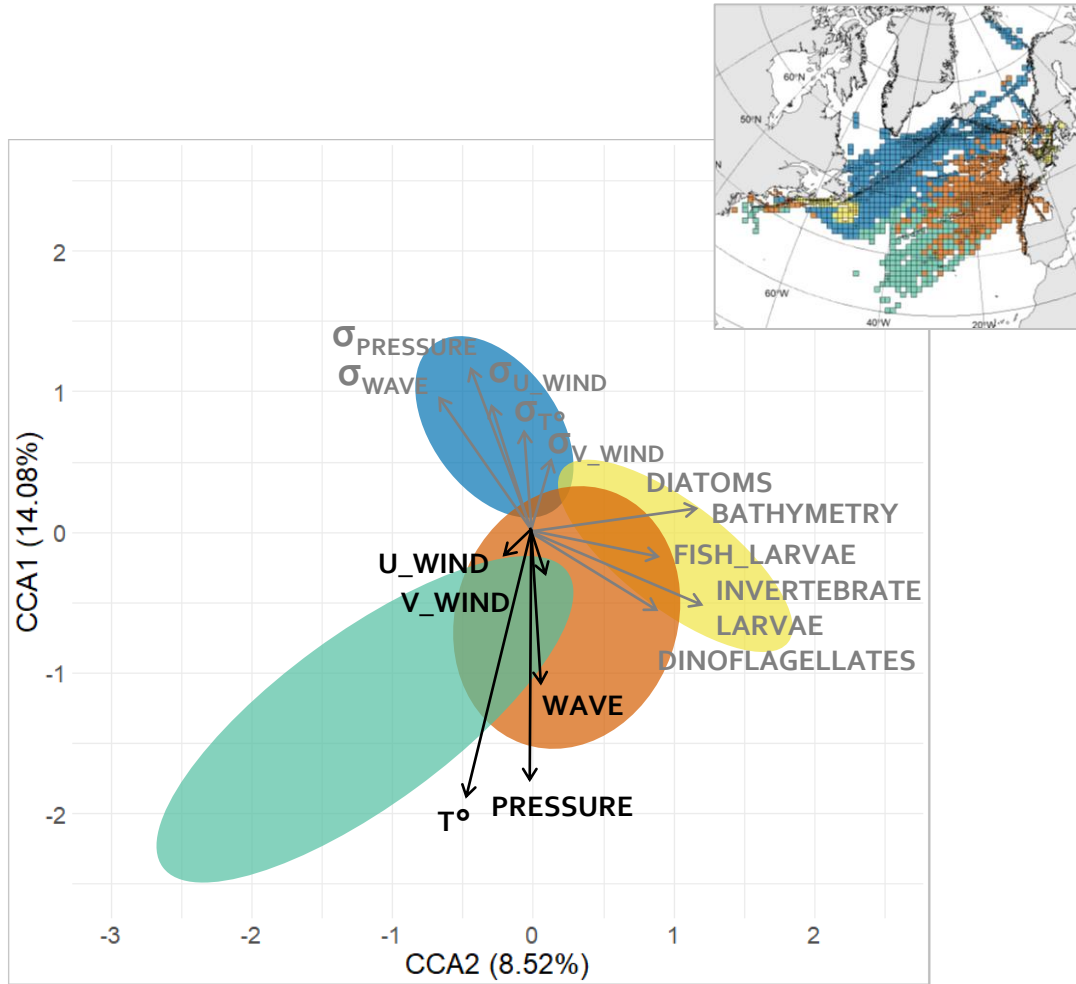
Bioregions environmental characteristics

High latitudes
(env. variations)

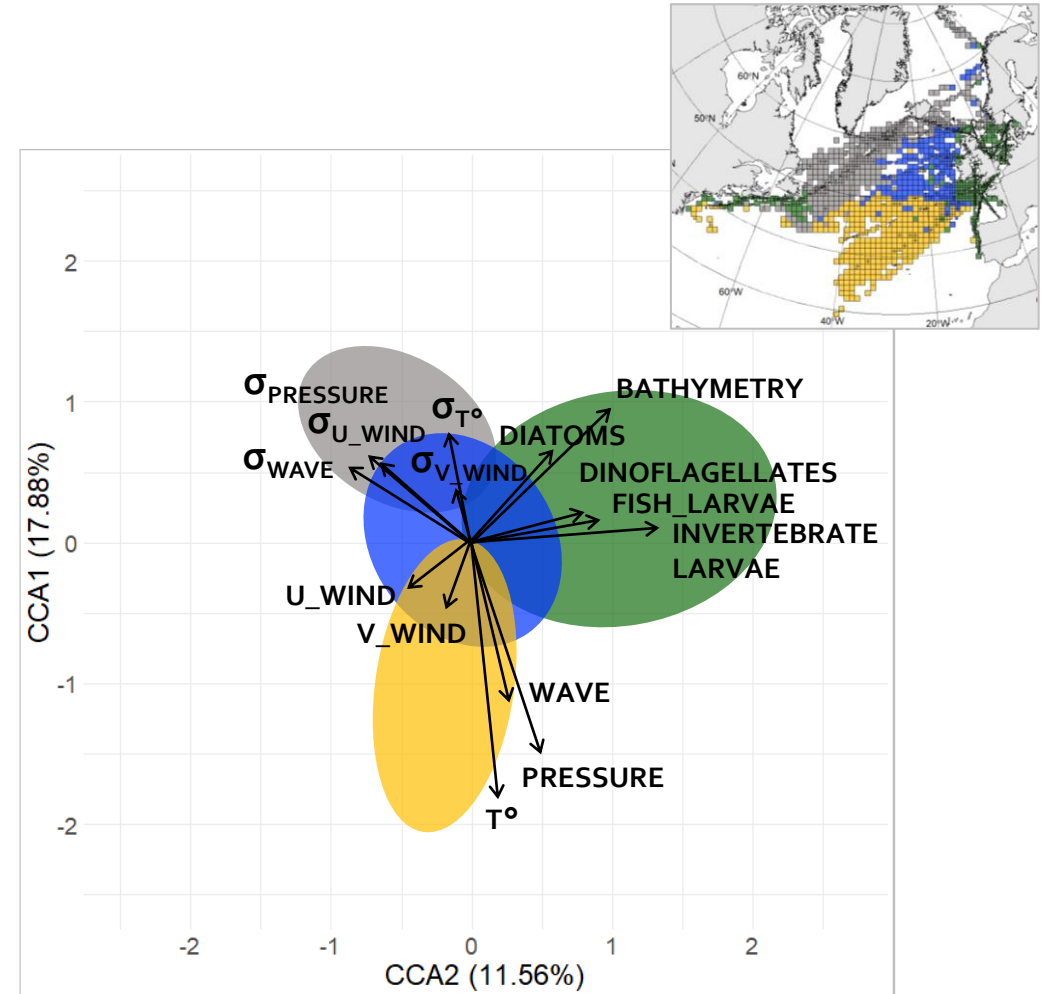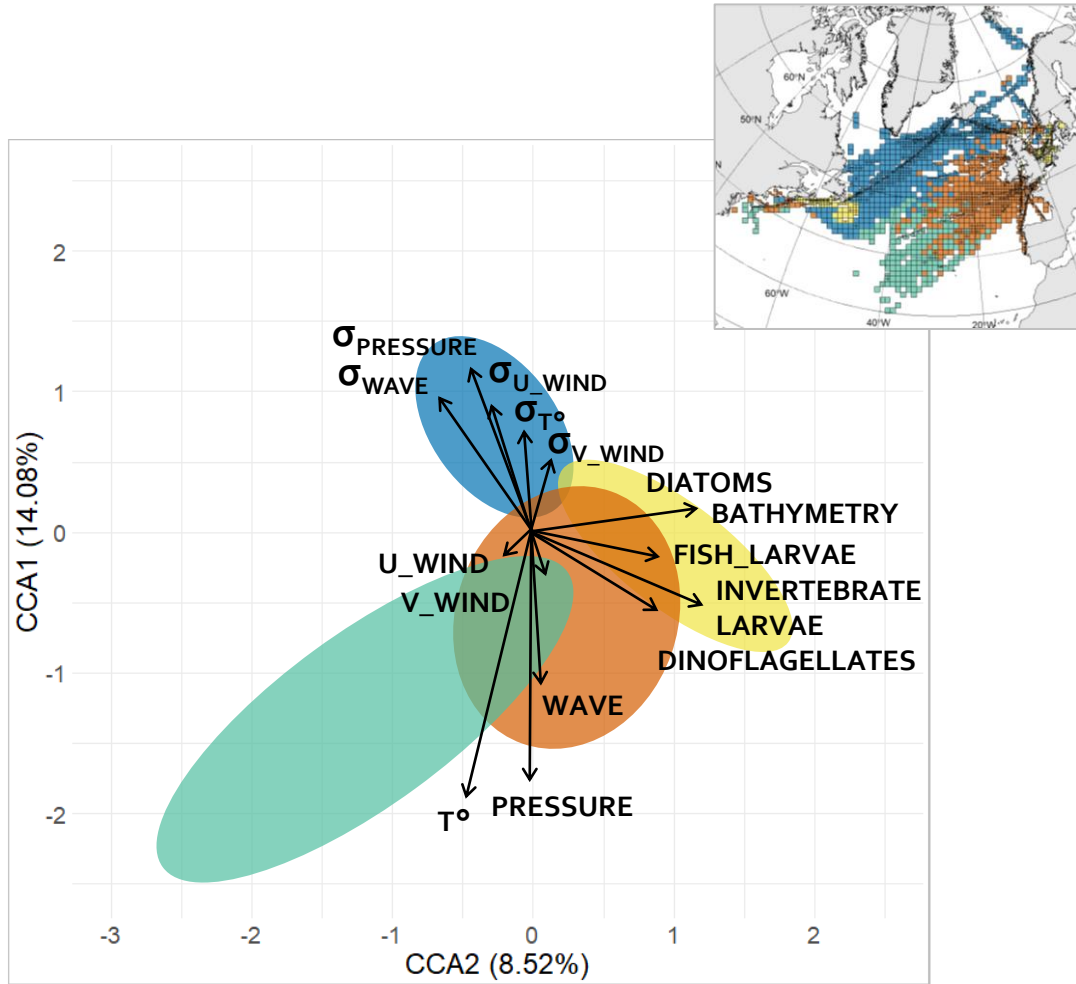Temperature

Low latitudes
(more stable)

Bioregions environmental characteristics

High latitudes
(env. variations)

Low latitudes
(more stable)

Temperature

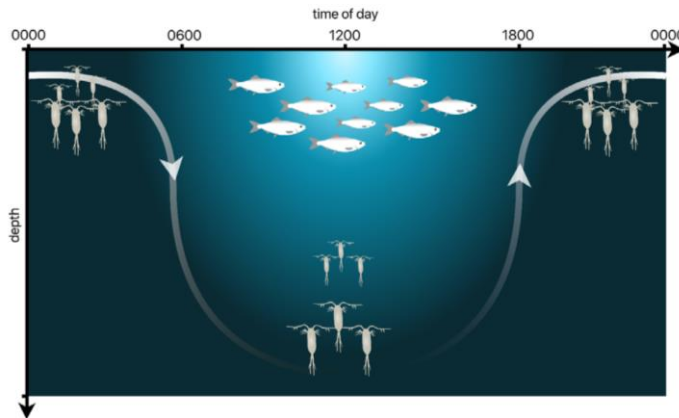Bathymetry

Open ocean → Inshore

Open ocean → Inshore

Towards functional bioregions

$$DVM_{index} = \frac{Ab_{Day} - Ab_{Night}}{Ab_{Day} + Ab_{Night}}$$

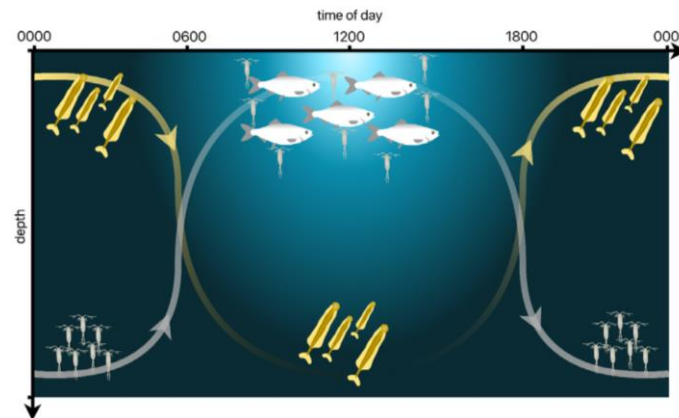**DVM_amplitude** = |DVM$_{index}$|

$DVM_{index} < 0$

DVM_classic

'Classic pattern'
Avoid visual predators

$DVM_{index} \geq 0$

DVM_reverse

'Reverse pattern'
Avoid non-visual
invertebrate predators
that perform classic DVM
to escape their own
visual predators

Bandara *et al.*, 2021

Trait dataset

Benedetti *et al.*, 2023

Community-weighted means
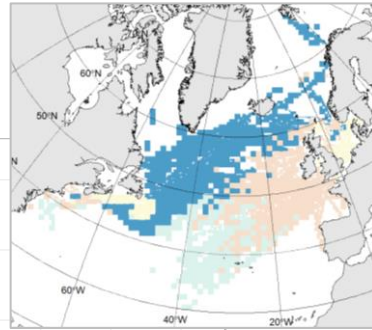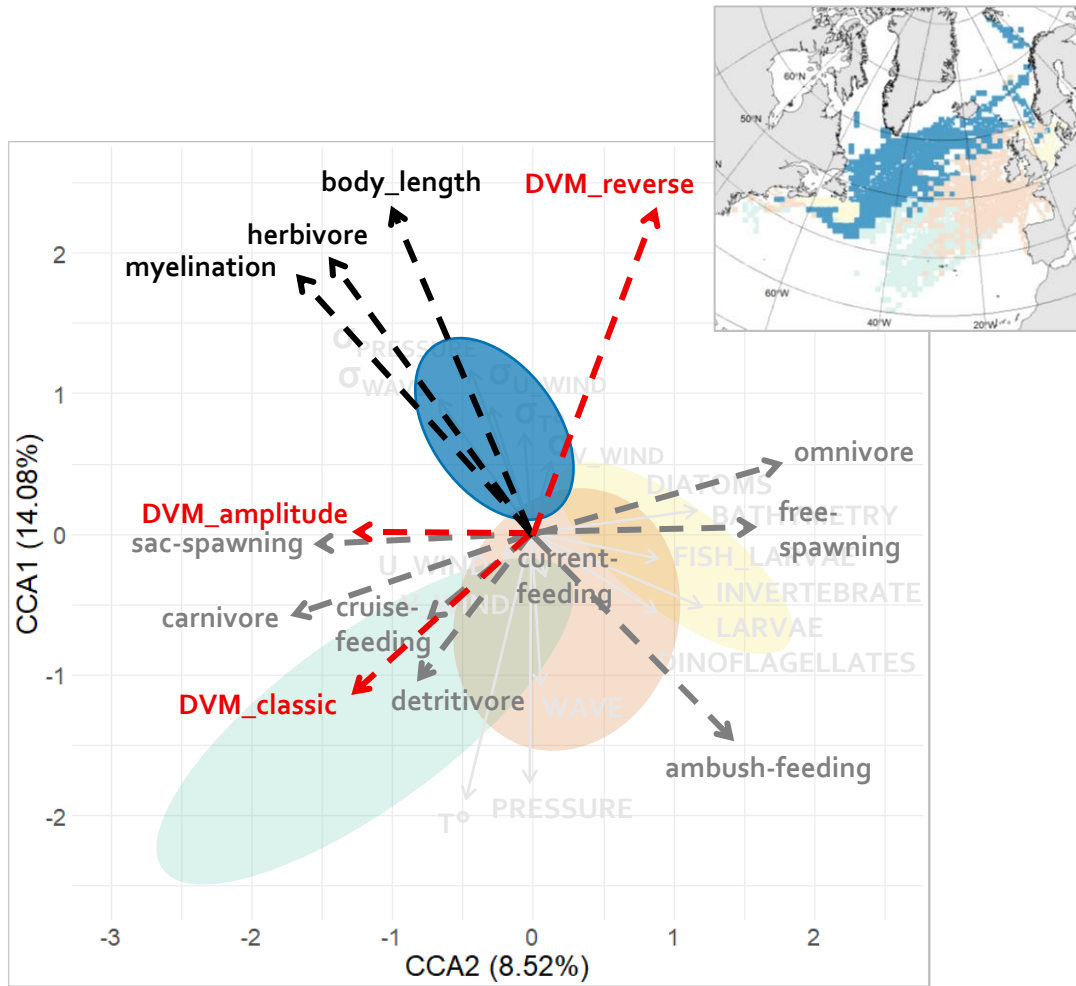define 'typical' traits of bioregions

Towards functional bioregions

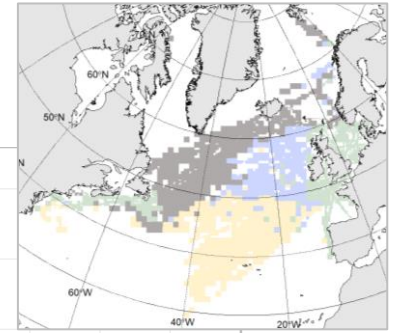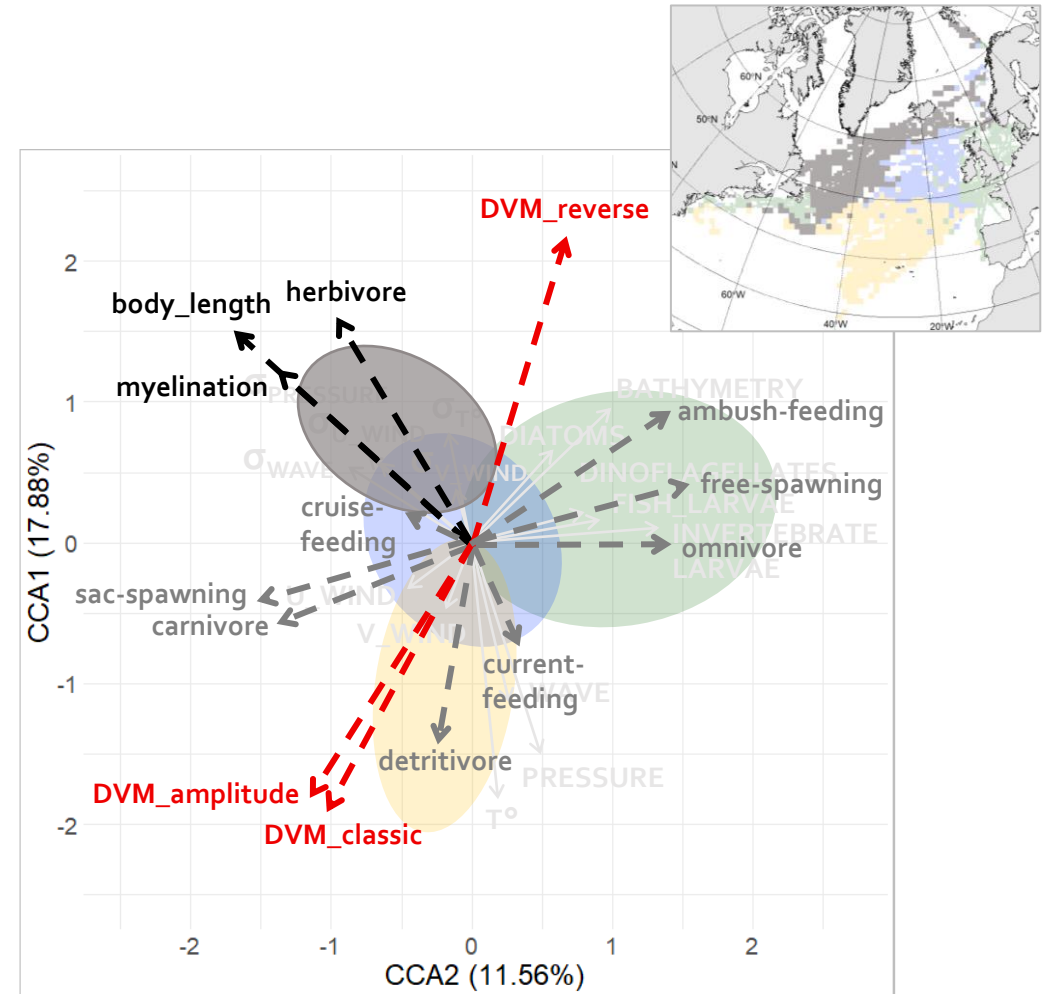High latitudes
(env. variations)

Temperature

Low latitudes
(more stable)

Open ocean → Inshore

Bathymetry

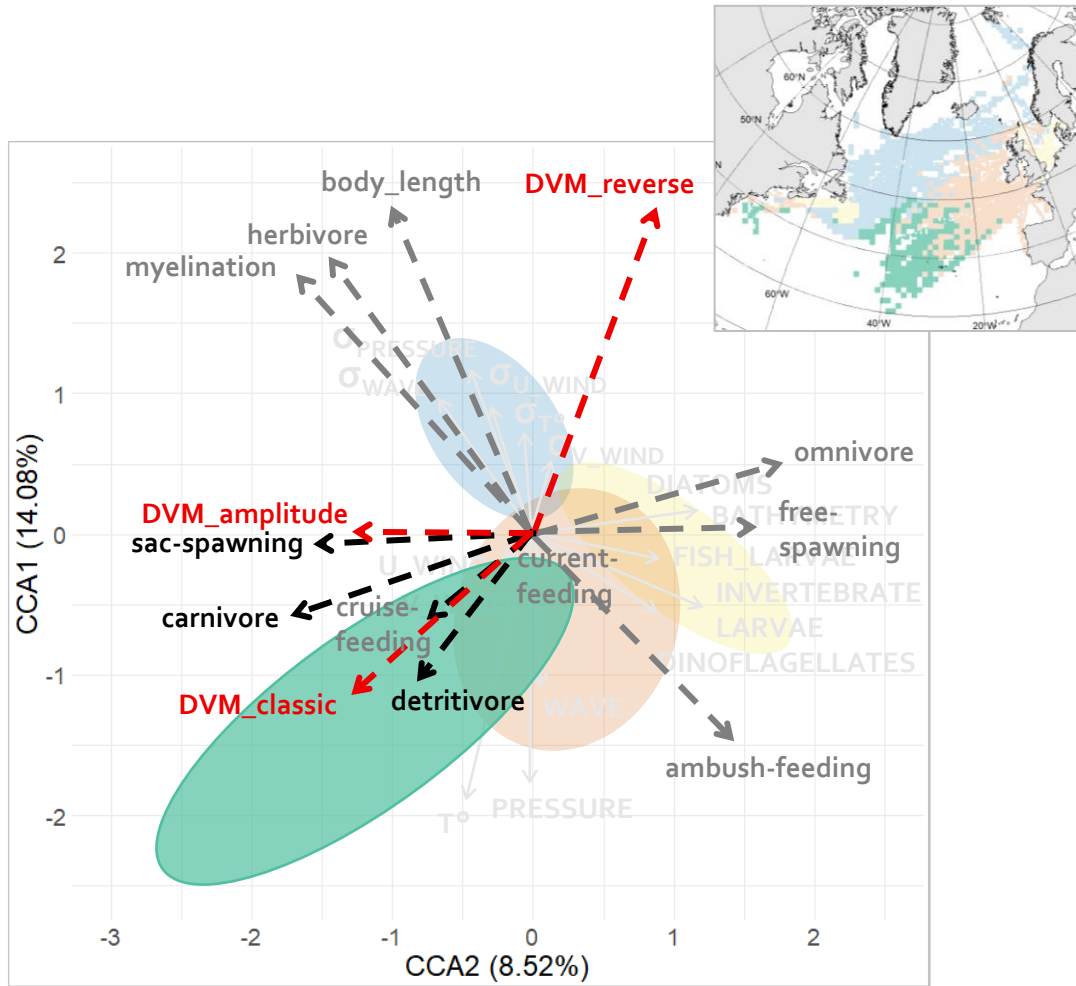# Towards functional bioregions
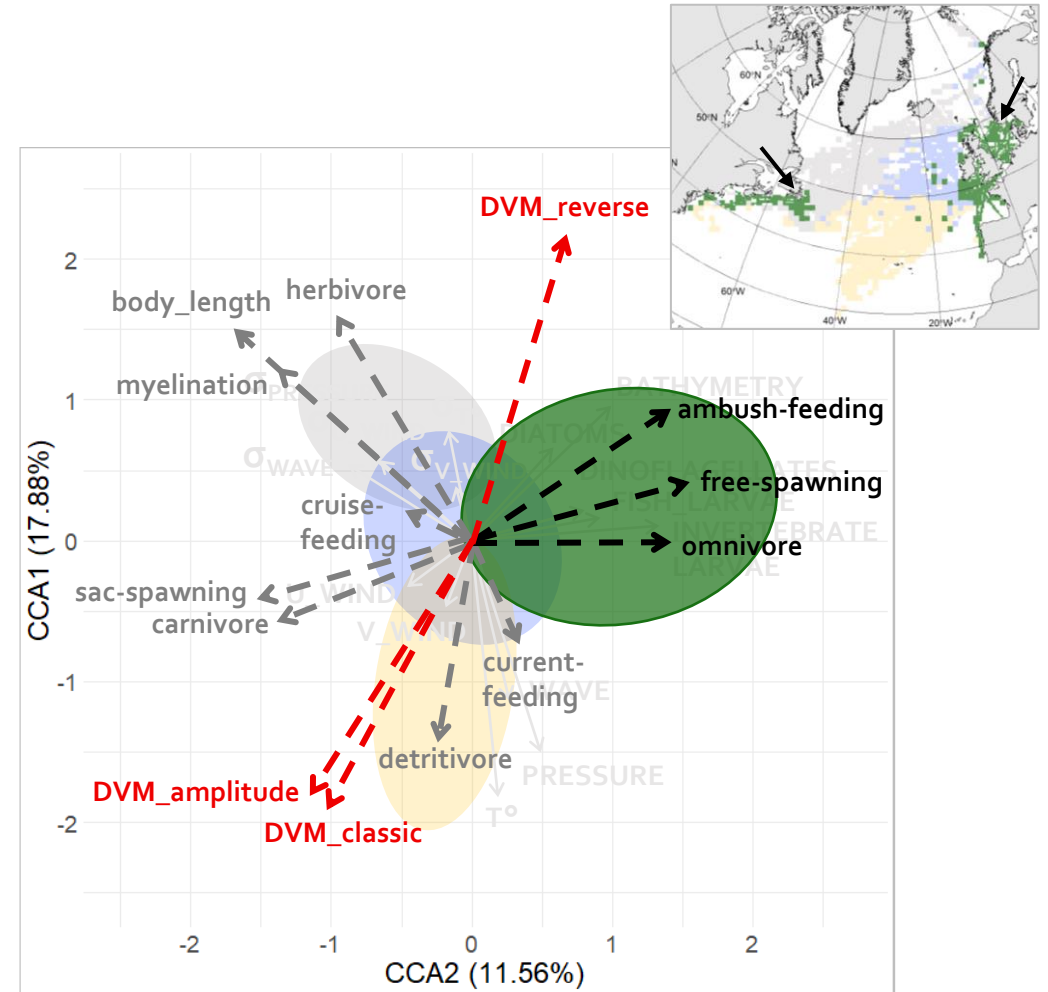
Towards functional bioregions

Towards functional bioregions

High latitudes
(env. variations)

Temperature

Low latitudes
(more stable)

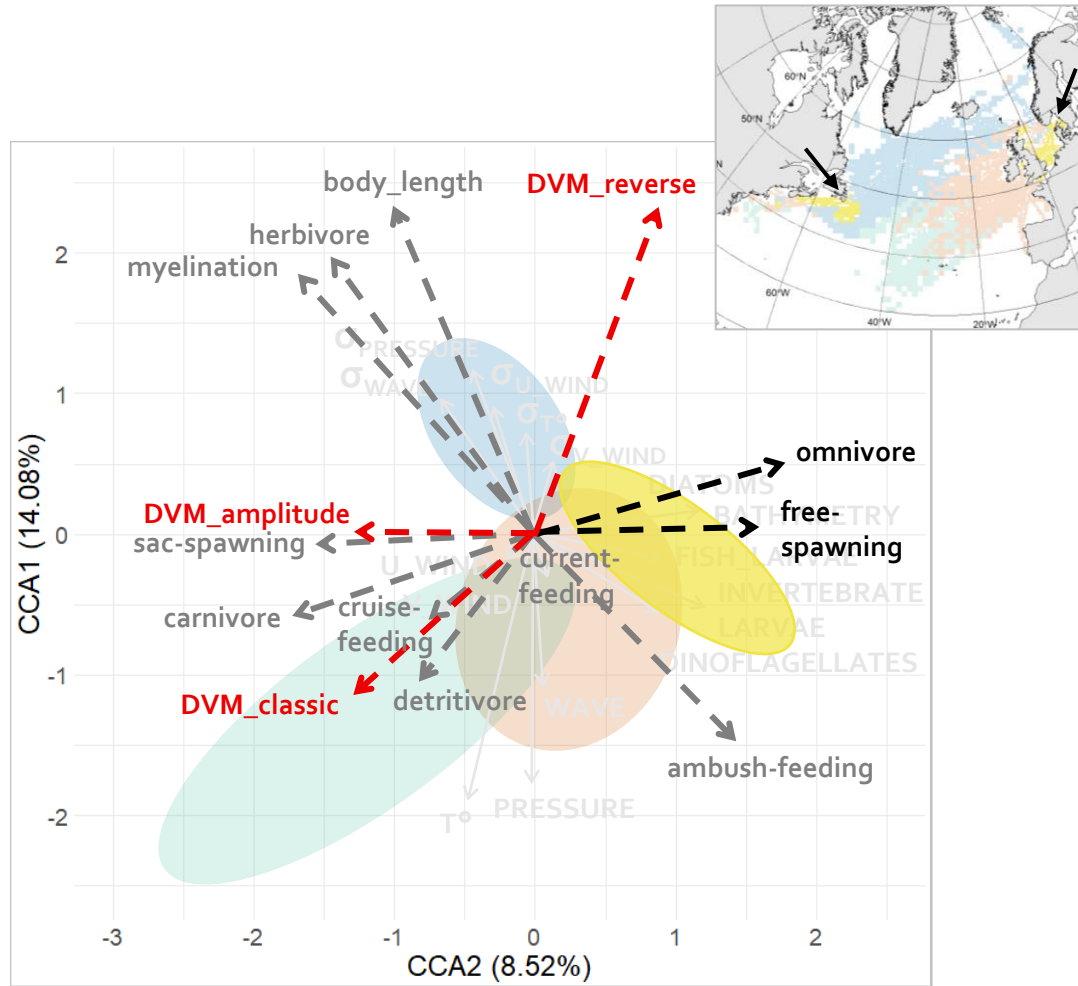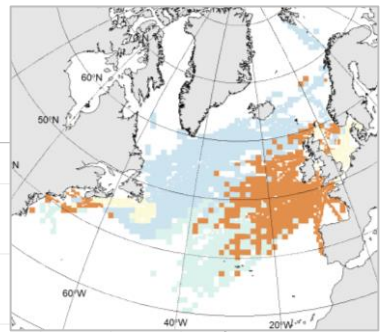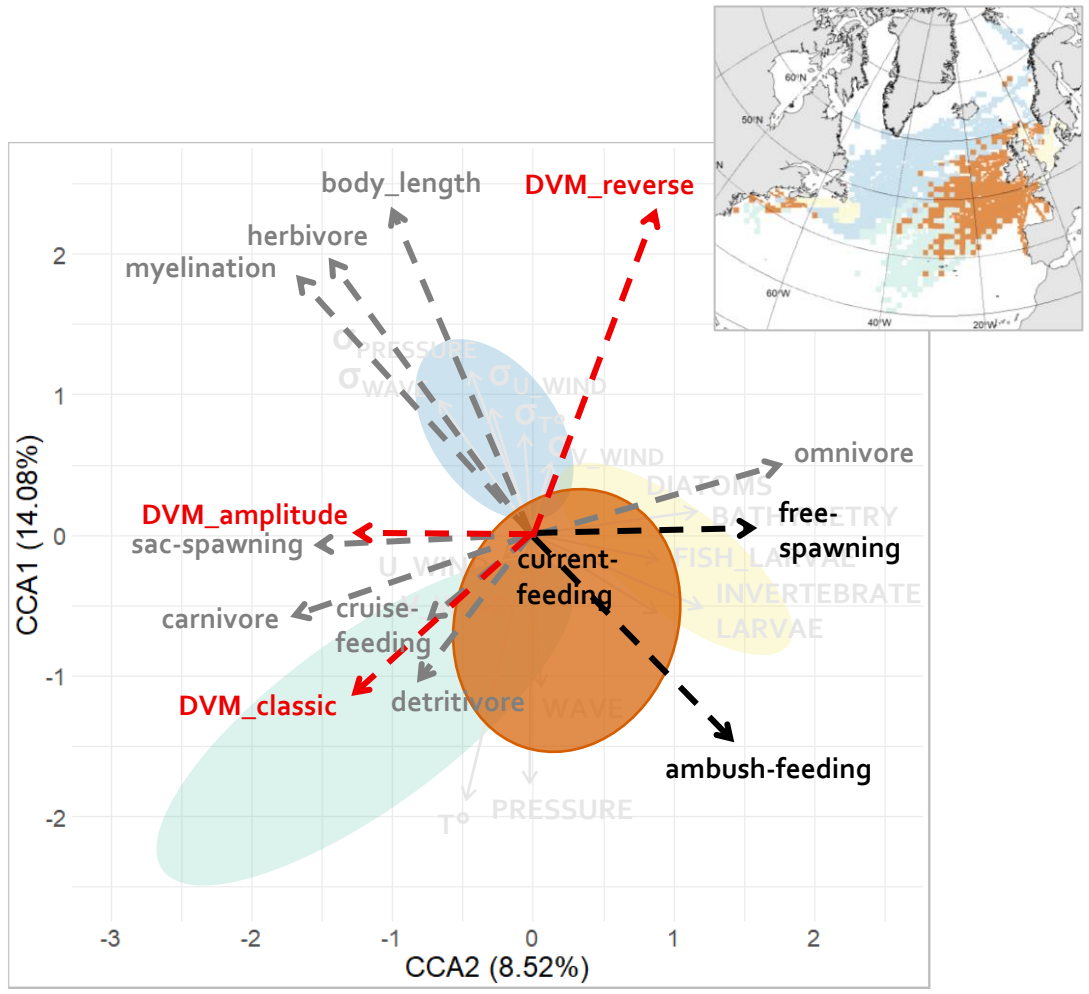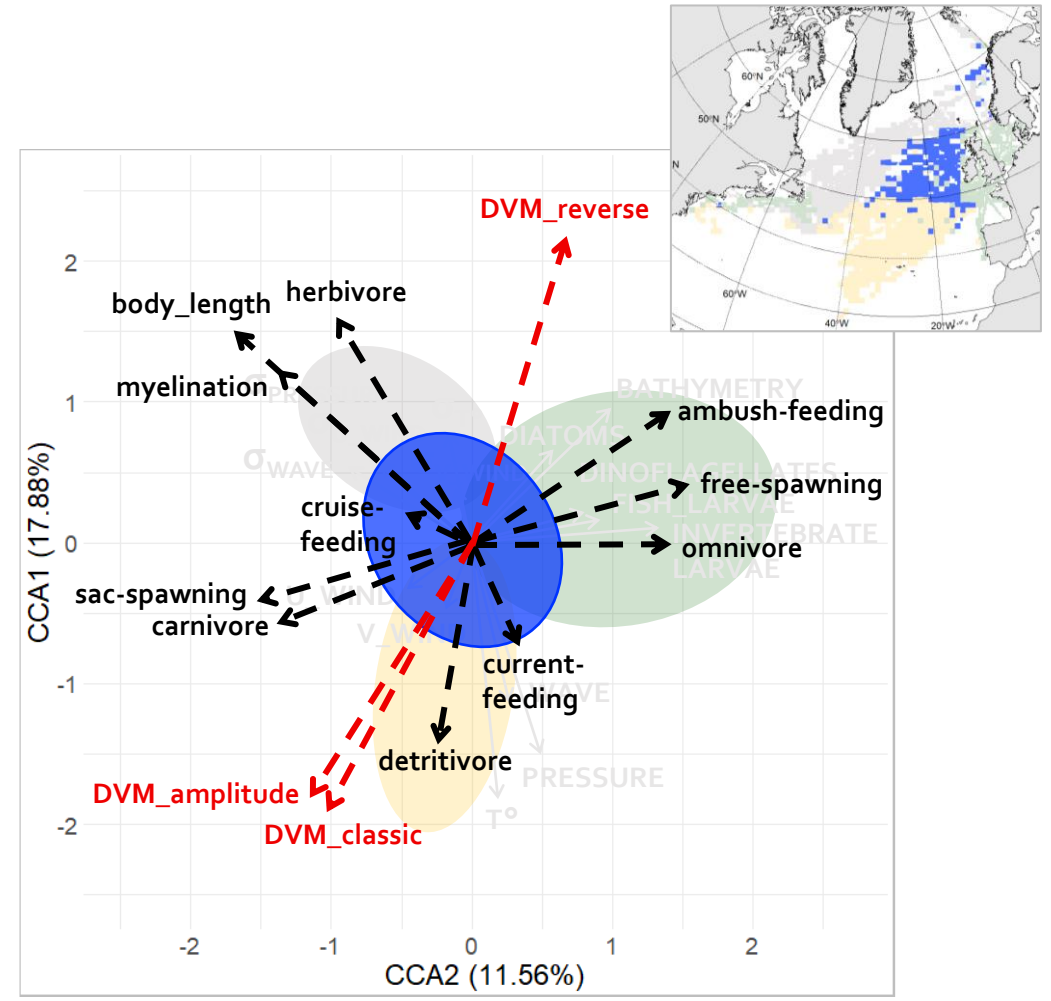Open
ocean

Bathymetry

Inshore

Open
ocean

Bathymetry

Inshore

Vilain *et al.* (in prep)   18

How can DVM shapes copepod communities distribution at macroscale ?

Broad biogeographic patterns...   **...refined with traits characterisation**

Robust latitudinal
and longitudinal gradients   **Stable bioregions**   **Variable bioregions**

// Longhurst, 2007   • diffuse boundaries
ENVIRONMENT   Beaugrand *et al.*, 2019   • transition zones
                         Kléparski *et al.*, 2021   **DVM**
                         Benedetti *et al.*, 2023

What's next ?   Towards a more **dynamic partitioning** including more ecological characteristics
                  to better understand communities structure and functioning

                  ⇨ Exploring transition zones in a context of climate change

                  ⇨ What about seasonal variations ?
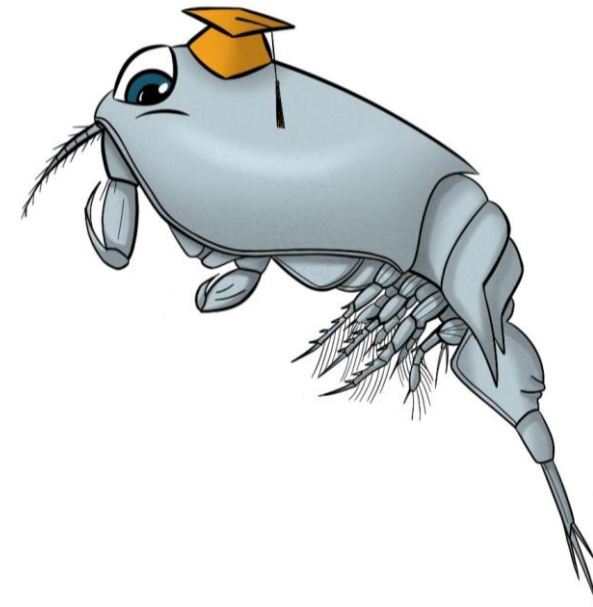
Aknowledgements

Fabio Benedetti for the trait dataset

Pierre Hélaouët for his help with CPR data

Boris Leroy for making the network clustering approach so much more accessible

Looking for a postdoctoral opportunity in 2025

Contact : marion.vilain@protonmail.com