Global distribution of macroplankton biomass estimated by *in situ* imaging

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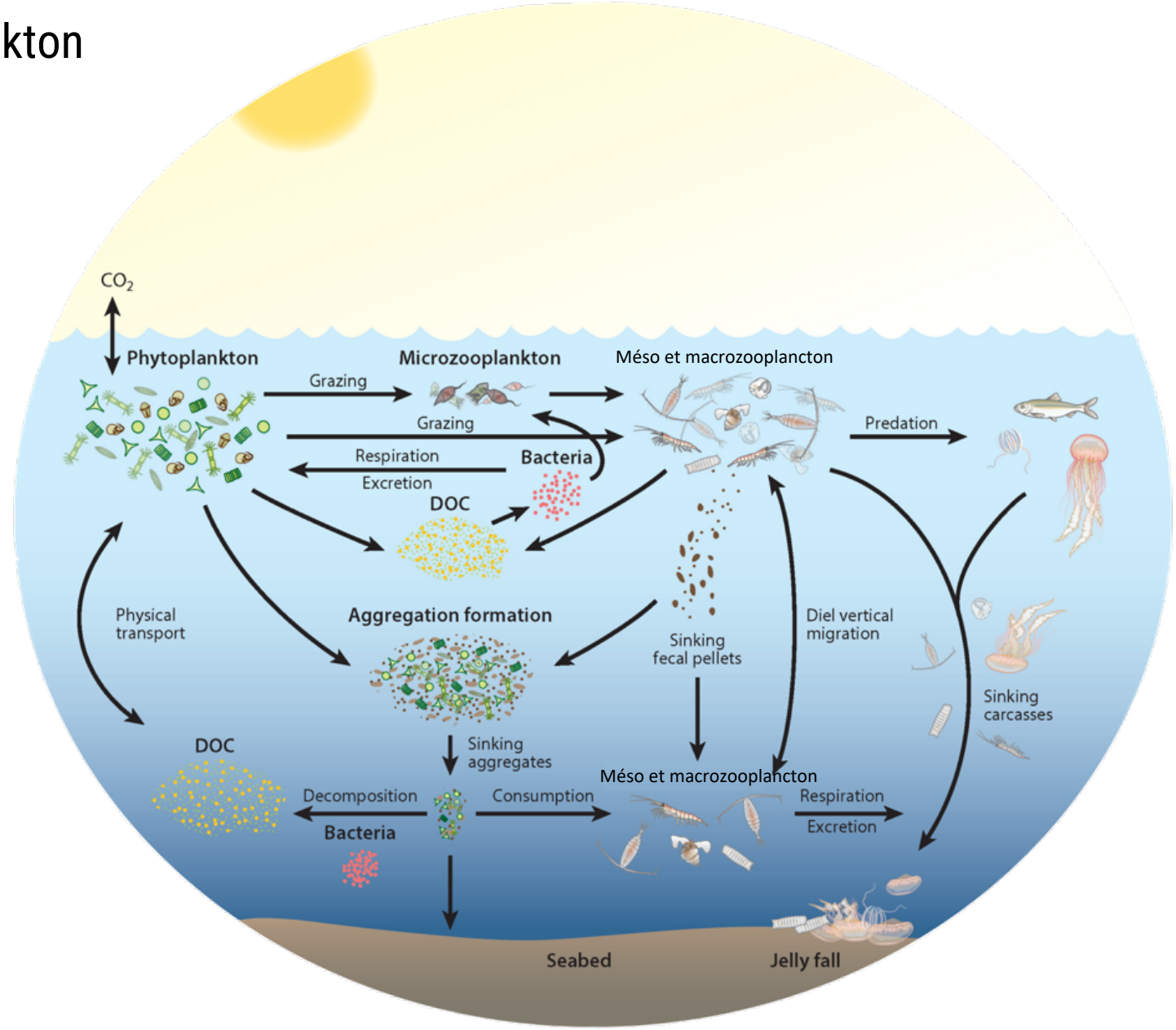
Institut de la Mer de Villefranche sur mer, France
COMPLEx (computational plankton ecology) team

Ecologic role of plankton

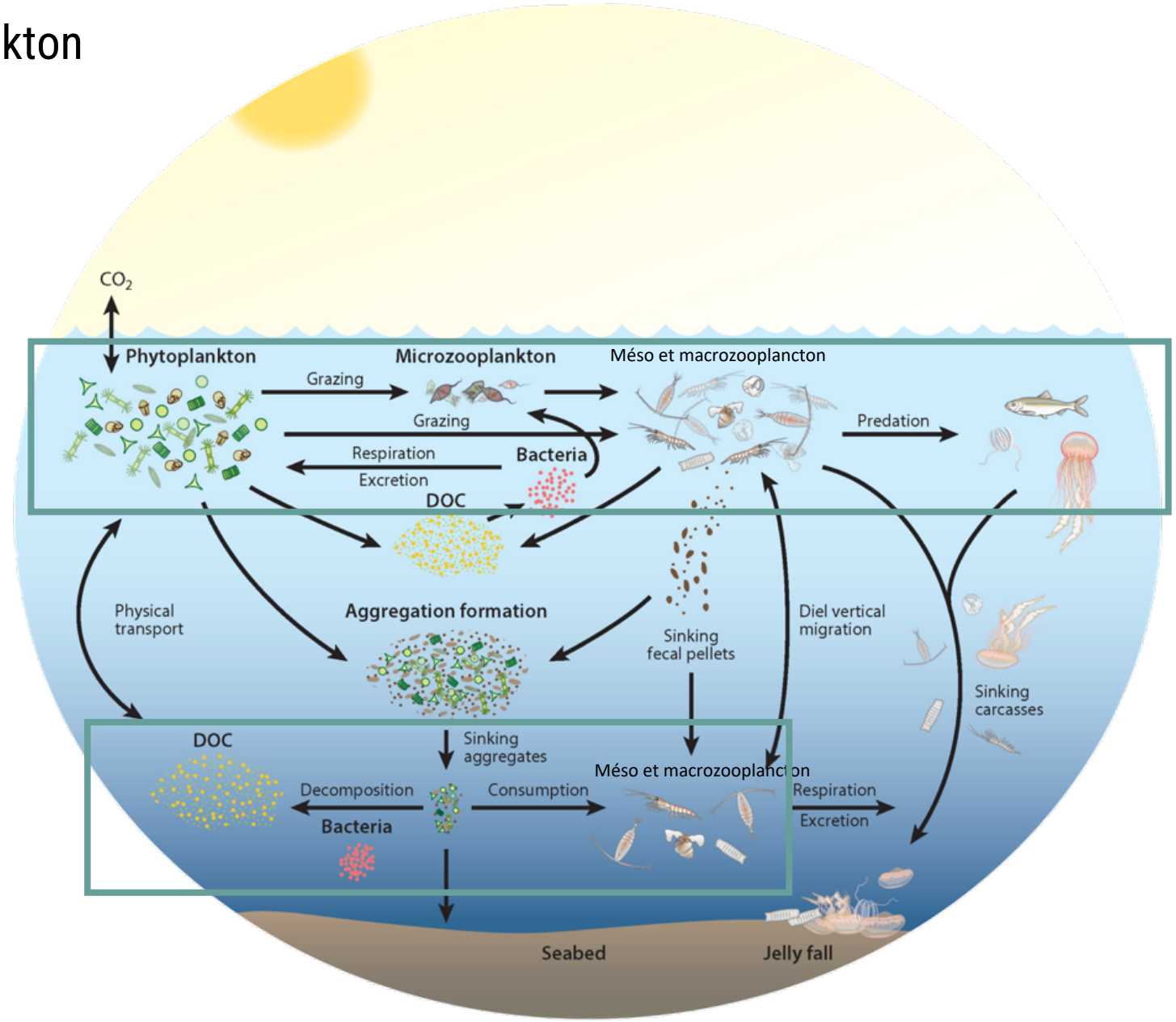


Adapted from Steinberg et Landry, 2017

Ecologic role of plankton

Epipelagic trophic chain

Mesopelagic trophic chain



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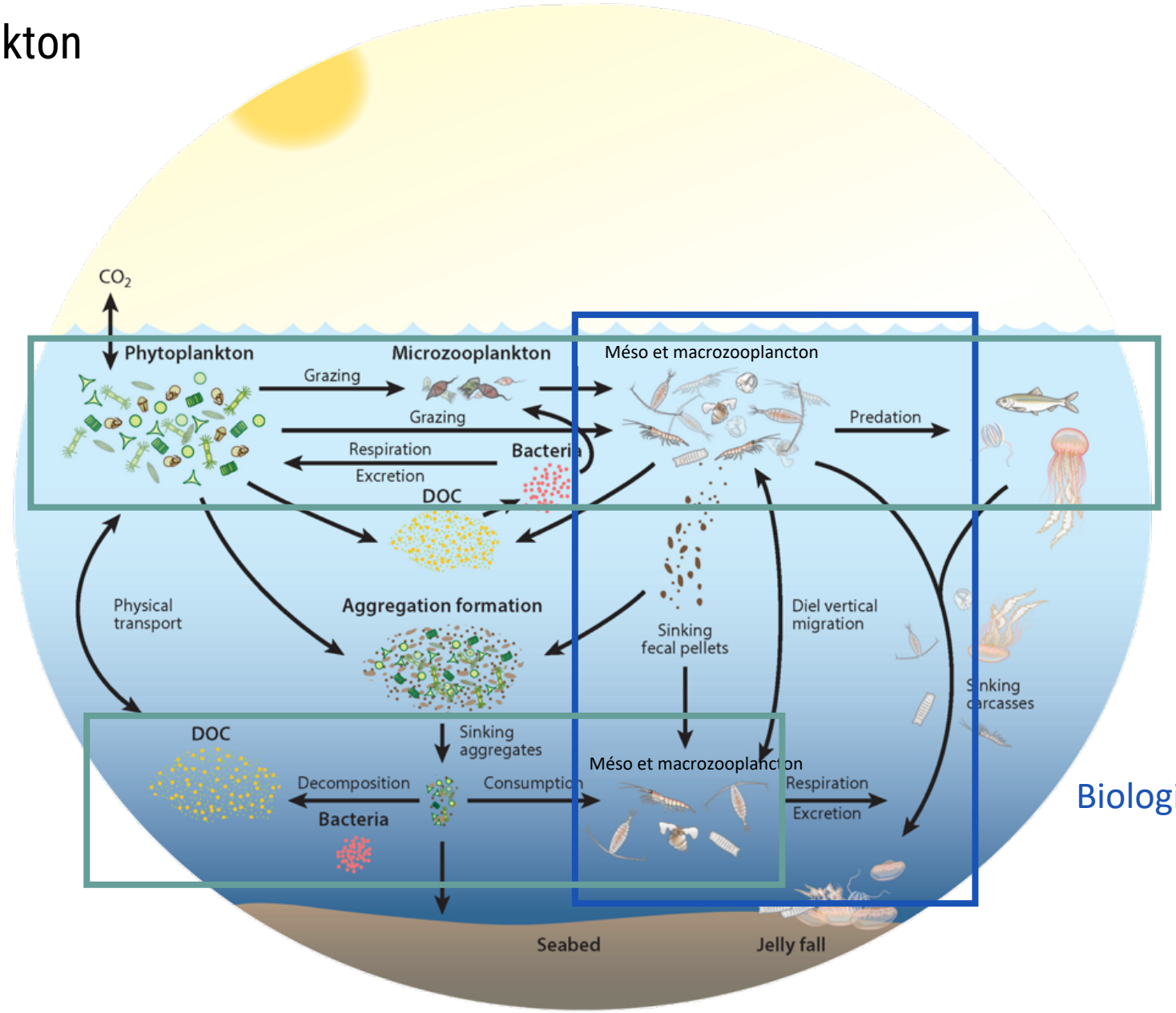
Ecologic role of plankton

Epipelagic trophic chain

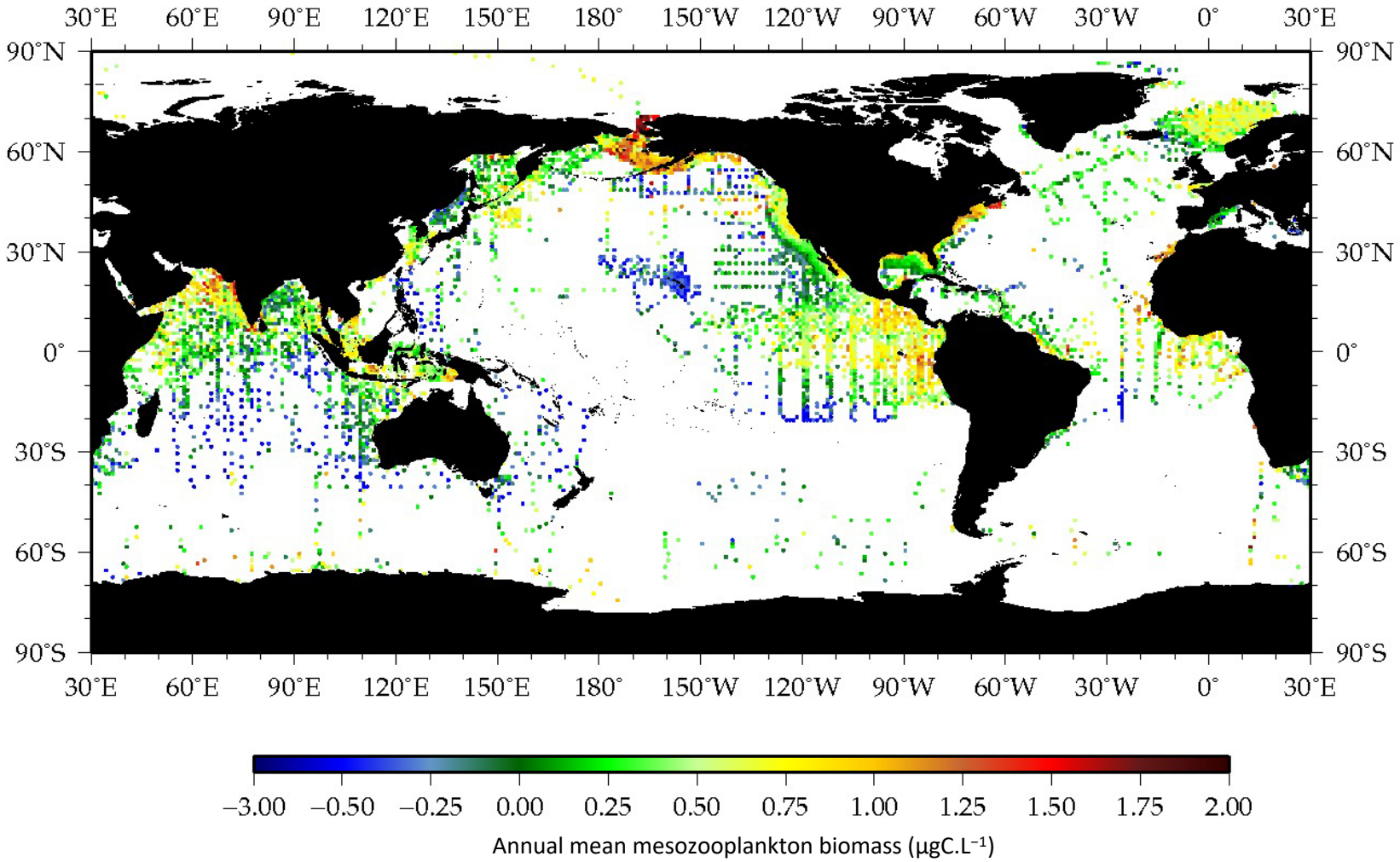
Mesopelagic trophic chain



Biological pump

Adapted from Steinberg et Landry, 2017

Plankton biomass geographic distribution patterns



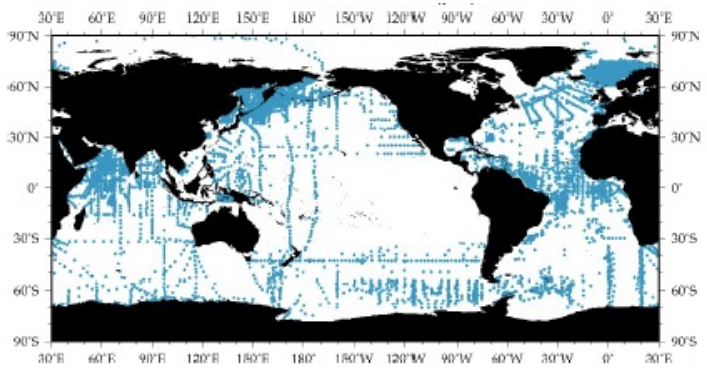
(Moriarty et *al.*, 2013)

Estimation of plankton biomass

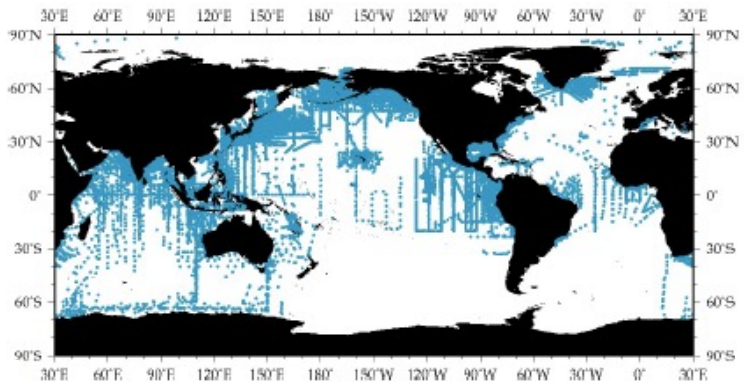
Heterogeneity of methods

- **Sampling** : season, location, depth, tools

Sampling (Moriarty et *al.*, 2013)



Mesh size = 200µm



Mesh size = 333µm

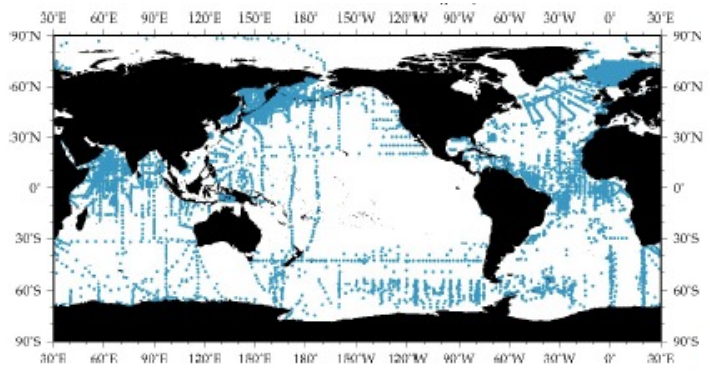
Estimation of plankton biomass

Heterogeneity of methods

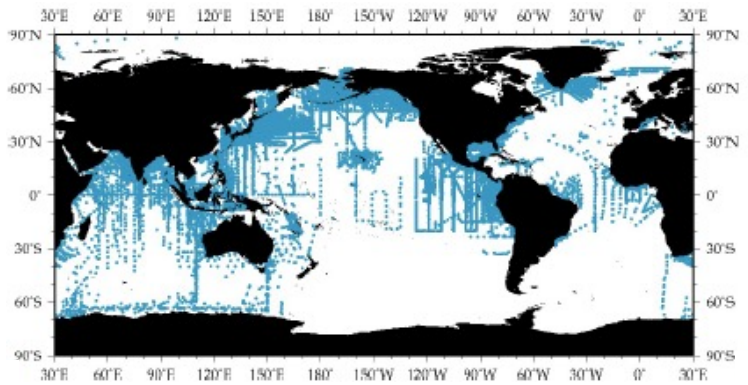
- **Sampling** : season, location, depth, tools
- **Measurements** : settling volume, wet weight, etc.
- Mainly **nets** : bias towards non gelatinous taxa (Lucas et *al.*, 2014)

Sampling

(Moriarty et *al.*, 2013)

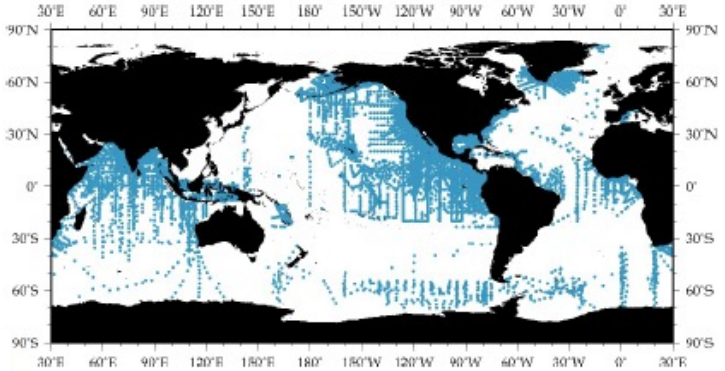


Mesh size = 200µm

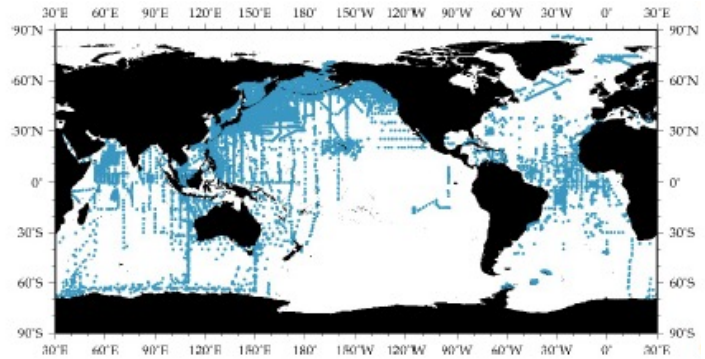


Mesh size = 333µm

Measurements



Settling volume



Wet weight

OBJECTIVES

- Estimate the geographic distribution of large groups of plankton
- Estimate global plankton biomass

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HYPOTHESIS

The distribution of organisms and their biomass depends on environmental factors

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HYPOTHESIS

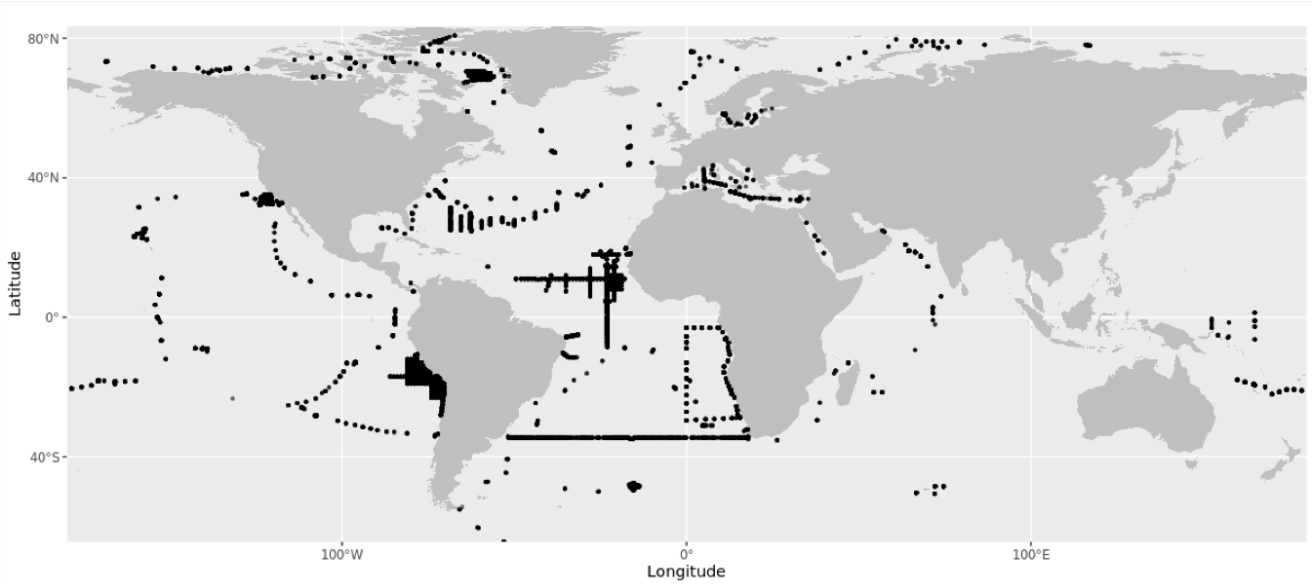
The distribution of organisms and their biomass depends on environmental factors

APPROCHE

Individual biomass of plankton by *in situ* imaging

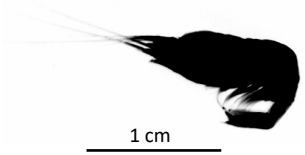
Habitat models

Data acquisition



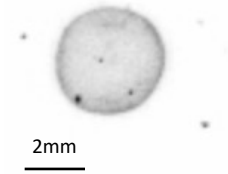
Distribution of profiles Underwater Vision Profiler 5 (≈ 2700 vertical profiles)

Image dataset
(650 000 georeferenced images)

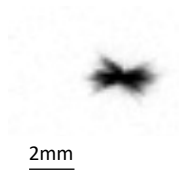


Eumalacostraca

Copepoda

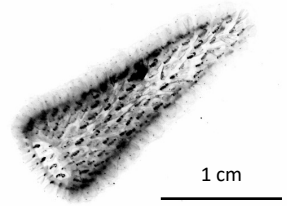


Collodaria



Trichodesmium

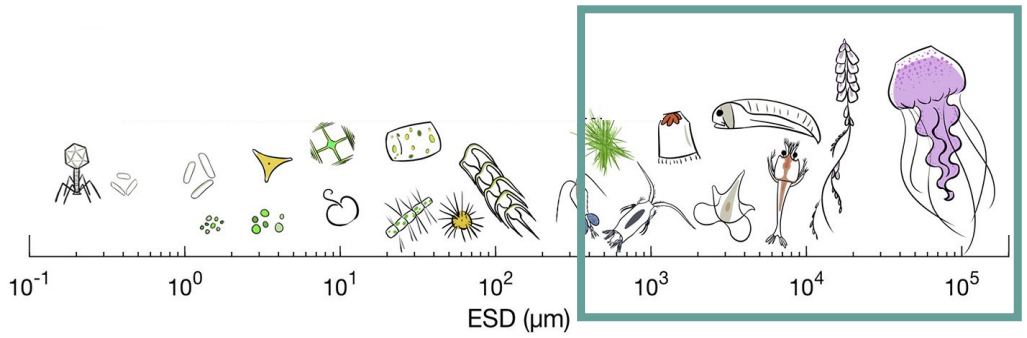
Appendicularia



Pyrosoma

UVP5
≥ 600µm

(Picheral et al., 2010)



Plankton size spectrum adapted from Lombard et *al.*, 2019

1. From image to biovolume

Image

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Image

Taxonomic identification

Selection size 1-50mm

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Image

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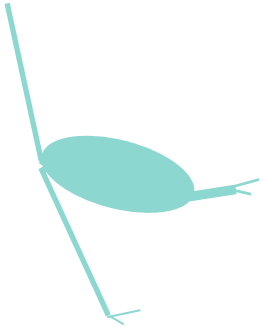


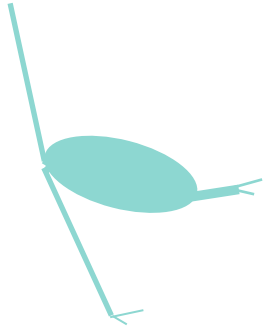
area = n pixels

1. From image to biovolume

Image

Taxonomic identification

Selection size 1-50mm



area = n pixels

Area transformed into circle

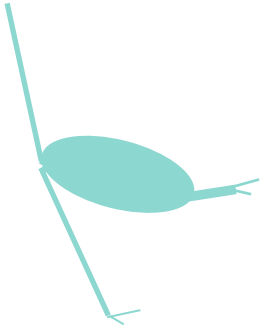
area = n pixels

1. From image to biovolume

Image

Taxonomic identification

Selection size 1-50mm



area = n pixels

Area transformed into circle

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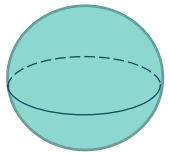
Biovolume

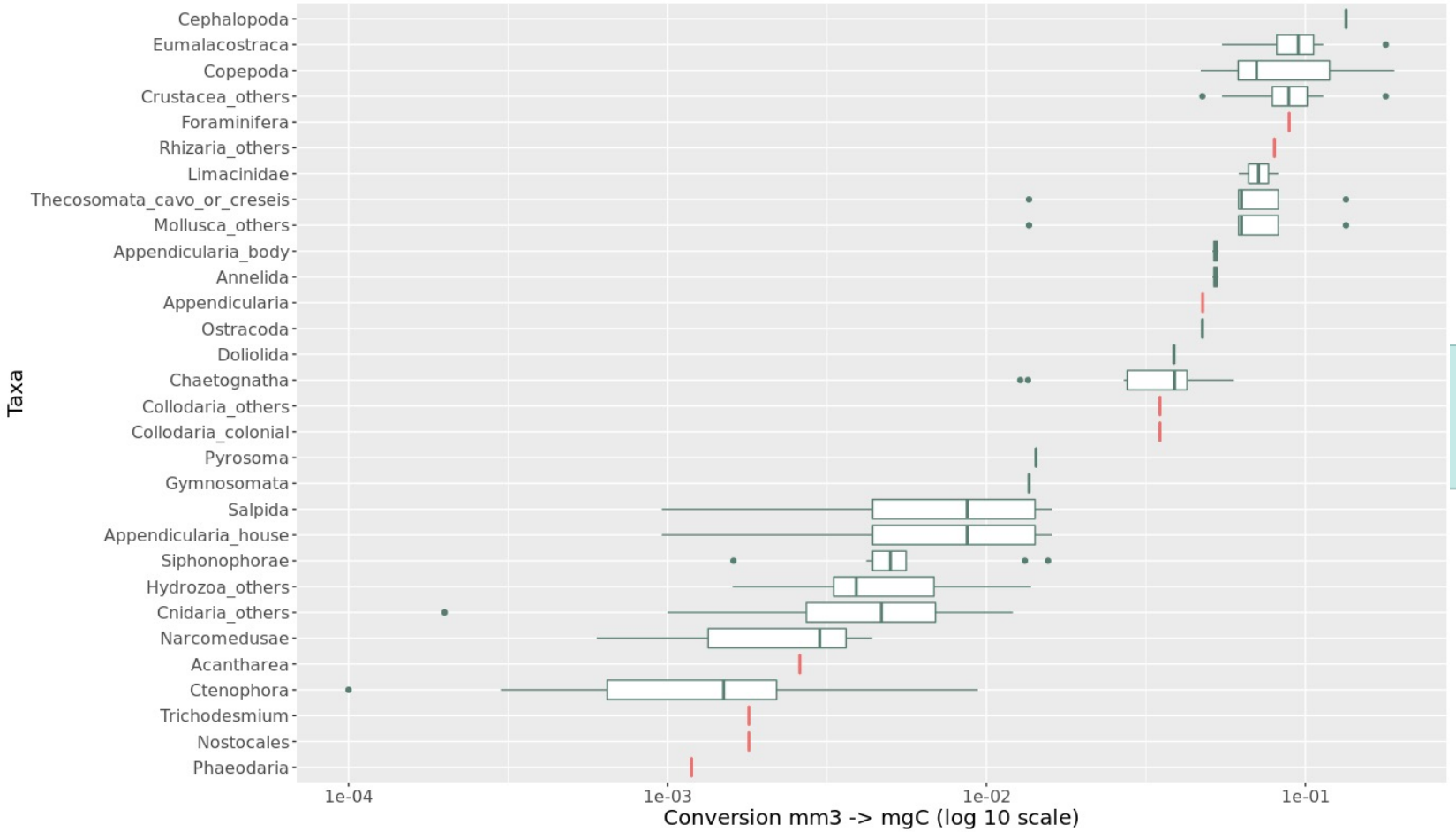
($mm^3.individual^{-1}$)



Equivalent spheroid

2. From biovolume to biomass

Biovolume
($mm^3.individual^{-1}$)



Biomass
($mgC.individual^{-1}$)

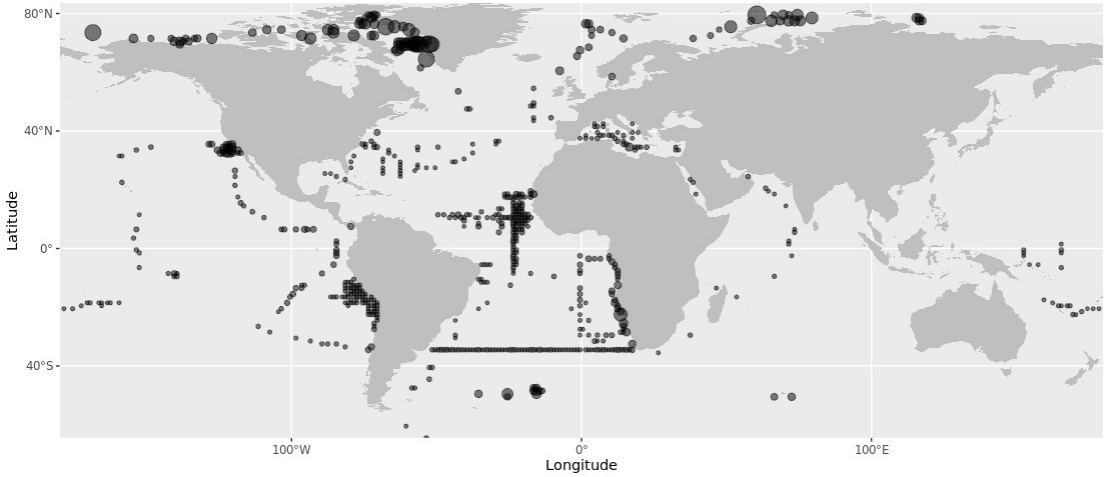
Conversion factors (scale log10)

(McConville et *al.*, 2016 and 7 other references)

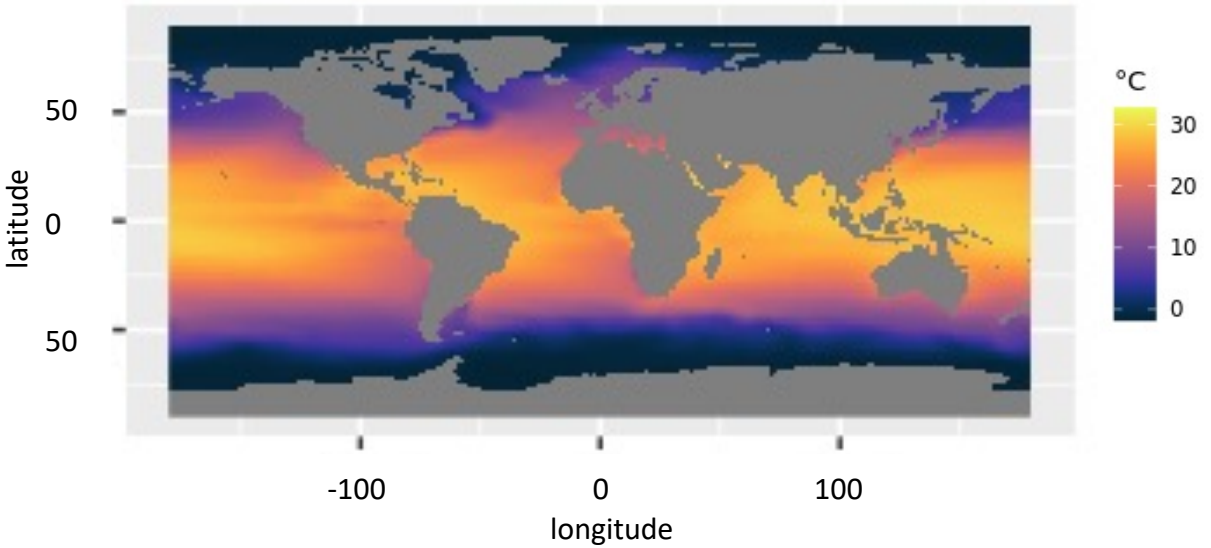
Use of median

3. Habitat models

Biomass of epipelagic copepods (mgC.m^{-3}) in each UVP5 station



Temperature



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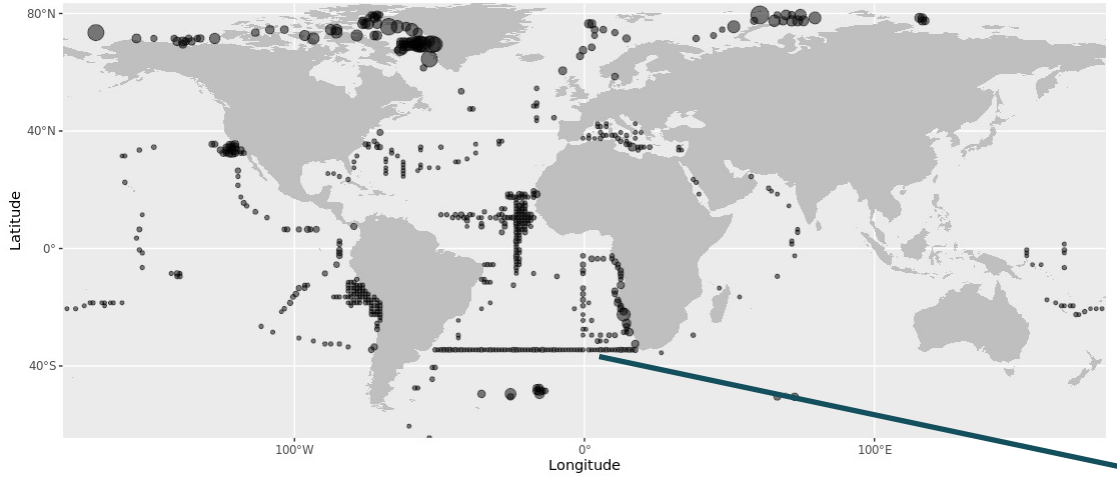
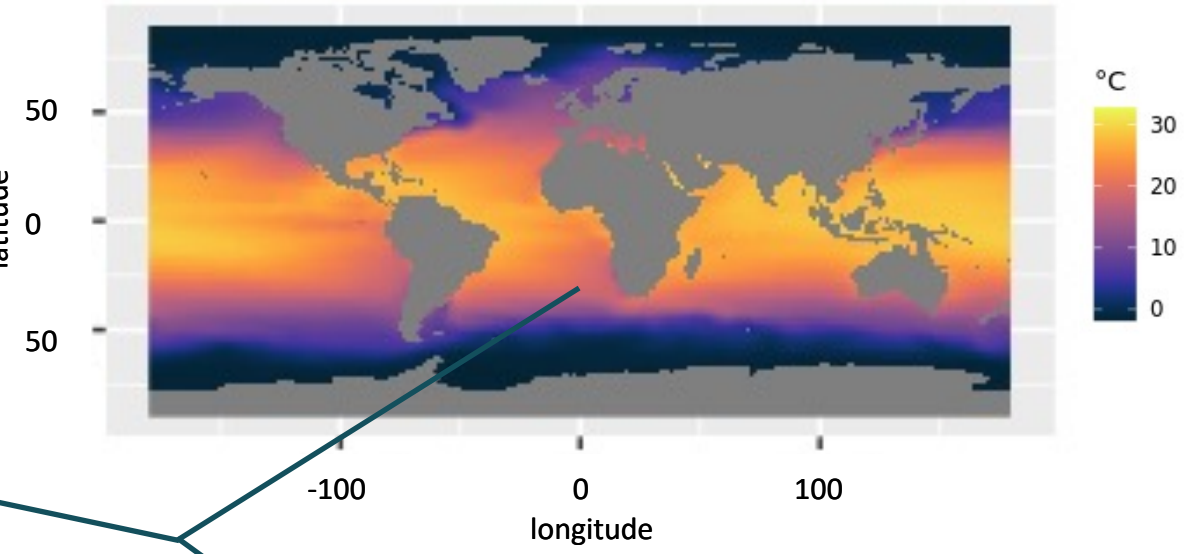
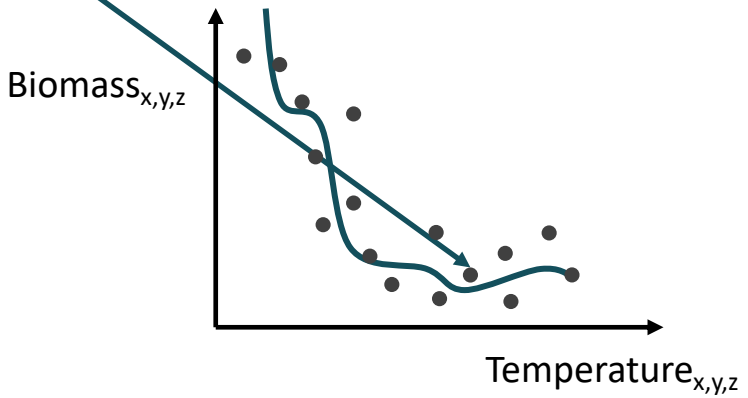


Temperature





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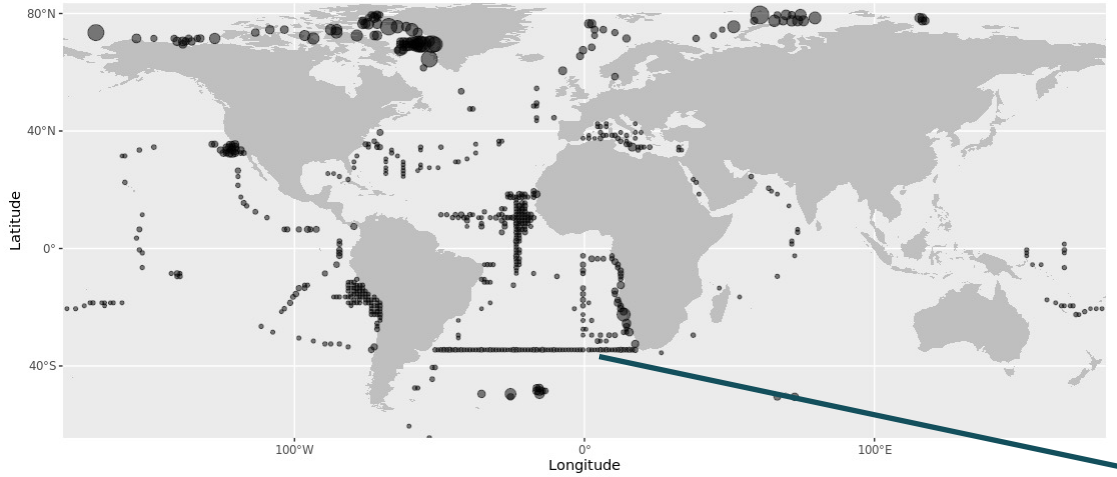

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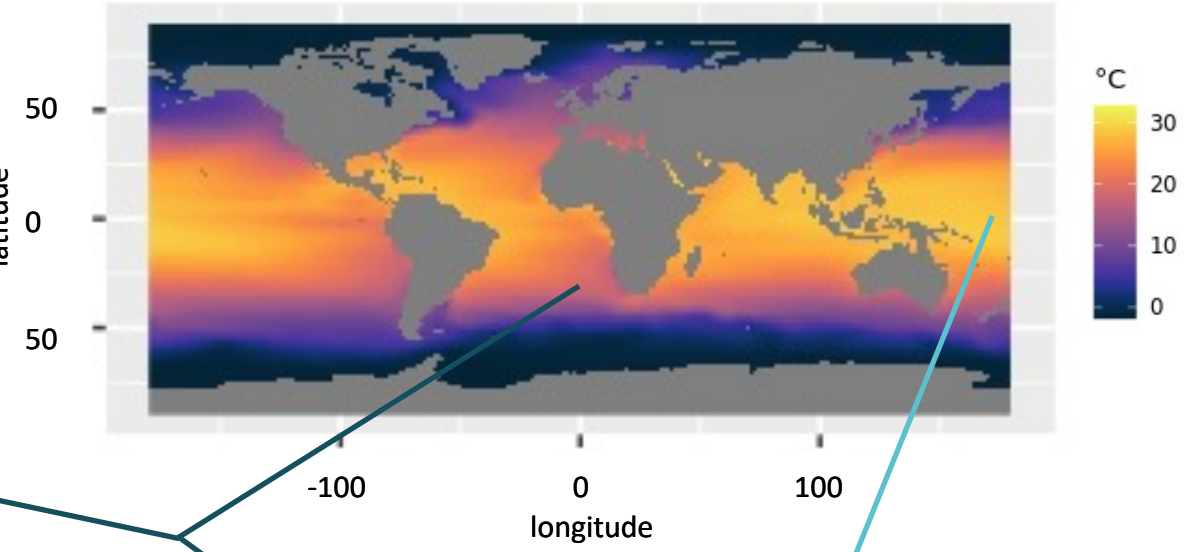

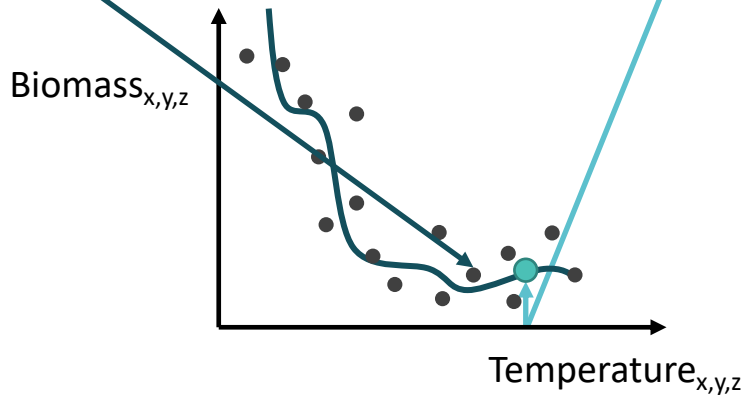

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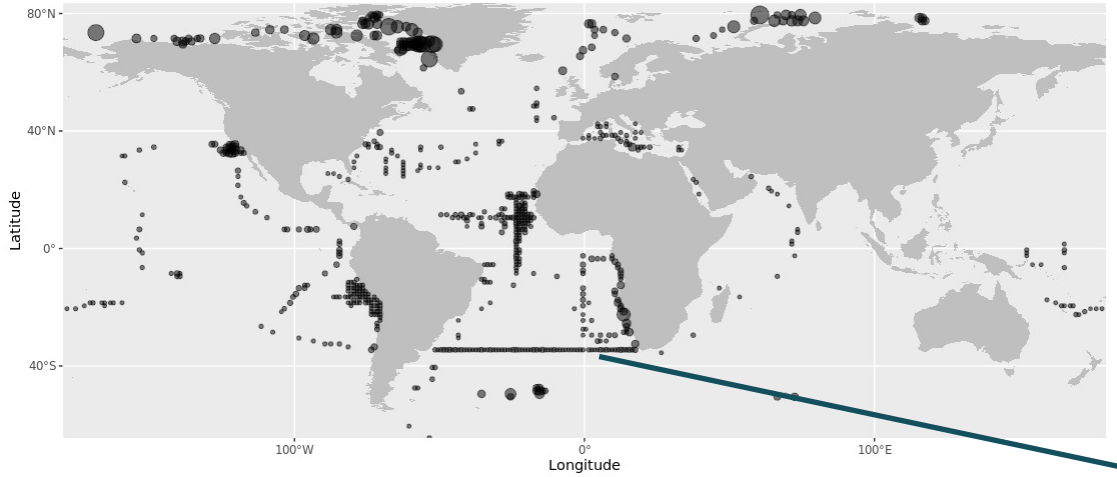
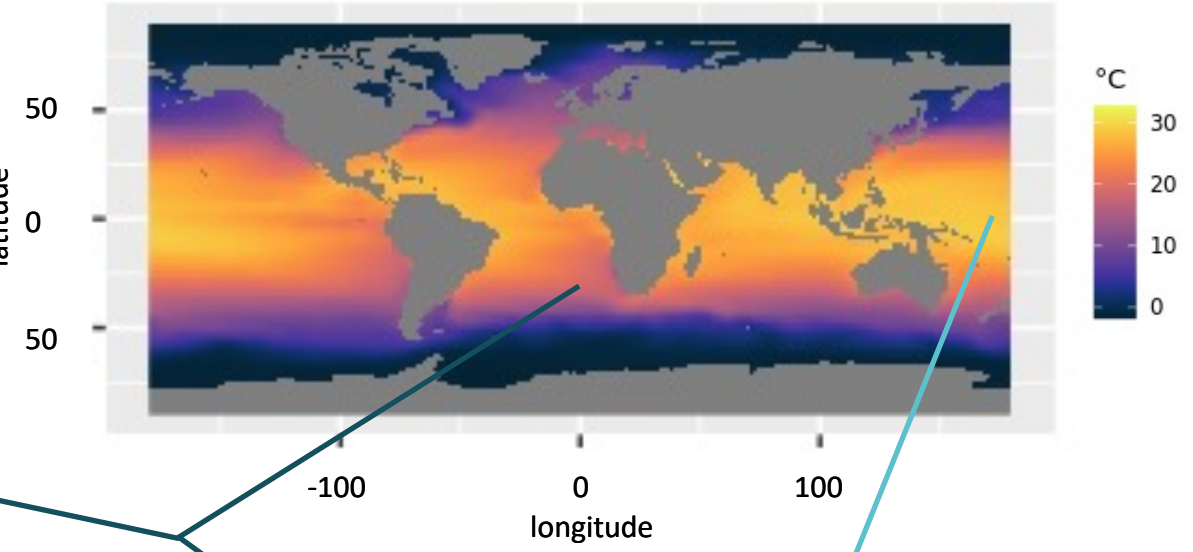
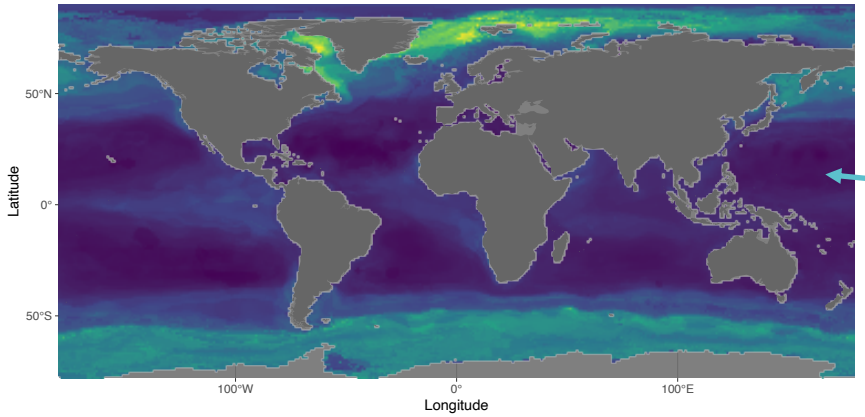


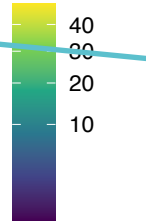
Temperature

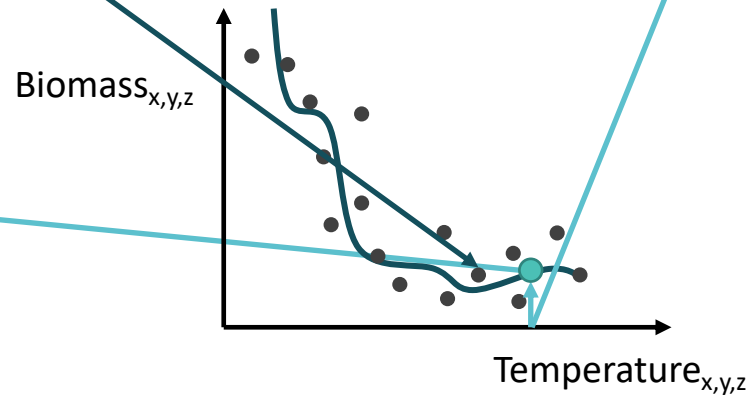


Prediction for epipelagic copepods



Predicted biomass (mgC.m^{-3})

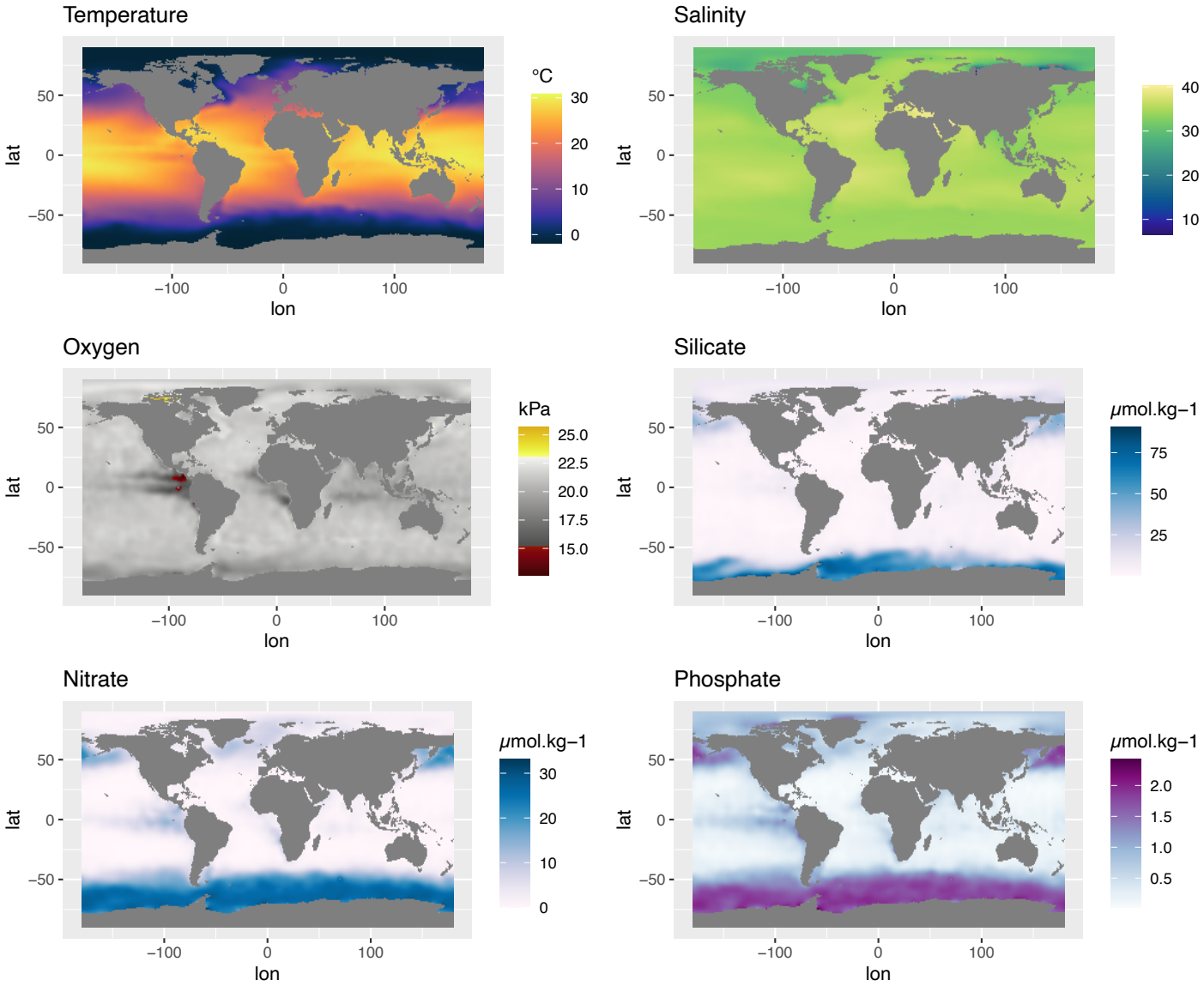


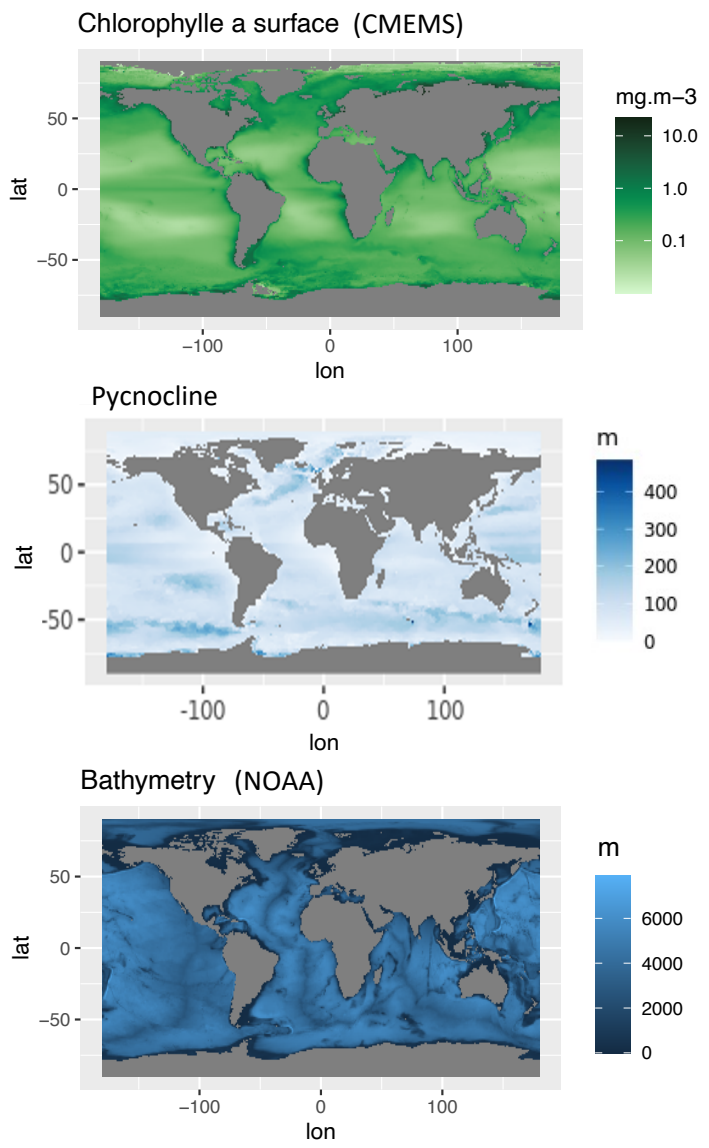


Evalution of the model with the R^2
Computation of global biomass for the R^2 > 10%

3. Habitat models in epi and mesopelagic : multivariate approach

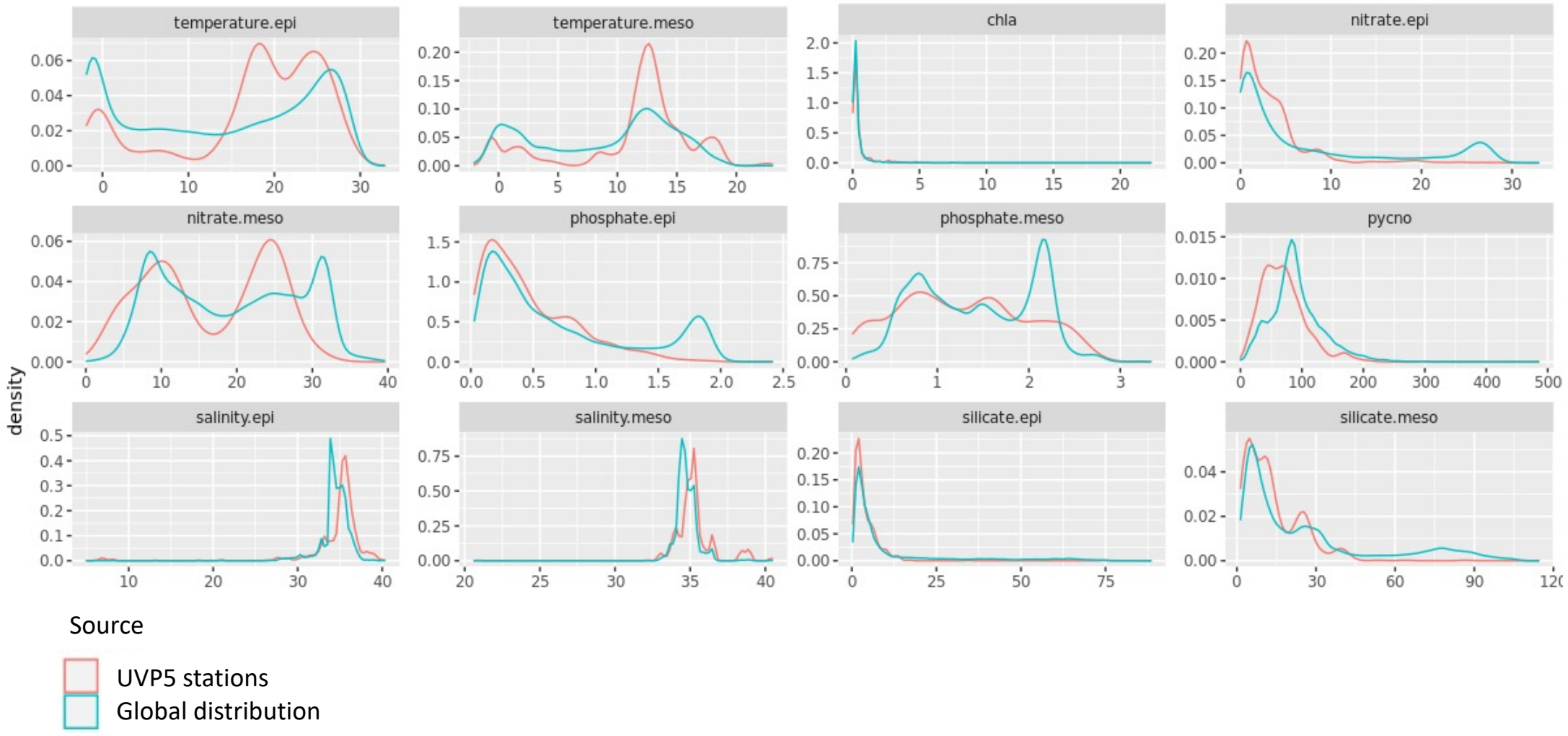
$Biomass_{x,y,z} = f(environmental\ variables_{x,y,z})$



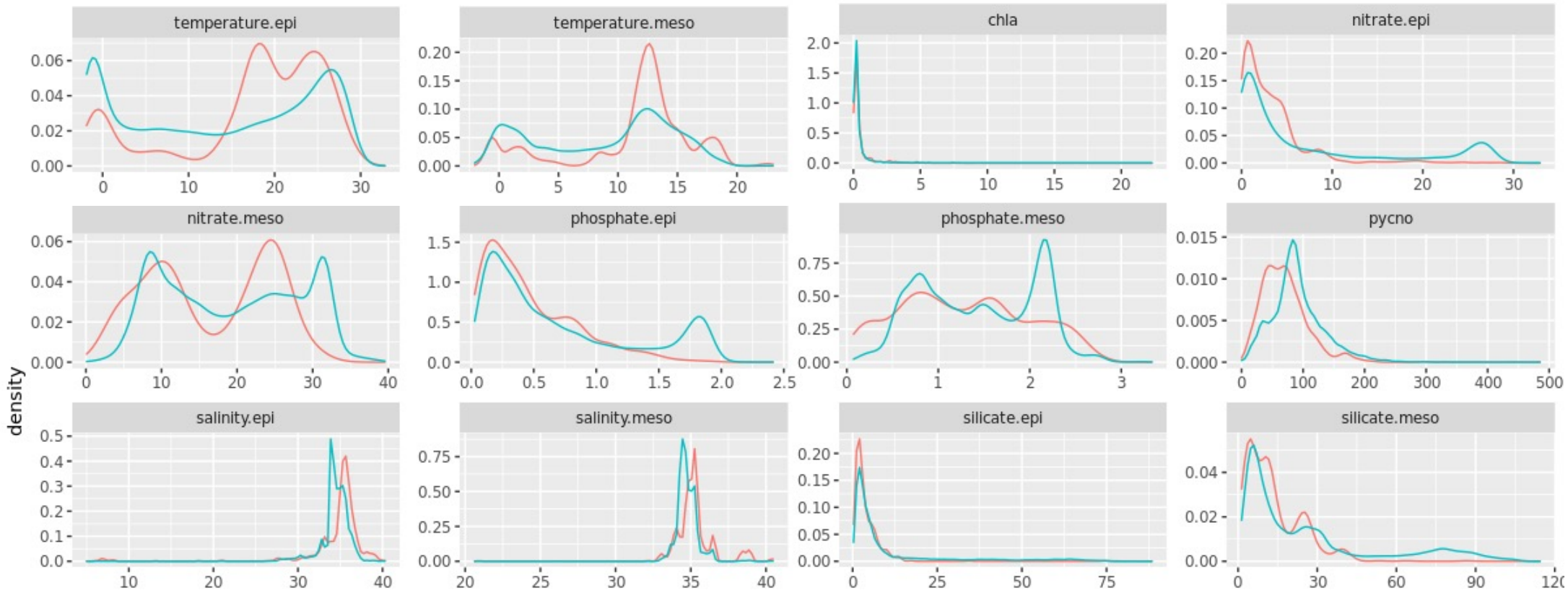


Epipelagic climatologies (World Ocean Atlas)

Environmental conditions coverage



Environmental conditions coverage

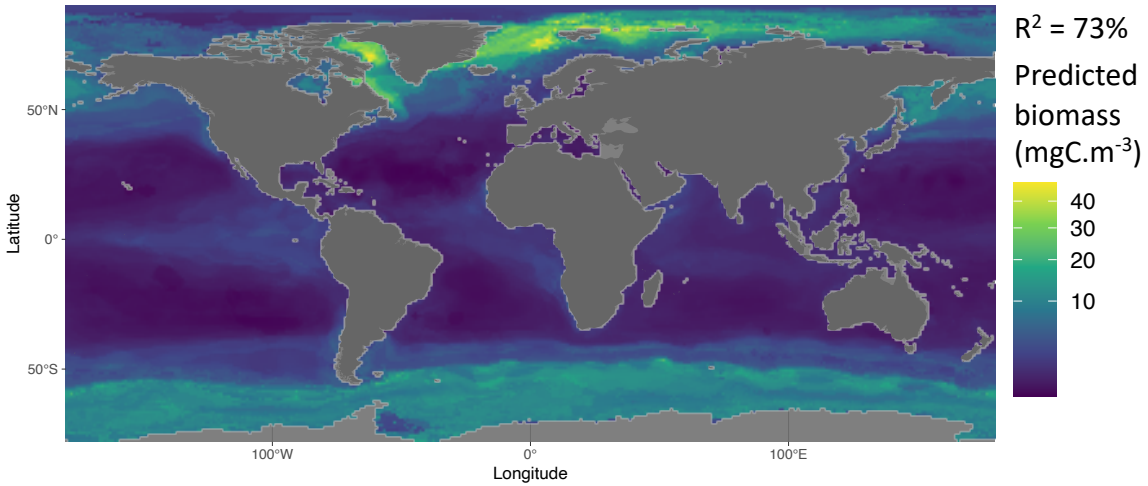


Good coverage of the environmental space

Biomass distribution of organisms: Copepoda

Maps of predicted distribution

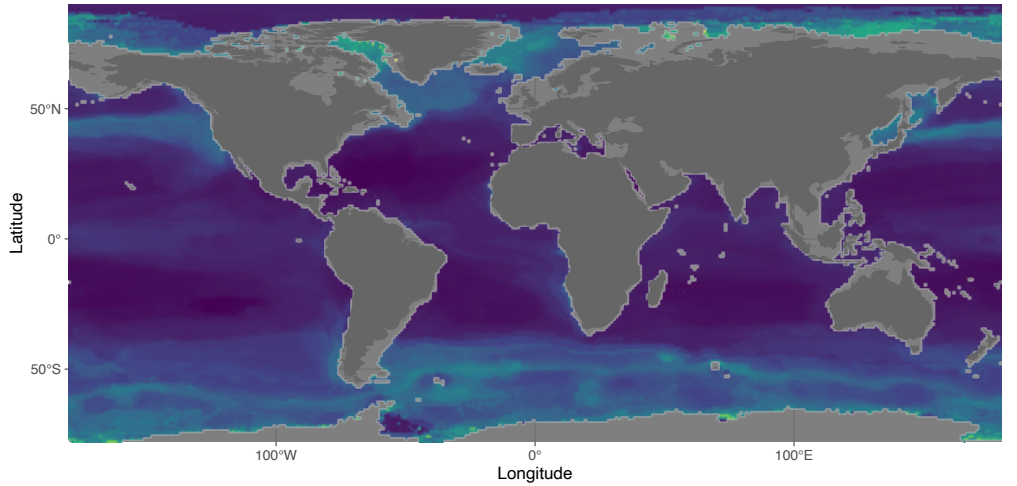
Epipelagic



R^2 = 73%

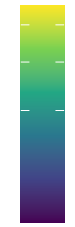
Predicted biomass ($mgC.m^{-3}$)

Mesopelagic

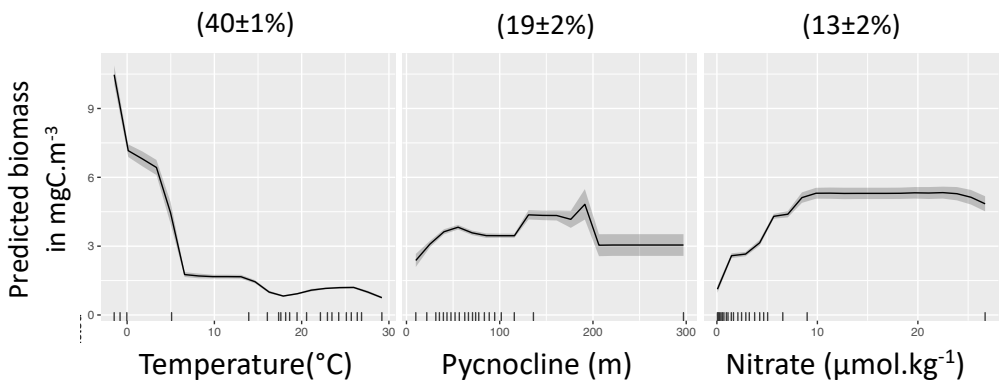


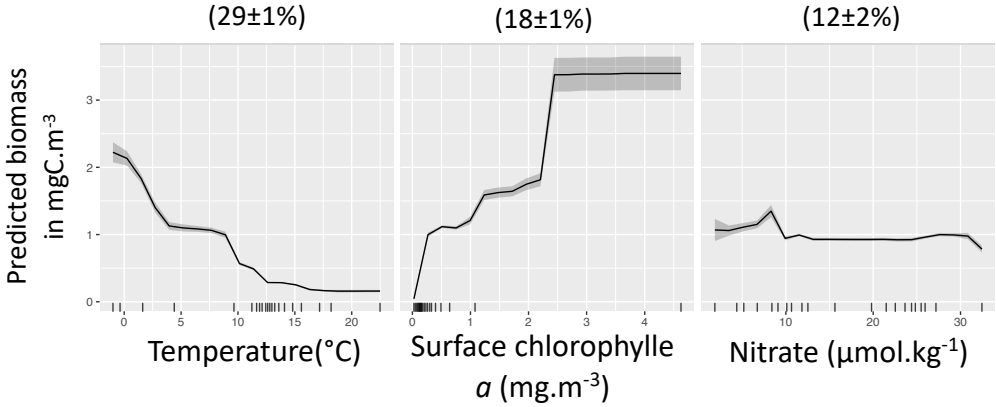
R^2 = 35%

Predicted biomass ($mgC.m^{-3}$)

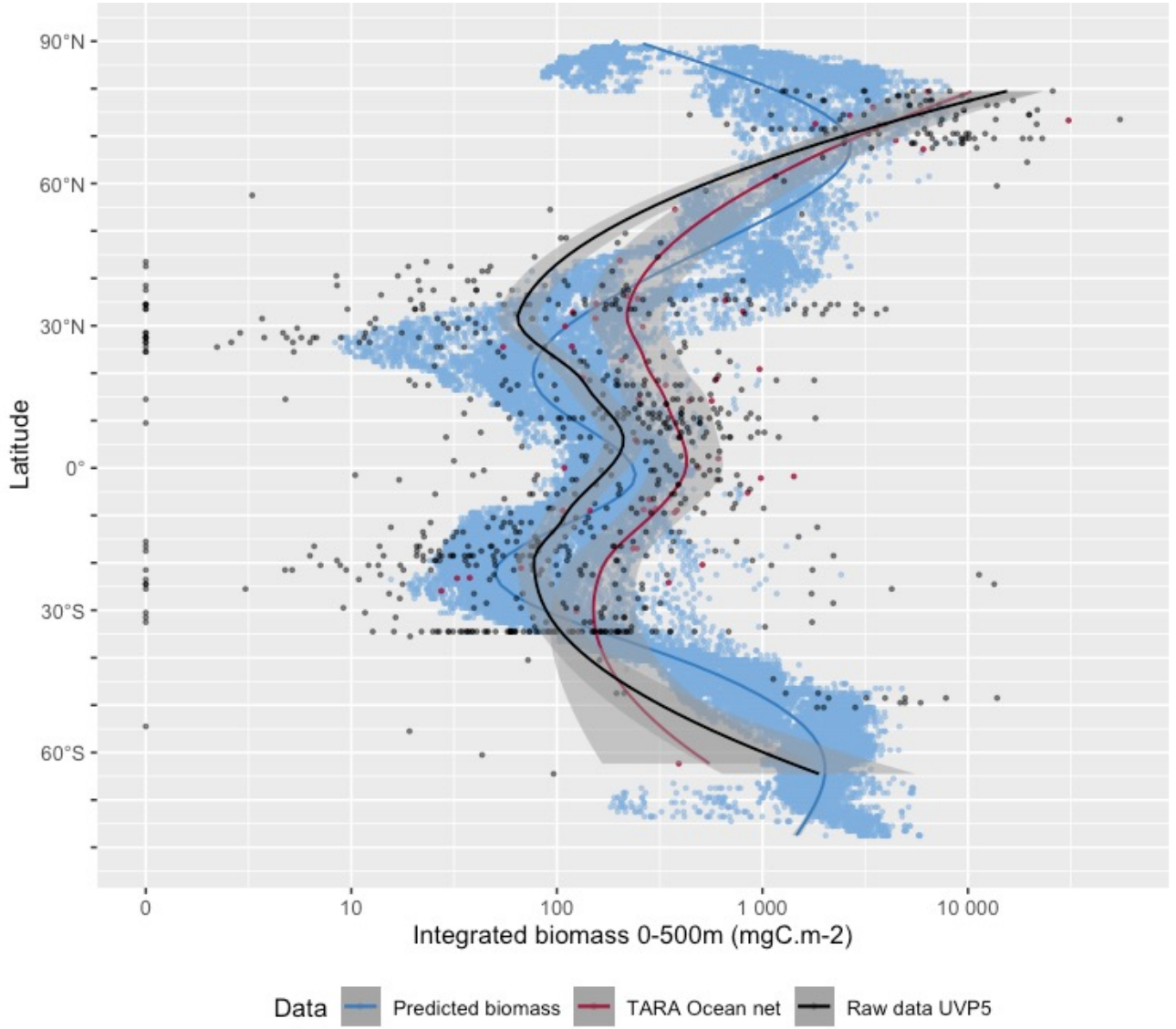


Partial dependance plots



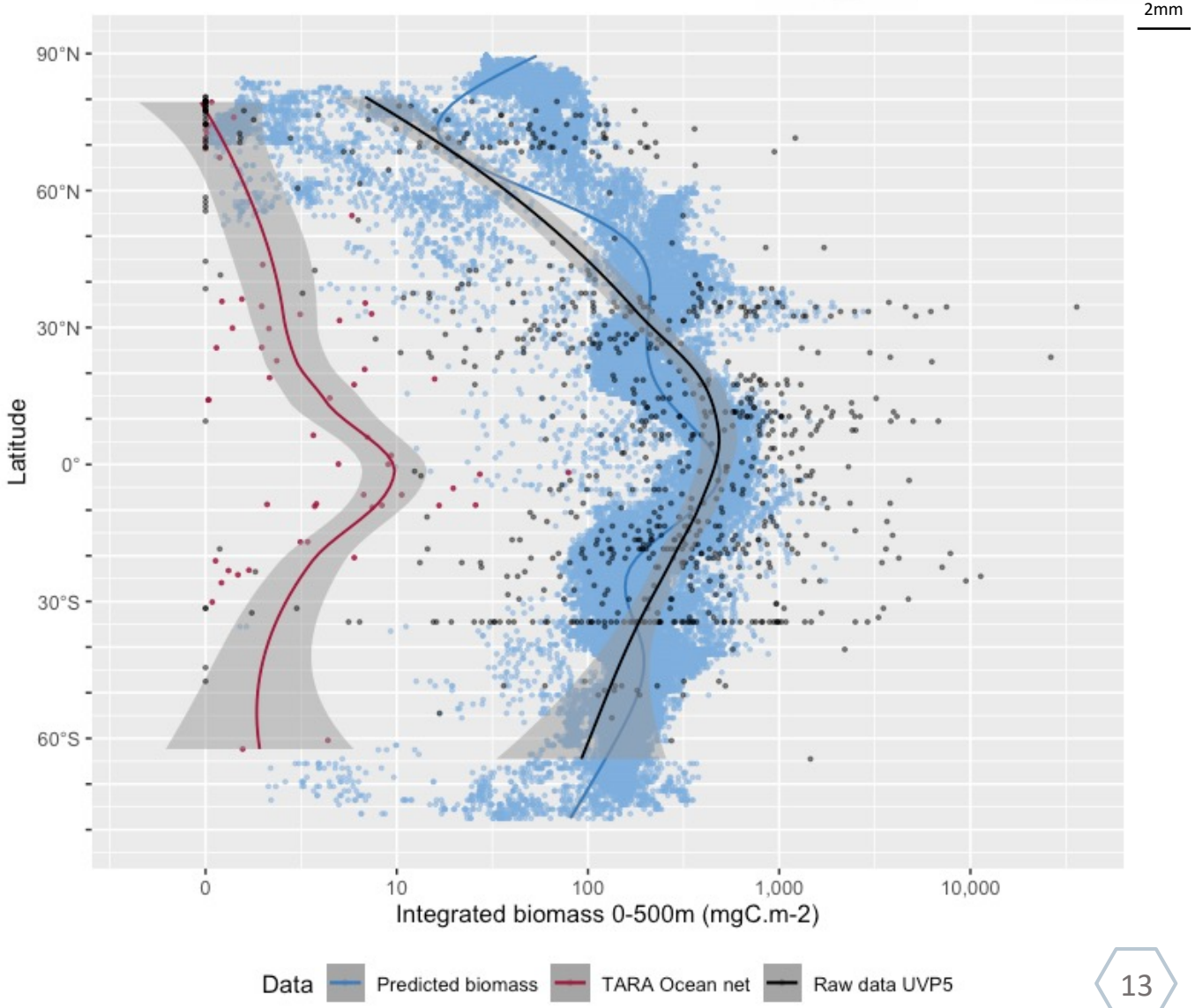


Biomass distribution of organisms: Copepoda



Biomass distribution of organisms: Rhizaria

2mm



Biomass distribution of organisms: Rhizaria

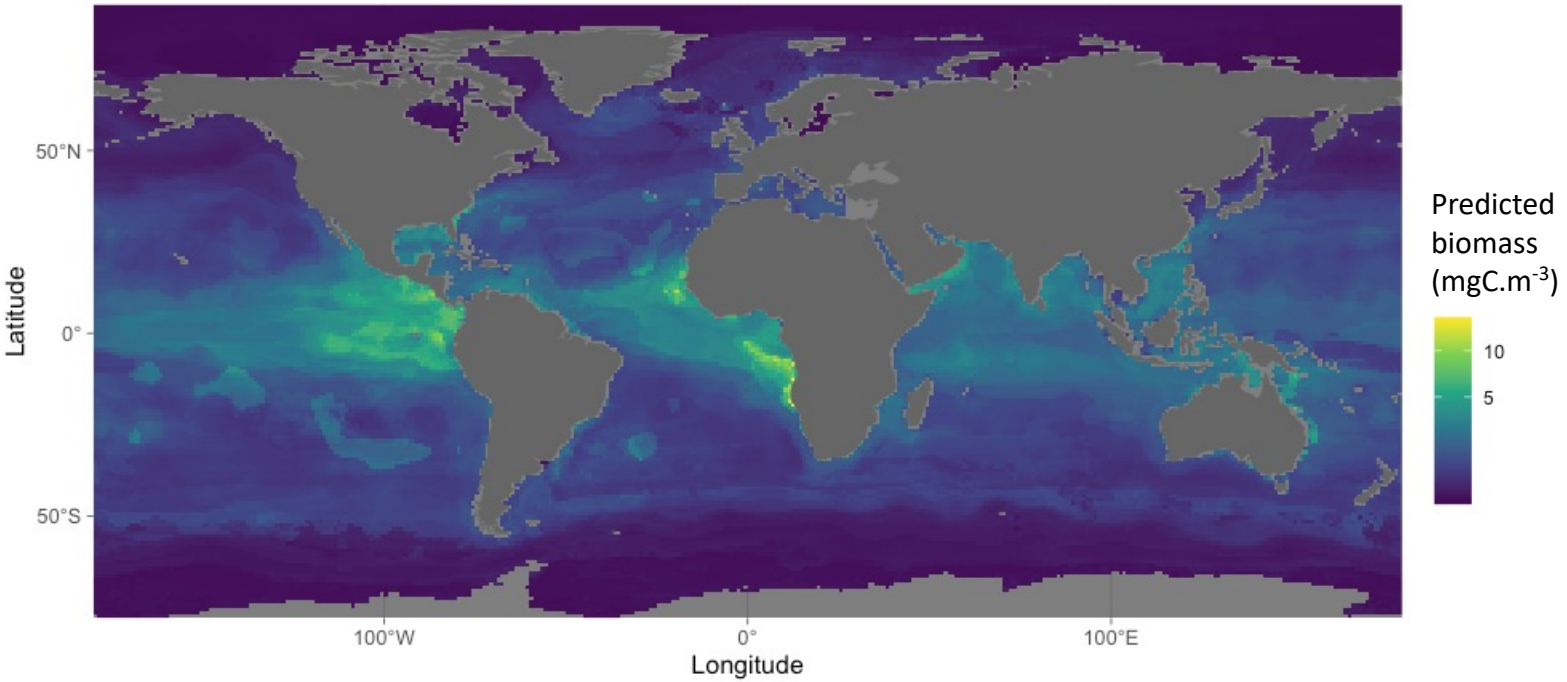
Median value of biomass

- TARA: 2.12 mgC.m-2
- Predicted from UVP5 images: 170.90 mgC.m-2

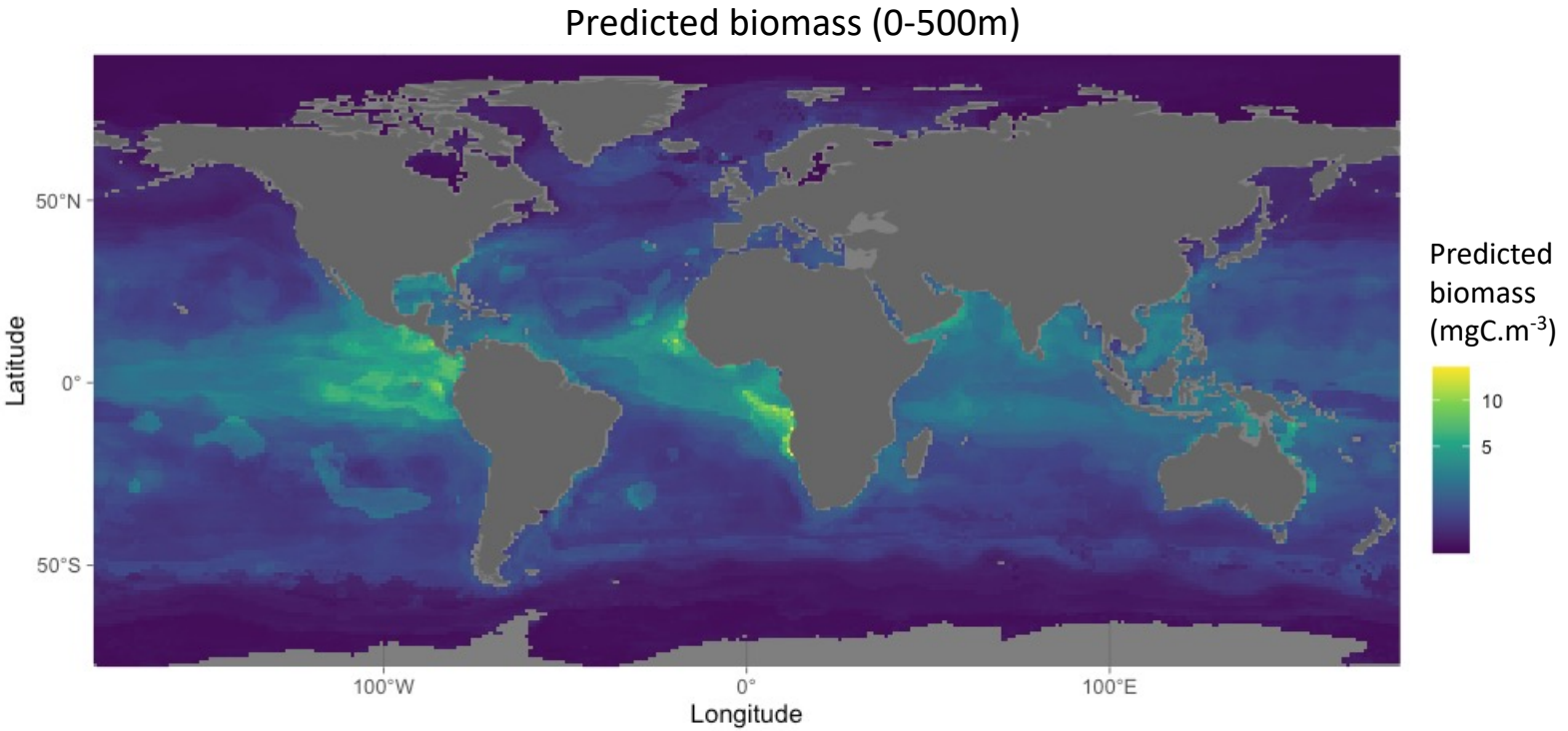
x 80

Biomass distribution of organisms: Rhizaria

Predicted biomass (0-500m)

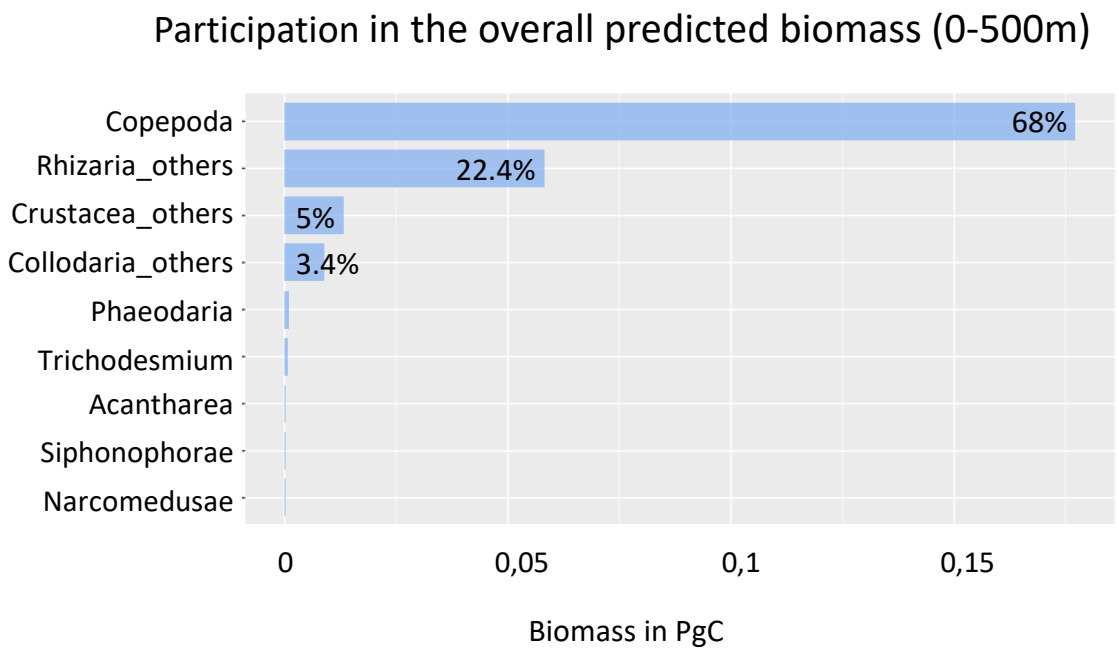


Biomass distribution of organisms: Rhizaria



	1st and 2nd driving variables	
Taxonomic group	Epipelagic	Mesopelagic
Acantharea	Nitrate, Salinity	Nitrate, Oxygen
Collodaria non colonial	Pycnocline, Oxygen	Phosphate, Pycnocline
Foraminifera		Chla, Silicate
Phaeodaria	Salinity, Temperature	Silicate, Oxygen
Rhizaria_others	Nitrate, Temperature	Salinity, Pycnocline

Estimation of global biomass



Large dominance of copepods

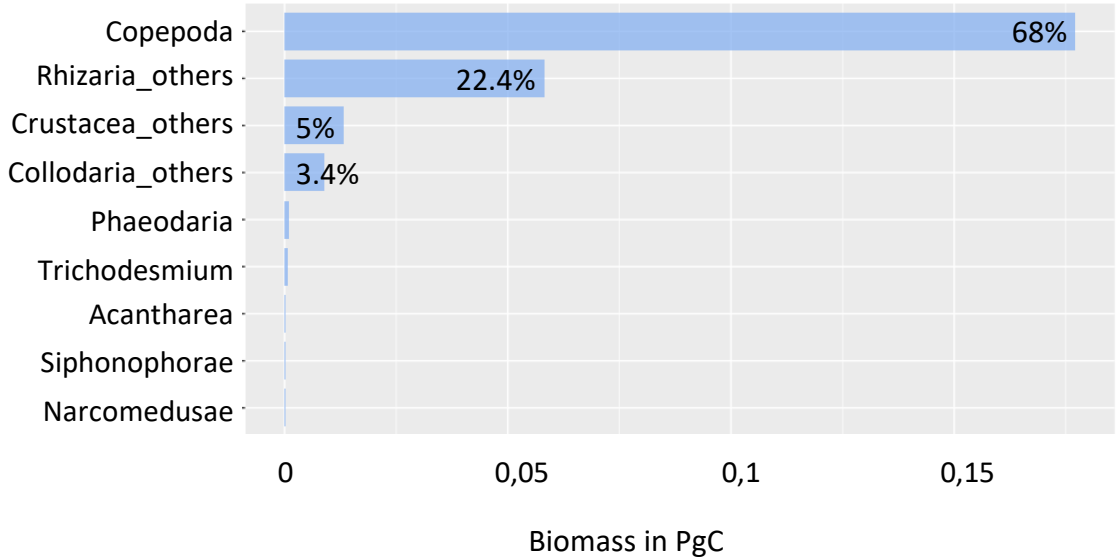
Copepoda : 68%

Rhizaria: 26.2%

Crustacea_others = all crustaceans except Copepoda, Ostracoda, Eumalacostraca

Estimation of global biomass

Participation in the overall predicted biomass (0-500m)



0.31PgC

Copepoda : 68%

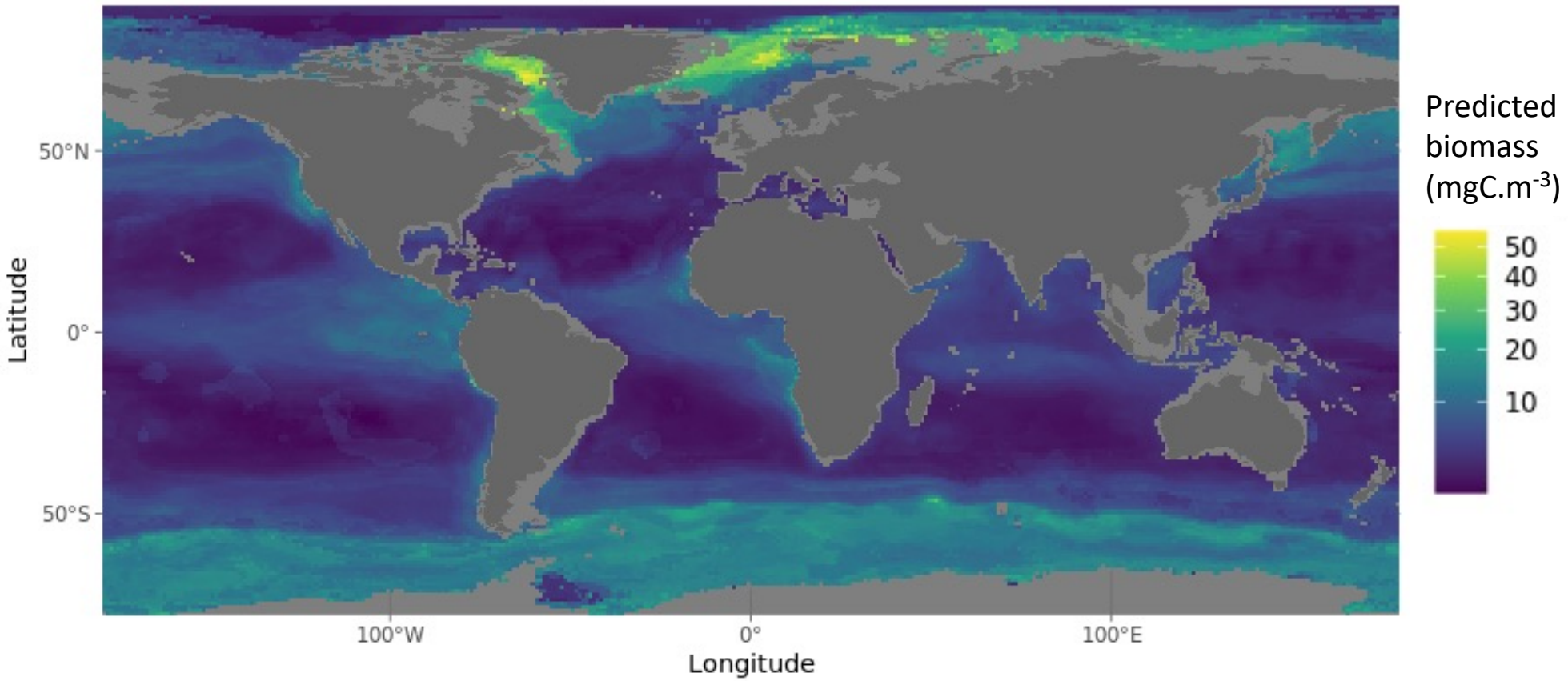
Rhizaria: 26.2%

Large dominance of copepods

Crustacea_others = all crustaceans except Copepoda, Ostracoda, Eumalacostraca

Estimation of global biomass

Total biomass (0-500m)



Plankton processes

- Better understanding of association with water masses
- Copepods: temperature
- Rhizaria: diverse

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Global biomass distribution

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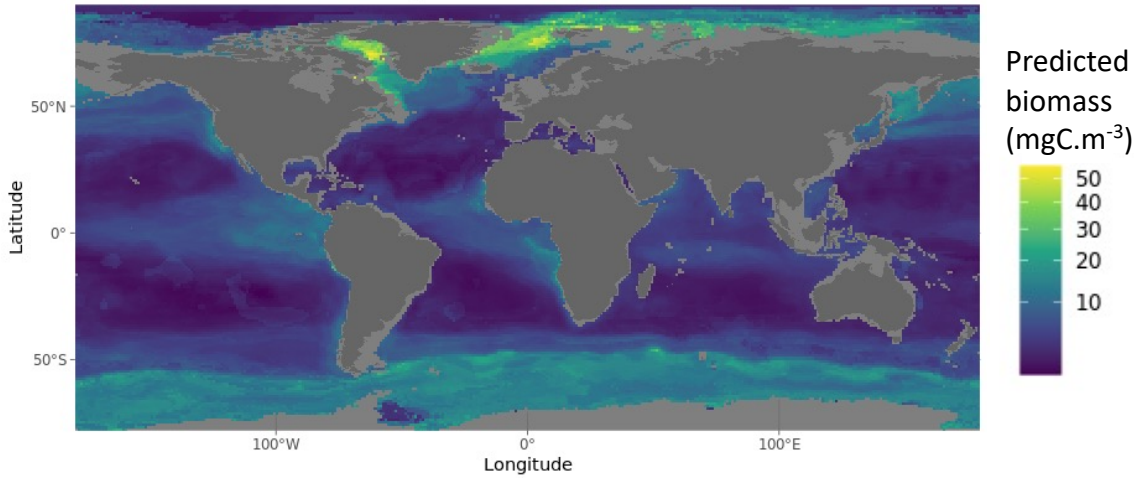
Integrated predicted global biomass (0-500m)



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Perspectives

- Global or regional scales
- Seasonality
- Digital ocean

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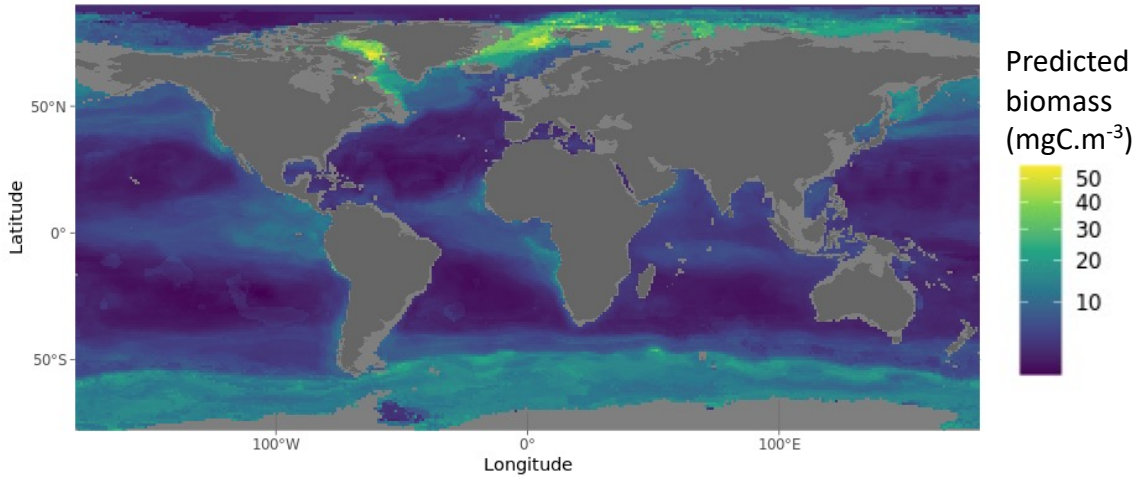
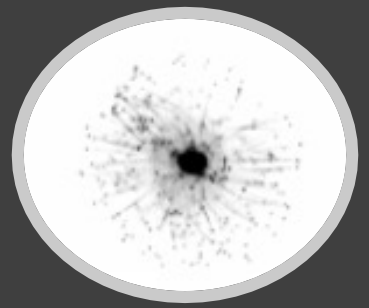
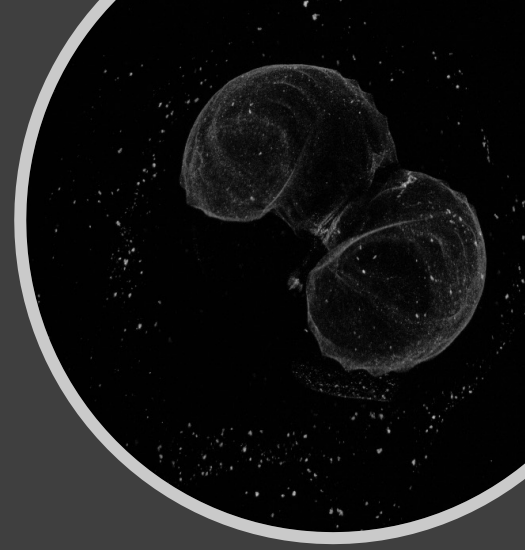
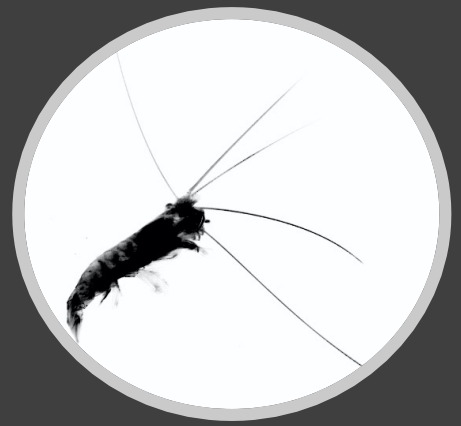
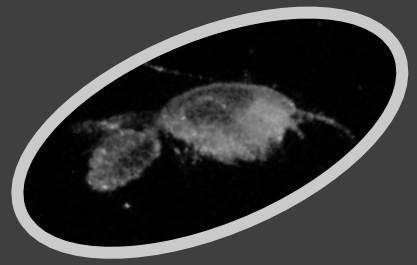
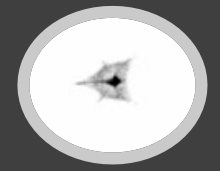
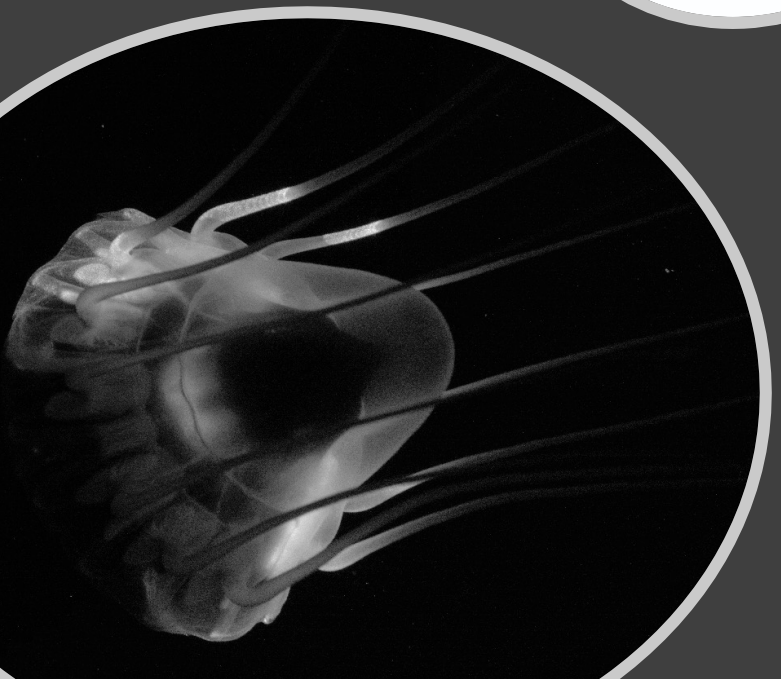
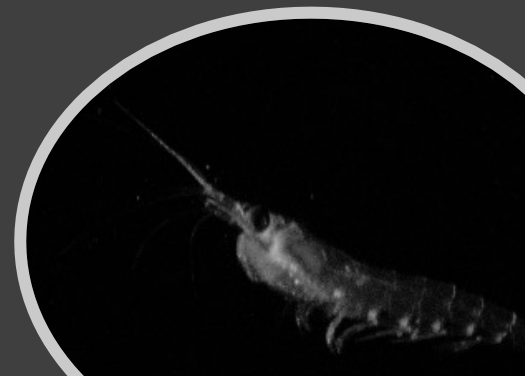


UVP6 mounted on an Argo float

Image: Hydroptics

Thank you for your attention !

Any questions ?

Contact me at laetitia.drago@imev-mer.com