EGU General Assembly 2025

Modeling the contribution of micronekton diel vertical migrations to carbon export in the mesopelagic zone

Hélène Thibault, Frédéric Ménard, Jeanne Abitbol-Spangaro, Jean-Christophe Poggiale, and Séverine Martini

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Session: Biodiversity, and Animals in the Earth System: A Geoscience Perspective

28th April 2025

mio Mediterranean Institute of Oceanography

amU Aix Marseille Université

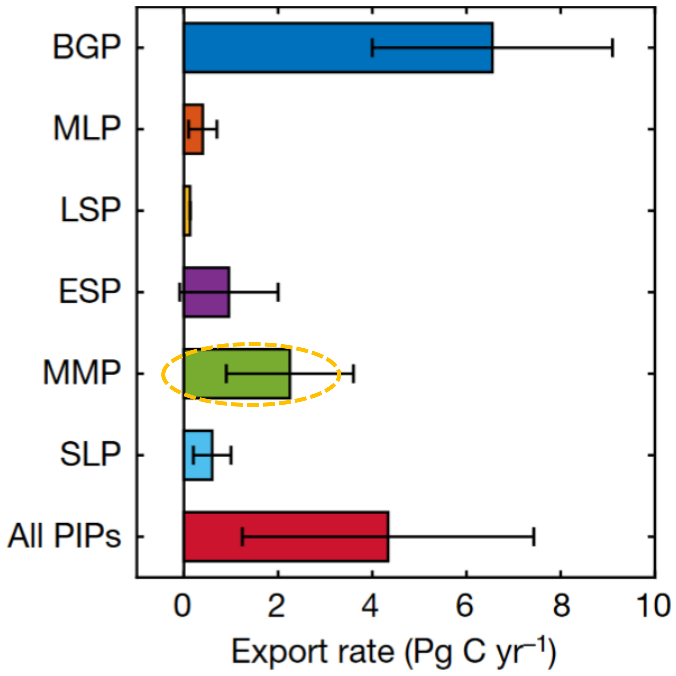
Institut Pythéas Observatoire des Sciences de l'Univers Aix Marseille Université

APERO

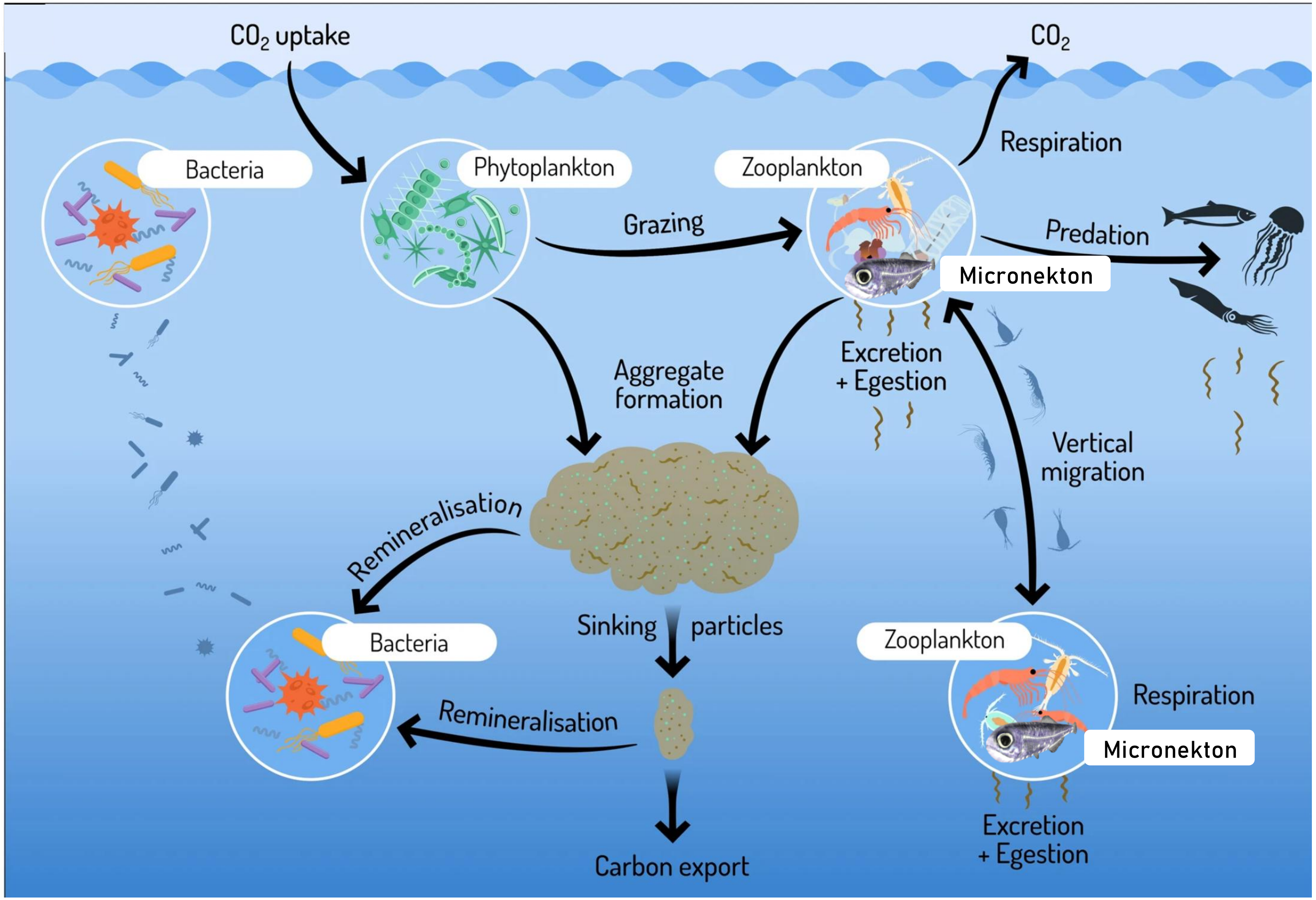
Biological carbon pump

BGP - Gravitational pump

MMP - Mesopelagic-migrant pump



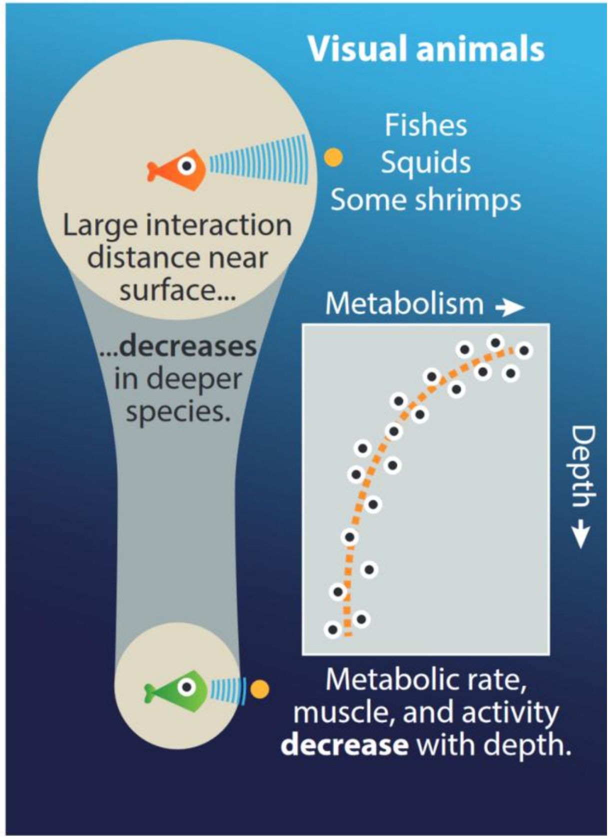
Boyd et al. 2019



Ratnarajah et al. 2023

Micronekton

- Fish, crustacean, cephalopod and gelatinous organisms
- **2-20** cm length
- **Planktivores**



Haddock and Choy, 2024

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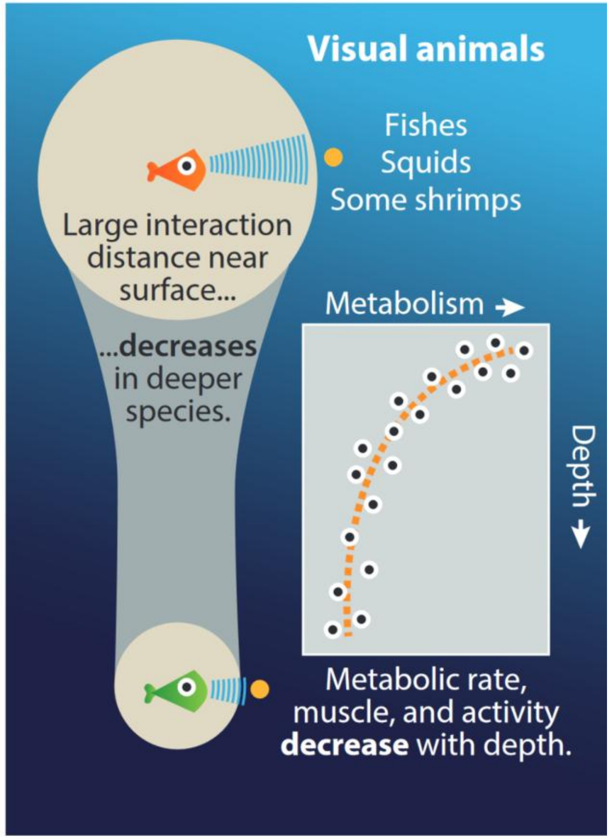

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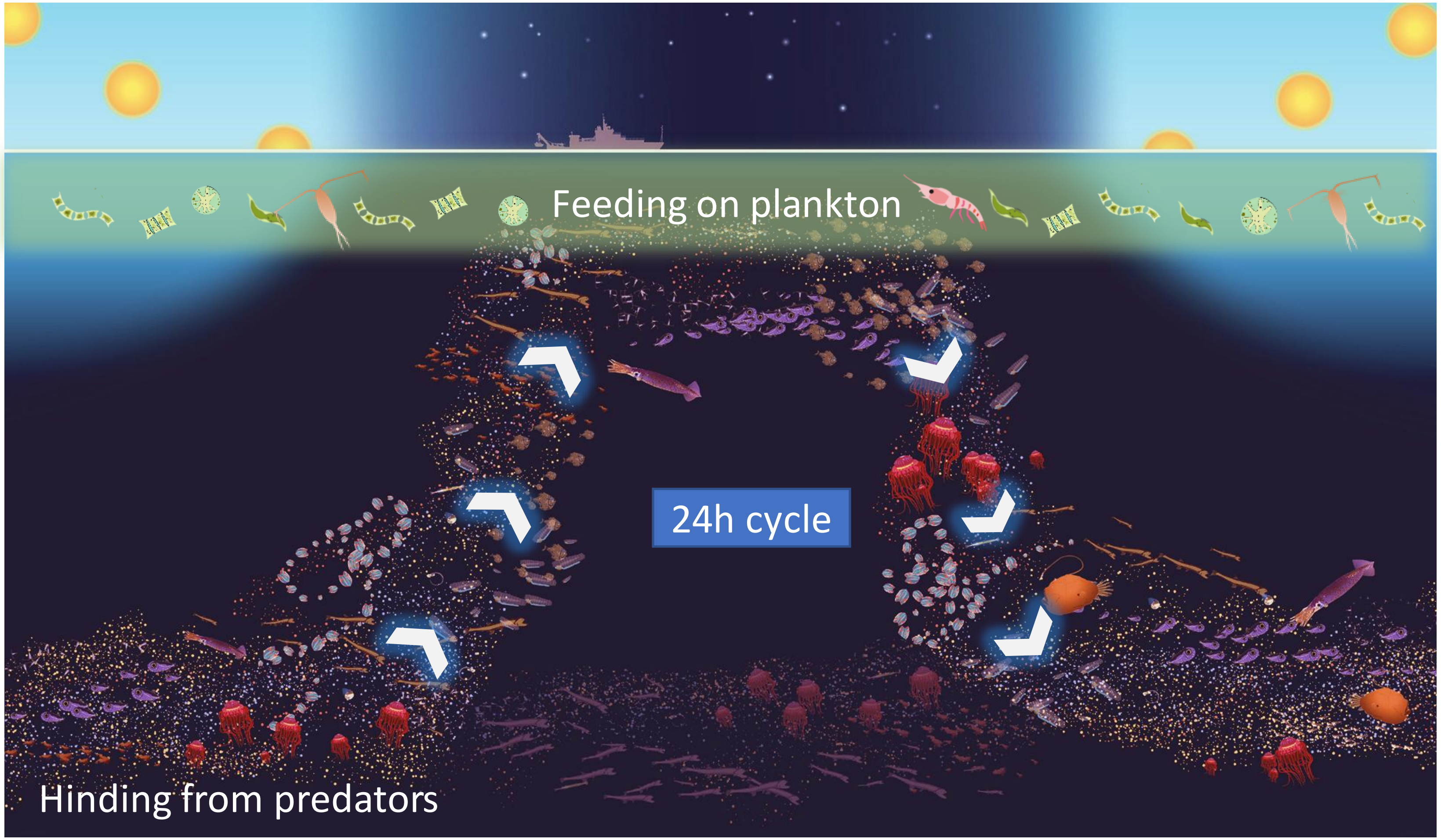


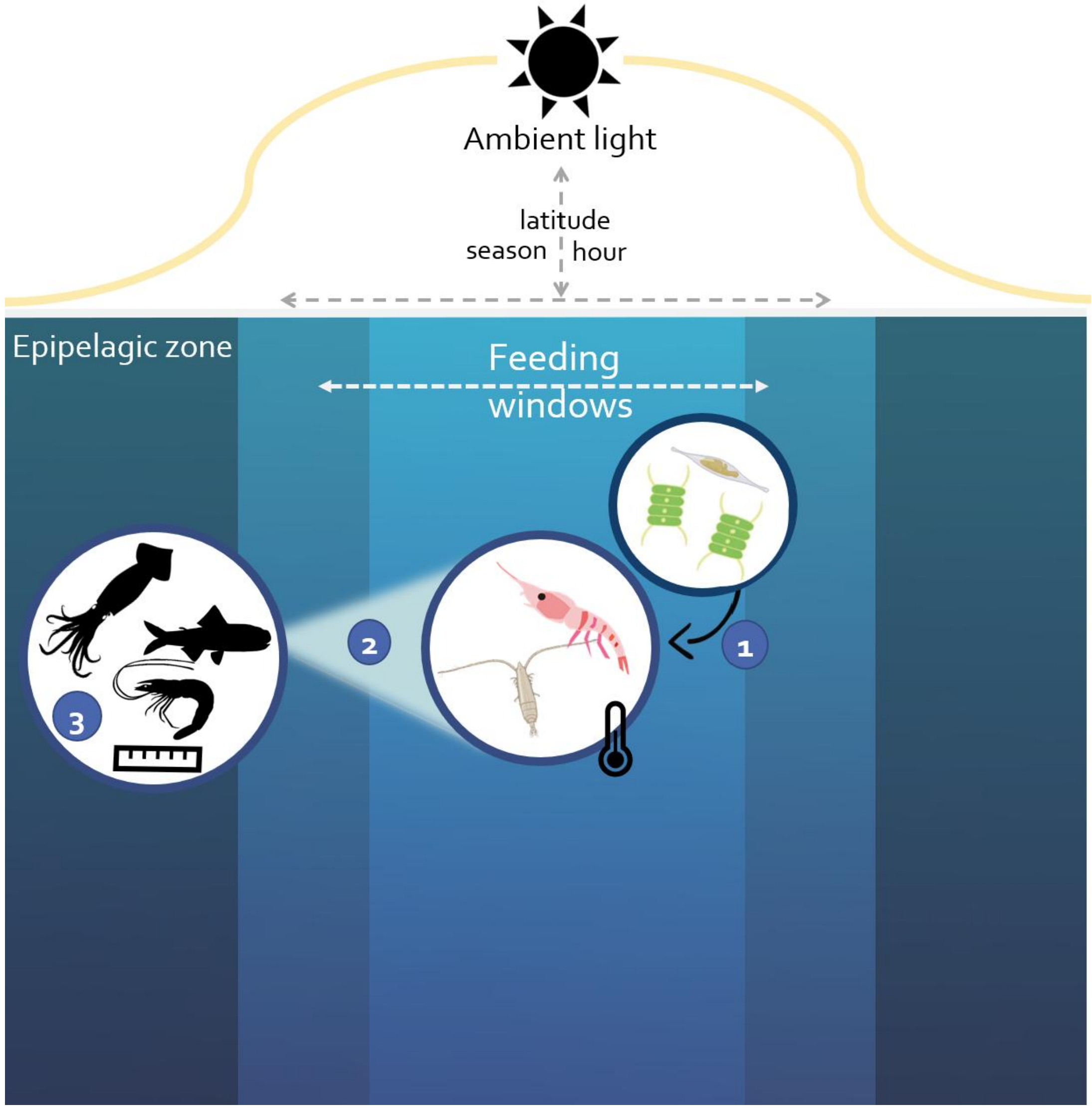
Adapted from WHOI ©

Modeling carbon transport

Spatio-temporal dynamics

Prey-predators interactions

- Dynamic population model
- Importance of visual predation in capture rate



Modeling carbon transport

Spatio-temporal dynamics

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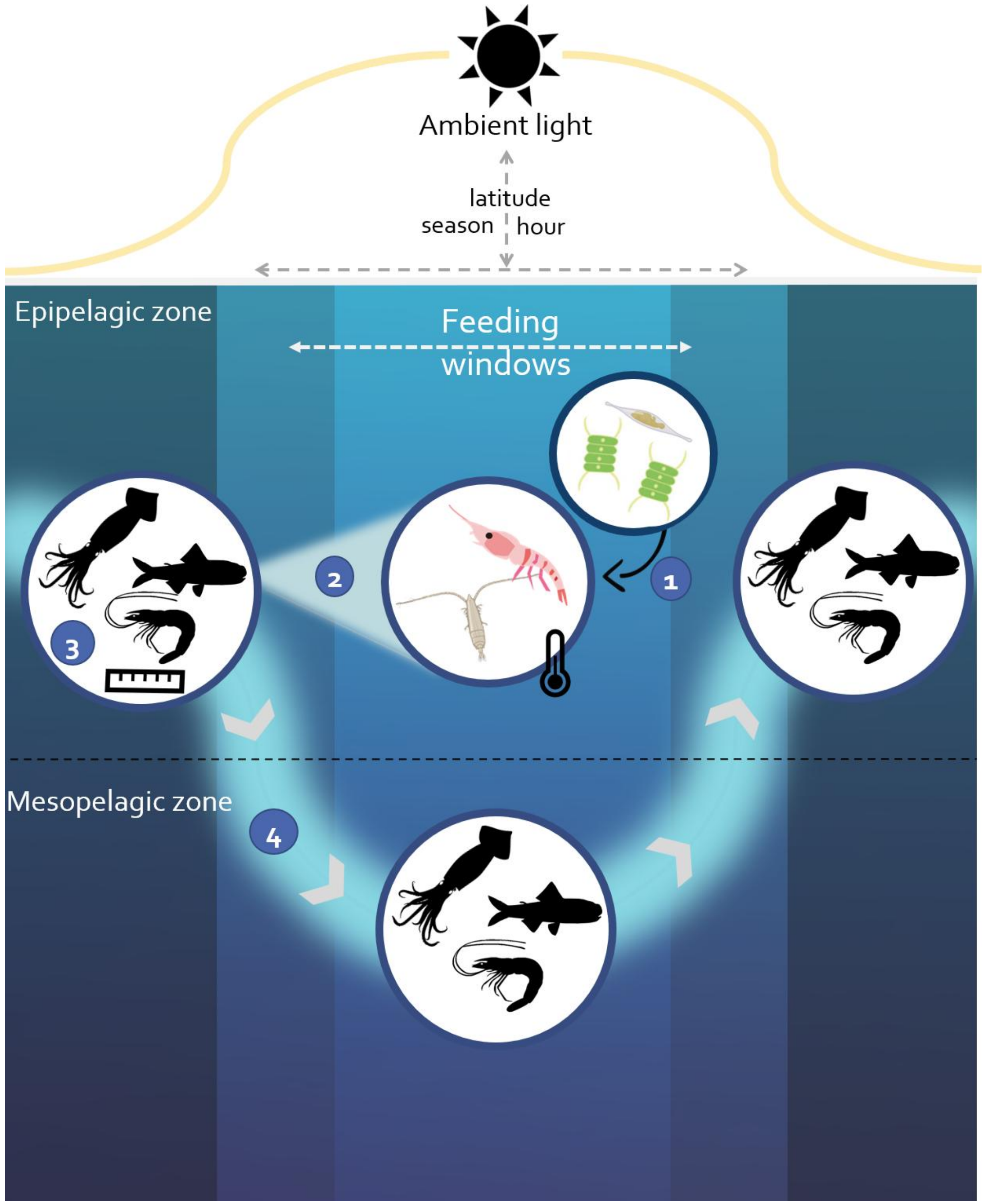
Diel Vertical Migrations

- Trigger: **surface irradiance** rate of change
- Migration dynamic: depends on **size** and **taxonomic** groups

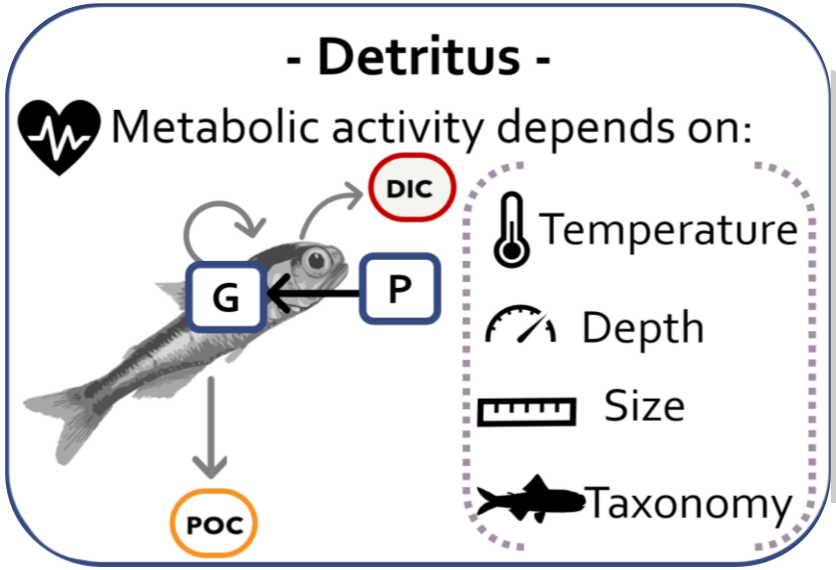


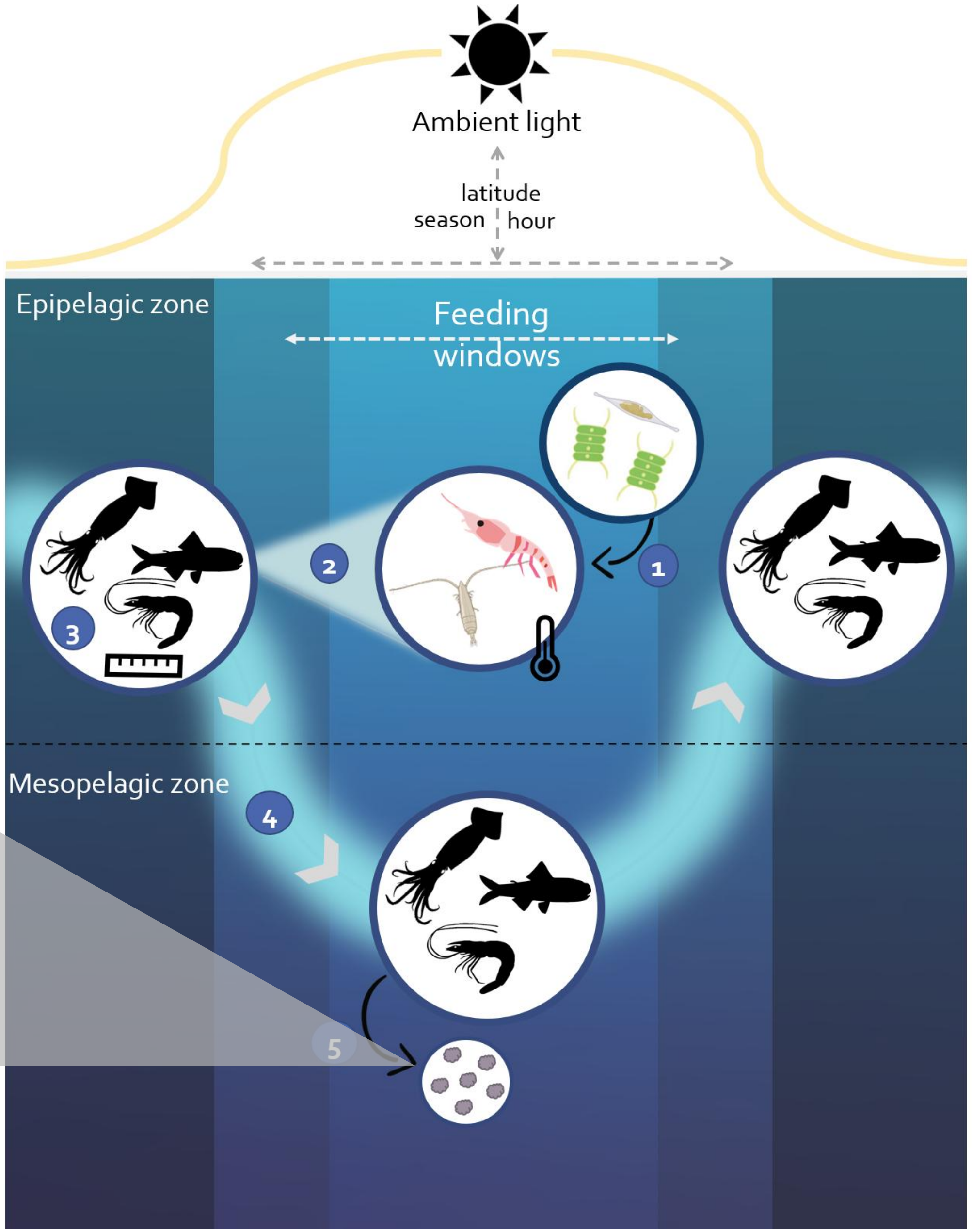
Modeling carbon transport

Bioenergetics

Modeling metabolism:

Growth = Ingestion – Metabolic losses - Egestion – Dead bodies





Modeling carbon transport

Bioenergetics

Modeling metabolism:

Growth = Ingestion – Metabolic losses - Egestion – Dead bodies

P: Plankton
G: Micronekton's gut
C: Micronekton

Resource

$$\frac{\partial P}{\partial t} = \rho P\left(1 - \frac{P}{K}\right) - \frac{\alpha(t,z)P}{1+\beta P}C$$

Transfer to the guts

$$\frac{\partial G}{\partial t} = -\frac{\partial (wG)}{\partial z} + \frac{\alpha(t,z)P}{1+\beta P}C - (d+\mu)G$$

A part is assimilated

$$\frac{\partial C}{\partial t} = -\frac{\partial (wC)}{\partial z} + edG - m(t,z)C - \mu C$$

The rest is egested as fecal pellets

$$\frac{\partial D_g}{\partial t} = (1-e)dG$$

Parameters

ρ: *growth rate*

K: *carrying capacity*

α: *capture rate*

β: *handling time*

w: *migration speed*

d: *evacuation rate*

μ: *mortality rate*

m : *maintenance cost*

e : *assimilation coefficient*

Modeling carbon transport

Bioenergetics

Modeling metabolism:

Growth = Ingestion – Metabolic losses - Egestion – Dead bodies

- Parameters depend on size and taxonomic groups:

→ Fish, crustacean and cephalopod

- No interaction between groups

Modeling carbon transport

Bioenergetics

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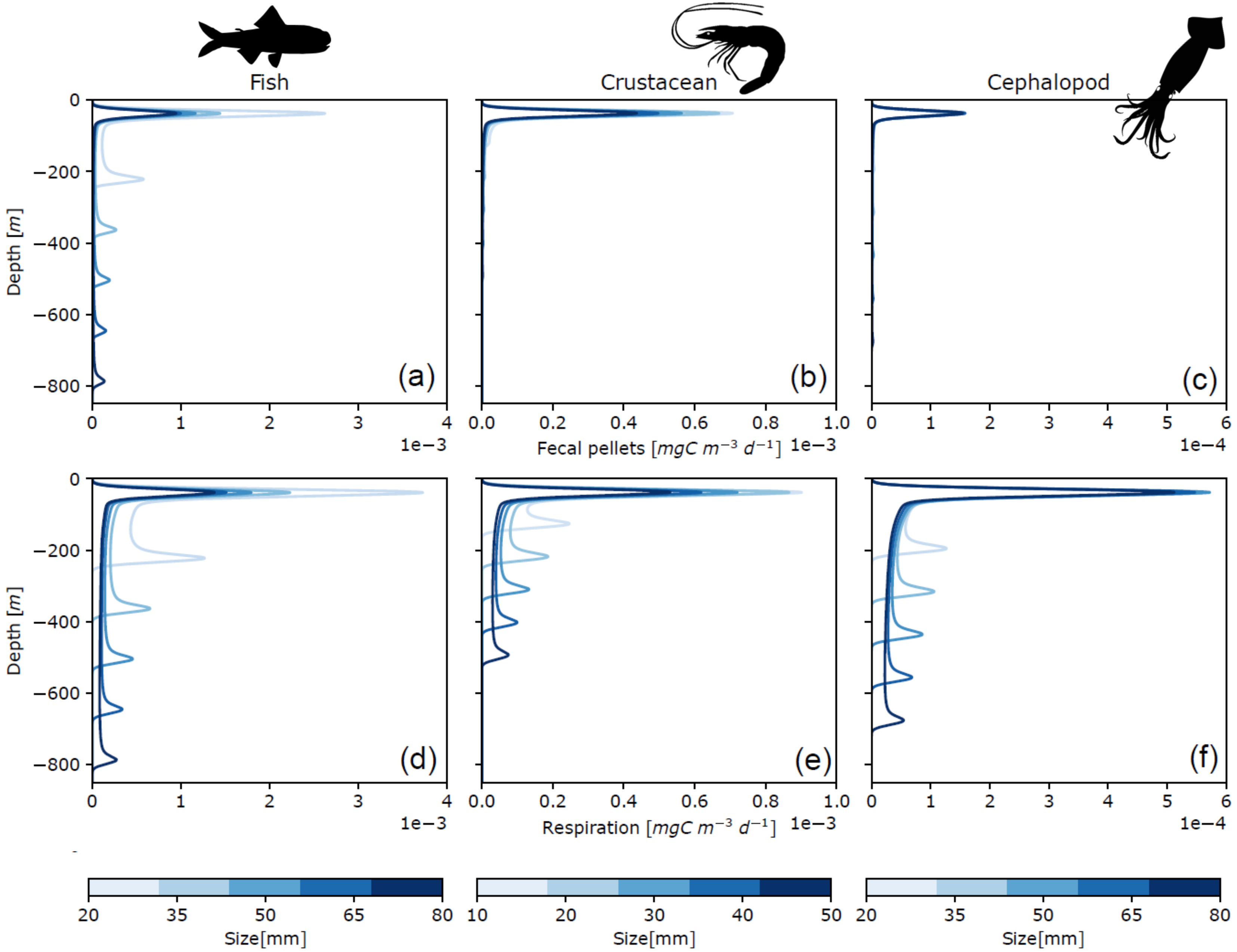
1. How size and taxonomy influence the efficency of carbon export by micronekton ?

2. How environment variability impacts their transport of carbon ?

Influence of size and taxonomy



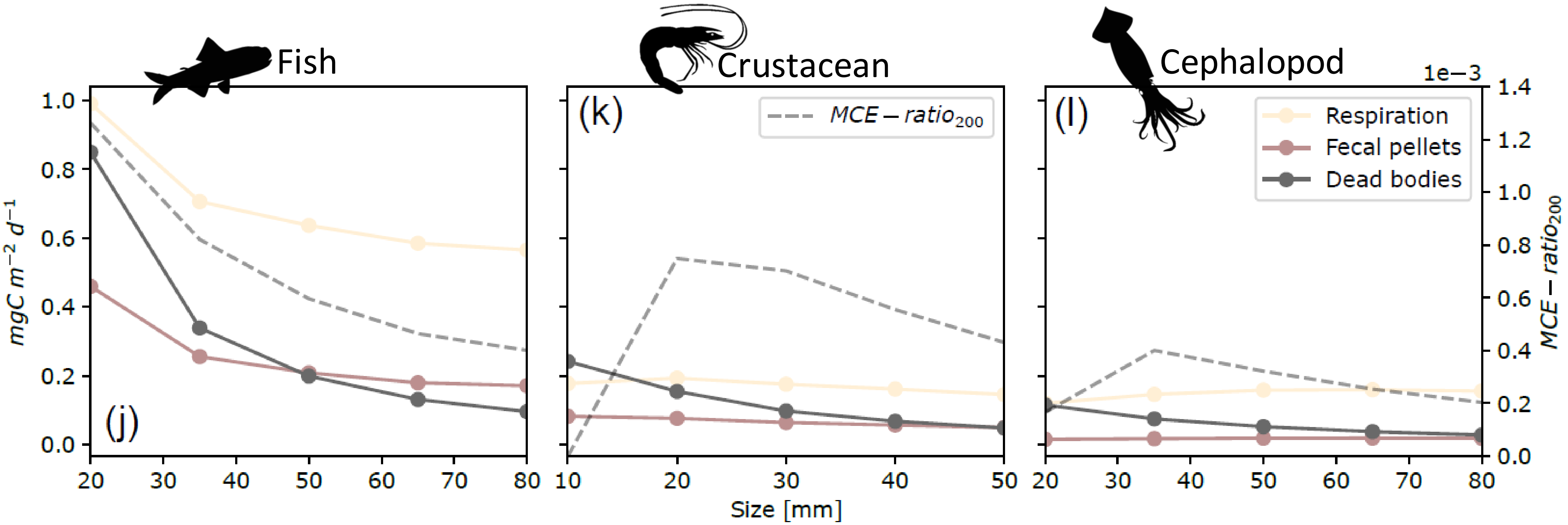
Sharing is encouraged

- One curve (color) = one simulation
- Two peaks of carbon production
- Different **swimming abilities** depending on **size** and **taxonomy**
- No significant transport of fecal pellets by crustaceans and ceohalopods

Influence of size and taxonomy

$$\mathrm{MCE} - ratio_{200} = \frac{\sum POC_{>200m}}{PP}$$

Integrated carbon production along depth

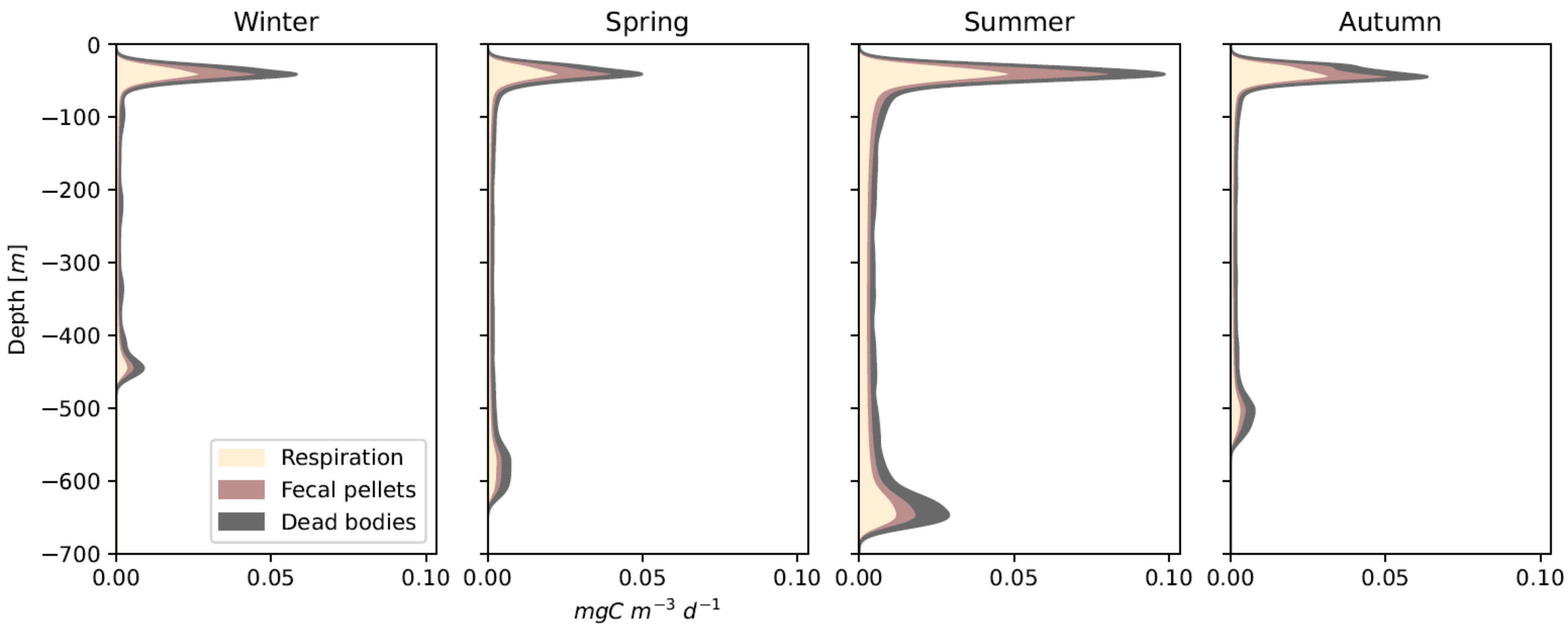


- Fish transport carbon more efficiently in the mesopelagic zone
- Smaller individuals produce relatively more carbon: active metablism
- Intermediate size showing highest carbon transport efficiency

Sharing is encouraged

Impact of seasons on carbon export

Northeast Atlantic: seasonal variation of primary production, temperature and daylight



- More production of carbon in **summer** and at **deeper depth** in a temperate region

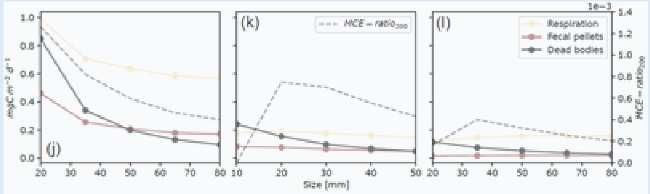
→ Effect of **daylight variability** with primary production affecting capture rates and migration speed

Sharing is encouraged

Key messages

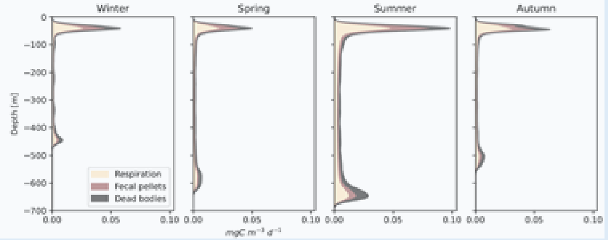
1

Importance in taking into account both size and taxonomic group when estimating the MMP



2

Need for seasonal *in situ* sampling for model validation, even in open ocean and in light with climate change



Key messages

CV

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Importance in taking into account both size and taxonomic group when estimating the MMP

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EGUsphere Preprint repository

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