COULD COLOR BE AN INDICATOR OF COPEPOD FITNESS ?

A FOCUS ON CAROTENOID PIGMENTATION

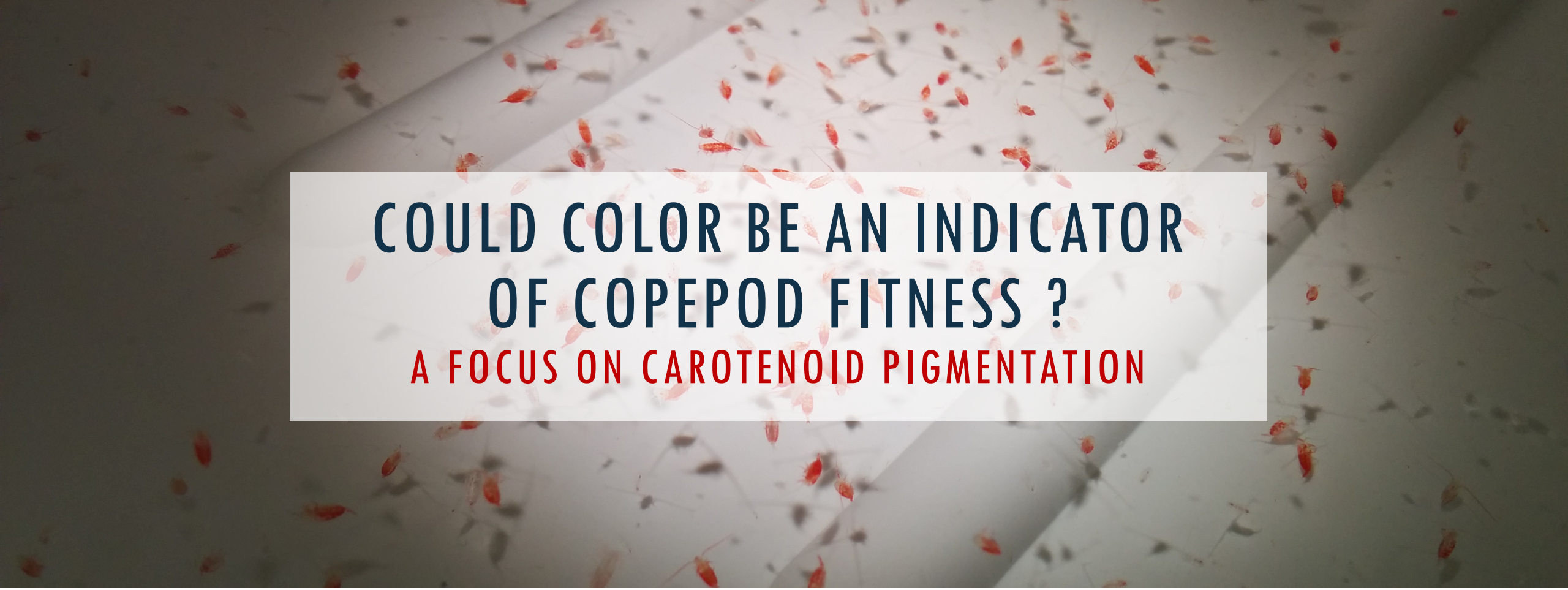


Photo: Maria Scheel, Aarhus University

Laure Vilgrain, Maps F., Trudnowska E., Basedow S., Niehoff B., Madoui A., Irisson J-O. & Ayata S-D.

UNIVERSITÉ LAVAL

LOV LABORATOIRE D'OCÉANOGRAPHIE DE VILLEFRANCHE

SORBONNE UNIVERSITÉ

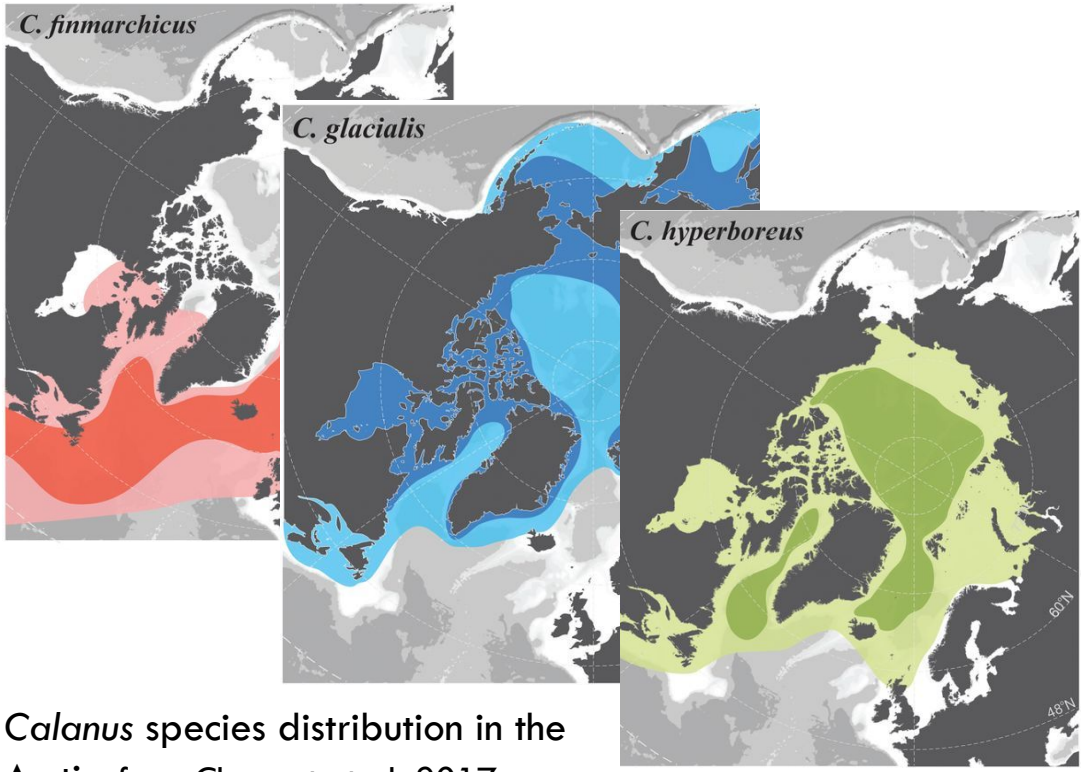
ASLO virtual meeting

SS31 - Imagine/Imaging the Ocean

June 22-27th, 2021

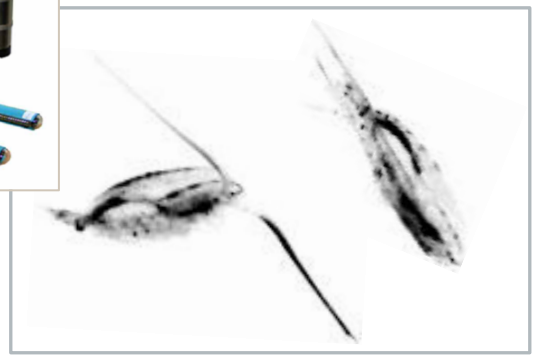
I. INTRODUCTION

PhD project :
« Contribution of imaging data to a trait-based approach of arctic copepod ecology »



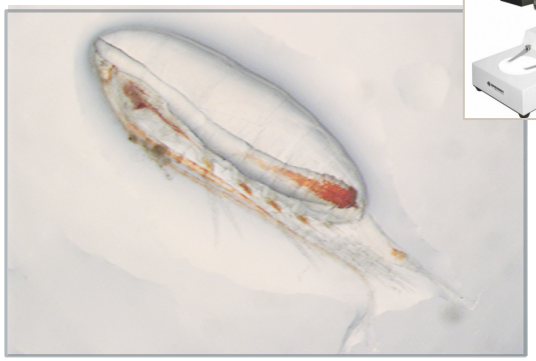
Calanus species distribution in the Arctic, from Choquet et al. 2017

Underwater Vision Profiler (UVP)



Automatic acquisition _____ ✓
In situ _____ ✓
Inter-calibration _____ ✓
Datasets: large and recent ___ ✓
Image quality + color _____ ✗

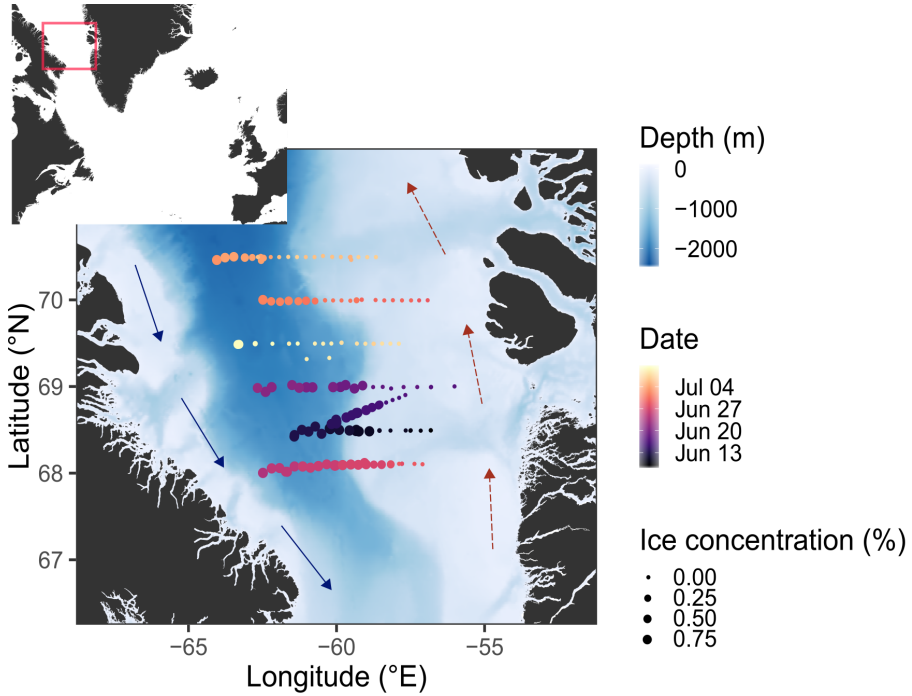
Stereo-microscope

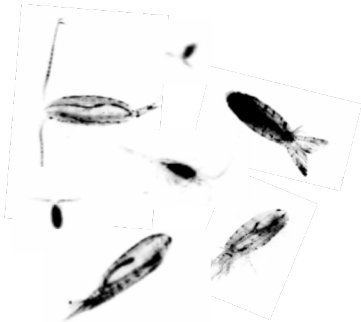


Automatic acquisition _____ ✗
In situ _____ ✗
Inter-calibration _____ ✗
Datasets: large and historical _ ✓
Image quality + color _____ ✓

I. INTRODUCTION

Lisière de glace depuis le CGCS Amundsen - © Pascaline Bourgain





~ 28 000 copepod images in a surface layer (0-100m)

Vilgrain et al., *Limnology & Oceanography*, 2021

Picheral *et al.*, 2010

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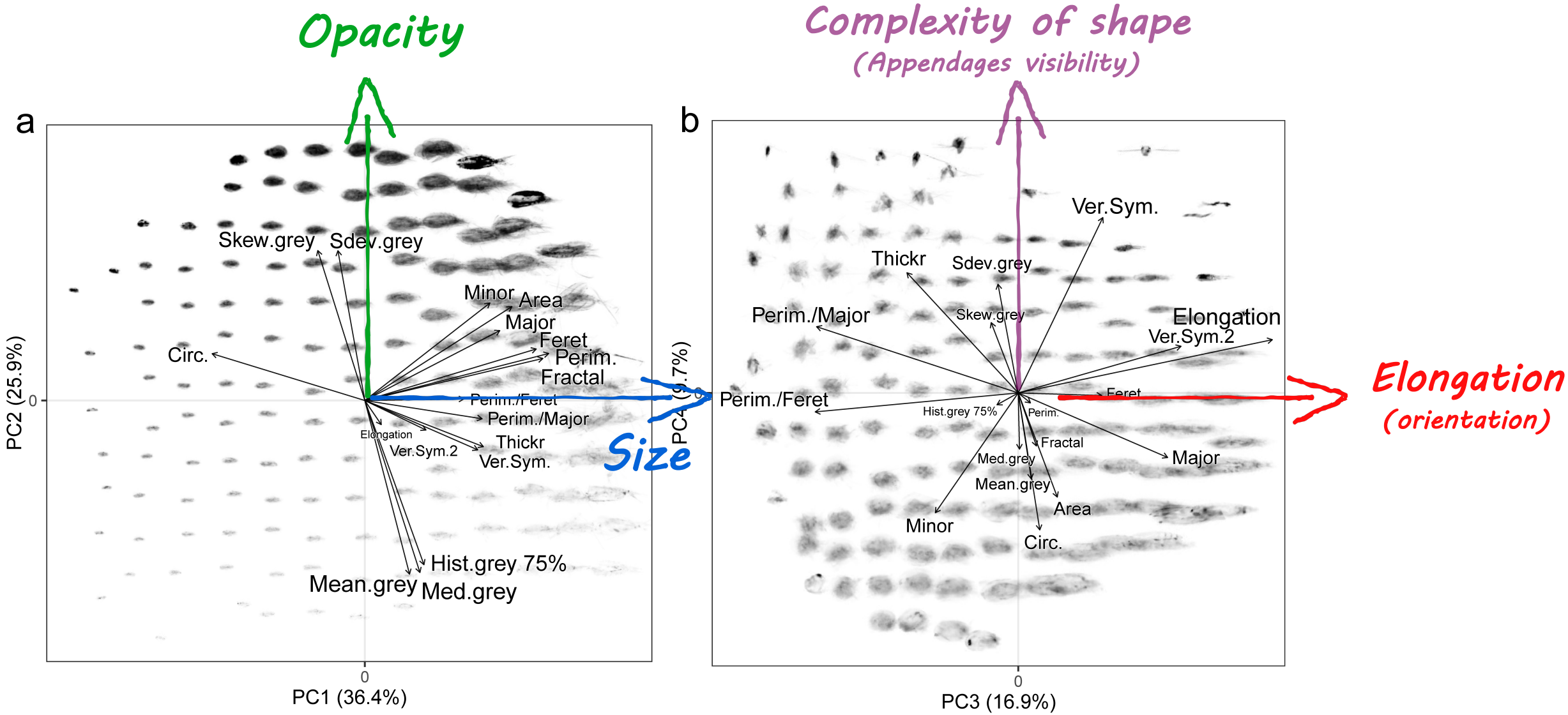

Vilgrain et al., *Limnology & Oceanography*, 2021

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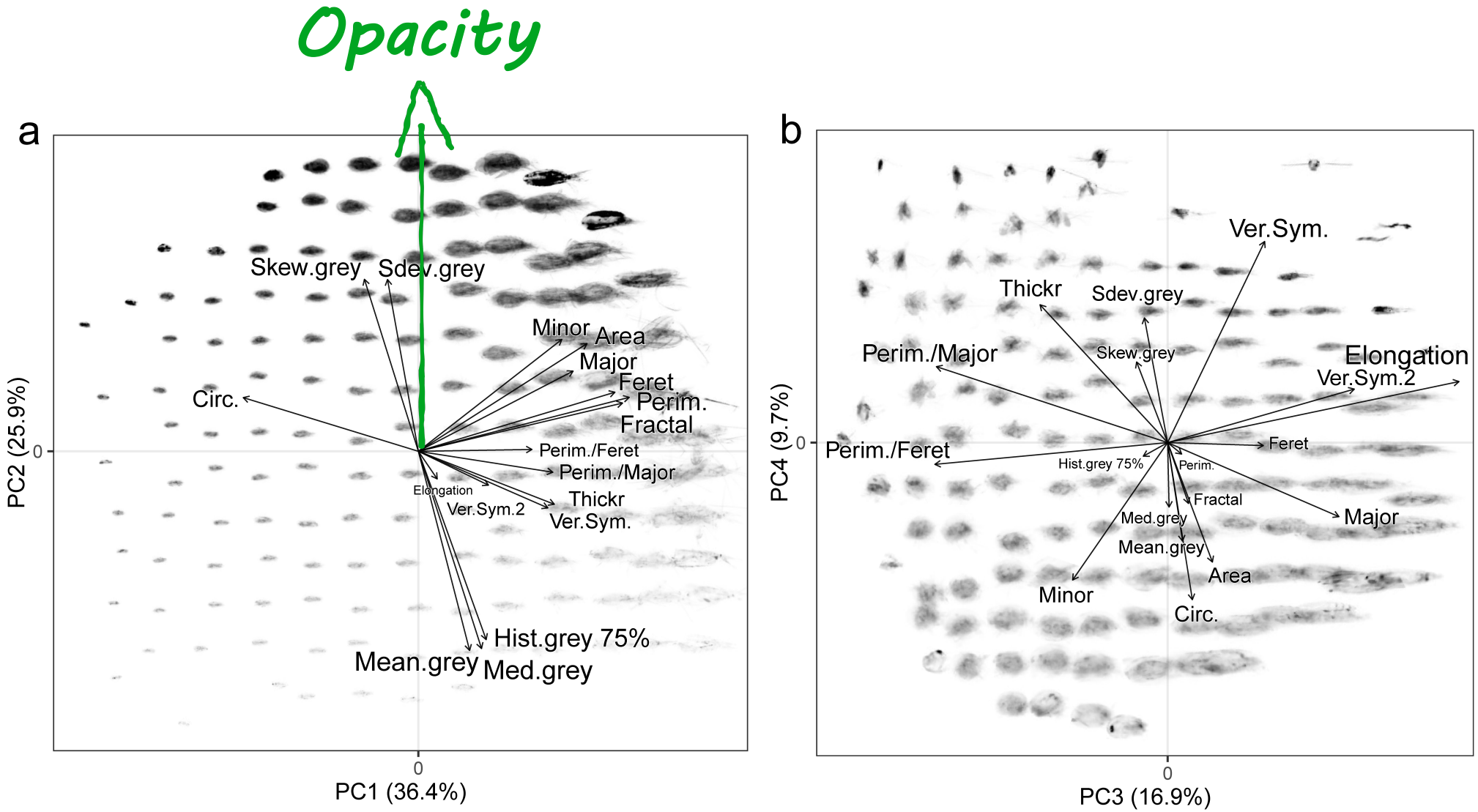

Vilgrain et al., *Limnology & Oceanography*, 2021

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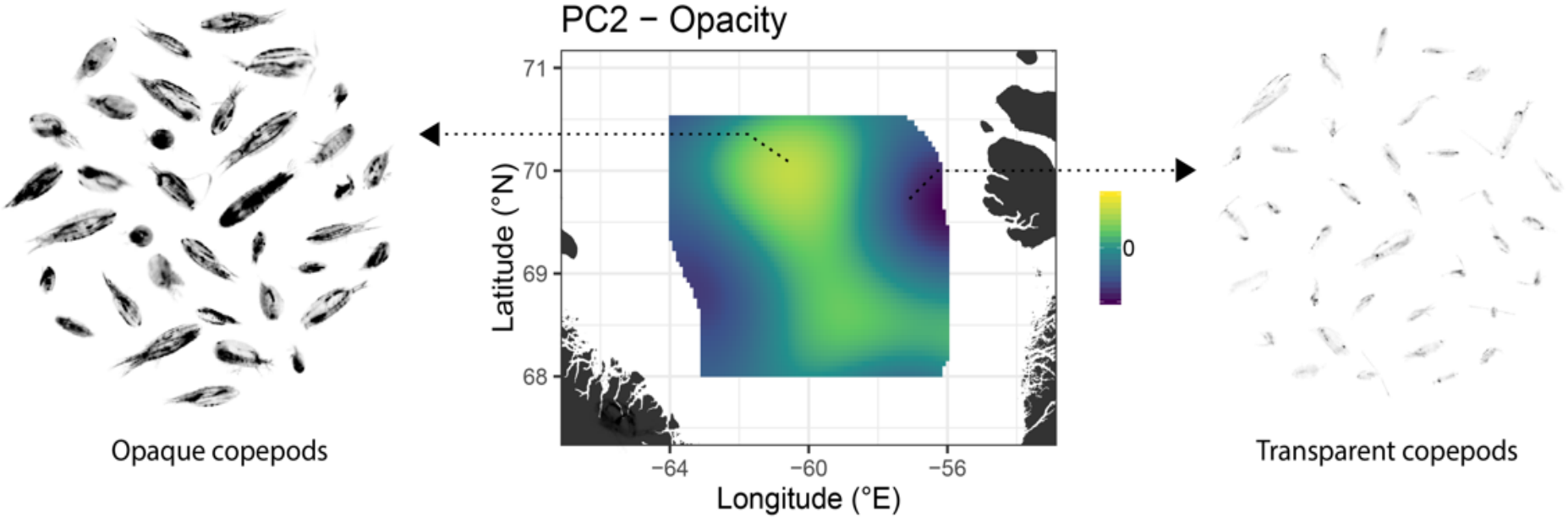


Hypotheses about redness at the ice edge :

(i) the recent bloom : provide good red pigment precursors

(ii) copepods feeding on a shallow bloom : need to fight against light oxidative stress

Vilgrain et al., *Limnology & Oceanography*, 2021

II. ECOLOGICAL IMPORTANCE OF RED PIGMENTATION IN COPEPODS

Diaptomus spp.

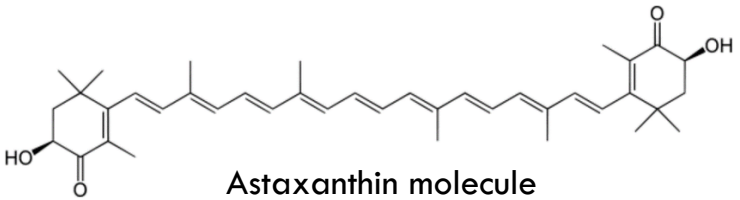
Freshwater copepod

First observation of redness in 1890, in the French Alps

Calanus spp.

Marine (polar) copepod

« Red feed »



Astaxanthin molecule

II. ECOLOGICAL IMPORTANCE OF RED PIGMENTATION IN COPEPODS

Astaxanthin

Respiratory chain
(active metabolism)

External stressors
(UV, pollutants)

Reactive oxygen species (ROS)

Hydroxyl radical :

OH•

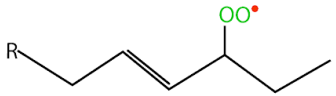
Singlet oxygen :

$^1O_2$

Protein oxydation

Astaxanthin

Lipid peroxidation



DNA damages

II. ECOLOGICAL IMPORTANCE OF RED PIGMENTATION IN COPEPODS

Main hyphotheses about carotenoids accumulation :

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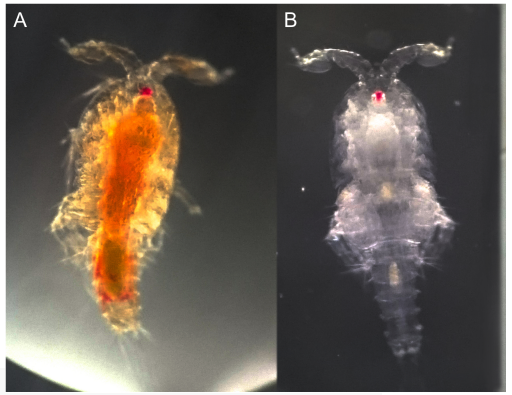
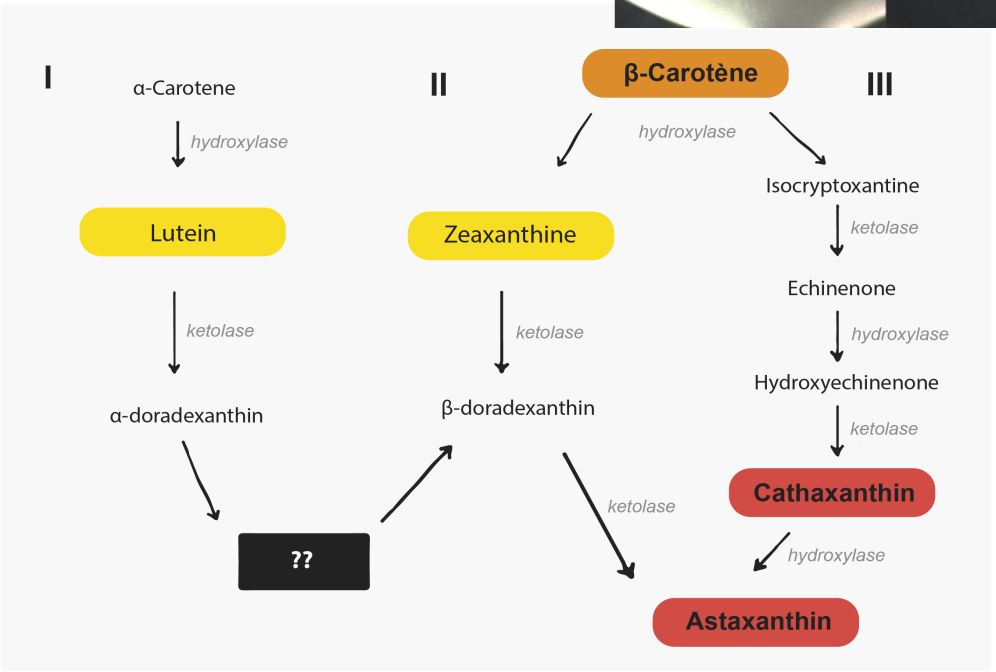
(a) Diet composition





Weaver et al., 2018a

II. ECOLOGICAL IMPORTANCE OF RED PIGMENTATION IN COPEPODS

Main hyphotheses about carotenoids accumulation :

(a) Diet composition

(b) Advantages against UV radiation

Proc. Nat. Acad. Sci. USA 73 (1976)

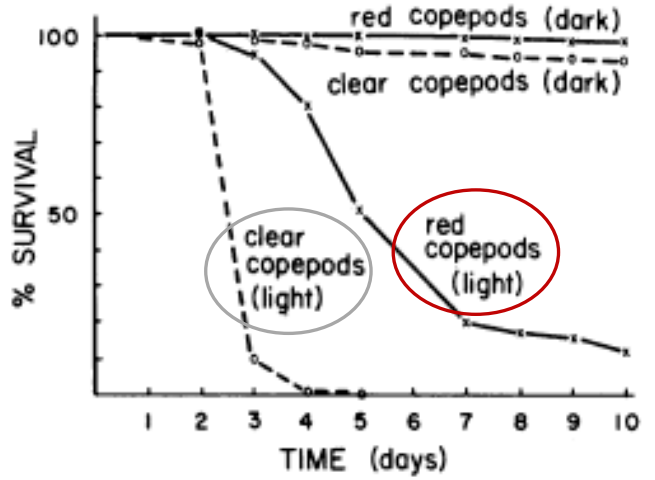


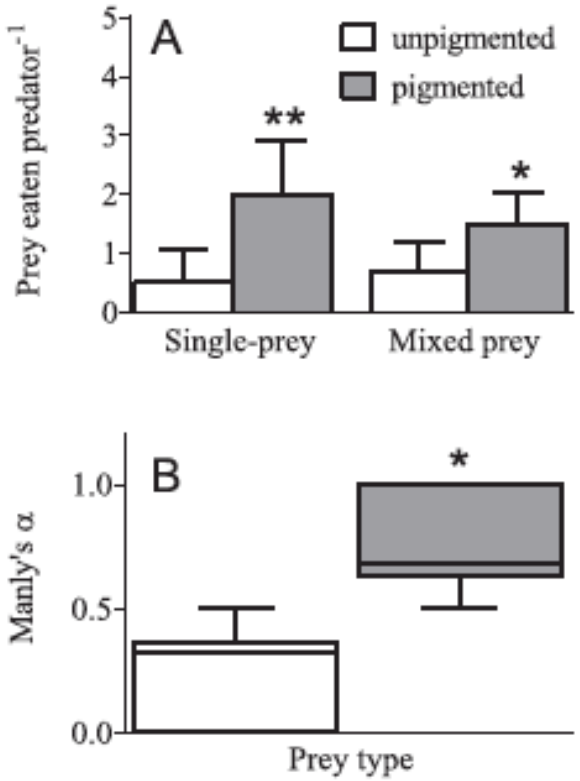
FIG. 1. Survivorship of *Diaptomus nevadensis* with large (red copepods) and small (clear copepods) amounts of carotenoid pigment when exposed to visible blue light (450 nm) at peak summer intensity (1.6 mW/cm^2).

Hairston et al., 1976

II. ECOLOGICAL IMPORTANCE OF RED PIGMENTATION IN COPEPODS

Main hyphotheses about carotenoids accumulation :

(a) Diet composition
(b) Advantages against UV radiation
(c) Trade-offs with predation pressure

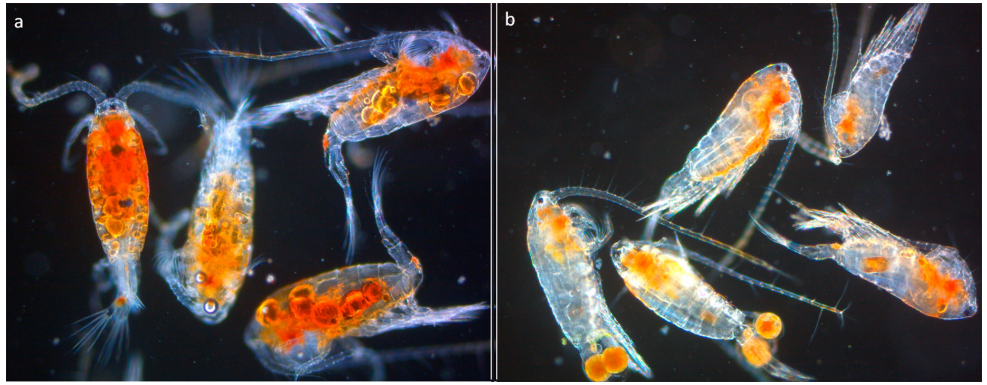


Gorokhova et al., 2013

II. ECOLOGICAL IMPORTANCE OF RED PIGMENTATION IN COPEPODS

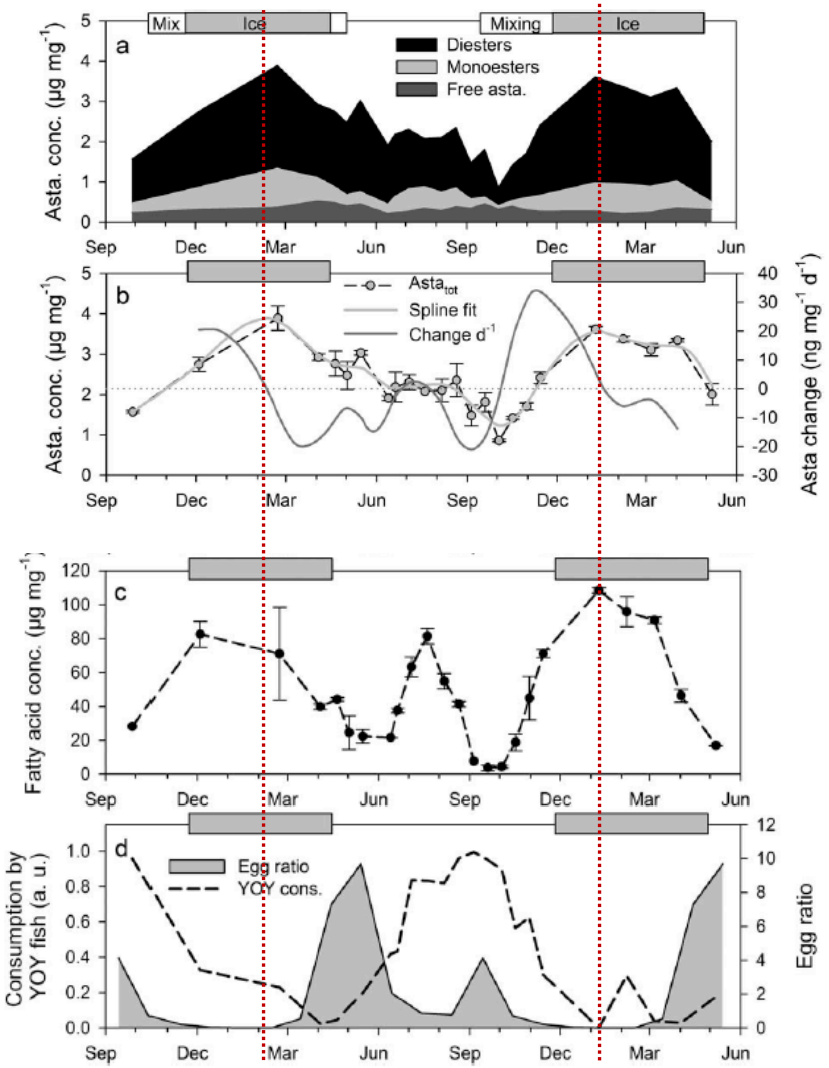
Main hyphotheses about carotenoids accumulation :

(a) Diet composition
(b) Advantages against light radiations
(c) Trade-offs with predation pressure
(d) Protection of lipid stores
(e) Eggs production and protection



Grobois et al. 2018

Schneider et al. 2016



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Main hyphotheses about carotenoids accumulation :

(a) Diet composition
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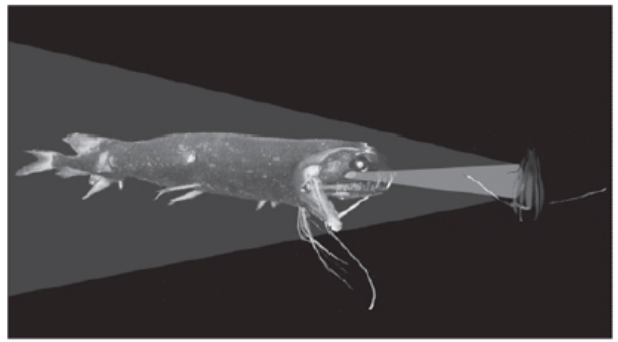
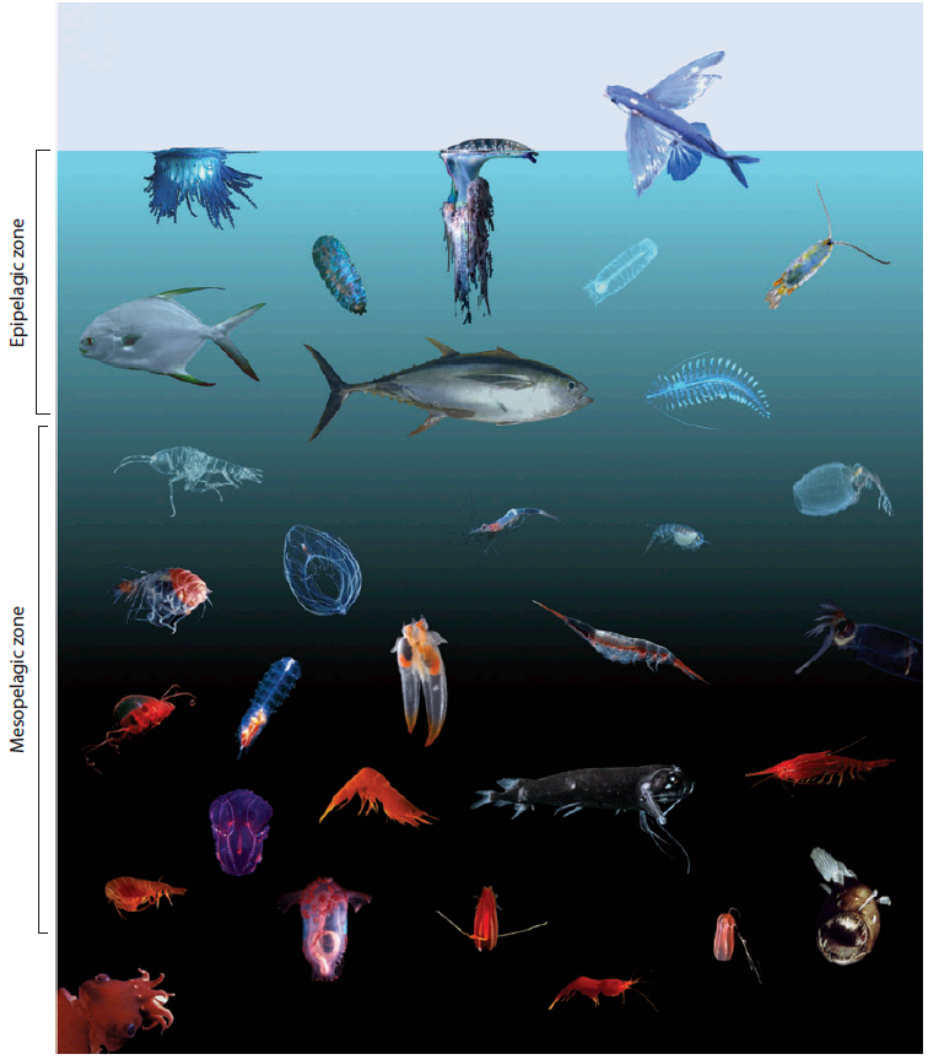
(d) Protection of lipid stores
(e) Eggs production and protection
(f) Camouflage at depth ? Blue vs red color

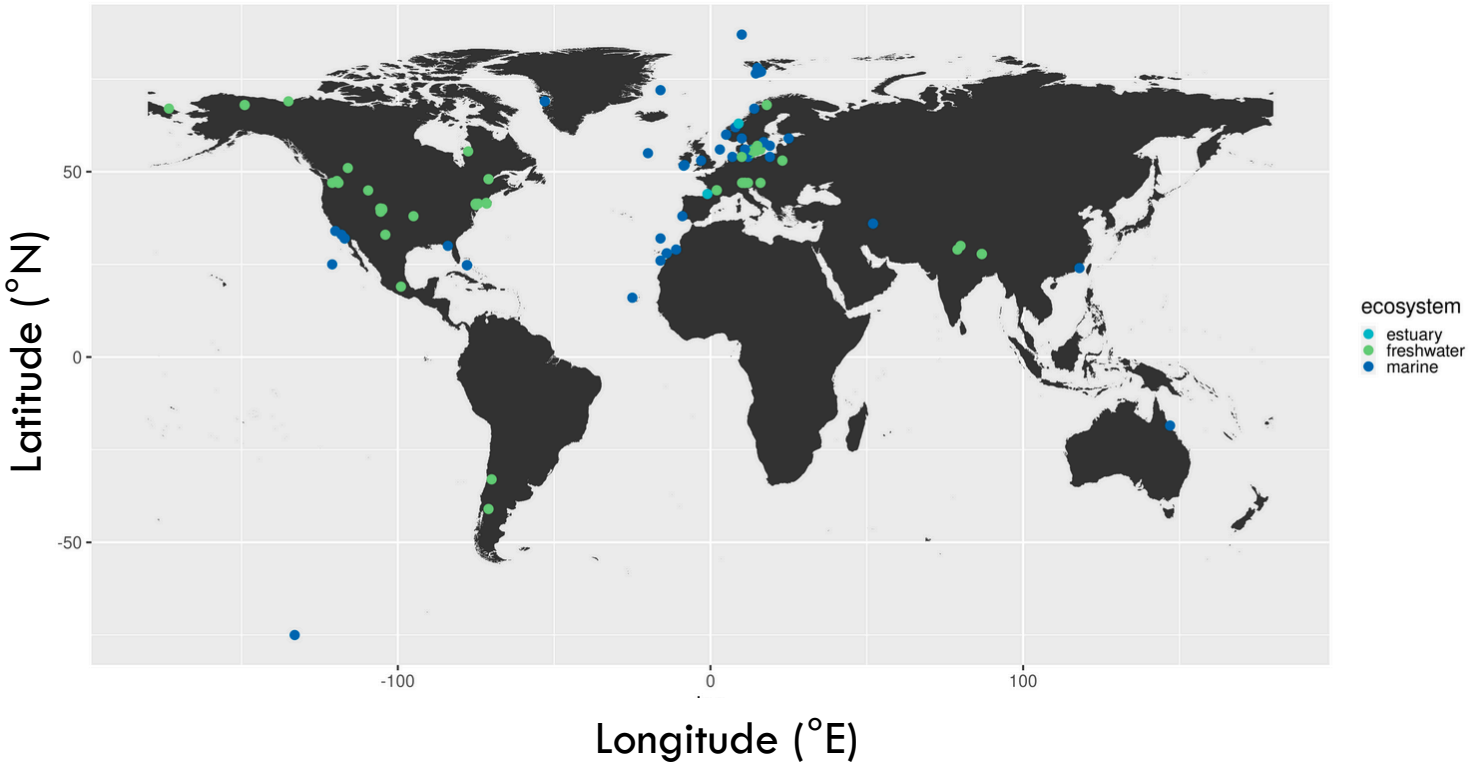




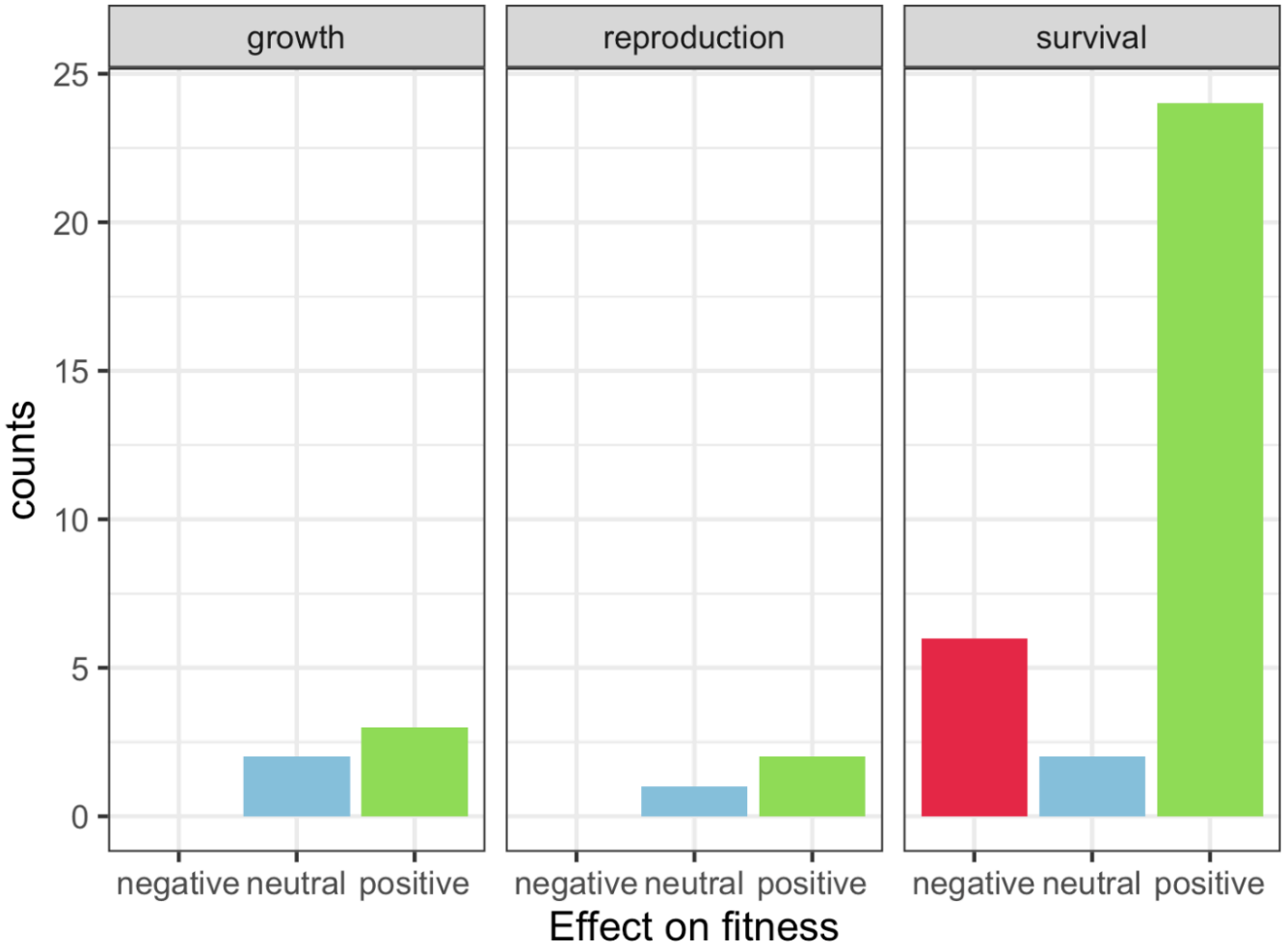
Johnsen et al., 2005

III. TO SUMMARISE : A SMALL META-ANALYSIS

- **71 studies** containing the words « copepod » & « carotenoids OR astaxanthin » (1949 – 2020)
- **~150 species** among 61 copepod genus
- 256 astaxanthin HPLC measures from **121 locations (marine + freshwater)**



When copepod are red, how are fitness components impacted ?

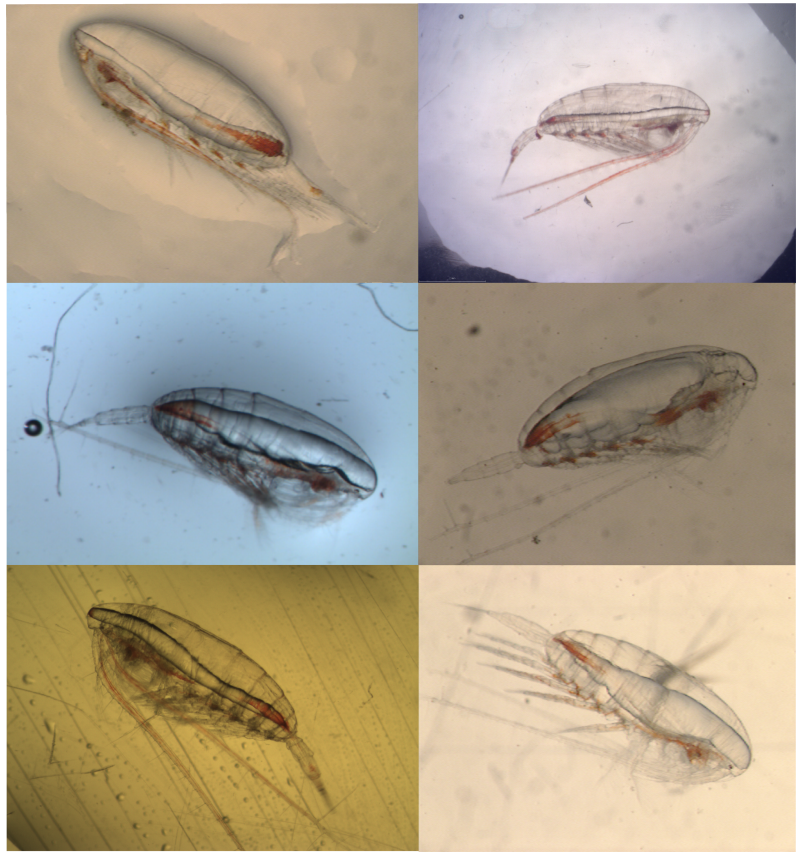


- **Examples of response variables :**

%survival or mortalily, swimming speed, RNA:DNA, respiration rate, egg ratio, number of nauplii produced, % of male choice, etc ..

45 measures

VI. AUTOMATIC REDNESS QUANTIFICATION



- large historical datasets, most common imaging method

- various light conditions

>>> compute **redness indices**

Relative : % of copepod body

Absolute : total redness amount (taking pixel size into account)

A - Original image: various light conditions and apperance

↓

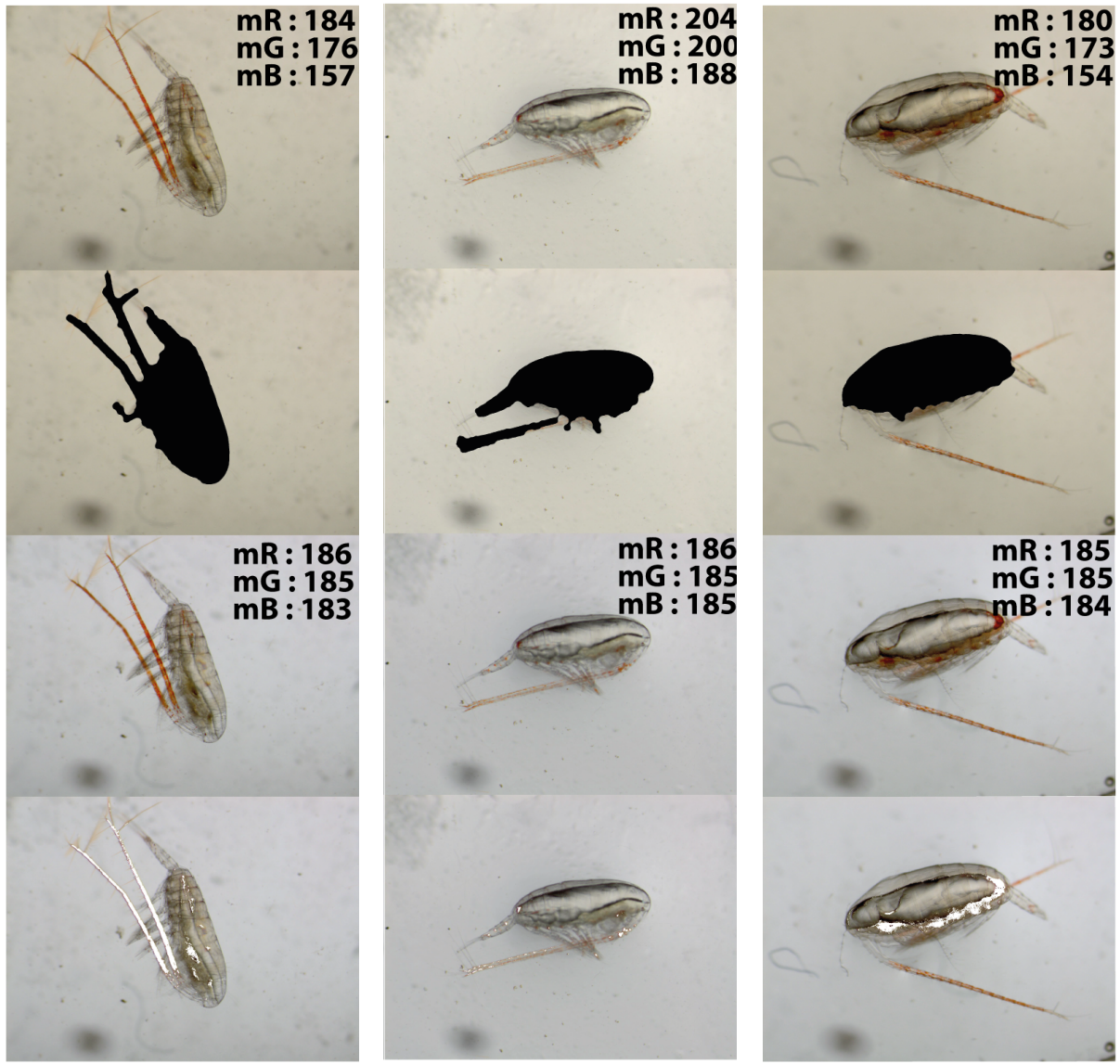
B - Segmentation: copepod/background

↓

C - Calibration of RGB color channels from the background

↓

D - Identification of red pixels on copepods for calibrated images (HLC color space)



	Example 1	Example 2	Example 3
Segmentation	✓	✓	✗
Calibration	✓	✓	✓
Red pixels	✓	✗	✗

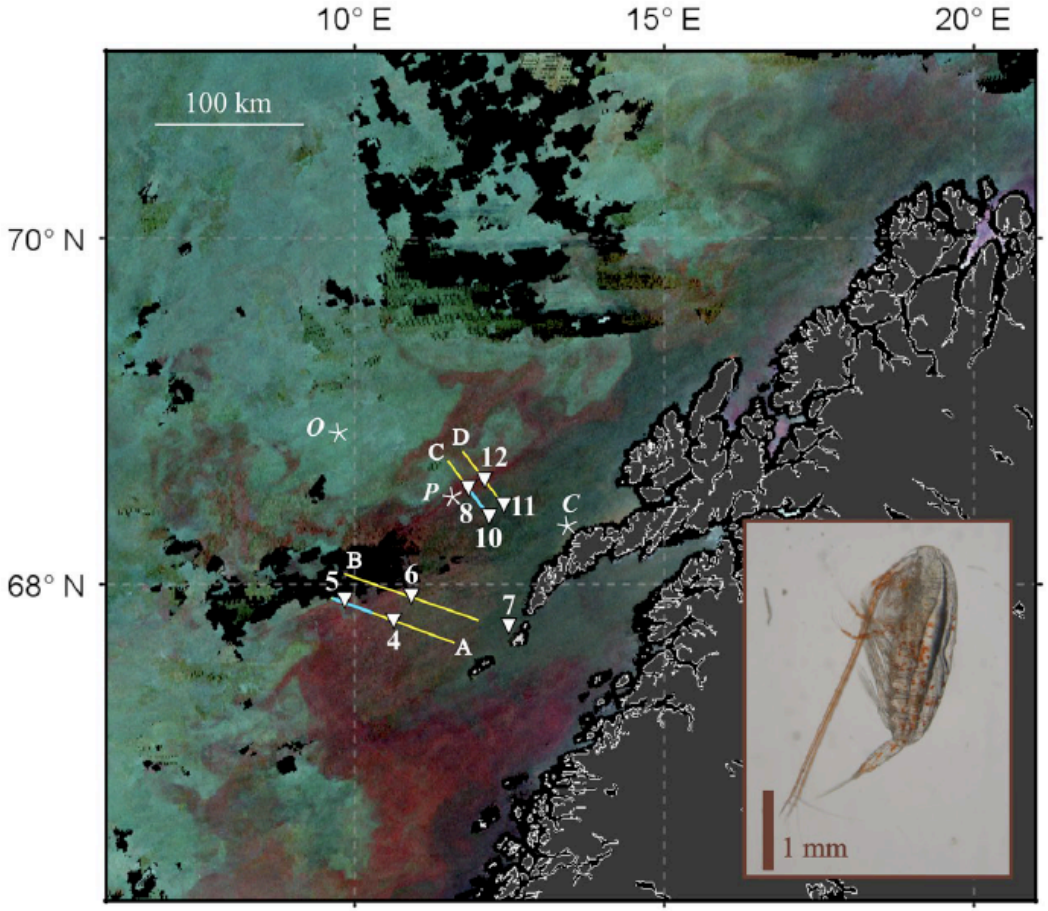
python

V. POTENTIAL ECOLOGICAL IMPLICATIONS/APPLICATIONS

>> **good health index** of arctic copepod communities and food chains

>> quantification of **copepod biomass** with a coupling with satellite imaging

>> future analyses with *in situ* and **high throughput imaging systems in color** ?



Basedow et al., 2019

laure.vilgrain@imev-mer.fr

THANK YOU!