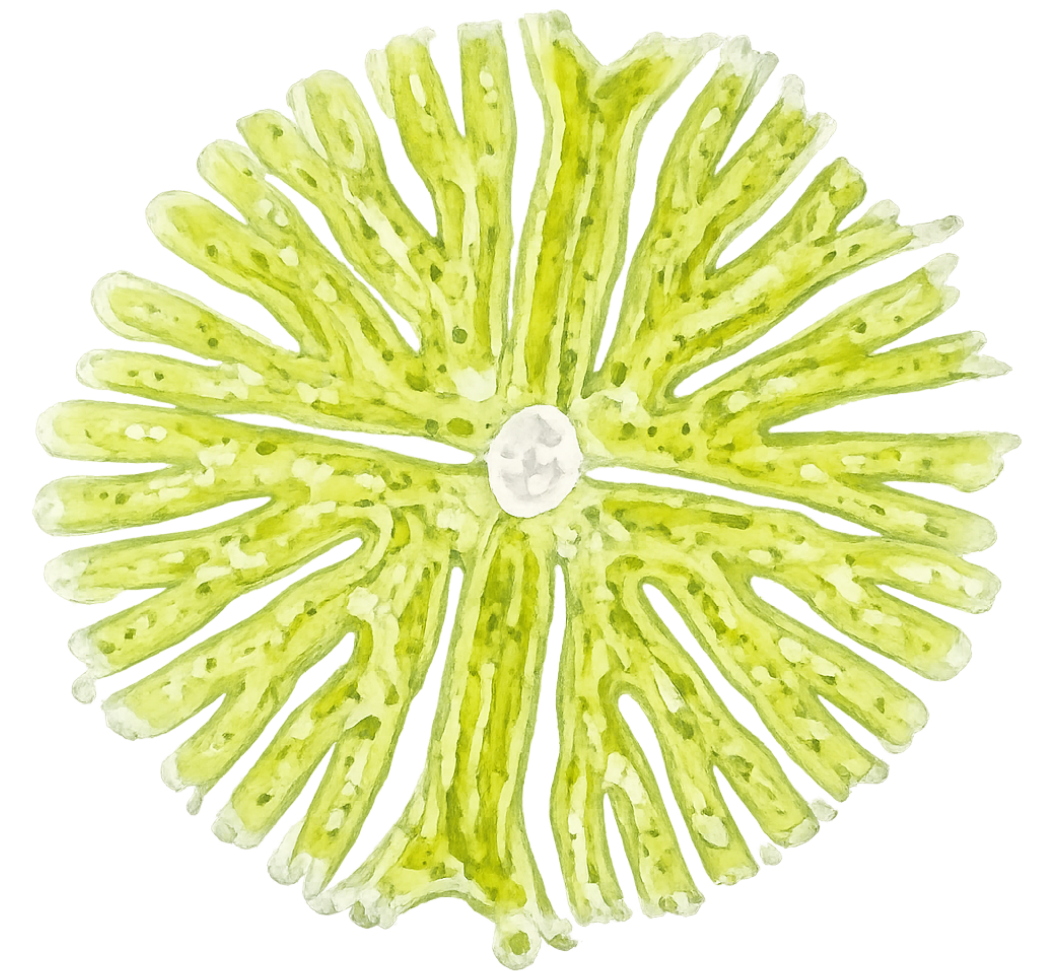
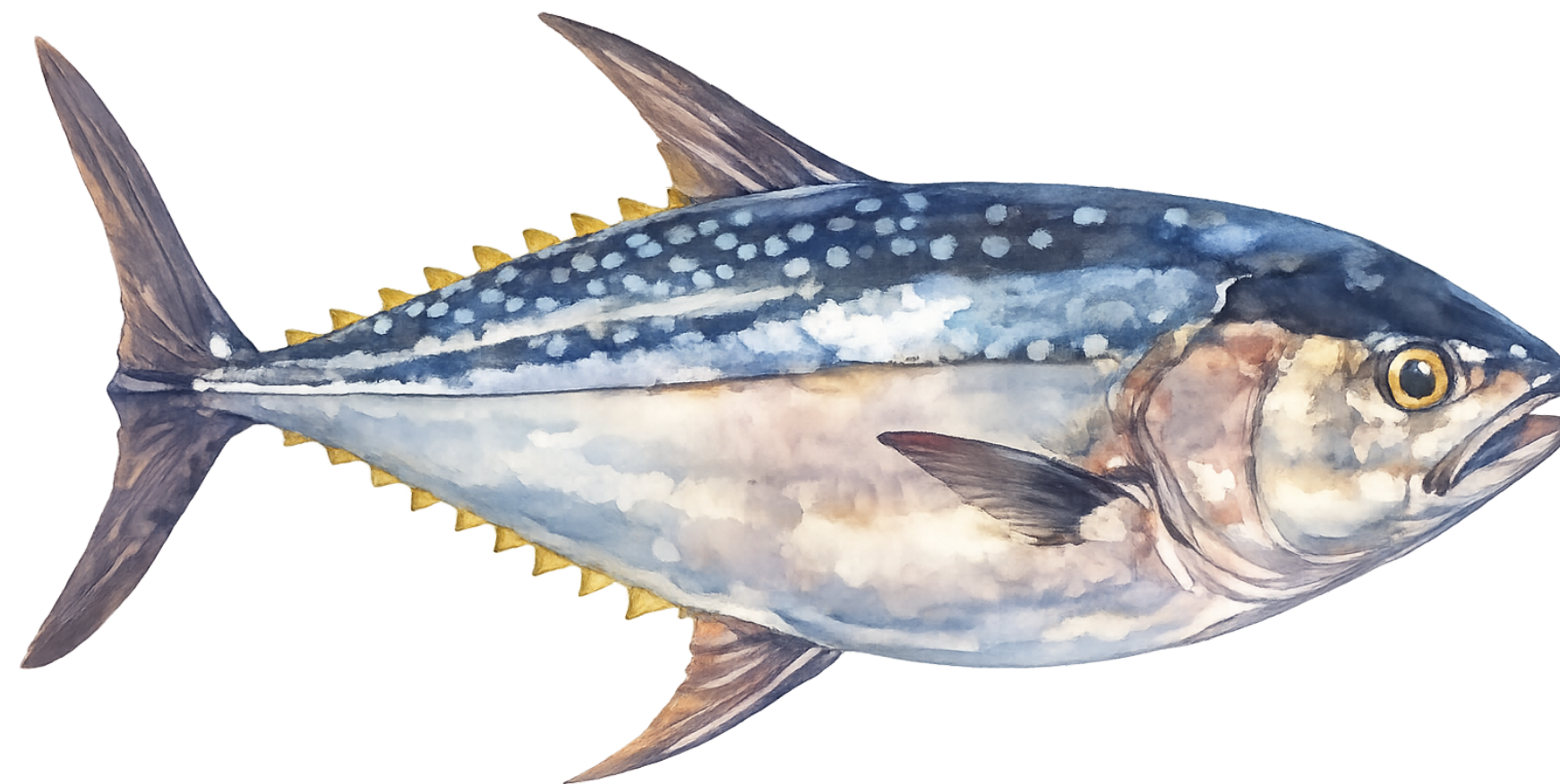
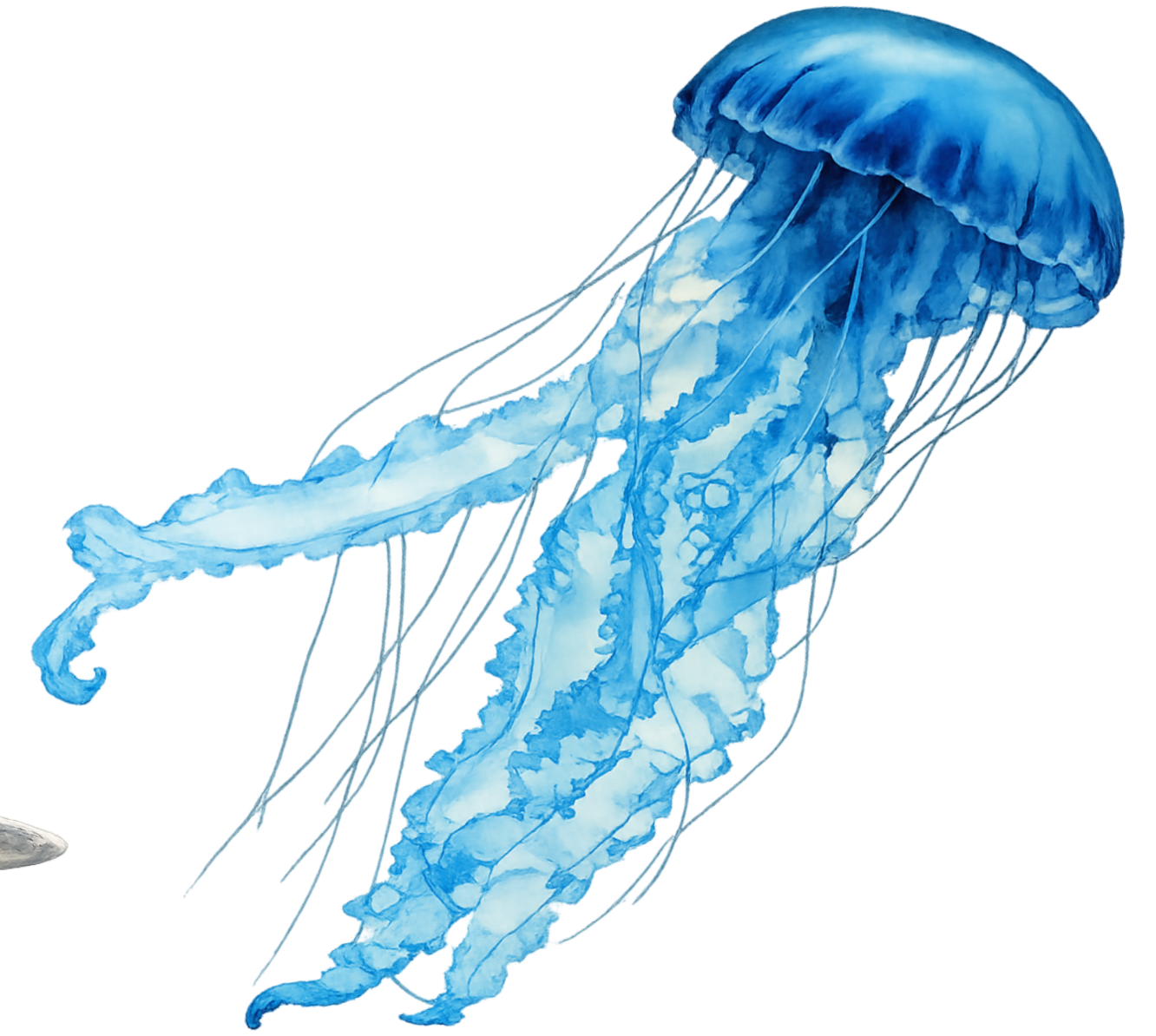
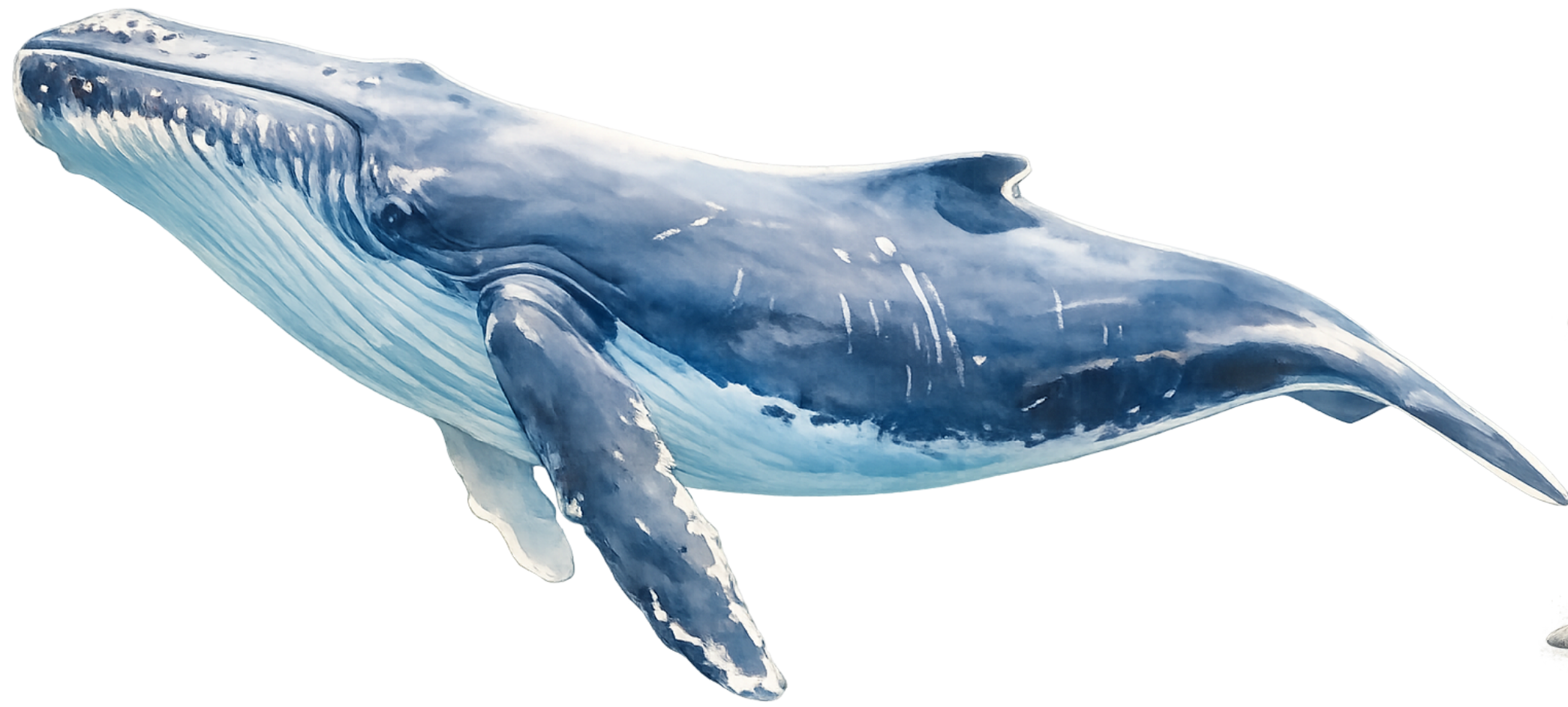


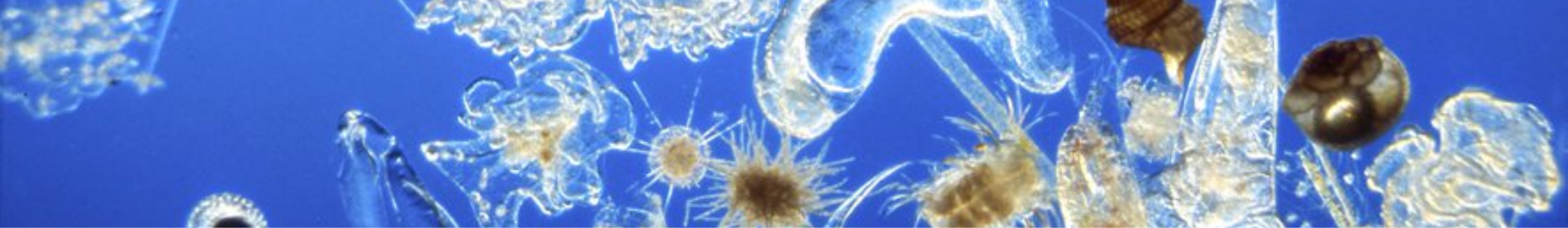
Marine biodiversity

With a special focus on plankton



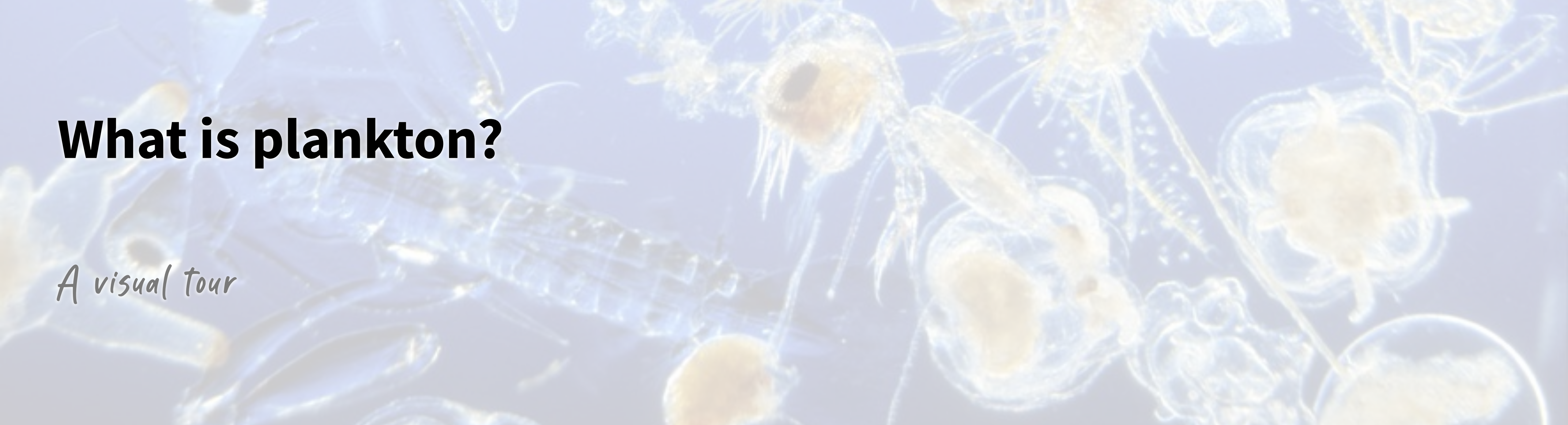
Which ones do you know?





What is plankton?

A visual tour



Definition of plankton

*All organisms that drift
with ocean currents*



Most life in the ocean is small plankton

1L sea water

10,000,000 bacteria

100,000 unicellular

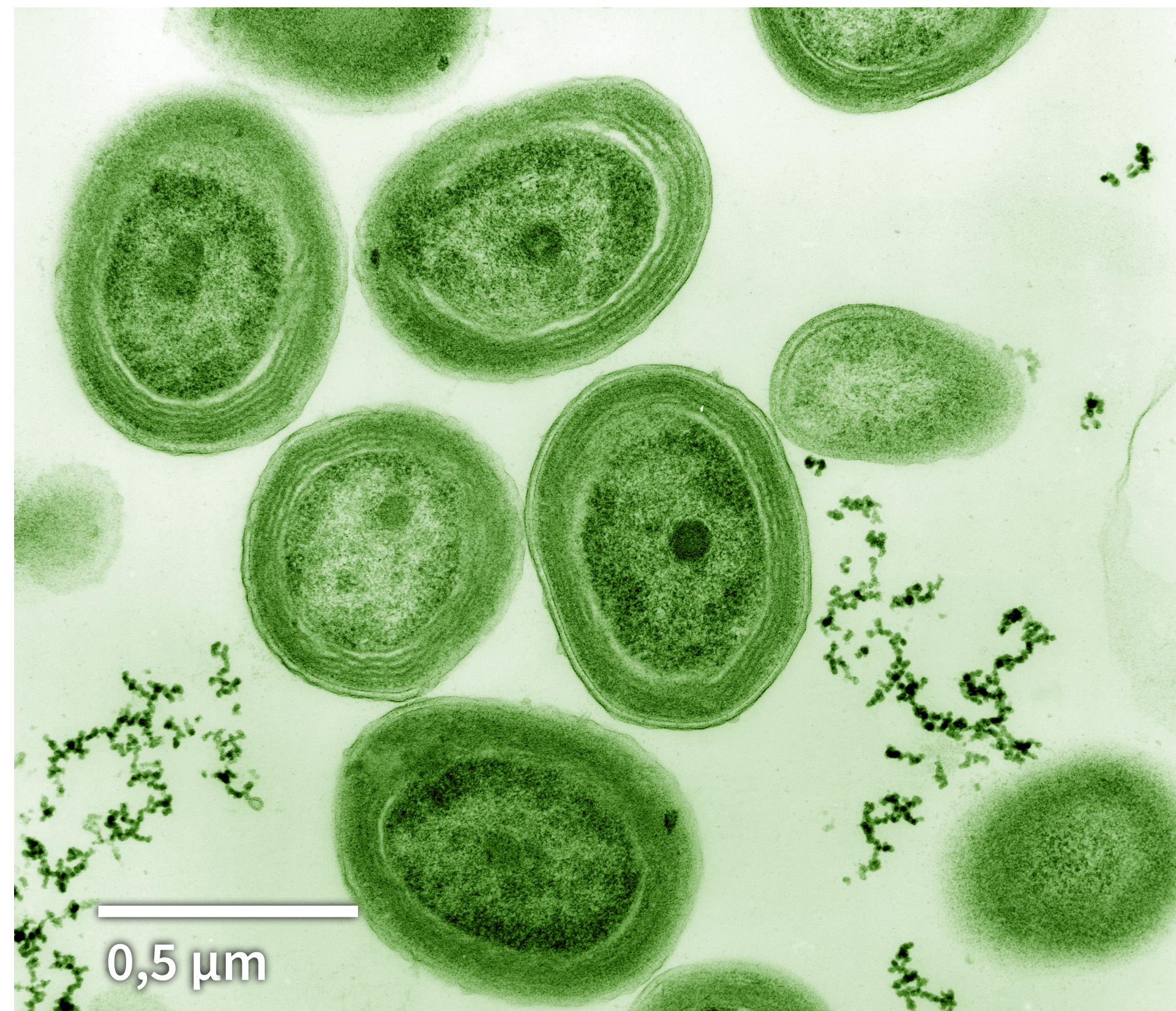
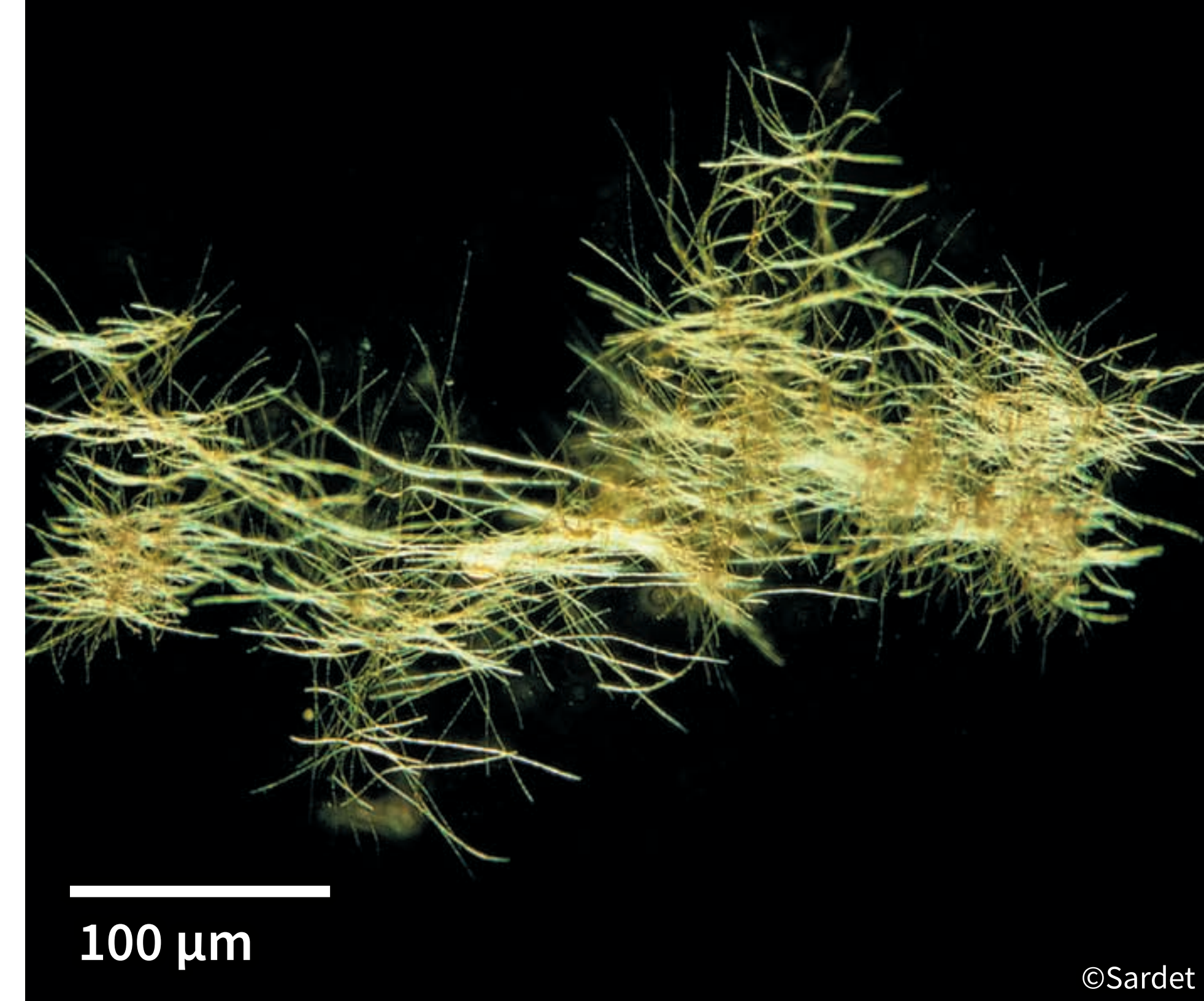
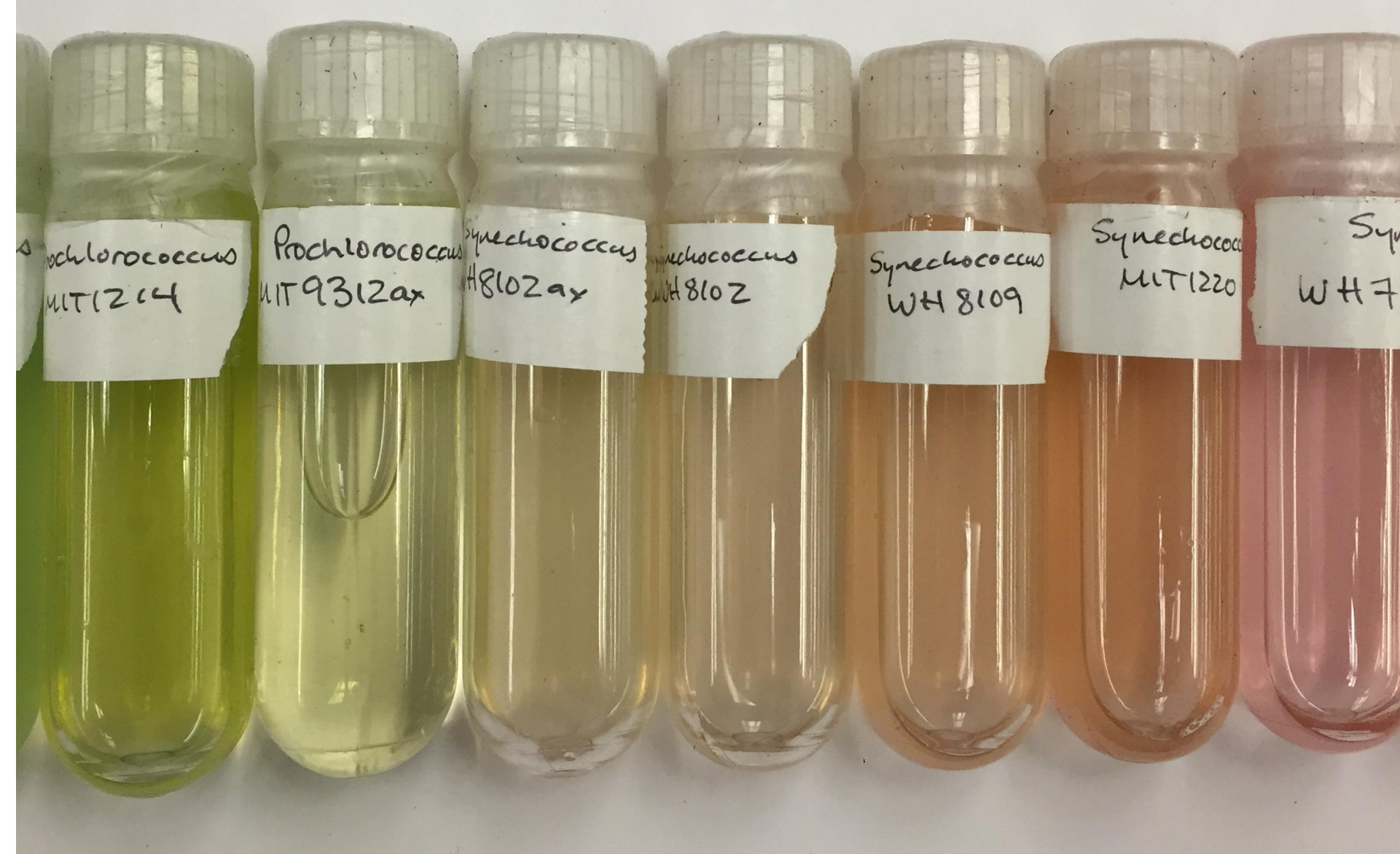
1000 multicellular

Phyto vs. zooplankton



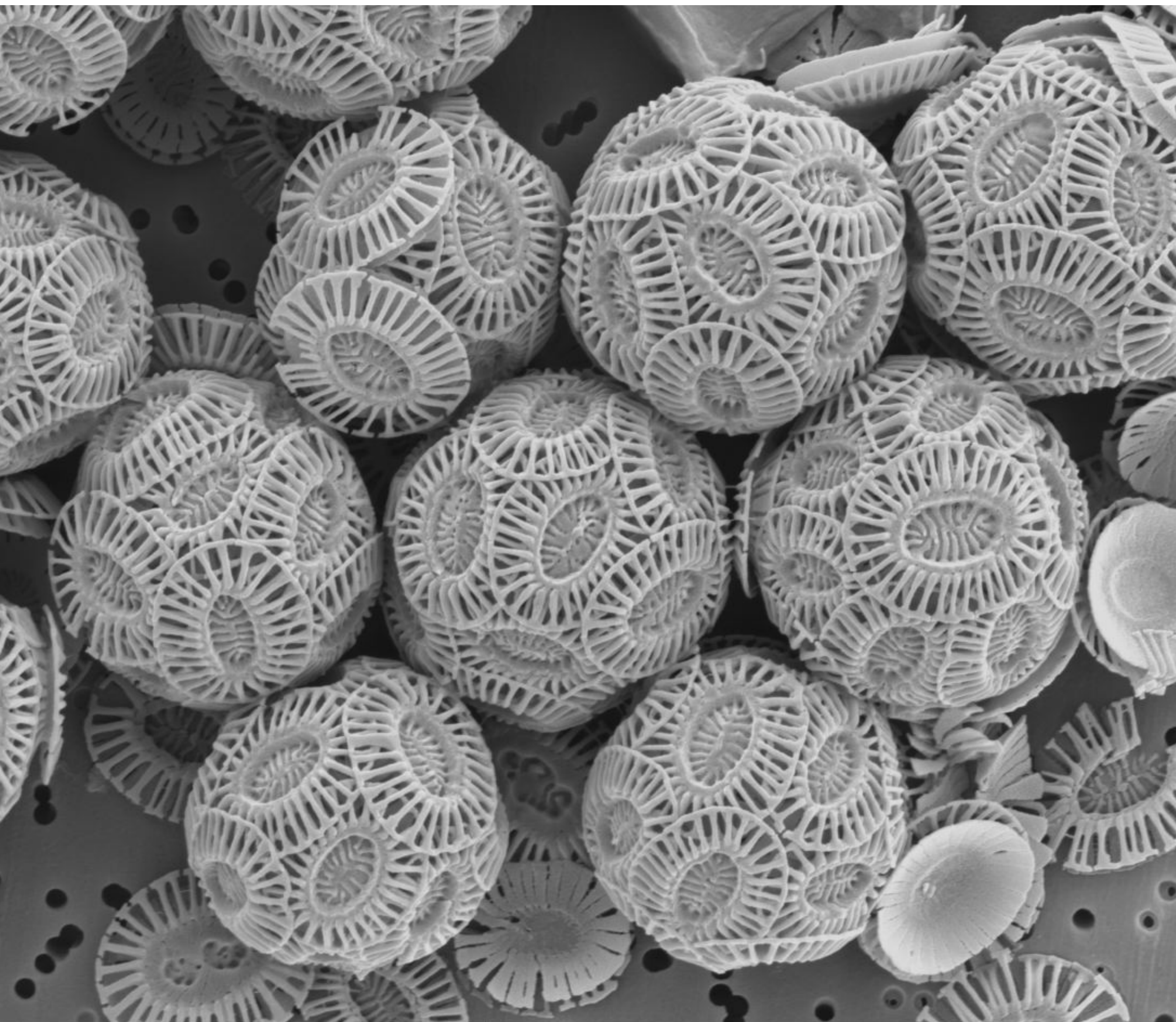
Cyano bacteria

Small but strong in
numbers

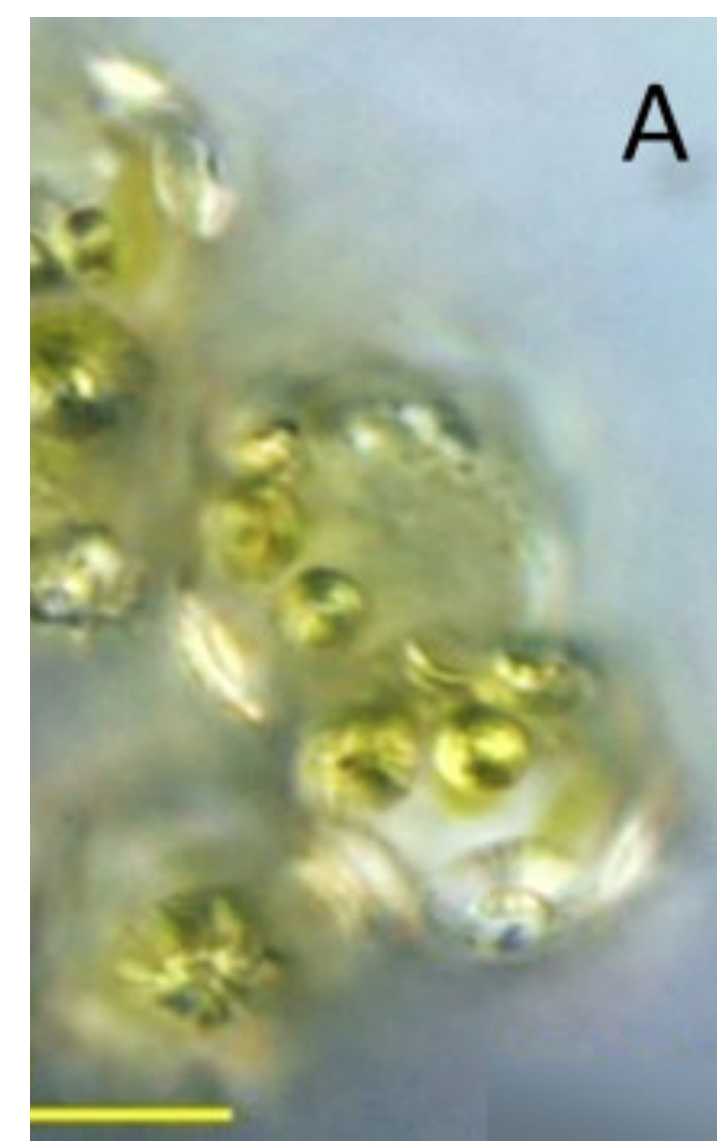


Coccolithophores

Chalk balls

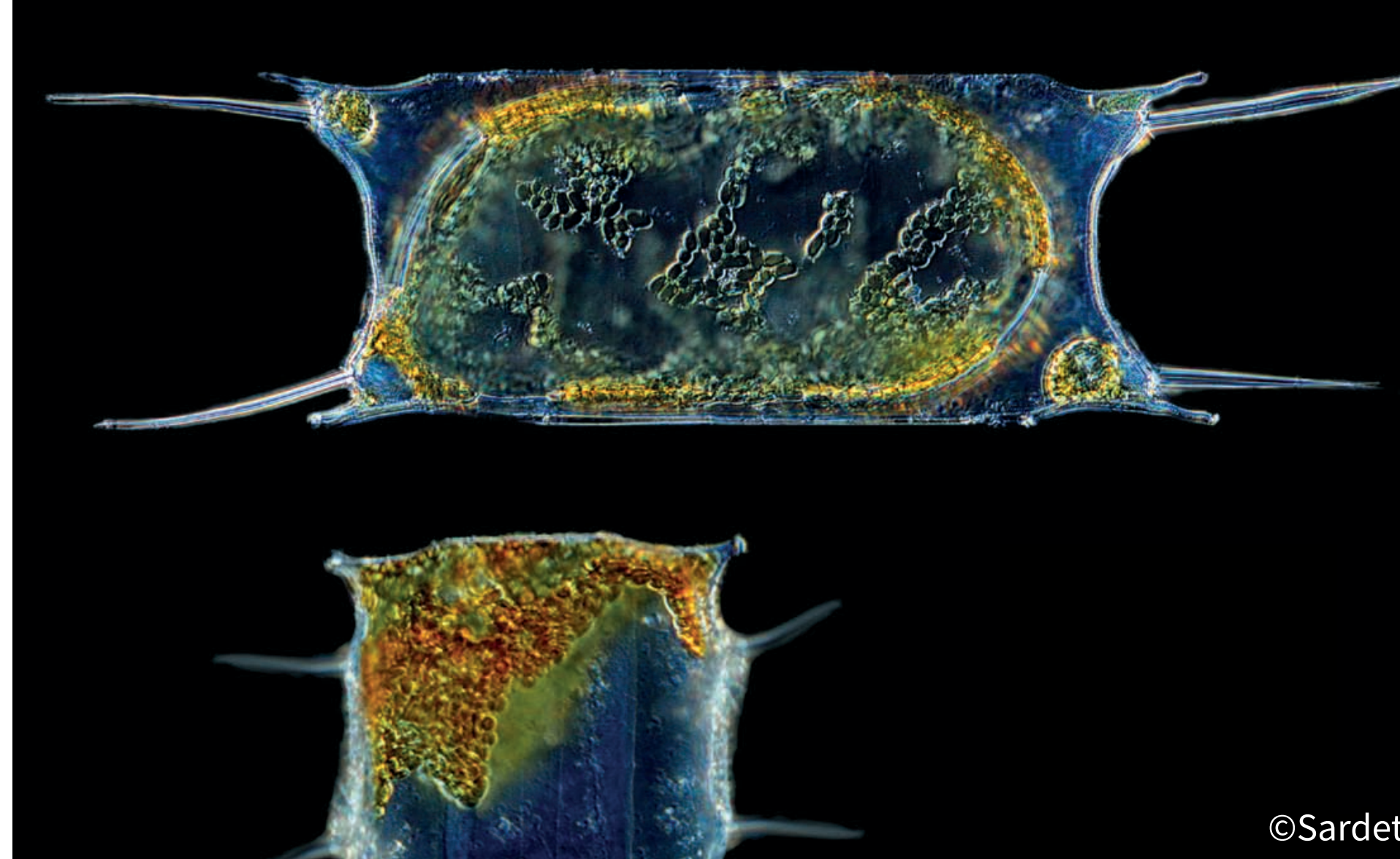


Spot Magn Det WD
/ 3.0 6500x SE 10.0 JRY 218 2 μ m

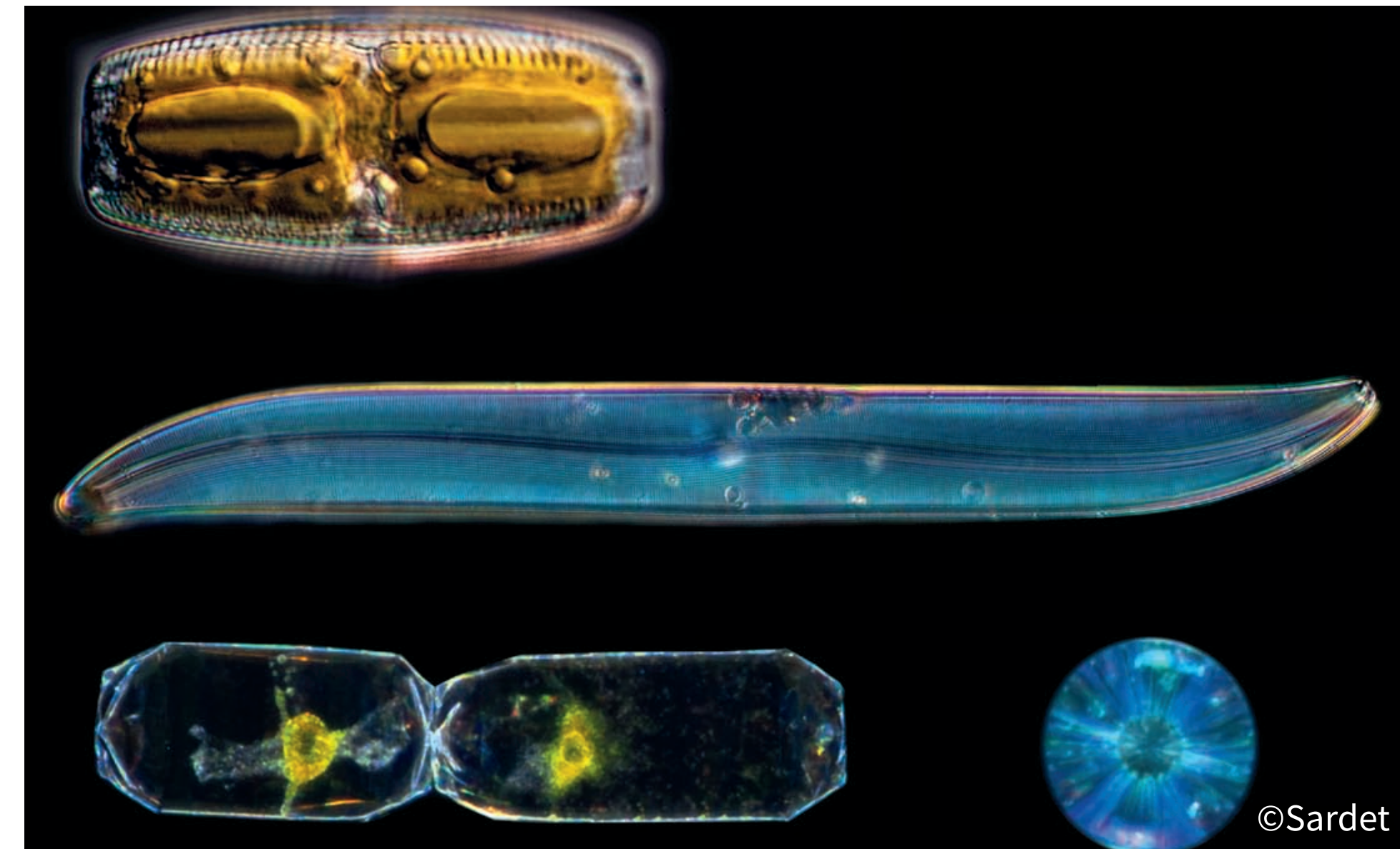
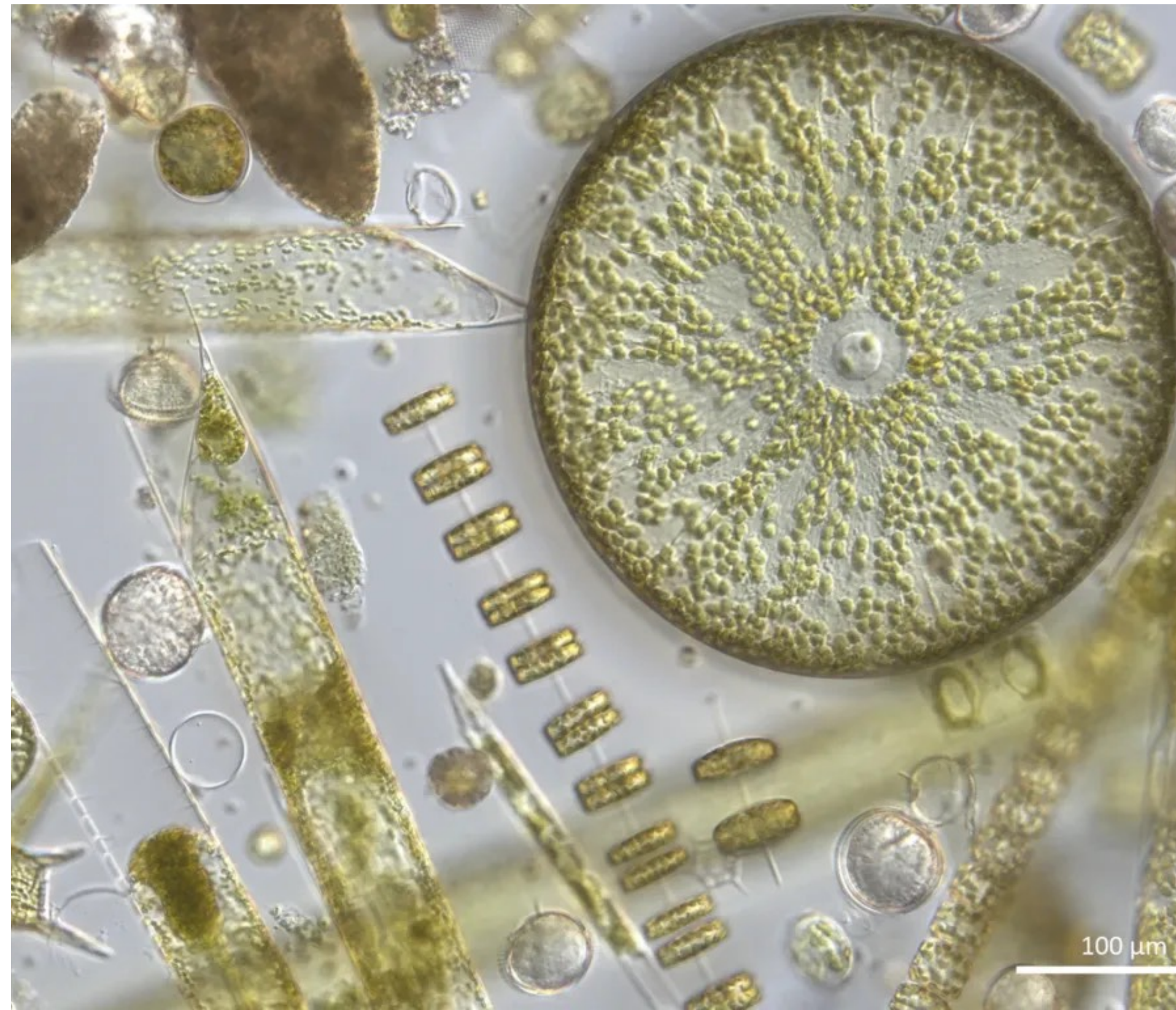
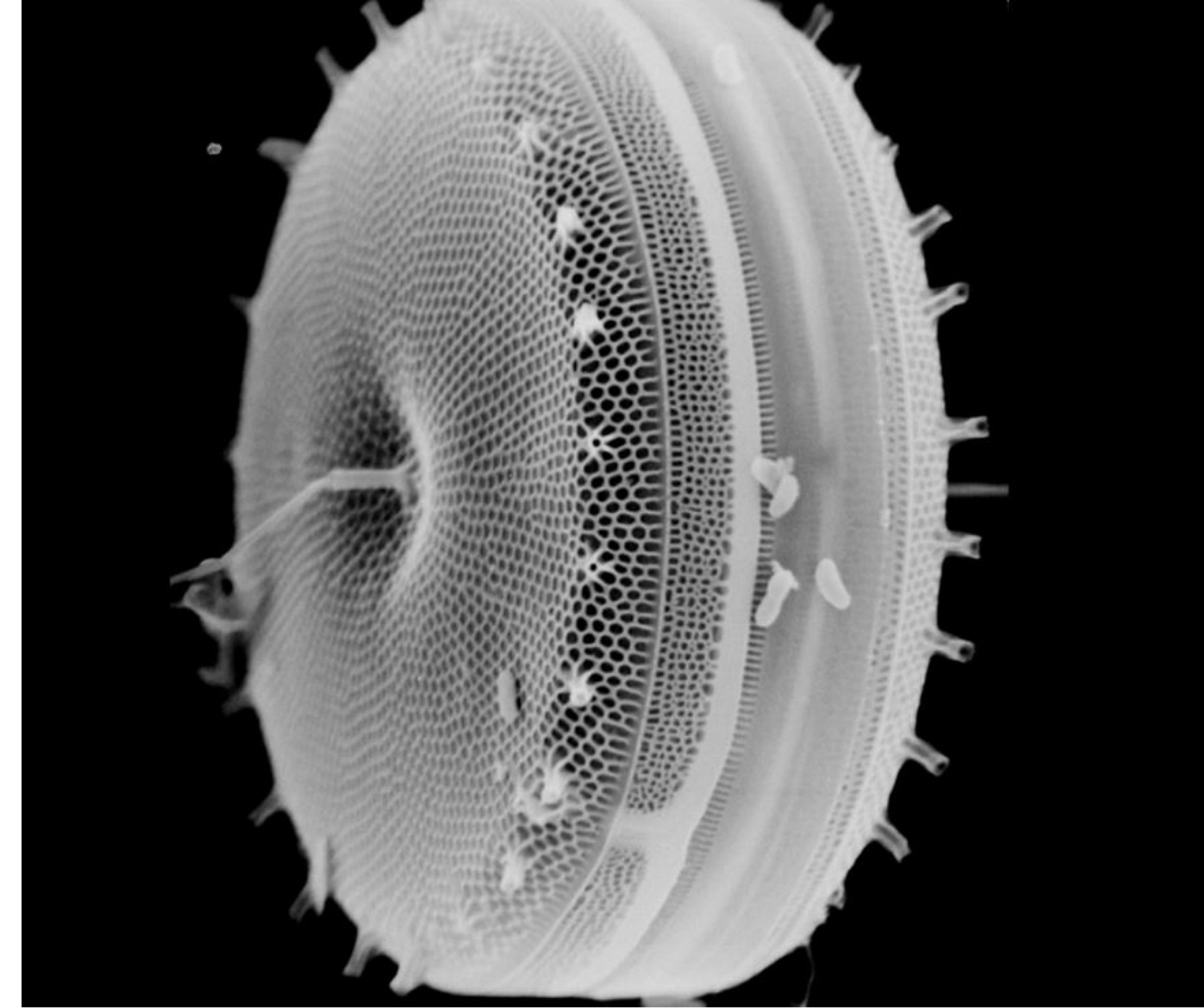


Diatoms

Glass algae



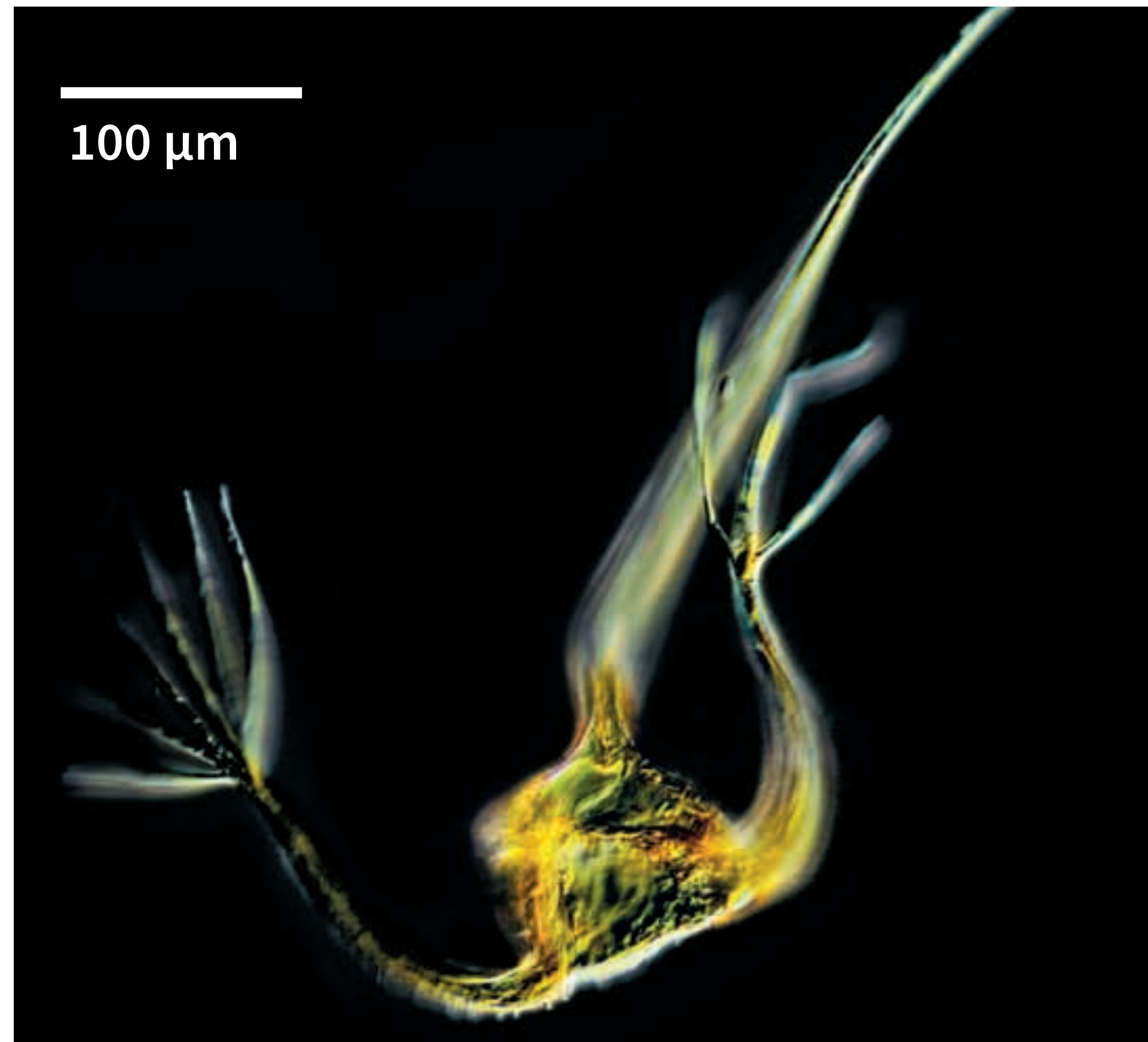
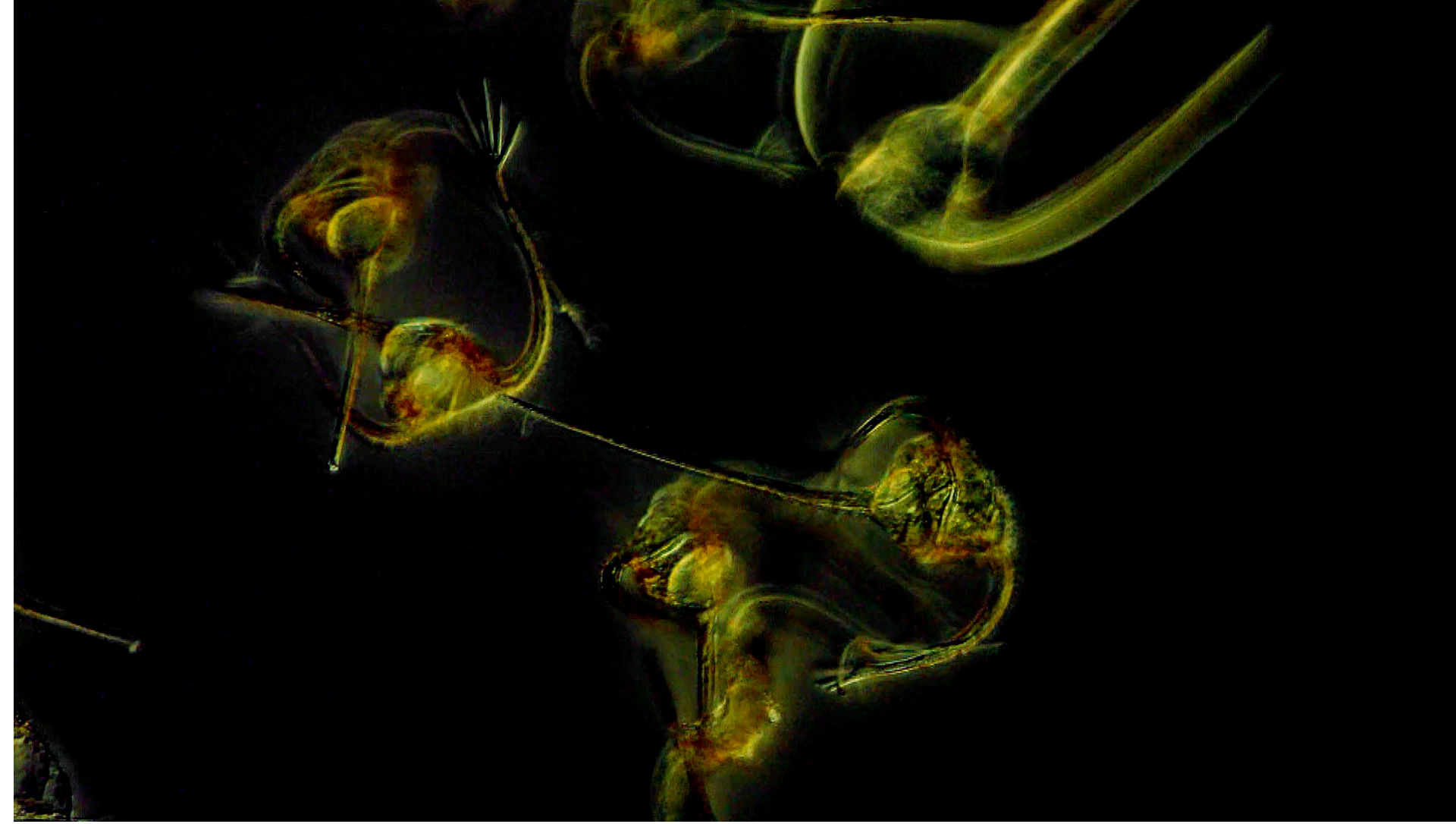
©Sardet

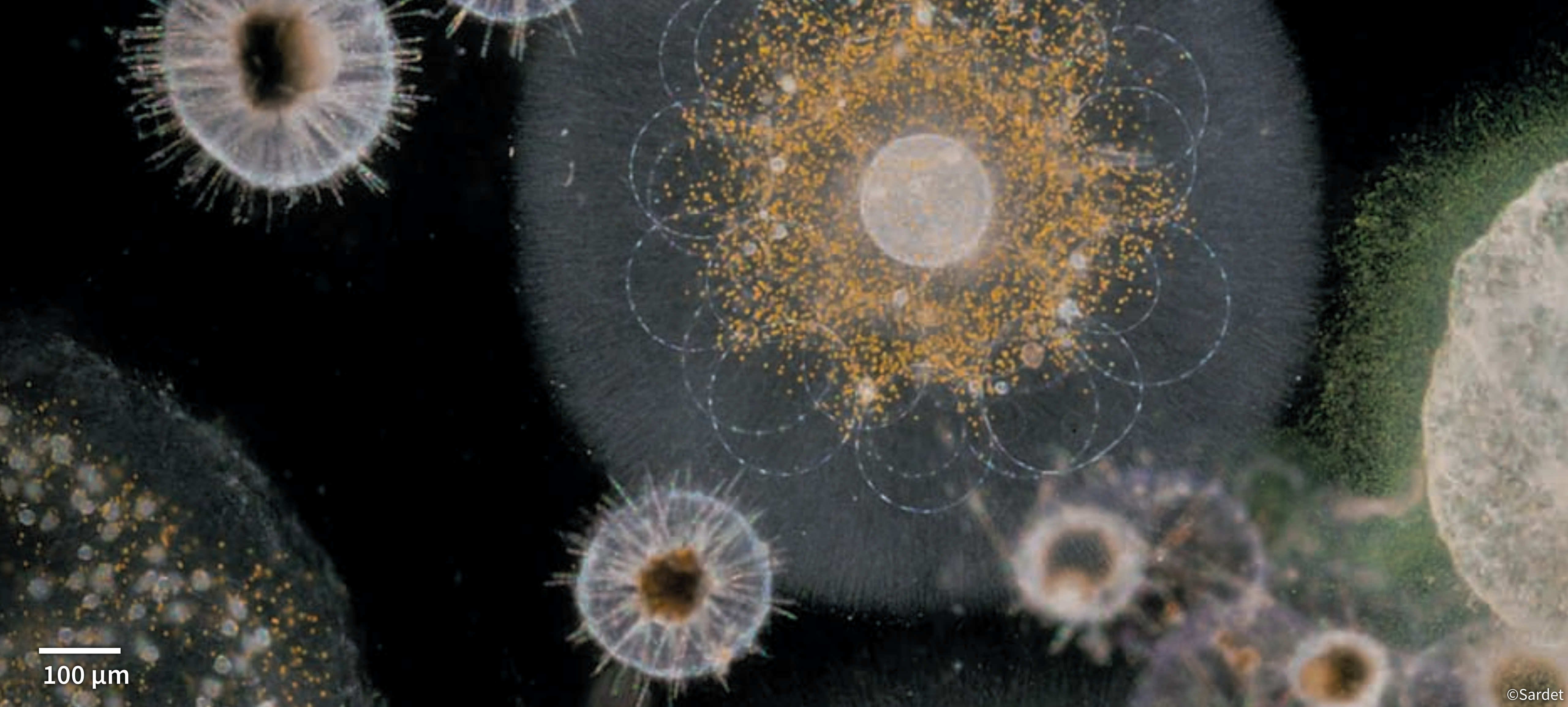


©Sardet

Dino- flagellates

Plants that eat





100 μm

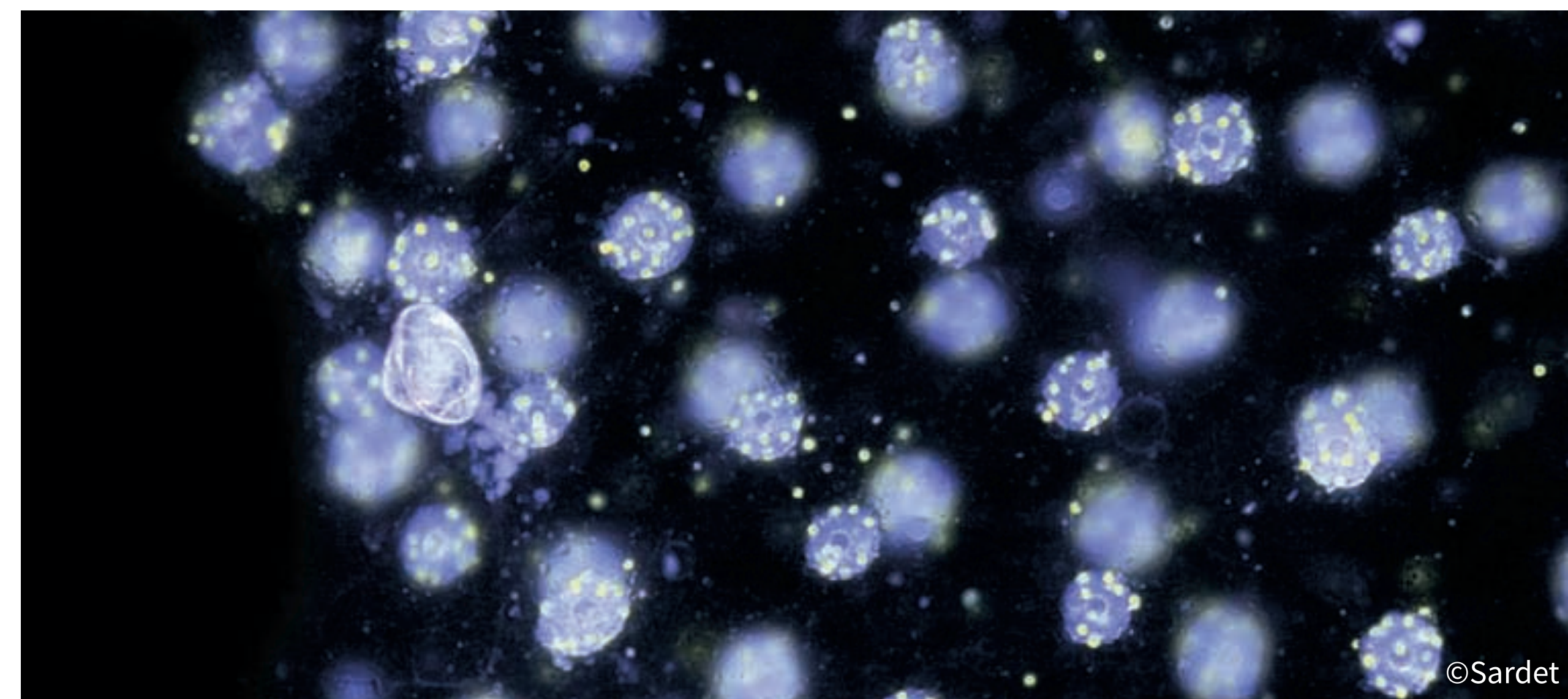
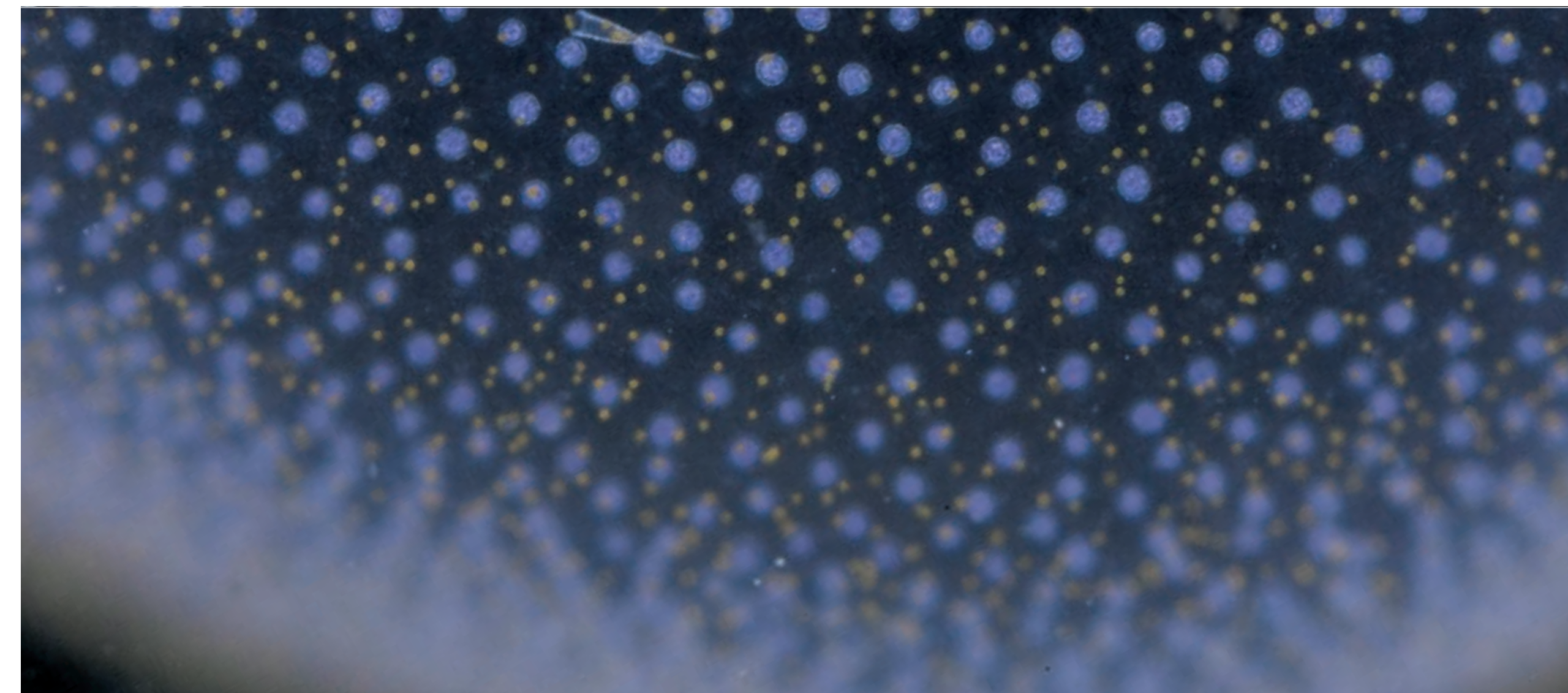
©Sardet

Polycystine radiolarians

Giant cells that rely on symbiosis

Collodarians

Colonial life



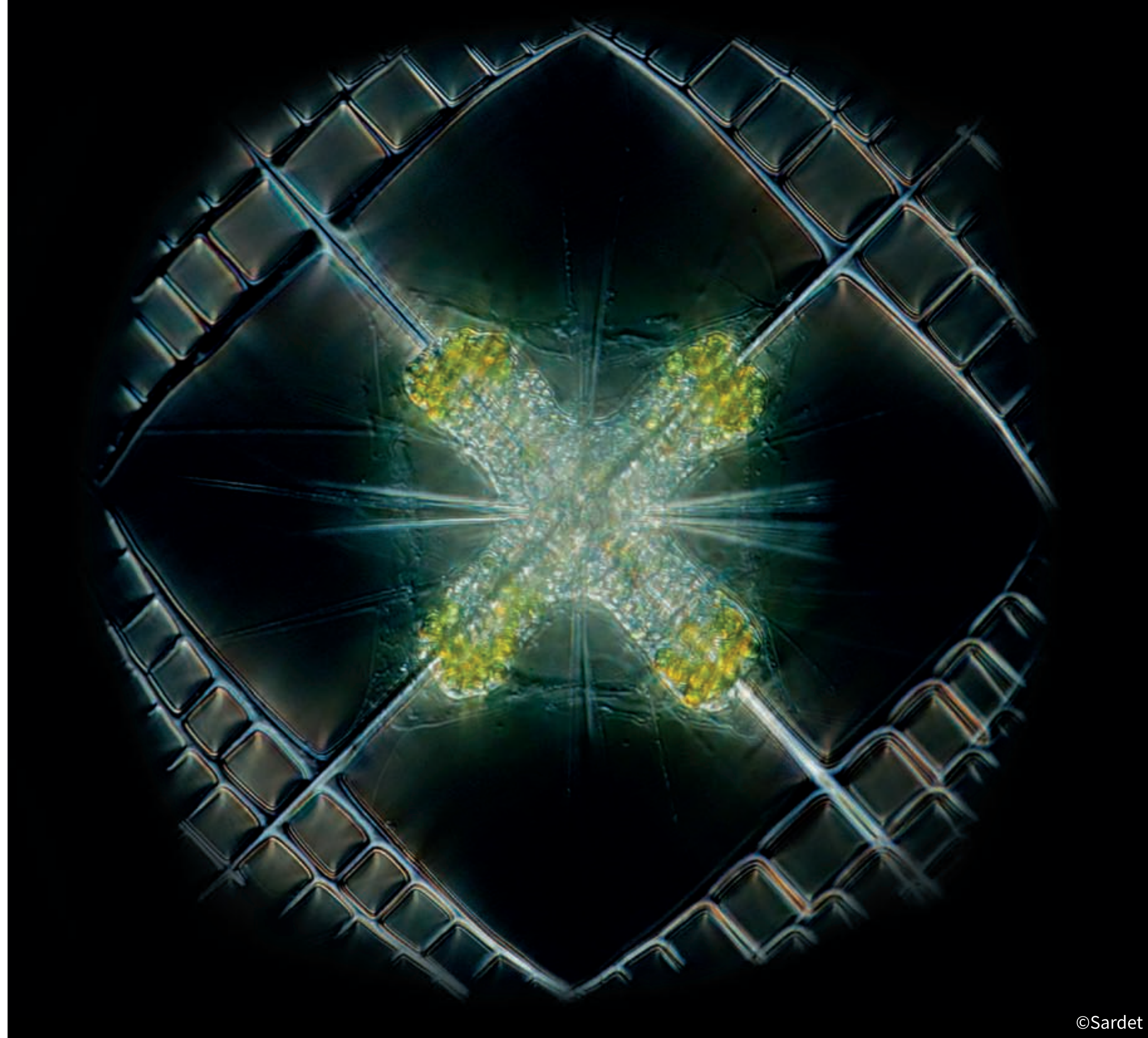
Acantharians

Strontium sulfate skeleton

Green: cytoplasm

Red: symbiotic microalgae

Blue: nuclei



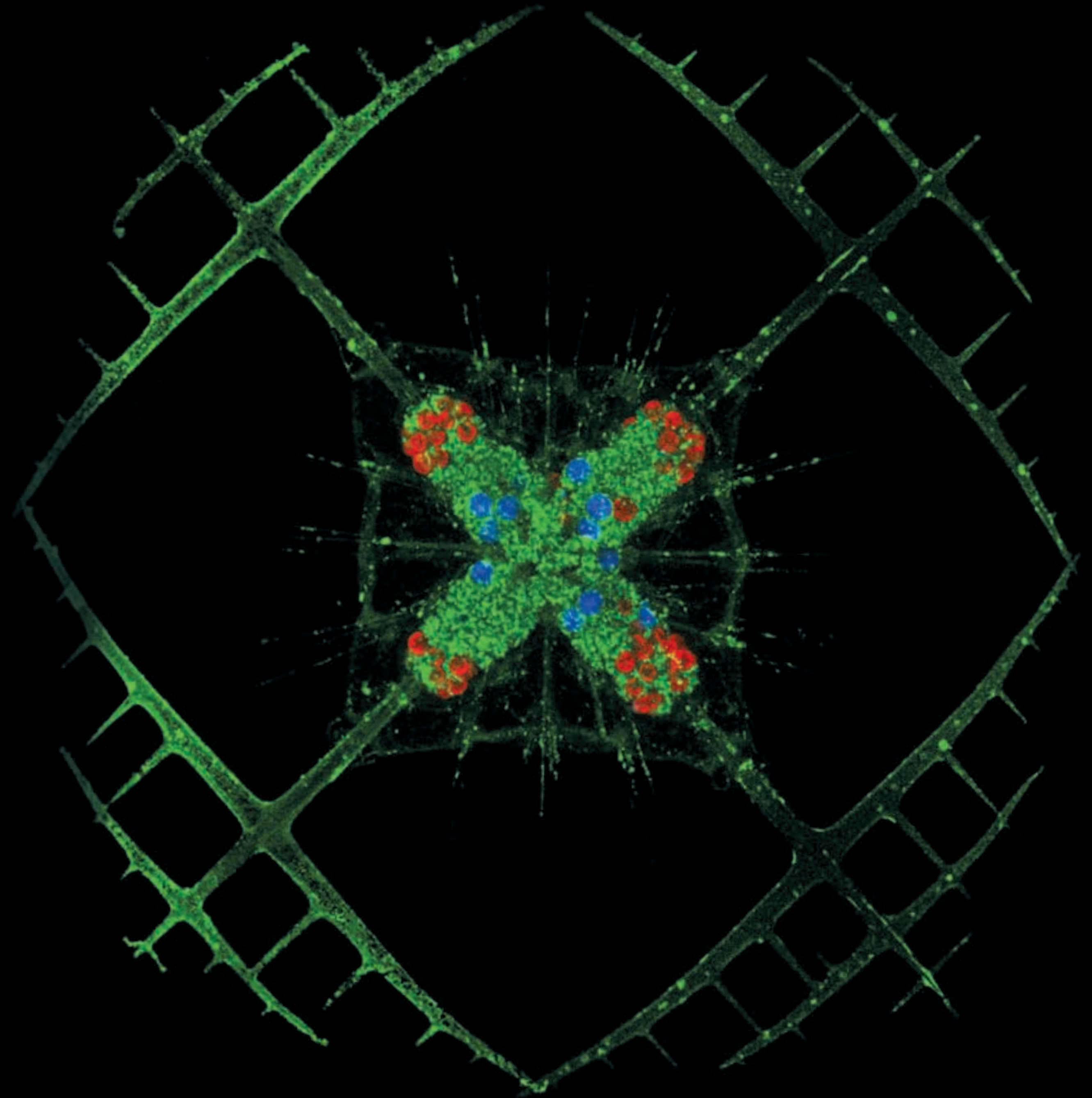
Acantharians

Strontium sulfate skeleton

Green: cytoplasm

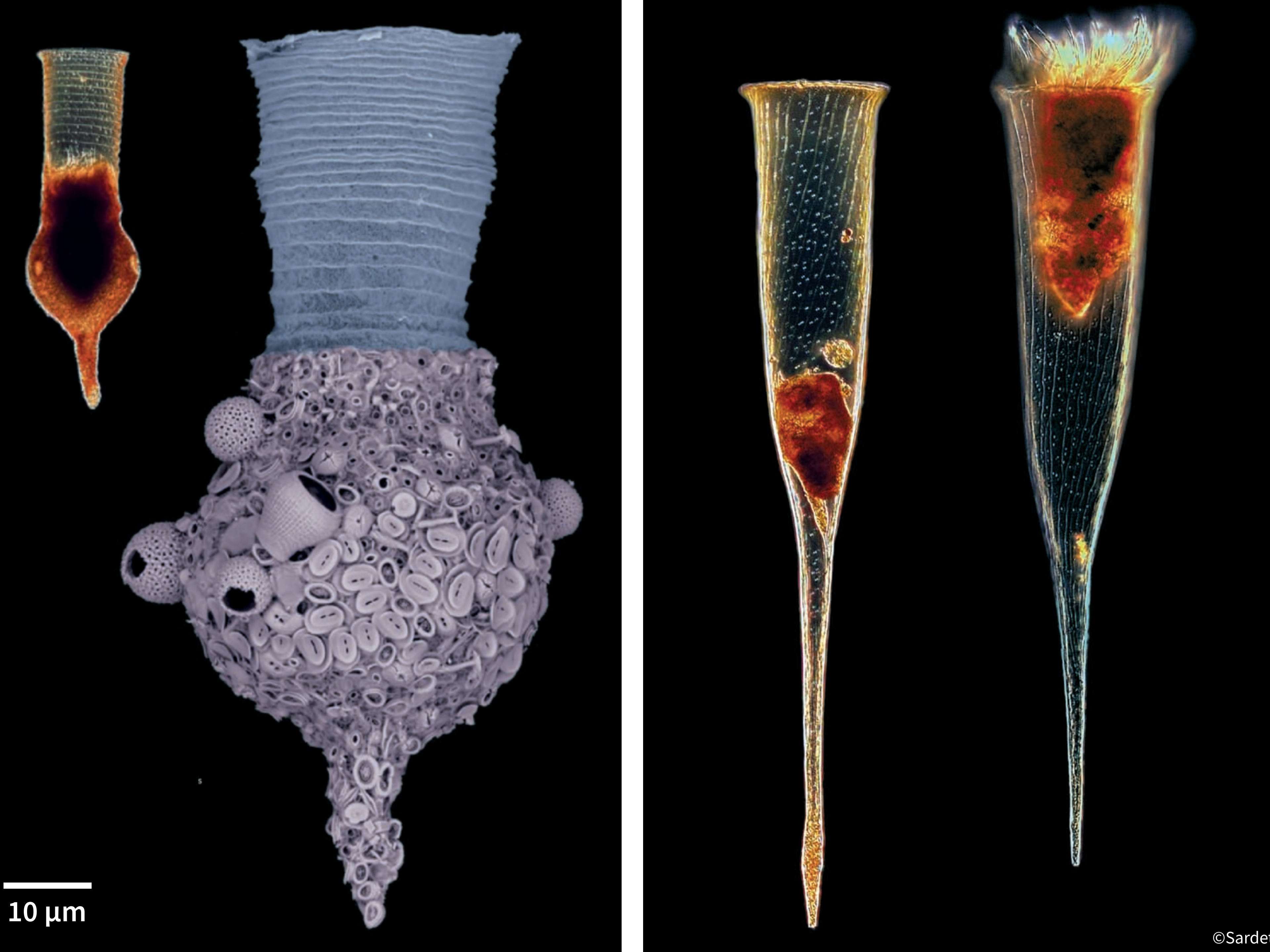
Red: symbiotic microalgae

Blue: nuclei



Tintinnids

Home designers



Copepods

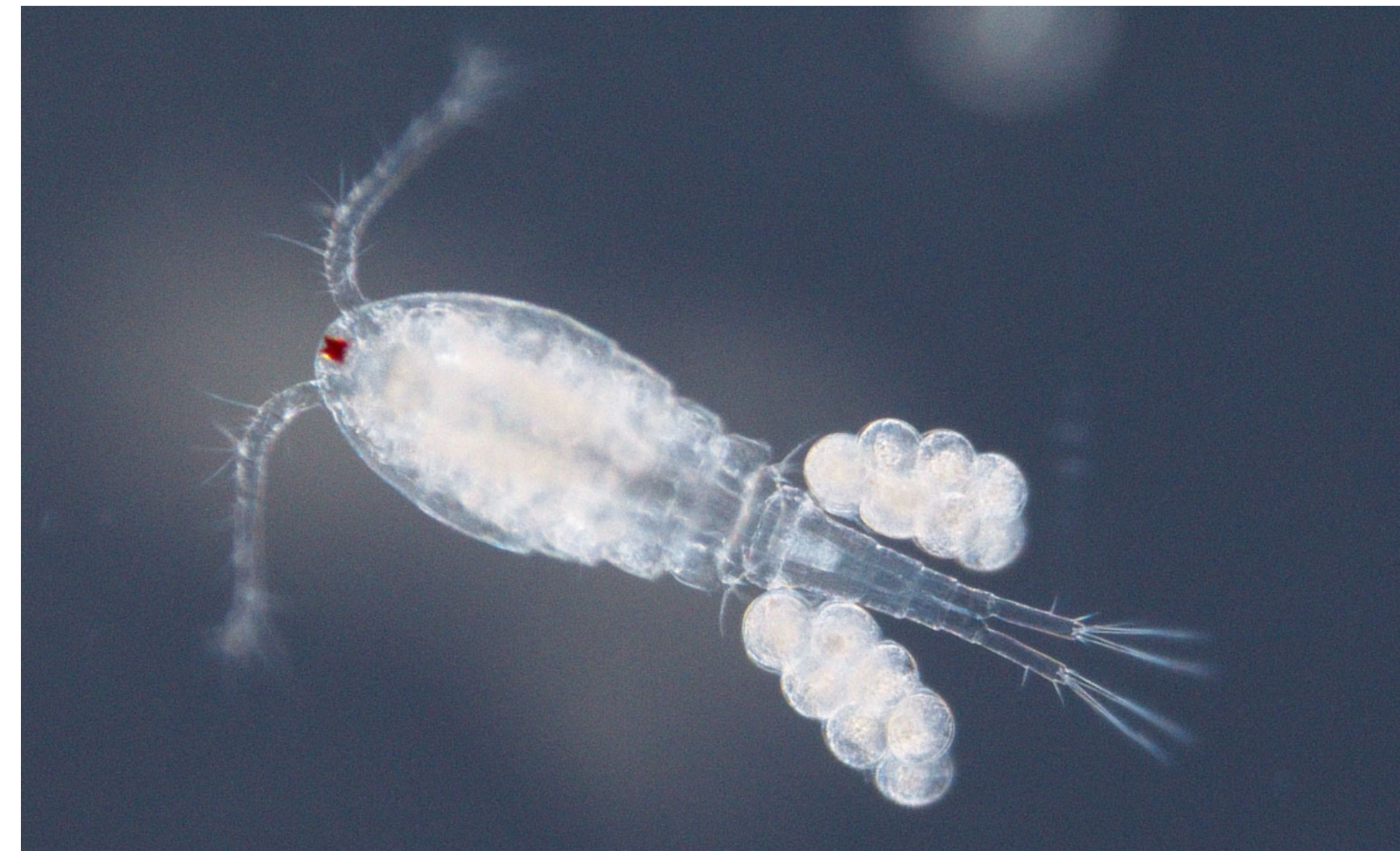
There are only

1,347,000,000,000,000,000,000

or

1.34×10^{21}

of them...



More copepods

In all colours and shapes



Pteropods

Sea-snails and slugs

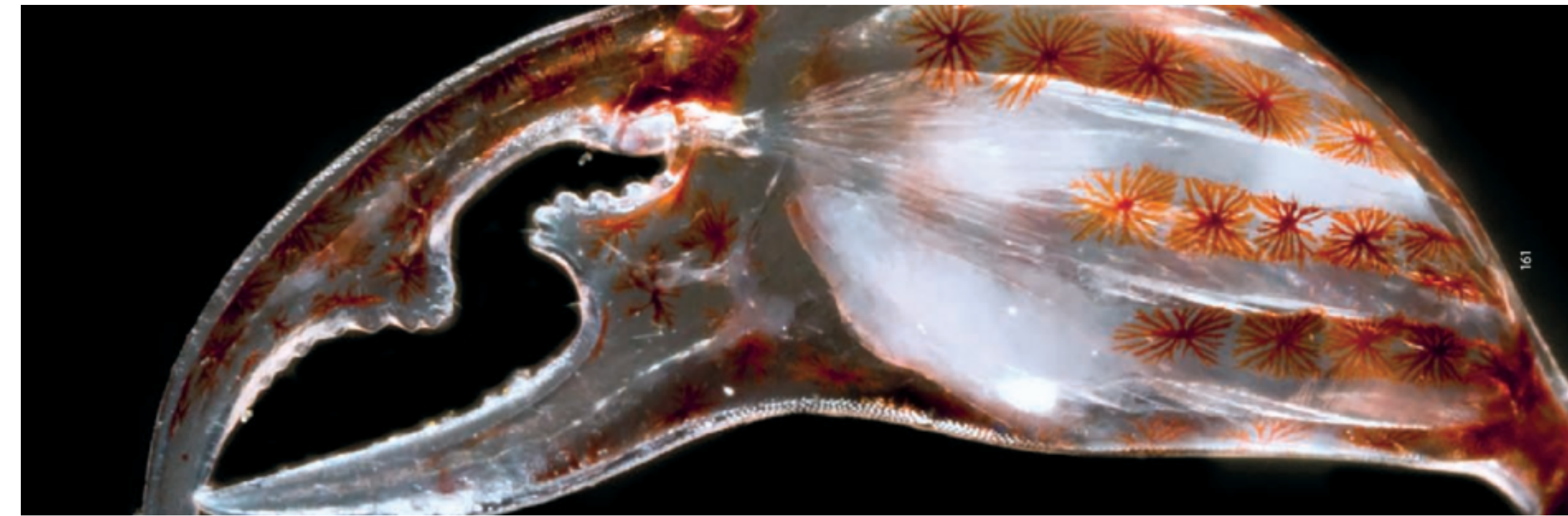


500 μm



Amphipod: Phronima

An alien on earth



Salpida

The clonal vacuum cleaners

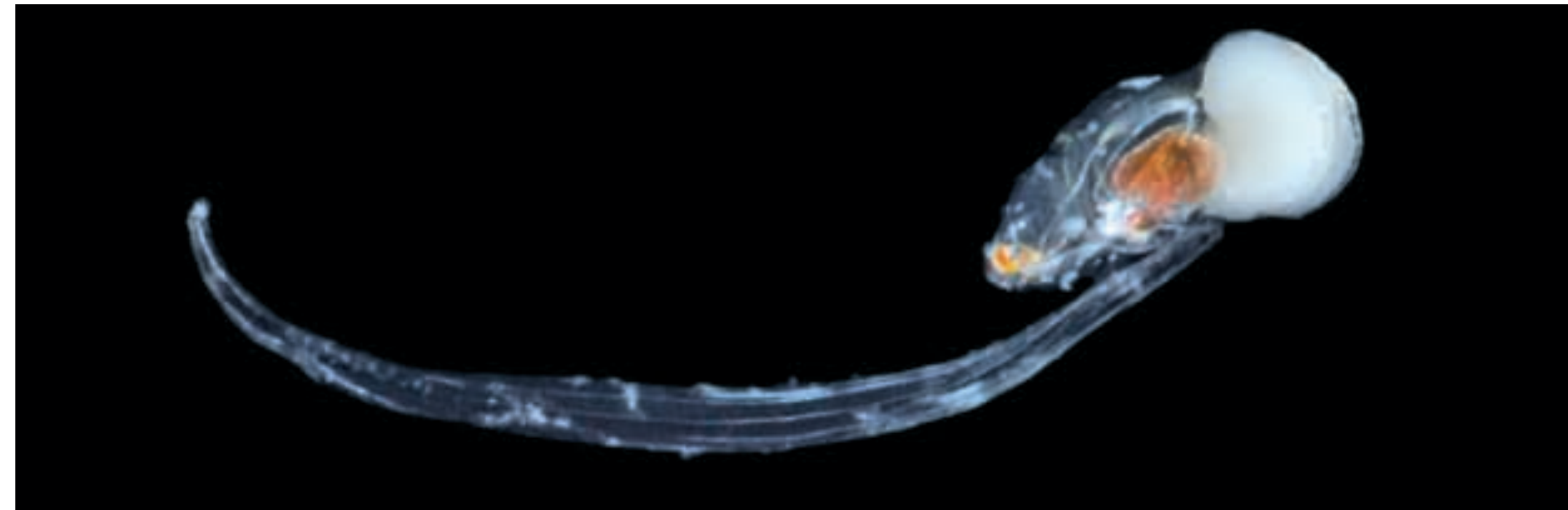


5 mm



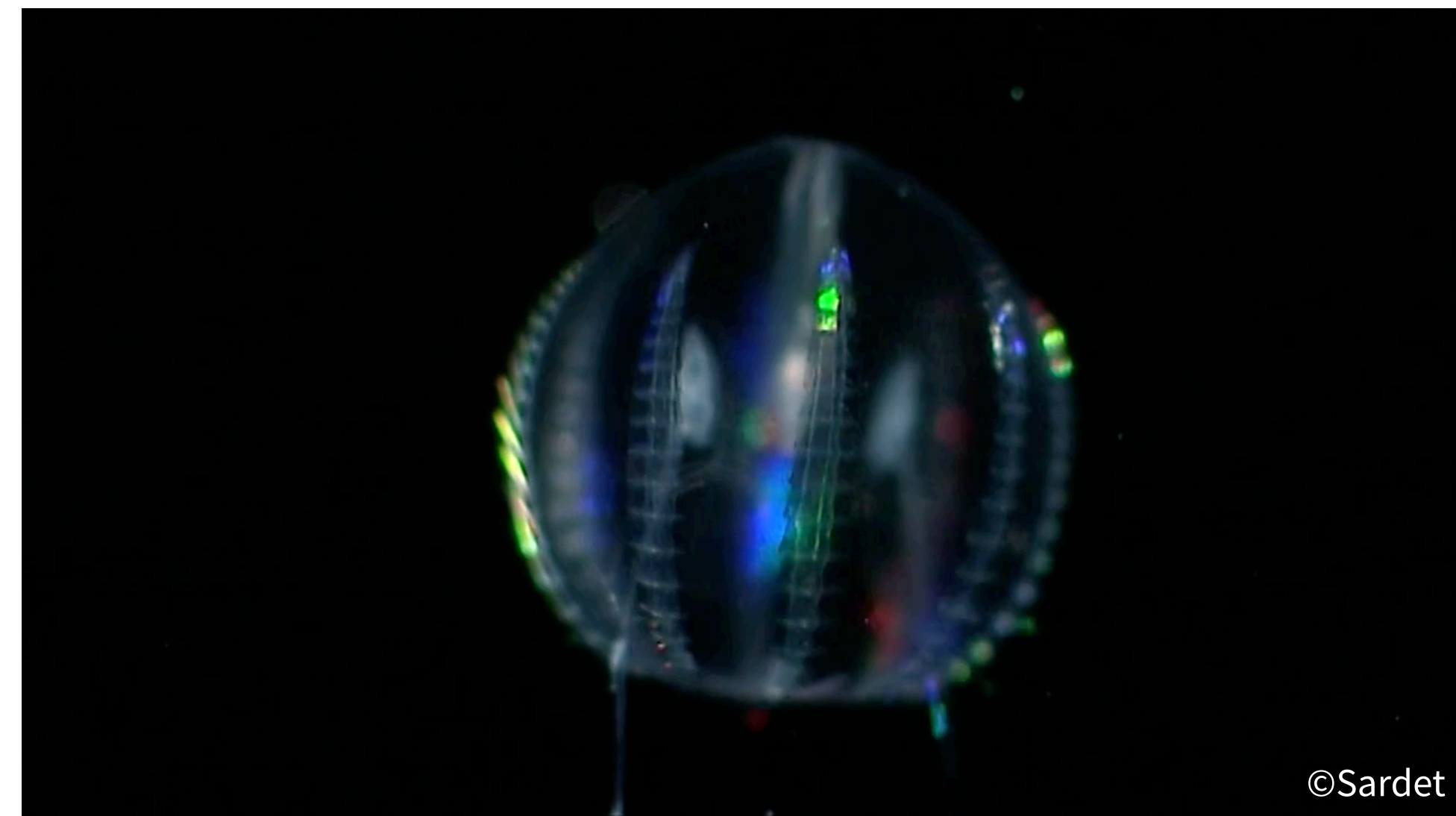
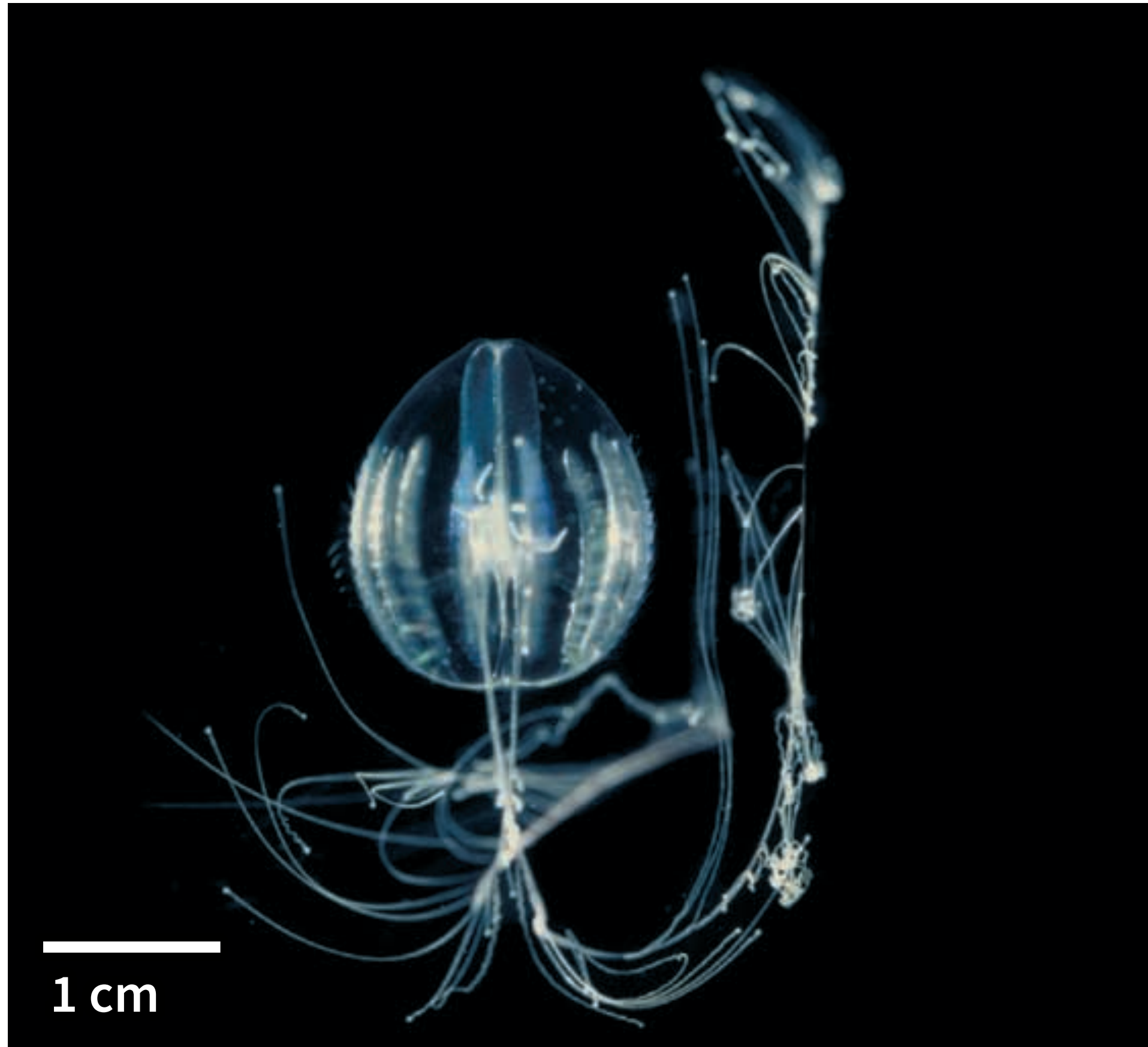
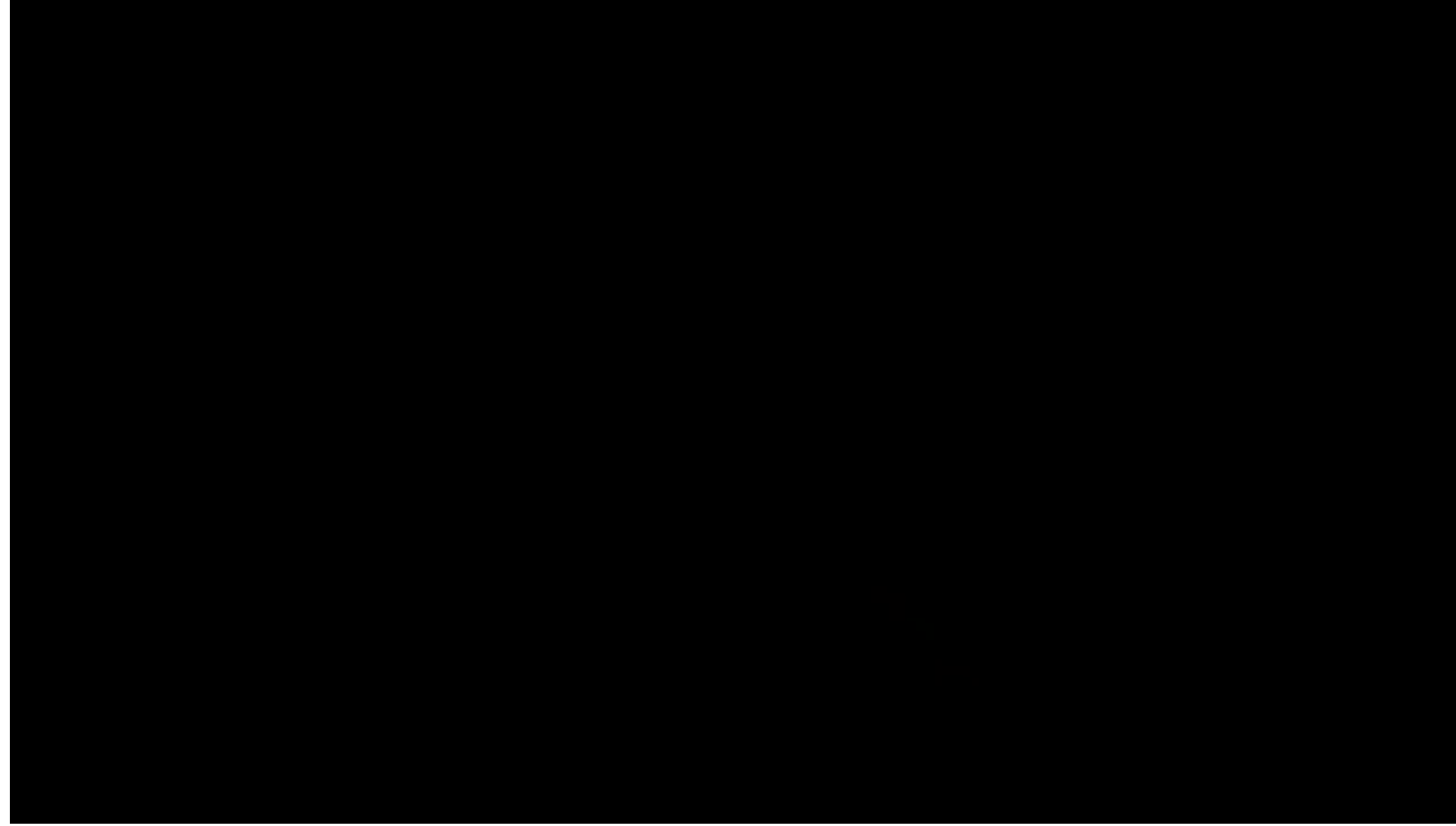
Appendicularians

Disposable filters



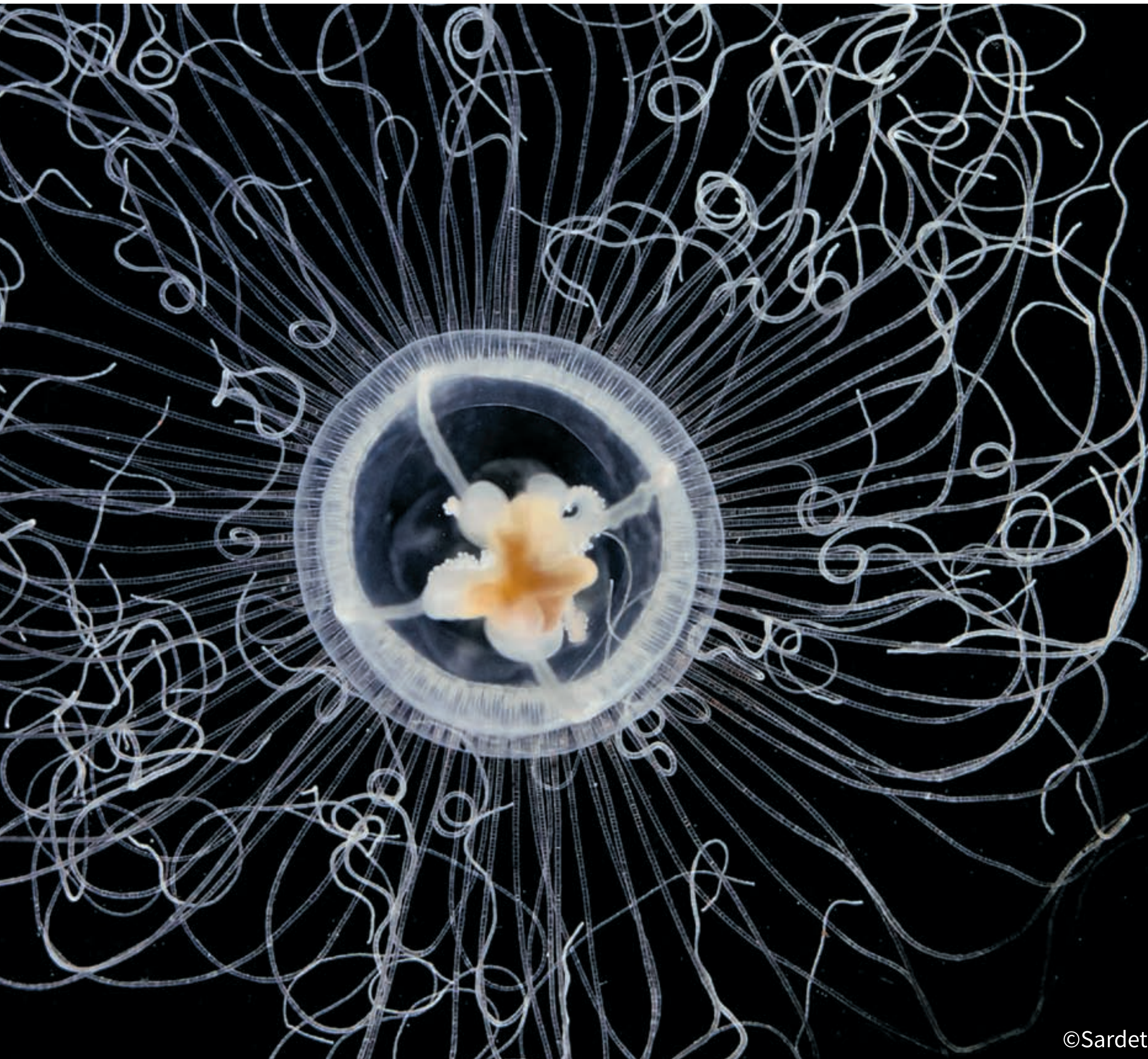
Ctenophores

Voracious predators

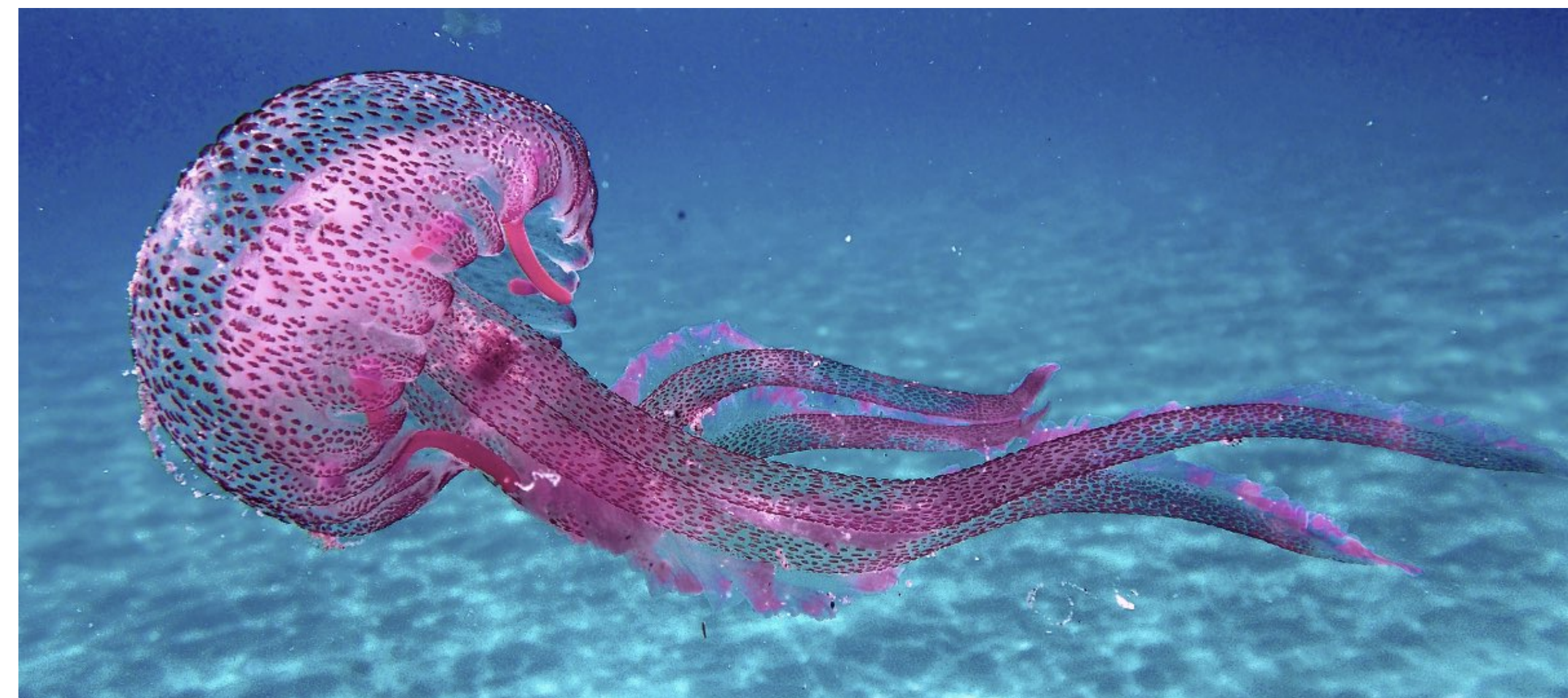
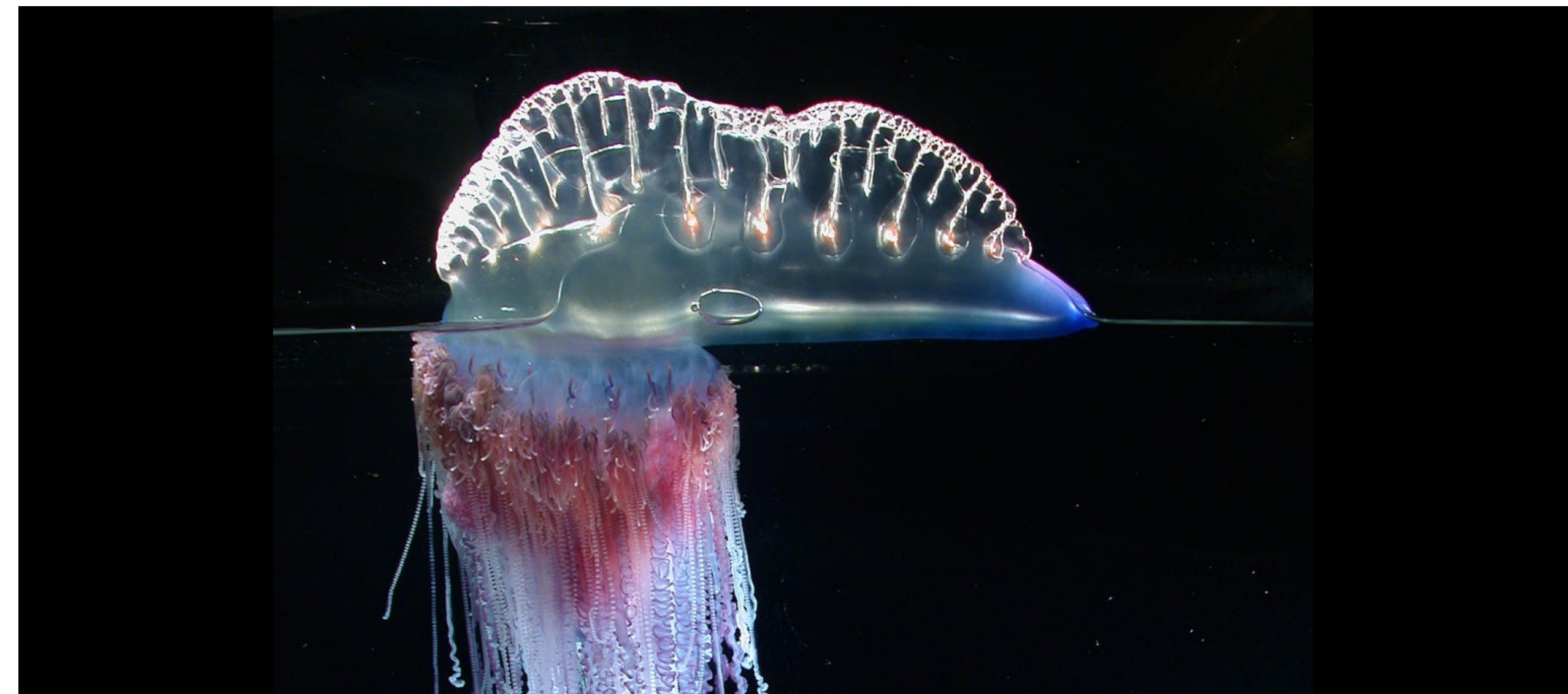


Cnidaria

Immortal, deadly, largest, superorganisms ... only superlatives

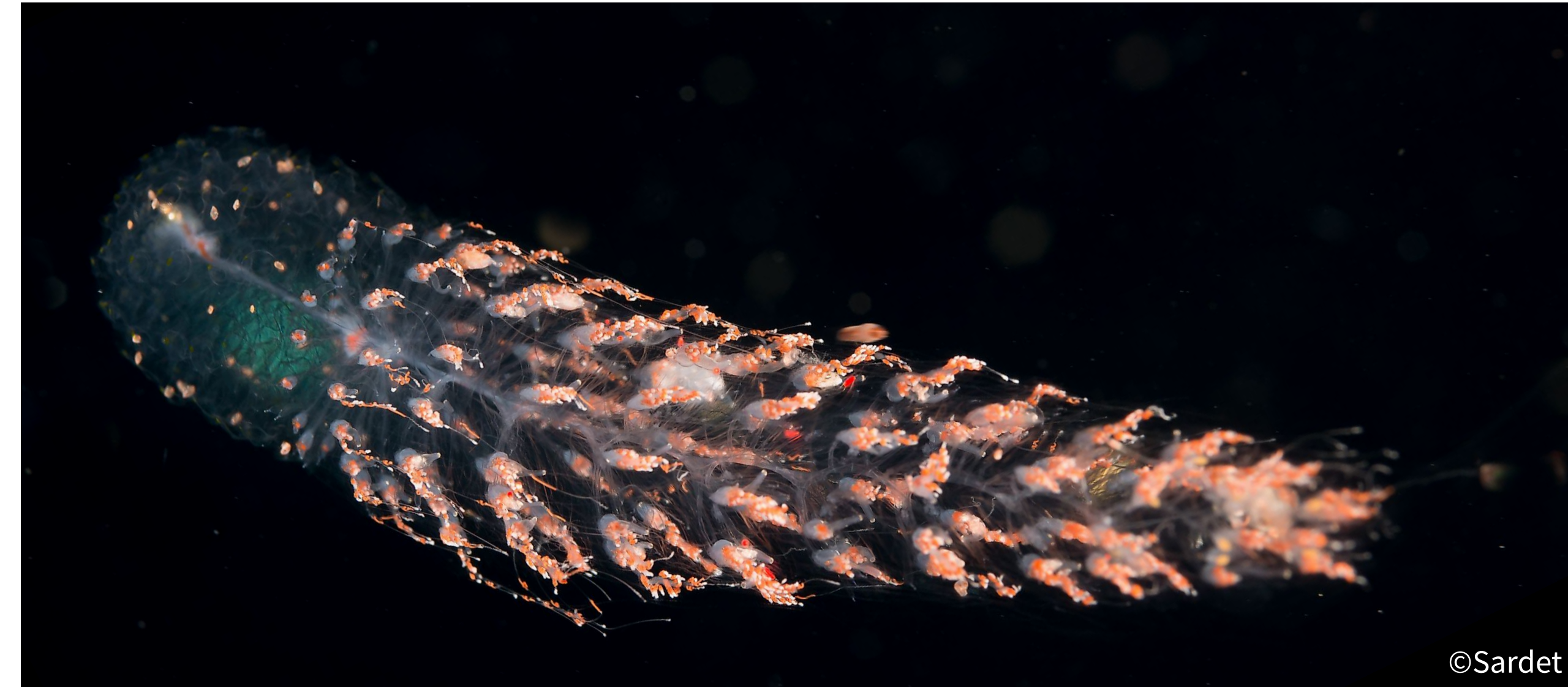


©Sardet



Cnidaria

Immortal, deadly, largest, superorganisms ... only superlatives

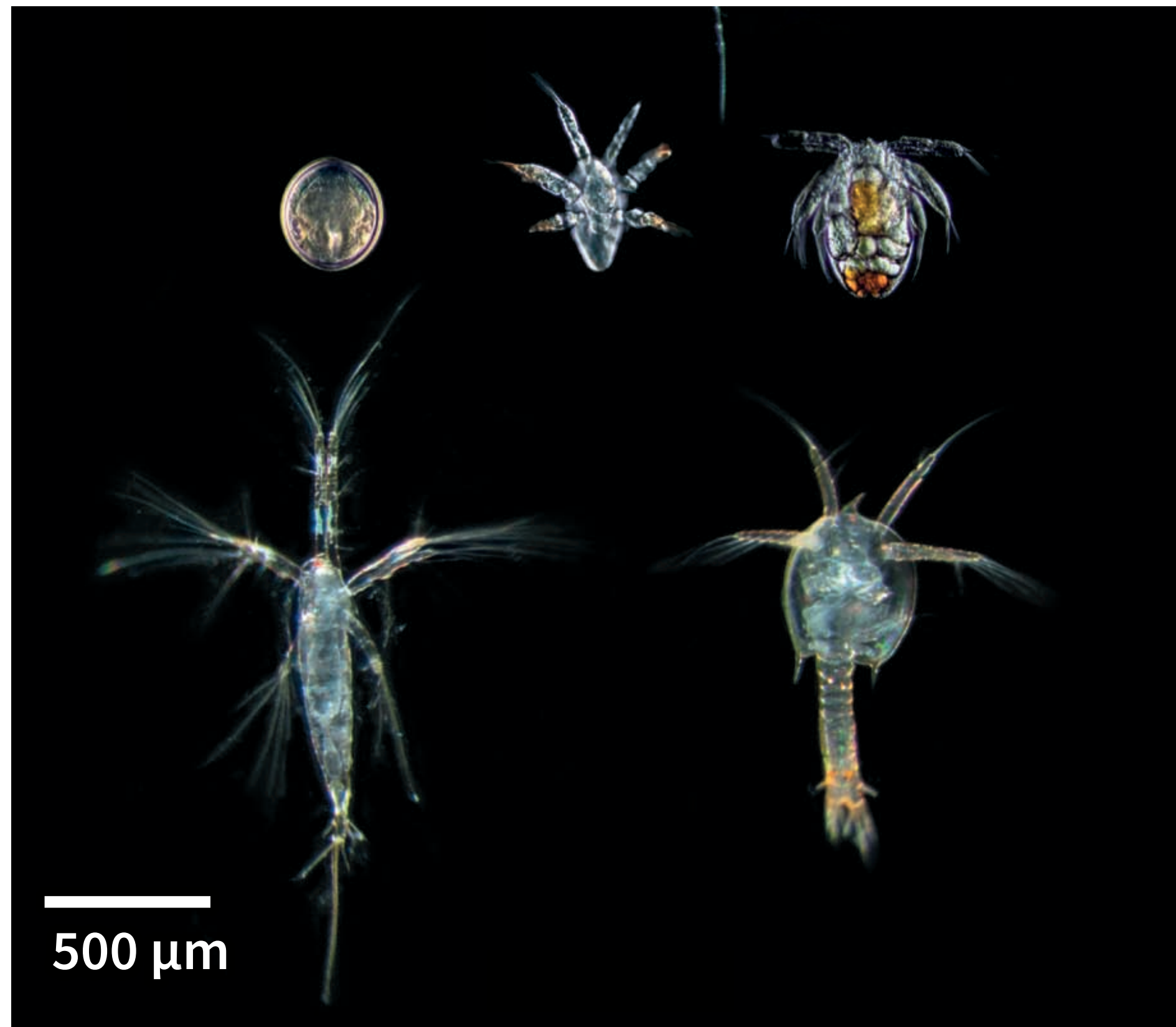


Diverse larvae

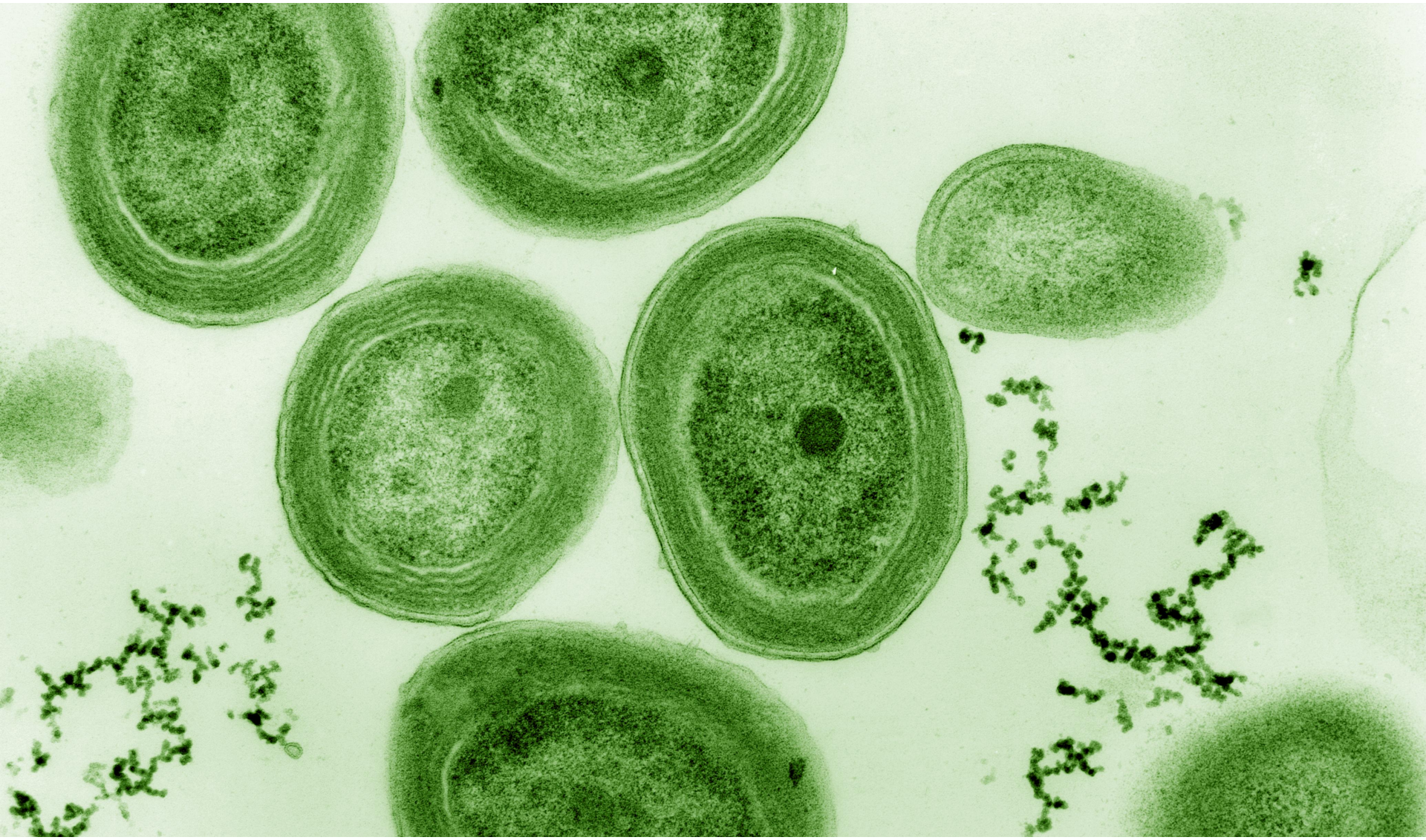
Mero-plankton

=

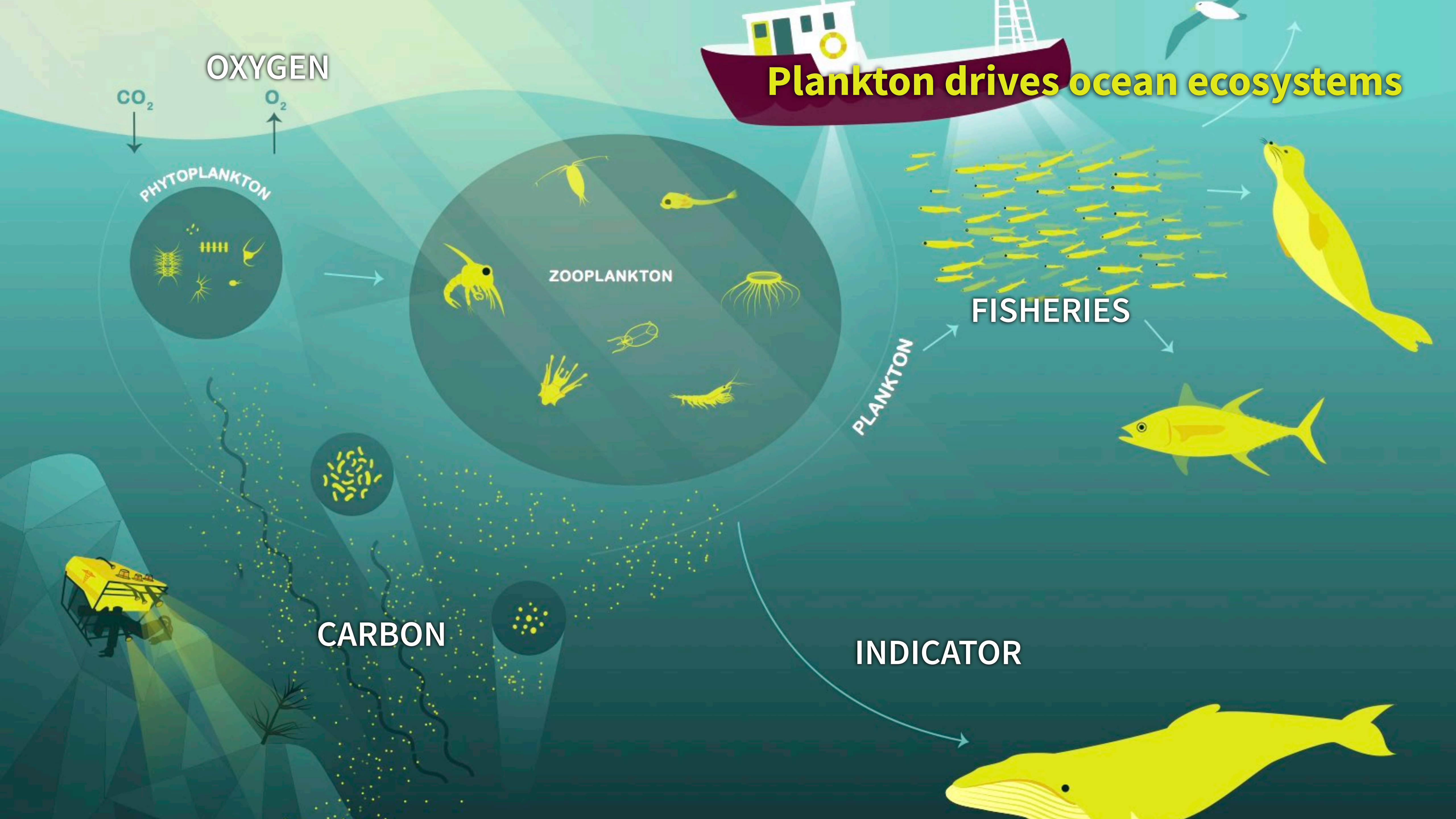
temporary plankton



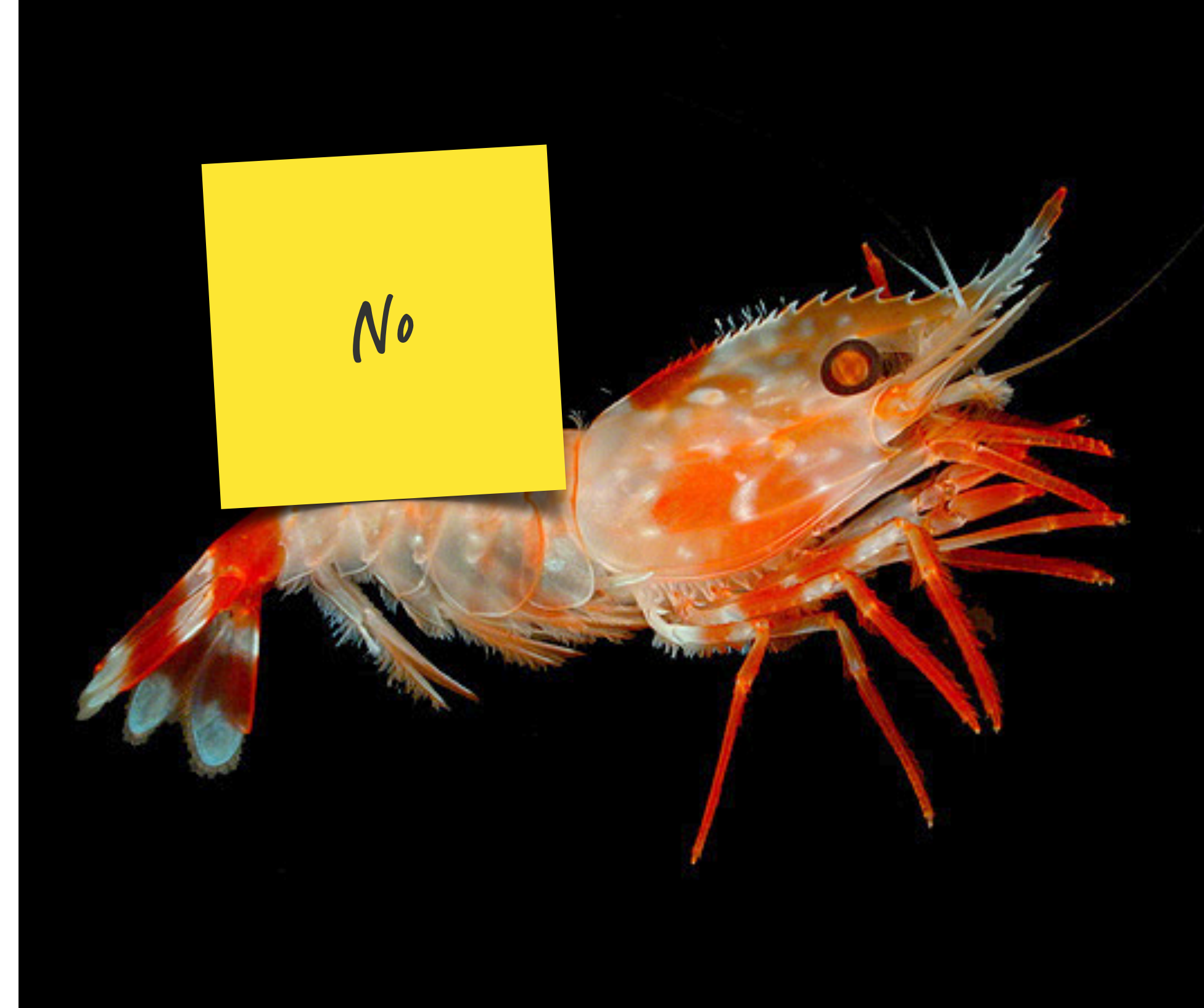
Diversity in size



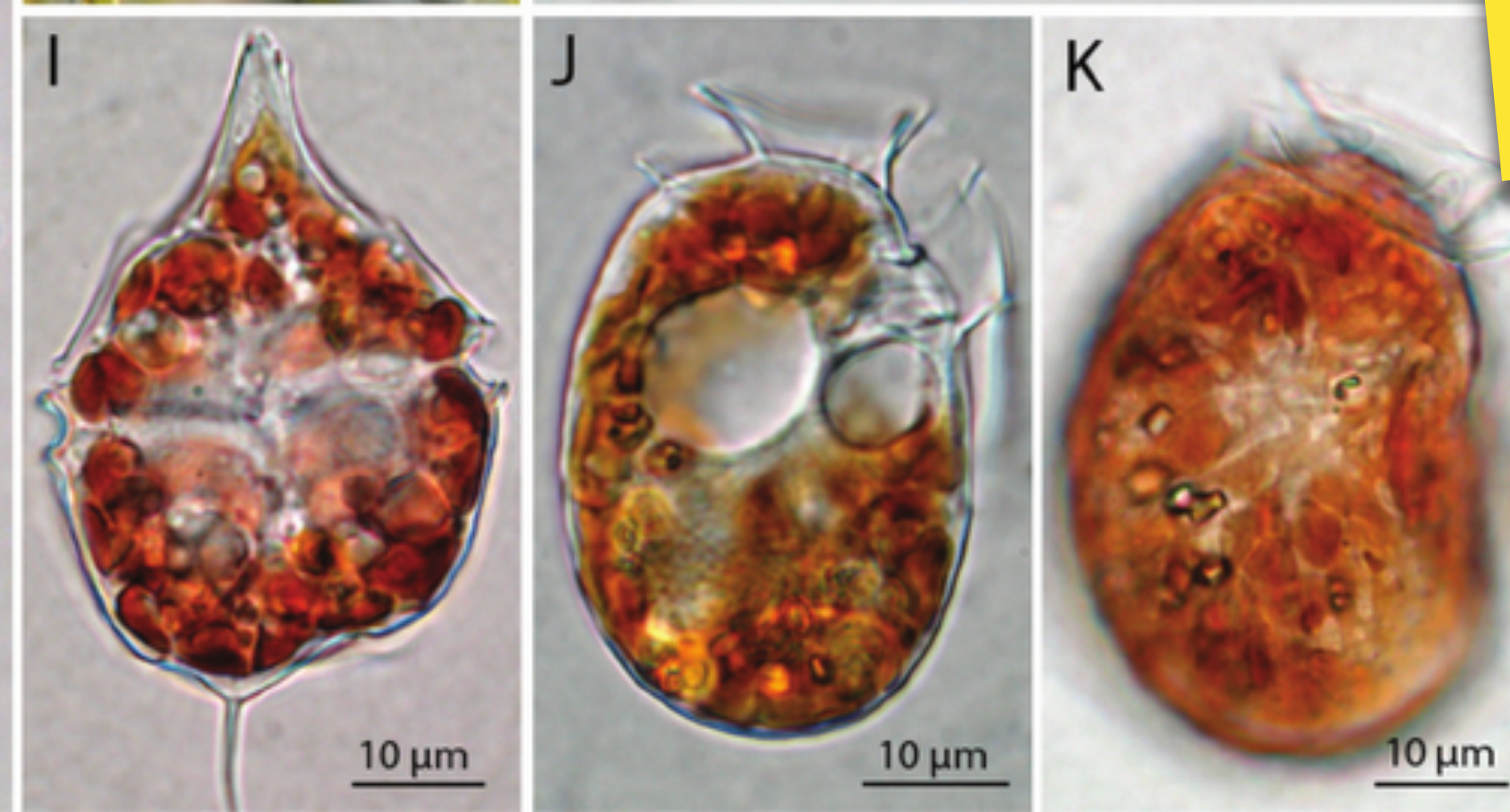
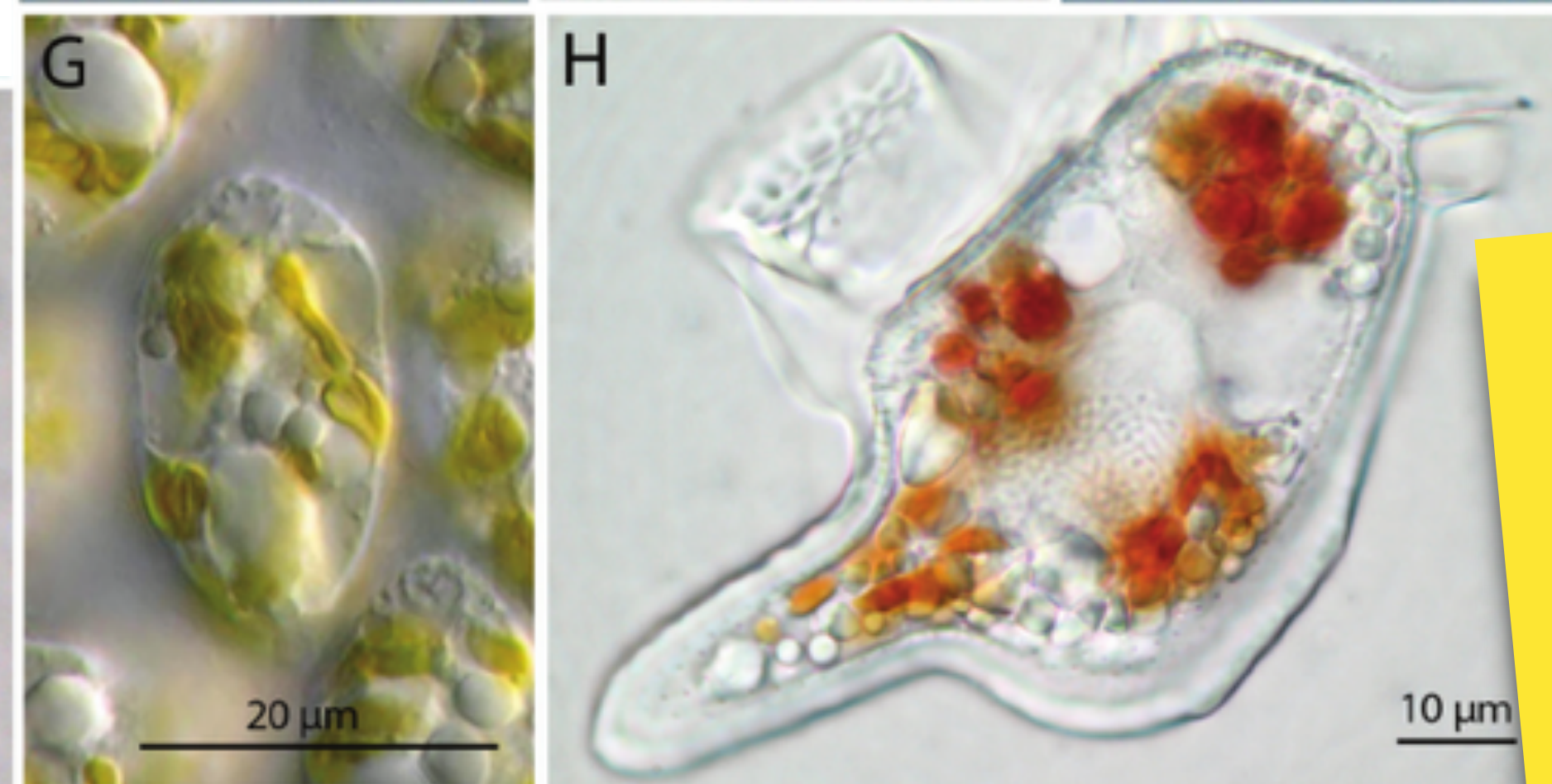
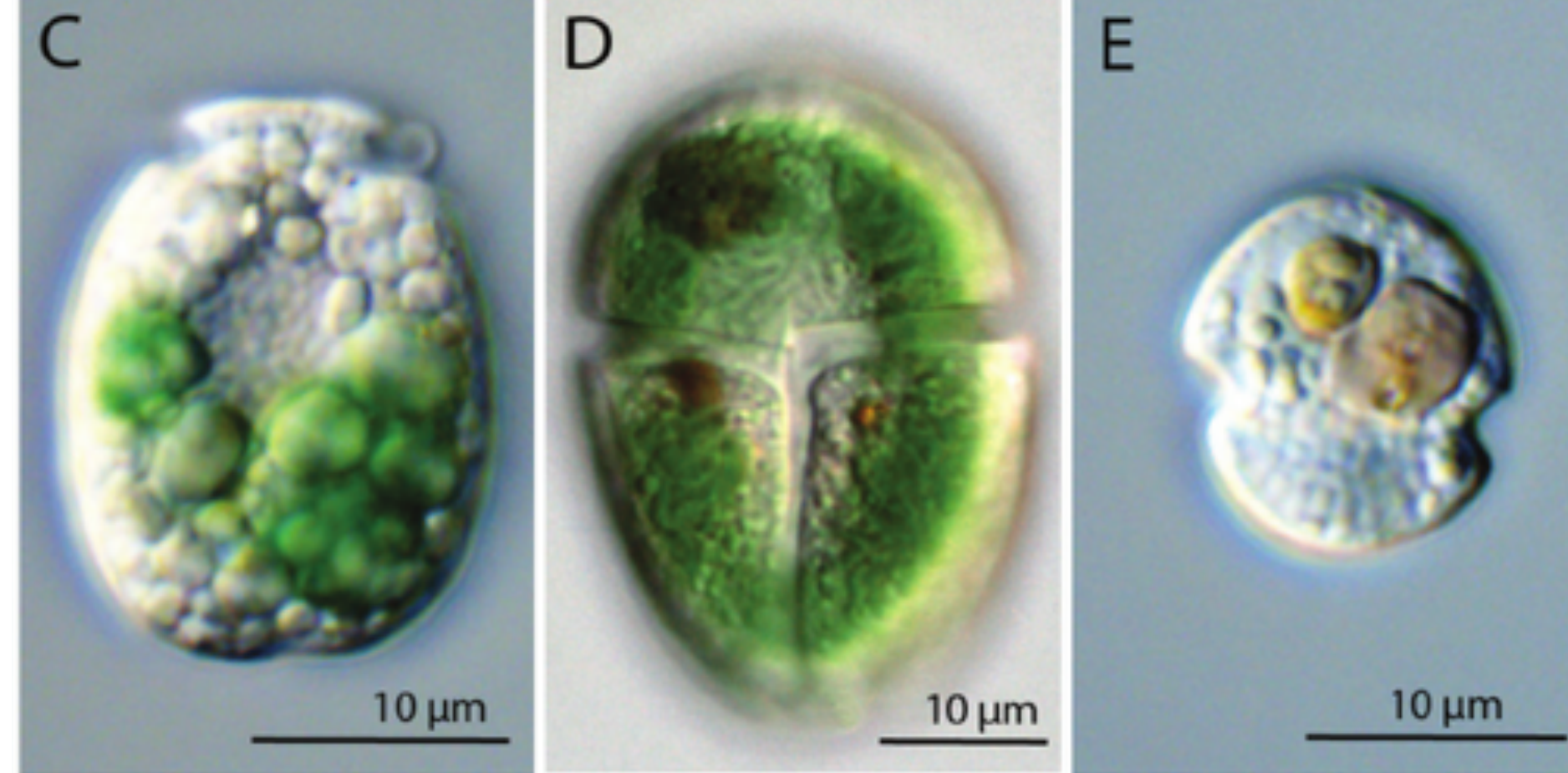
Plankton drives ocean ecosystems



Which are
plankton?



Animal or plant?



Both!

What size?



What size?

It depends!





What is biodiversity?

And how to measure it



Taxonomic diversity, α (alpha) diversity

Which ecosystem is the most diverse?



$$R = 2$$



$$R = 7$$

A more gradual view

Which ecosystem is the most diverse?



$$R = 2$$

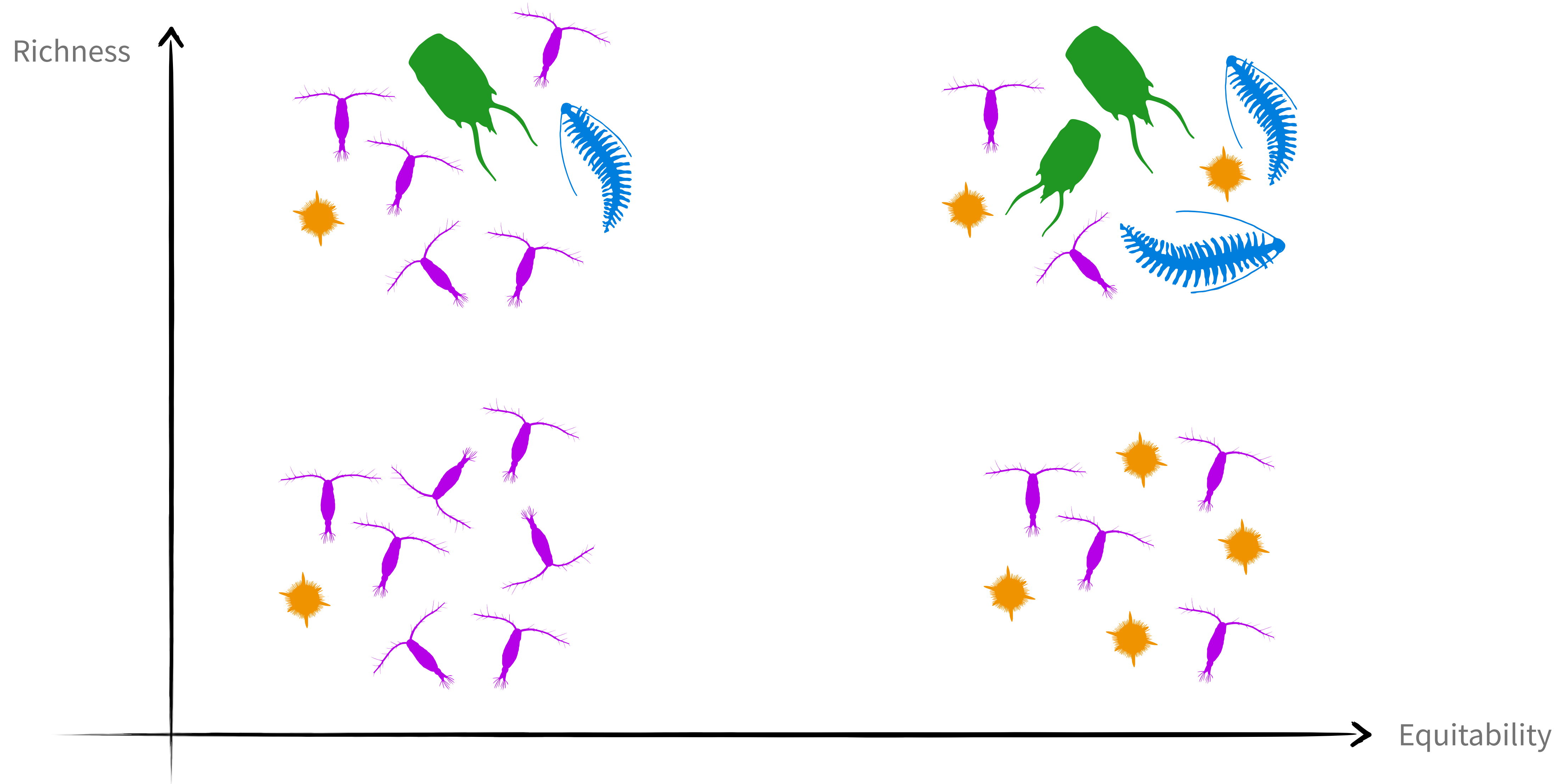


$$R = 7$$



$$R = 7$$

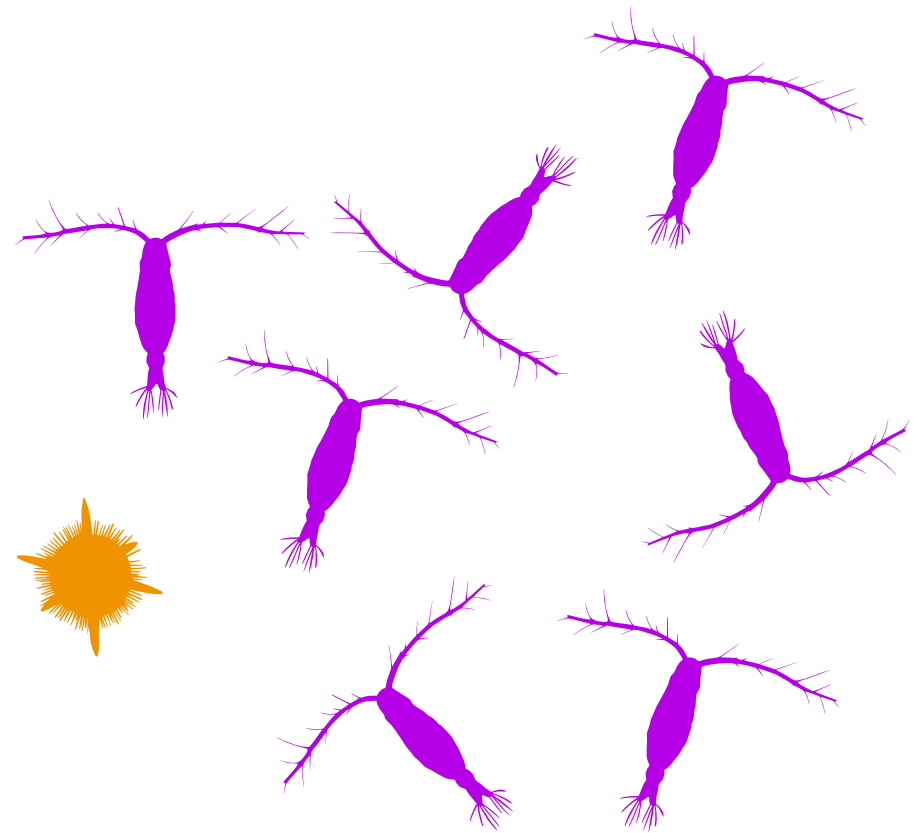
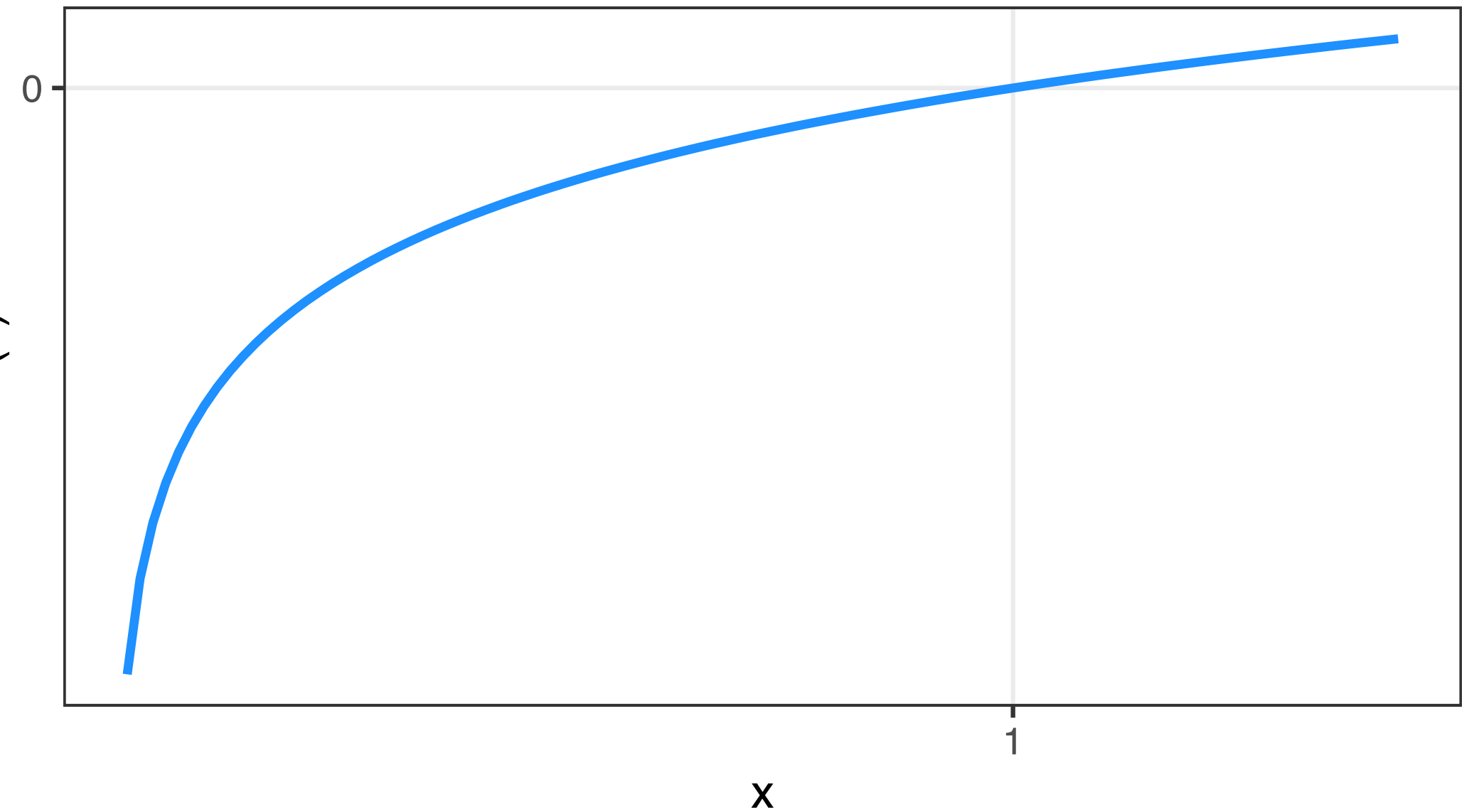
Measures of α diversity



Shannon's diversity index

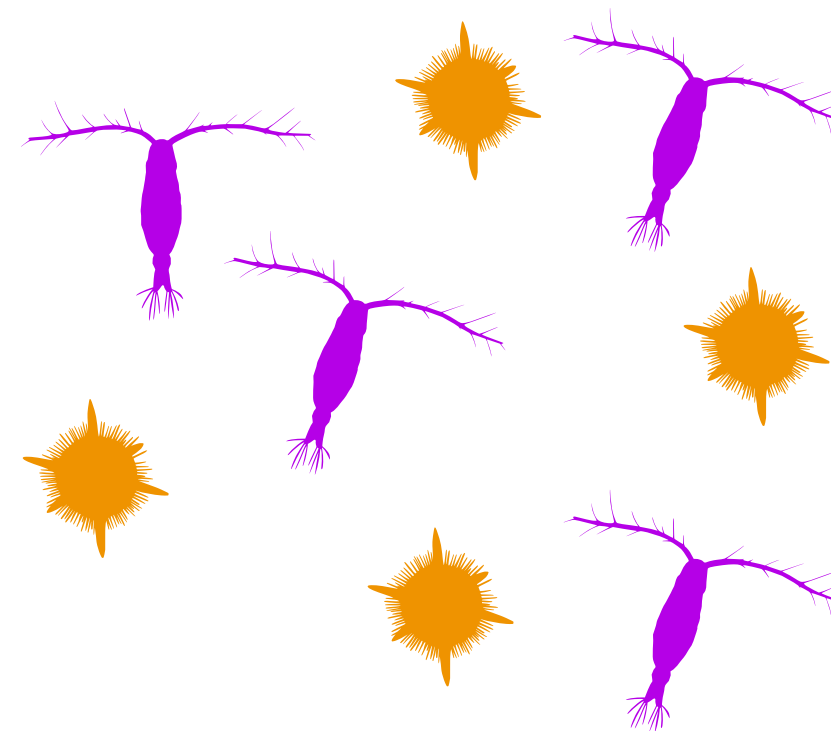
$$H' = - \sum_{i=1}^R p_i \ln(p_i)$$

$\ln(x)$



$$\begin{cases} p_1 = 1/8 \\ p_2 = 7/8 \end{cases}$$

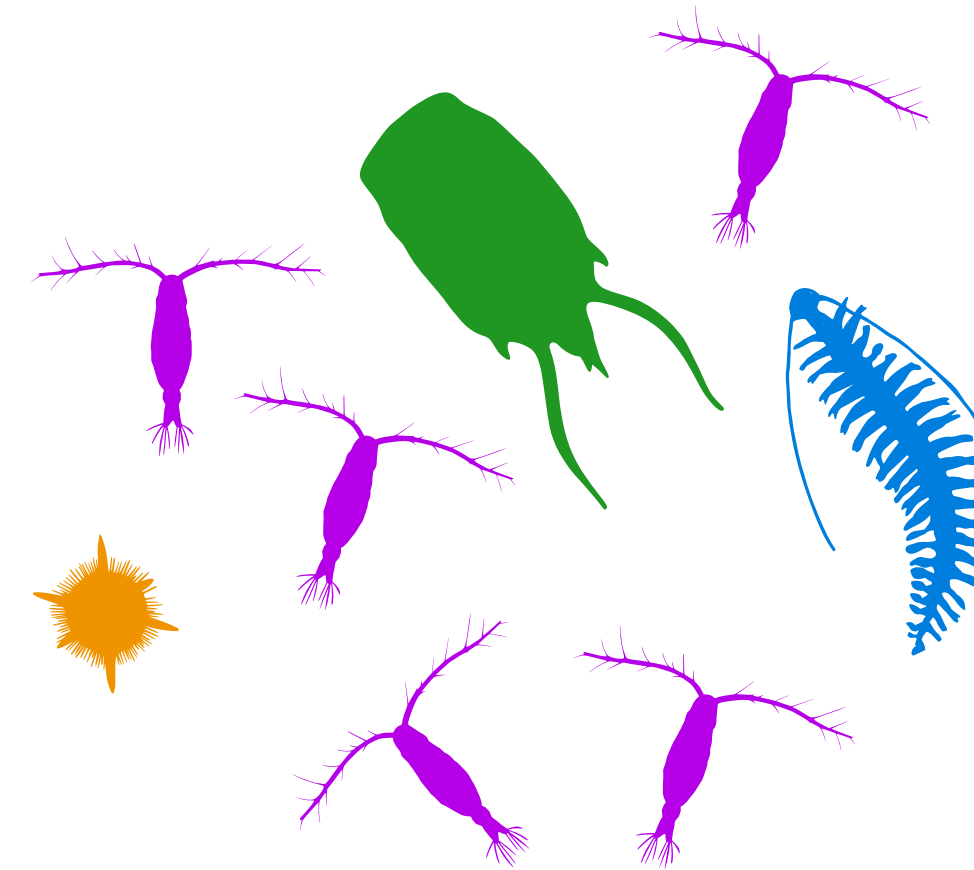
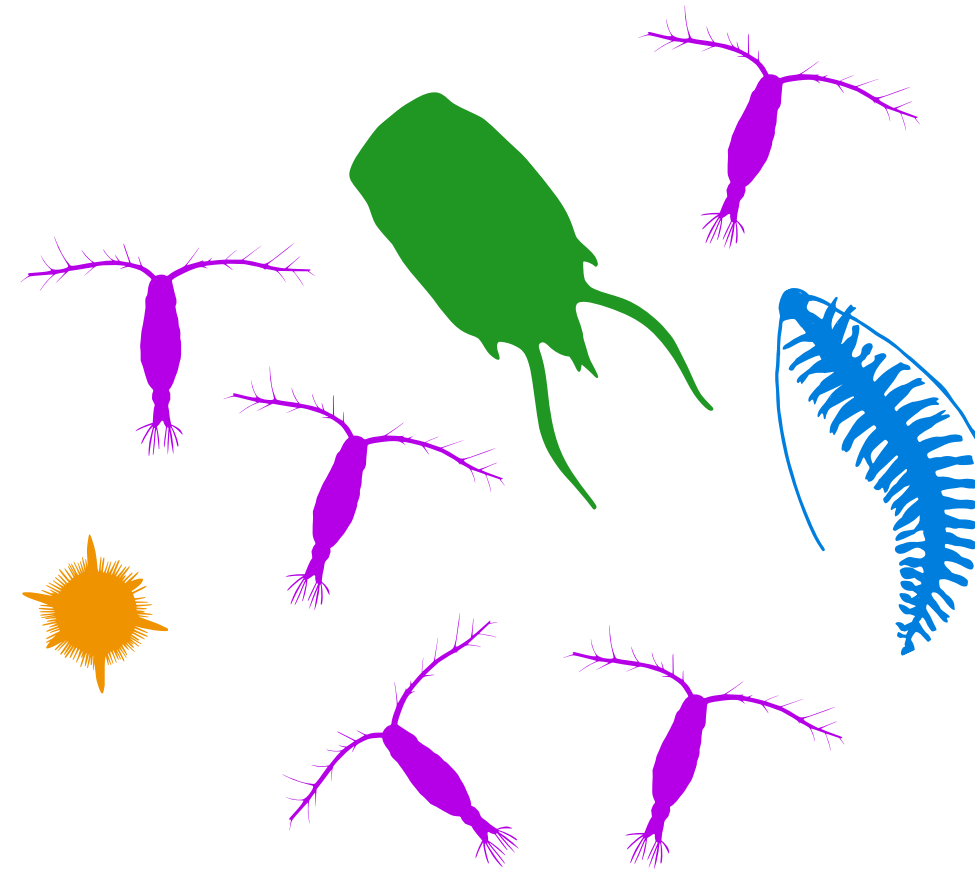
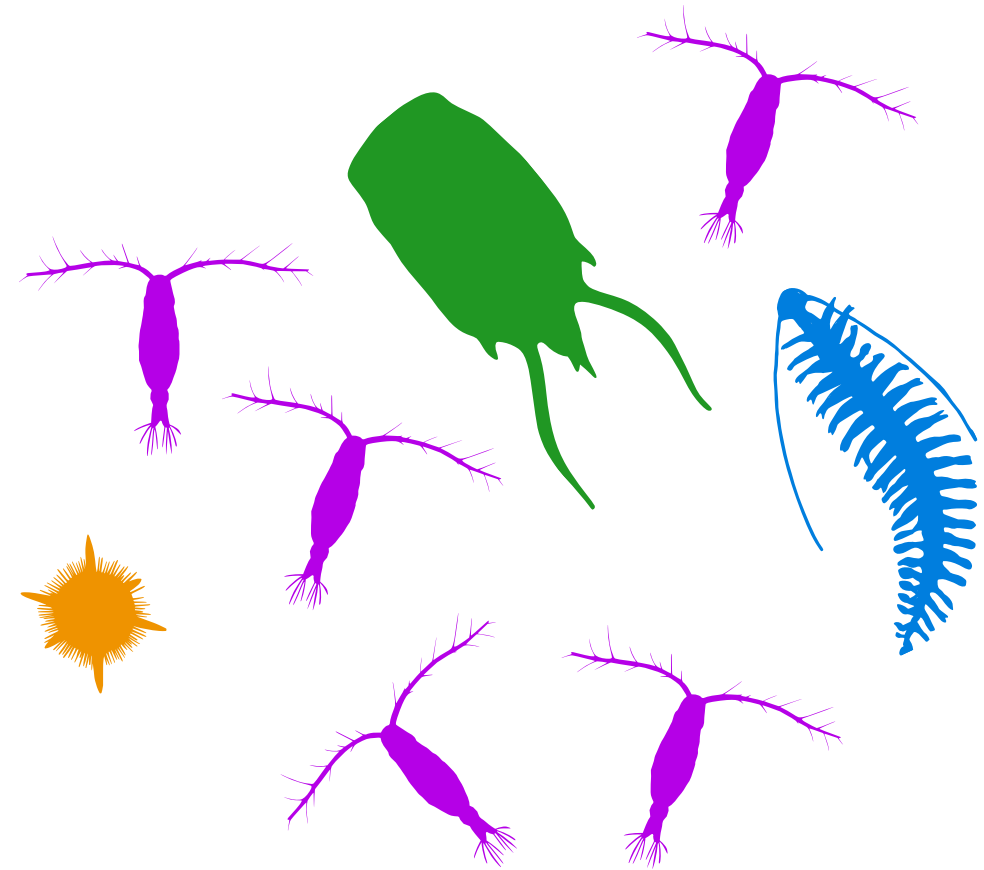
$$H' = 0.38$$



$$\begin{cases} p_1 = 4/8 \\ p_2 = 4/8 \end{cases}$$

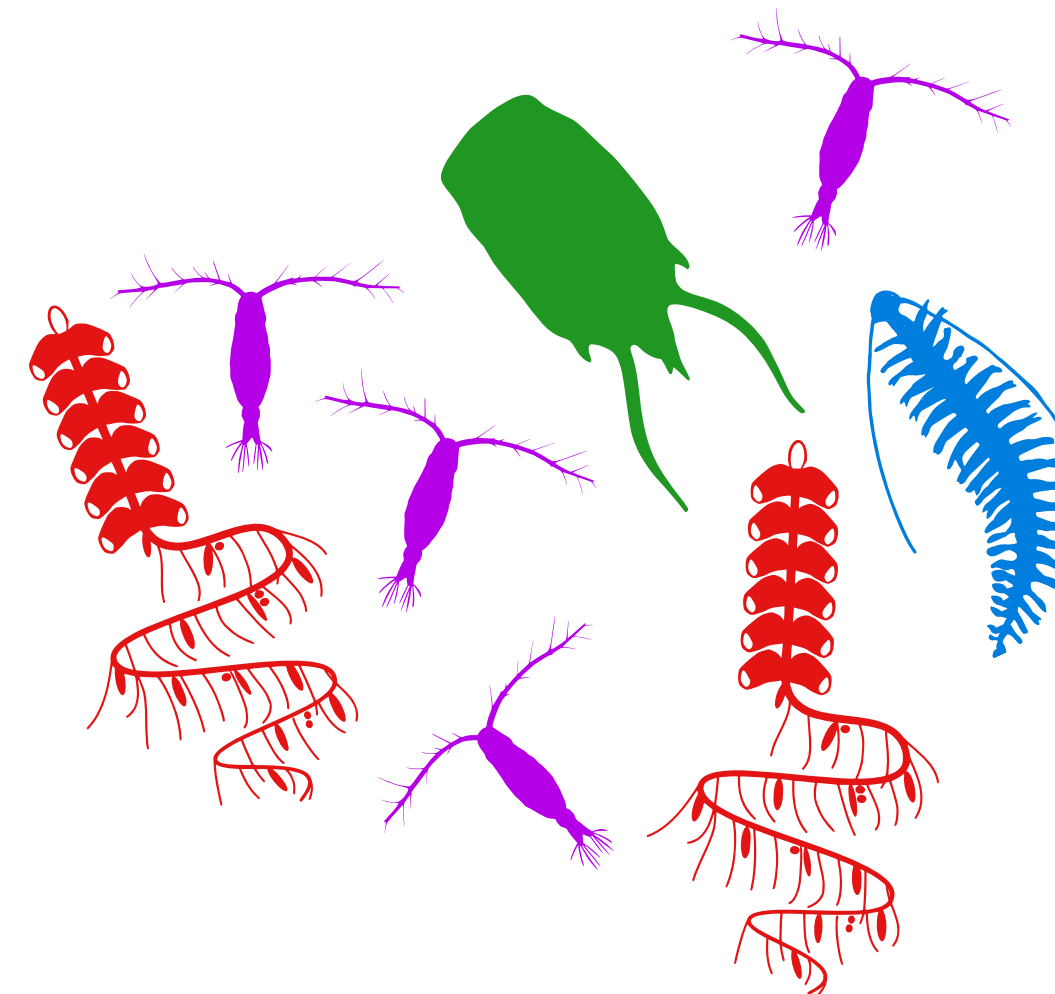
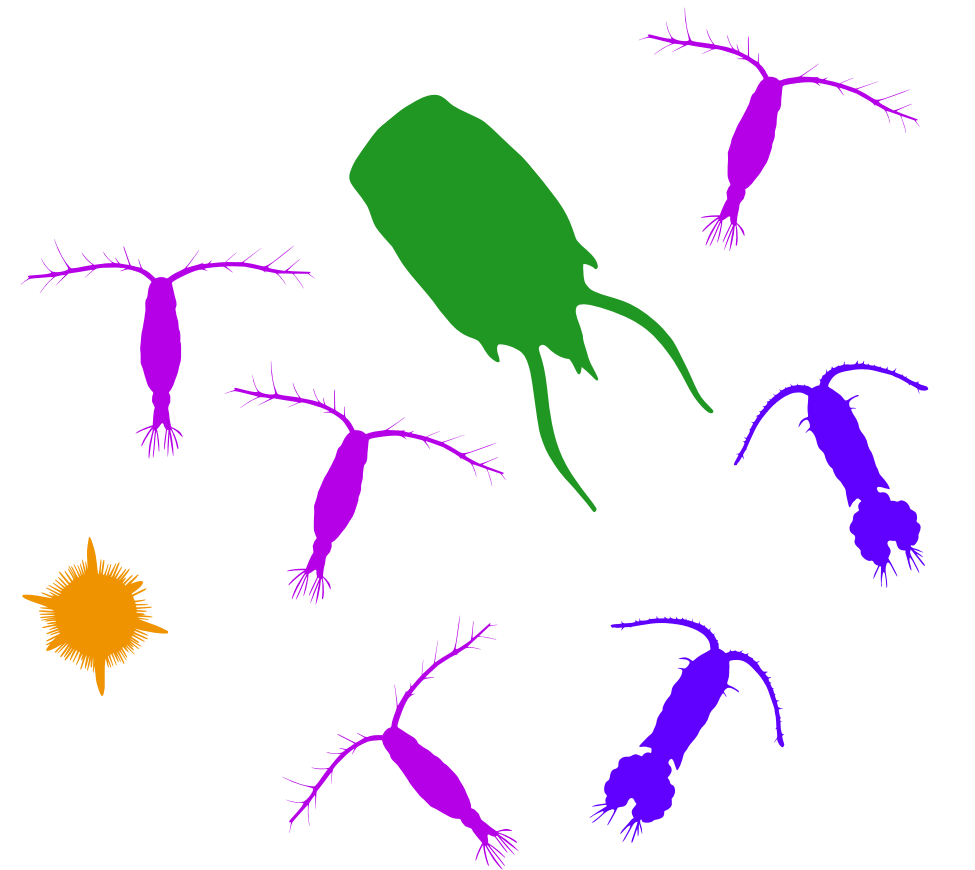
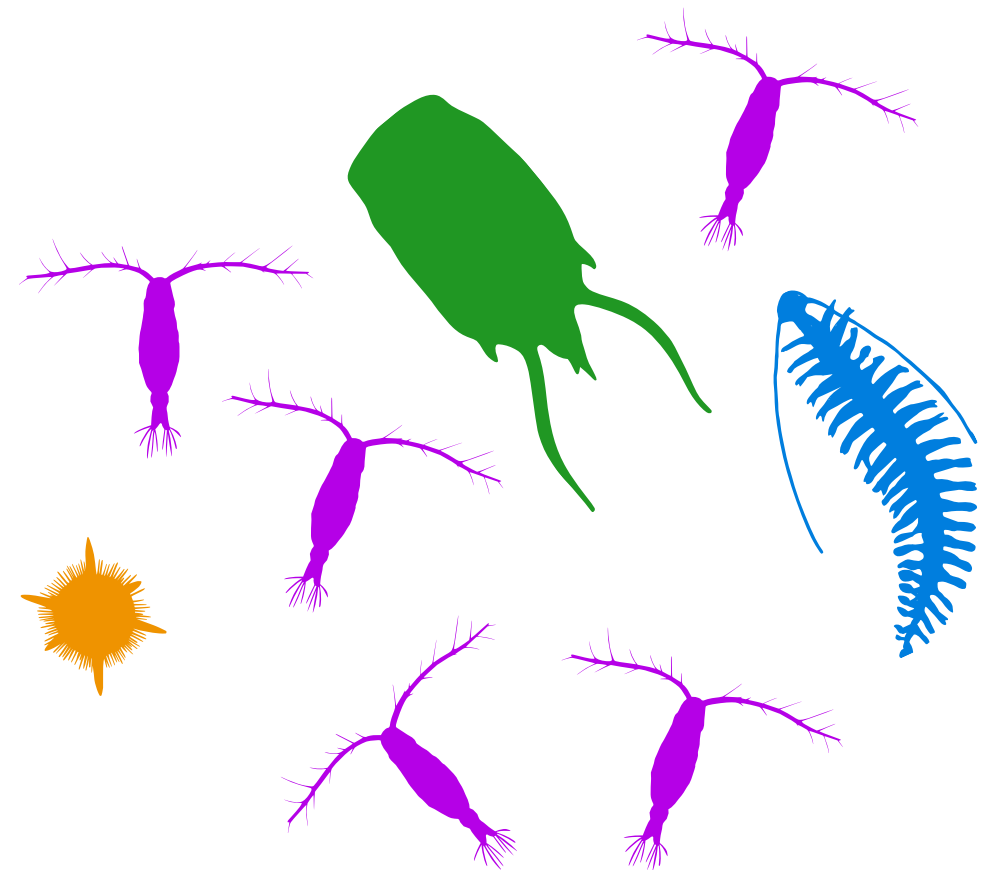
$$H' = 0.69$$

Ecosystem diversity, β diversity



$\alpha = 4$ everywhere

$\beta = 1$



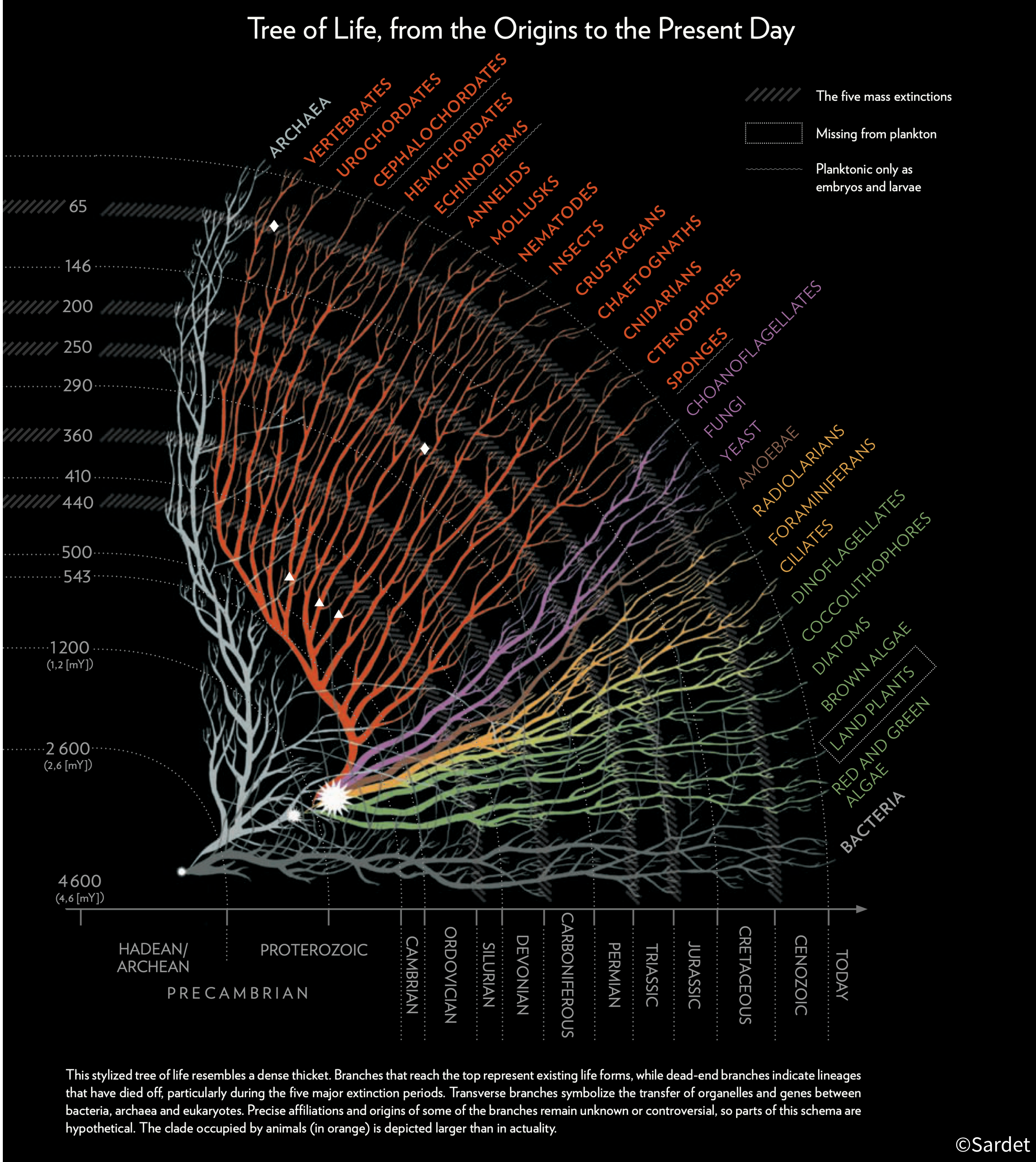
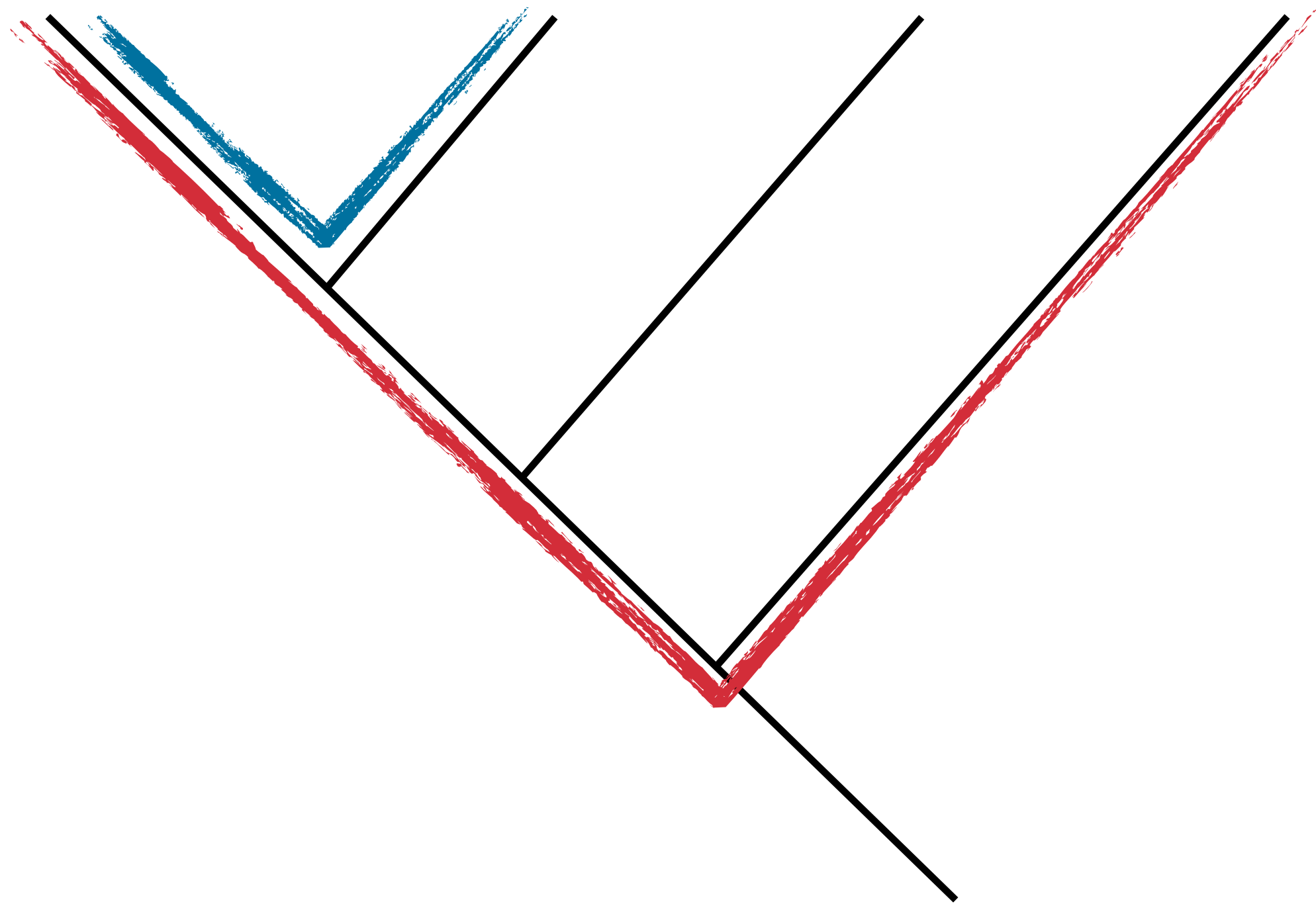
$\alpha = 4$ everywhere

$\beta > 1$

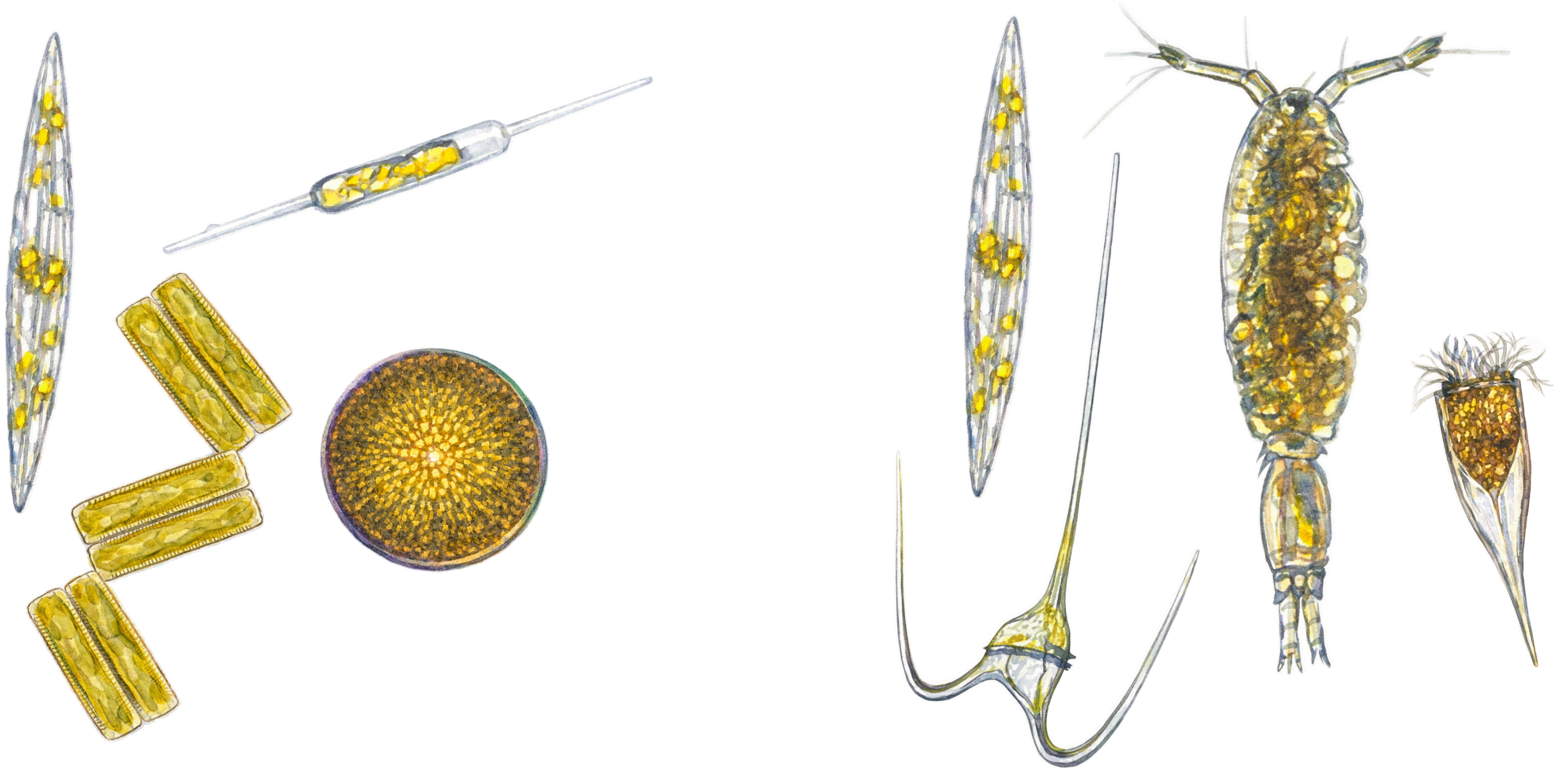
Phylogenetic diversity

Based on the tree of life

Quantifies the total time of evolution

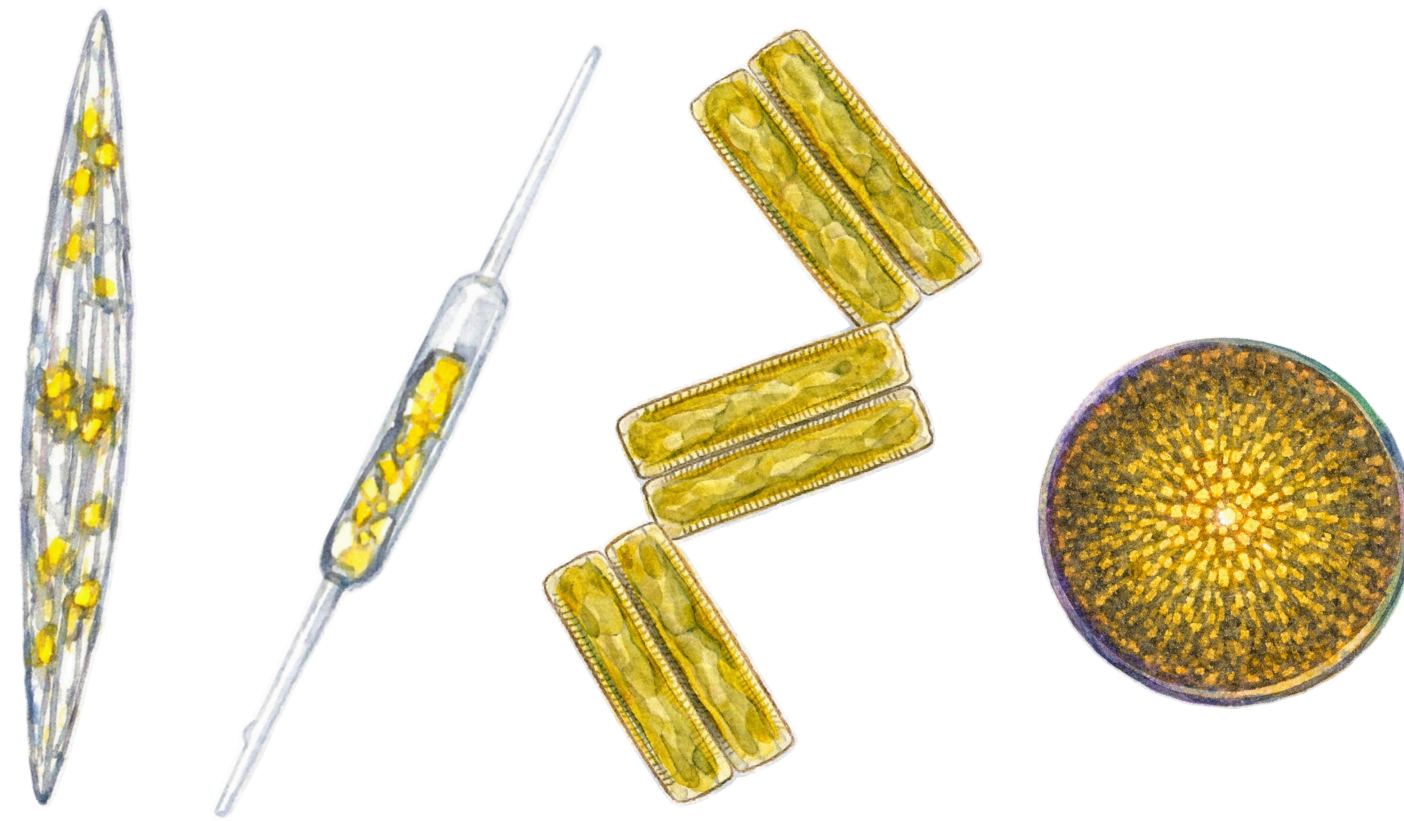
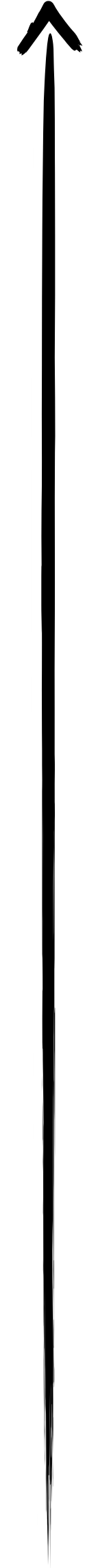


Functional diversity



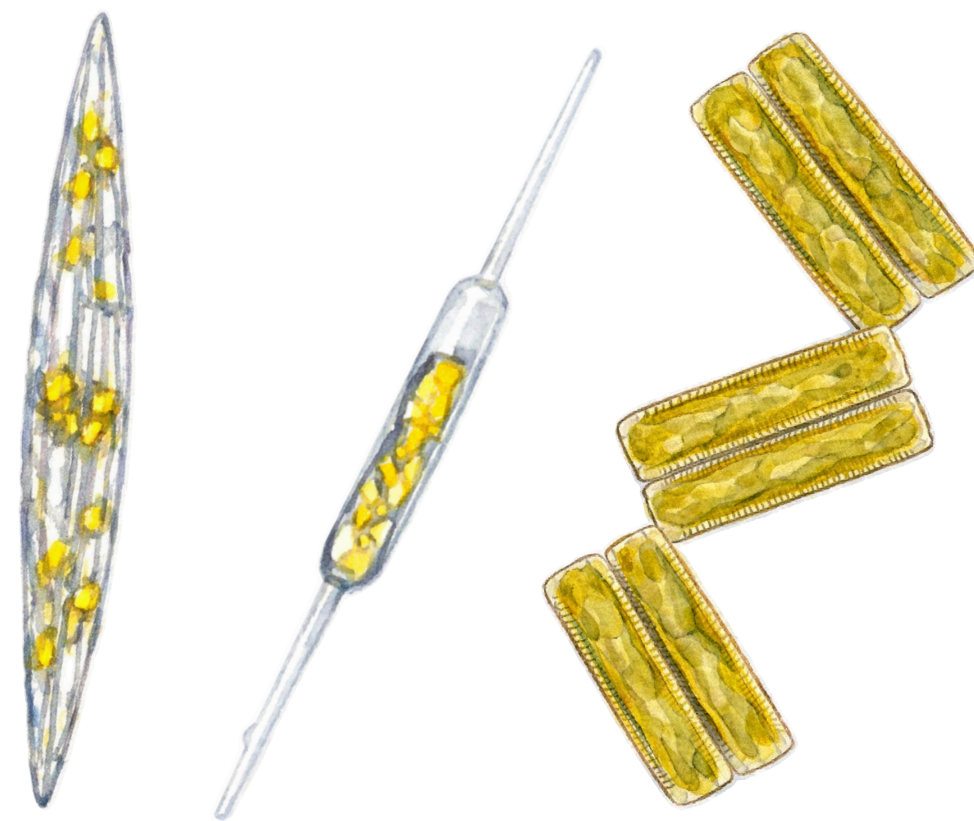
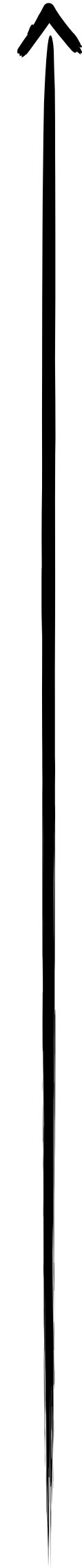
Functional diversity

Trophic
level



Functional diversity

Trophic
level



Produce O_2



Produce O_2

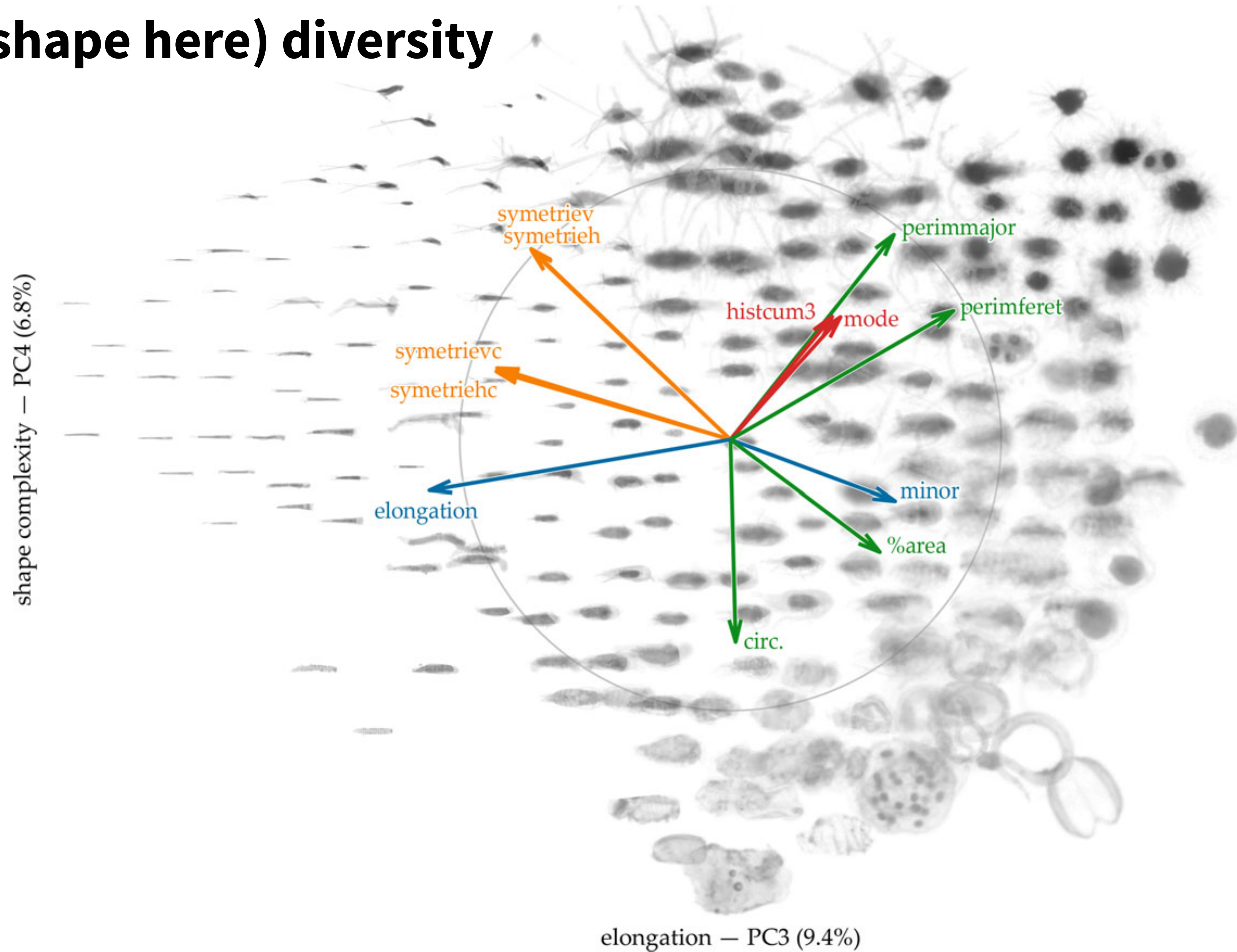


Recycle matter



Food source

“Trait” (shape here) diversity



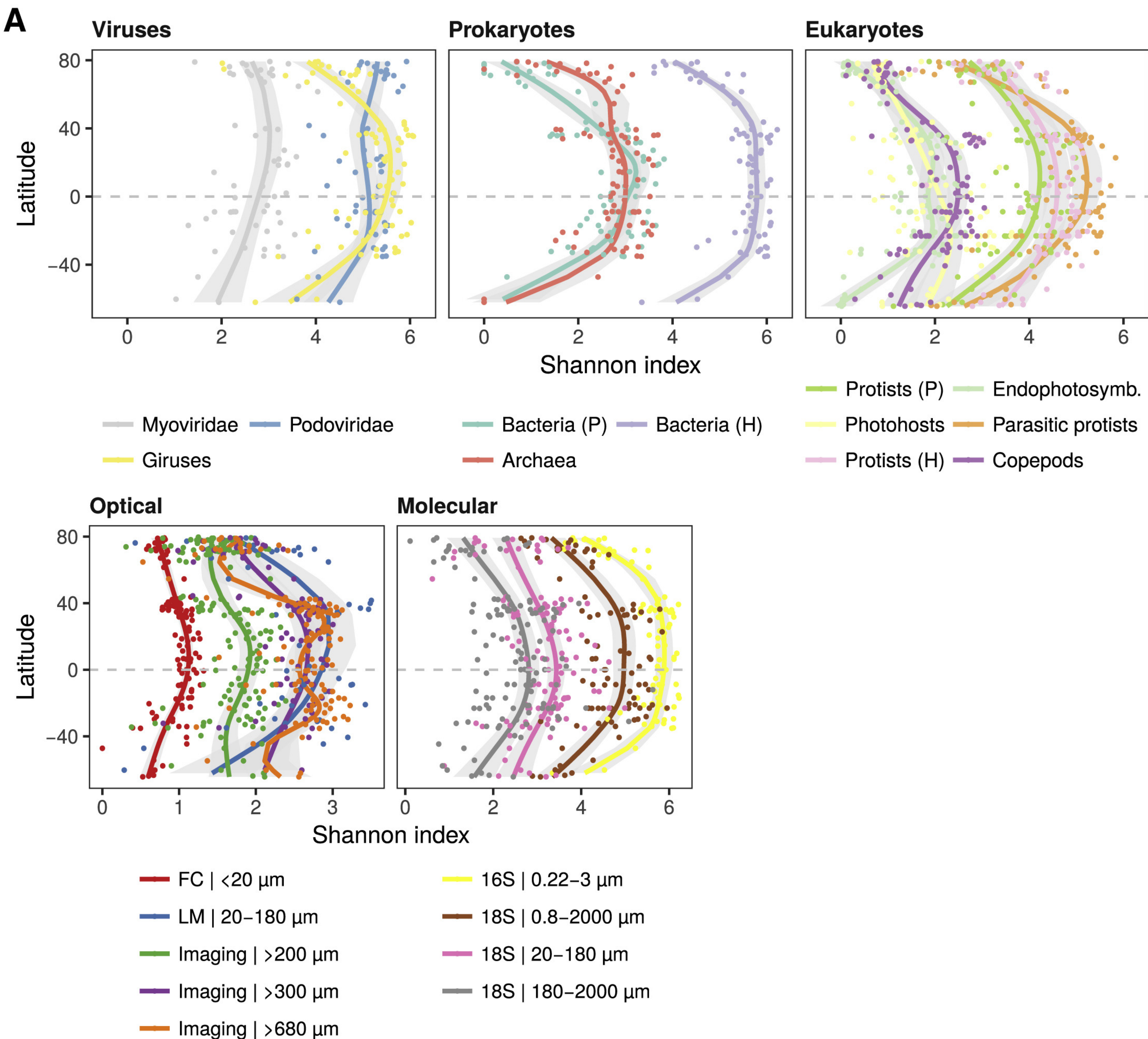
Distribution of plankton diversity



From the north pole

through the
equator

to the south pole



Which is more diverse?

$R=3$
Equit = OK



$R=3$
Equit = KO



Which is more diverse?

$R=3$
Equit = OK



$R=5$
Equit = KO



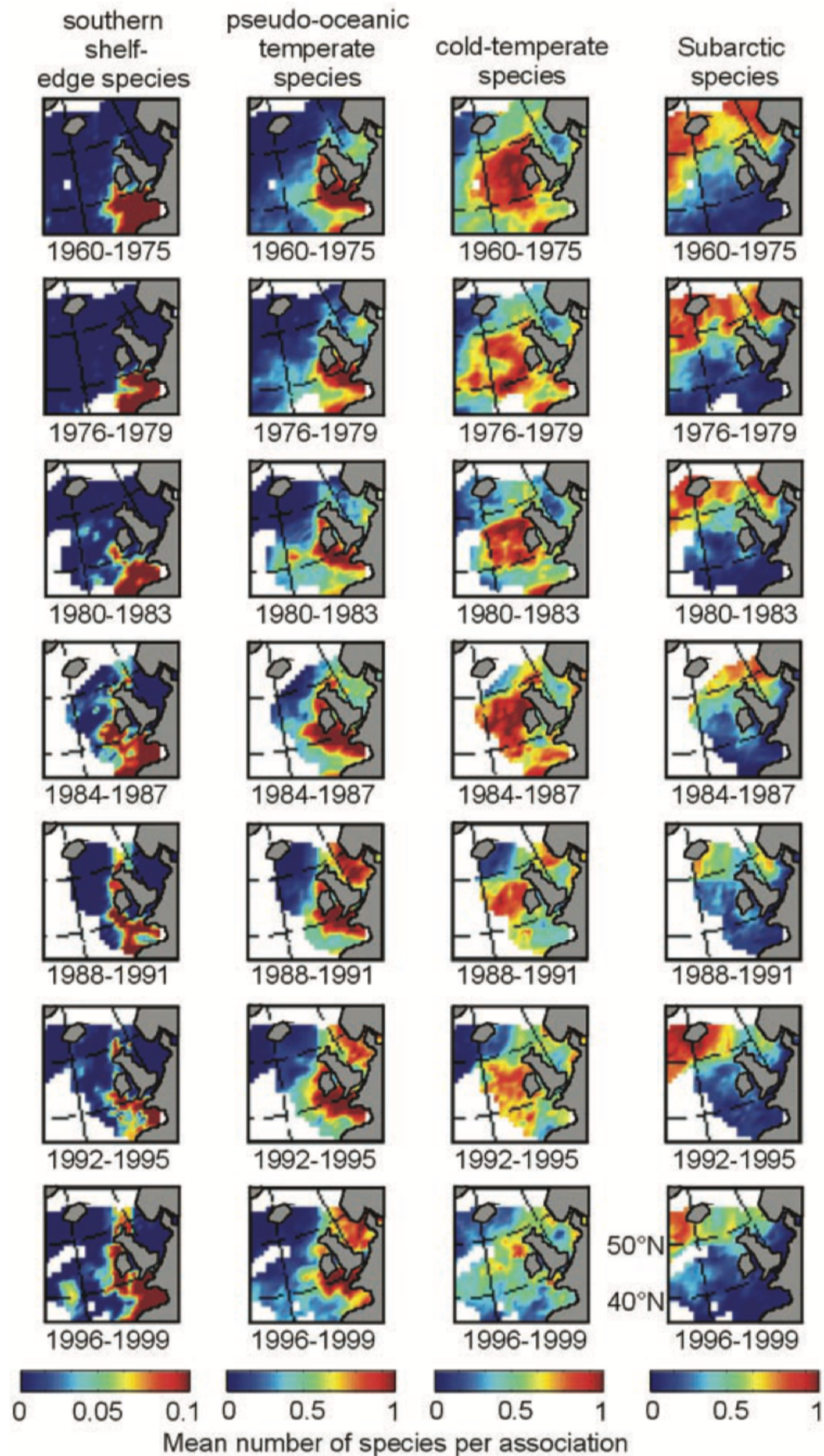
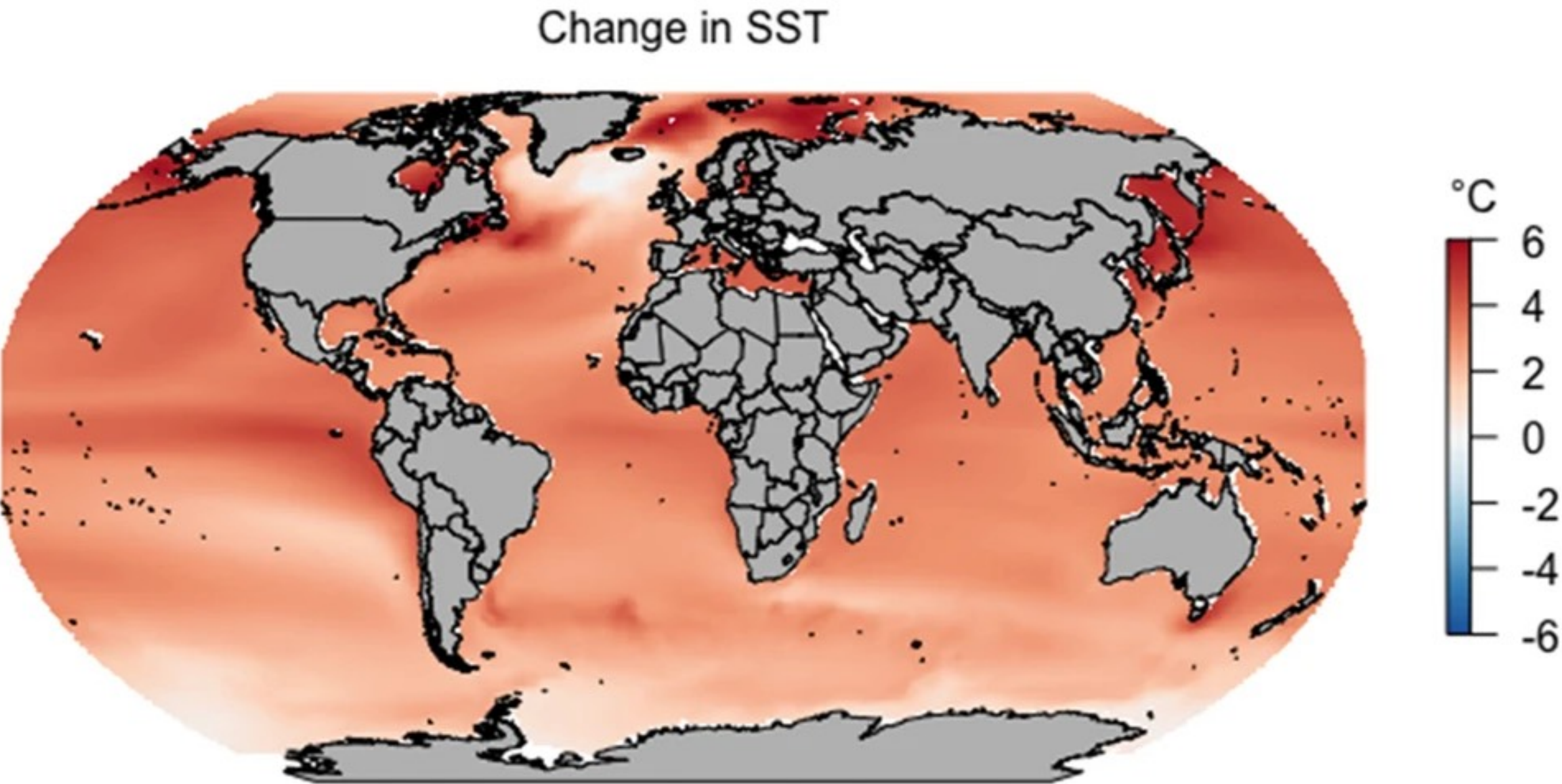
Threats to marine biodiversity

are unfortunately numerous

Climate warming induces shift in species ranges

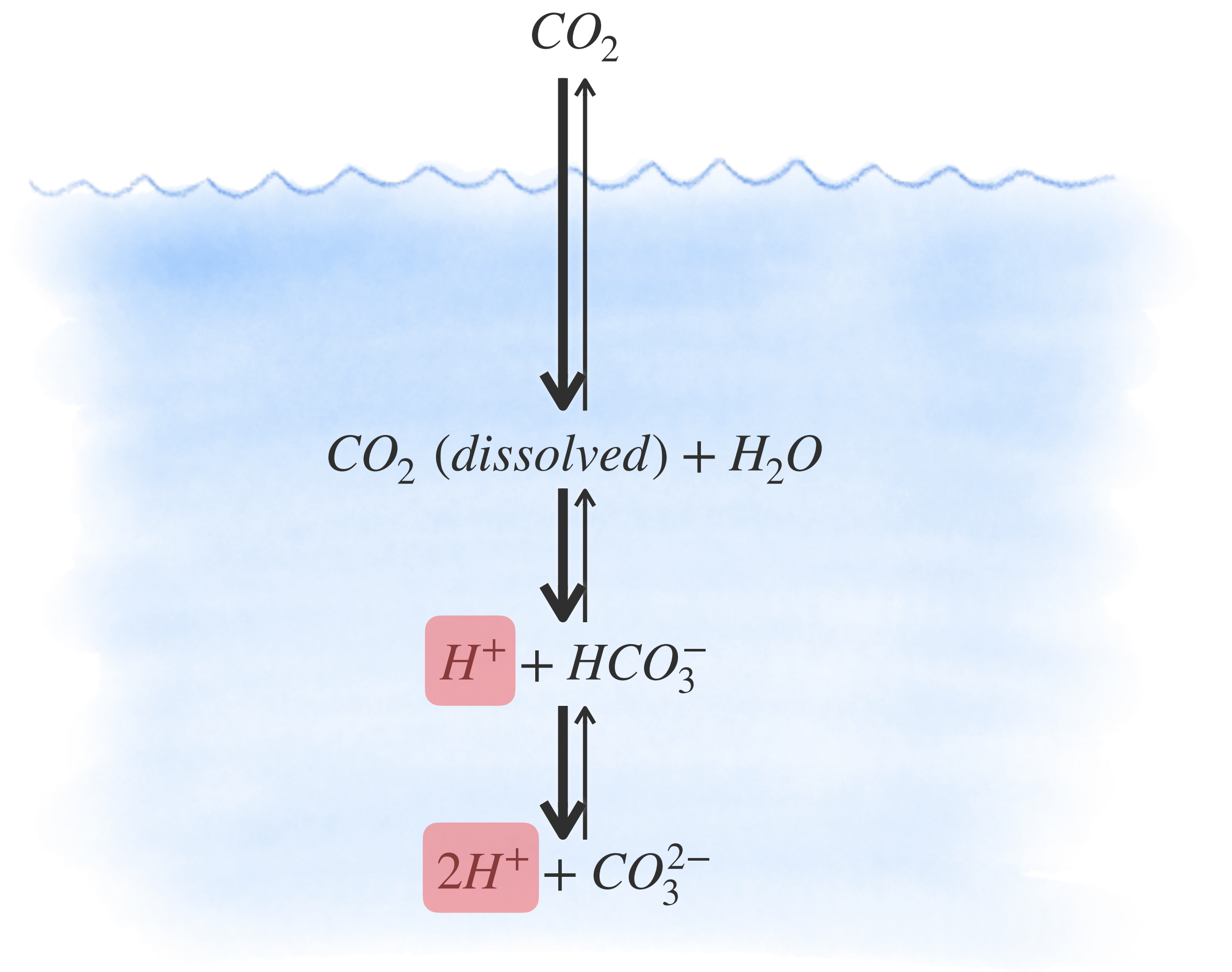
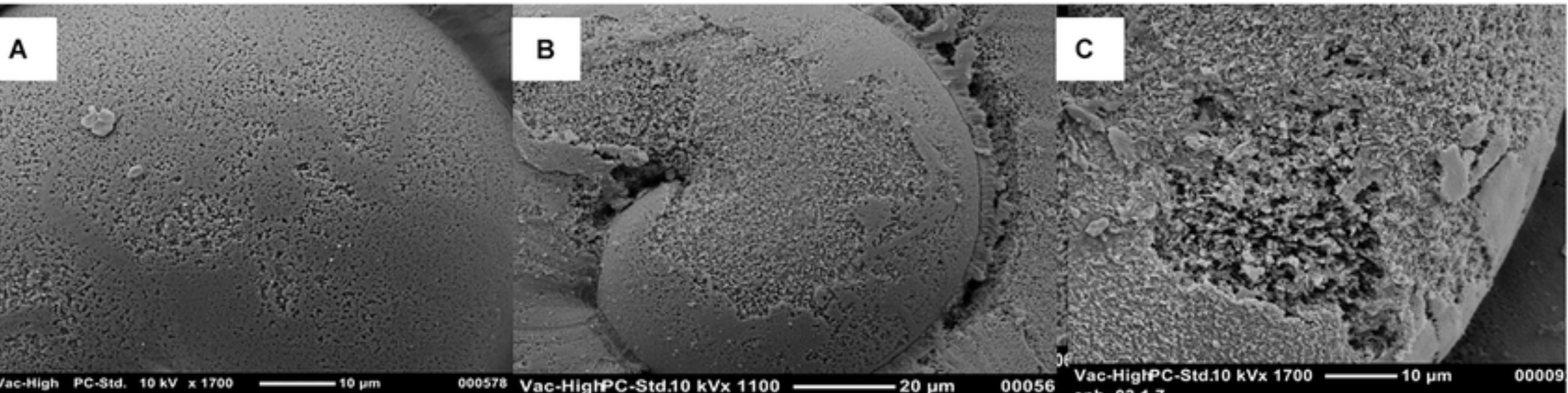
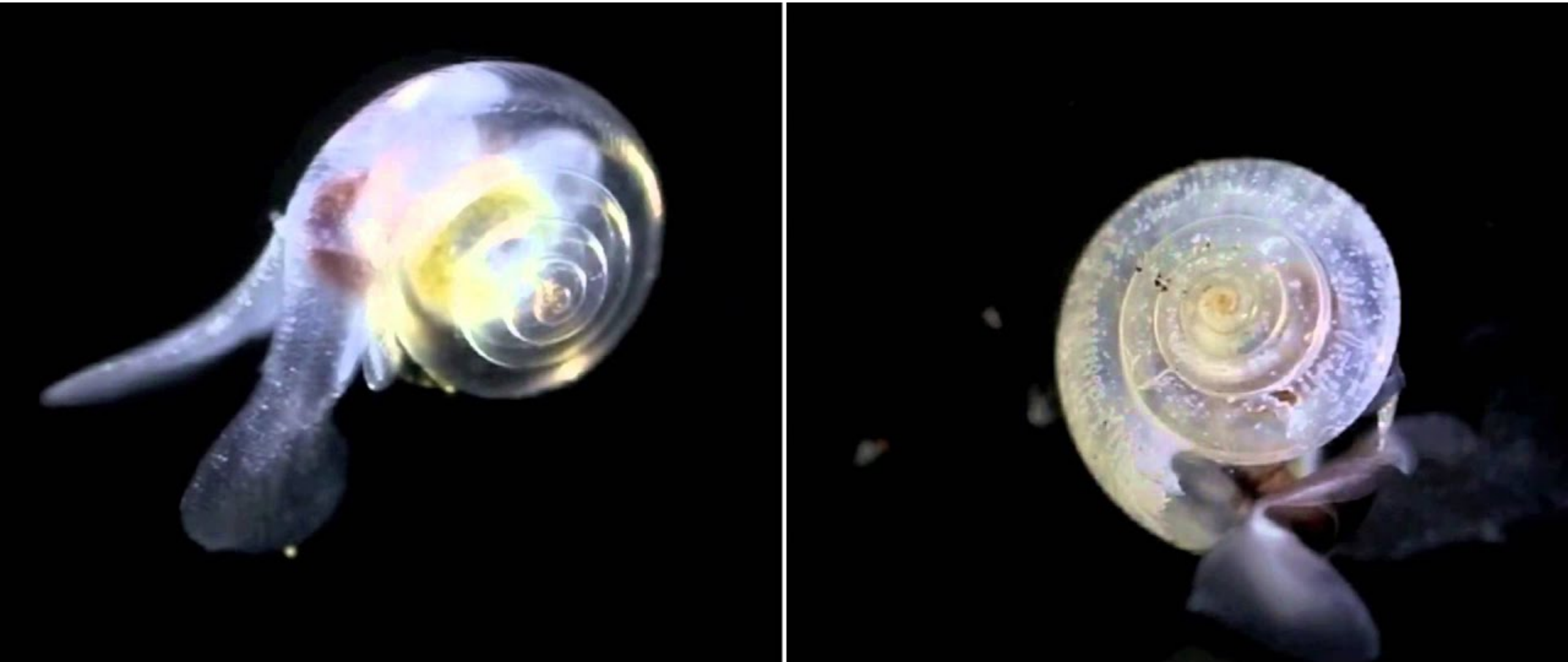
Increased greenhouse gases in the atmosphere induce warming

Warming in temperate regions pushes cold water species northwards

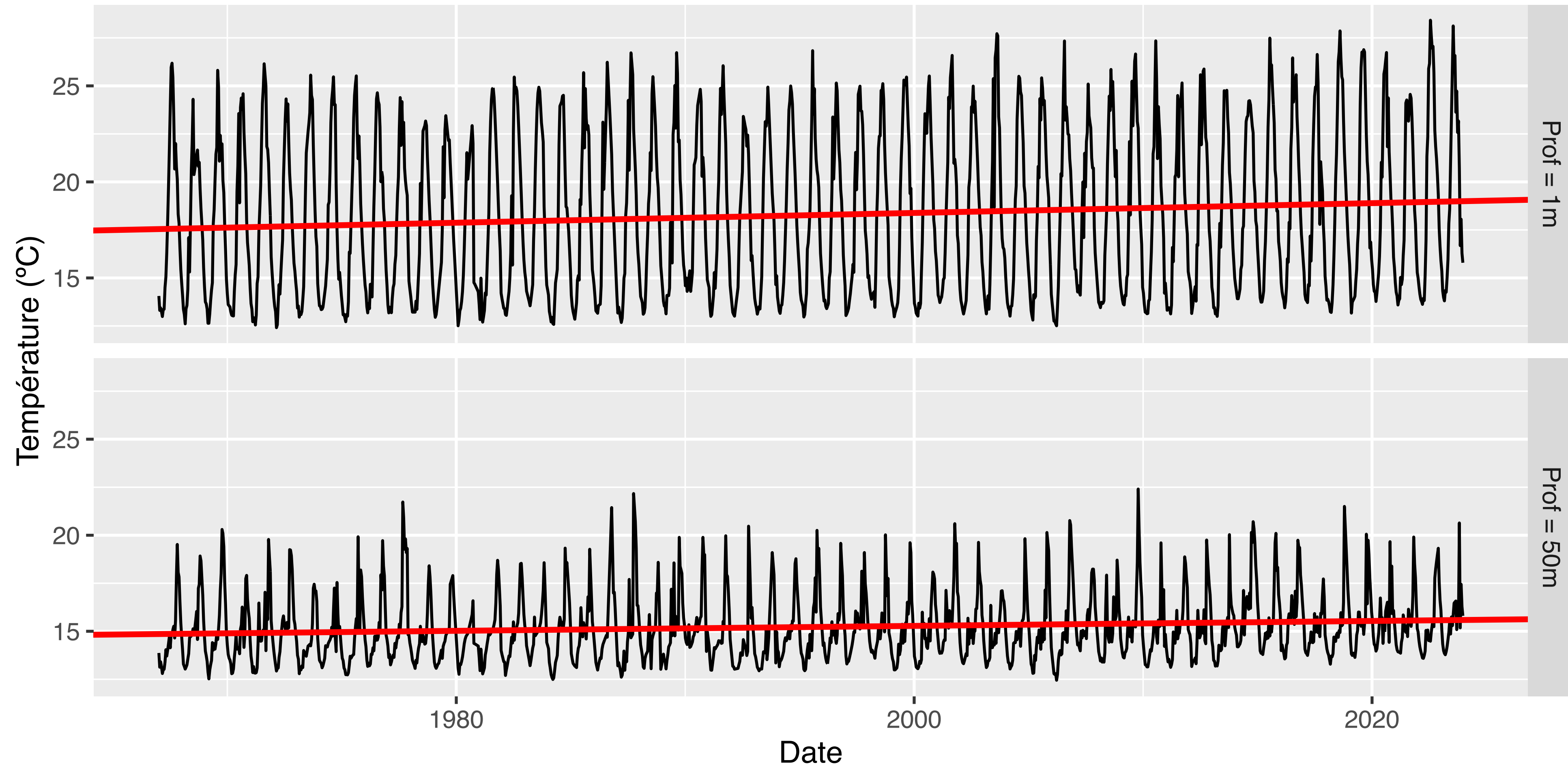
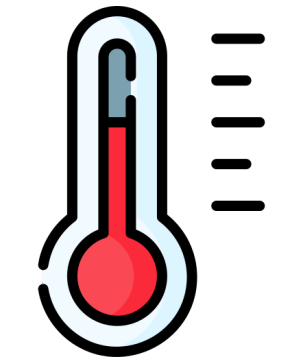




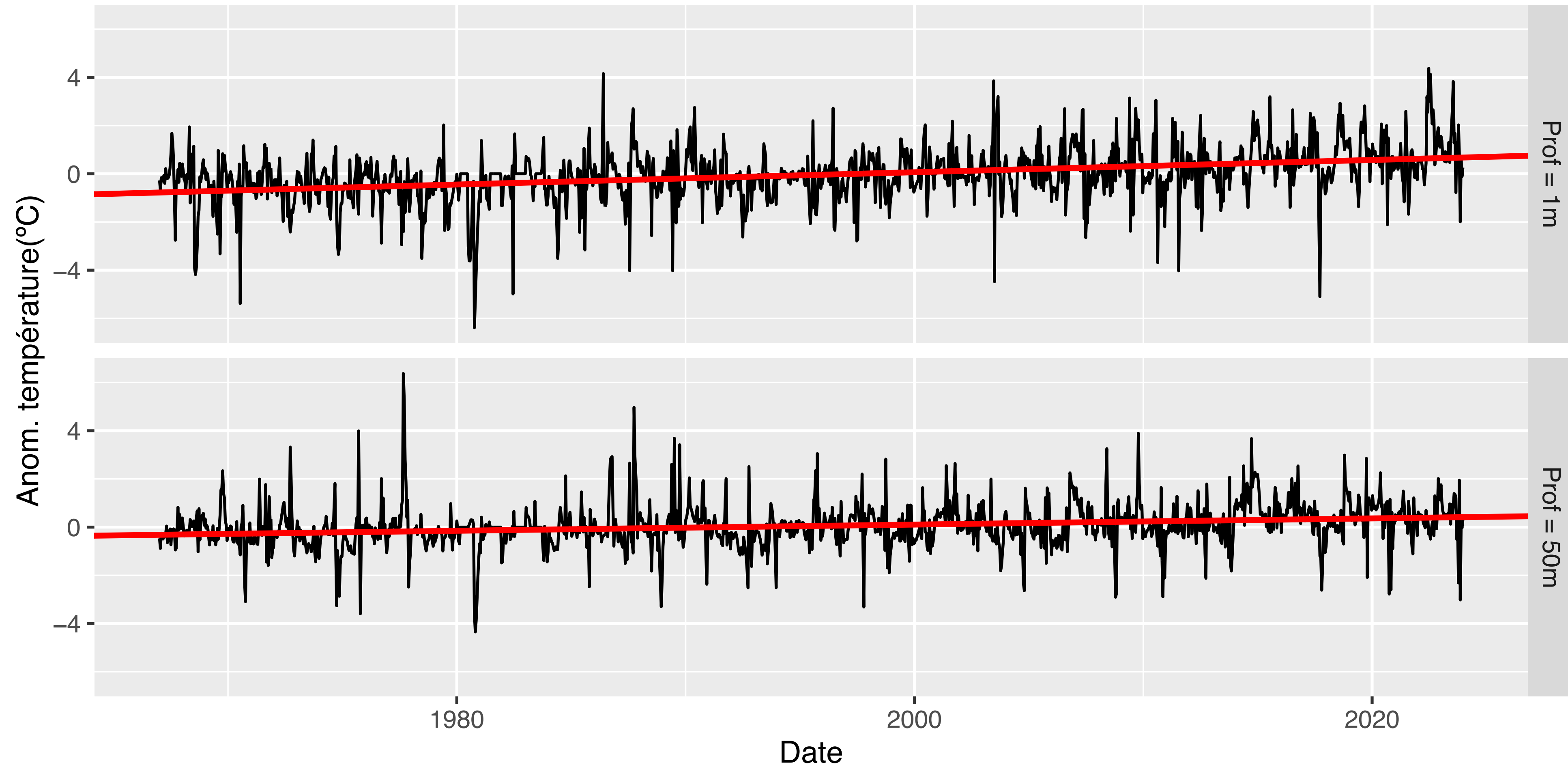
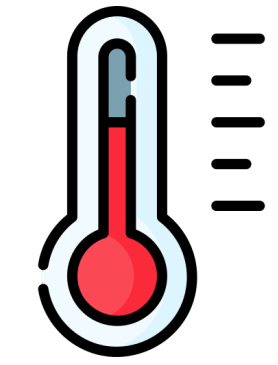
Increased CO₂ causes ocean acidification



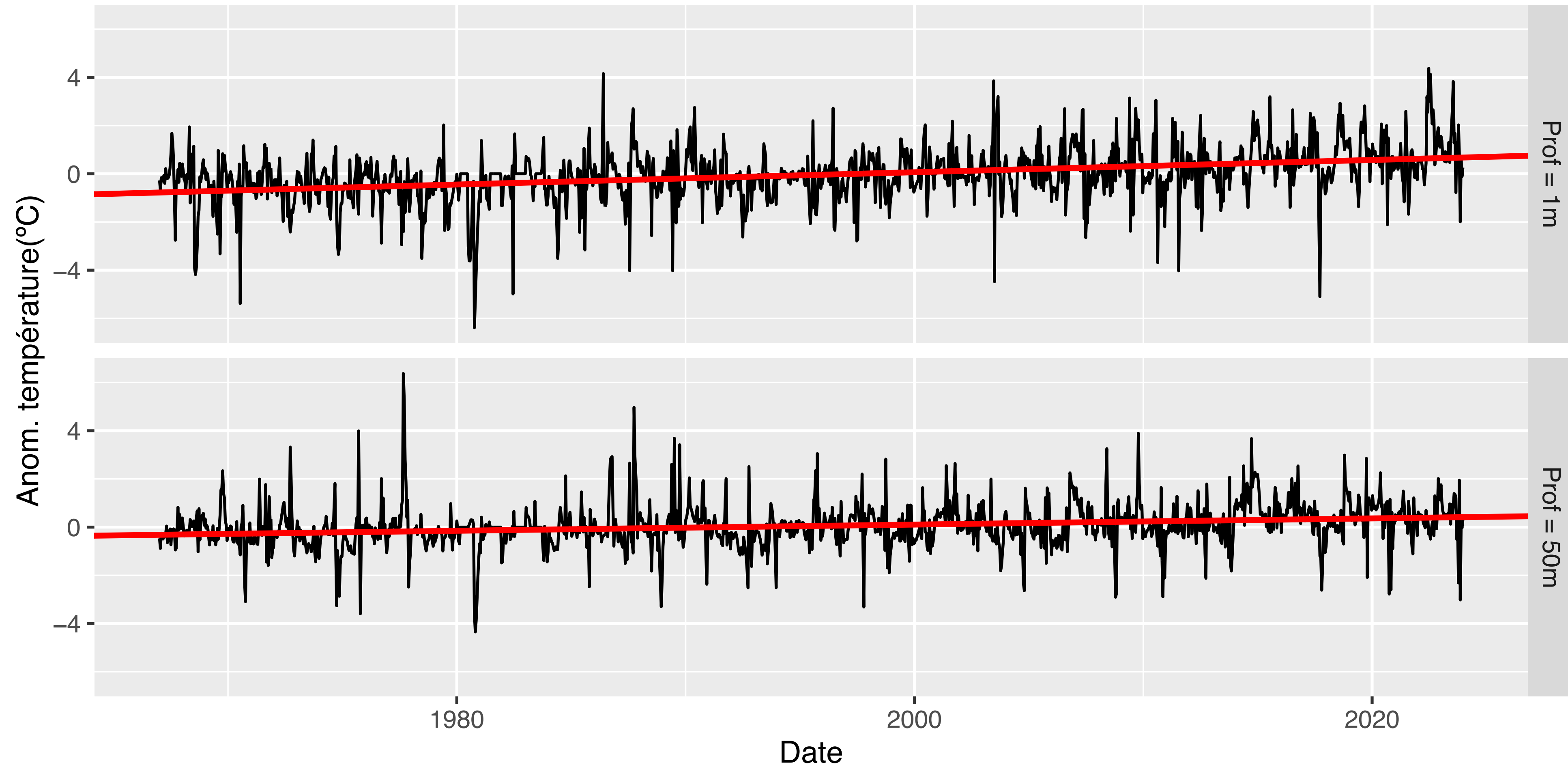
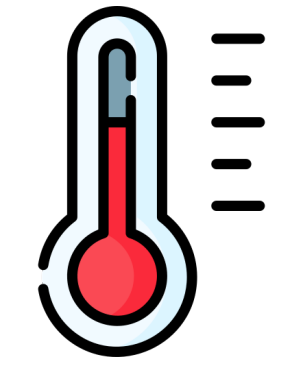
In the Bay of Villefranche: warming



In the Bay of Villefranche: warming



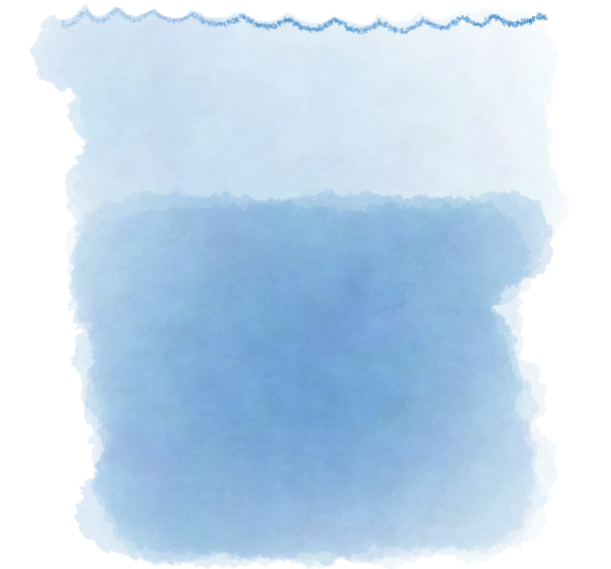
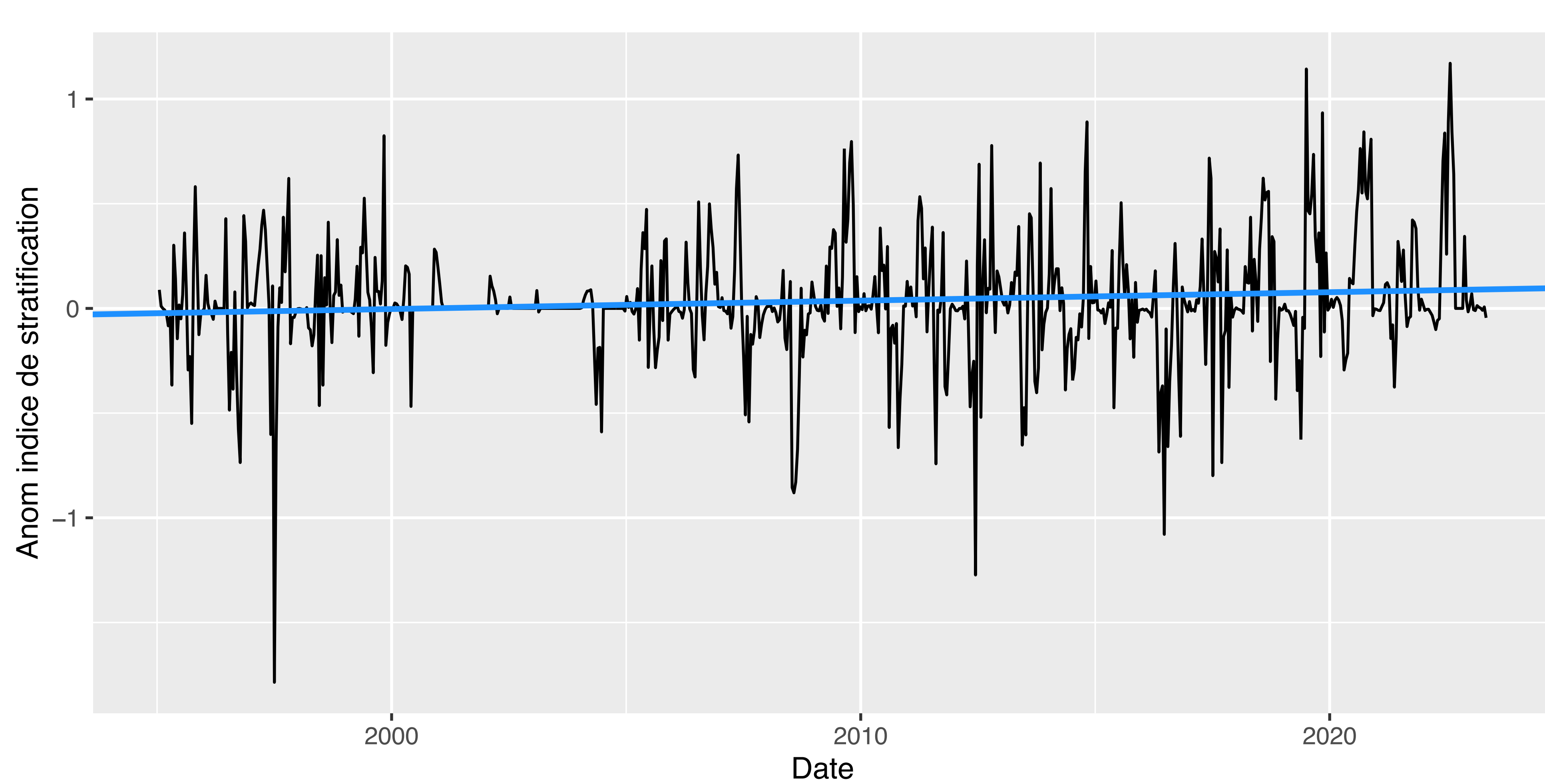
In the Bay of Villefranche: warming



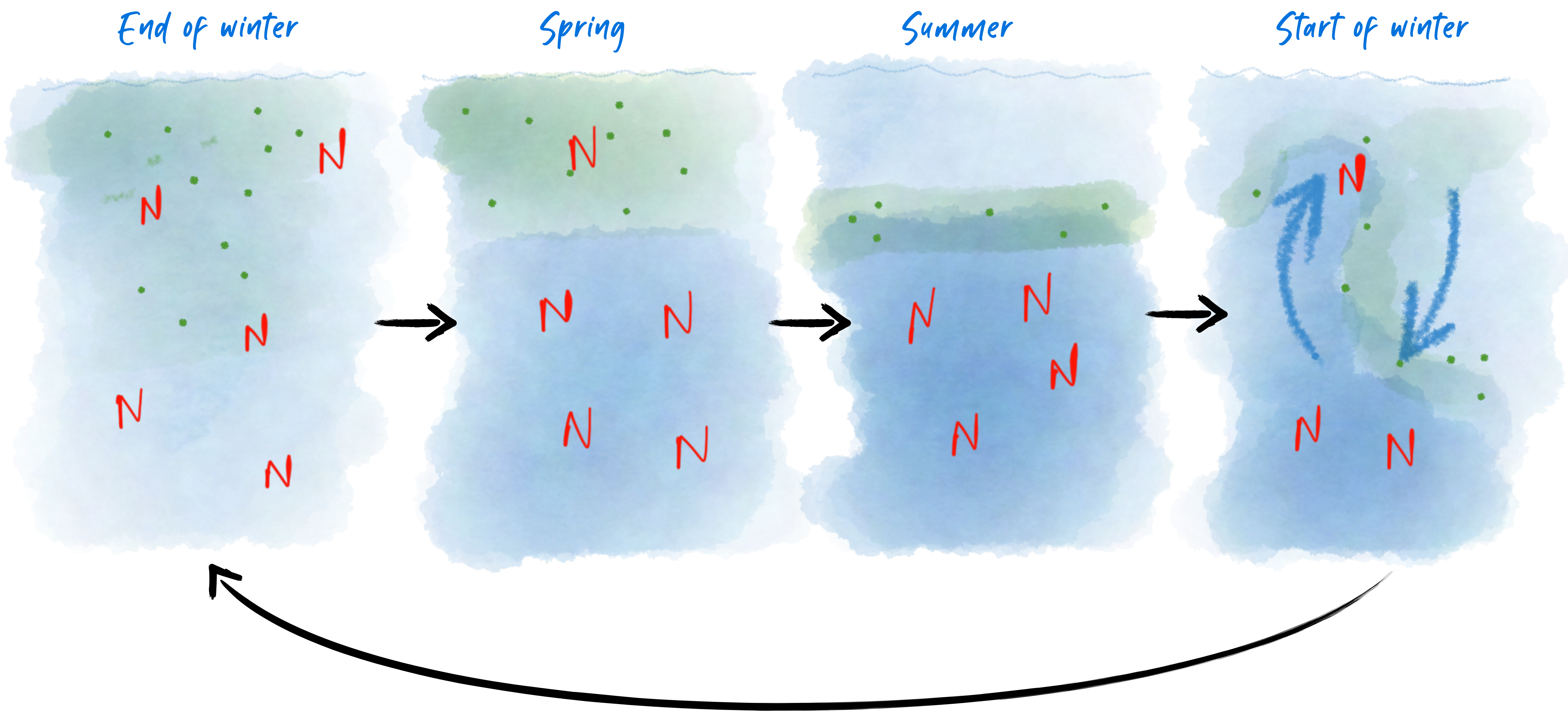
+1.5°C in 60 years

+0.77°C in 60 years

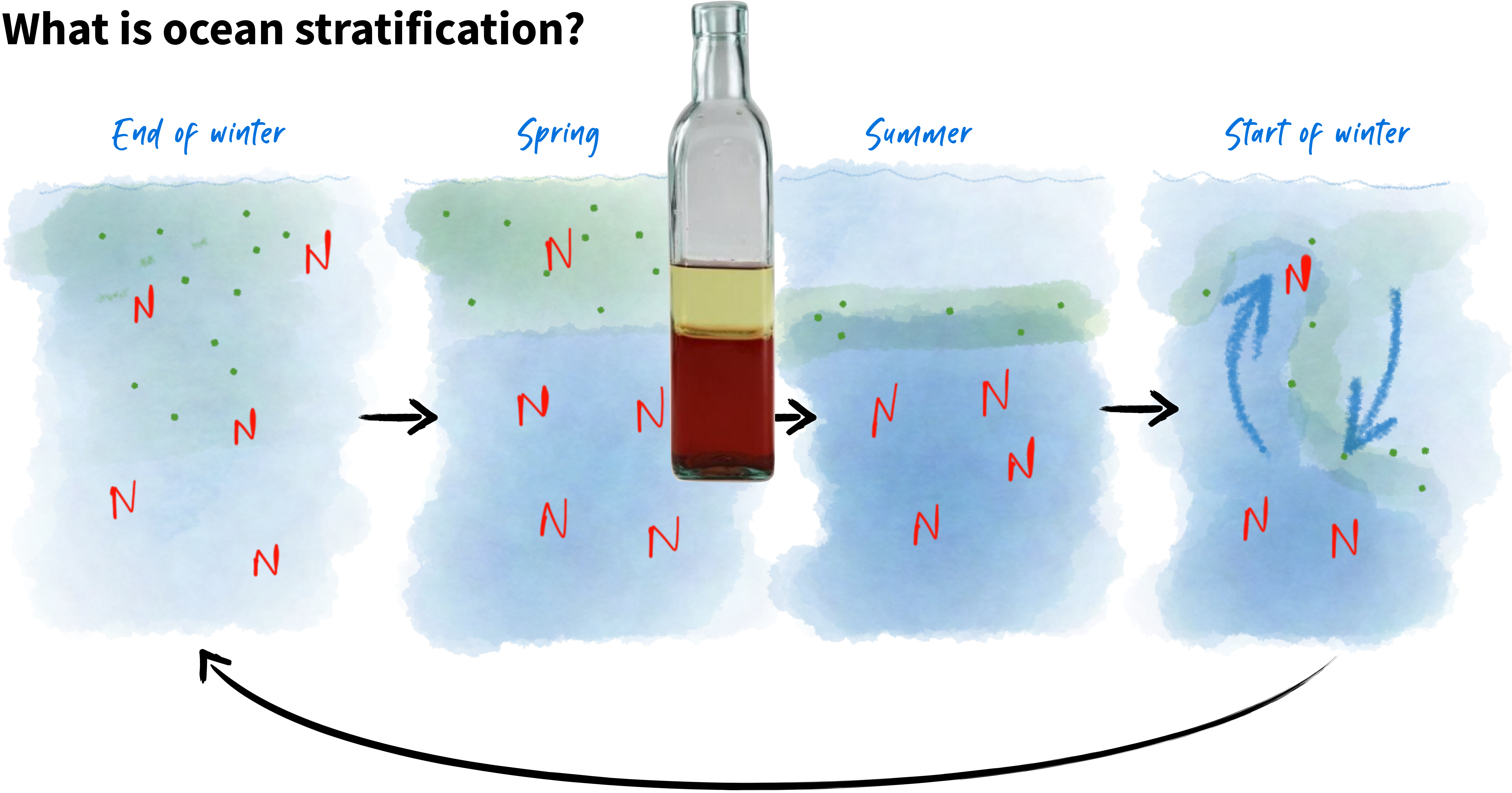
In the Bay of Villefranche: increase in stratification



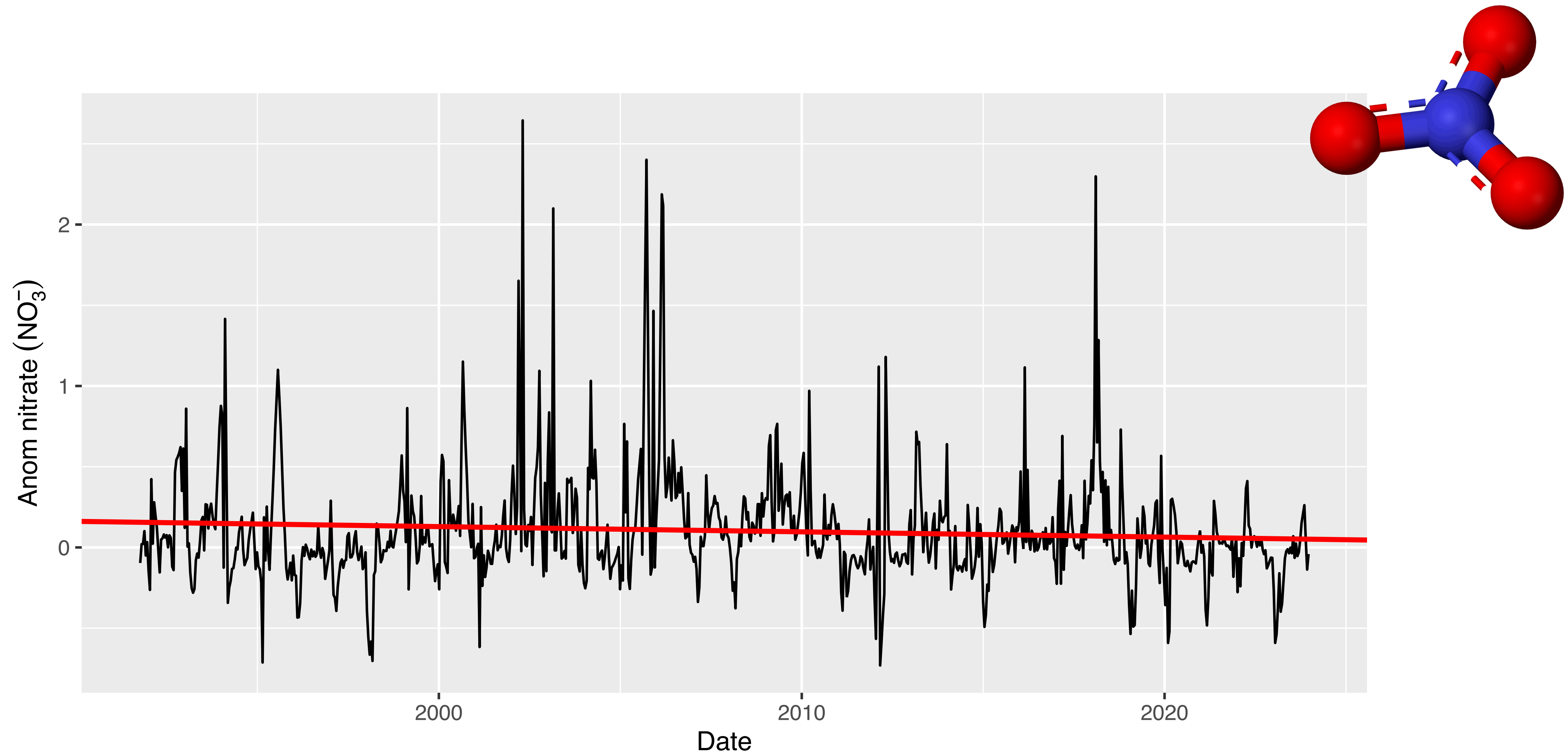
What is ocean stratification?



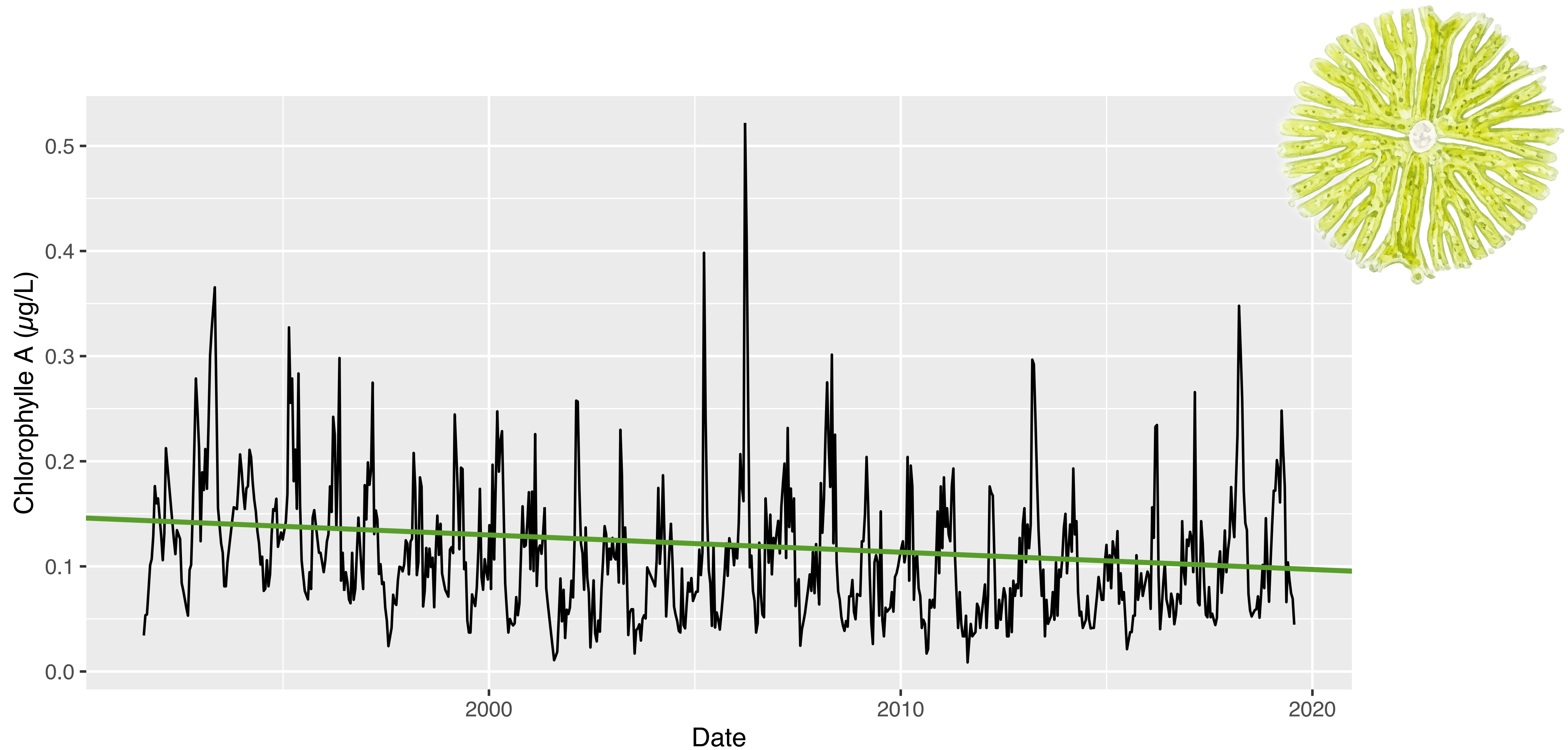
What is ocean stratification?



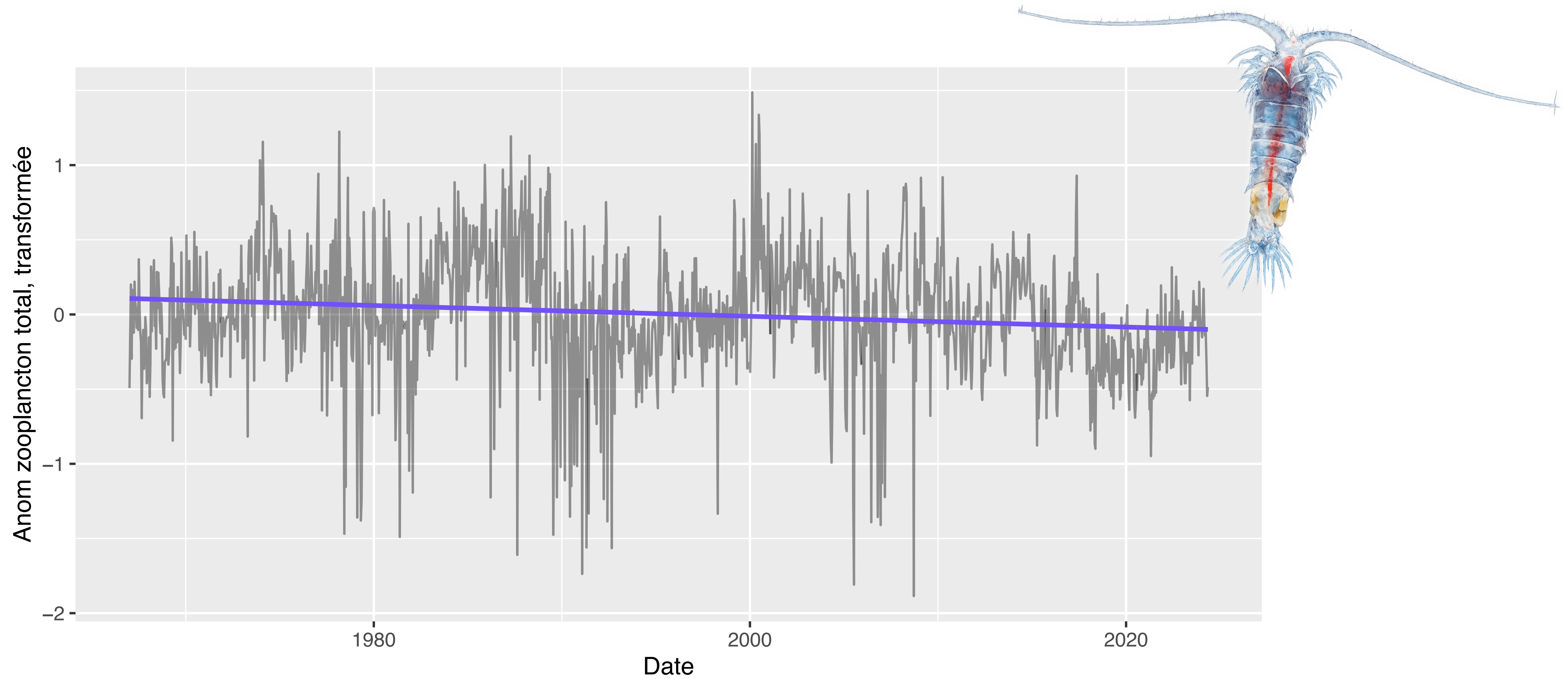
Decrease of nutrients



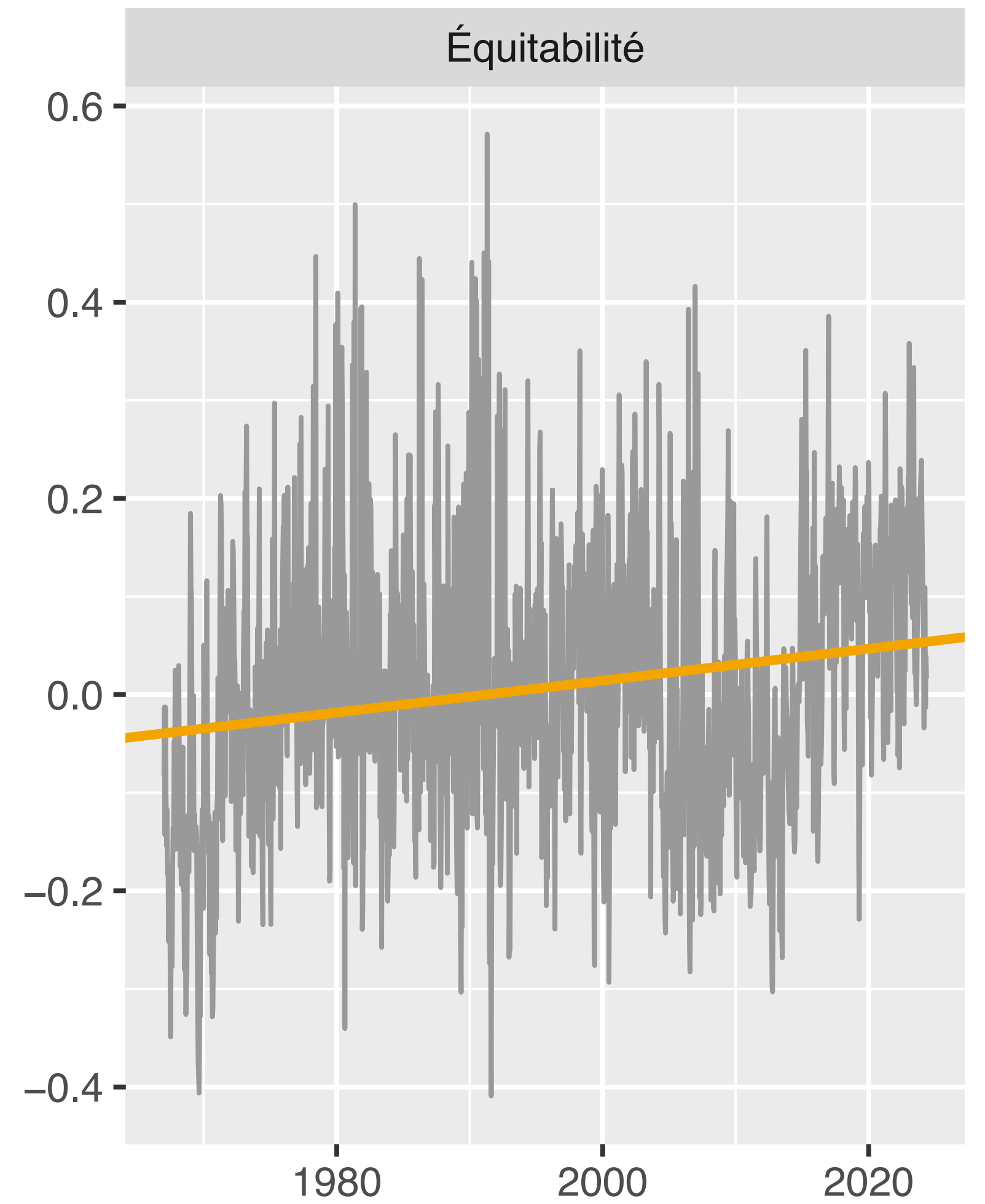
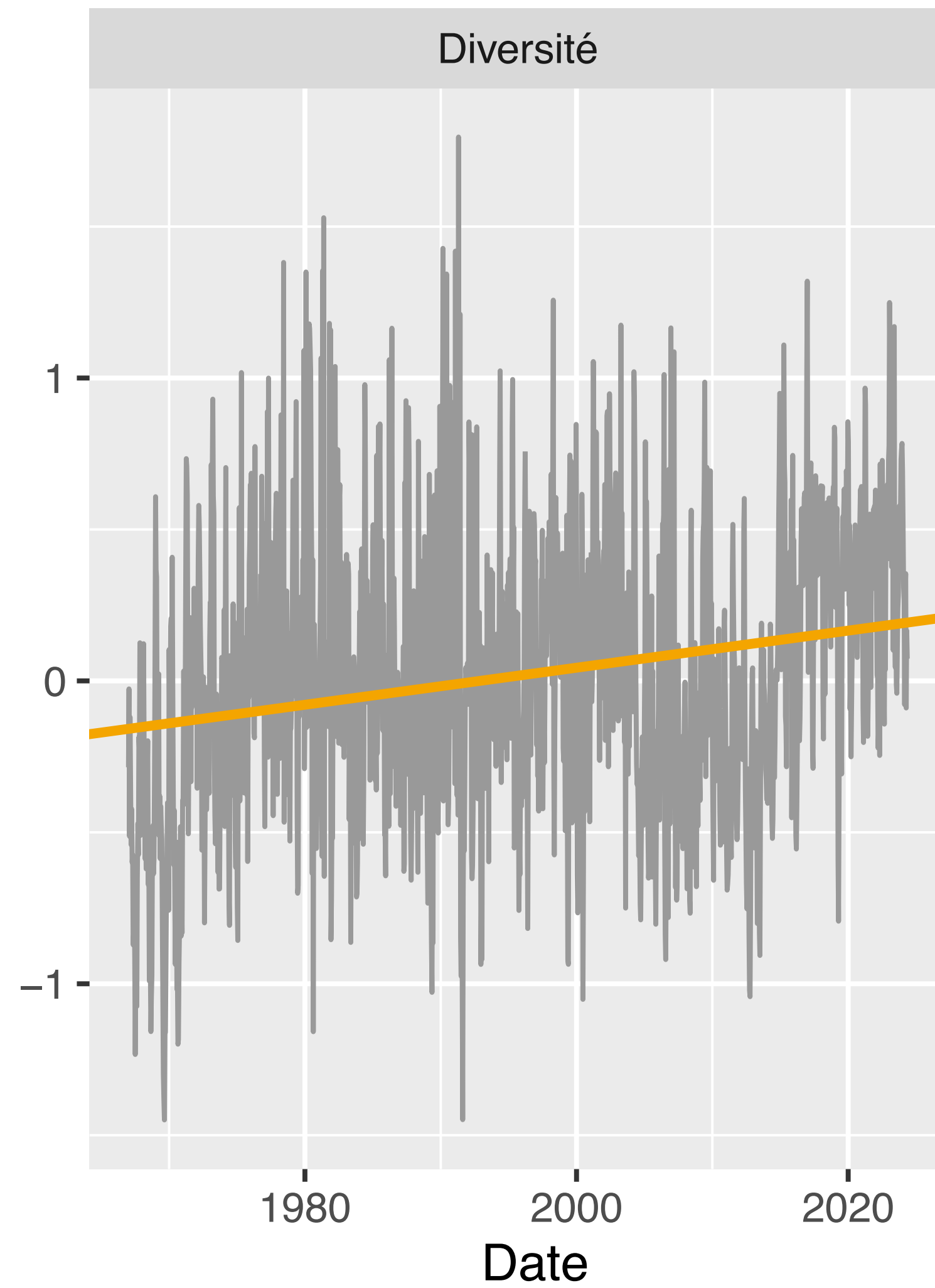
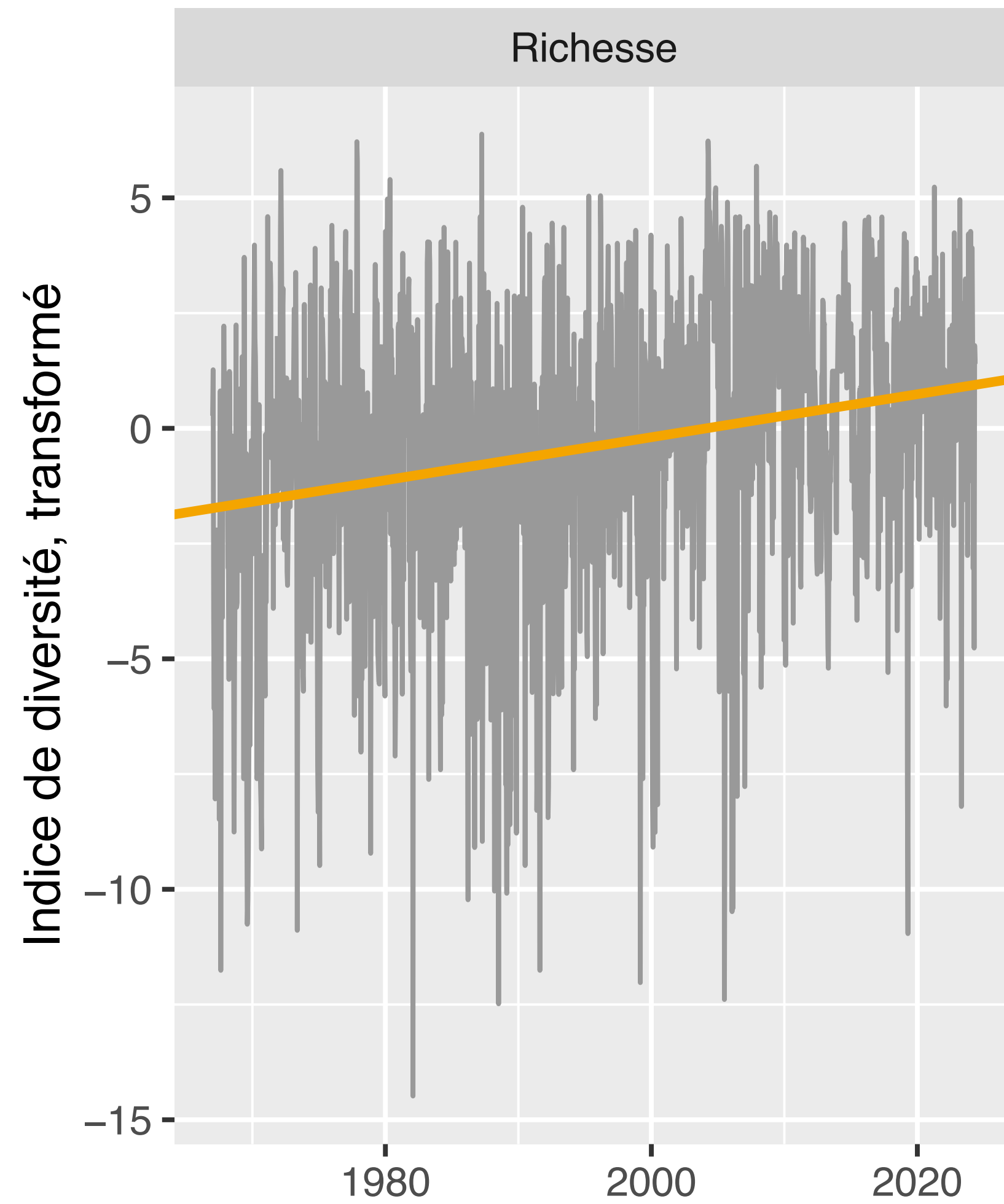
Decrease in the quantity of phytoplankton



Decrease in the quantity of zooplankton



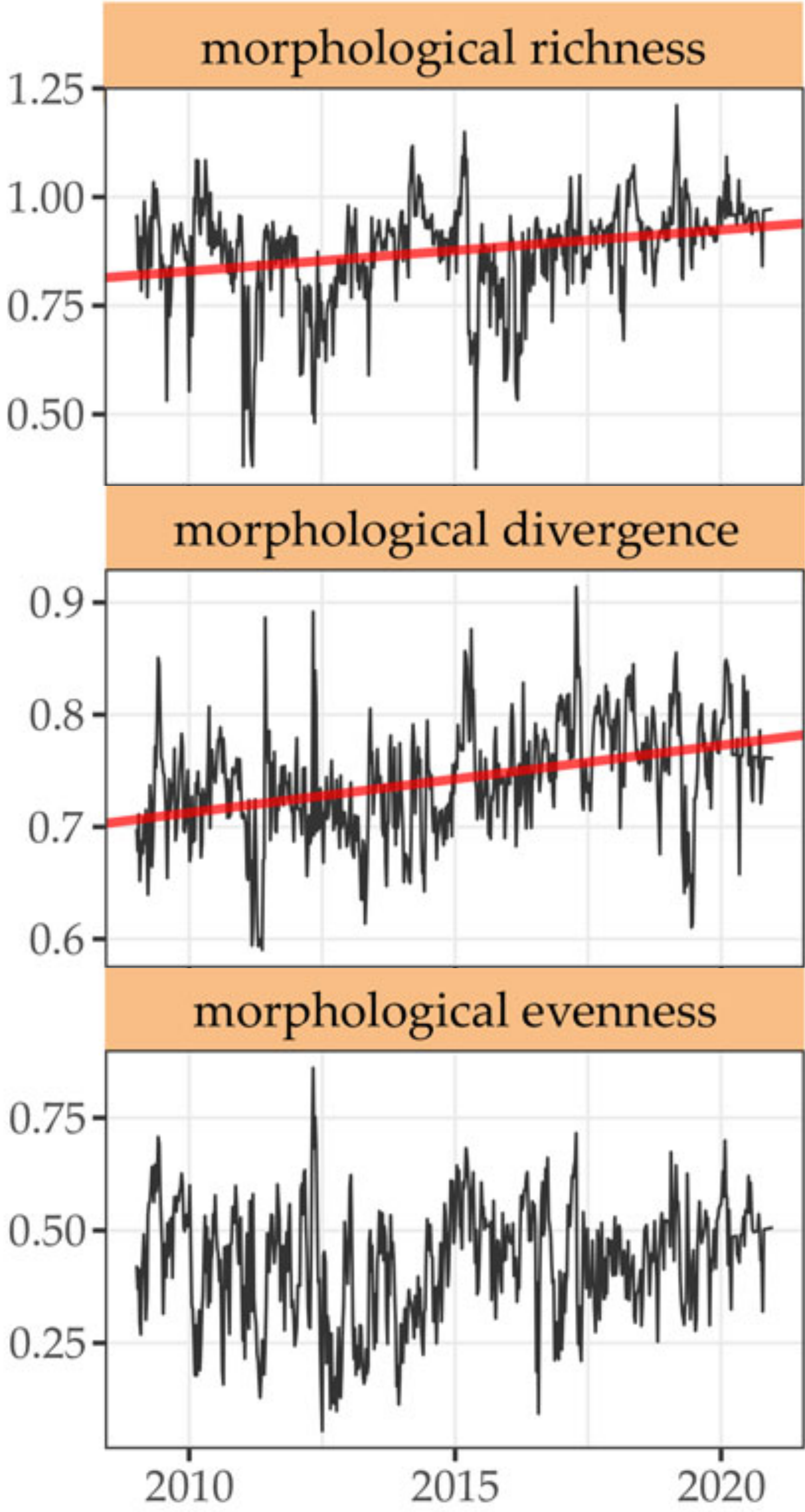
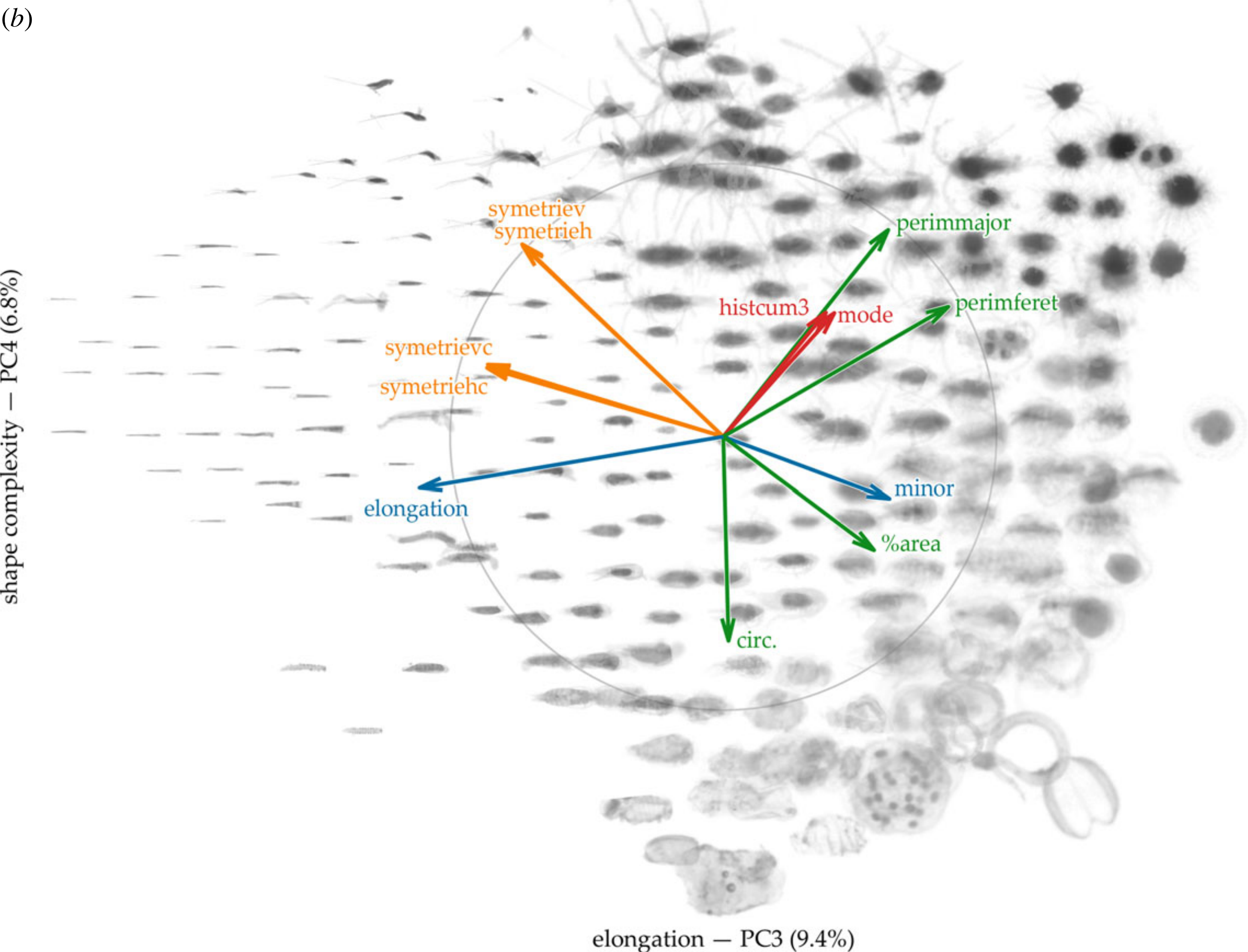
Increase in biodiversity!



Why is diversity increasing? Is it “good”?



Increase in trait diversity !



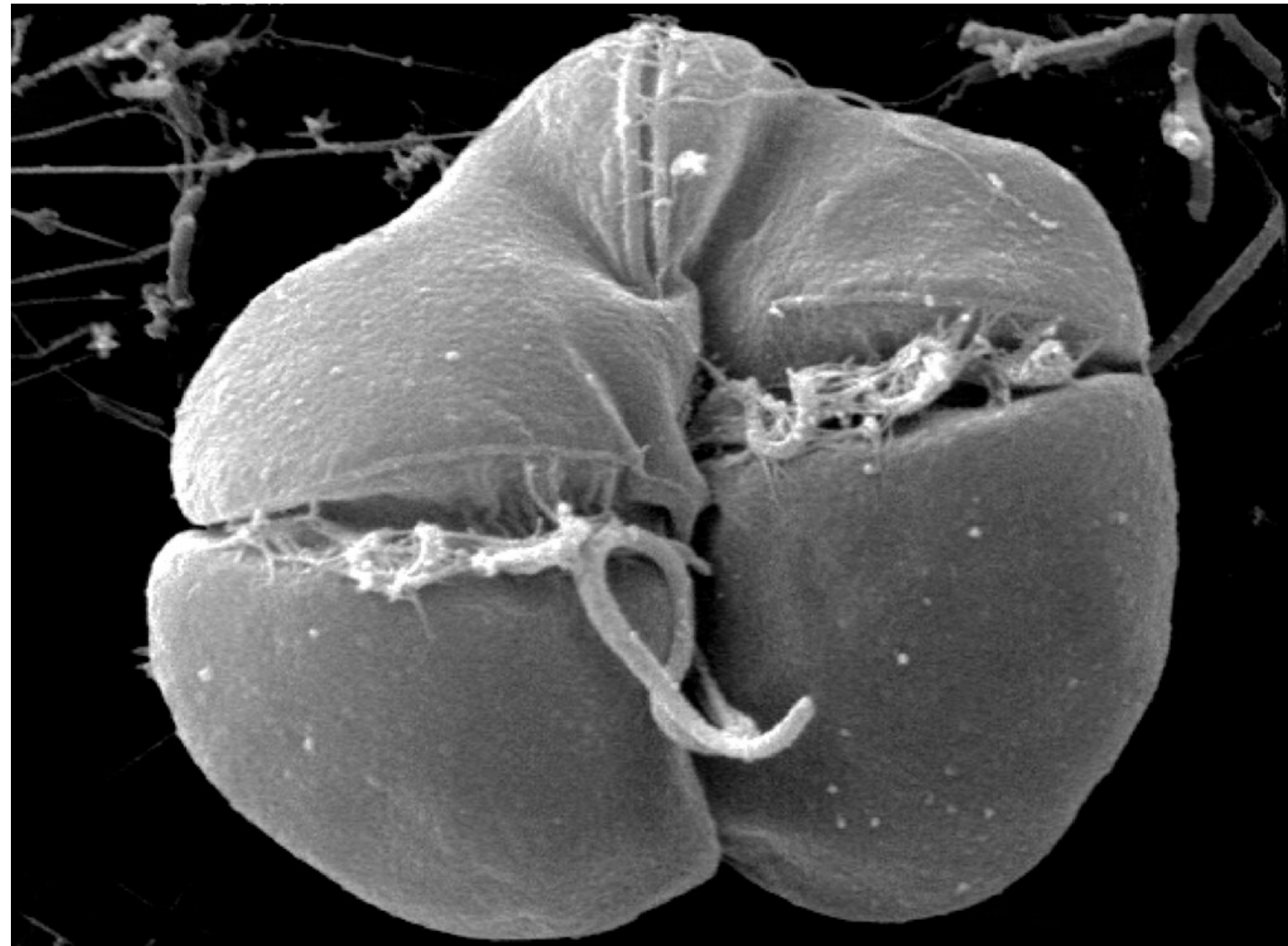
Eutrophication and harmful algal blooms

Increase in nutrients because of human activity (and temperature)

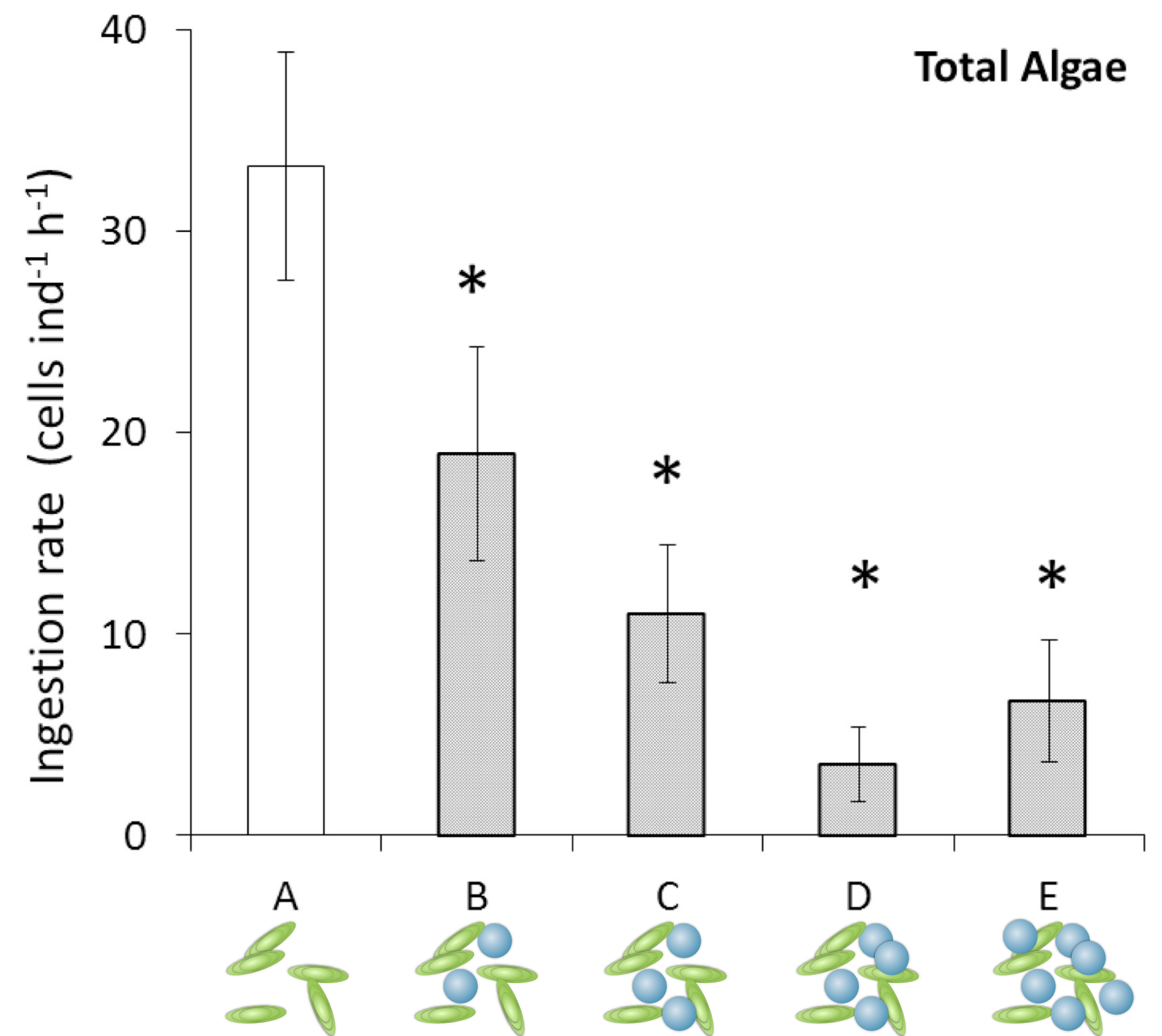
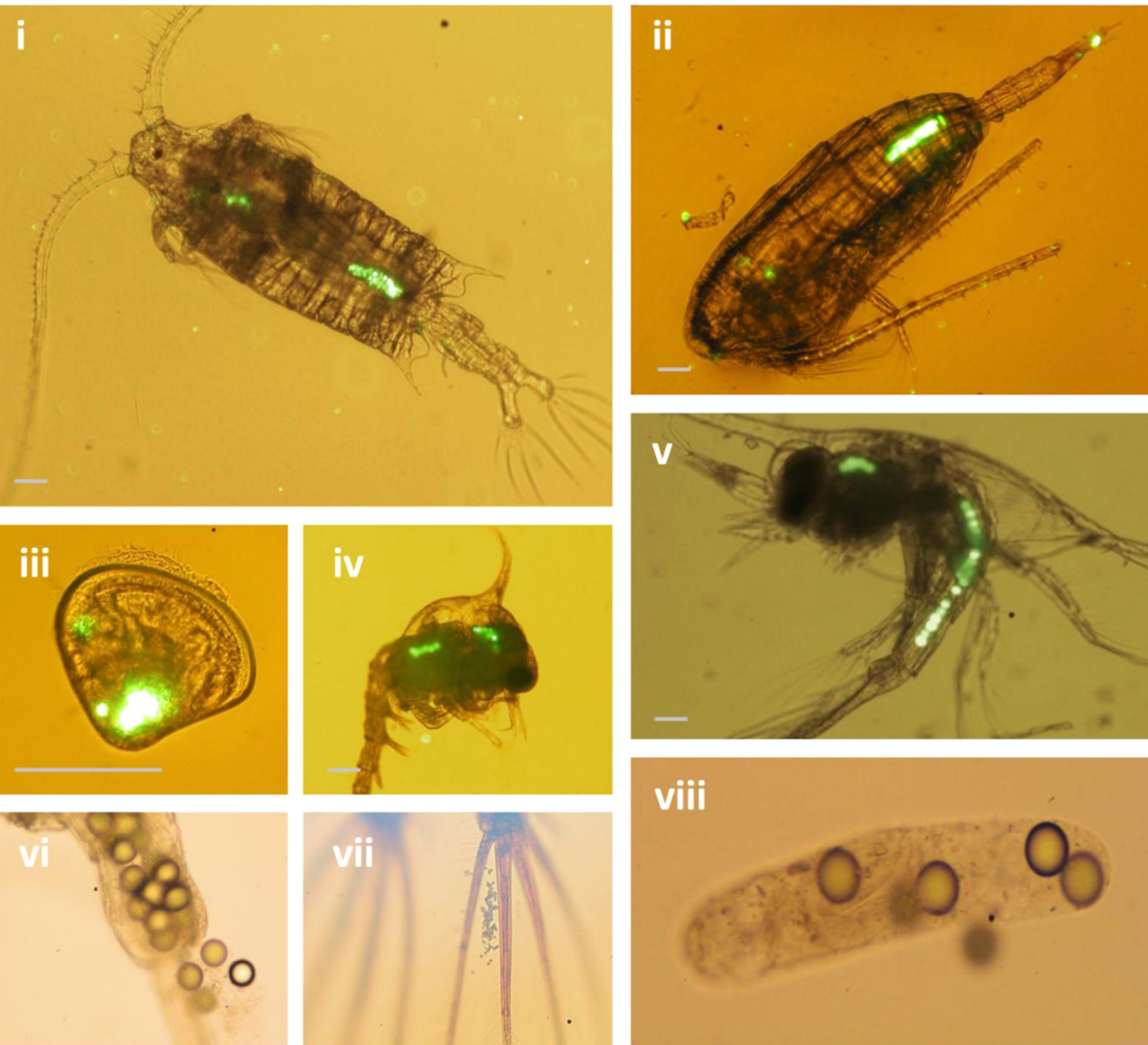
Incredible development of microalgae = “bloom”

Emit toxins in the water (and the air) that cause fish death (and human discomfort)

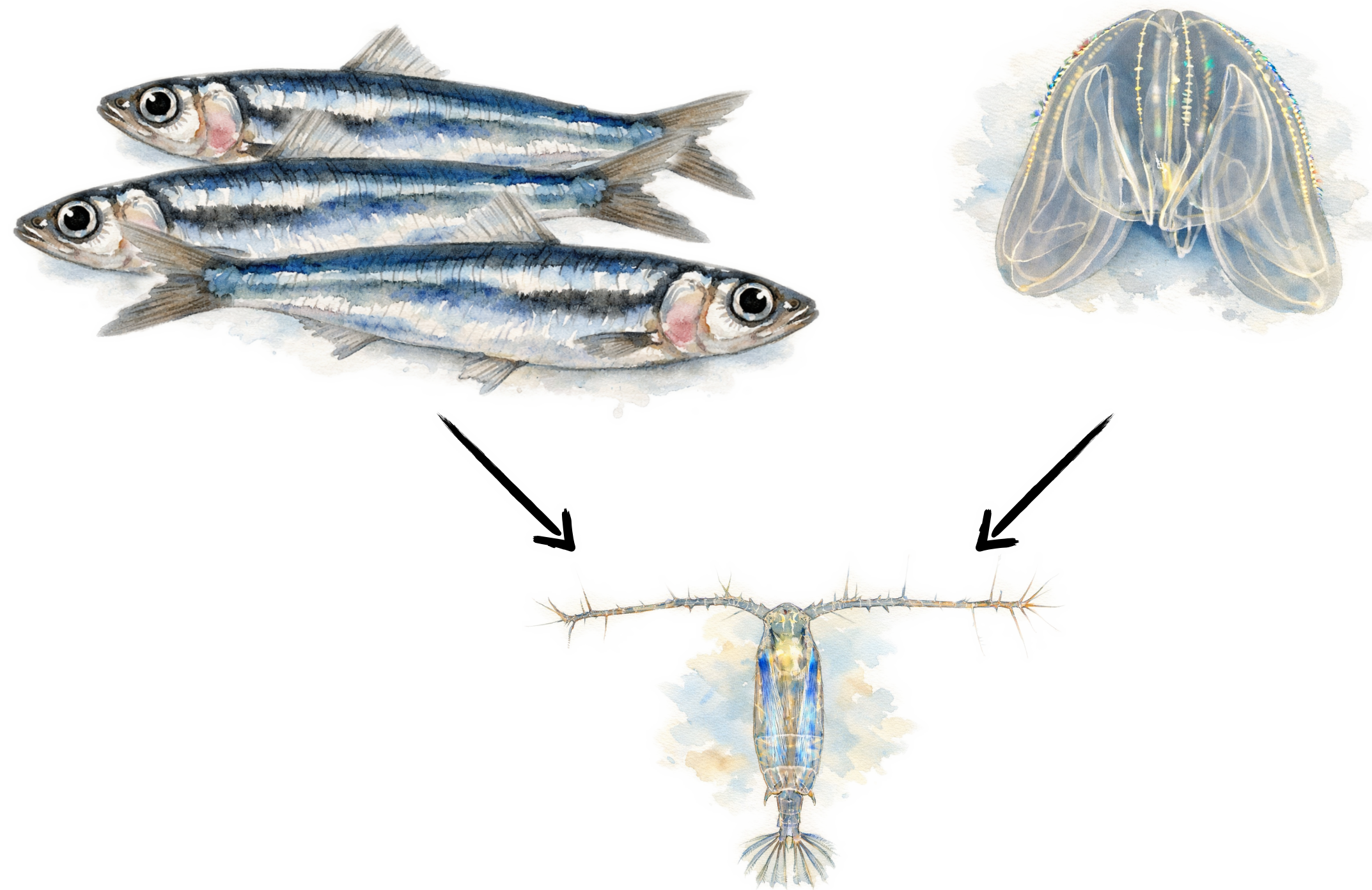
Karenia brevis in Florida



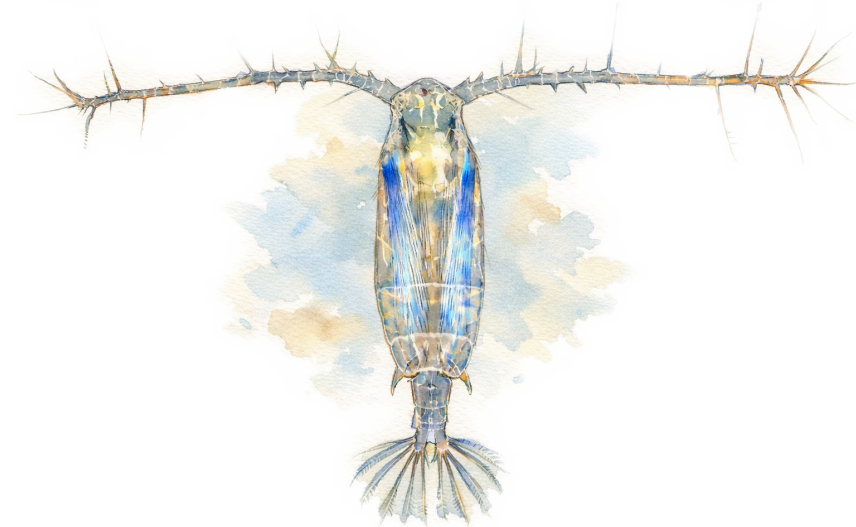
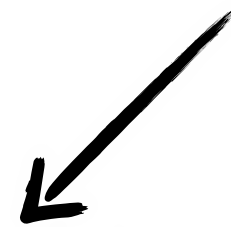
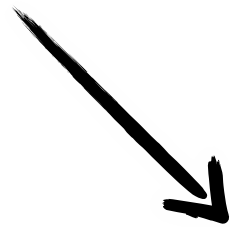
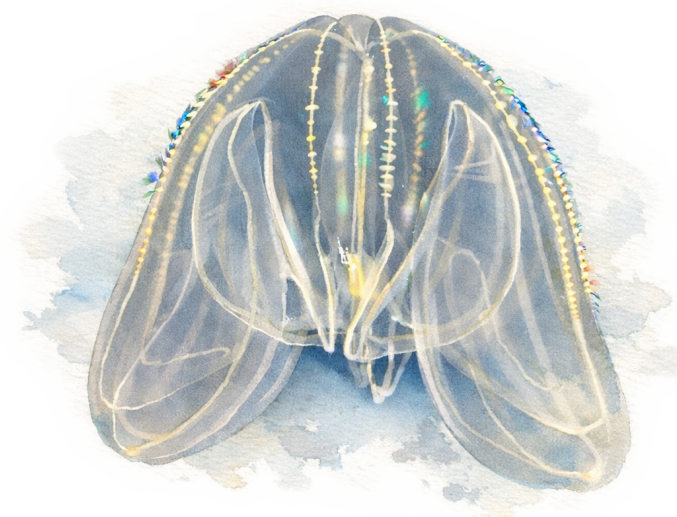
Microplastics



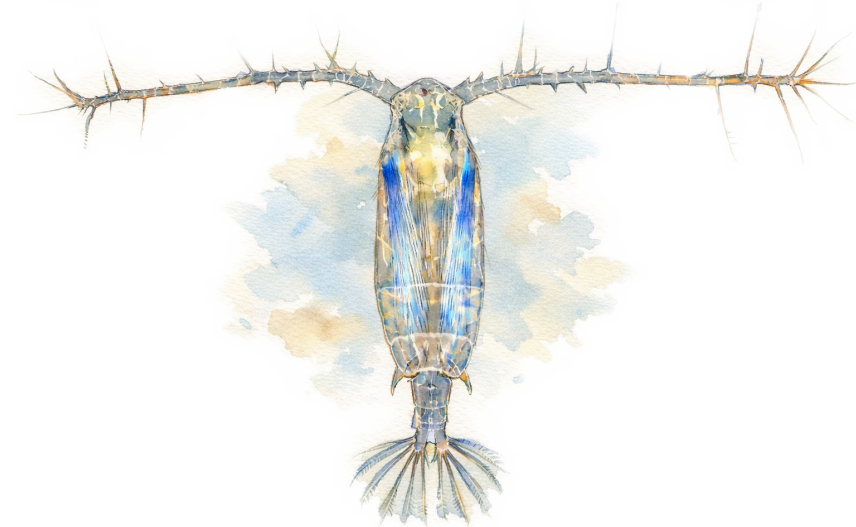
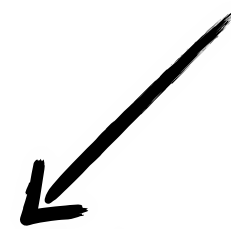
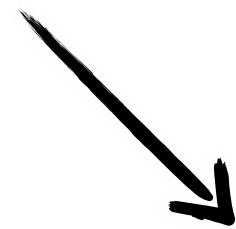
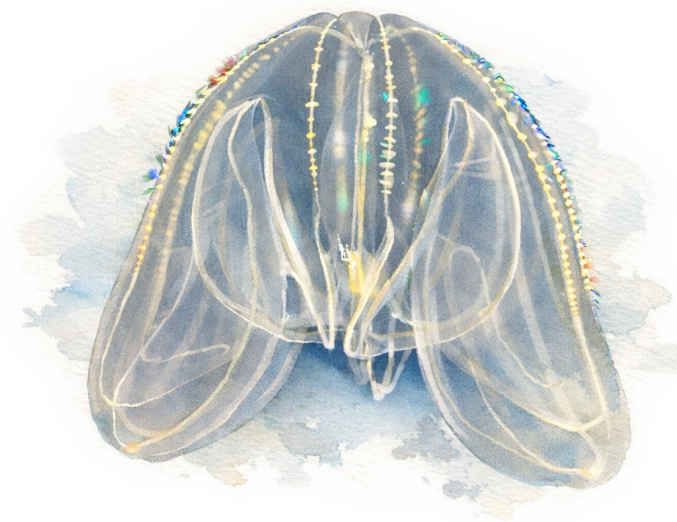
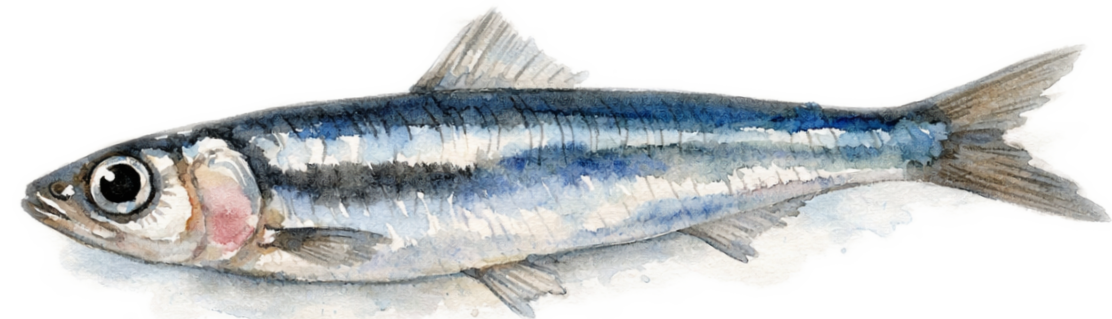
Overfishing and cascading effects



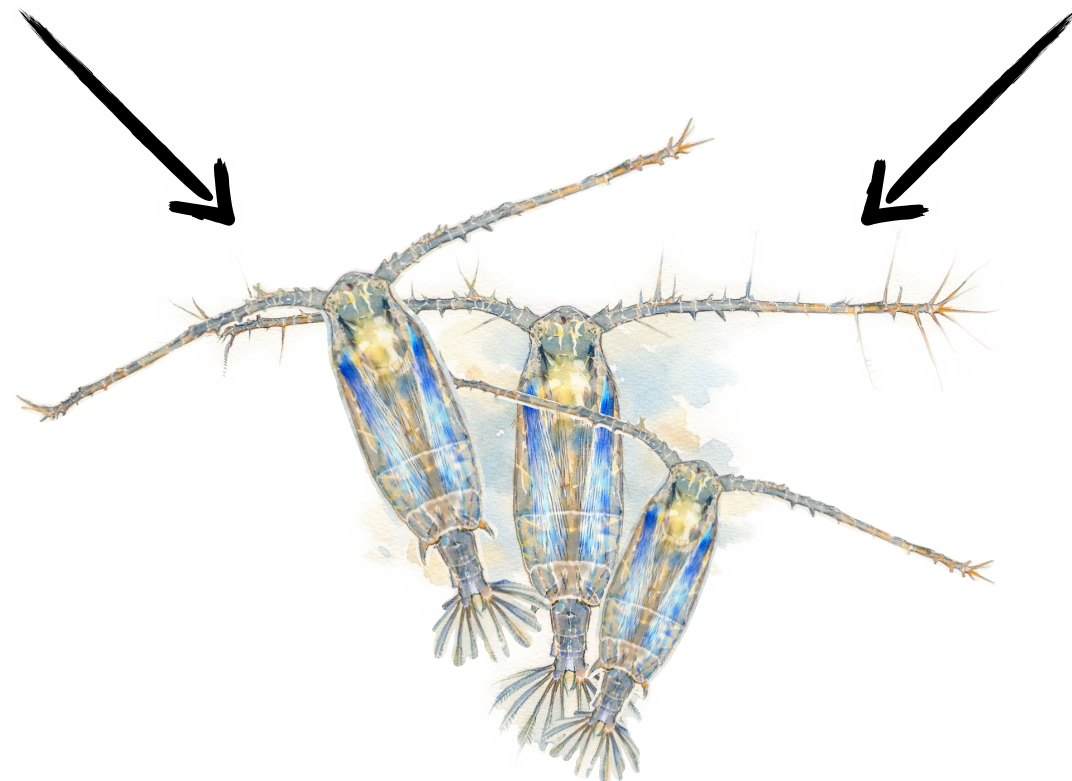
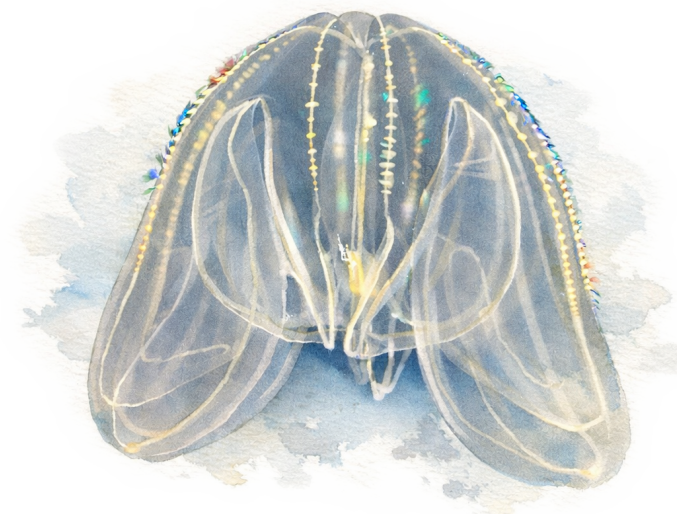
Overfishing and cascading effects



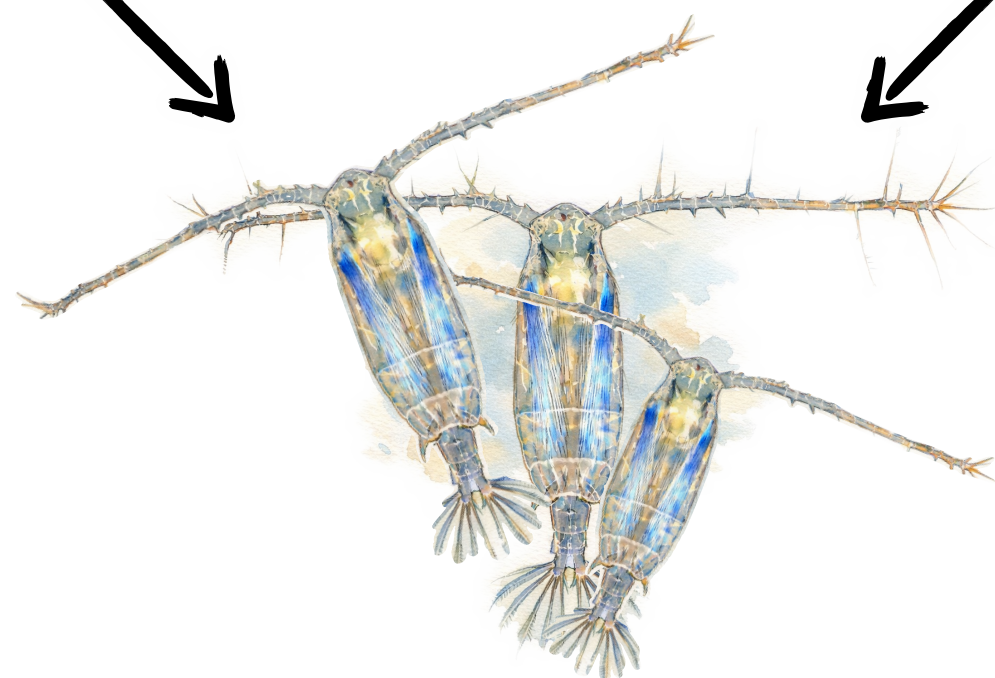
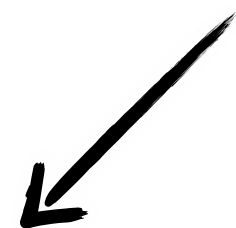
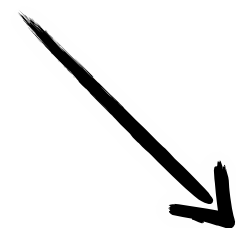
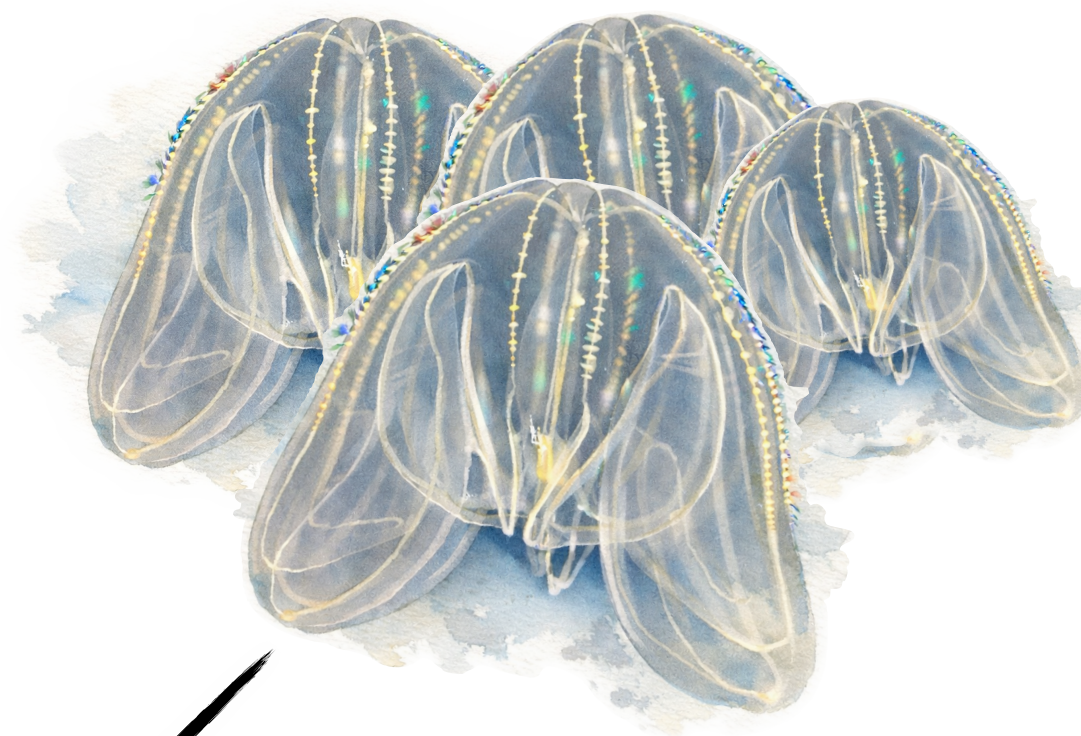
Overfishing and cascading effects



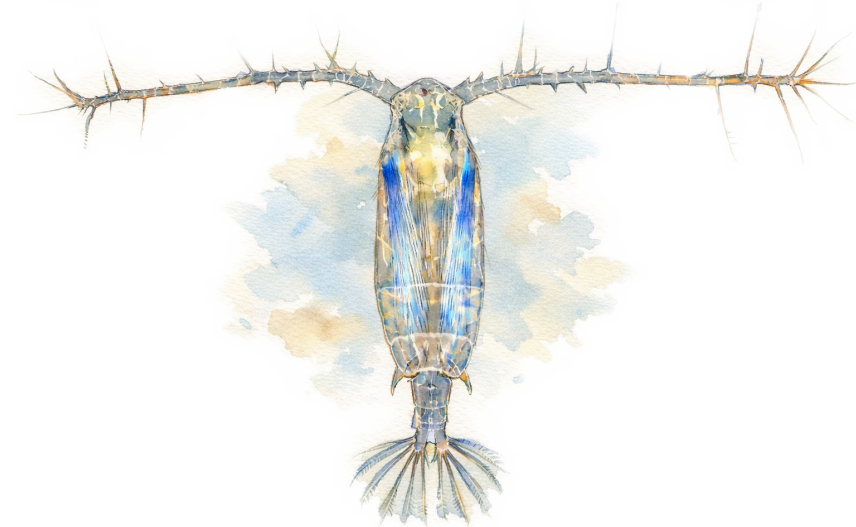
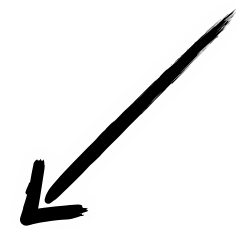
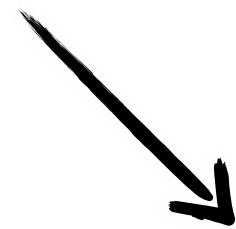
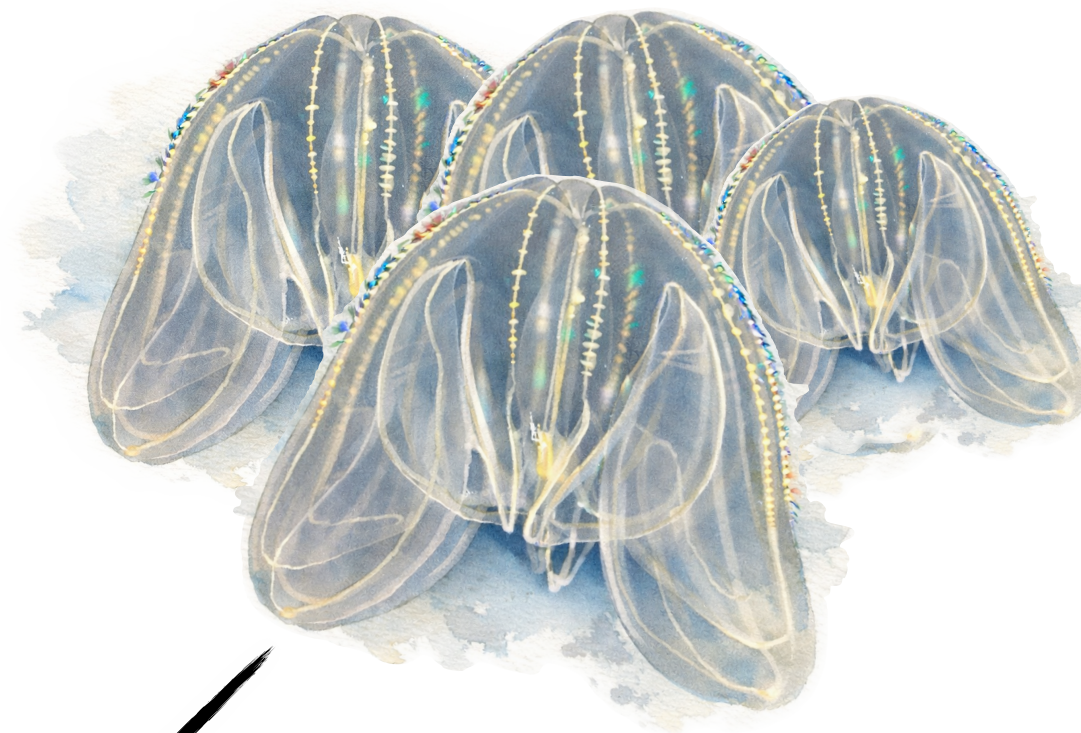
Overfishing and cascading effects



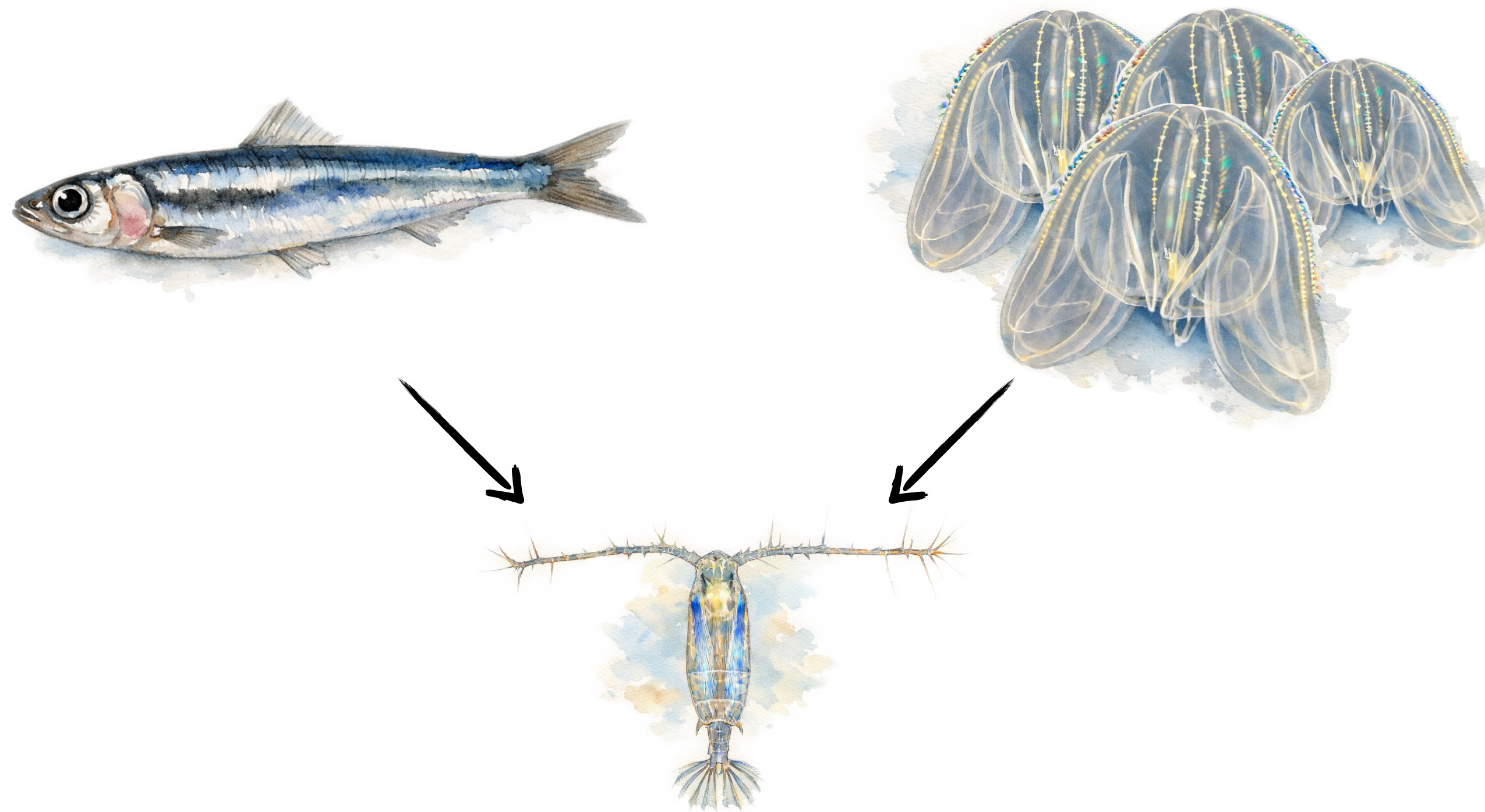
Overfishing and cascading effects



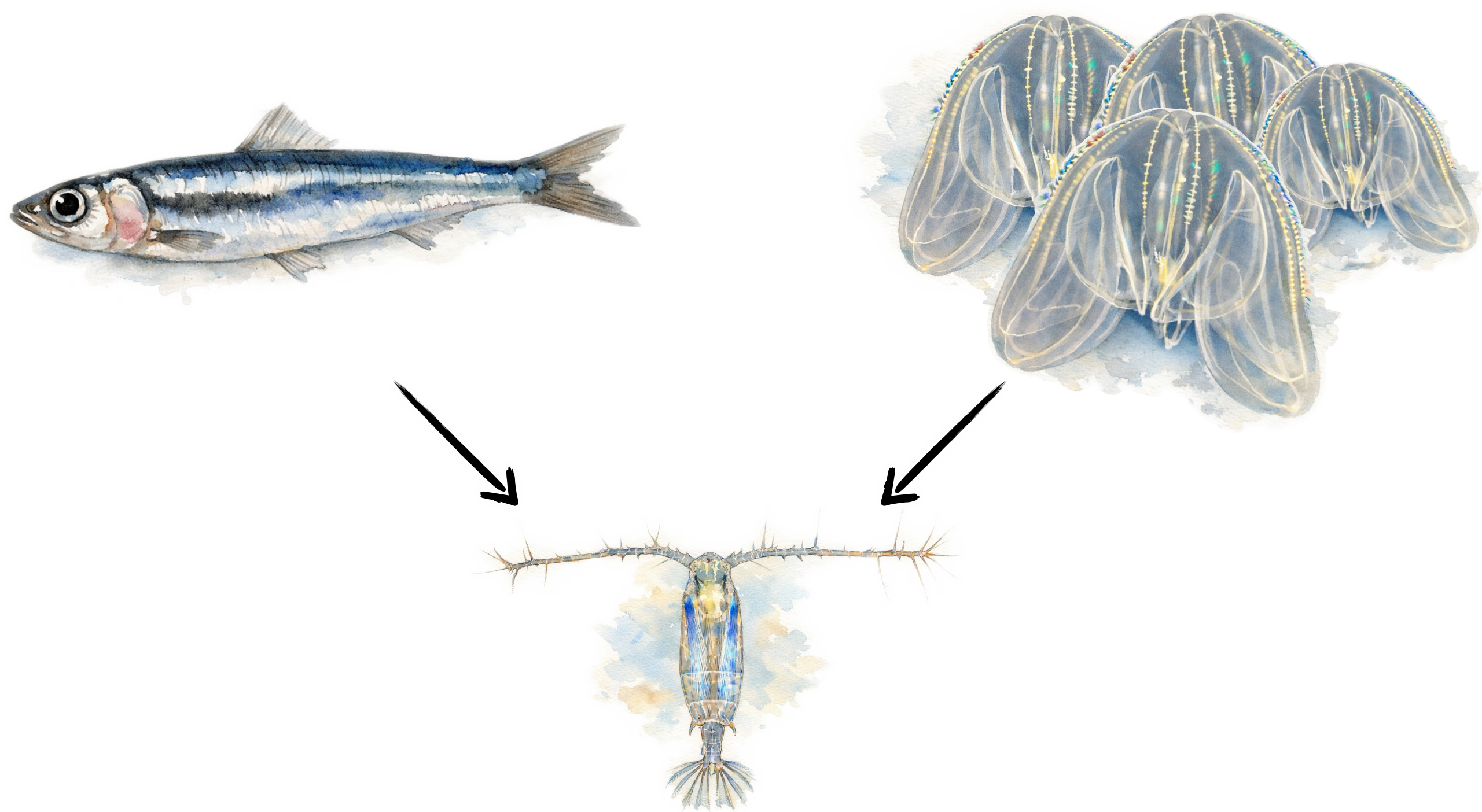
Overfishing and cascading effects

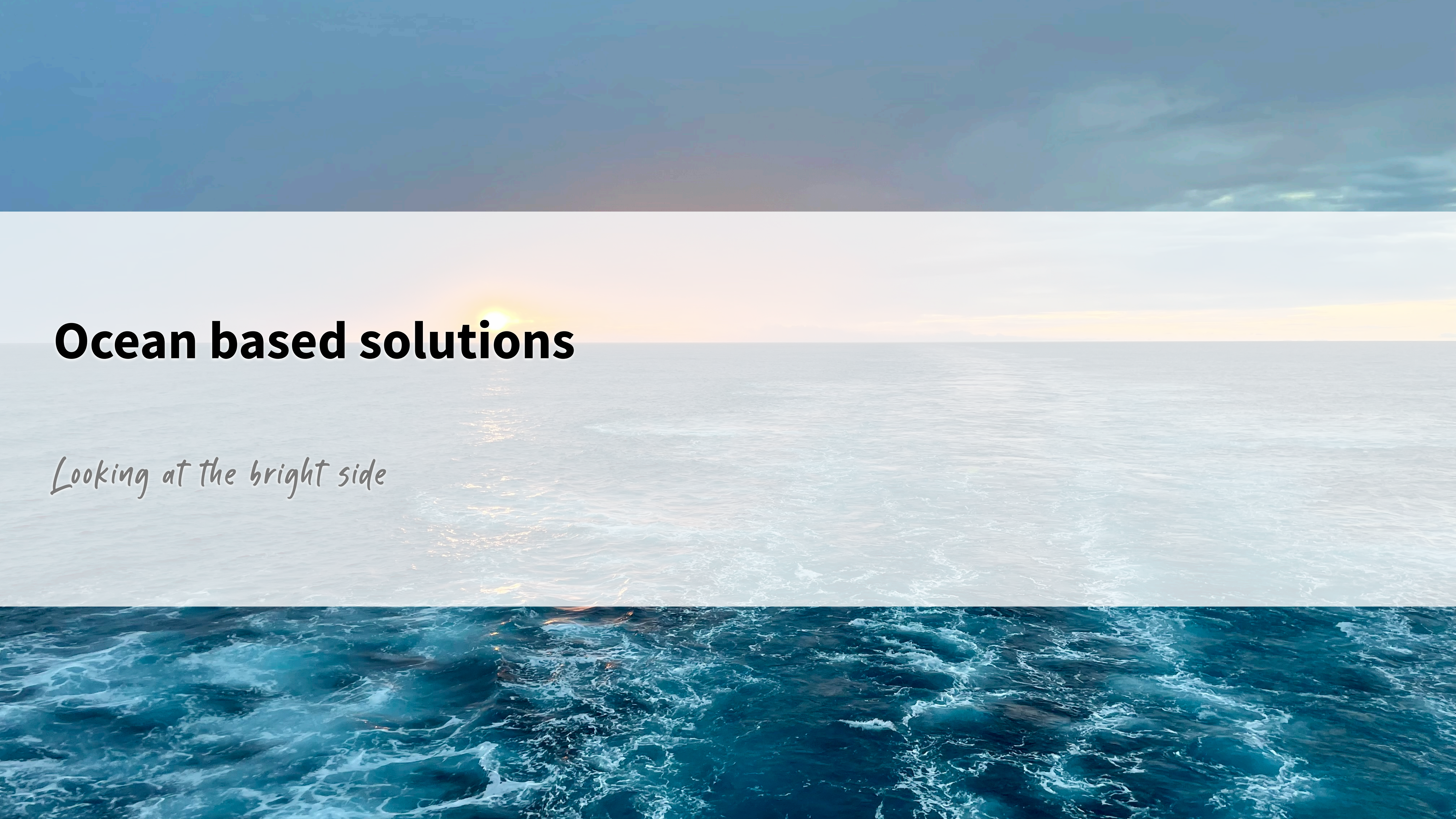


Overfishing and cascading effects



Overfishing and cascading effects



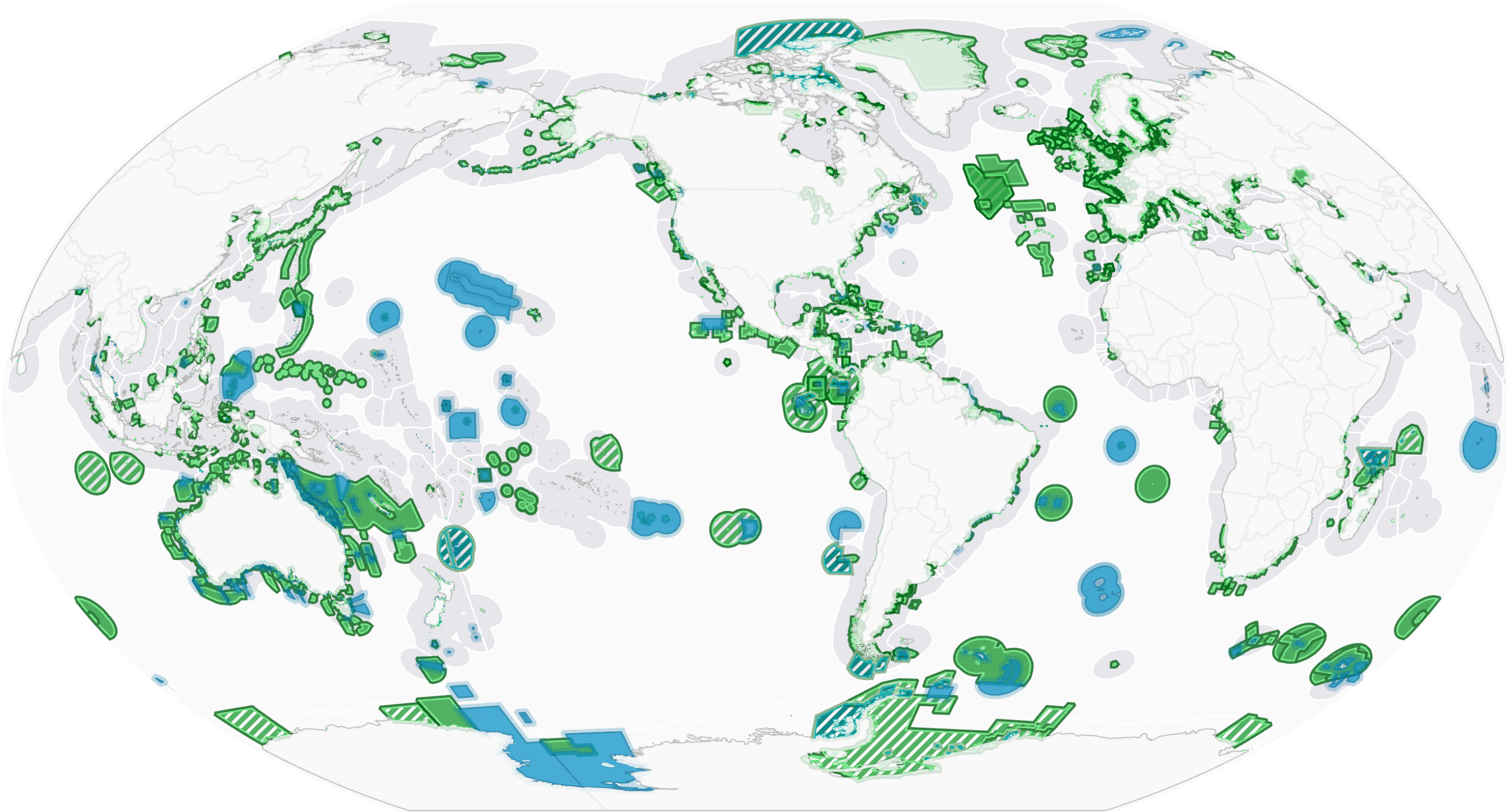
A composite image of the ocean at sunset. The top portion shows a dark, cloudy sky. The middle portion is a bright, hazy white band where the sun is setting. The bottom portion shows the dark, choppy surface of the ocean with white foam from a ship's wake.

Ocean based solutions

Looking at the bright side

Offshore marine reserves

Most marine reserves are coastal, within the countries Exclusive Economic Zones



Marine Protected Areas

Level of Protection

- Highly-Fully Protected Zones
- Less Protected Zones / Unknown
- Pending Implementation / Proposed



United Nations

Agreement on Marine Biological Diversity of Areas beyond National Jurisdiction
BBNJ Agreement

Home

BBNJ Agreement ▾

Information-sharing under the Agreement ▾

Meetings ▾

Capacity-building ▾

Media and resources ▾

The **Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Resources of Areas beyond National Jurisdiction** (BBNJ Agreement) was adopted on 19 June 2023 by the [Intergovernmental Conference on Marine Biological Diversity of Areas Beyond National Jurisdiction](#) convened under the auspices of the United Nations, and entered into force on 17 January 2024. The Agreement becomes the third implementing agreement to the [United Nations Convention on the Law of the Sea](#).



Andy Schmid, UN World Oceans Day 2023 photo competition / A

Under the overall objective of the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction, for the present and future, and for the effective implementation of the relevant provisions of the Convention, the Agreement provides for international cooperation and coordination, the Agreement addresses:

- Marine genetic resources, including the fair and equitable sharing of benefits
- Measures such as area-based management tools, including marine protected areas
- Environmental impact assessments; and
- Capacity-building and the transfer of marine technology.



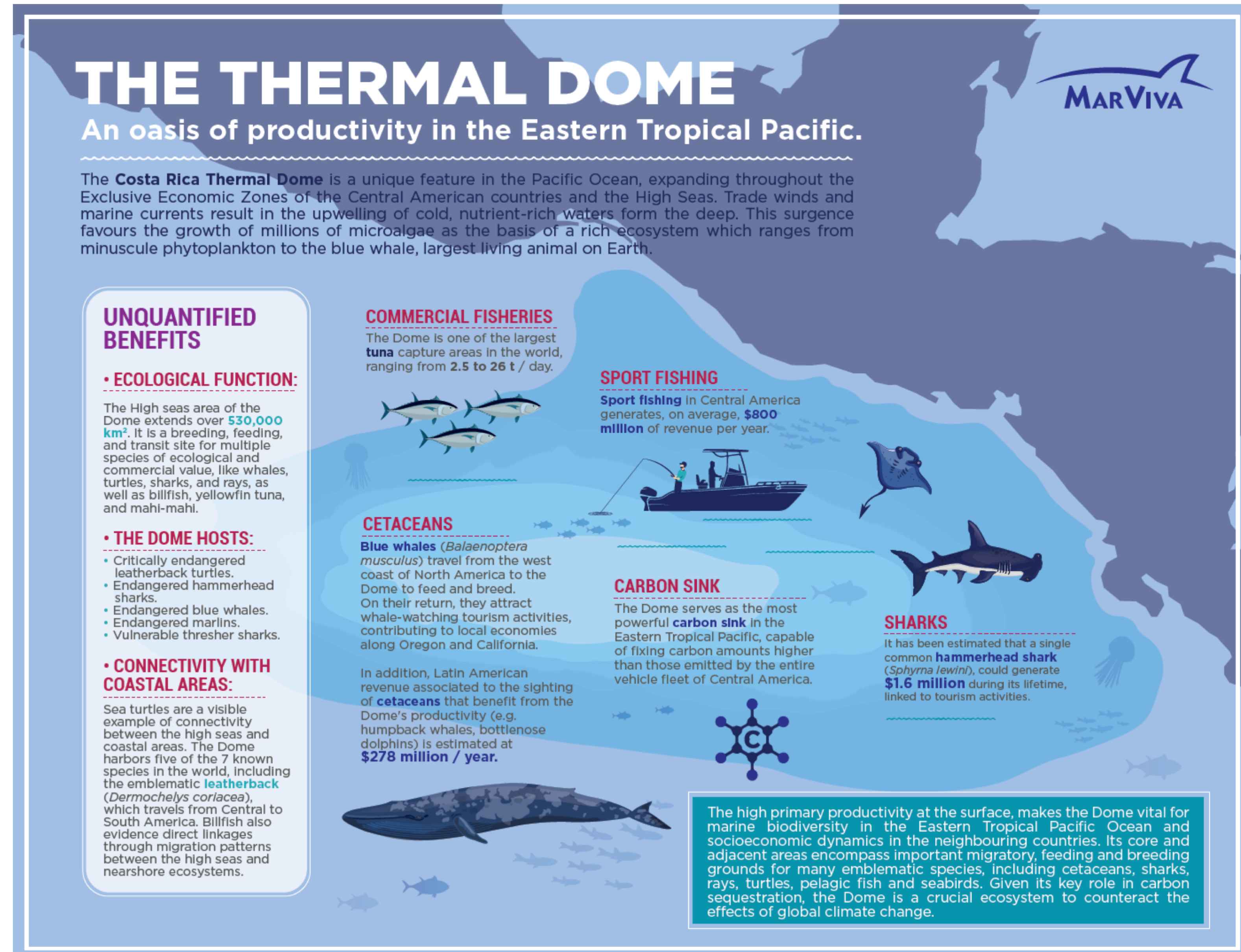
Offshore marine reserves

Most marine reserves are coastal, within the countries Exclusive Economic Zones

Last July: signing of a historic United Nations agreement on “Biodiversity Beyond National Jurisdiction”

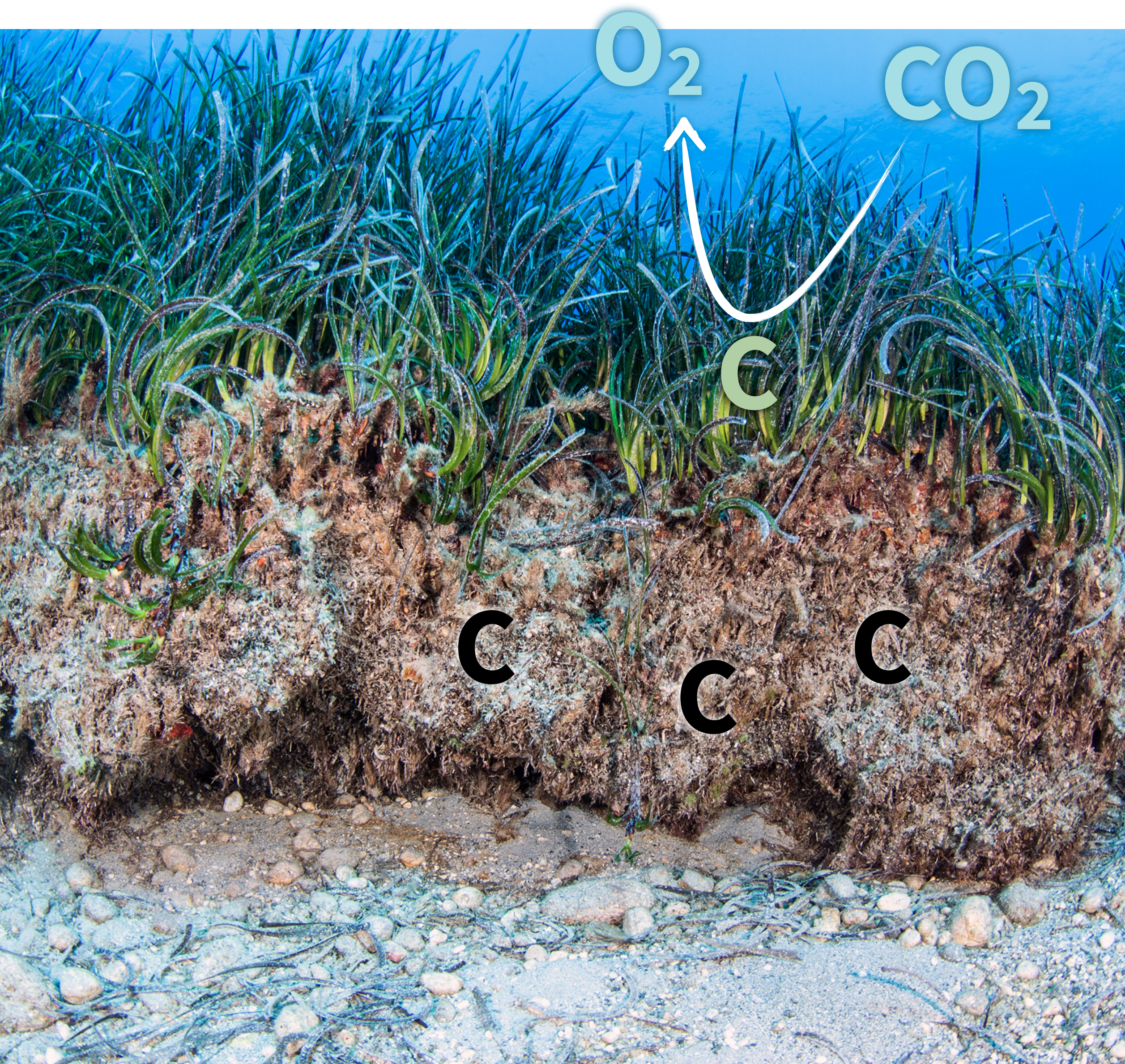
Opens the possibility to create offshore marine reserves

One proposed region is the thermal dome of Costa Rica

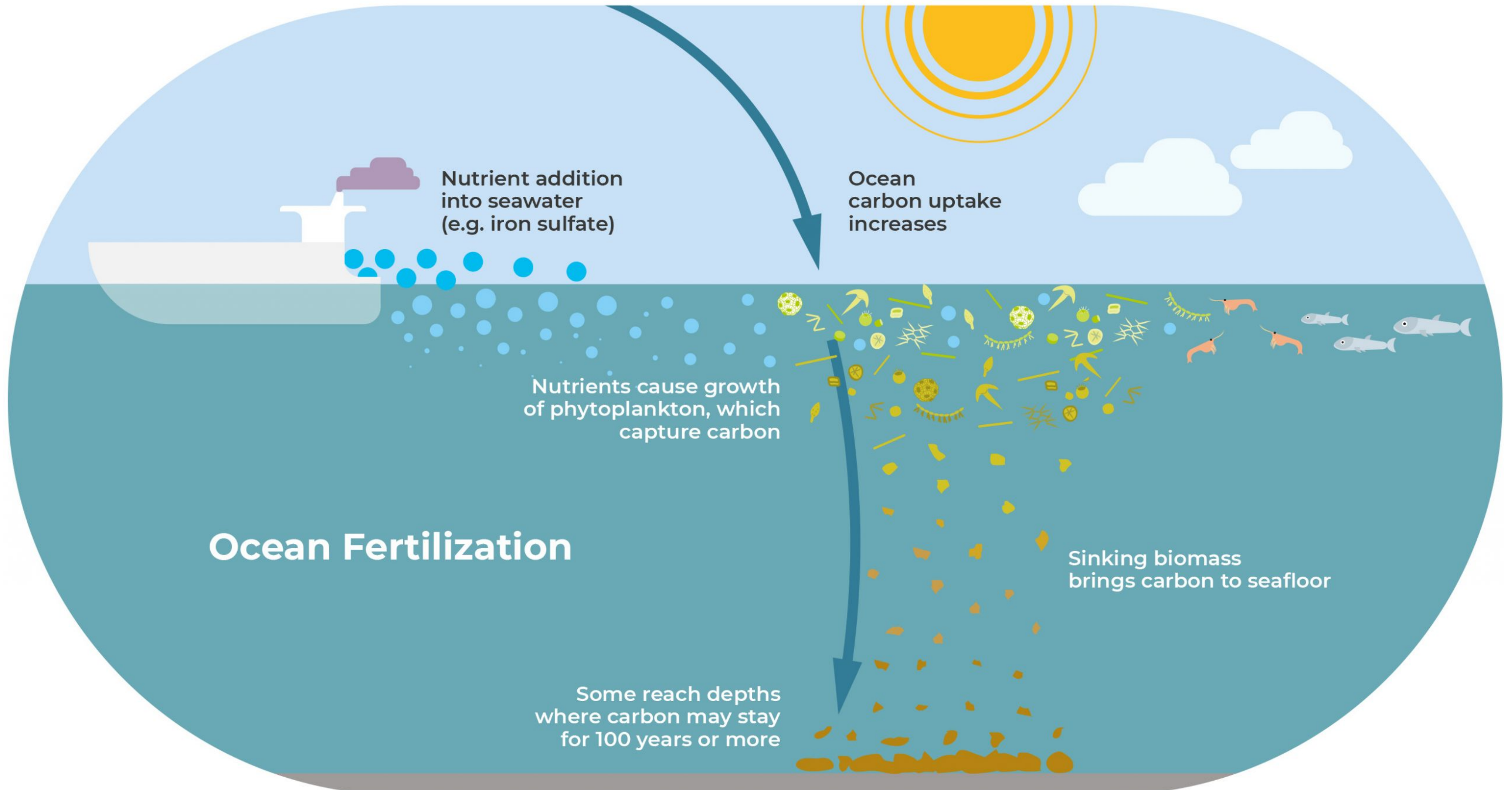


Blue carbon

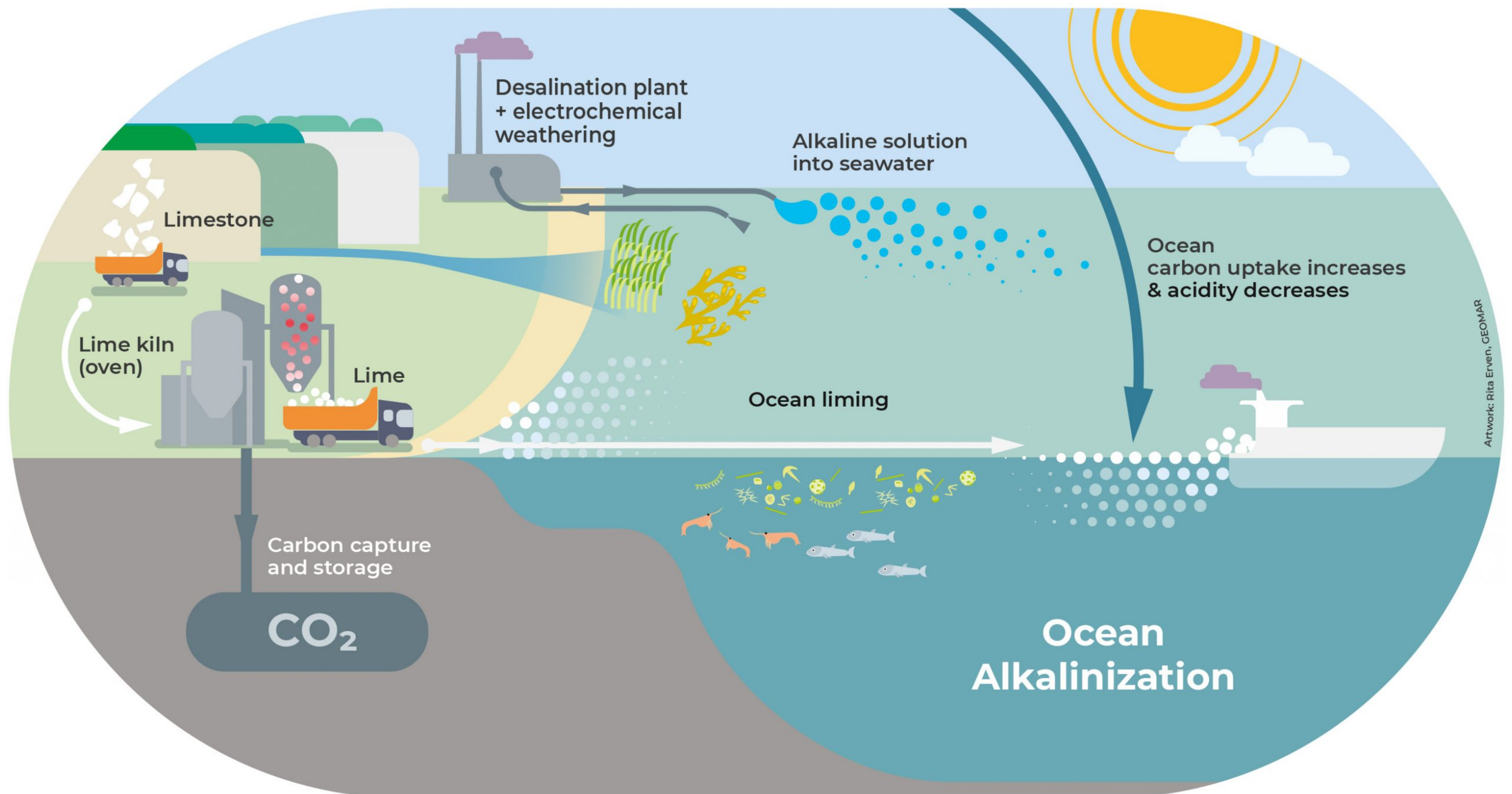
Storage of organic matter



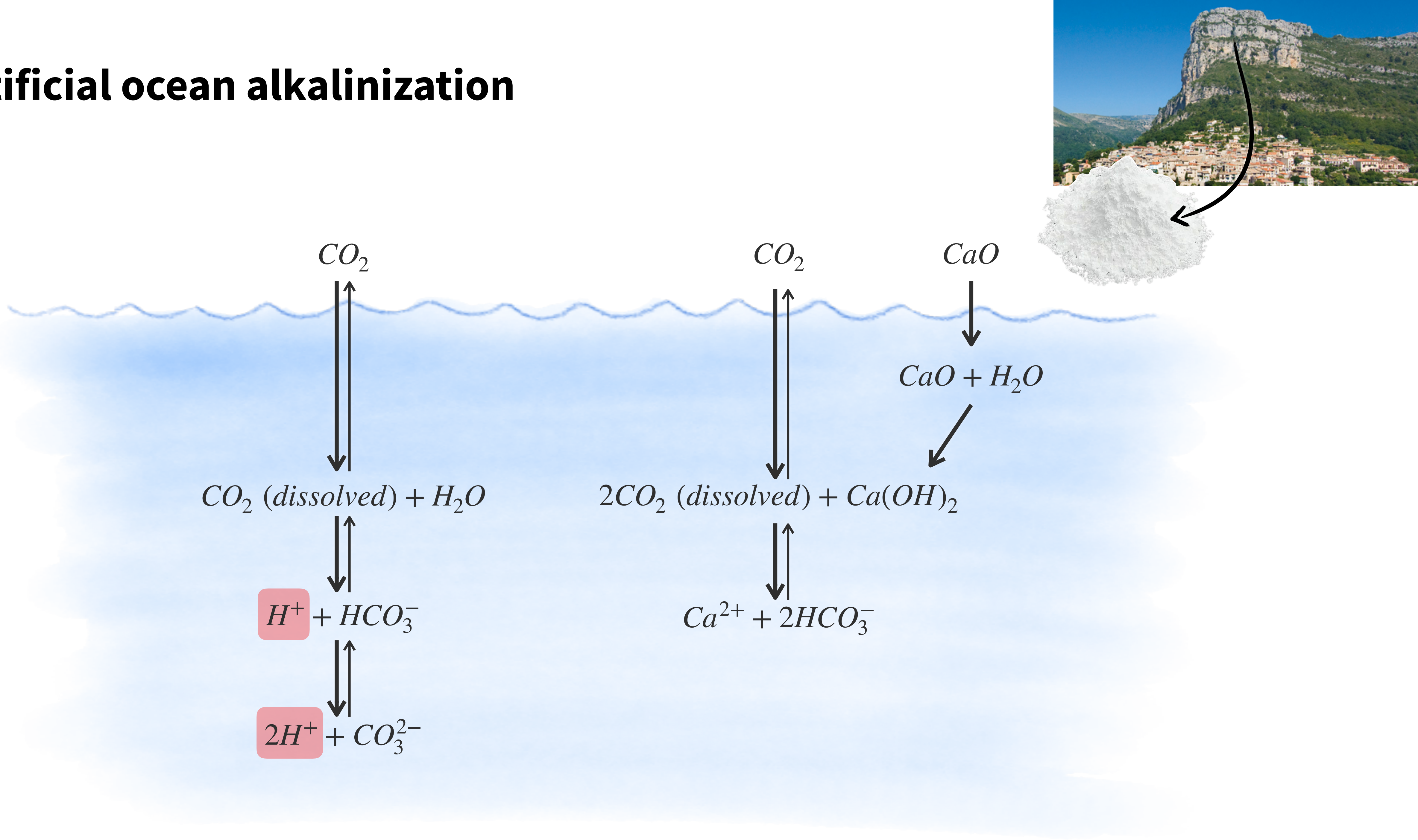
Artificial ocean fertilisation



Artificial ocean alkalization



Artificial ocean alkalization

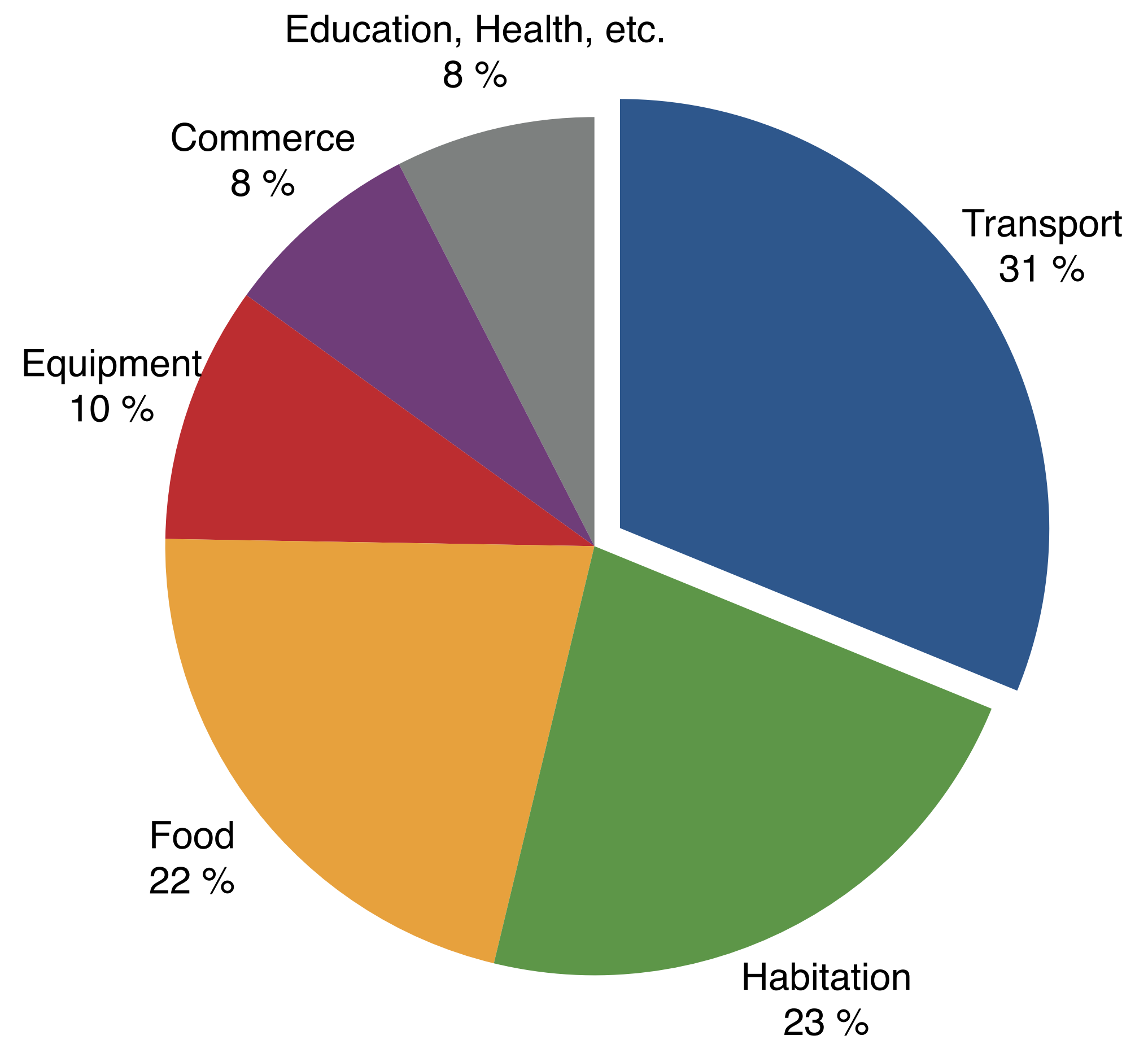
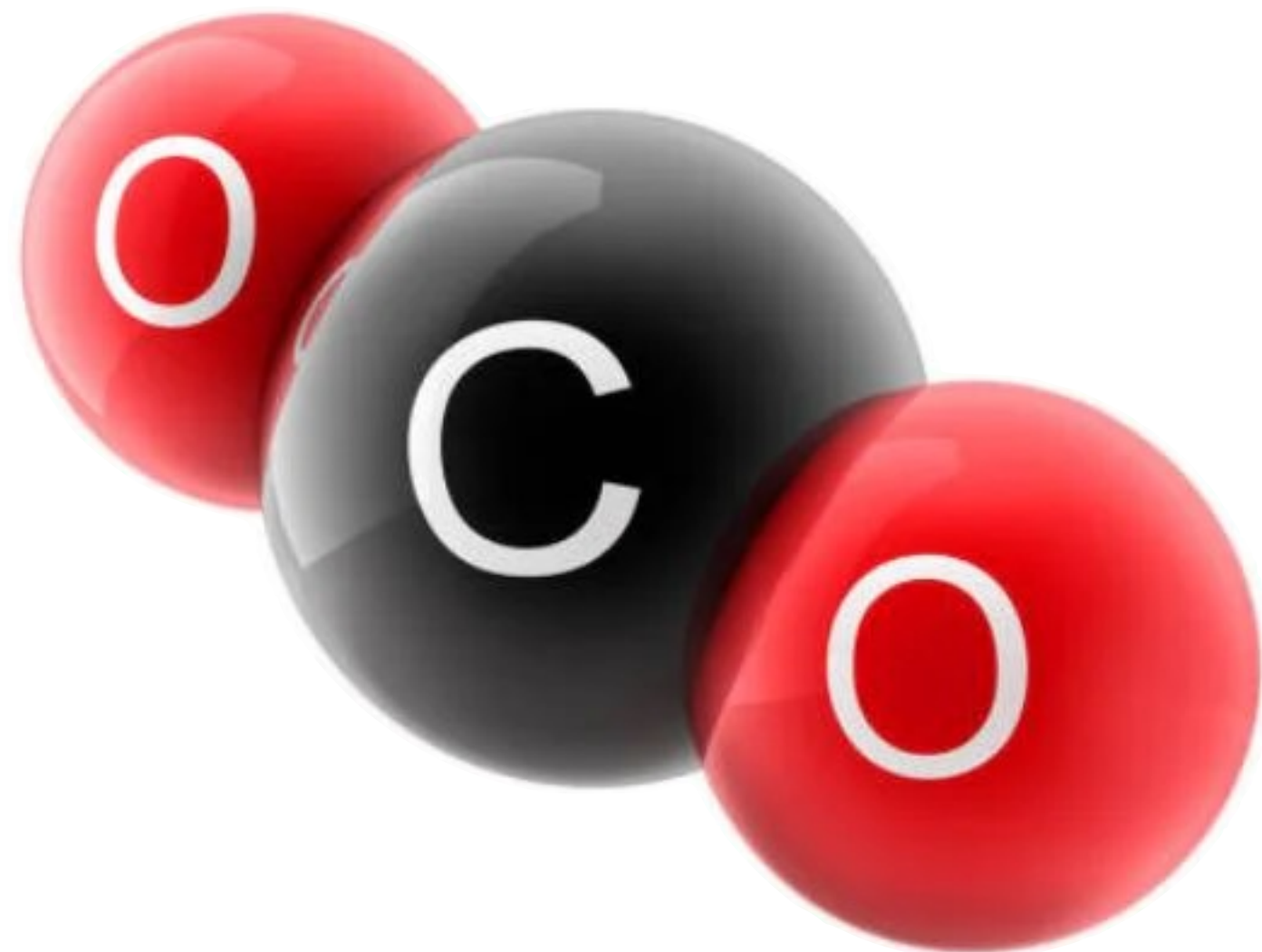


Questions

What is the main source of disruption of plankton biodiversity?

What is the best solution to reduce this source?

Answers



A wide-angle photograph of a calm, deep blue ocean stretching to the horizon under a clear, light blue sky. The water's surface is covered in gentle, rhythmic ripples. Centered over the ocean is a quote in a white, handwritten-style font with a thin black outline.

*In the ocean, the invisible world
often controls the visible one*