AIV presentation
14/10/05

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Global diversity patterns of marine phytoplankton and zooplankton

X.Irigoien, J.Huisman and R.P.Harris

Nature **429**, 863-867 (2004)

Presentation's overview

- Introduction
- Methodology explanation
- Critical presentation of the principal results
- Supplementary experiments' proposals and discussions
- Conclusion

Article’s aims

- Abstract beginning:

  « Although the oceans cover 70% of the Earth's surface, our knowledge of biodiversity patterns in marine phytoplankton and zooplankton is very limited compared to that of the biodiversity of plants and herbivores in the terrestrial world. Here, we present biodiversity data for marine plankton assemblages from different areas of the world ocean.[...] »

- Questions:
  - ➔ What is biodiversity? How to measure it?
  - ➔ What does it mean? How to explain it?

Definitions

- Plankton:
  - Set of organisms that float or drift in water
- Biomass:
  - Mass measurement of living beings, (common unity: carbon)
- Biodiversity (here):
  - Diversity of living beings: number of species in an ecosystem (specific richness), number of individual in each species, ...

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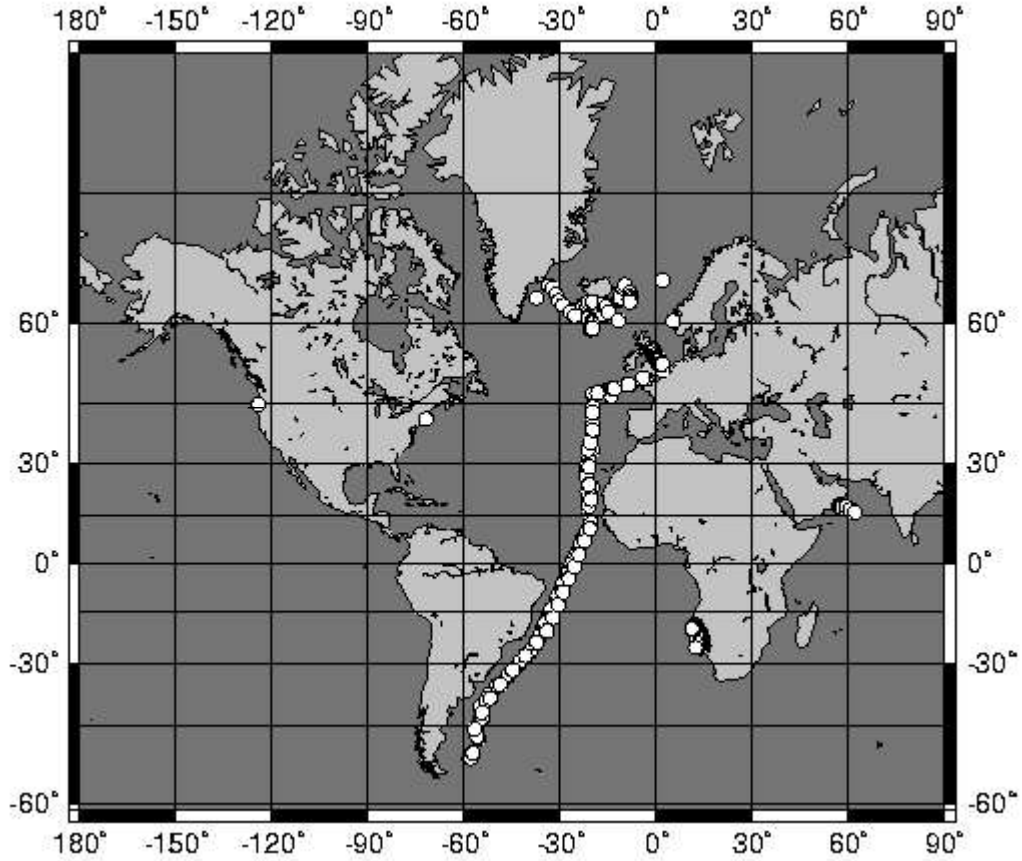
Methodology

- How to estimate biodiversity in the oceans?
  - Sampling
  - Plankton observation, species recognition, and counting
  - Biomass estimation
  - Diversity index calculation
  - Simple and multiple regression (statistics)

Sampling location choices



Prelevements map

Sampling

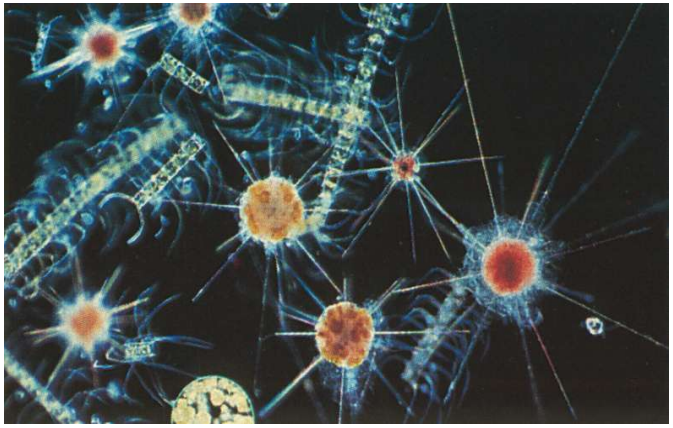
- How to sample?
  - Materiels: bottles, nets

  - Sample size
  - Depth choice: With maximum plankton concentration

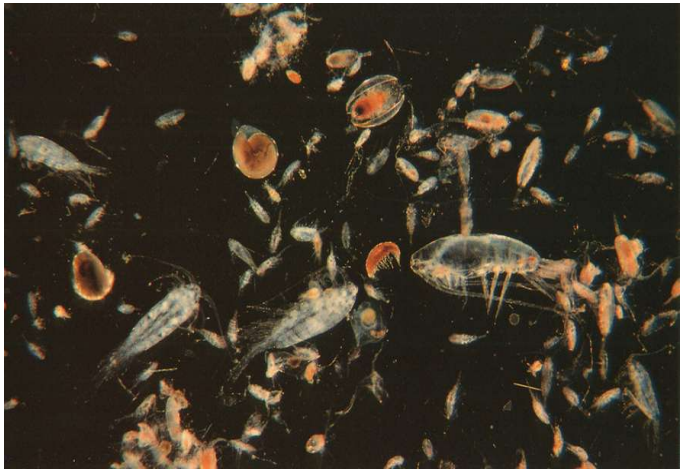
- Sample fixation

Plankton observation

- Fonctional distinction:
  - Phytoplankton:
    - Unicellular algae
    - photosynthetic organisms (autotrophic)

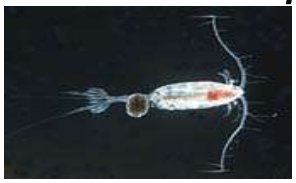


  - Zooplankton:
    - animal (one or several cells)
    - herbivores or carnivores (heterotrophic)



Species recognition

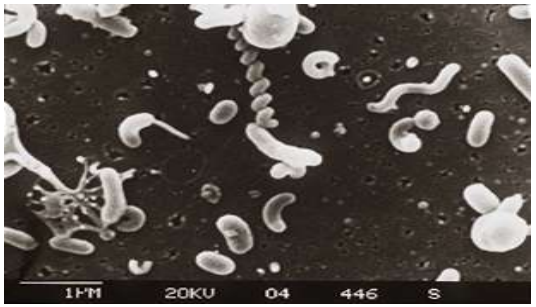
- Size distinction:
  - Mesoplankton *(200-20.000 µm)*
    - *Copepods*

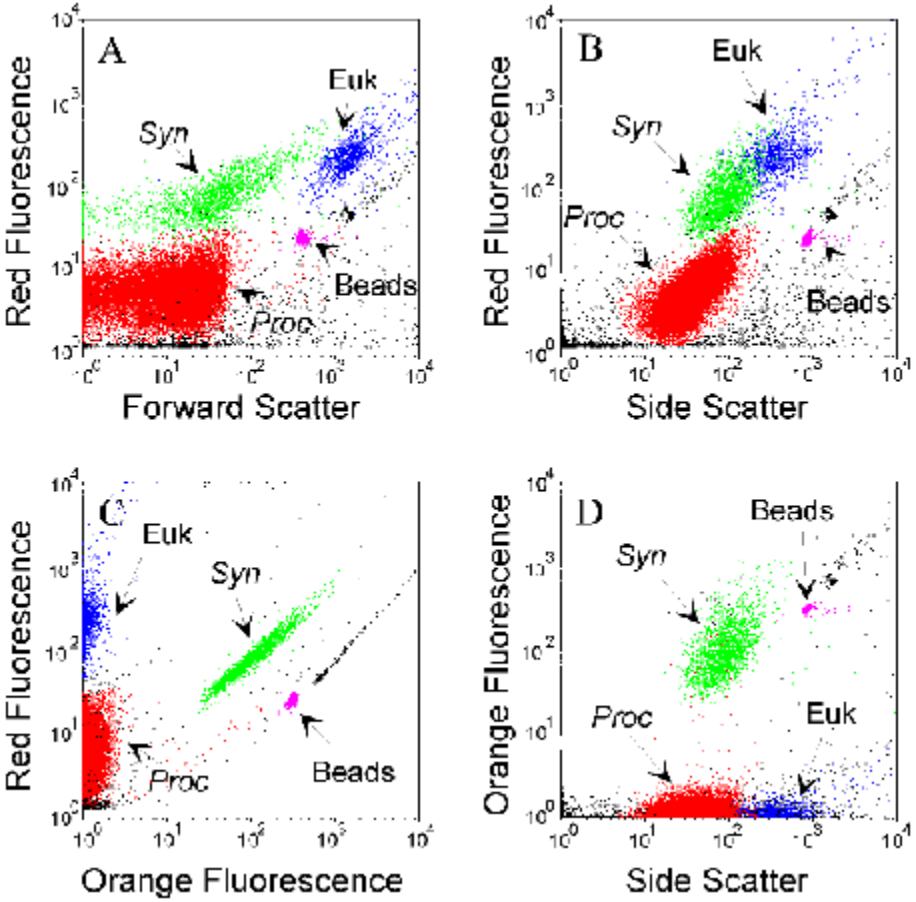


  - Microplankton (20-200 µm)
    - *Dinoflagelates*
    - *Ceratium, diatoms,*

  - Nanoplankton (2-20 µm)
  - Picoplankton (0,2-2 µm)
    - *Prochlorococcus,Synechococcus*

Picoplankton
(0,2-2µm)





Flow cytometry analysis: The analysis of the fluorescence of natural photosynthetic pigments (chlorophyll, phycoerythrin) allows the identification of different groups that differ in terms of size and pigment contents. Synechococcus population (Syn, green), Prochlorococcus cells (Proc, red) , Picoeukaryotes (Euk, blue)

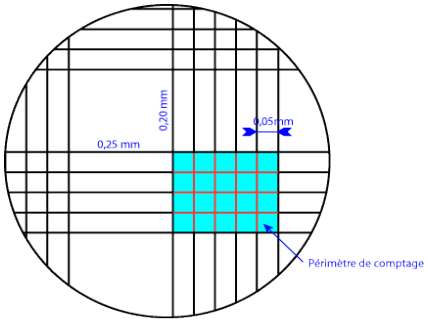
Counting methodology

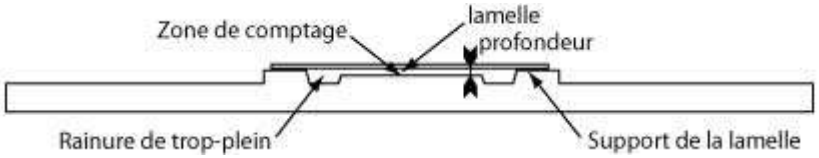
- Automatic measurement
  - Flow cytometry

  - Image analysis, shape recognition
    - Exemple: zooscan

Manual Counting

- Microscopy
  - Mallassez cell





- Binocular glass
  - Dollfus counting cell

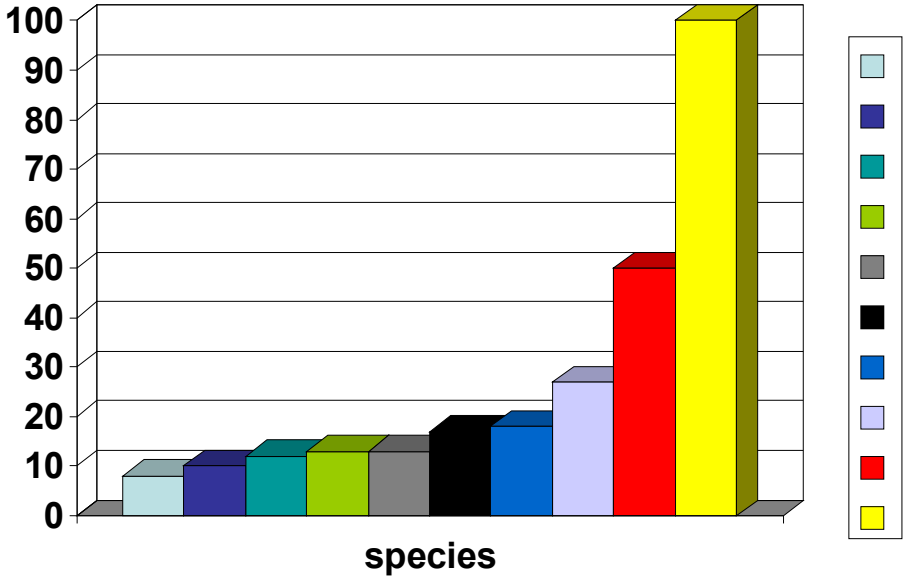
Biomass measurement

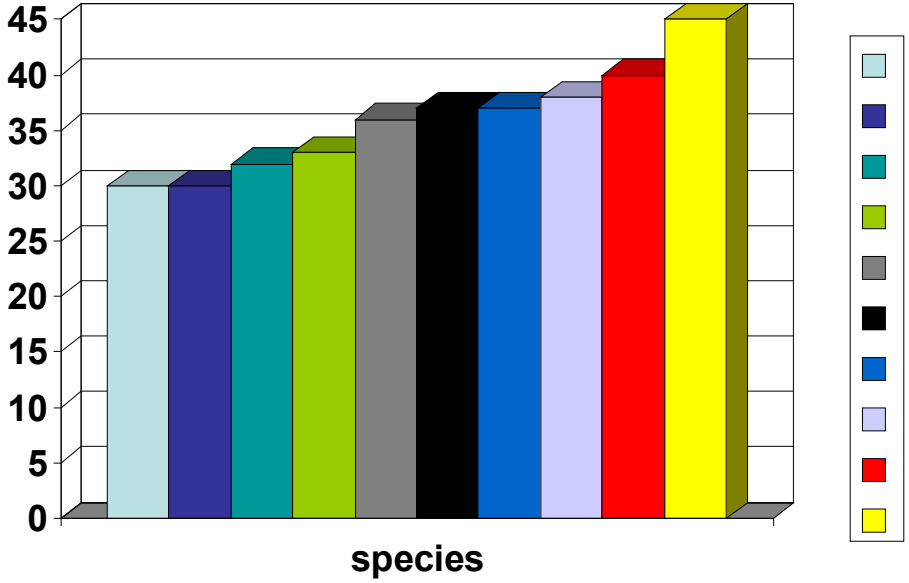
- Direct measurement?

- Indirect methods:
  - Relationship with cell volume:
    - phytoplankton
    - dinoflagelates
  - Species-specific conversion factors
    - copopods

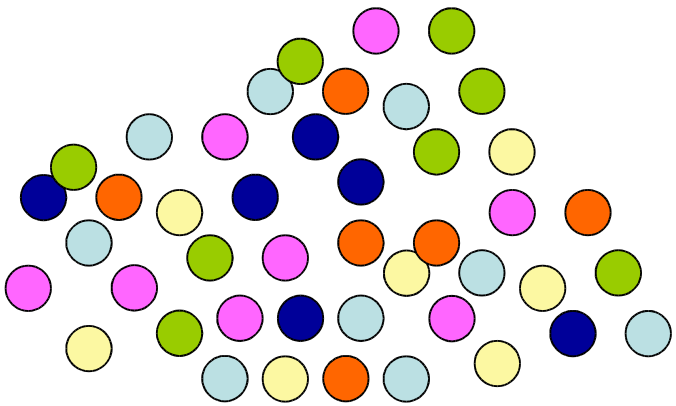
Biodiversity indexes

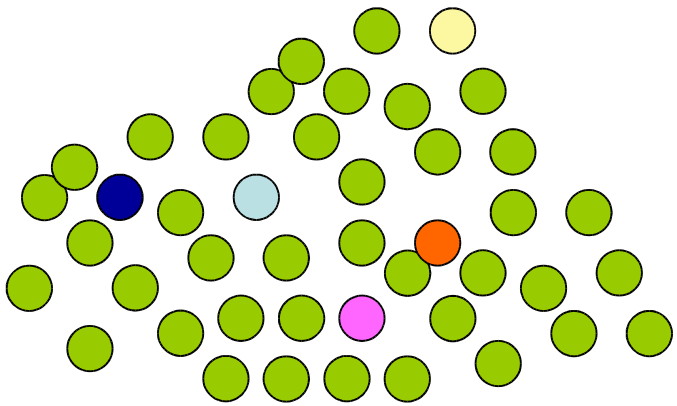
- Number of species





Simpson index

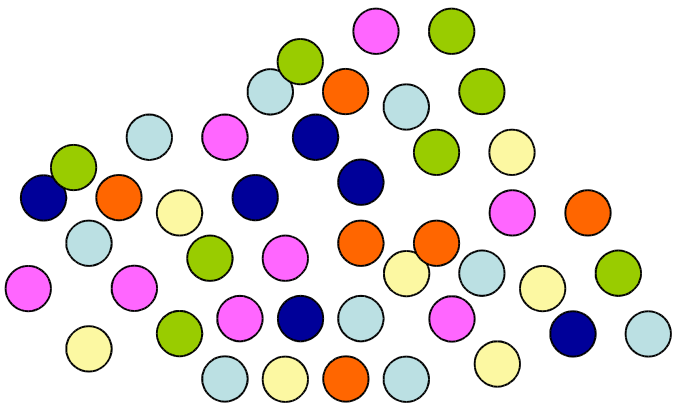


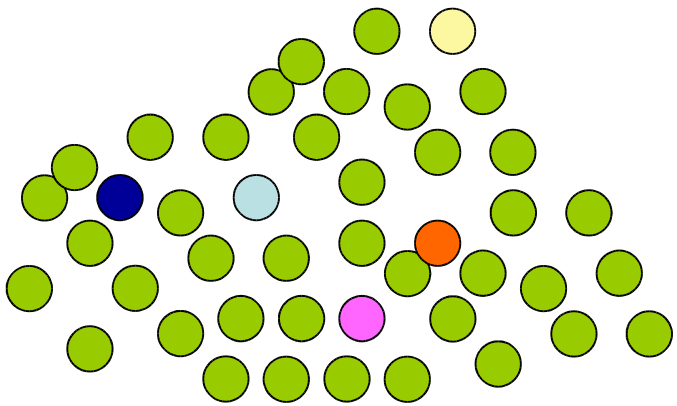


$$Simpson = \sum_{1}^{S} \frac{n_i(n_i - 1)}{N(N-1)}$$

$$Diversity = 1 - Simpson$$

Shannon-Weaver index





$$Shannon = -\sum_{1}^{S} \frac{n_i}{N} ln_2(\frac{n_i}{N})$$

$$Diversity = \frac{Shannon}{ln_2 S}$$

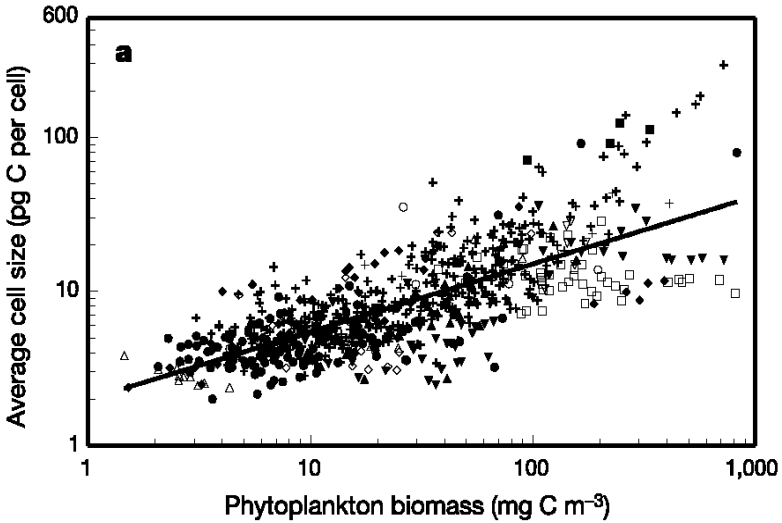
Hill index

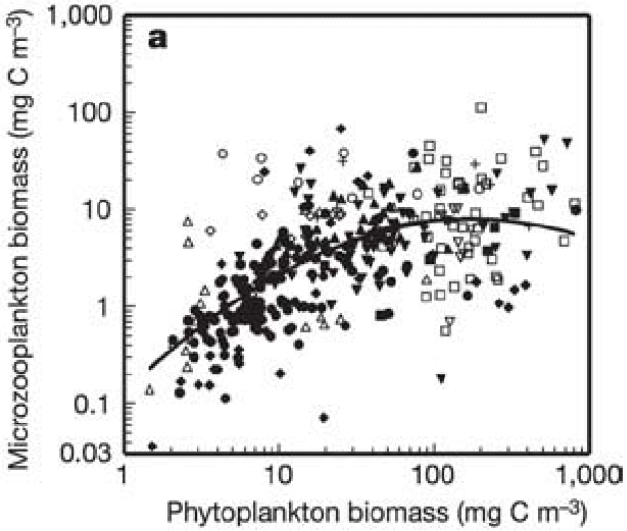
$$Hill = \frac{1}{Simpson} e^{-Shannon}$$

$$Diversity = 1 - Hill$$

Data treatment

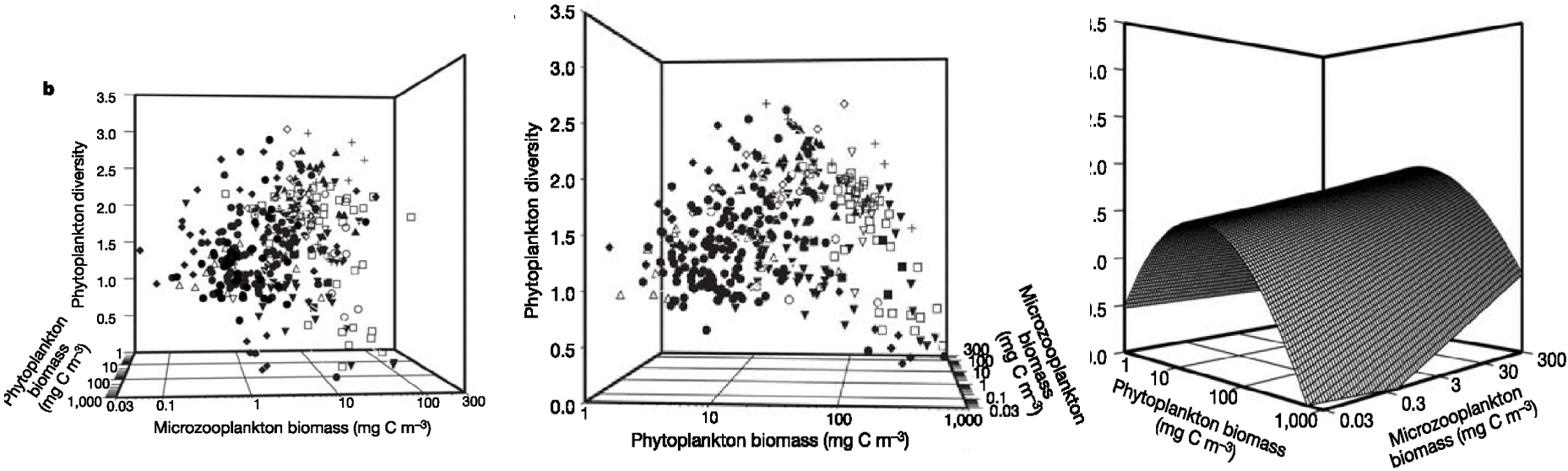
$$y = ax + b \qquad\qquad y = a + bx + cx^2$$





$$R^2 = 1 - \frac{\sum \left(y_i - y_{i,estimated}\right)^2}{\sum \left(y_i - y_{mean}\right)^2}$$

Data treatment



$$y = a + bx_1 + cx_1^2 + dx_2 + ex_2^2 + fx_1x_2$$

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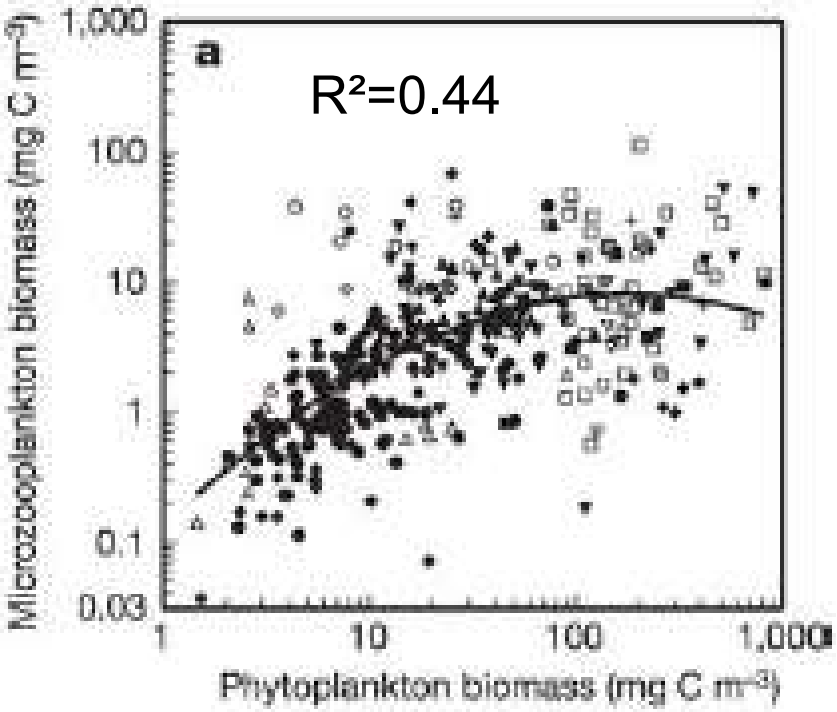
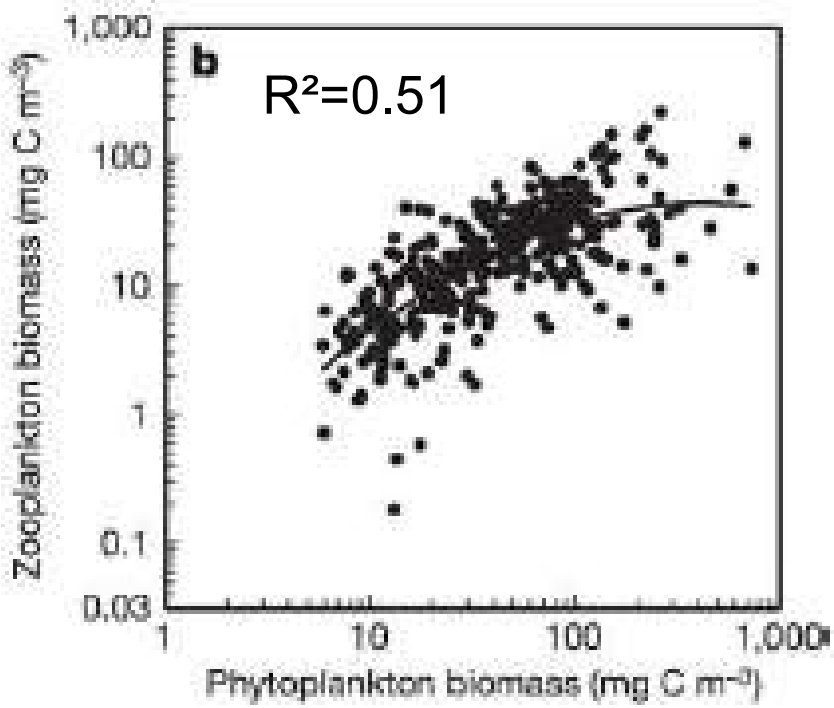
Results

- Abstract:

« [...] Similar to terrestrial vegetation, marine phytoplankton diversity is a unimodal function of phytoplankton biomass, with maximum diversity at intermediate levels of phytoplanton biomass and minimum diversity during massive blooms.
Contrary to expectations, we did not find a relation between phytoplankton diversity and zooplankton diversity.
Zooplankton diversity is a unimodal function of zooplankton biomass.
Most strikingly, these marine biodiversity patterns show a worldwide consistency, despite obvious differencies in environmental conditions of the various oceanographic regions [...] »

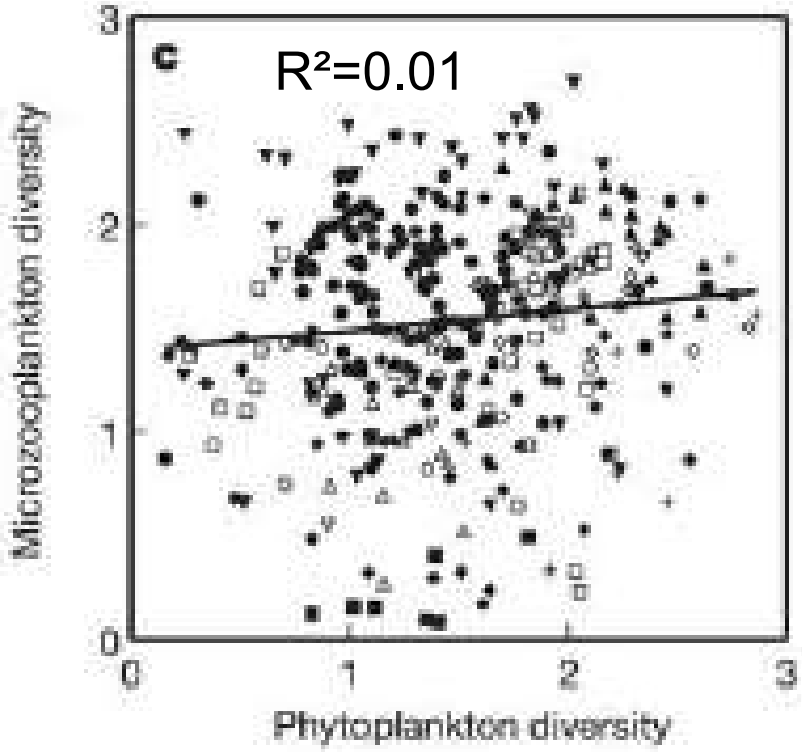
Phytoplankton biomass and zooplankton biomass

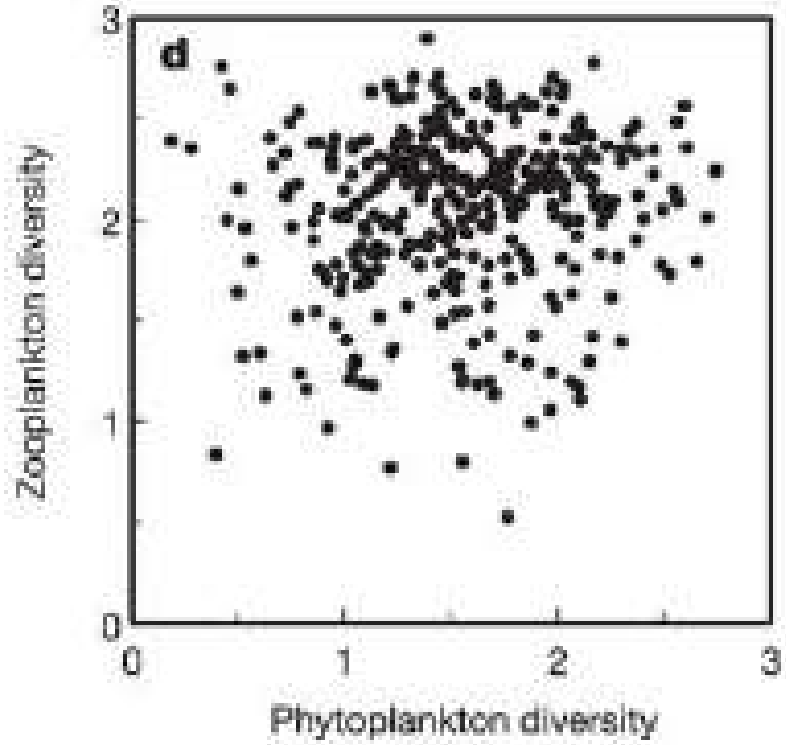




- No hypothesis to explain the saturation

No correlation between phytoplankton diversity and zooplankton diversity

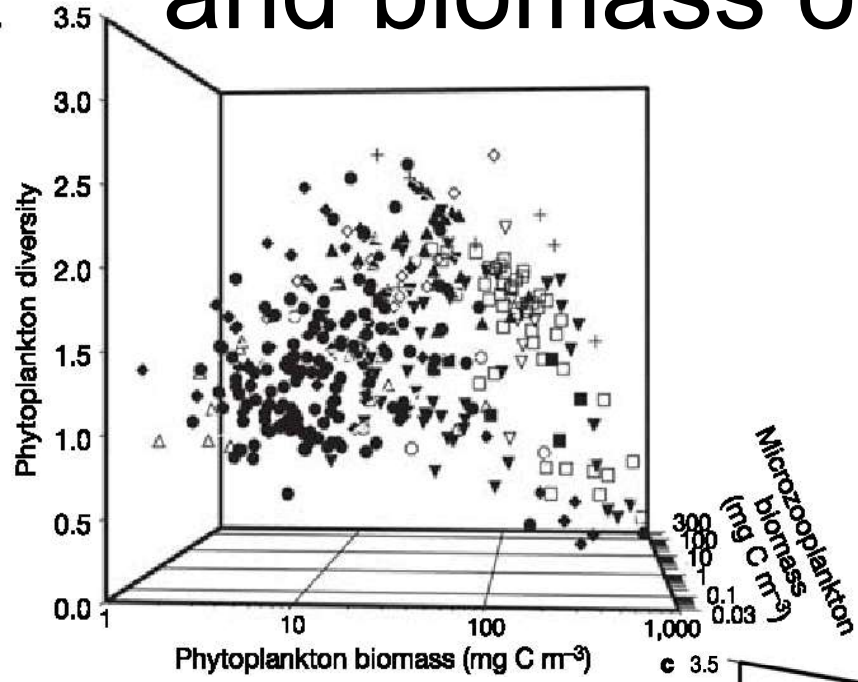


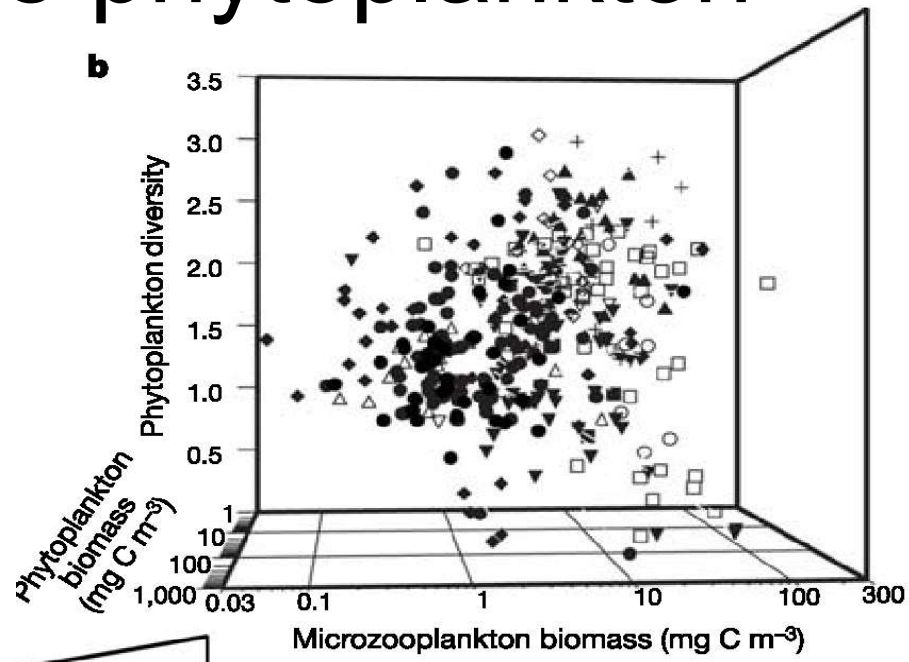


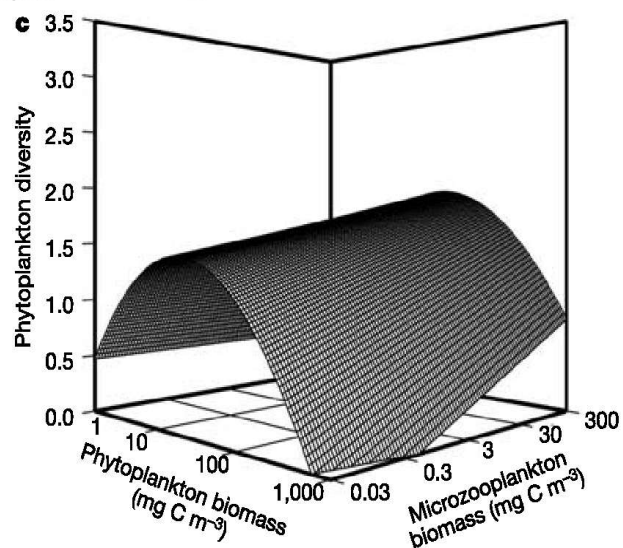
Unexpected result

- Proposed explanation : less structured marine environments, and less specialized zooplankton
- How to check it?

Unimodal relation between diversity and biomass of the phytoplankton

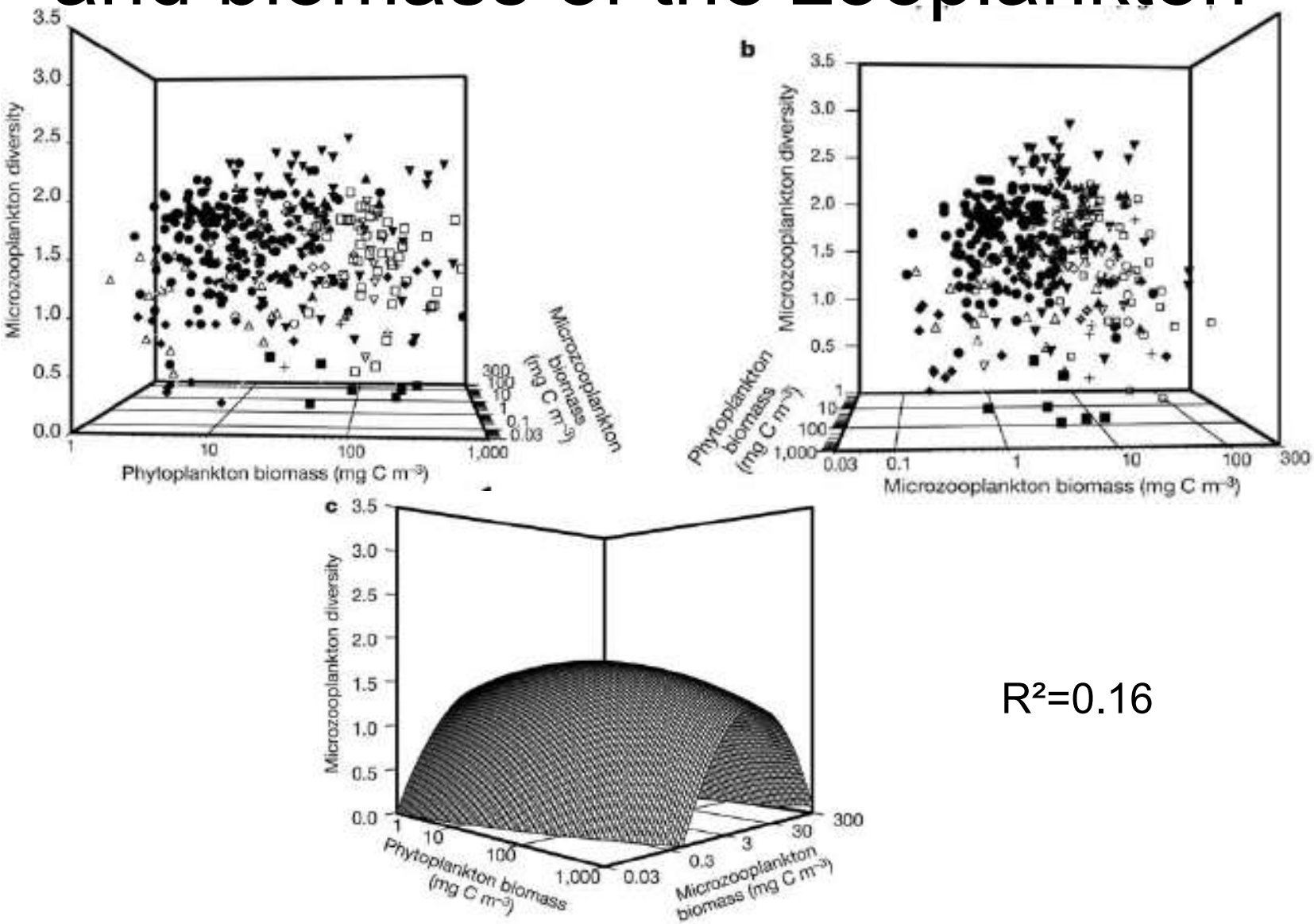






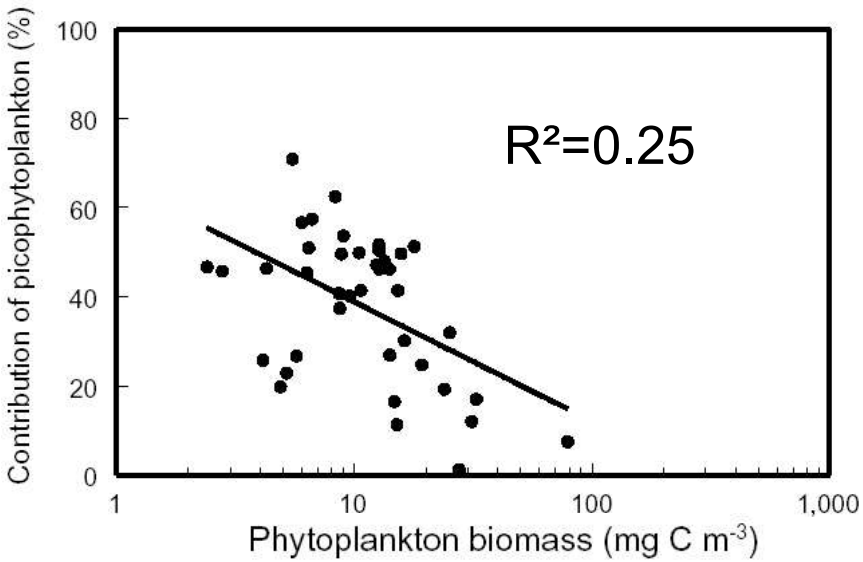
$R^2=0.21$

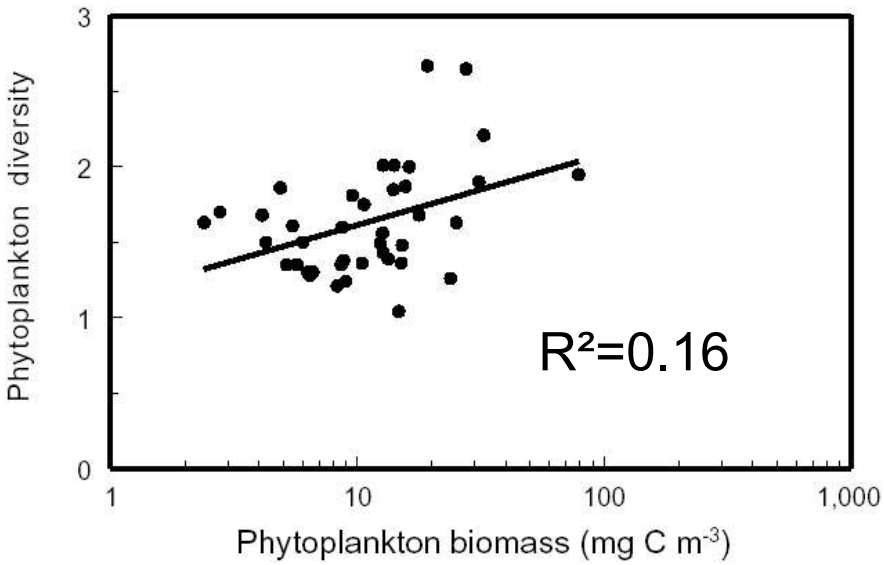
Unimodal relation between diversity and biomass of the zooplankton



R^2=0.16

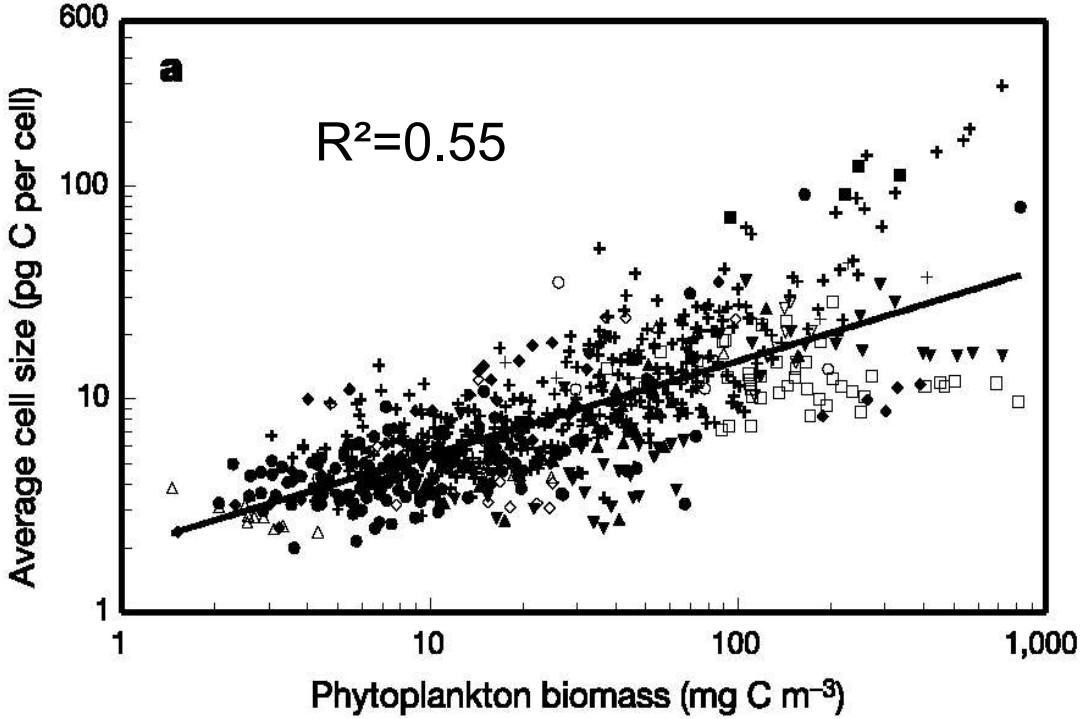
Hypothesis 1: limiting nutriments at low biomass





- When low nutriments concentration, codomination of few picoplankton species
- How to check it?

Hypothesis 2: predation limits the species number at high biomass

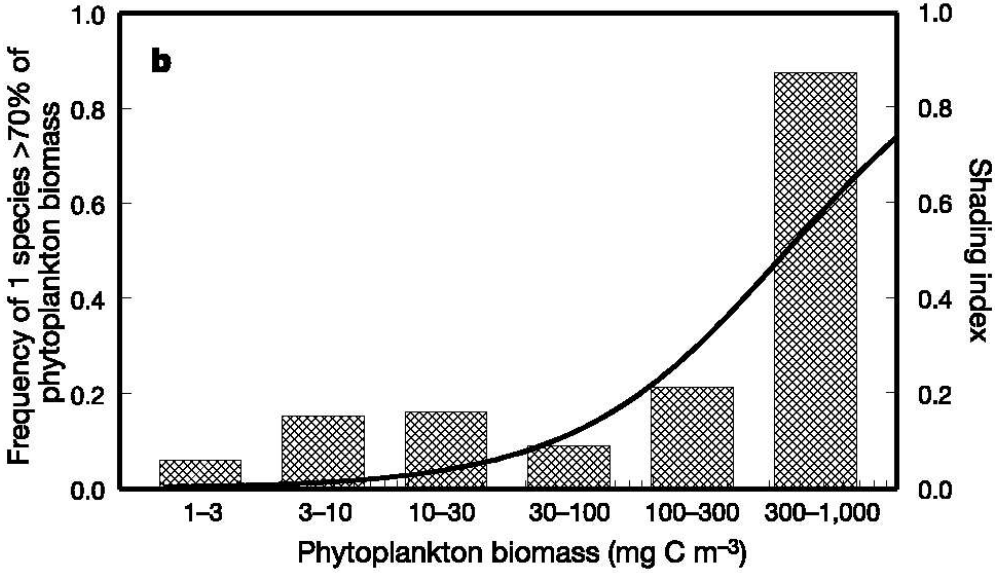


- At high phytoplankton biomass, only the big or protected phytoplanktons are able to bloom, because they are less affected by grazing
- How to check it?

Hypothesis 3: light

- The more the biomass, the more the light is absorbed
- A way to measure it : shading index
- Does this rarefaction of light explain the lower diversity? How to check it?

$$Shading = \frac{kC}{kC + k_{bg}}$$



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Supplementary experiments' proposals

- A different analysis of the data:
  - Estimating a diversity index based on
    - a single level of the phylogenic tree
    - species' fonctional position
    - individuals' size
  - Grouping results by sampling date to test a seasonal effect

Supplementary experiments' proposals

- New experiments to test their explanations:
  - Herbivory effect on diversity
    - dynamics?
    - influence of herbivory pressure on phytoplankton diversity?
    - specialization of the herbivores and diversity?
  - Light competition, shading, and bloom

Discussion on Biodiversity

- Definition problems
- What does it mean? Interest?
- How to explain it?
- How to create it? How to maintain it?
- Dynamic aspects?

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Conclusion

- Main results and interests
- Weakest/strongest point(s)
- Biodiversity studies