



# The French Alpine Lakes Observatory (ALO): a tool for assessing the effects of the global change on lake ecology

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SPECIAL SESSION « Assessing the impacts of global change and anthropogenic pressures on freshwater ecosystems, a role for long term-ecological research.

# The French Alpine Lakes Observatory (ALO): a tool for assessing the effects of global change on lake ecology.

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# The Alpine Lakes Observatory

- French part of the Alps
- 3 lakes



LAC	Volume (km <sup>3</sup> )	Temps de séjour (an)	Profondeur max (m)	Surface BV (km <sup>2</sup> )
LEMAN	89	12	310	7395
BOURGET	3,6	8,5	145	580
ANNECY	1,12	3,8	82	251

## OBJECTIVES

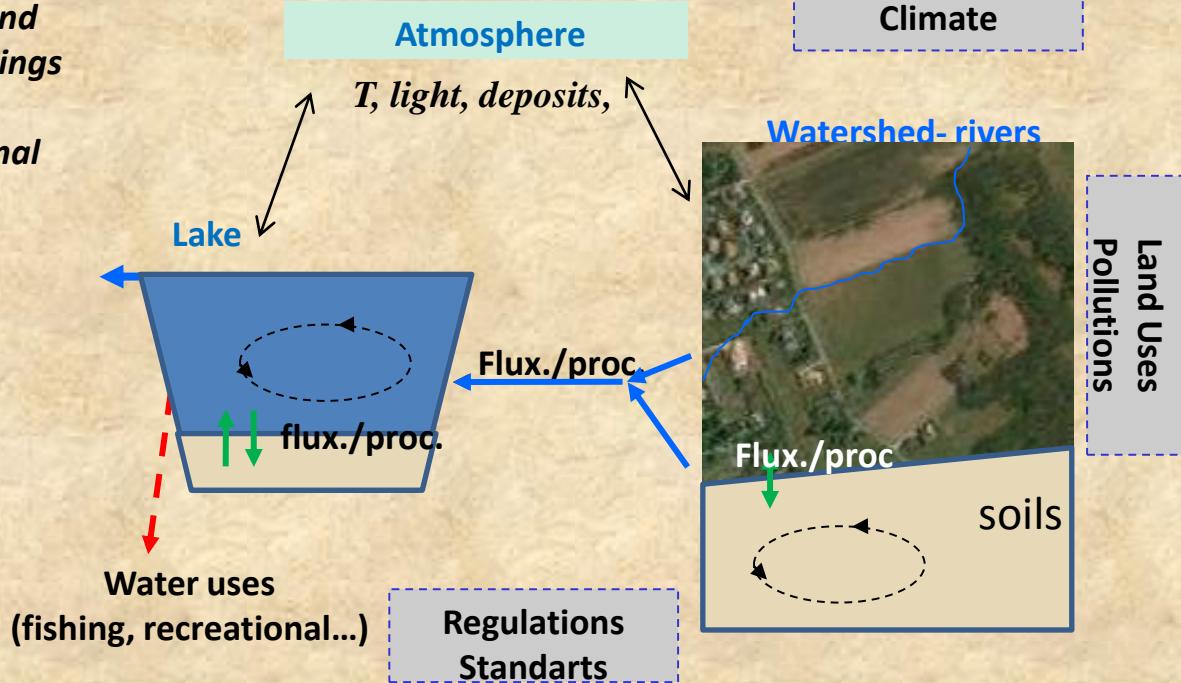
« Scrutinizing, understanding and modelling the trajectories and the ecological mechanisms controlling the lake systems exposed to changes in anthropic and climatic pressures, at a 10 years time steps ».

# The ALO

- 3 Sub systems and specific functionnings

- Fluxes and internal exchanges

- External drivers



- Long term surveys (state variables)
- Biological and physicochemical processes controlling water quality and productivity
- Ecological trends
- Global change consequences

Long-term Limnology

> 10 years

ALO

- Functional ecology
- Fluxes assessment
- Trophic functionning and biodiversity

Short and mid term processes

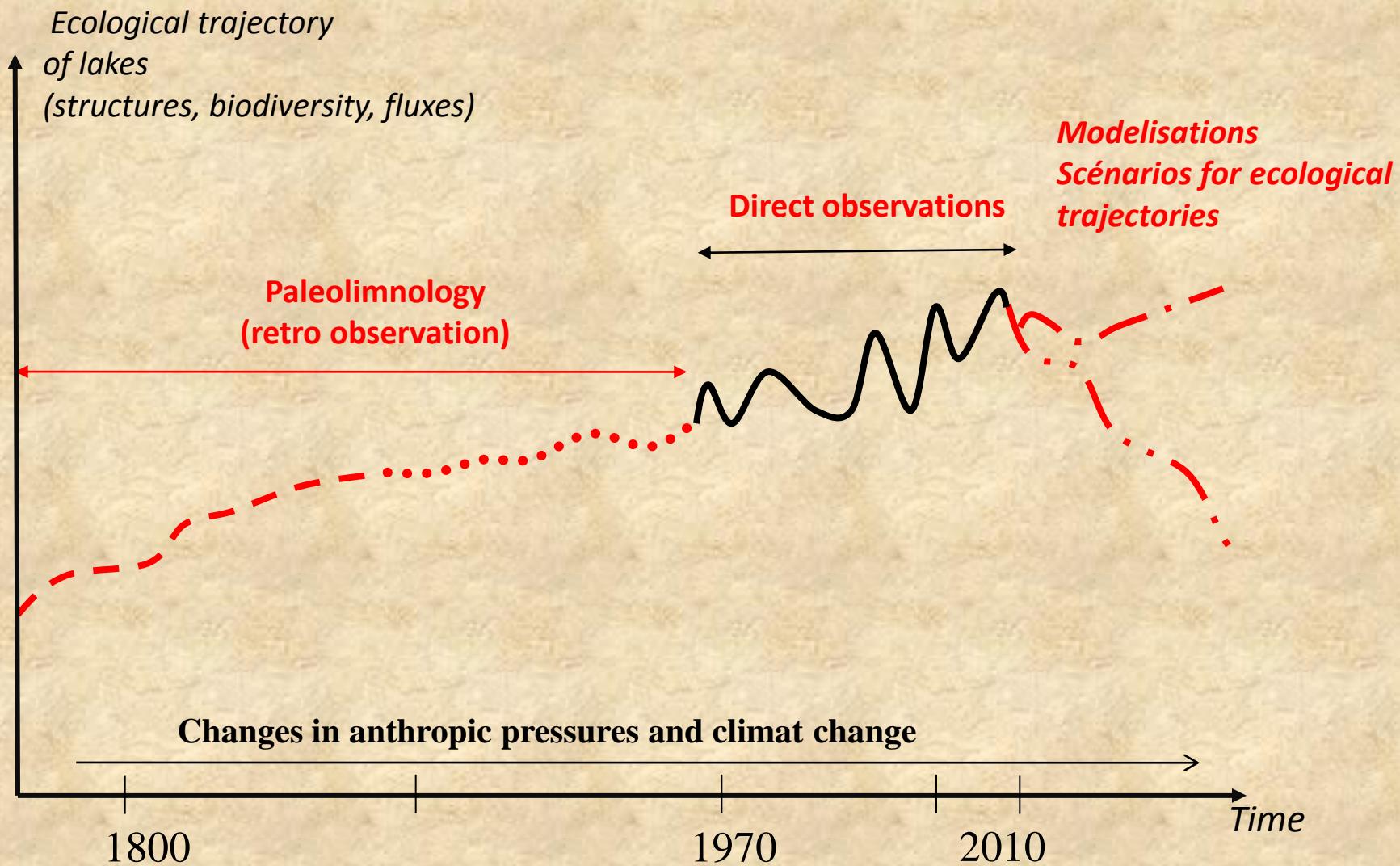
1 < < 10 years

Associated projects

- small mountain lakes
- BPC ecodynamic

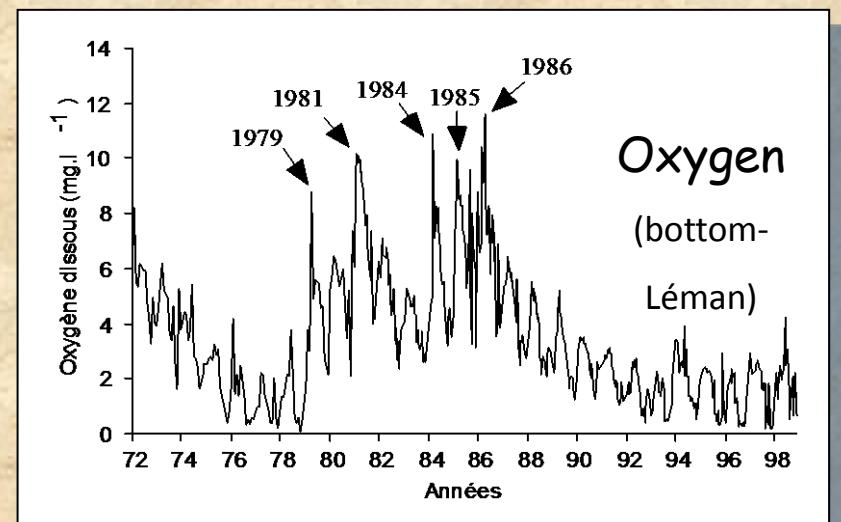
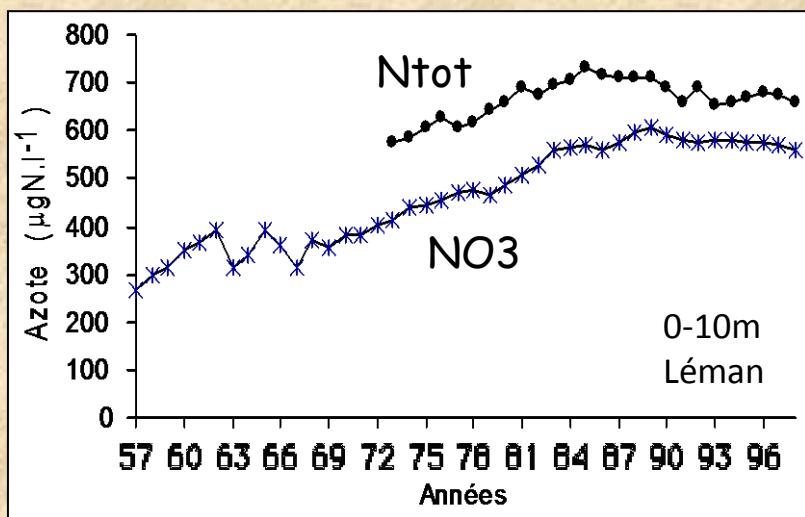
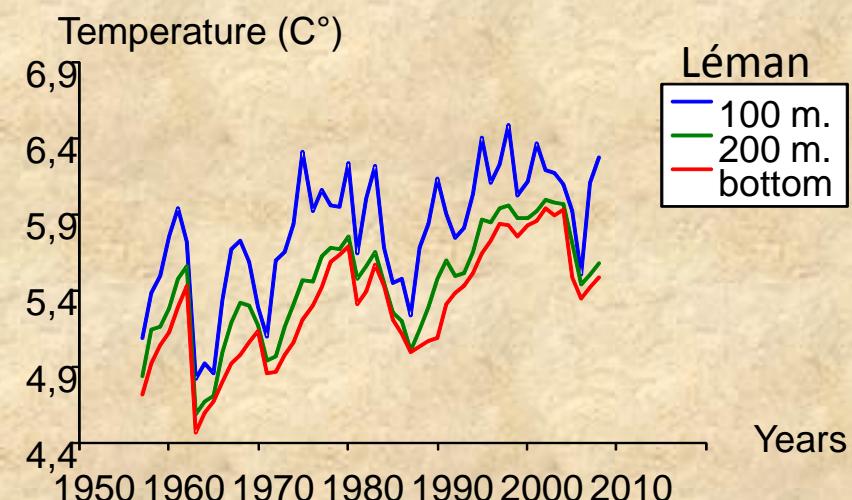
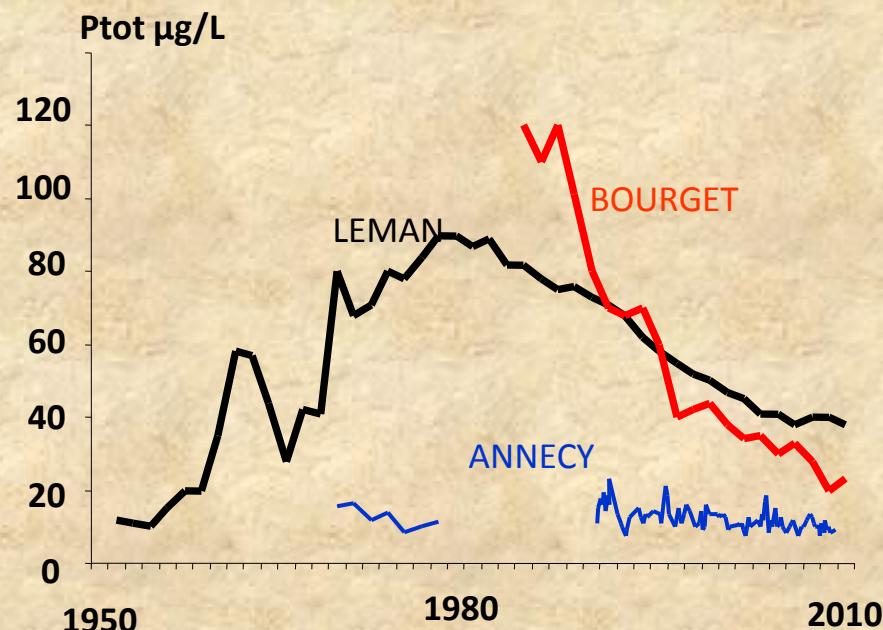
- Scientific knowledge
- Tools for lake managers

# 1/ Long term observations



# 1/ Long term observations: the global physico-chemical changes

Anneville 2010, pers com



# 1/ Long term observations: trophic network dynamics (Leman)

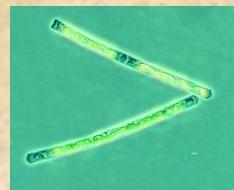
Anneville 2010, pers com



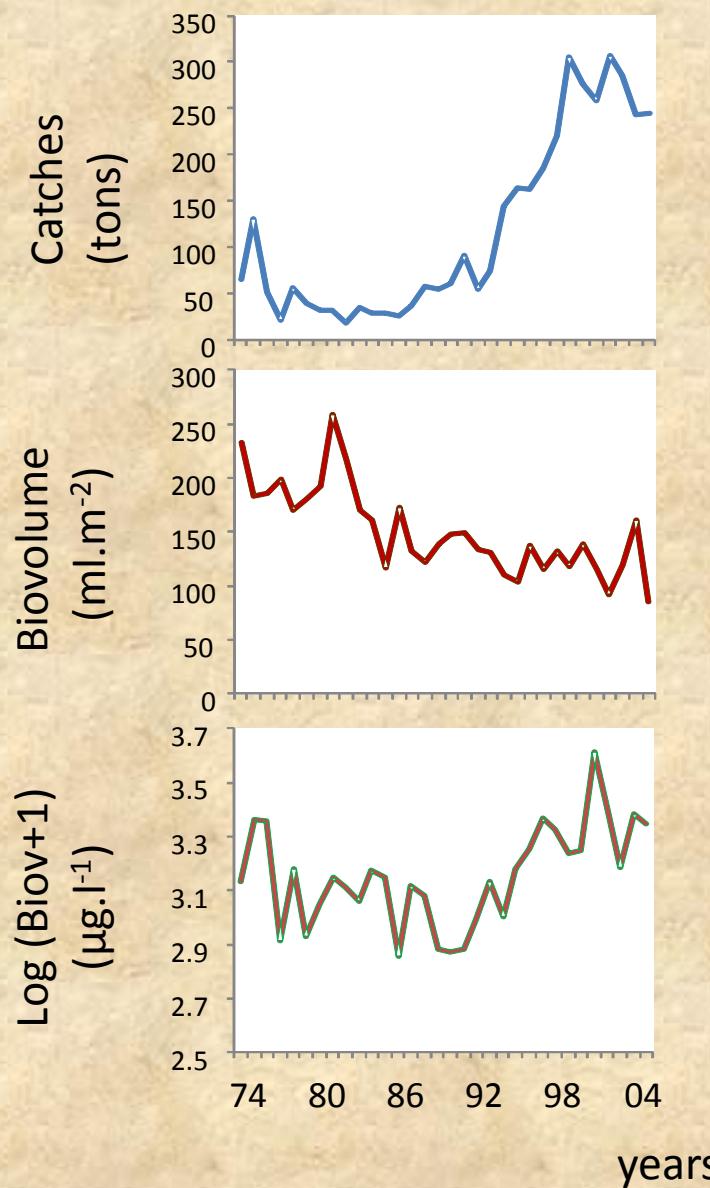
Whitefish



Zooplankton



Phytoplankton



Increasing predation

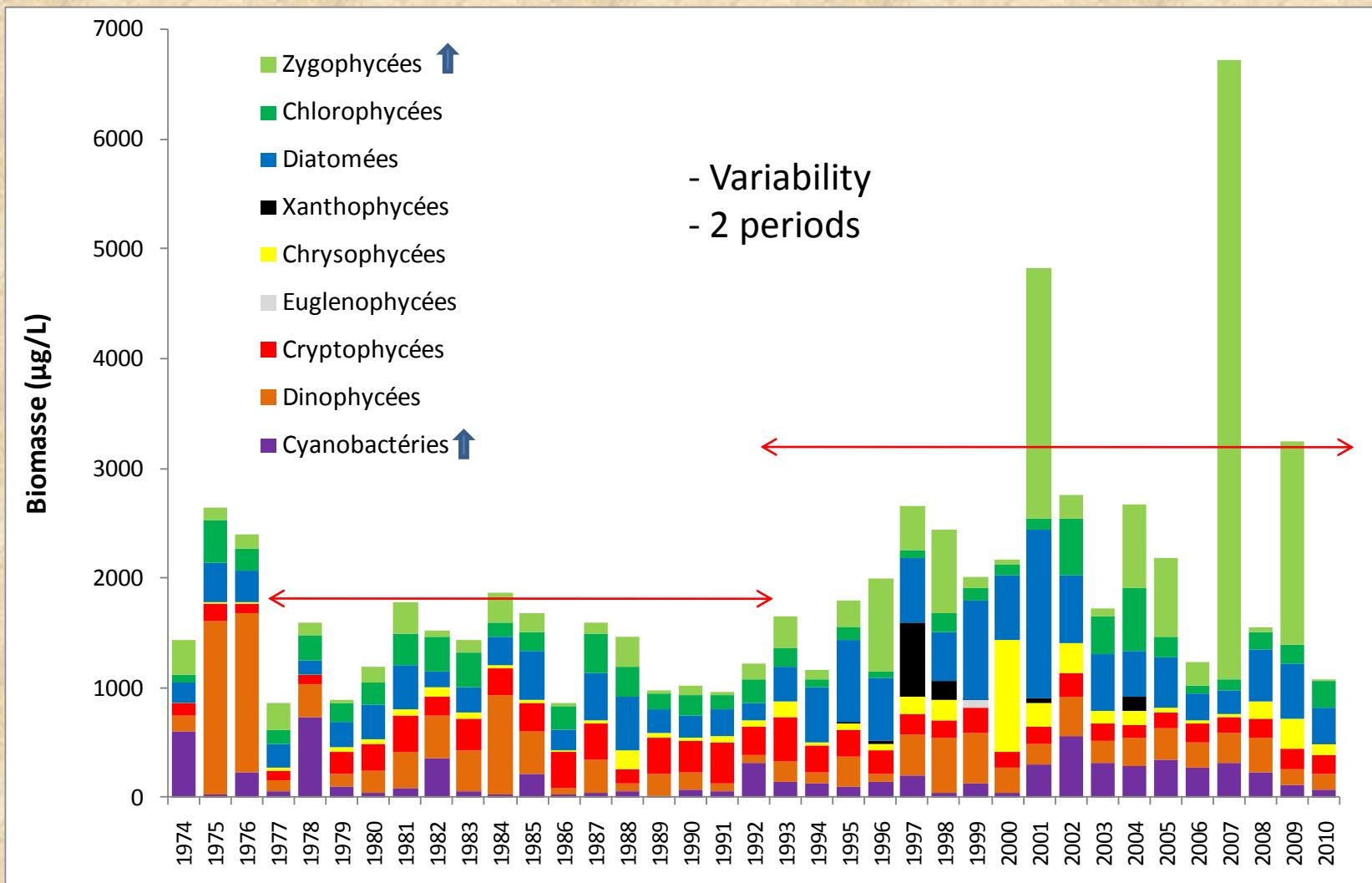
Decreasing ZoopK  
biomass

increasing PhytopK  
biomass

→ Long-term changes in the functioning of the pelagic communities

# 1/ Long term observations: algae diversity

Anneville 2010, pers com



→ Long-term changes in the diversity of planctonic communities

# 1/ Long term observations: Paleolimnology

Perga M-E, 2010, Limnol Oceanogr.

Study of sediment cores:

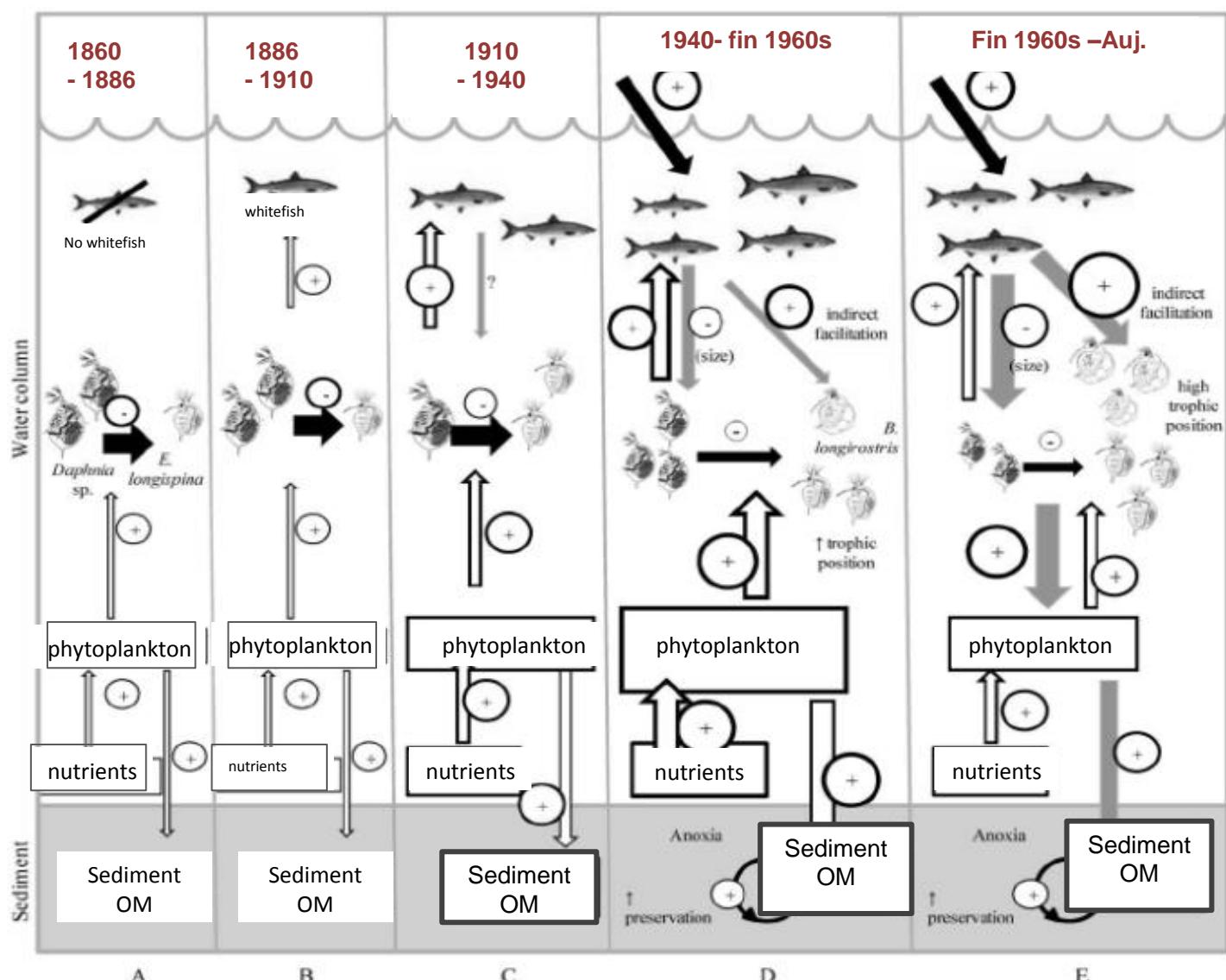
- Macro remains of organisms
- Preserved macro-molecules (pigments)
- Isotopic characteristics of remains and OM ( $^{13}\text{C}$  and  $^{15}\text{N}$ )



150 years of bottom-up and top-down response of trophic network (Lake Annecy)



Conceptual model on changes of trophic network



## 2/ Short term observations: microbial loop changes (Le Bourget)

Domaizon & Comte, 2006

	Early spring (March – April)	Clear water phase (May)	Early summer (June – July)
Conceptual scheme for upper layers (2, 6, 10 m depth)	<pre> graph TD     HB[Heterotrophic bacteria] --&gt; F[Flagellates]     HB --&gt; M[Mixotrophs]     F --&gt; C[Ciliates]     C --&gt; Z[Zooplankton]     M --&gt; Z   </pre> <p>The diagram illustrates the energy flow in the upper layers of the water column (2, 6, 10 m depth). It shows a vertical stack of trophic levels: Heterotrophic bacteria at the bottom, followed by Flagellates and Mixotrophs, then Ciliates, and finally Zooplankton at the top. Arrows indicate the direction of energy transfer between adjacent levels. In the early spring (March–April) and clear water phase (May), the Flagellates layer is highlighted with a red box. In the early summer (June–July), the Zooplankton (Copepods) layer is highlighted with a red box.</p>	<pre> graph TD     HB[Heterotrophic bacteria] --&gt; F[Flagellates]     HB --&gt; M[Mixotrophs]     F --&gt; C[Ciliates]     C --&gt; ZC[Zooplankton Cladocerans]     M --&gt; ZC   </pre> <p>This row contains the same conceptual scheme as the first, but with a different trophic structure. The Zooplankton layer is specifically identified as "Zooplankton (Cladocerans)" and is highlighted with a red box. The other layers (Flagellates, Mixotrophs, Ciliates) are shown below it.</p>	<pre> graph TD     HB[Heterotrophic bacteria] --&gt; F[Flagellates]     HB --&gt; M[Mixotrophs]     F --&gt; C[Ciliates]     C --&gt; ZC[Zooplankton Copepods]     M --&gt; ZC   </pre> <p>This row contains the same conceptual scheme as the first, but with a different trophic structure. The Zooplankton layer is specifically identified as "Zooplankton (Copepods)" and is highlighted with a red box. The other layers (Flagellates, Mixotrophs, Ciliates) are shown below it.</p>
[Chlorophyll <i>a</i> ]	Peak on 2 April (2m)	Low values	Increase - peak on 3 July (6m)
[Heterotrophic Bacteria]	moderate values	Increase	high values
[Bacterial Filaments]	Peak on 22 April	Low values	Peak on 19 June
Bacterial groups proportion	Dominance of CF	Dominance of CF	Increase of $\alpha$ and $\beta$ proteobacteria
% FDC (bacterial production)	highest values	lowest values	low values
Protozoan grazing	- Moderate to high flagellates grazing rates - Low ciliates grazing impact	- Mainly mixotrophic flagellates predation - Low ciliates and heterotrophic flagellates grazing impact	peak on 3 July - Highest flagellates grazing rates - Large increase in ciliates predation
Regulation pressure	Bacteria regulation : mainly BU (grazing rates lower than bacterial production)	Bacteria regulation : probably simultaneous BU control and TD control due to metazooplankton	Bacteria regulation : mainly BU control although high protozoan predation
TD : Top Down control BU : Bottom Up control	Protozoan regulation : mainly BU, especially during April	Protozoan regulation : mainly TD	Protozoan regulation : mainly BU for flagellates (2 and 6m) and ciliates Mainly predation for flagellates at 10m

  High Predation pressure

→ Main C transfer pathway

## Conclusions:

- ALO has a large database (public access)
- long and short term studies
- paleolimnology and ecological trajectories
- drivers of changes in lake status : fish stocking, phosphorus



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Thank you for attention