The importance of climate for mountain Lake Tovel, a long-term and short-term perspective

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FONDAZIONE EDMUND MACH dal 1874

Lake Tovel:

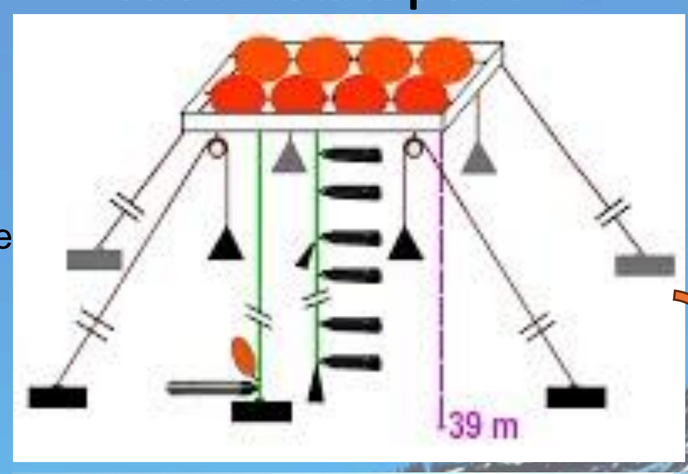
- **Altitude**: 1,177 m above sea level;
- **Area**: 0.4 km^2;
- **Maximum depth**: 39 m
- **Italian long-term ecological research site** (LTER_EU_IT_090) in the Brenta Dolomites
- **Trophic state**: oligotrophic (annual mean values over the whole water column: total dissolved phosphorus (P_{tot}) < 10 µg L^{-1}, dissolved organic carbon < 1 mg L^{-1}, conductivity ~ 180 µS cm^{-1}; coefficient of light attenuation ≤ 0.18, and water transparency > 10 m; depth layer surface to 20 m depth: chlorophyll a < 3 µg L^{-1})
- **Surrounding forest**: spruce forest mixed with *Fagus sylvatica* and *Abies alba*.
- **Classical limnological sampling**: monthly during the ice-free period and once during the ice period since 1995 to present

How does Lake Tovel respond to climate change?

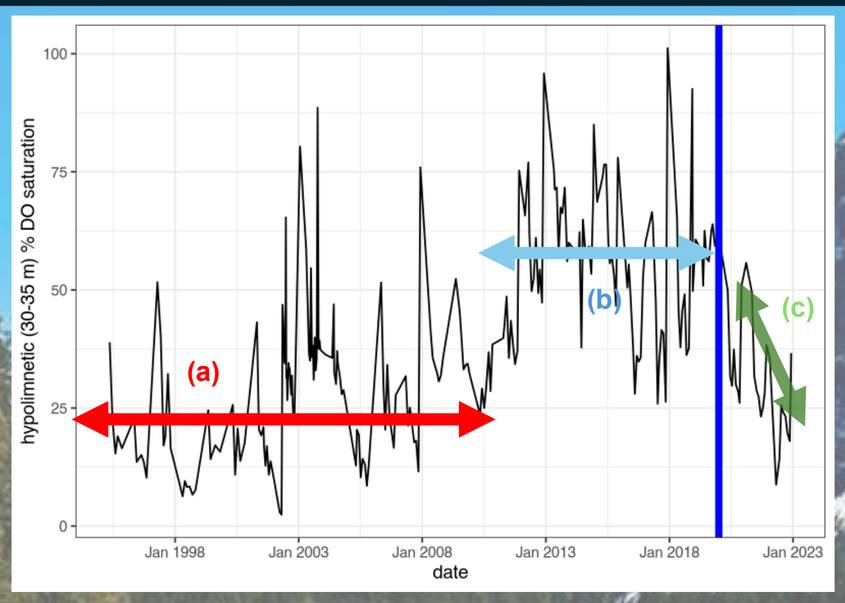
Sensors:
Located over the deepest part of the lake

- temperature
- dissolved oxygen
- conductivity
- light
- water level
- measurements every 30 minutes year-round

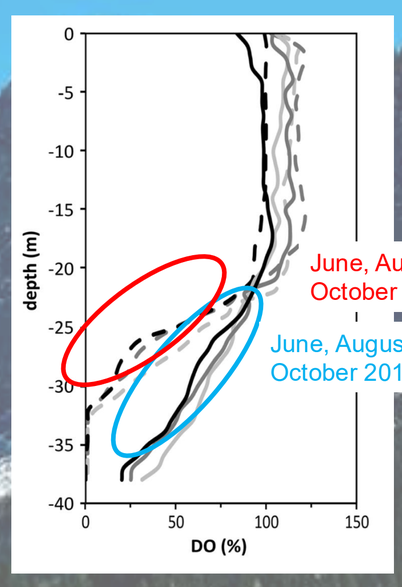
Scientific lake platform



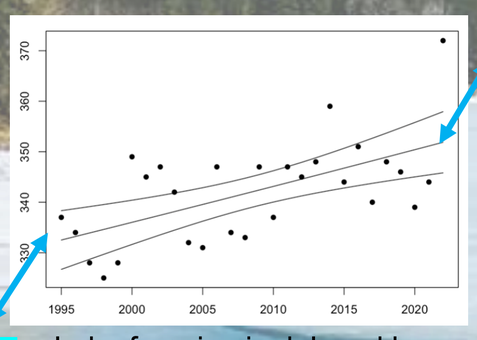
View from south to north. Scientific platform on the right



Temporal hypolimnetic DO evolution from 1995 to 2023



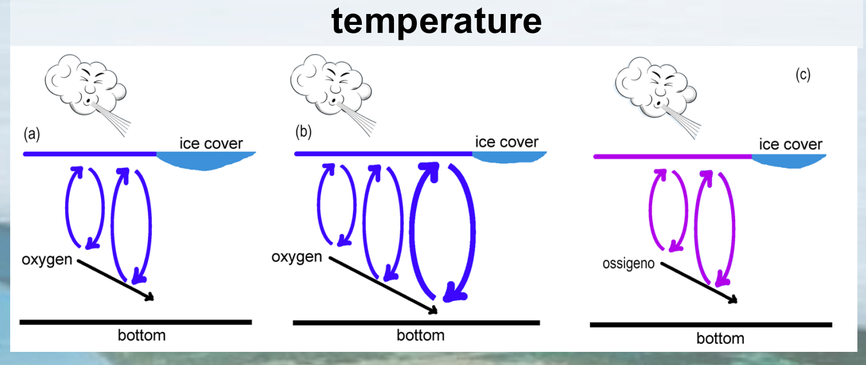
Summer DO profiles

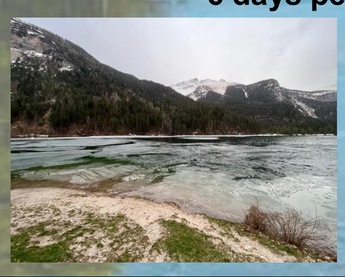


12th Dec. **1st** Dec.

Lake freezing is delayed by **6 days per decade**

Climate change in action:
the lake freezes later because of **increased air temperature**





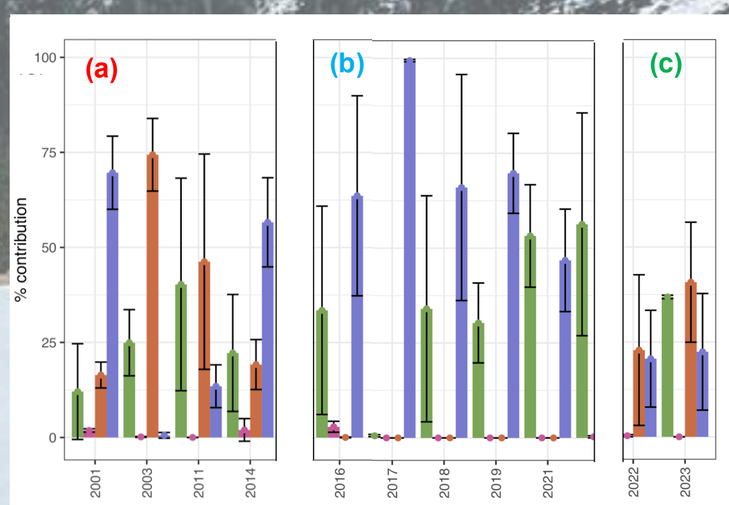
Ice off in spring

(a) Incomplete mixing, before 2010

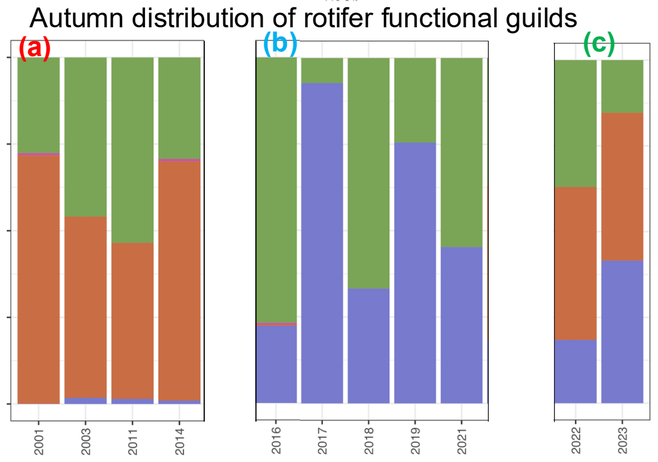
(b) more time to mix the water and to oxygenate the deeper layers

(c) further warming impedes mixing leading again to incomplete mixing

Rotifer functional diversity



Autumn distribution of rotifer functional guilds

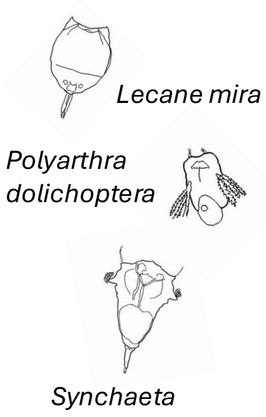


Under-ice distribution of rotifer functional guilds

Monthly zooplankton sampling;
0-35 m;
50 µm plankton net

rotifer functional guilds:

- Polyphagous
- Microphagous
- Macrophagous algivores

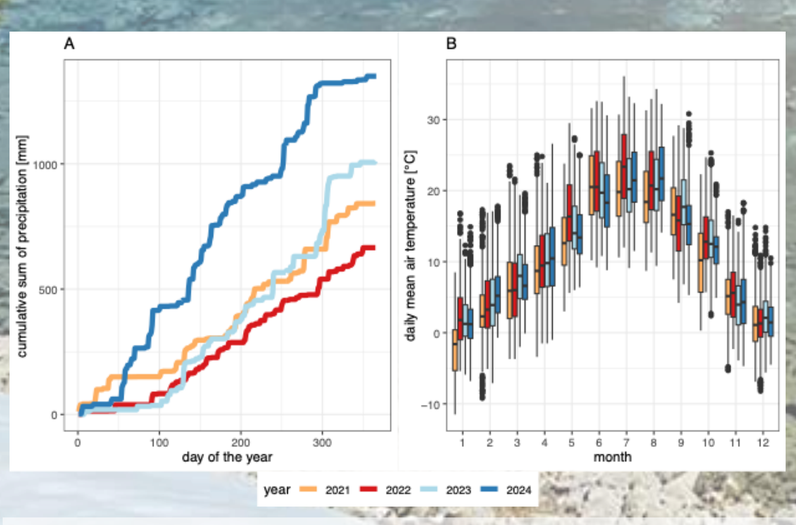


Lecane mira

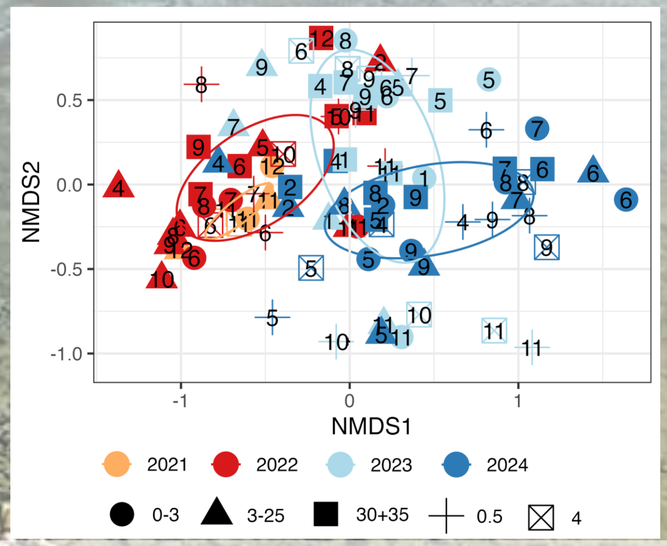
Polyarthra dolichoptera

Synchaeta lakowitziana

Spatiotemporal distribution of fungi over more than three years (September 2021 to February 2025) using metabarcoding (ITS1 ASVs)



Temporal evolution of precipitation and air temperature in different years (2021-2024);
(A): yearly cumulative sum of precipitation;
(B): monthly boxplots of daily mean air temperature



NMDS (stress = 0.16) with fungal ASVs and environmental fitting of years (95% envelope of confidence interval for year; P < 0.001); upper euphotic layer - A0-3; lower euphotic layer - A3-25; deep hypolimnion - A35; surface of the shallow basin (sb) - B0; bottom layer of sb - B4. Numbers = months.

Fungal communities are different between warm 2022 and rainy 2024

Rotifer feeding categories sensu Gilbert (2022) indicate the changes in mixing patterns

Relevant literature

- Flaim, G., Andreis, D., Piccolroaz, S. and Obertegger, U., 2020. Ice cover and extreme events determine dissolved oxygen in a placid mountain lake. *Water Resources Research*, *56*(9), p.e2020WR027321. doi.org/10.1029/2020WR027321
- Obertegger, U., Corradini, S., Cerasino, L. and Weiss, L.C., 2024. Decadal changes in surface CO2 concentrations and CO2 fluxes in a mountain lake. *Limnology and Oceanography*, *69*(5), pp.1143-1156. doi.org/10.1002/lno.12557
- Obertegger, U., Corradini, S. and Cerasino, L., 2025. Inter-Period and Inter-Season Variability of Zooplankton of a Mountain Lake With an Emphasis on Under-Ice Communities. *Freshwater Biology*, *70*(8), p.e70085. doi.org/10.1111/fwb.70085
- Obertegger, U., Corradini, S., Pindo, M., and Cerasino, L., 2026. Fungal diversity in a mountain lake is explained by weather patterns. Accepted in *Freshwater Biology* 2026

Regional Mountain Conference 2026, 05.07.2026 - 08.07.2026 Austria, Obergurgl