Modelling the impact of changes in the physical environment on plankton succession with special emphasis on *Daphnia*-algae interactions
Influence of climate variability on plankton interactions

- **NAO**
  - Mean Air Temperature (Dec.-March) [°C] vs. NAO-Index
  - \( r = 0.62, \ p < 0.01 \)

- **Local Meteorology**
  - Water Temperature vs. NAO-Index
  - \( r = -0.55, \ p < 0.05 \)

- **Daphnia**
  - Growth and biomass vs. Water Temperature
  - \( r = 0.73, \ p < 0.005 \)

- **Daphnia**
  - Grazing

- **Timing of the clear-water phase**
  - Start clear-water phase vs. log(Daphnia biomass in May)
  - \( r = -0.84, \ p < 0.0001 \)

- **Start clear-water phase**
  - vs. log(Daphnia biomass in May)
  - \( r = 0.62, \ p < 0.01 \)

- **Straile et al. (2003)**

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**Graphs:**
1. Scatter plot showing Mean Air Temperature (Dec.-March) [°C] vs. NAO-Index.
2. Scatter plot showing Water Temperature vs. NAO-Index.
3. Scatter plot showing log(Daphnia biomass in May) vs. Start clear-water phase [julian day].
4. Scatter plot showing log(Daphnia biomass in May) vs. log(Daphnia biomass in May).
Clear-water timing in Central European lakes

Clear-water timing [julian day]

n = 136, from 28 lakes

Straile (2002)
Impact of climatic change

Phytoplankton growth in spring sensitive to light (mixing) conditions

Daphnia growth sensitive to water temperature

Anticipated effect of climatic warming for deep monimictic lakes in spring

light conditions (mixing) remain unchanged

water temperatures increase

algae growth rate unchanged

Daphnia growth occurs earlier

Shift in ecosystem interactions

Straile (2000)
Models

1) 1-dimensional vertical mixing model
Comparison of simulated and measured temperatures

Peeters et al. 2002

Zürichsee: Epil/Metalimnion (0 - 20m)

Zürichsee: Hypolimnion (20 - 136m)
Comparison of simulated and measured temperatures
Models

1) 1-dimensional mixing model  (✓)
2) Algae-growth model
   (dependent on solar radiation, diffusivities and water temperatures)
3) *Daphnia* – model
   (different complexities)
   a. biomass model
   b. size-structured dynamic model
   c. different parameterizations of growth and reproduction rates
Modelling the impact of environmental conditions on plankton succession

1. Development of a dynamic algae-Daphnia model including physical transport

\[
\frac{\partial n}{\partial t} = -\frac{\partial (g \cdot n)}{\partial s} - d \cdot n
\]

\[n(s > s_{\text{max}}) = 0\]

\[g(s) \cdot n(t, s_b) = b(t)\]

\[b(t) = \int_{s_b}^{s_{\text{max}}} \beta(s) \cdot n(t, s) \cdot ds\]

1D-vertical diffusion model considering algae growth and heat flux

2. Simulating the effects of temporal variation in environmental conditions from late winter/spring to early summer in Lake Constance
Calibration and validation of the models based on field data

Measurements of temperature and fluorescence with high temporal resolution
Calibration and validation of the models based on field data

... with long-term data of *Daphnia* abundances and size distributions

Measured size class distribution of *Daphnia* from 1979 - 1998
Tasks

1. Development of the model(s)

2. Calibration and validation of the model based on field data (Lake Constance)
   - existing long term data set
   - data collected specifically during this project
     (temporal resolution, data quality)

3. Investigation of the effect of model refinement (Daphnia sub-models) on overall model performance

4. Assessment of the impact of changes in the physical environment on plankton succession in Lake Constance using hypothetical warming scenarios