Risk **A**nalysis of **D**irect and **I**ndirect **C**limate effects on deep **A**ustrian **L**ake Ecosystems (RADICAL)

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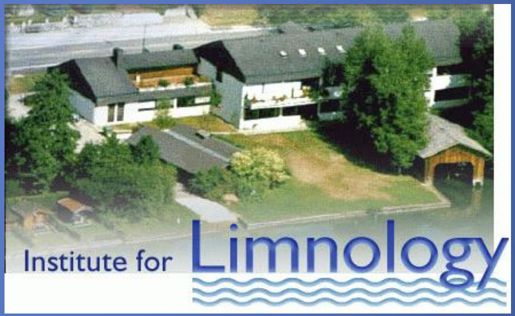
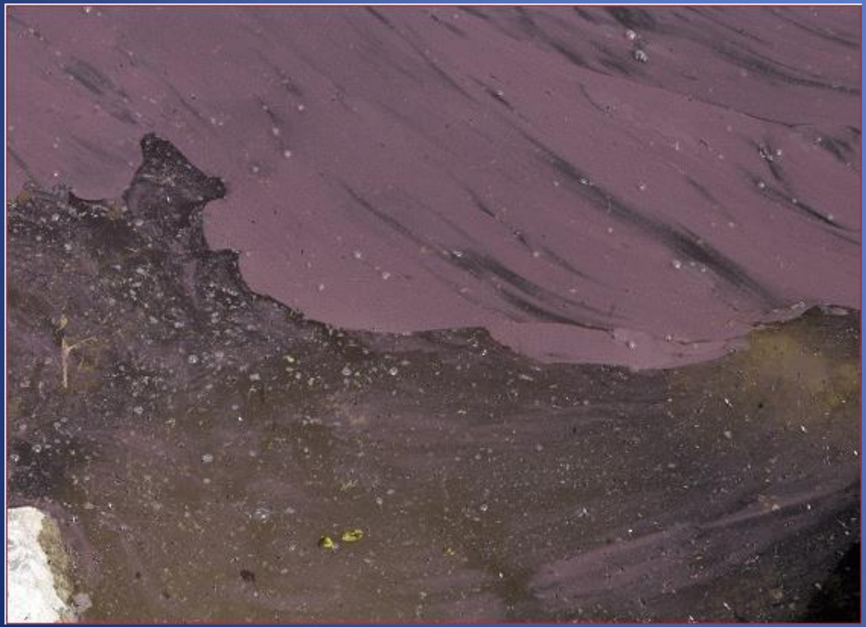


http://www.oeaw.ac.at/limno/projects/radical.html

Österreichischer Klimatag, 14.-15. Juni 2012, Universität für Bodenkultur, Wien

Deep lakes in the Alps

- Eutrophication (1950 – 1970ties)
- Re-oligotrophication (since 1980ties)



•Nutrient input – especially Phosphorus

• ….leads to Algal blooms and low water trasparency

•….causes low oxygen concentrations in deep water layers

Deep lakes in the Alps

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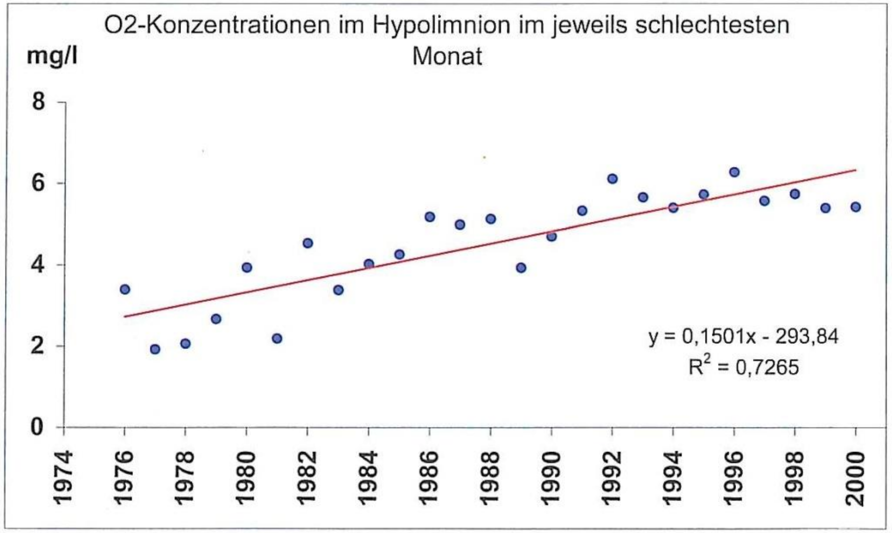
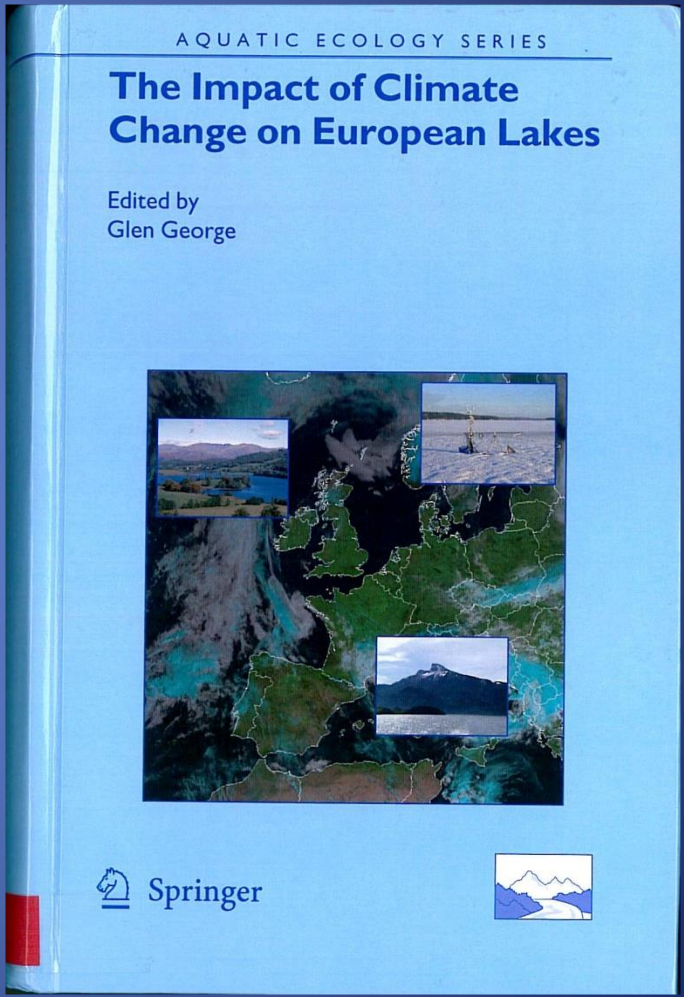


Abbildung 65: Verlauf der Sauerstoff-Konzentrationen im Hypolimnion des Mondsees im jeweils schlechtesten Monat

Deep lakes in the Alps

The effects of global change are likely to run counter to the reductions in nutrient loading rather than reinforcing re-oligotrophication, i.e. increasing phytoplankton and toxic cyanobacteria.



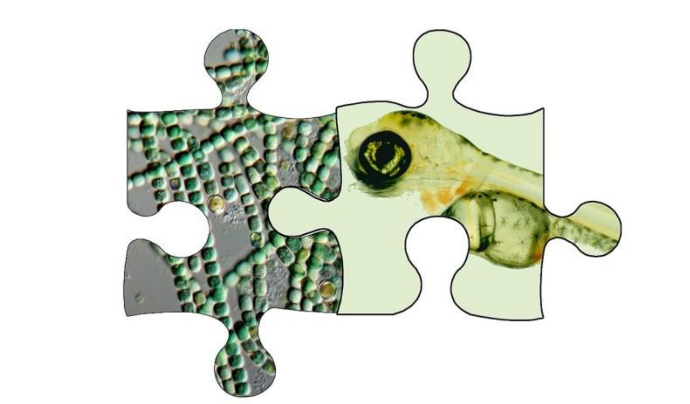
Whitefish occurring in deep lakes in the Alps

Whitefish (Coregonus sp.) are one of the most temperature sensitive fish species as they depend on low egg developmental temperatures and high oxygen concentrations, which is only found in the cold, deep water zone of Alpine lakes.

Whitefish occurring in deep lakes in the Alps

Whitefish are of high fishing value and due to their endemic nature these populations are of concern in conserving our biodiversity.

Whitefish occurring in deep lakes in the Alps



In this project, we follow the hypothesis that deep Alpine lakes are at risk to lose a major part of their ecological and socio-economic value in the course of climate change, because

- coregonid fish stocks will slump, due to direct demographic effects of increased temperature and indirect effects, since
- filamentous, toxic cyanobacteria will (re-) increase, thus counteracting re-oligotrophication efforts and adversely affecting other biota including coregonid fish.

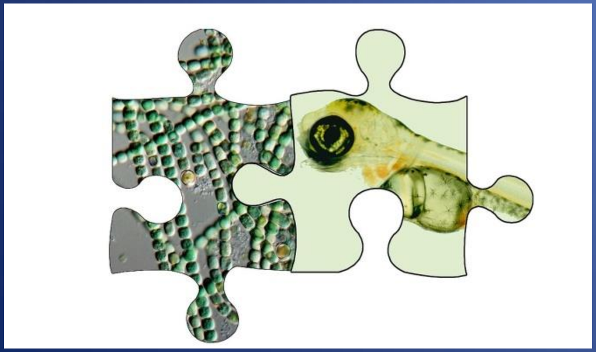
Project aim:

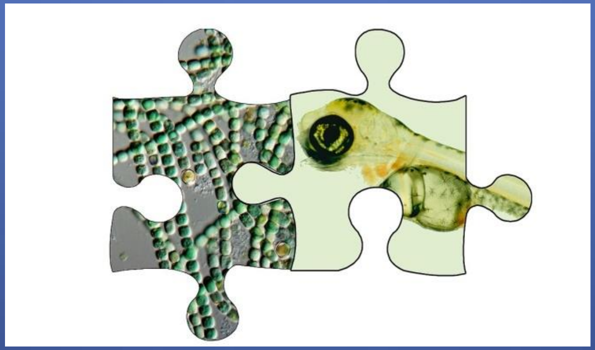
to estimate the direct and indirect consequences of climate effects on autochthonous whitefish populations by analysing:

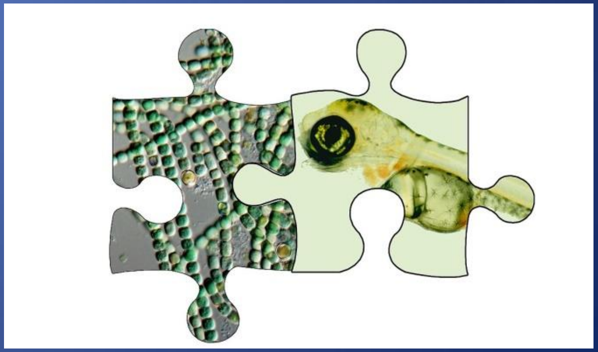
•the effects of regional climate changes on phytoplankton growth,

•the exposure of early life stages of whitefish to toxic cyanobacteria at chronic/subchronic levels,

•the demographic consequences for autochthonous whitefish populations in the next few decades under a changing plankton community composition subject to various climate scenarios.







The effects of regional climate changes on phytoplankton growth

Provide quantitative data on:

•lake physics (vertical stratification, vertical mixing, light availability in the water column) as basis for modelling of cyanobacterial stratification

•the variability of occurrence of hepatotoxic cyanobacteria in relation to environmental (climatic) factors in the field both temporally and vertically through the water column (as basis for algal modelling and fish exposure assessment)

•Model cyanobacterial population/phytoplankton abundance and vertical/horizontal distribution in dependence on climate effects, physical conditions

The effects of regional climate changes on phytoplankton growth

Freshwater Biology (2005) **50**, 1404–1411 doi:10.1111/j.1365-2427.2005.01409.x

Combining a regional climate model with a phytoplankton community model to predict future changes in phytoplankton in lakes

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†Centre for Ecology and Hydrology Wallingford, Wallingford, U
‡Met office, Hadley Centre for Climate Prediction and Research,

SUMMARY

1. Linking a regional climate model
greenhouse gas concentrations, with
produced realistic simulations of 20
Bassenthwaite Lake, in the North-W
2. Meteorological drivers were deriv
scenario involving a 1% per annum
tions until 2100. Using these drivers,
representing the last two decades of
3. Comparison of these present and
current seasonal phytoplankton dev
simulated spring bloom showed an i
success of *Planktothrix*. Also, the sum
nutrient limitation caused by the inc
did not change.
4. Analysis showed that these predic
temperature, which were in turn trig
RCM.

Keywords: blooms, blue-green algae, clim

ECOLOGICAL MODELLING 202 (2007) 421–426

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ELSEVIER

Phytoplankton modelling of Lake Erken, Sweden by linking the models PROBE and PROTECH

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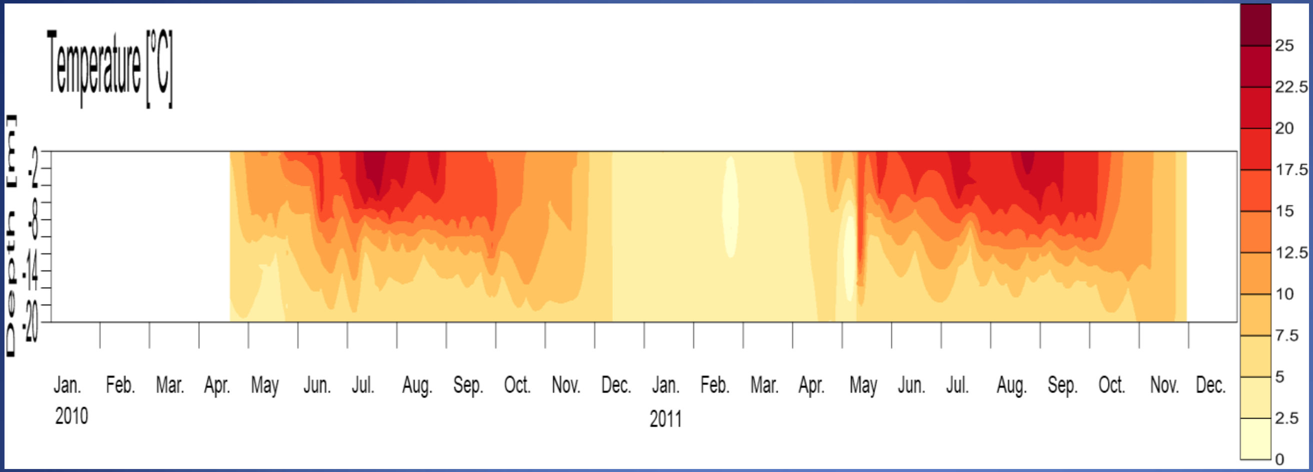
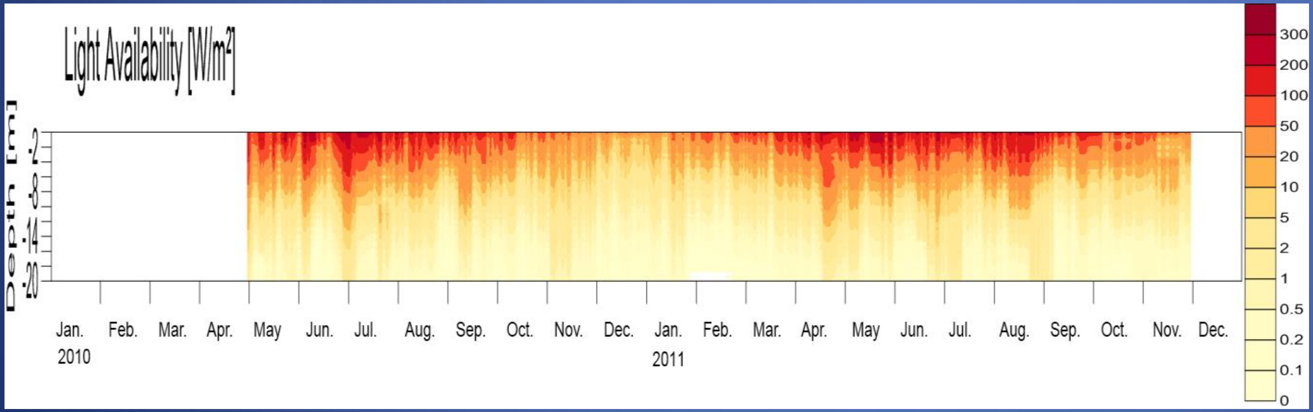
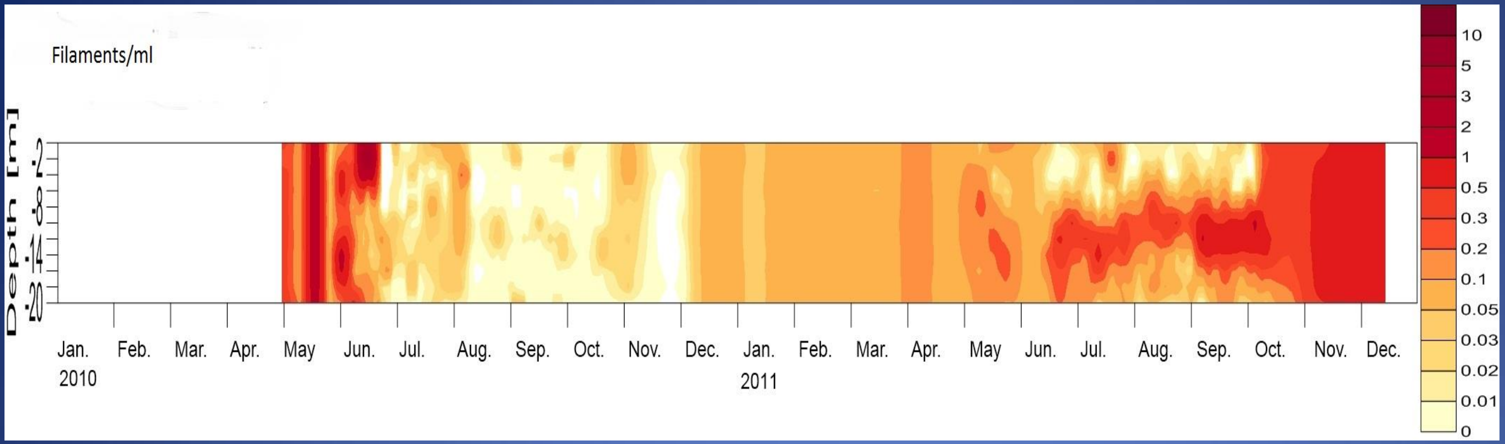
ABSTRACT

A phytoplankton community model (PROTECH) and a lake physical model (PROBE) were linked, for the first time, to simulate the phytoplankton community of Lake Erken (Sweden). This allowed the physical effects of ice formation to be incorporated into the calculations of PROTECH. This is the highest latitude lake simulated by PROTECH thus far and was a further test of its biological application to lake ecosystems in general. A new cyanobacteria species was added to the PROTECH model: *Gloeotrichia echinulata* (Smith) Richter which had functional characteristics never before simulated in PROTECH and was an order of magnitude larger than species previously simulated. The biological outputs of total chlorophyll *a* were successfully validated against quantitative observations from the lake (EF = 0.76). The addition of *G. echinulata* to the model notably improved this fit, particularly in the period from July to October. Key taxa biomass were also simulated, with good fits for diatoms (EF = 0.70) and cyanobacteria (EF = 0.83). Furthermore, the characteristic periodic blooms of *Gloeotrichia* were captured, thus supporting its assigned model parameters and suggesting that PROTECH's growth equations can be applied to this significantly larger species. Furthermore, it appears that *Gloeotrichia*'s simulated seasonal pattern of growth was greatly dependent upon the water temperature.


Temperature [°C]
Depth [m]
-2
-8
-14
-20
Jan. 2010
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
Jan. 2011
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
25
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0


Light Availability [W/m²]
Depth [m]
-2
-8
-14
-20
Jan. 2010
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
Jan. 2011
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
300
200
100
50
20
10
5
2
1
0.5
0.2
0.1
0


Filaments/ml
Depth [m]
-2
-8
-14
-20
Jan. 2010
Feb.
Mar.
Apr.
May
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Aug.
Sep.
Oct.
Nov.
Dec.
Jan. 2011
Feb.
Mar.
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May
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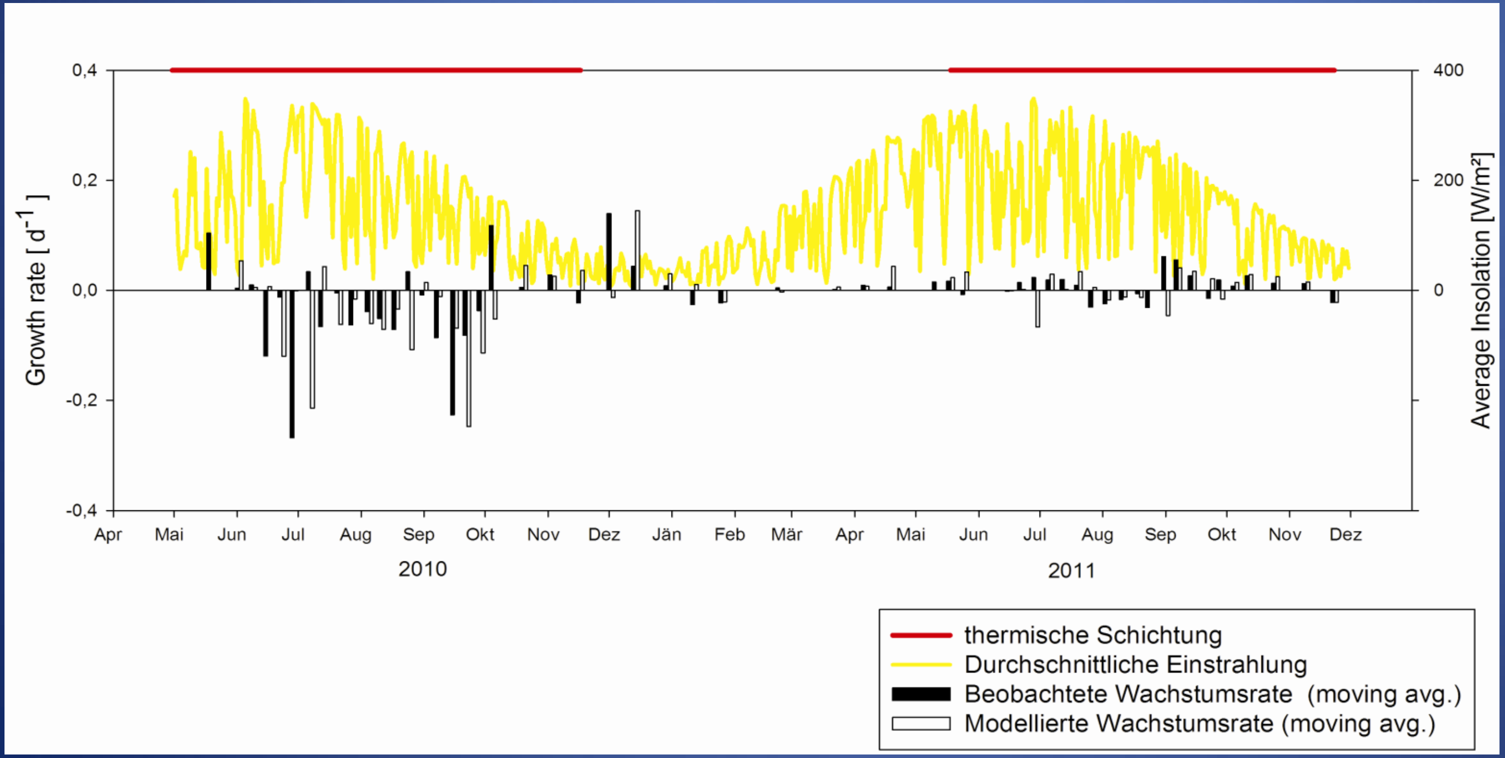
Aug.
Sep.
Oct.
Nov.
Dec.
10
5
3
2
1
0.5
0.3
0.2
0.1
0.05
0.03
0.02
0.01
0

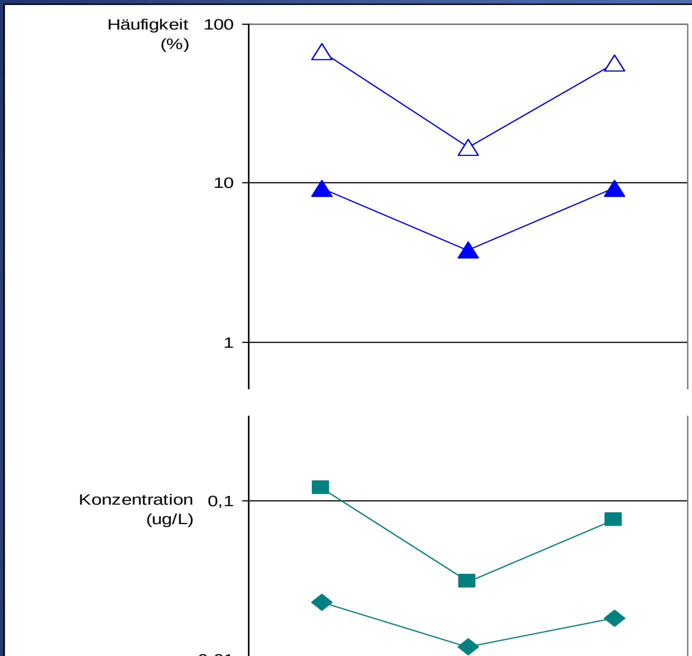

Growth rate [d-1]
0,4
0,2
0,0
-0,2
-0,4
Average Insolation [W/m²]
400
200
0
Apr
Mai
Jun
Jul
Aug
Sep
Okt
Nov
Dez
Jän
Feb
Mär
Apr
Mai
Jun
Jul
Aug
Sep
Okt
Nov
Dez
2010
2011
thermische Schichtung
Durchschnittliche Einstrahlung
Beobachtete Wachstumsrate (moving avg.)
Modellierte Wachstumsrate (moving avg.)

Exposure of early life stages of whitefish to toxic cyanobacteria at chronic/subchronic levels

Assess effects of cyanobacteria on whitefish populations in Mondsee and Hallstättersee conducting a field survey on free-living fishes to check histopathological damages as observed in exposure experiments.

Aim of the laboratory experiments is to characterize the developmental and behavioural toxicity of Cyanobacteria/Microcystins on early life stages of the fish by means of conventional Effective Concentrations (EC-values).

Exposure of early life stages of whitefish to toxic cyanobacteria at chronic/subchronic levels



	2. Hj. 2010	1. Hj. 2011	2. Hj. 2011
MC-Max-i (ug/L)	0,023	0,012	0,018
MC-Max-m (ug/L)	0,120	0,031	0,075
Häufigkeit (%) blau-positiver Fische (Galle)	9,21	3,8	9,3
Höchste je Fangtag beobachtete Häufigkeit (%) blau-positiver Fische (Galle)	66,7	16,67	57,14
Häufigkeit (%) blau-positiver (Galle) Fangtage	25	33,3	20
Anzahl analysierter Fische (Galle)	76	79	43

Abbildung 9: – Übereinstimung der Beobachtungshäufigkeiten Blaufärbung der Gallenflüssigkeit der im Mondsee gefangenen adulten Fische (Coregonus sp.) mit den aus Algendichten (Planktothrix sp.) im gleichen Beobachtungszeitraum ermittelten Microcystin-konzentrationen im Mondsee
Legende: Hj.: Halbjahr; MC: Microcystin; MC-Max-i: höchste ermittelte mittlere MC-Konzentration in der Wassersäule; MC-Max-m: höchste ermittelte maximale MC Konzentration in der Wassersäule; ug: μg.

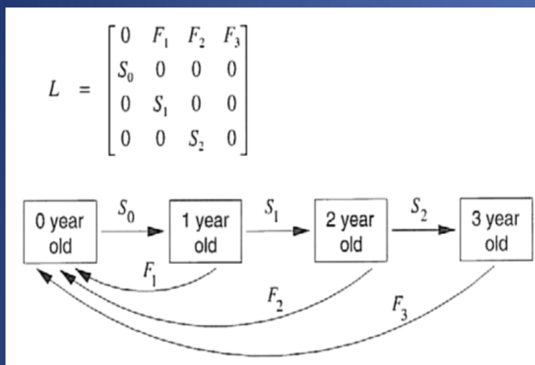
Fish Ecology

Construct an age-structured population model for whitefish in Mondsee and Hallstättersee using RAMAS (Risk Analysis and Management Alternatives Software).

Integrate the results obtained in other Modules to predict whitefish population developments under future climate scenarios (direct effects) and to assess risks of cyanobacterial blooms under future climate scenarios associated with increased production of toxins, effects on various components of the plankton community and especially on future whitefish population development considering ecotoxicological risks (indirect effects).

Fish Ecology

a)



b)

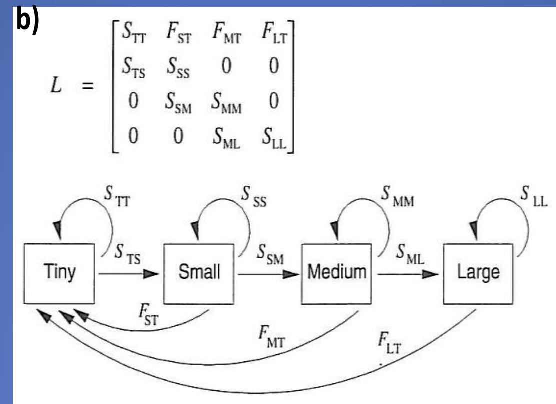


Abb.1: Struktur der altersbasierten Leslie-Matrix(a) und der längenbasierten Progressions-Martix (b) mit den Parametern Überlebensrate (S) und Reproduktion bzw. Fertilität (F).

Fish Ecology

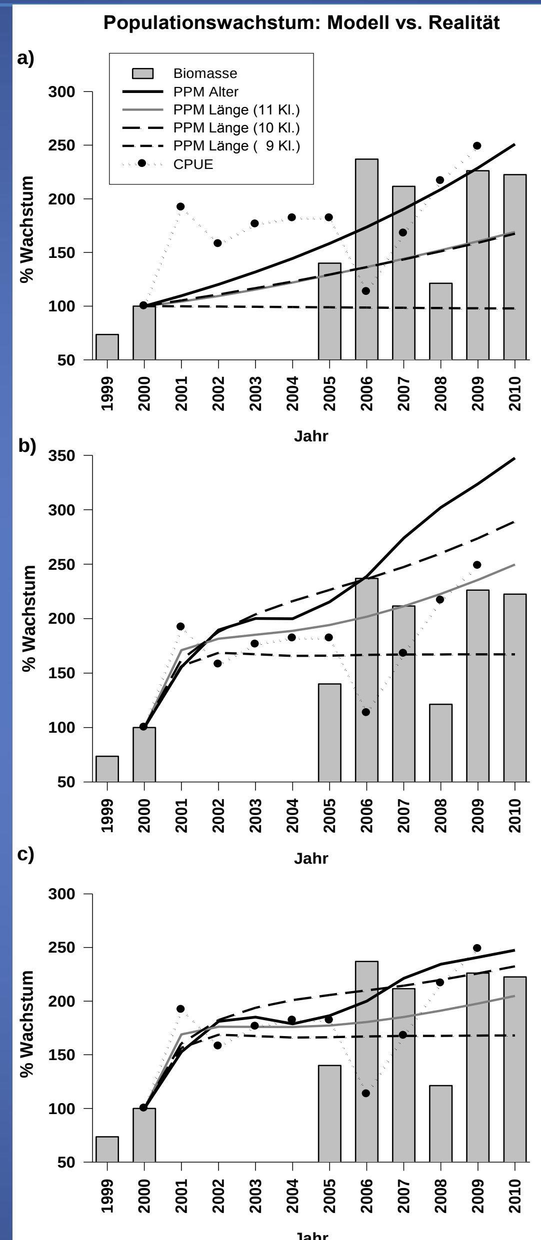


Abb. 3: Vergleich des modellierten Populationswachstums mit der beobachteten Populationsentwicklung über Fischbiomasse und CPUE, mit stabiler demographischer Verteilung (a), beobachteter Verteilung in den selektivitätskorrigierten Netzfängen im Jahr 2000 (b) und mit zusätzlich berücksichtigter Dichteabhängigkeit des Populationswachstums.