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

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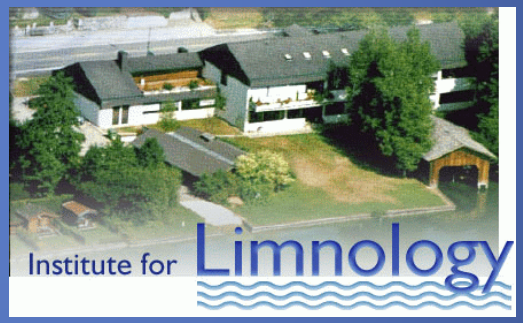

http://www.oeaw.ac.at/limno/projects/radical.html

Österreichischer Klimatag, 11.-12. März 2010, 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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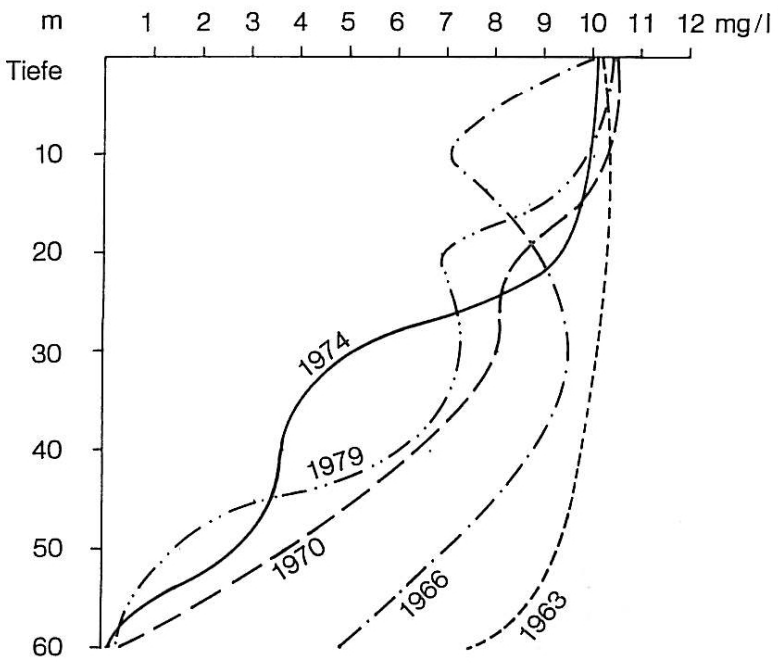

Abb. 86:
Mondsee,
Sauerstoffgehalt in den Jahren 1963, 1966, 1970, 1974, 1979 (Ende der Sommerstagnation)

Aus: Jagsch & Megay, 1982: Mondsee. In: Sampl, Gusinde, Tomek: Seenreinhaltung in Österreich. Heft 6 der Schriftenreihe Wasserwirtschaft. BM Land- und Forstwirtschaft.

Deep lakes in the Alps

- Eutrophication (1950 – 1970ties)
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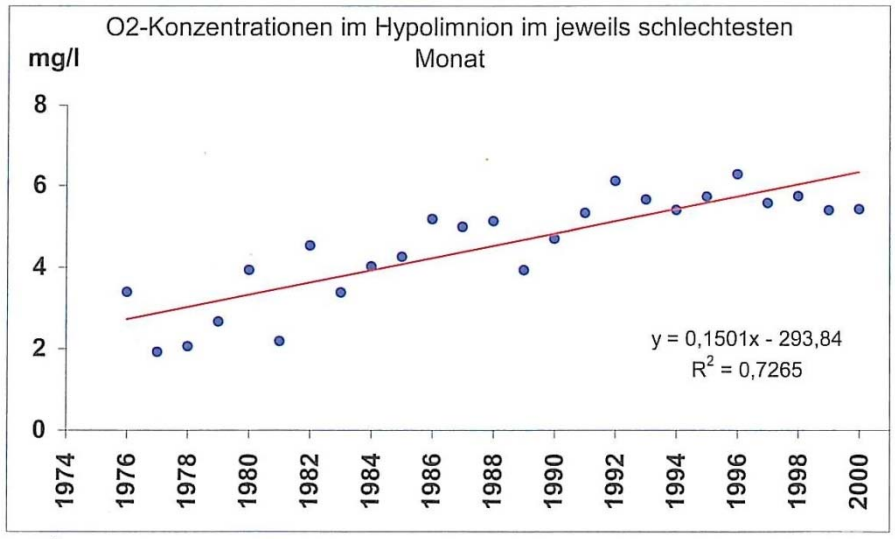
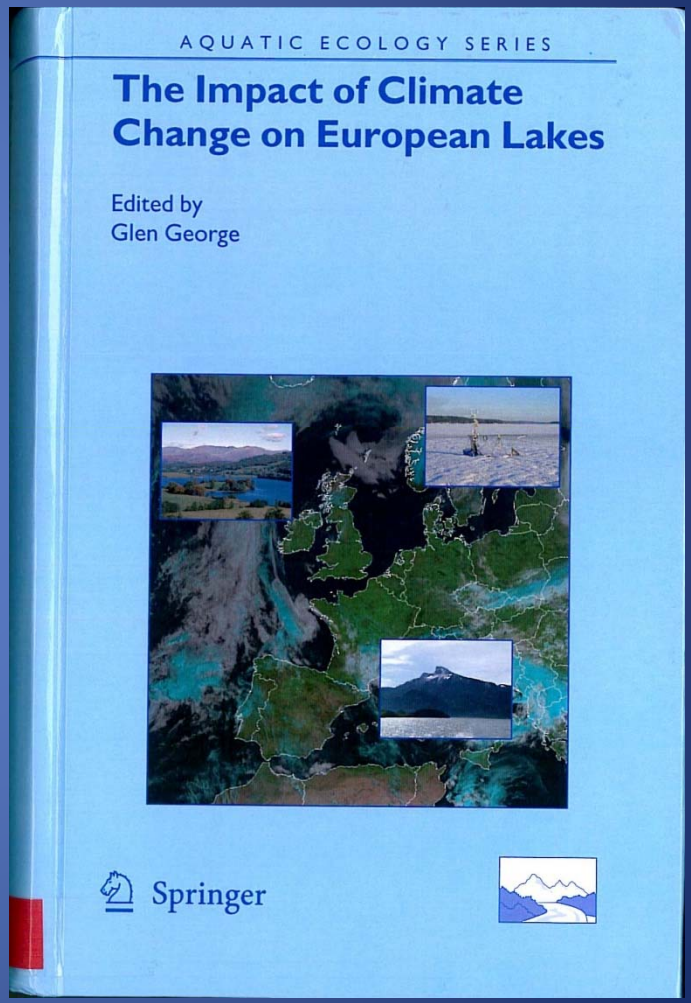


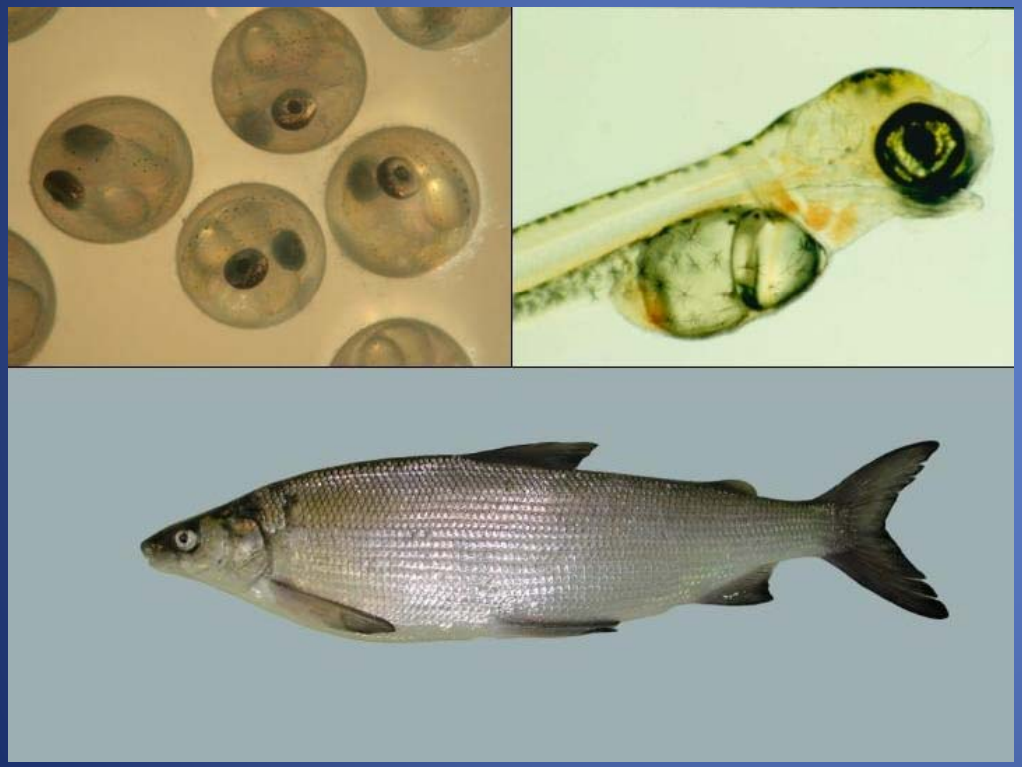
Abbildung 65: Verlauf der Sauerstoff-Konzentrationen im Hypolimnion des Mondsees im jeweils schlechtesten Monat

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.

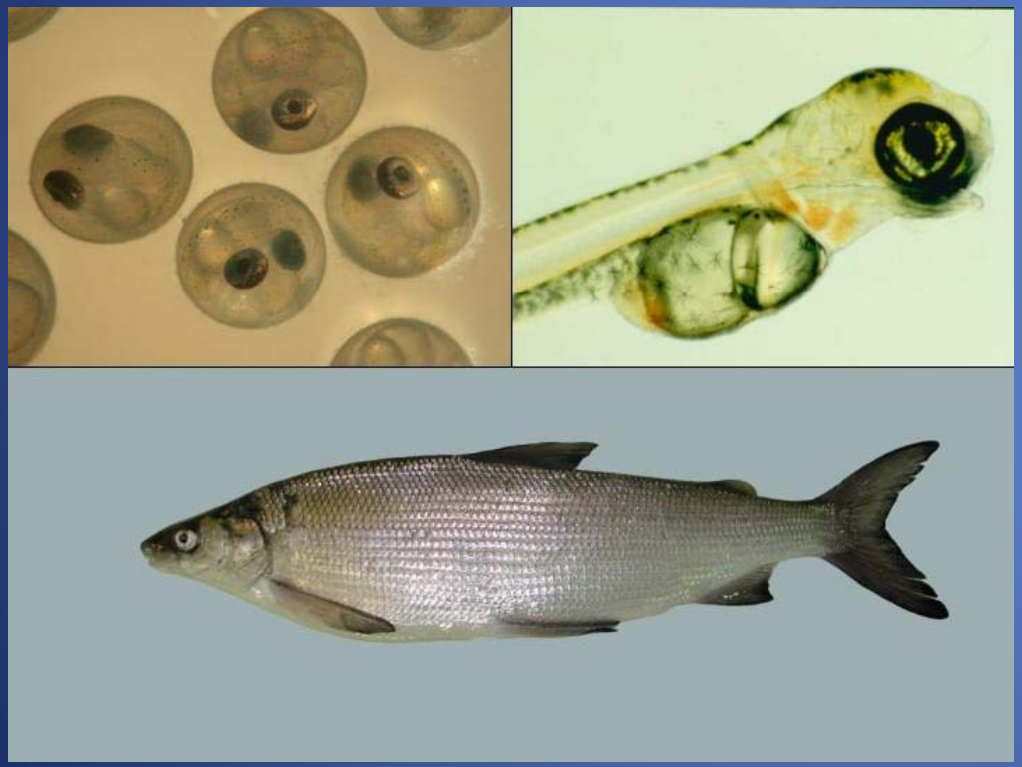


Whitefish occurring in deep lakes in the Alps



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.

FWF Der Wissenschaftsfonds.

ÖAW Österreichische Akademie der Wissenschaften

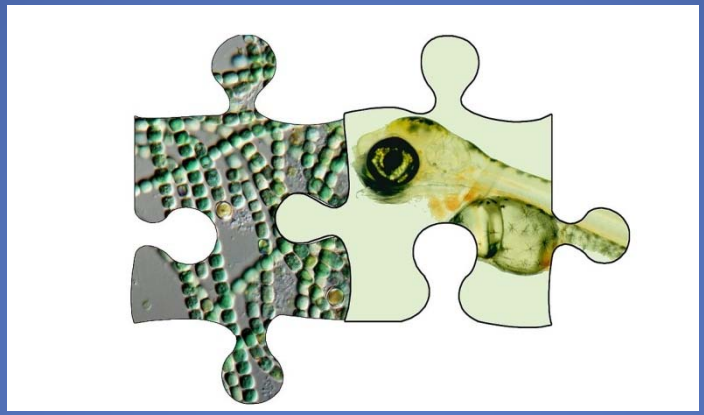
UNI GRAZ

Conservation of natural biological resources in Austria:

Identification of indigenous whitefish species and extent of potential hybridization with a Baltic species

**This FWF-project is a cooperation between the Institute of Limnology,
Austrian Academy of Sciences and the Institute of Zoology,
Karl-Franzens-University Graz**

Whitefish occurring in deep lakes in the Alps



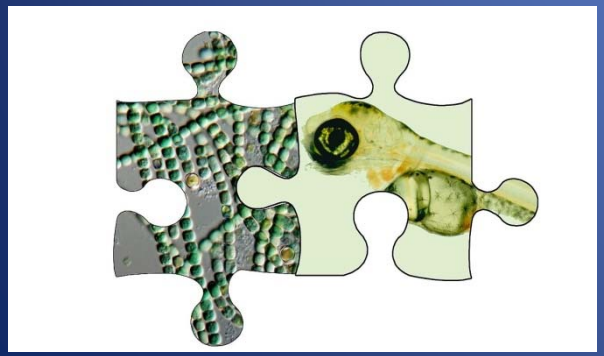
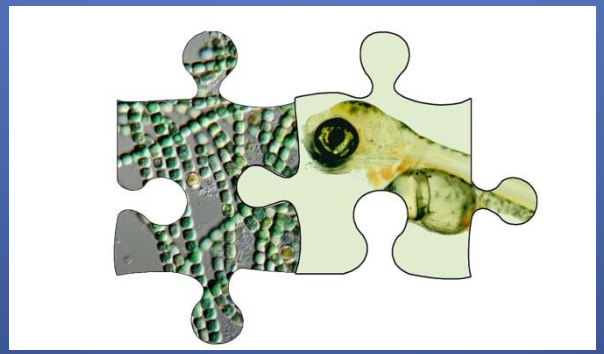
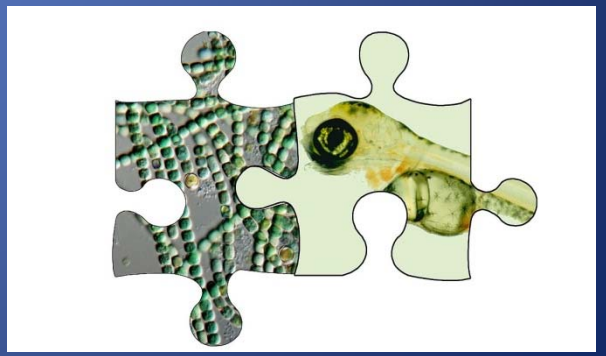
In this project, we follow the hypothesis that deep Alpine lakes are at risk to lose a major part of their ecological and socio-economic value in the course of climate change, because

- 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, t
‡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 deve
simulated spring bloom showed an ir
success of *Planktothrix*. Also, the sum
nutrient limitation caused by the incr
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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ARTICLE INFO

Article history:
Received 12 December 2005
Received in revised form
23 October 2006
Accepted 3 November 2006
Published on line 4 December 2006

Keywords:
PROTECH
PROBE
Gloeotrichia

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.

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

INVESTIGATIONS ON THE IMPACT OF

TOXIC CYANOBACTERIA ON FISH

- AS EXEMPLIFIED BY THE COREGONIDS IN LAKE AMMERSEE -

DISSERTATION

Zur Erlangung des akademischen Grades des
Doktors der Naturwissenschaften
an der Universität Konstanz
Fachbereich Biologie

Vorgelegt von
BERNHARD ERNST

ELSEVIER

Aquatic Toxicology 82 (2007) 15–26

AQUATIC TOXICOLOGY

www.elsevier.com/locate/aquatox

Physiological stress and pathology in European whitefish (*Coregonus lavaretus*) induced by subchronic exposure to environmentally relevant densities of *Planktothrix rubescens*

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Received 14 November 2006; received in revised form 27 December 2006; accepted 17 January 2007

Abstract

Planktothrix rubescens belongs to the most ubiquitous cyanobacterial species in mesotrophic and oligotrophic lakes in the pre-alpine regions. In most of these lakes, coregonids are among the dominant species of the ichthyofauna with great importance for the professional fishery. A possible link between the occurrence of toxic *Planktothrix* blooms and the recurrent slumps in coregonid yields has been suggested. Indeed, acute toxic effects of microcystins and other cyanobacterial toxins have been shown for various fish species. However, chronic exposure scenarios appear to be more common and thus more environmentally realistic than acute intoxications. The aim of this study was therefore to investigate the physiological stress response and organ pathology in coregonids sub-chronically exposed to ambient water containing low, medium and high *P. rubescens* densities, known to be typical of pre-alpine lakes. Coregonid hatchlings were exposed in four tanks containing 0 (sham-control) and approximately 1500 (low), 15,000 (medium) and 55,000 (high) *P. rubescens* cells/ml for up to 28 days. Temperature, oxygen concentration, pH-value, *P. rubescens* cell density and microcystin concentration were recorded and the fish were observed for behavioural changes and examined for parasite infestations. Gill ventilation rates, general condition factors and mortalities were determined and liver, kidney, gut and gill were assessed histopathologically and immunhistologically.

Depending on the cell density, exposed fish showed behavioural changes, including increased ventilation rates possibly representing a physiological stress response. Susceptibility to ectoparasitic infestation and increased mortality in exposed fish suggested *P. rubescens* associated effects on fish fitness. Histopathological alterations in liver, gastrointestinal tract and kidney, which were also immunopositive for microcystin suggested causality of tissue damage and the presence of microcystins. In contrast, observed gill pathology appeared to result primarily from mechanical abrasion and irritation due to ectoparasitic infestation. The current exposure experiment confirmed the hypothesis that subchronic and chronic exposure to low cyanobacterial cell densities and hence microcystins can exacerbate physiological stress and sustained pathological alterations in exposed coregonids. The study therefore supports the theory that *P. rubescens* blooms may be causal to the observed weight reduction and hence fitness of coregonids in pre-alpine lakes such as Lake Ammersee (Germany).

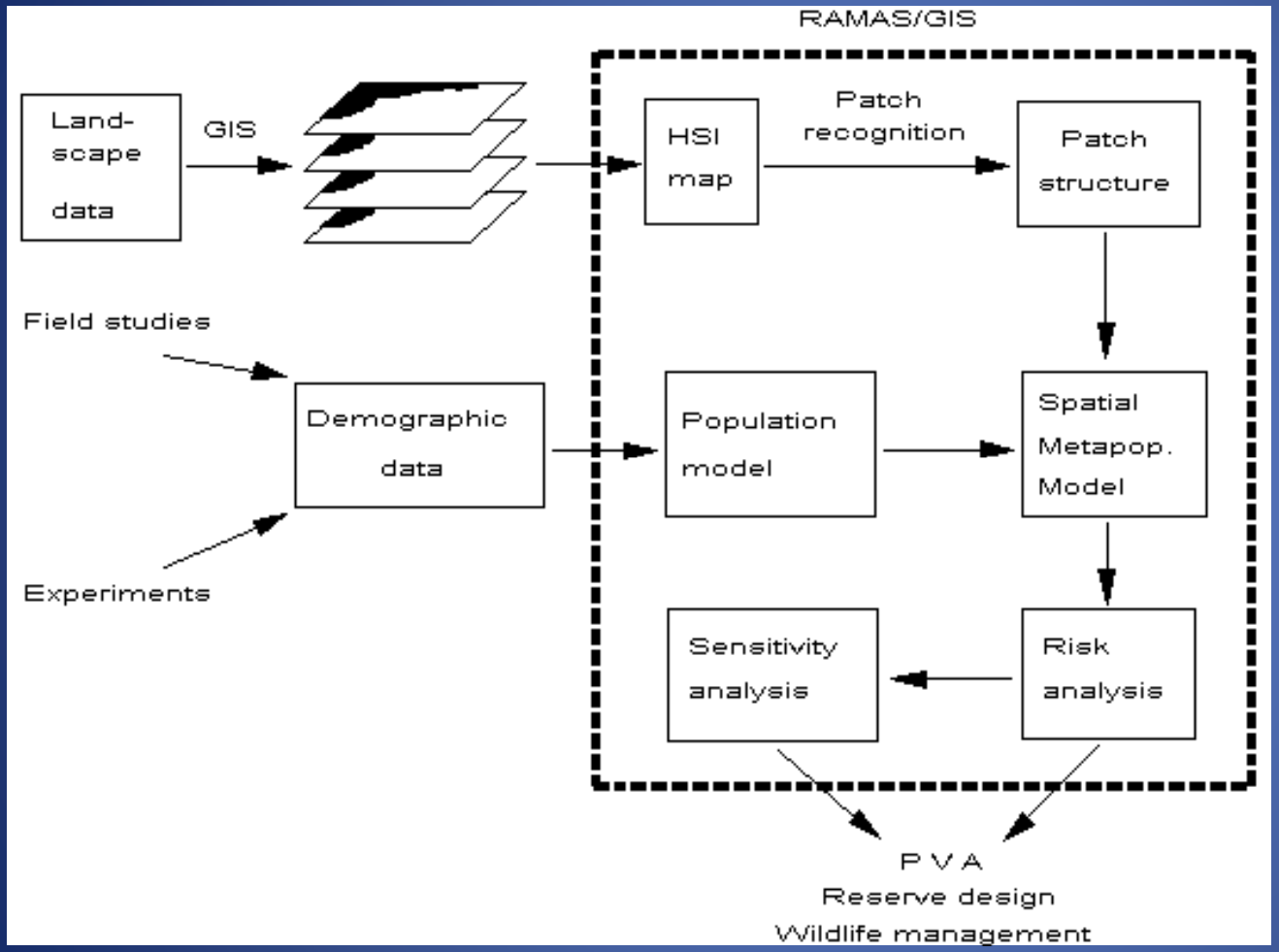
Keywords: Fish; Microcystin; Planktothrix; Coregonid; Cyanobacteria; Whitefish; Stress; Pathology

Fish Ecology

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

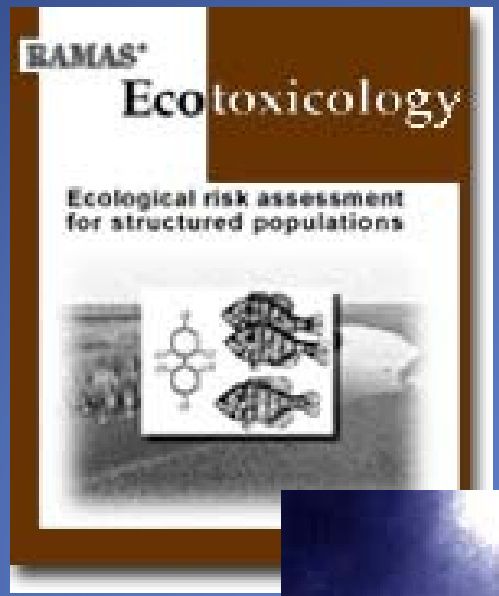
Integrate the results obtained in other Modules to predict whitefish population developments under future climate scenarios (direct effects) and to assess risks of cyanobacterial blooms under future climate scenarios associated with increased production of toxins, effects on various components of the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

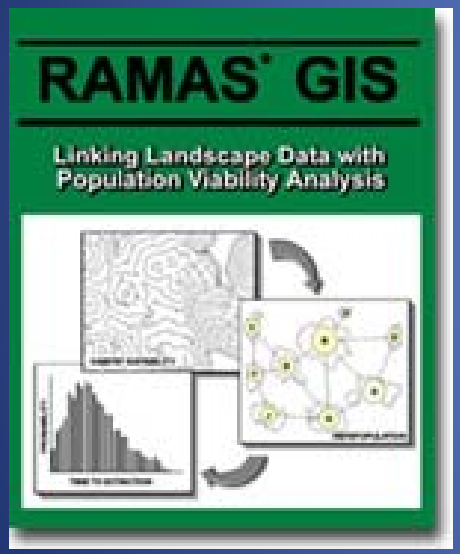
Fish Ecology

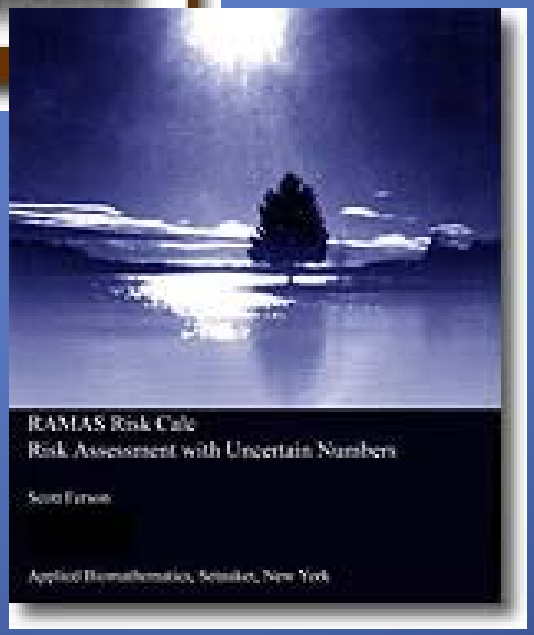


http://www.ramas.com/

Fish Ecology







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