Hints for the oral examination of the course "Modelling aquatic ecosystems"

Main goals of the course: The students are able to:

- build mathematical models of aquatic ecosystems that consider the most important physical, chemical, biogeochemical, biological, and ecological processes
- explain the interactions between these processes, especially between ecological and biogeochemical processes, and the behaviour of the system that results from these interacting processes based on a model they developed themselves
- formulate, implement and apply simple ecological models
- describe the main sources of uncertainty and key concepts of parameter estimation

The oral exams are aligned with these objectives. However, the technical model implementation with R is not part of the examination.

Important aspects of the exams are:

1. Formulation of mass balance equations and transformation processes; consideration of conservation laws for elements and charge for the formulation of biological and chemical transformation processes, parameterization of process rates, process table notation, important processes in aquatic ecosystems (lakes and rivers)
2. Qualitative behaviour of model solutions; how model outputs change due to changes in parameter values or external influence factors; important interactions in model outputs (interdependencies between state variables), dominant mass fluxes in the models (and the systems described by the models)
3. Important sources for uncertainty in model outputs; how they can be considered in the model.

Prerequisite for participating in the oral exam is that the student has submitted their model assignment (see program, submission deadline is 24.05.2024).

Half of the time of the oral exam will be devoted to discussing the results of the model assignments. The other half will cover other course topics.

Minimum requirement for passing is that the student can correctly describe how to derive the stoichiometric coefficients and how to formulate the transformation rate for a given biological process.

The oral exams will take place on 07./10./11. of June 2024 at Eawag, Dübendorf. The exams take 30 minutes and will be graded.

Typical example questions can be found on the next page.

Typical examples for examination questions

Explain the model that you have developed during the course. What were the most important changes compared to the model 11.4? Please describe the temporal development of the state variables. Explain the results of your sensitivity analysis.

Explain the process table notation using a simple lake model as an example.

For a simple one box model, explain how to derive the differential equations based on the process table.

How can you calculate the total net transformation rate for a single substance, which is involved in several transformation processes?

Given a biological process x (from those described in chapter 8), explain what is happening in this process. How can you derive the stoichiometric coefficients for this process? How can you find out, if additional constraints are needed?
Which are drawbacks of the simplified approach to address this question?

How can you avoid additional manual calculations to derive the stoichiometric coefficients, if the composition of a substance changes?

How can you formulate the additional stoichiometric constraints that are needed for the growth of secondary producers (e.g. zooplankton)?

When do you need to introduce a yield for the death process of algae and zooplankton?
What would be an alternative solution to the introduction of such a yield?

Given the biological process x, how can you formulate the process rate?

What are the typical elements for process rates of biological processes?
How can you decide for which substances in the process rate a limitation term is needed?

Which alternatives may be used to formulate the limitation and inhibition terms?

Sketch the food web of the benthic (pelagic) zone of a river (lake).

Which transformation processes have to be considered in a lake model to describe the phosphorus (nitrogen) cycle?

What are important transport processes that have to be considered in a lake model?

What are important transport processes that have to be considered in a river model?

What must be considered when discretizing a river model as a system of mixed reactors?

What influences the flow velocity in a river? What influences the water depth in a river?

Which processes affect the oxygen concentration in a river/lake?

Which alternatives do you know to model the mineralisation of organic material in aquatic ecosystems?

Which alternatives do you know to model nitrification in aquatic ecosystems?

How can you assess the sensitivity of a model to single parameters in a simple way?

What are important sources of model uncertainty? How can they be considered in a model?

How can you obtain the values for the model parameters?

How can you use observed data to improve your parameter estimates?

Other examples are the questions from the exercises.