Topic 1: Simulating two scenarios for phosphorus reduction in a lake: extraction of deep water and reduction of inflow concentration

First, add a deep water extraction line (outflow) to the hypolimnion in the model definition of model 11.4. For this, you have to make some changes to the water fluxes of the model and you have to introduce **one** new parameter: the outflow from the hypolimnion as a fraction of the inflow to the lake. The modification you make must not affect the total outflow from the lake, so that it remains equal to the inflow. The volumes of the two boxes should stay constant.

Once you implemented the model, investigate the efficiency of the two measures **separately**:

- Reduction of the inflow concentration of phosphorus by 50%
- Flow in the deep water extraction is 50% of inflow to the lake

Especially, look at the behaviour of the phosphate concentration in winter, the minimal oxygen concentration during the summer in the hypolimnion and the concentration of algae. Compare the effect of the two measures with the original situation.

Oftentimes, we have a considerable reservoir of degradable organic matter stored in the sediments of eutrophic lakes that is degraded only slowly over multiple years. This was not the case in the model studied so far. To consider this, increase the initial surface density of degradable organic matter in the sediment from 20 g_{DM}/m^2 to 300 g_{DM}/m^2 and decrease the rate constant for oxic and anoxic degradation of organic matter in the sediment from 5 $g_{DM}/m^2/d$ to 1 $g_{DM}/m^2/d$.

Now perform the exact same analysis as before, but with the new system. What is the effect of the two measures now? How does it compare to the effect for the other system and what might be the reason for the differences?

In your analysis, consider that the system might need considerable time to reach a periodic equilibrium depending on the initial conditions, i.e. choose simulation times that allow you to fully discuss the temporal dynamics, including the dependence on the initial density of sedimented degradable organic particles.

Finally, think about the most important shortcomings of this model that might lead to differences to what happens in real lakes.