ISEO: Improving the lake status from Eutrophy towards Oligotrophy

Work-package 3: Quantification of internal phosphorus fluxes

ISEO-Meeting
26th April 2017
Brescia

Leibniz Institute of Freshwater Ecology and Inland Fisheries
Berlin, Germany

IGB

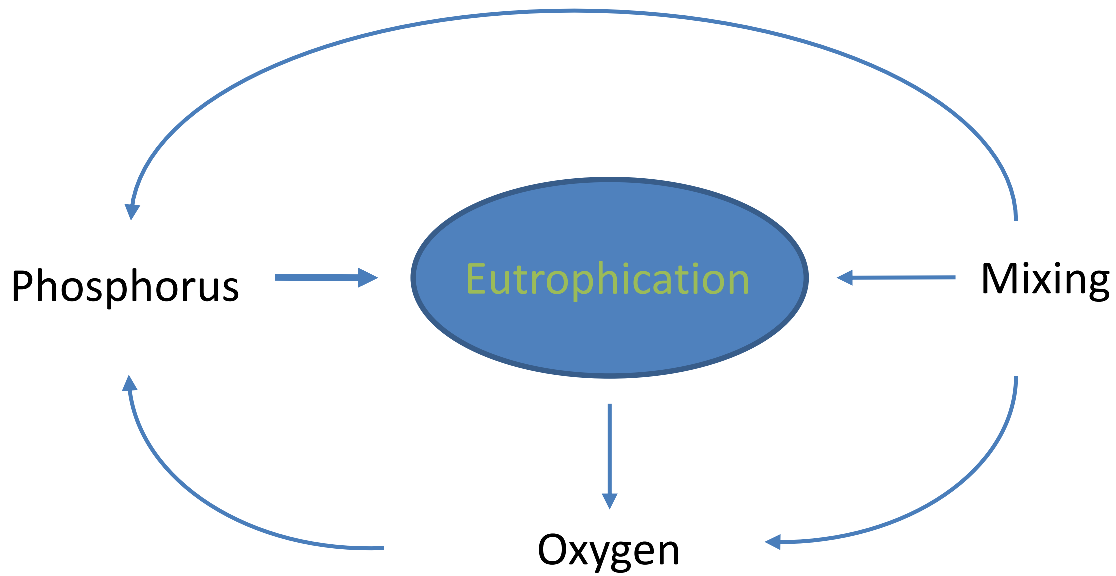
fondazione cariplo

Internal phosphorus cycle under changed climatic conditions

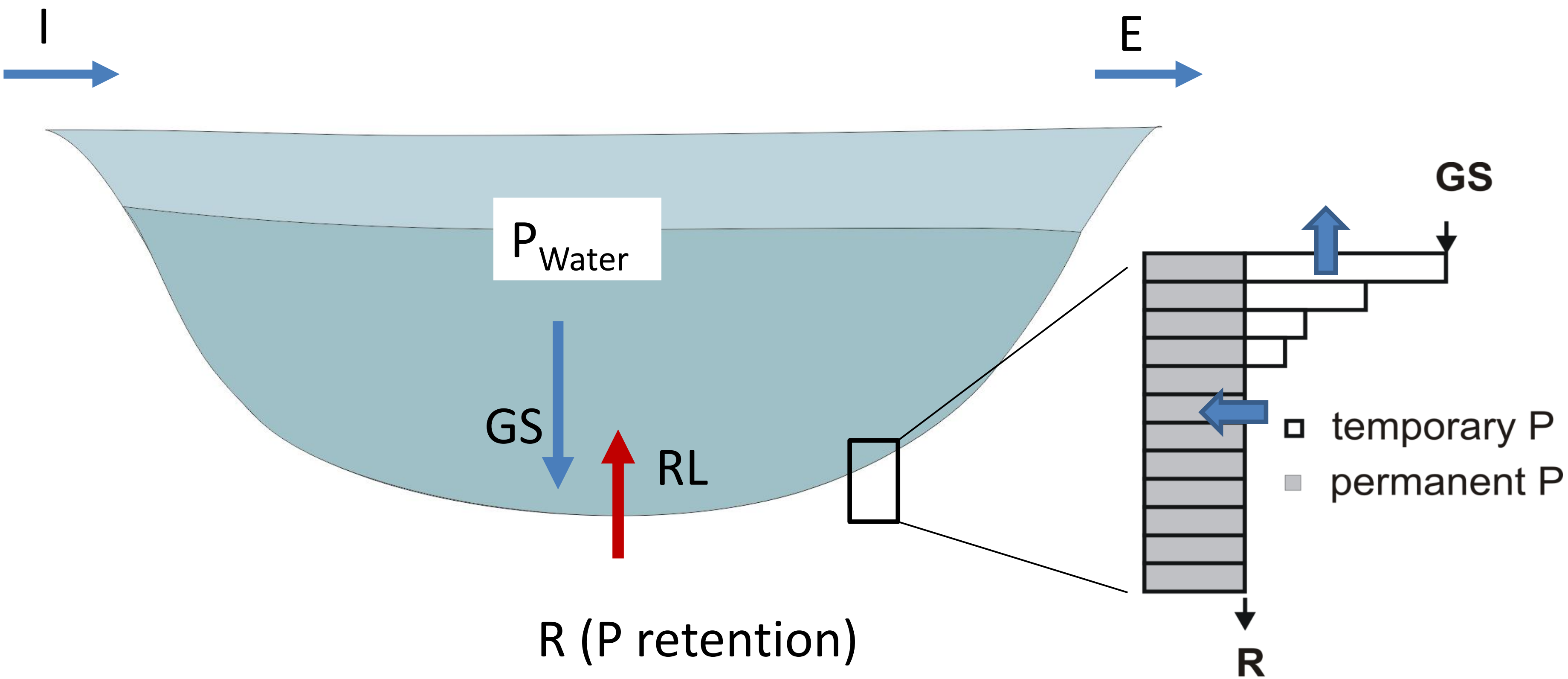
Hypotheses WP 3

Longer and more stable stratification favours anaerobic conditions at the sediment water interface leading to mobilisation of sedimentary phosphorus.

Phosphorus is stored in non-mixed water layers (trap effect). Under episodic mixing conditions the phosphorus is distributed in the whole water body and increases the phosphorus availability for the phytoplankton.



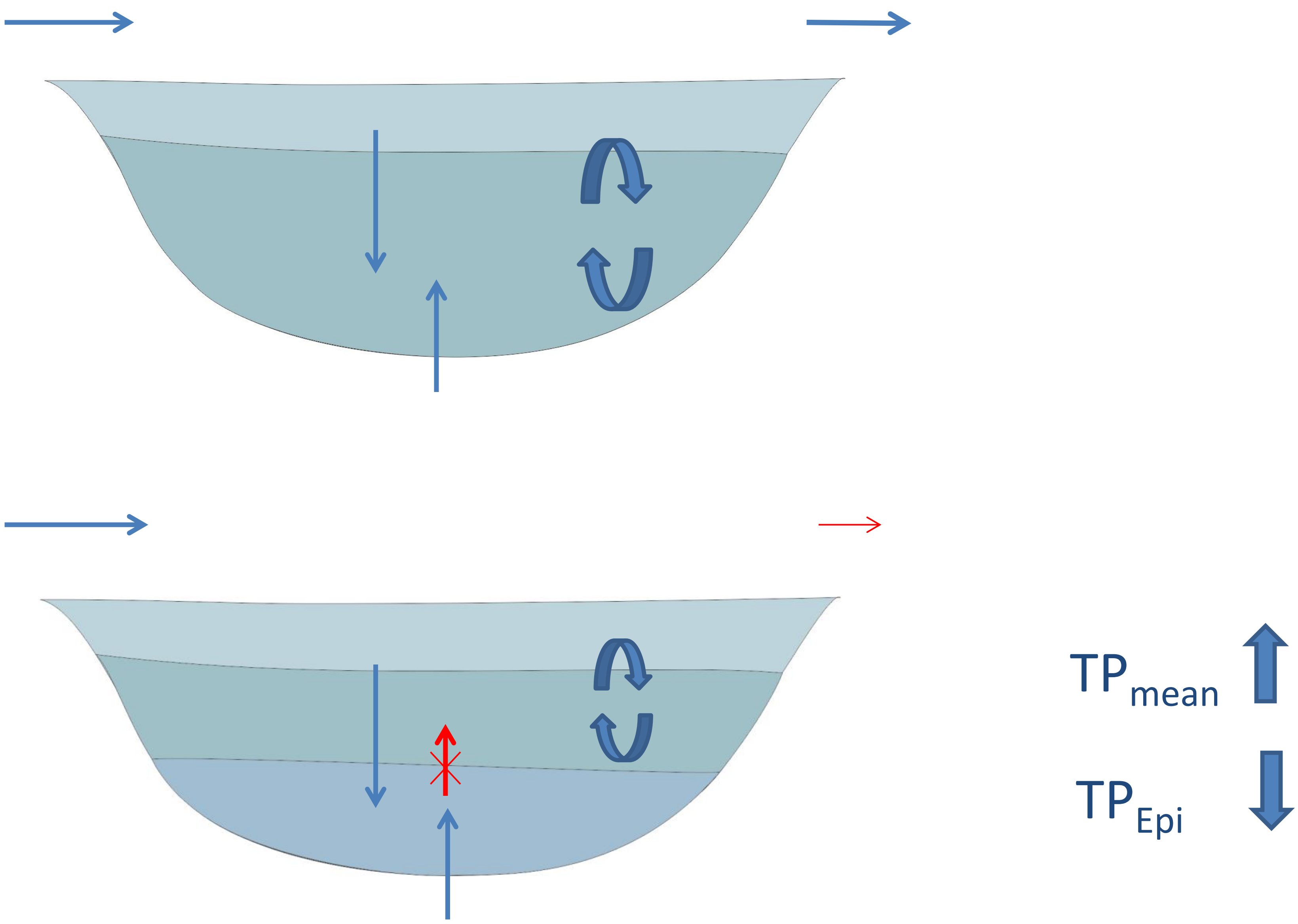
1. Anoxia and internal load



Mobilisation of temporary P

Lower Retention

2. Impact of changed stratification on phosphorus

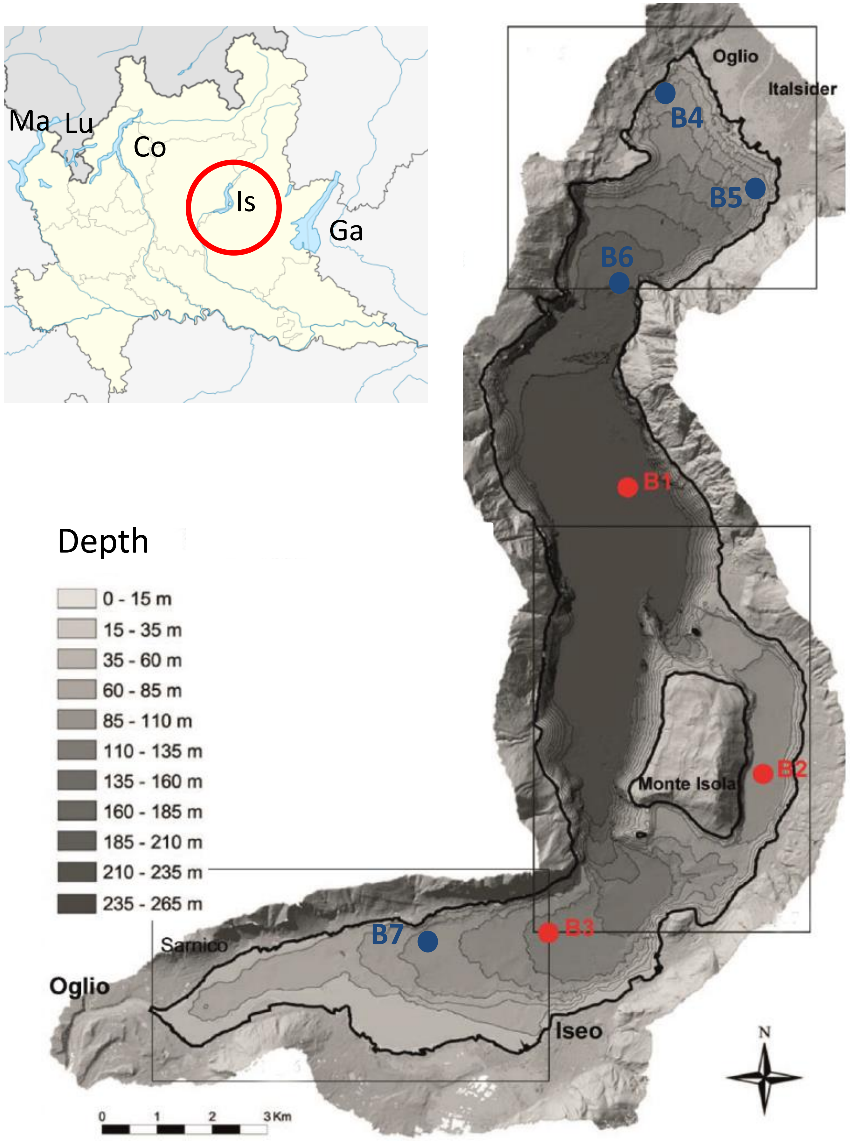


Methods

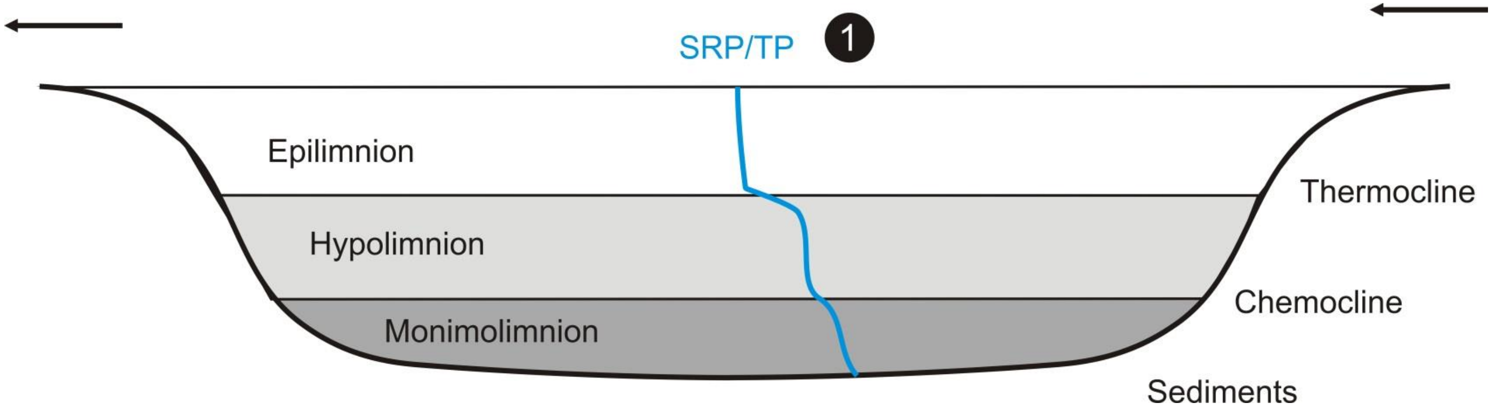
Three sampling campaigns
in April, October 2016
and April 2017

Three main sampling points
B1, B2 and B3

Additional points
N-S transect
B4, B5, B6 and B7



Research concept: Determination of pools and fluxes of P



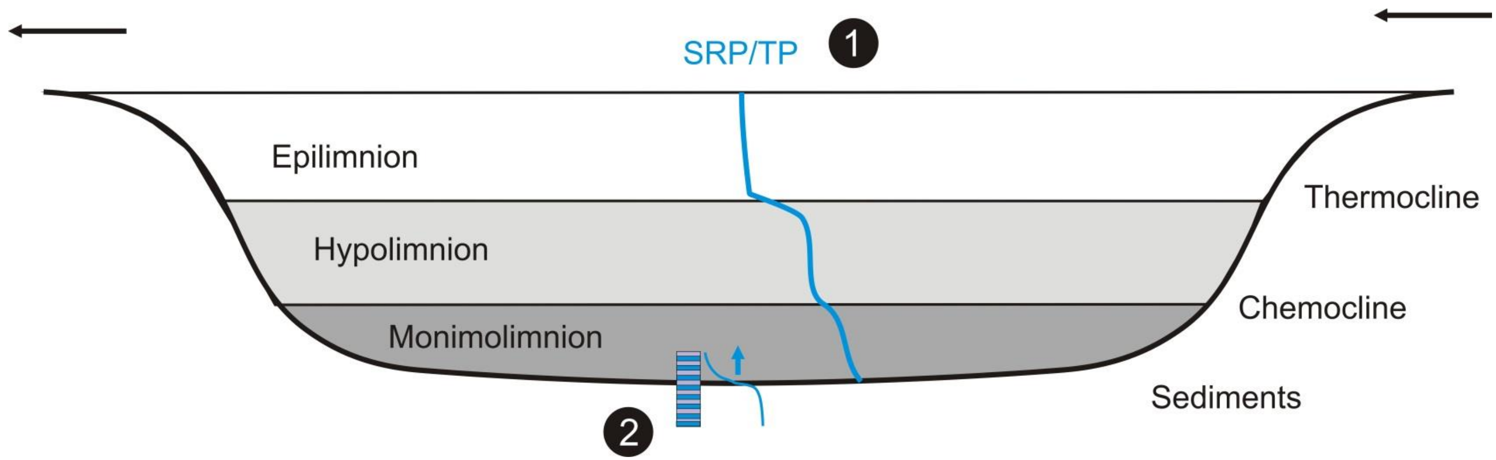
Method/data basis

- Water sampling at B1, B2 and B3 in a high resolution
- Additional parameters (multiprobe, chemical parameters)

Aims

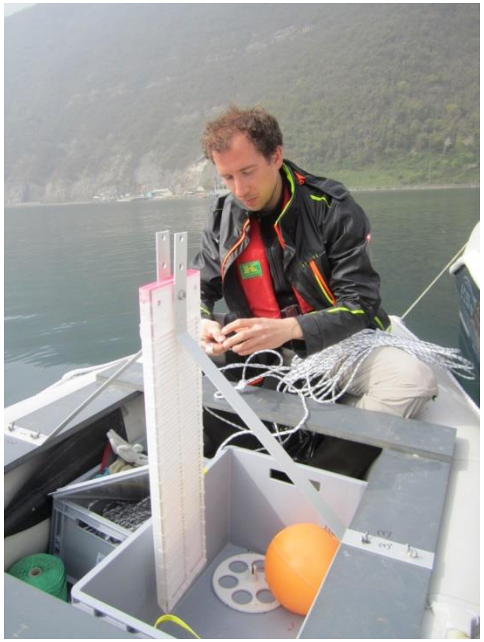
- Seasonality of vertical distribution of phosphorus (mass balance for Epi, Hypo, Moni)
- Internal vs external P sources (WP 1 and WP 2)
- Relations between physical structure and phosphorus transport, Input for modelling (WP6)

Research concept: Determination of pools and fluxes of P



Method

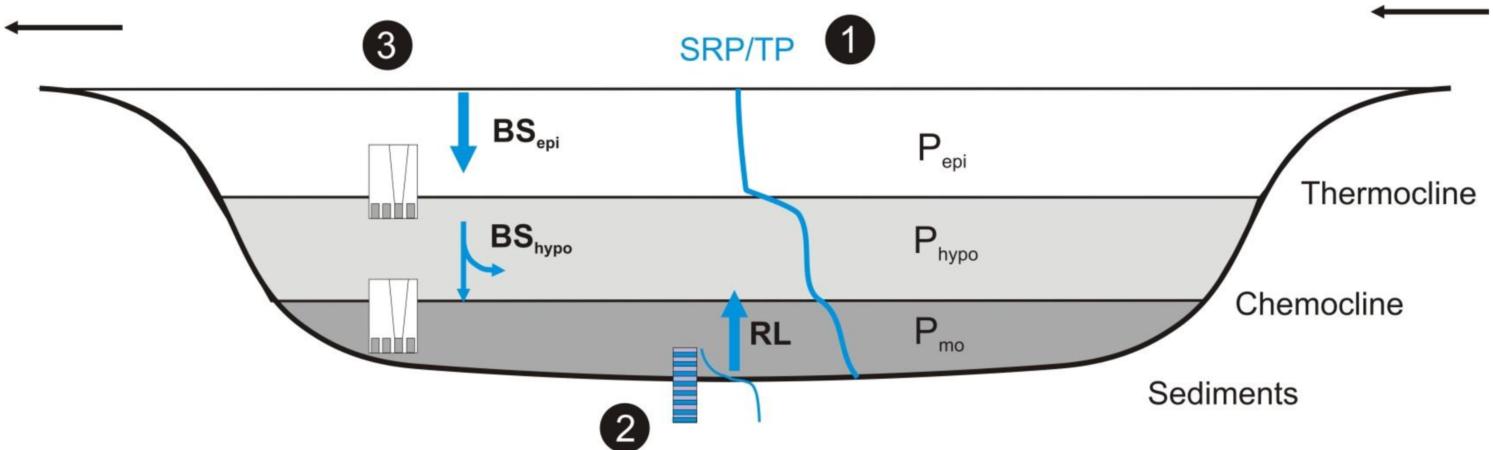
Exposition of dialyses sampler (peeper) to measure the gradientes of dissolved substances between sediment and water in a 1 cm resolution. Exposition at B1, B2 and B3 in April and October



Aims

- In-situ measurement of phosphorus release from sediments (sites, seasons)
- Characterisation of redox conditions
- Identification of P related processes

Research concept: Determination of pools and fluxes of P



Method

Exposition of automatic multi trap samplers to measure the vertical particulate P flux simultaneously at two depths (20 m and 80 m). One multi trap system is equipped with 22 flasks and two cylinders (parallel samples).

Aims

Quantification of vertical matter transport and their seasonal variability. Determination of changes during and after sedimentation by comparison of trap material in different depths with sediment surface.

Research concept: Determination of pools and fluxes of P

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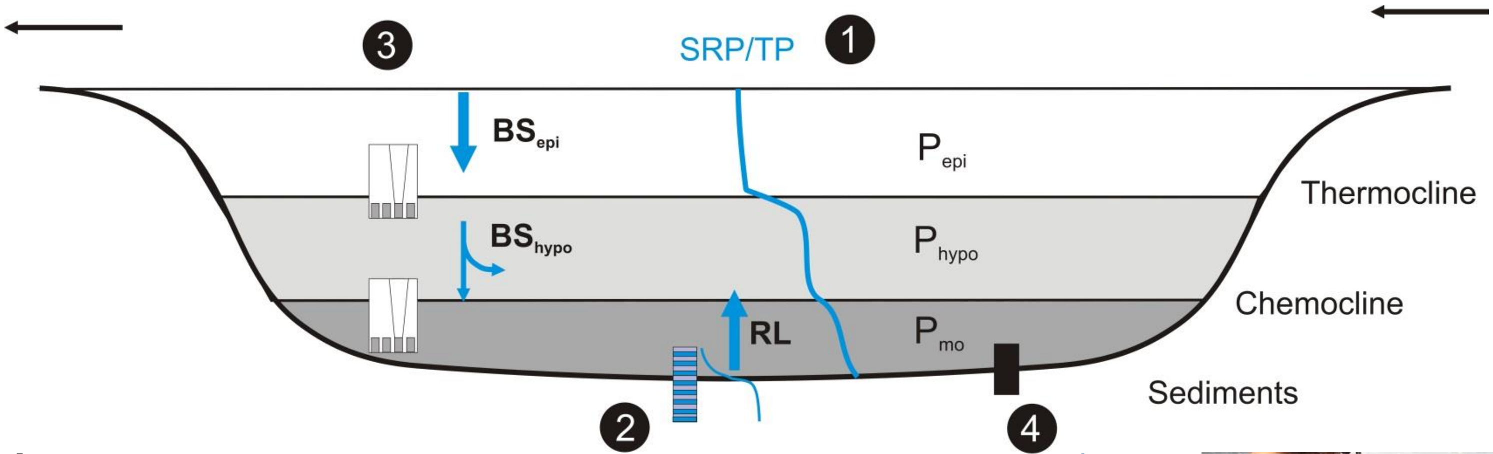


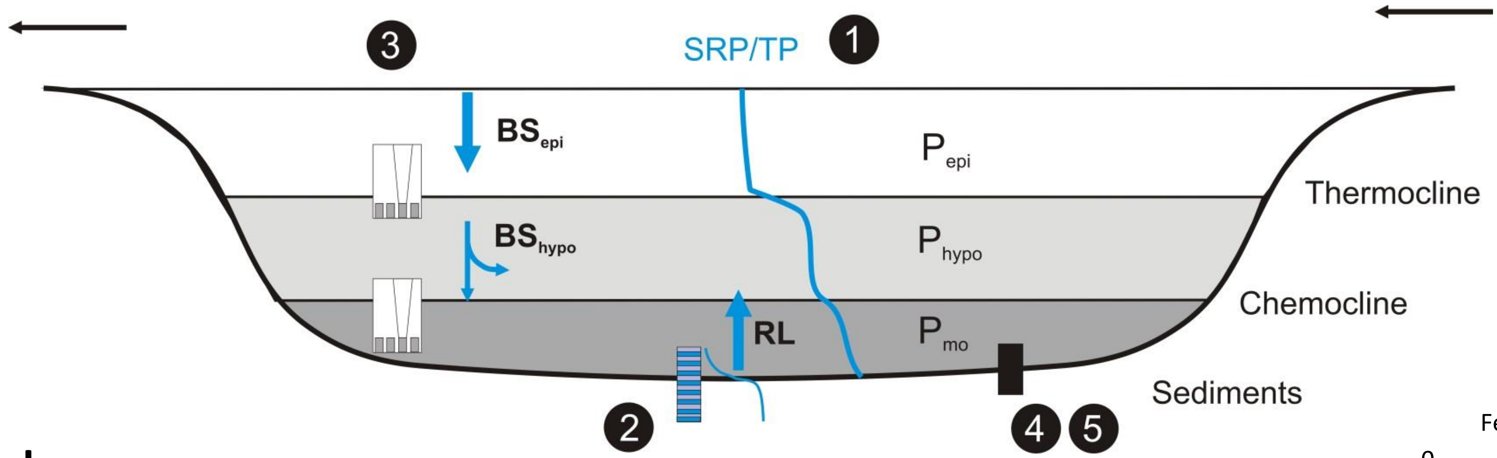
Method

Sampling of sediment cores for slicing of uppermost layers. Determination of P binding forms by sequential extraction procedure.

Aims

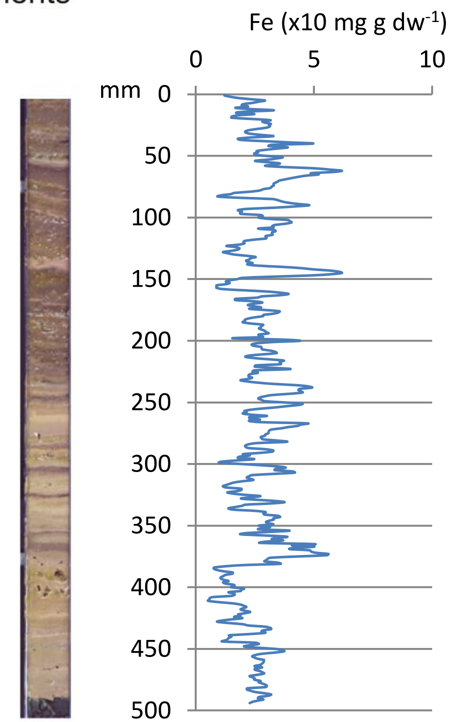
Quantification of **potentially mobile P forms** by analysis P species and by the gradient method.

Research concept: Determination of pools and fluxes of P



Method

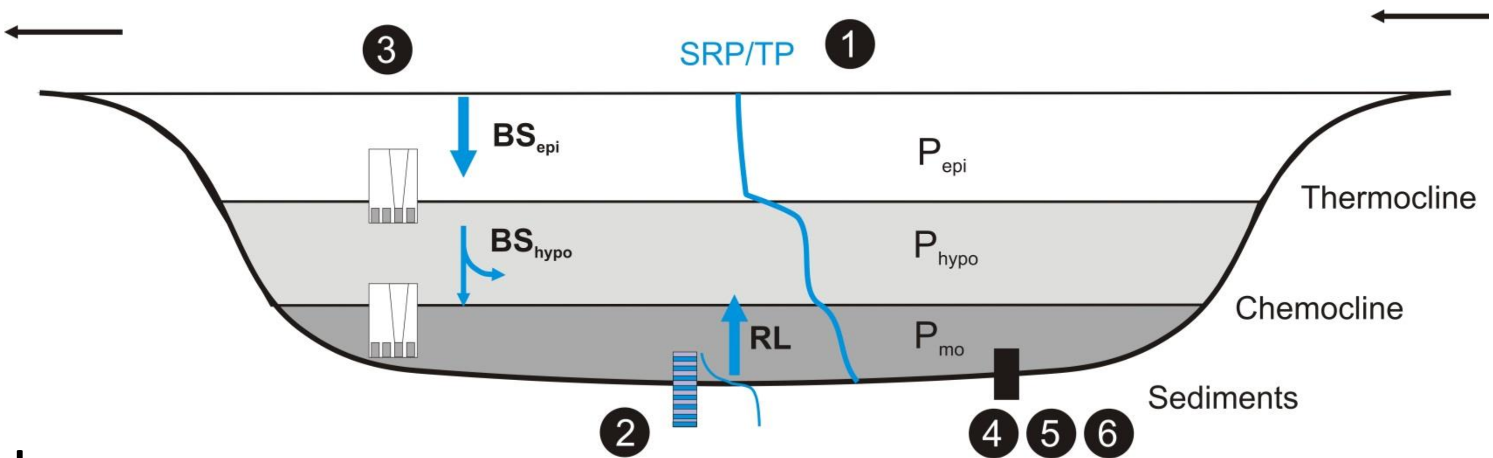
Sampling of sediment cores (40 to 50 cm long) for multi-element analysis with XRF core scanning (´Geo´-Scanner).



Aim

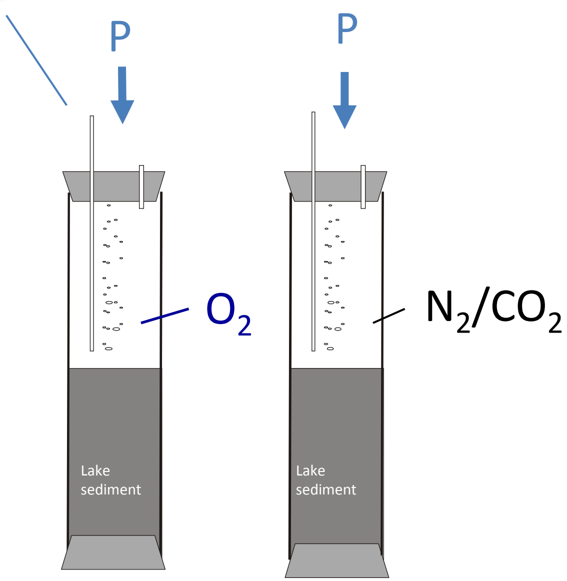
Evaluation of trends and sedimentation events with importance for internal phosphorus cycling (e.g. S:Fe ratio). Proxies for trophy and oxygen situation (Mn:Fe, …)

Research concept: Determination of pools and fluxes of P



Method

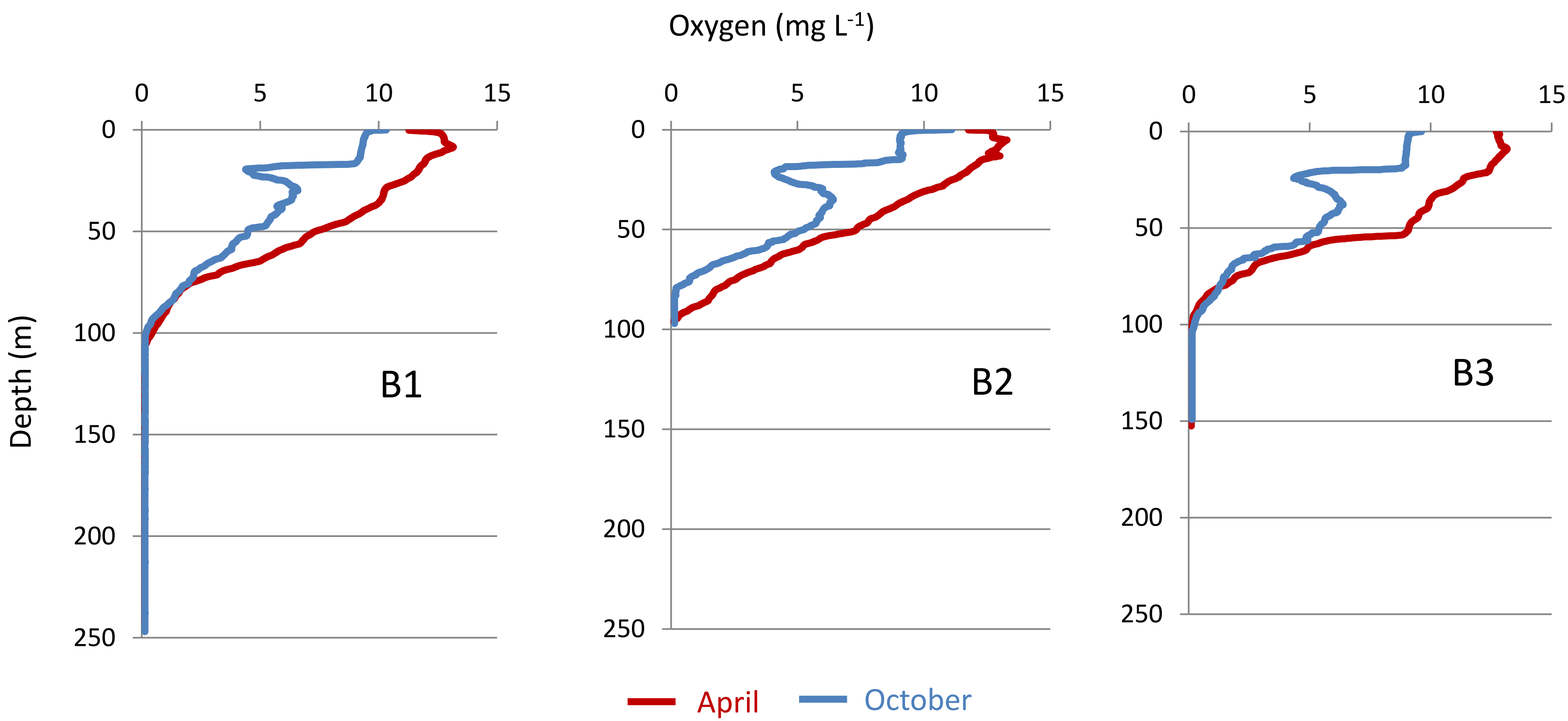
Sampling of sediment cores and exposition under anaerobic and aerobic conditions in the laboratory. Restocking of P in the overlying water. Quantification of P uptake by mass balance and sediment investigations.



Aims

Quantification of the **redox controlled P fixation** in the sediment

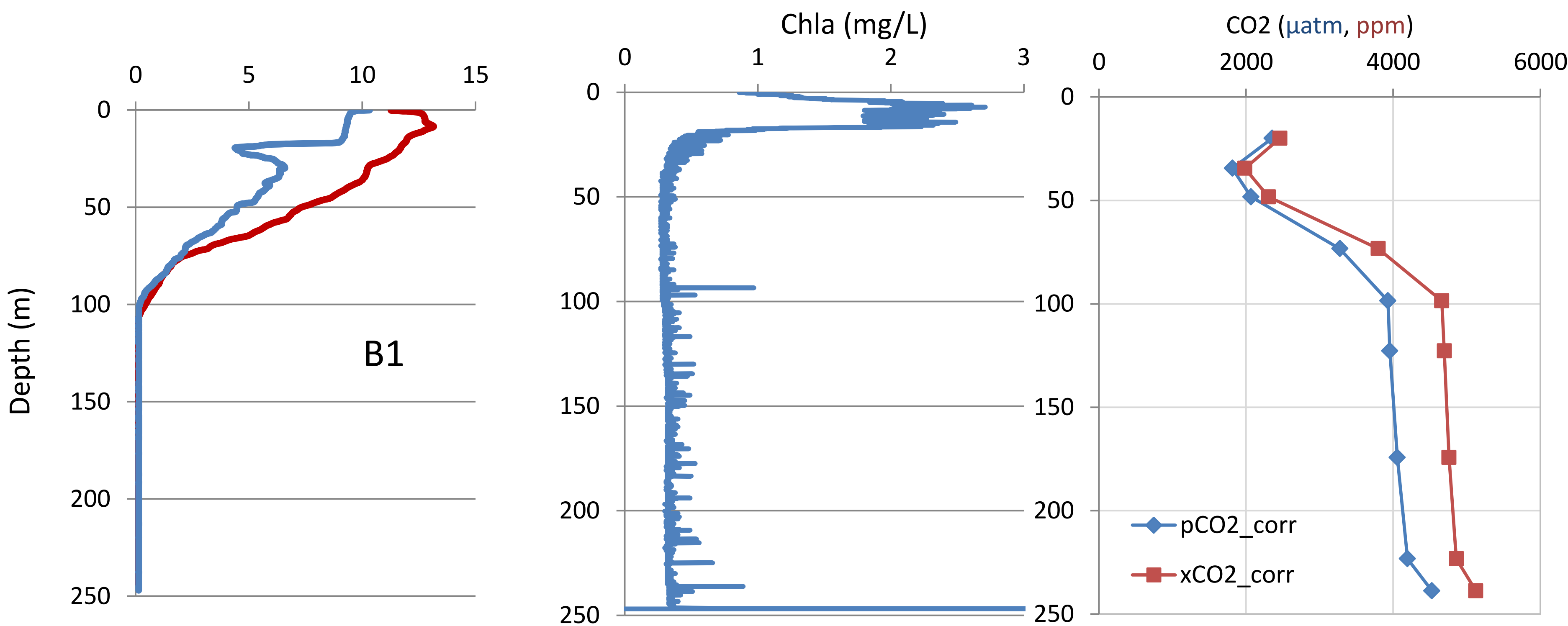
Oxygen



40% of the lake volume: oxygen free, metalimnetic oxygen minimum in summer

Accumulation of reductive potential in the hypo-/monimolimnion

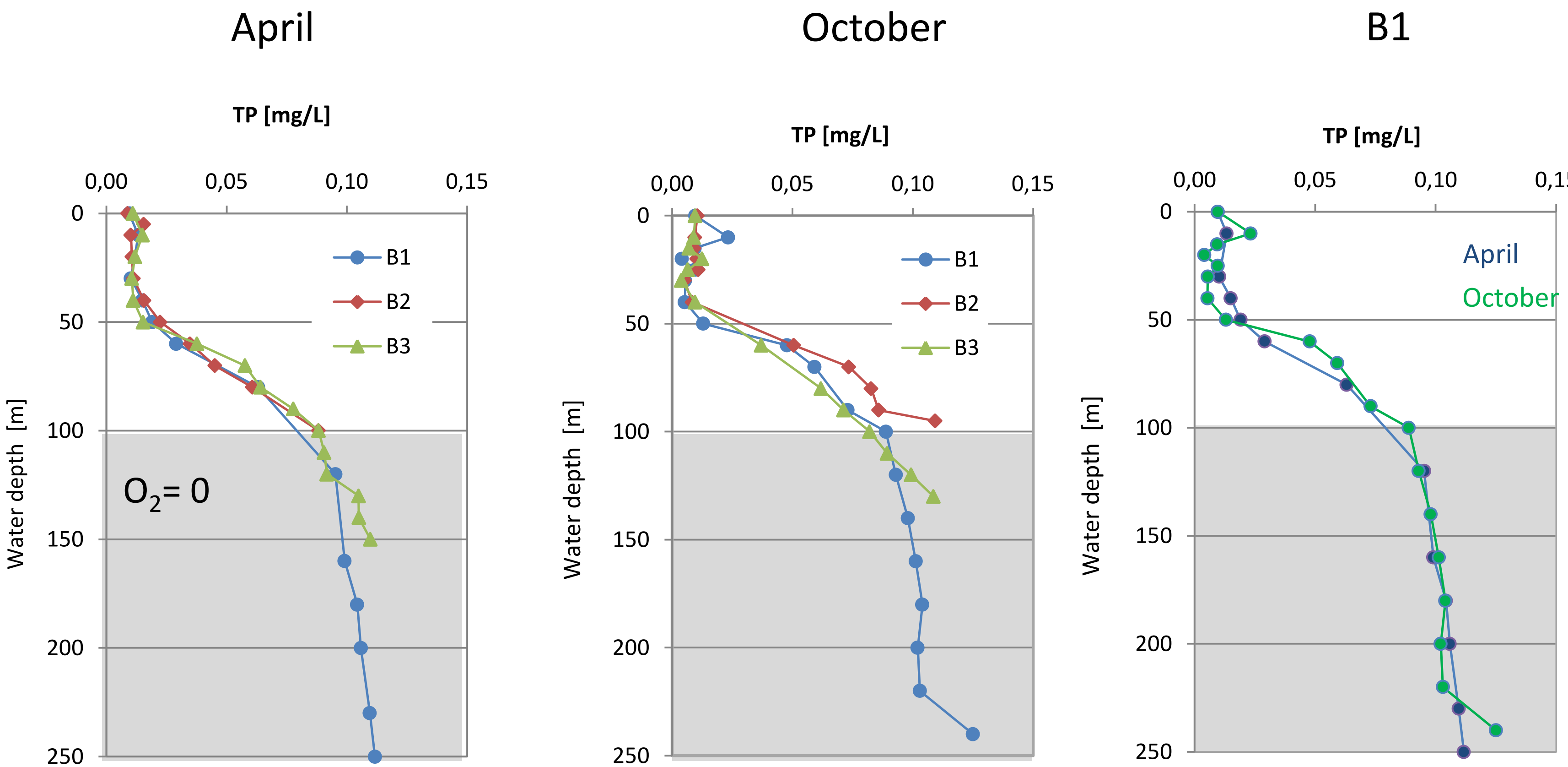
Oxygen, Chla and CO_2



40% of the lake volume: oxygen free, metalimnetic oxygen minimum in summer

Accumulation of reductive potential in the hypo-/monimolimnion

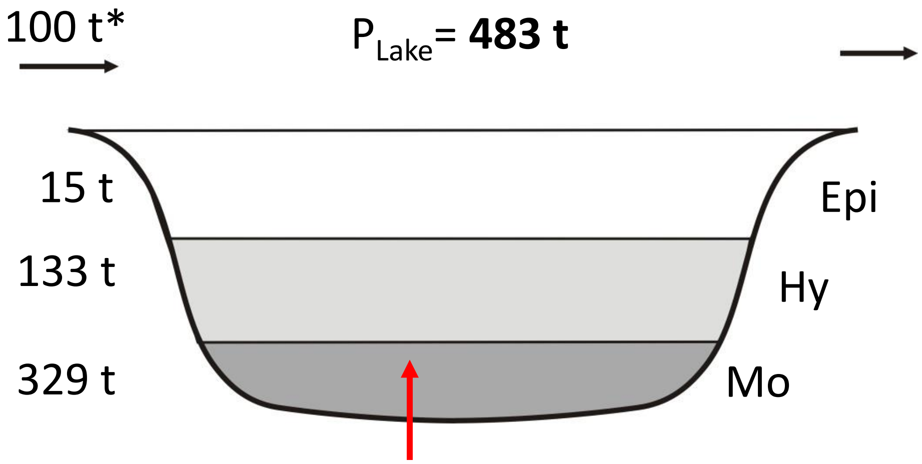
Balance of total P in the water



No significant changes between April and October

Epi	0-20 m	13 µgP/L	TP_{Lake} (average)
Hypo	20-100 m	38 µgP/L	60.5 µgP/L
Monimo:	100-252 m	102 µgP/L	

Preliminary P balance



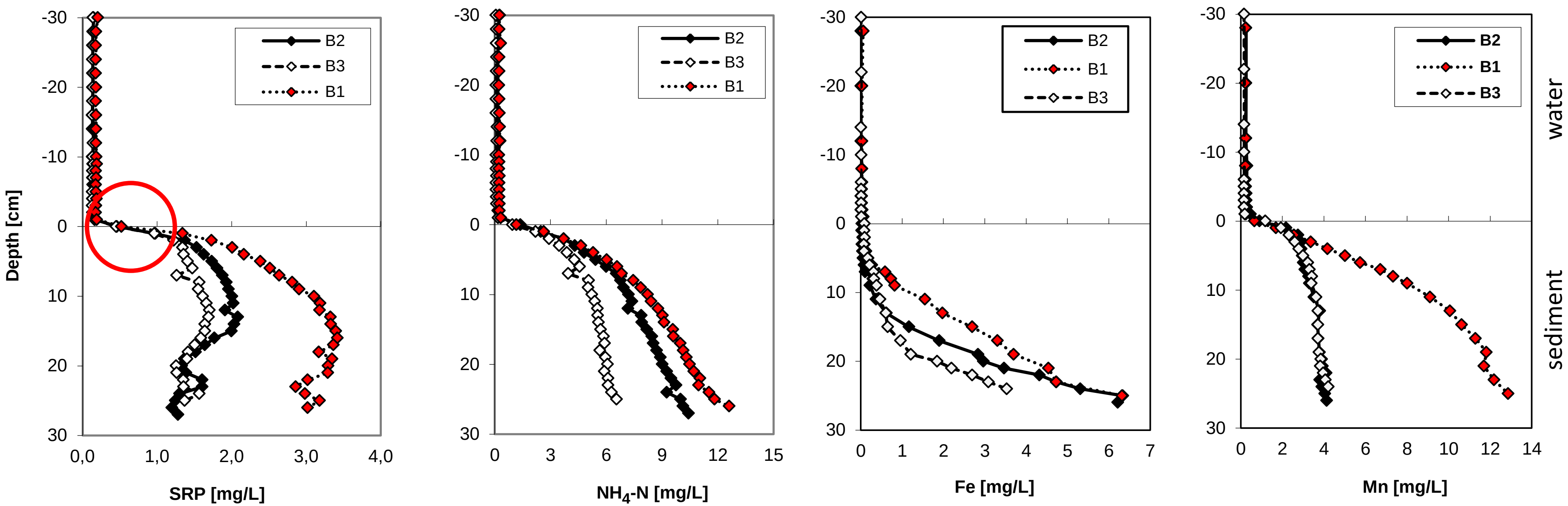
*Dalmiglio (2011)

P is accumulated in the monimolimnion (less P in the euphotic zone, but P in the monimolimnion could be a „*time bomb*“)

Determination of P release

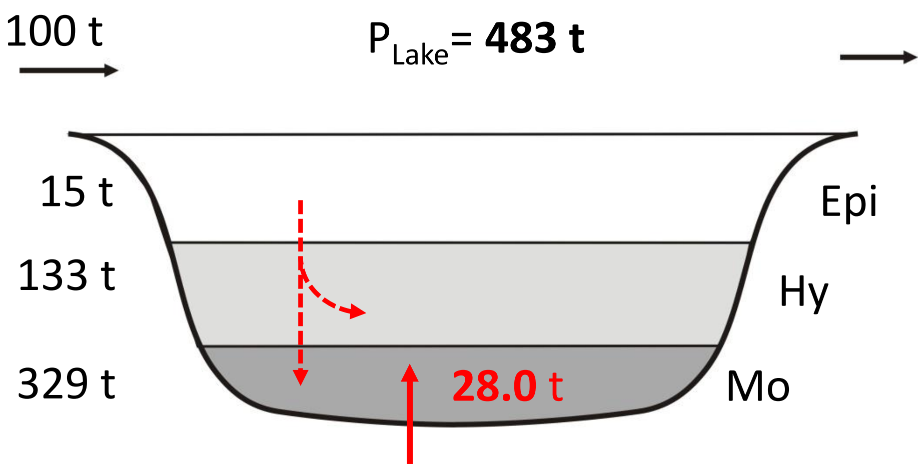
2

Profiles in the sediment water interface, April 2016



Phosphorus release rates ranged between 1.26 and 3.02 mgP m^{-2} d^{-1}

Preliminary P balance



P release from sediment ($mgP\ m^{-2}\ d^{-1}$)		
B1	2.58	1.90
B2	1.73	3.02
B3	1.78	1.26

$28.0\ t\ yr^{-1}$

„Discrepancy" between release rate and no increase in the monimolimnion

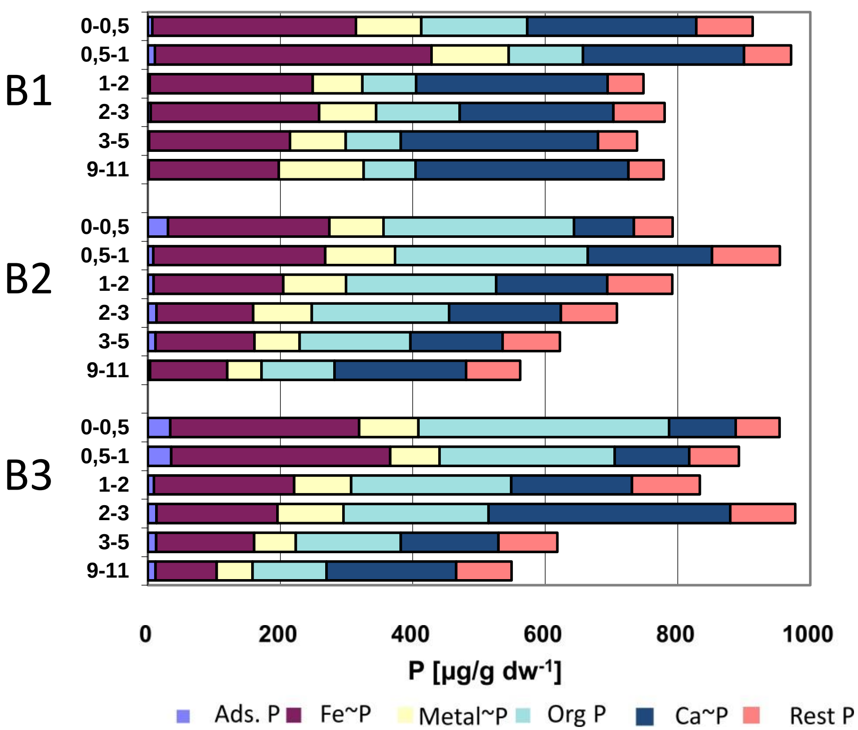
- Too short period between April to October
- Exchange accross redoxcline (chemocline)
- Re-precipitation of P in the monimolimnion

Determination of potentially mobile P pool

4

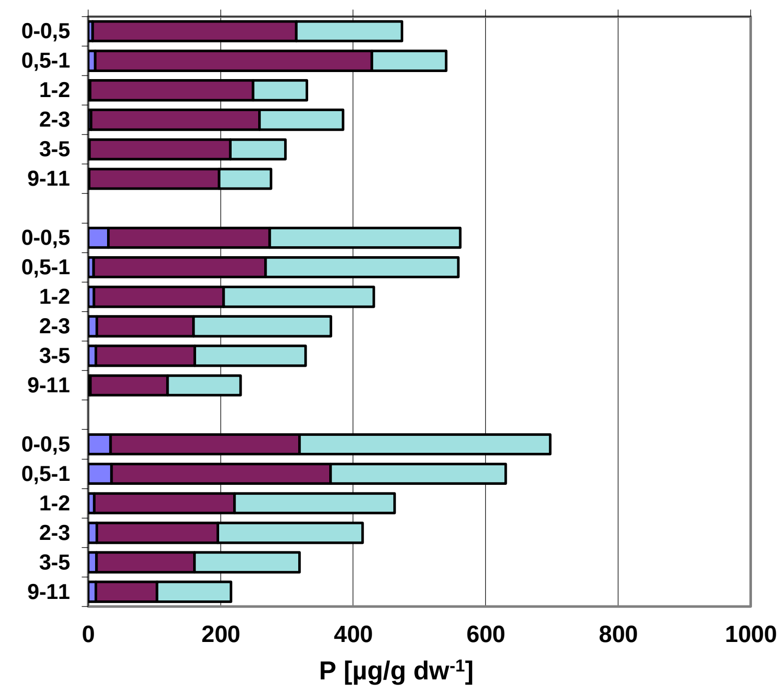
Phosphorus fractions

Depth (cm) **Fe~P** **Org. P** **Ca-P**

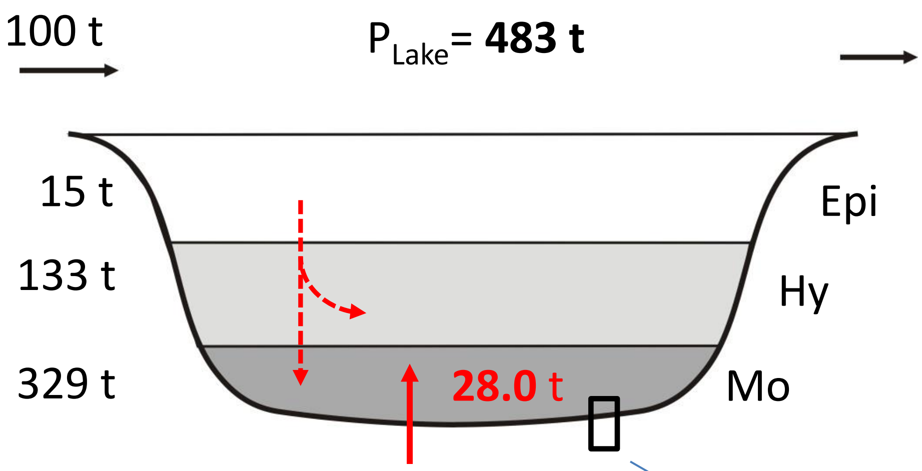


„Mobile“ P

Depth (cm)



Preliminary P balance



P release from sediment
(mgP m^{-2} d^{-1})

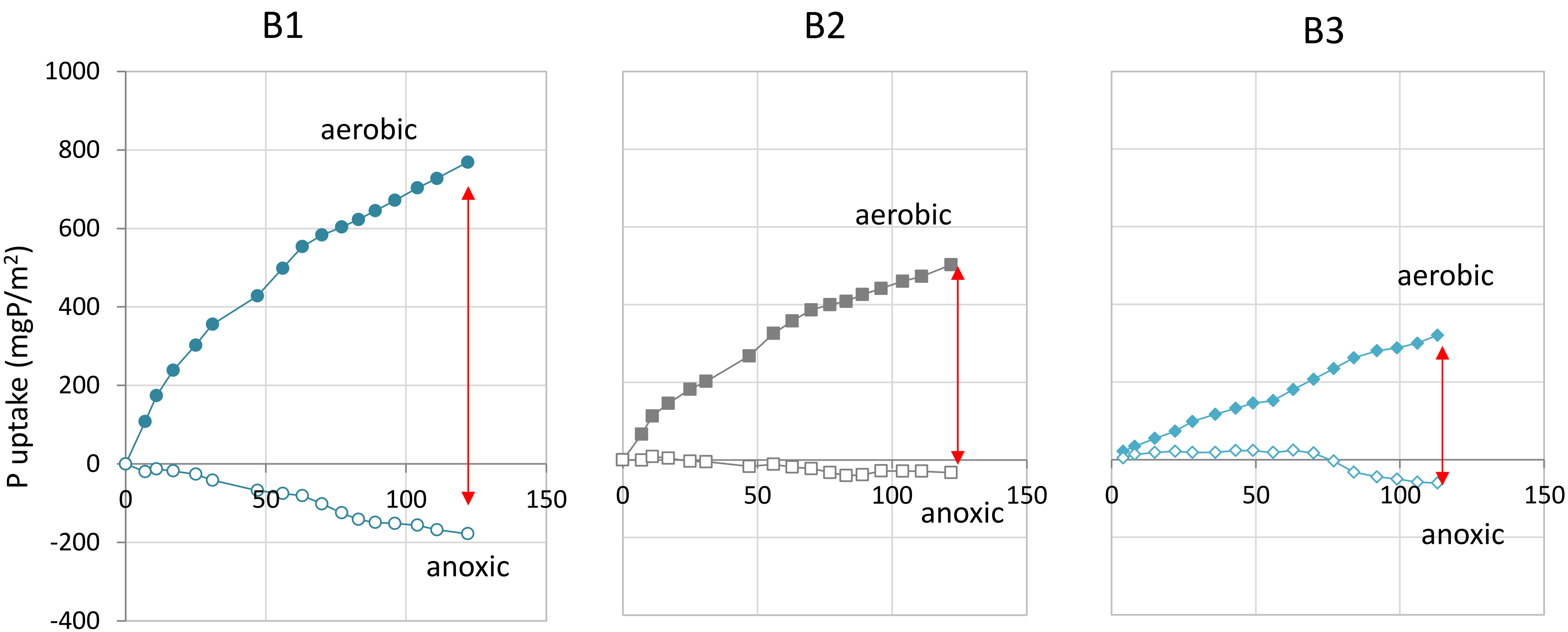
B1	2.58	1.90	
B2	1.73	3.02	28.0 t yr^{-1}
B3	1.78	1.26	

Pot. mobile P pool sediment
(mgP m^{-2})

B1	1200	
B2	873	41.2 t
B3	968	

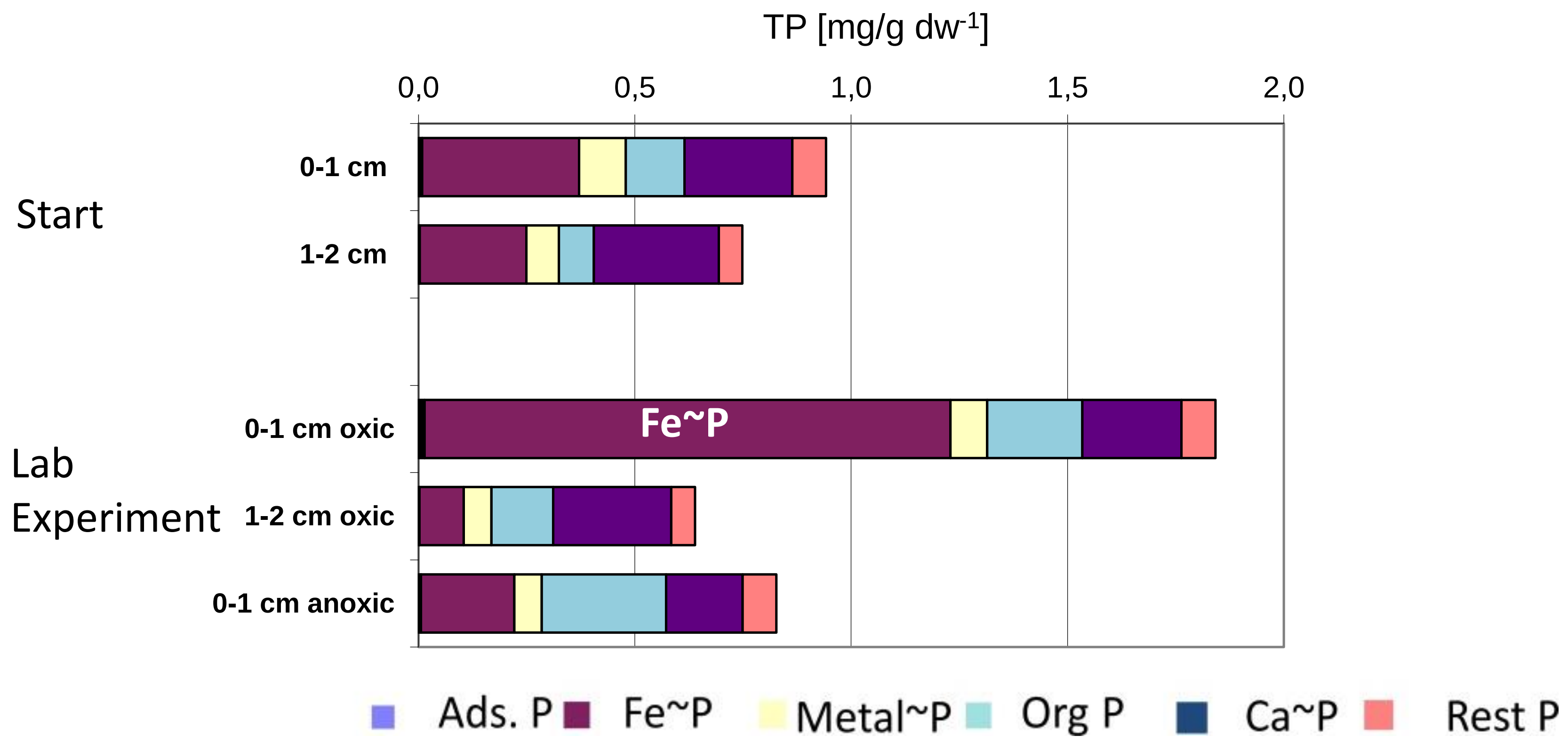
The P pool in the sediment is only sufficient für 1.5 years

Quantification of redox-controlled P



The higher the reductive potential the higher the impact of reoxidation.

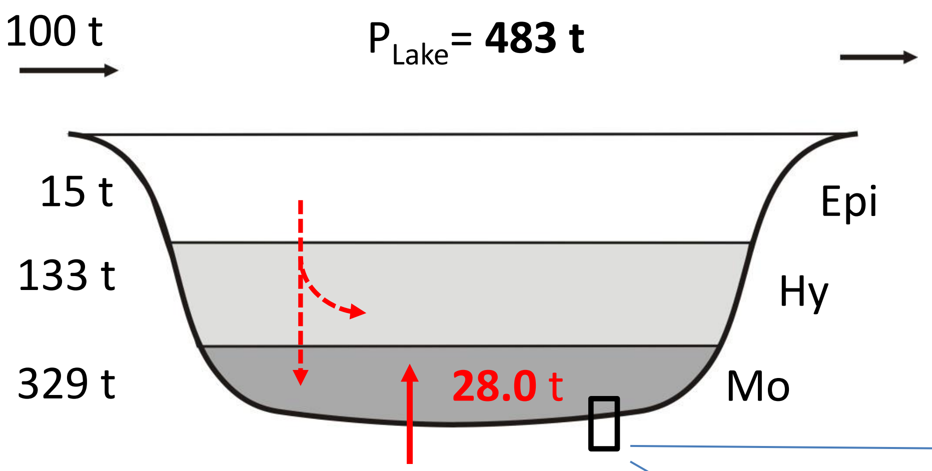
Quantification of redox-controlled P



Under aerobic conditions P is adsorbed to iron in the uppermost sediment layer.

Preliminary P balance

Master thesis of Juliane Roth (2017)



Redox controlled P sediment ($mgP\ m^{-2}$)

B1	1020	
B2	572	30.2 t
B3	380	

P release from sediment ($mgP\ m^{-2}\ d^{-1}$)

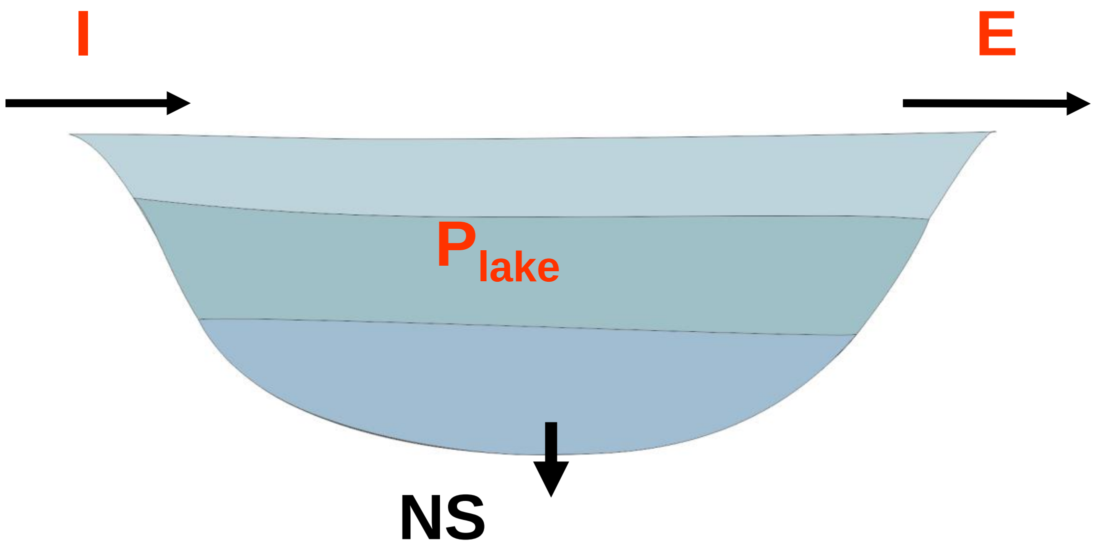
B1	2.58	1.90	
B2	1.73	3.02	$28.0\ t\ yr^{-1}$
B3	1.78	1.26	

Mobile P pool sediment ($mgP\ m^{-2}$)

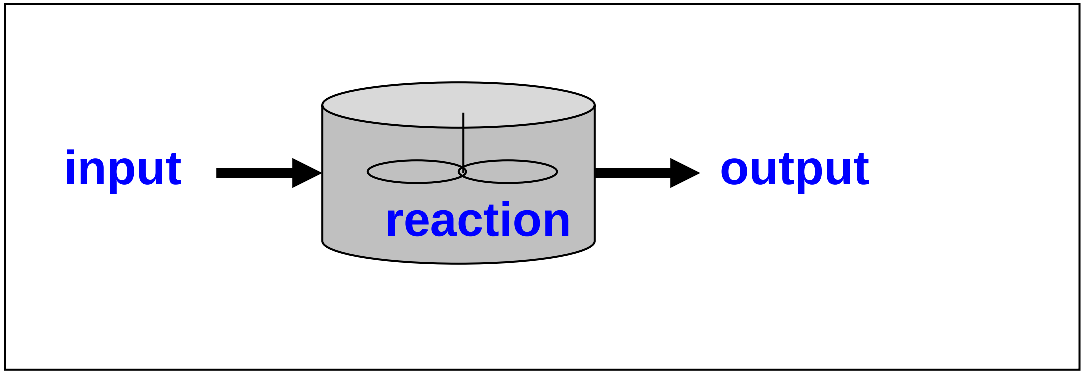
B1	1200	
B2	873	41.2 t
B3	968	

The eutrophication potential of mobile P in sediment is low compared to P_{lake} and P_{import}.

Outlook: Modeling of P development under changed mixing conditions



The one-box model



$I = E + NS - dP_{lake}/dt$

Steady state:
$dP_{lake}/dt = 0$

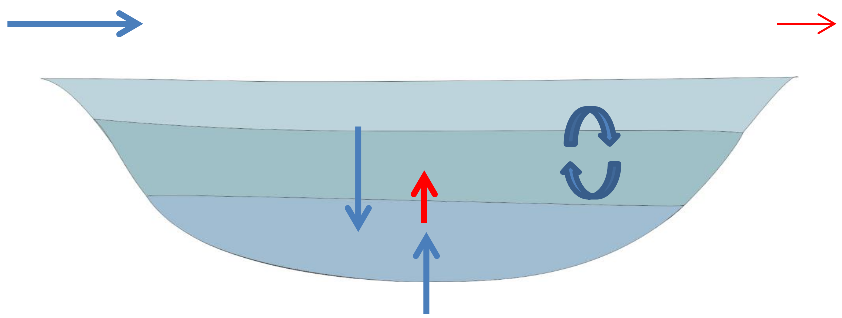
Net sedimentation coefficient
$\sigma = NS/P_{lake}$

Stratification factor
$\beta = cP_E / cP_{lake}$

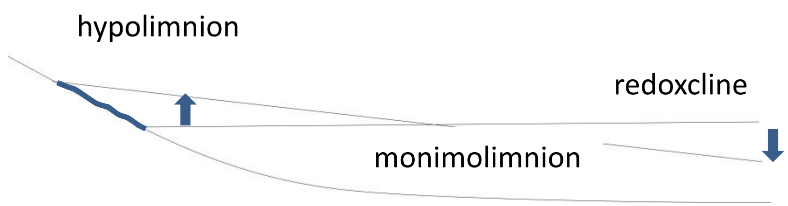
Water residence time
$\tau = Q/V$

Outlook: Coupling of hydrophysical conditions with P fluxes

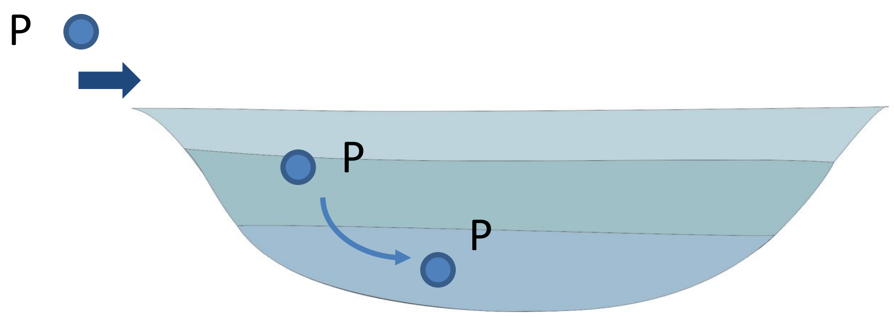
Monimolimnion as a trap for phosphorus, transport across chemocline



Movements of the redoxcline („seiches“).
Short term redox changes



Role of particles from the catchment.

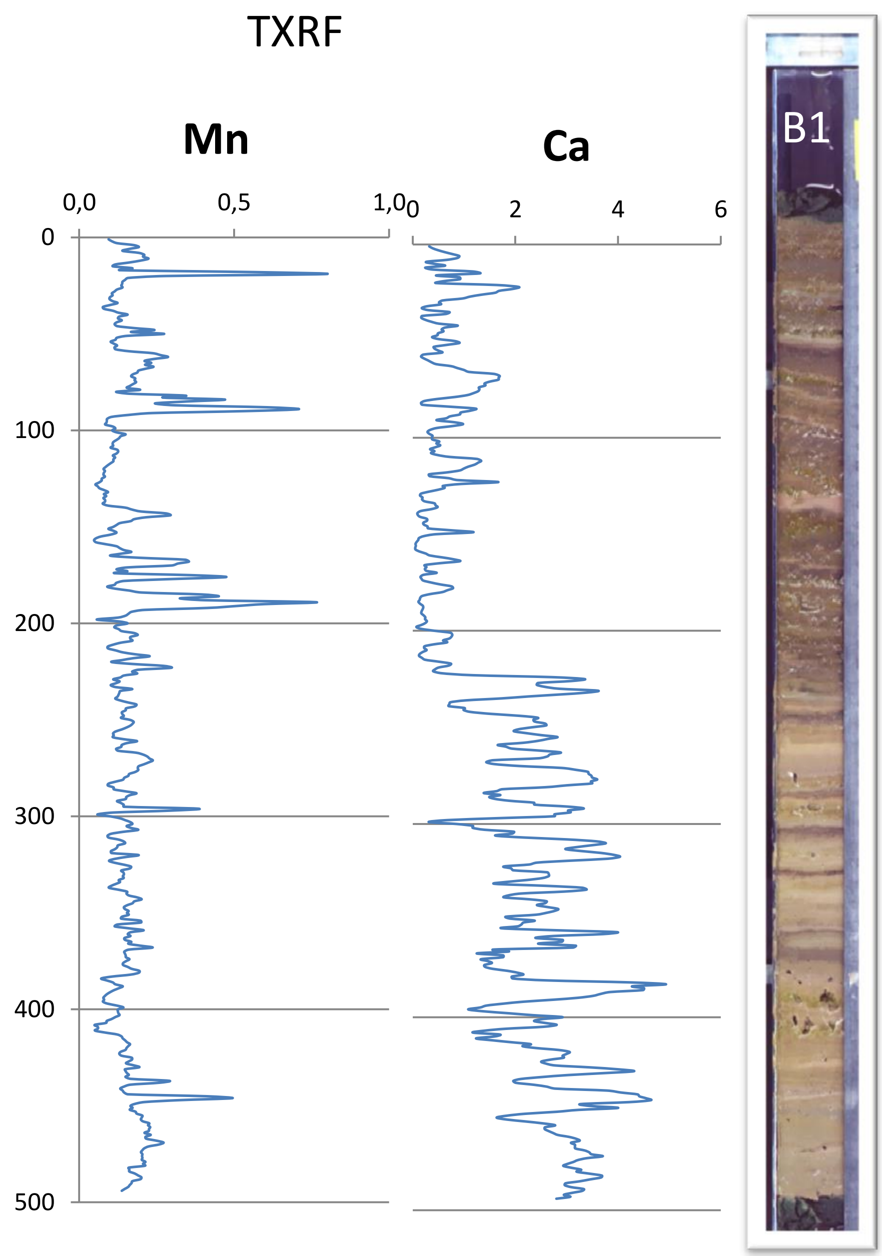


Outlook: Evaluation sediment profiles

Event stratigraphy

Proxies for oxygen situation

Pattern of elemental composition



Outlook: Evaluation sediment profiles

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Tracing bottom water oxygenation with sedimentary Mn/Fe ratios in Lake Zurich, Switzerland

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ABSTRACT

Redox dynamics of manganese (Mn) were studied in the sediment of Lake Zurich using precise sediment core age models, monthly long-term oxygen (O_2) monitoring data of the water column (1936–2010) and high-resolution XRF core scanning. The age models were based on bi-annual lamination and calcite precipitation cycles. If present, Mn exhibits distinct maxima, which coincide with the annual maximum deep-water O_2 concentrations in spring according to the monitoring data. In contrast, the iron (Fe) signal is mainly the result of calcite dilution, as indicated by a strong negative correlation between Fe and calcium (Ca) XRF data. The Mn/Fe ratio in the core from the maximum lake depth (ZH10-15, 137 m) revealed a moderate correlation with O_2 measurements in the lake bottom water confirming the successful application of the Mn/Fe ratio to semi-quantitatively reconstruct bottom water oxygenation in the lake. Mostly low ratios were observed between 1895 and the mid-1960s as a result of eutrophication. However, geochemical focusing and sedimentological factors can reduce the applicability of the Mn/Fe ratio in reconstructing O_2 concentrations in the bottom water of lakes.

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Status WP 1

	Sampling	Analysis	Evaluation
P fractionation	🟢	🟢	🟢 🟡
Pore water	🟢	🟢	🟢 🟡
Surface sediments transects	🟢	🟢	🟢 🟡
Multi-Traps	🟢	🔴	🔴
Geoscanner (long cores, 60 cm)	🟢	🟢	🔴
Lab core experiments	🟢 🟡	🟢 🟡	🟢 🟡
P profiles in water	🟢 🟡	🟢 🟡	🟢 🟡
Particles	🔴	🔴	🔴

🟢 Completed 🟡 In progress 🔴 To do

Thank you!

ISEO Project

Leibniz-Institute of Freshwater Ecology and Inland Fisherie, Department of Chemical Analytics and Biogeochemistry, local project leader: Michael Hupfer. Responsible for quantification of the phosphorous fluxes from the sediments (WP3).

Michael Hupfer, PhD in Limnology, coordinator of the IGB activites

Christiane Herzog, Diploma Chemistry, contributing to the laboratory analysis of the water and sediment samples

Juliane Roth, MSc Environmental Studies, contributing to the preparation of campaigns, lab and field work

Maximilian Lau, PhD in geochemistry, resposible of the field work development, and contributing to the data analysis

Sylvia Jordan, Diploma in Geography, resposible of the data processing and contributing to the preparation of field campaigns

Thomas Rossoll, Diploma in Environmental process engineering, contributing to the the field work and the samples analysis

http://hydraulics.unibs.it/hydraulics/attivita-scientifica/iseo-project/