ISEO: Improving the lake status from Eutrophy towards Oligotrophy

Work-package 3: Quantification of internal phosphorus fluxes

ISEO-Meeting
17th April 2018
Brescia

Leibniz Institute of Freshwater Ecology and Inland Fisheries
Berlin, Germany

fondazione cariplo

Focus of WP 3

Determination of pools and fluxes of phosphorus

Distribution of P in the water

Fluxes from and to sediment

P pools in the sediment

Impact of physical conditions on the internal P cycle

Oxygen depletion (anoxic mobilisation)

Trap effect of monimolimnion

Seiches and P mobility

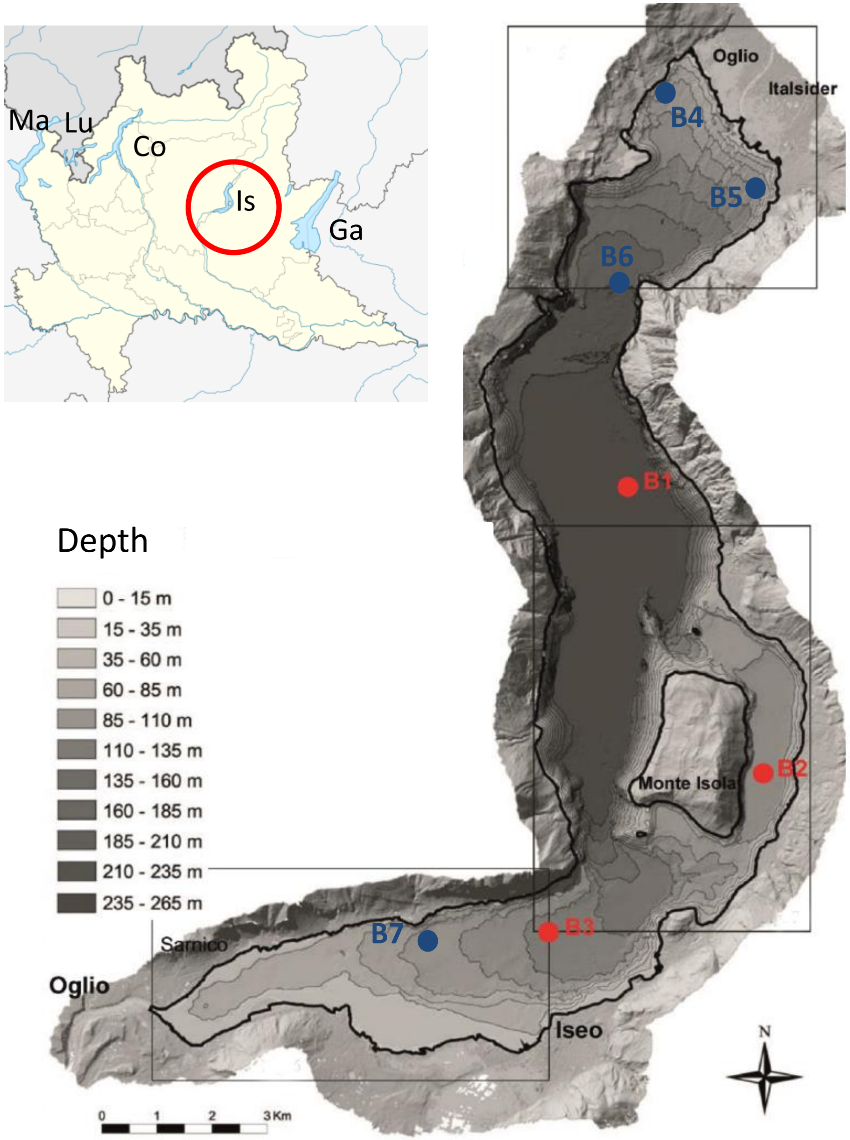
Consequences for the lake management

Methods

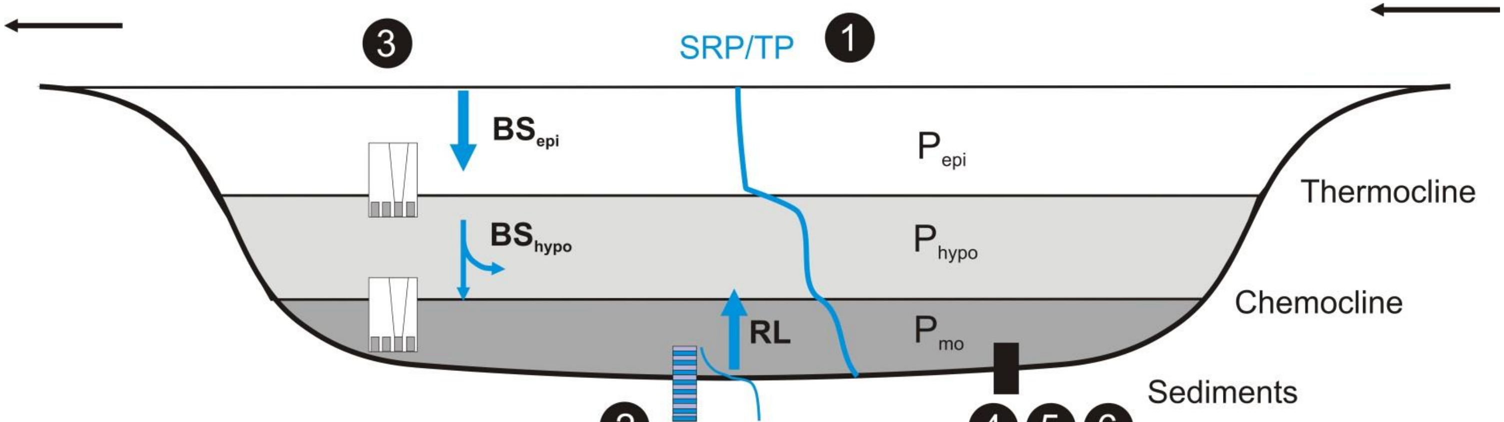
Sampling campaigns
2016: April, October
2017: April, July, October
2018: April, October

Three main sampling points
B1, B2 and B3

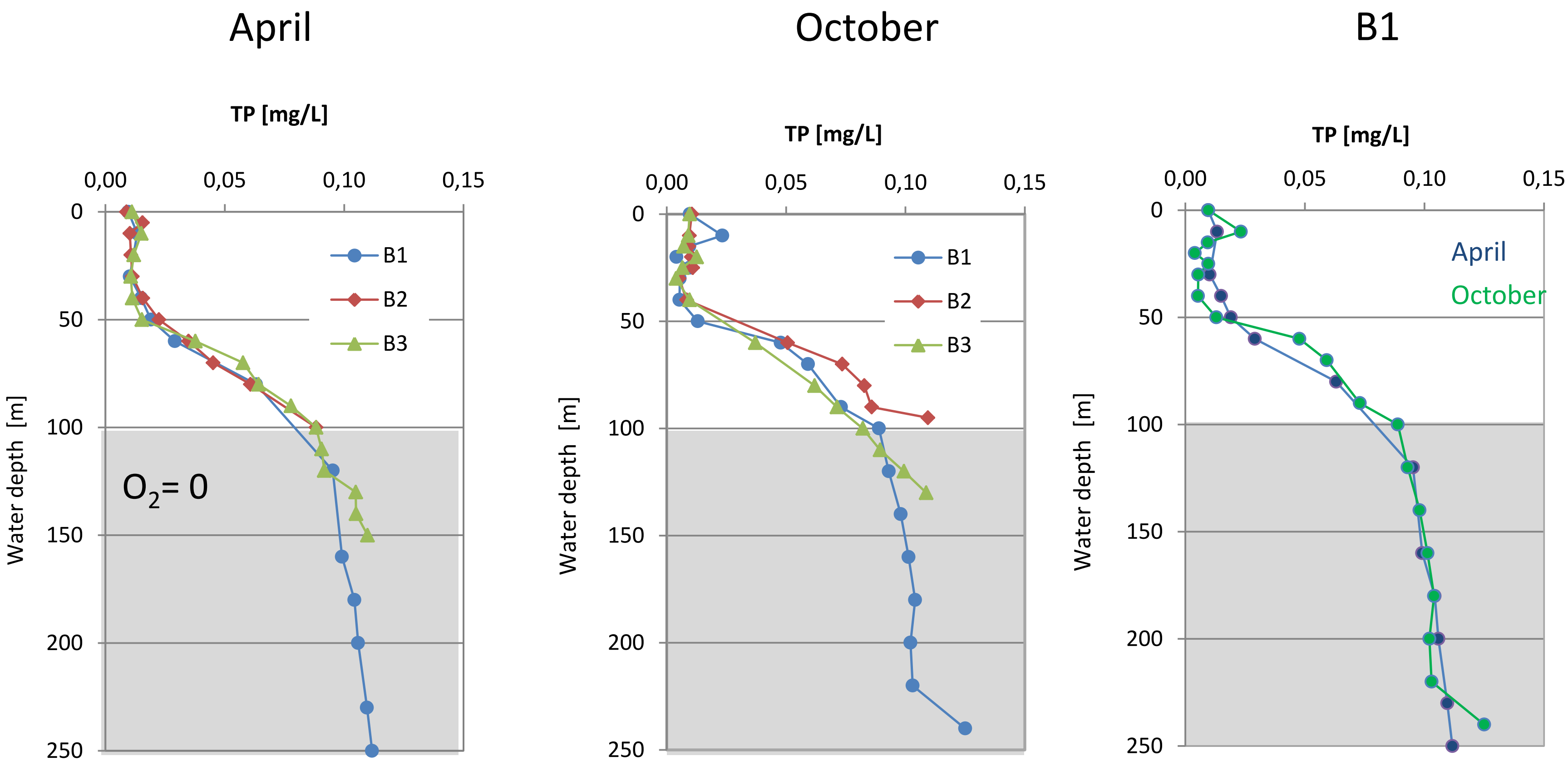
Additional points
N-S transect
B4, B5, B6 and B7



Methods


3
SRP/TP
1
BS epi
BS hypo
P epi
P hypo
P mo
RL
Thermocline
Chemocline
Sediments
2
4
5
6

Distribution of total P in the water

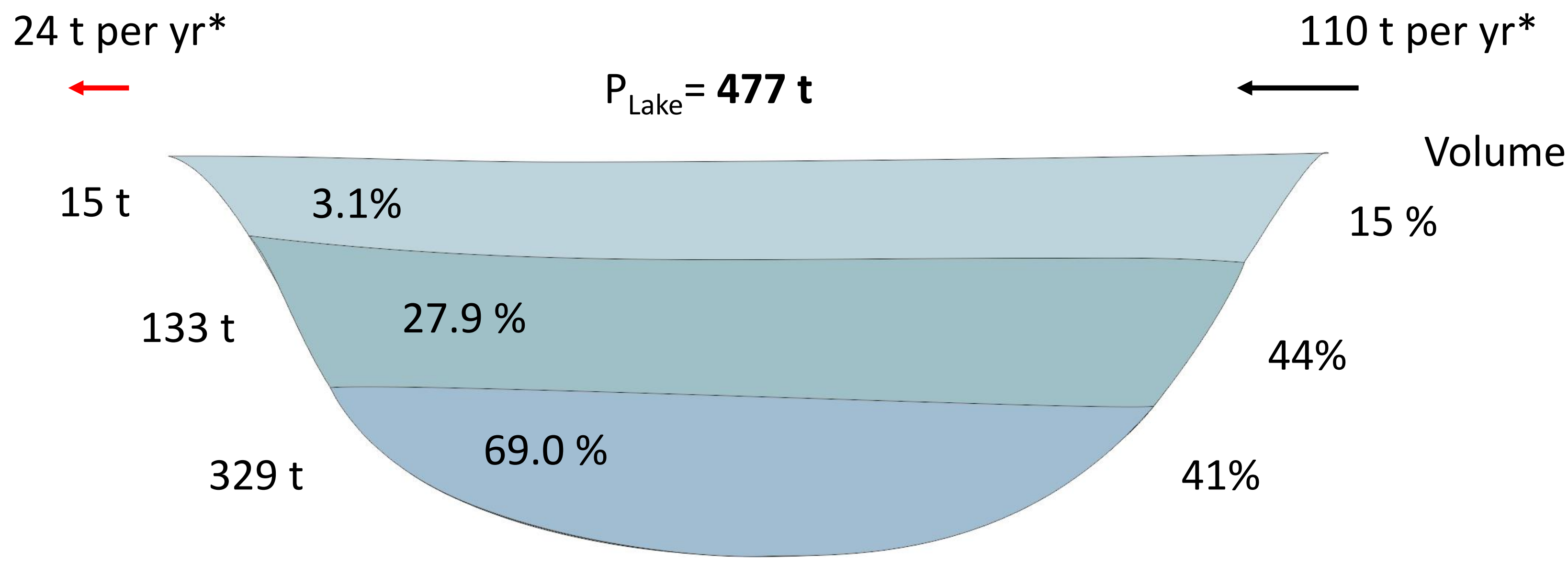


No significant changes between April and October 2016 at between positions

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	

Distribution of total P in the water

2016

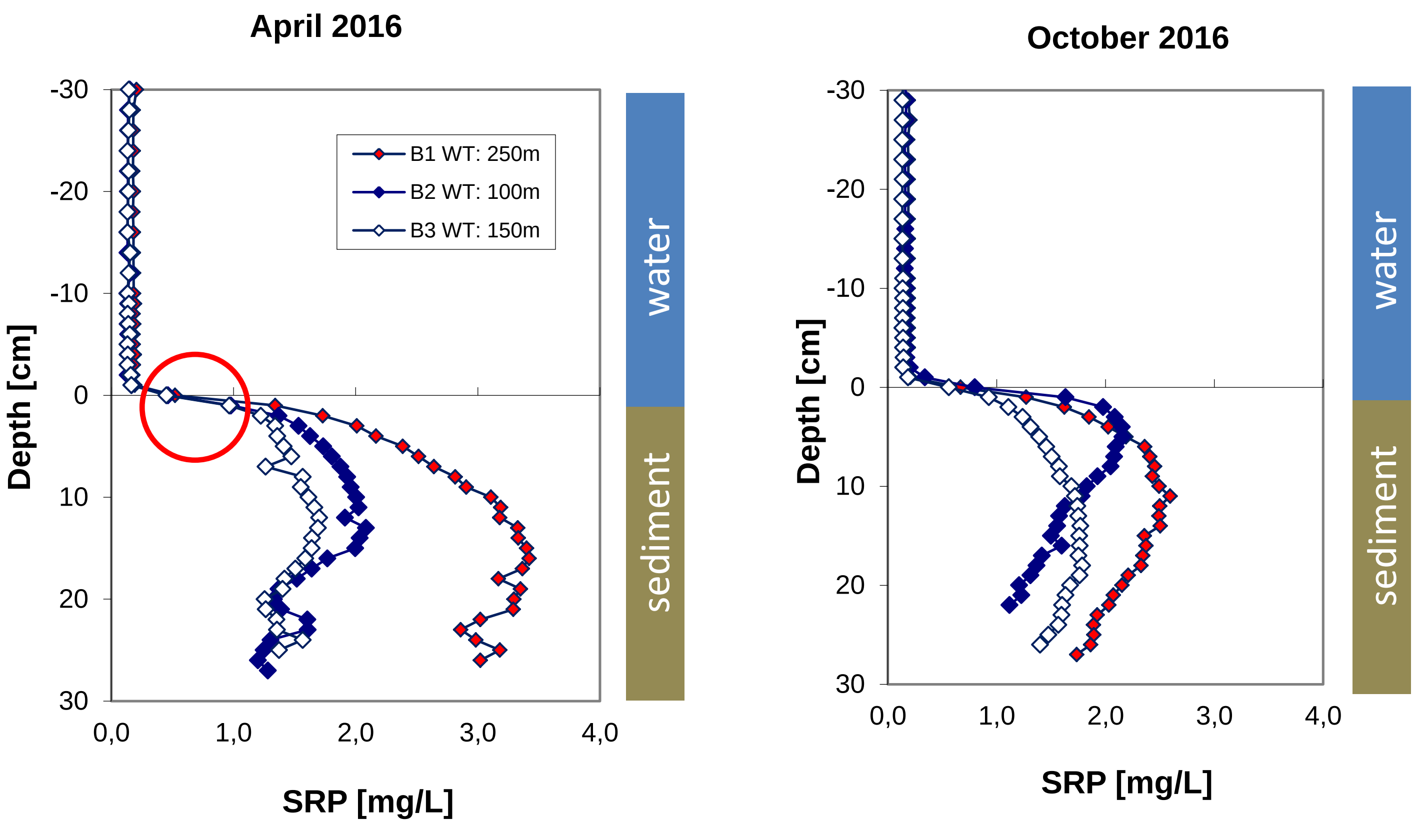


*Nizzoli et al.

- Less P in the euphotic zone
- Monimolimnion is acting as an (efficient) P trap
- Balance point of view: **P export is decreased** due to meromixis

Determination of P release

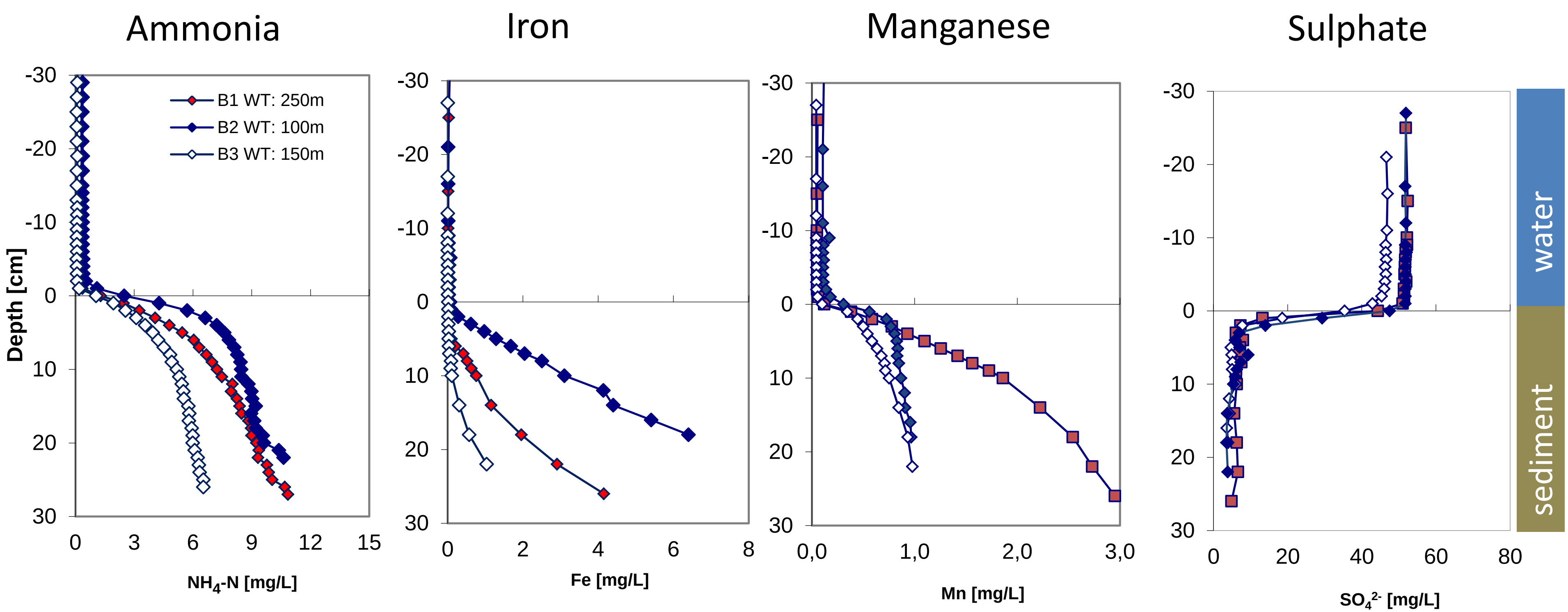
April and October 2016



„Diffusive“ phosphorus release rates ranged between 1.26 and 3.02 mg P m^{-2} d^{-1}

Redox parmeters at the Sediment water interface

Profiles in the sediment water interface, October 2016



Despite the long time of meromixis we could observe steep gradients between sediment and water: No significant accumulation near the sediment water interface.

Sedimentation

3

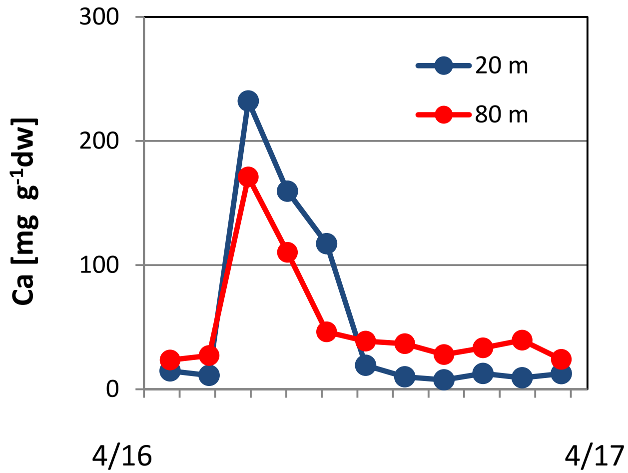
08.04.16 11.05.16 13.06.16 16.07.16 18.08.16 20.09.16 23.10.16 25.11.16 28.12.16 30.01.17 04.03.17

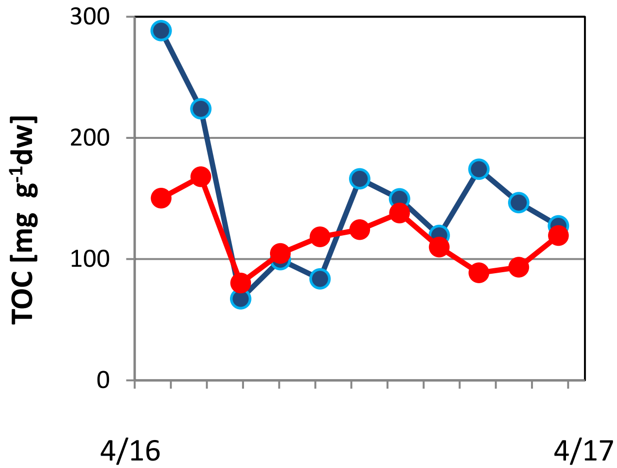
20 m

90 m

Trap material in 20 m and 90 m water depth

Sedimentation

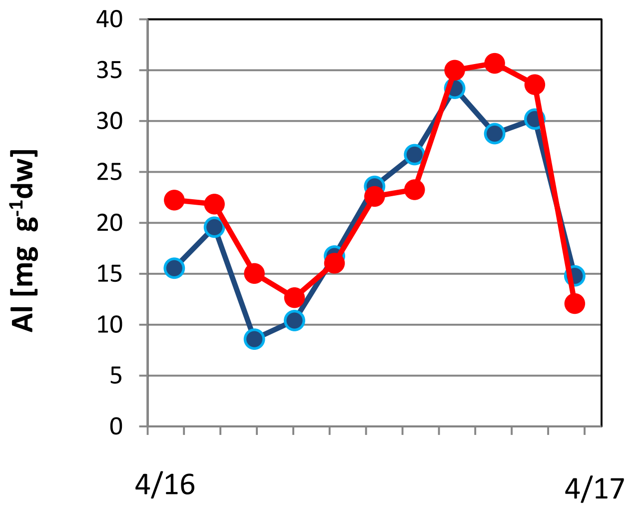


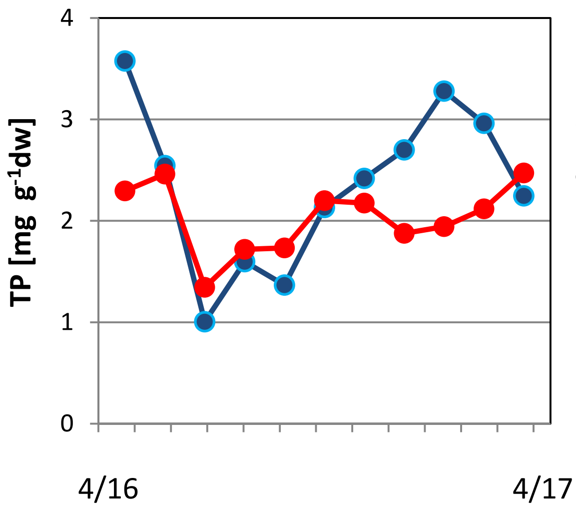


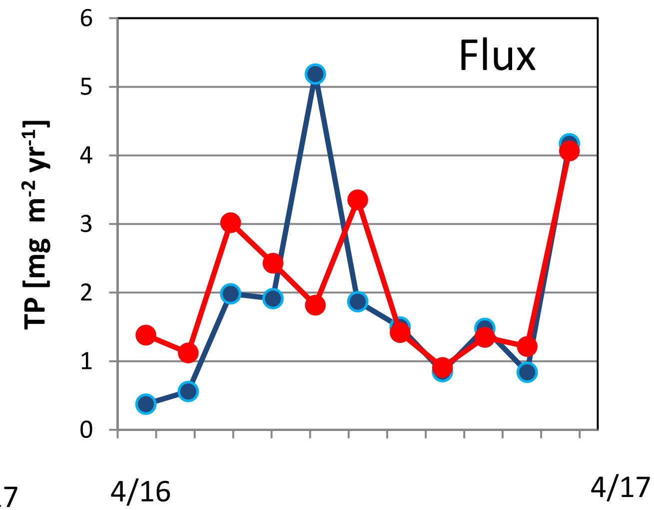
1.88 mg P m^{-2} d^{-1}

2.01 mg P m^{-2} d^{-1}

Specific P content:
1,95 mg gw d^{-1}



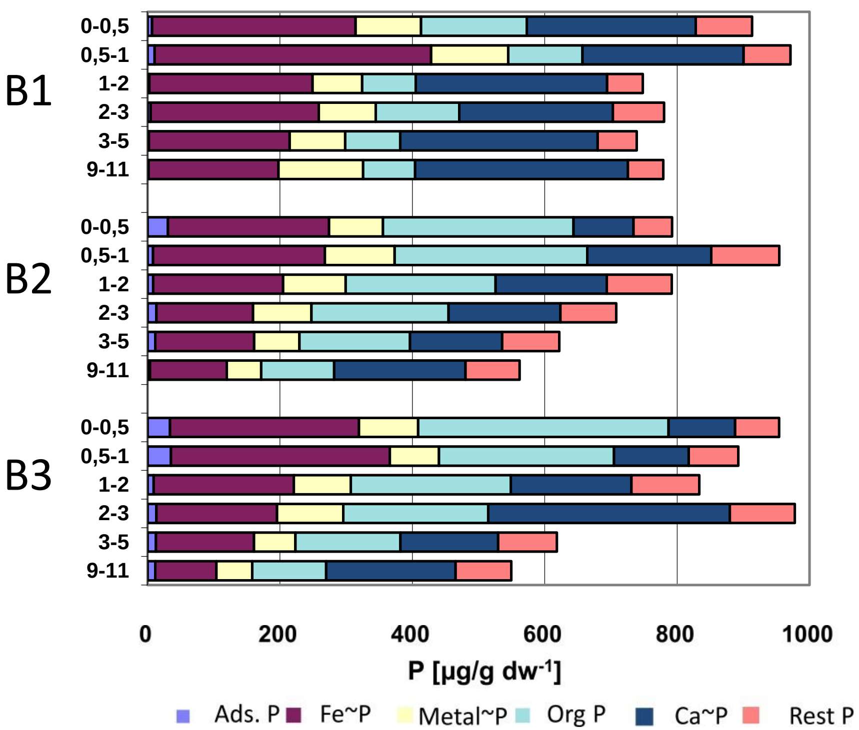




Determination of potentially mobile P pool

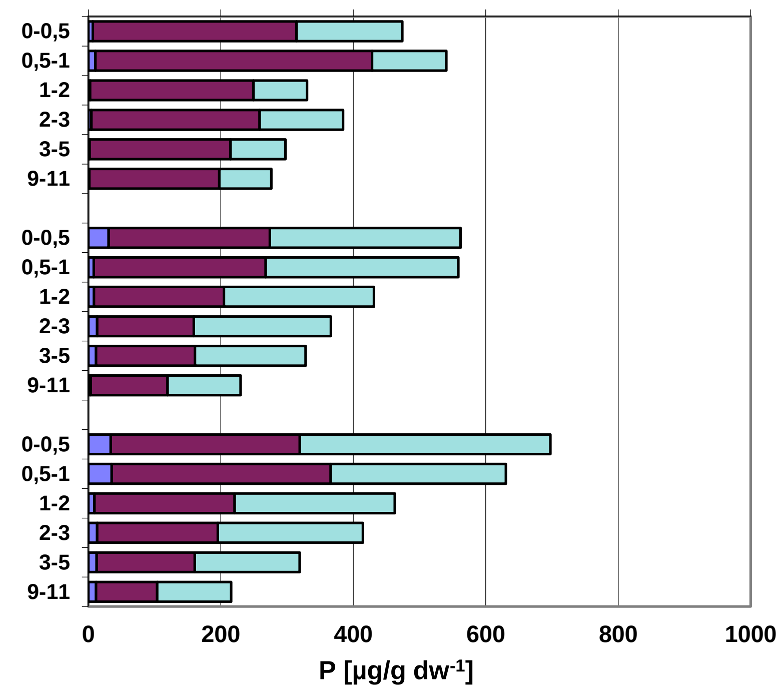
Phosphorus fractions

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

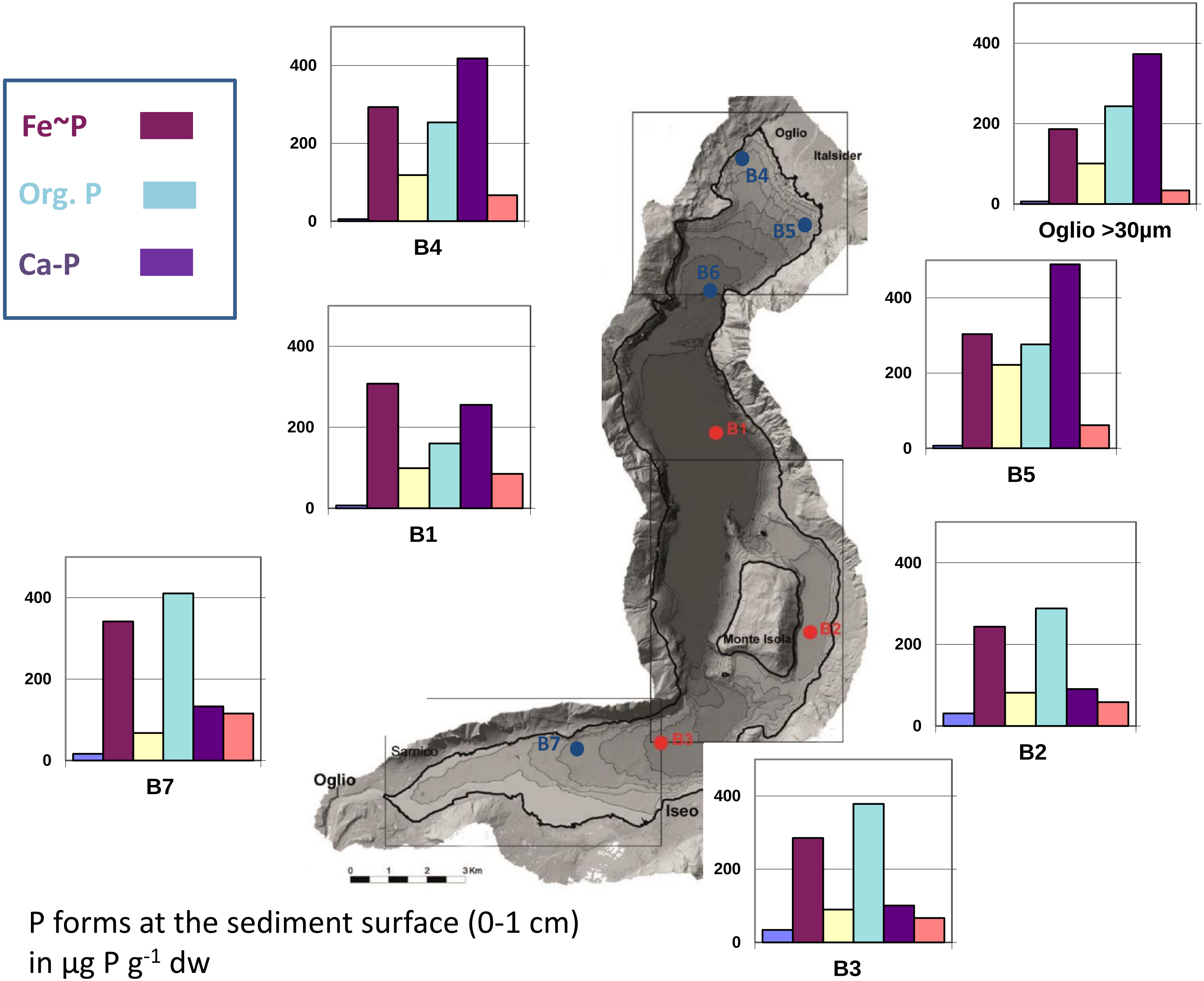


„Mobile“ P

Depth (cm)

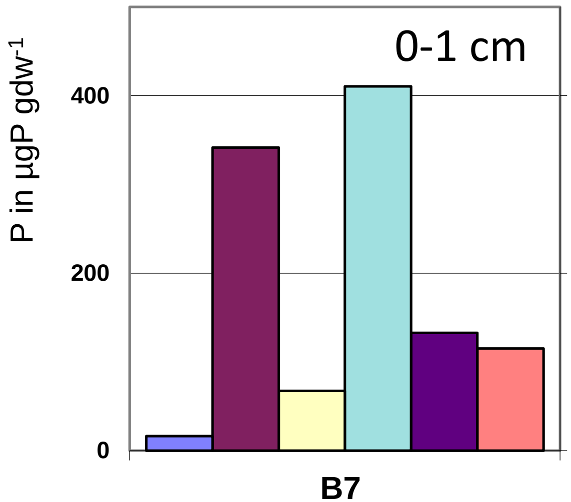


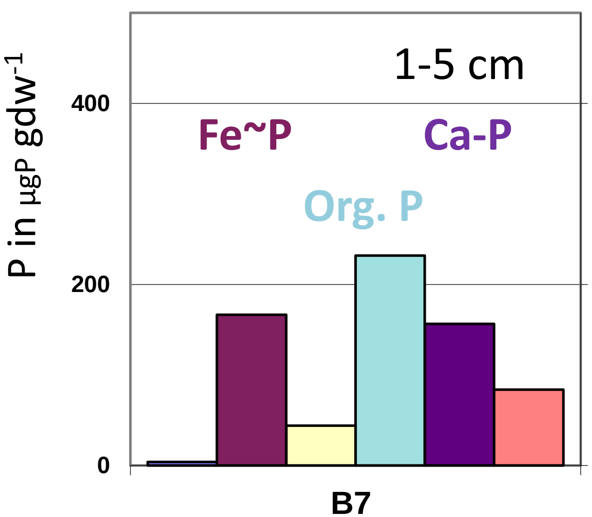
The total P is low in comparison to other lakes. The mobile P varried between 873 and 1200 mg P m^{-2}.



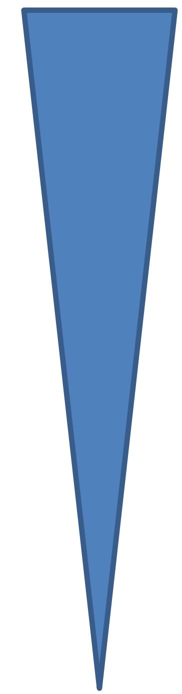
P forms at the sediment surface (0-1 cm)
in μg P g^{-1} dw

Phosphorus diagenesis

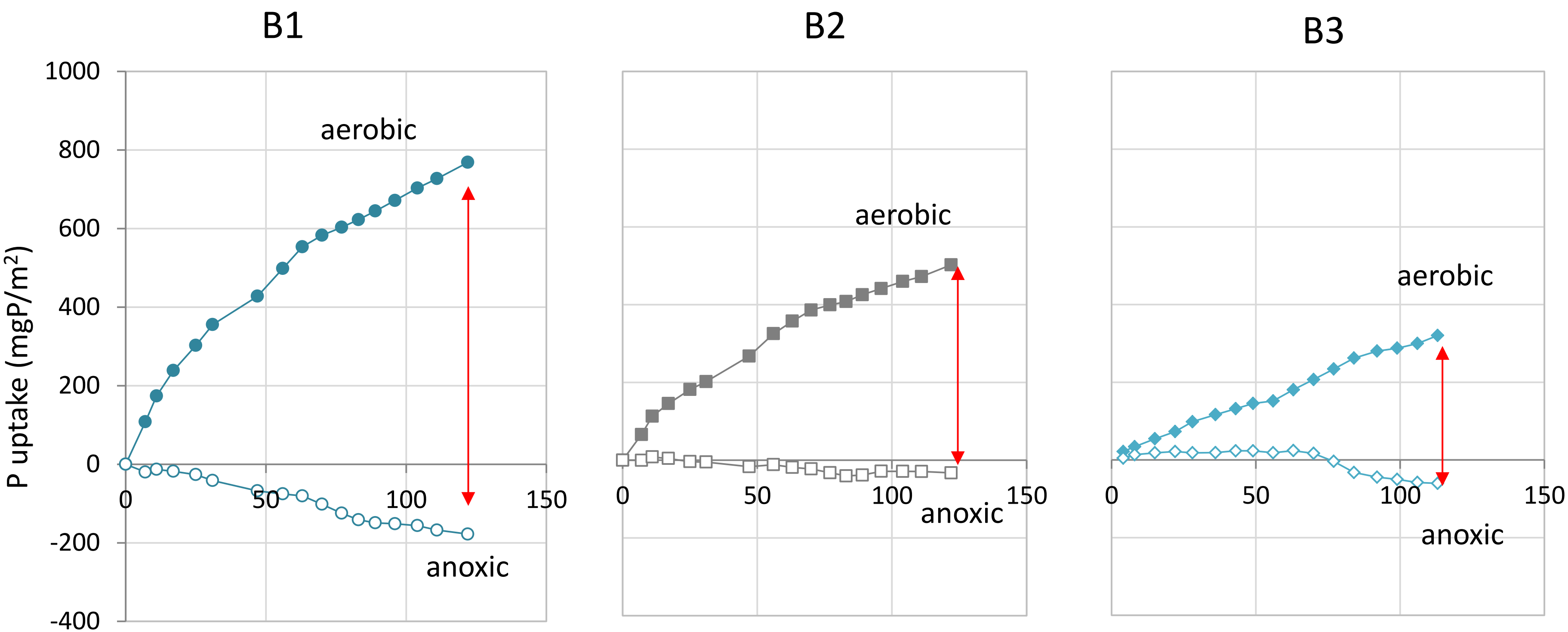




	P content mg g dw^{-1}
Settling seston	1.95
Sediment Surface (0-1 cm)	1.06
Sediment below surface (1-5 cm)	0.83



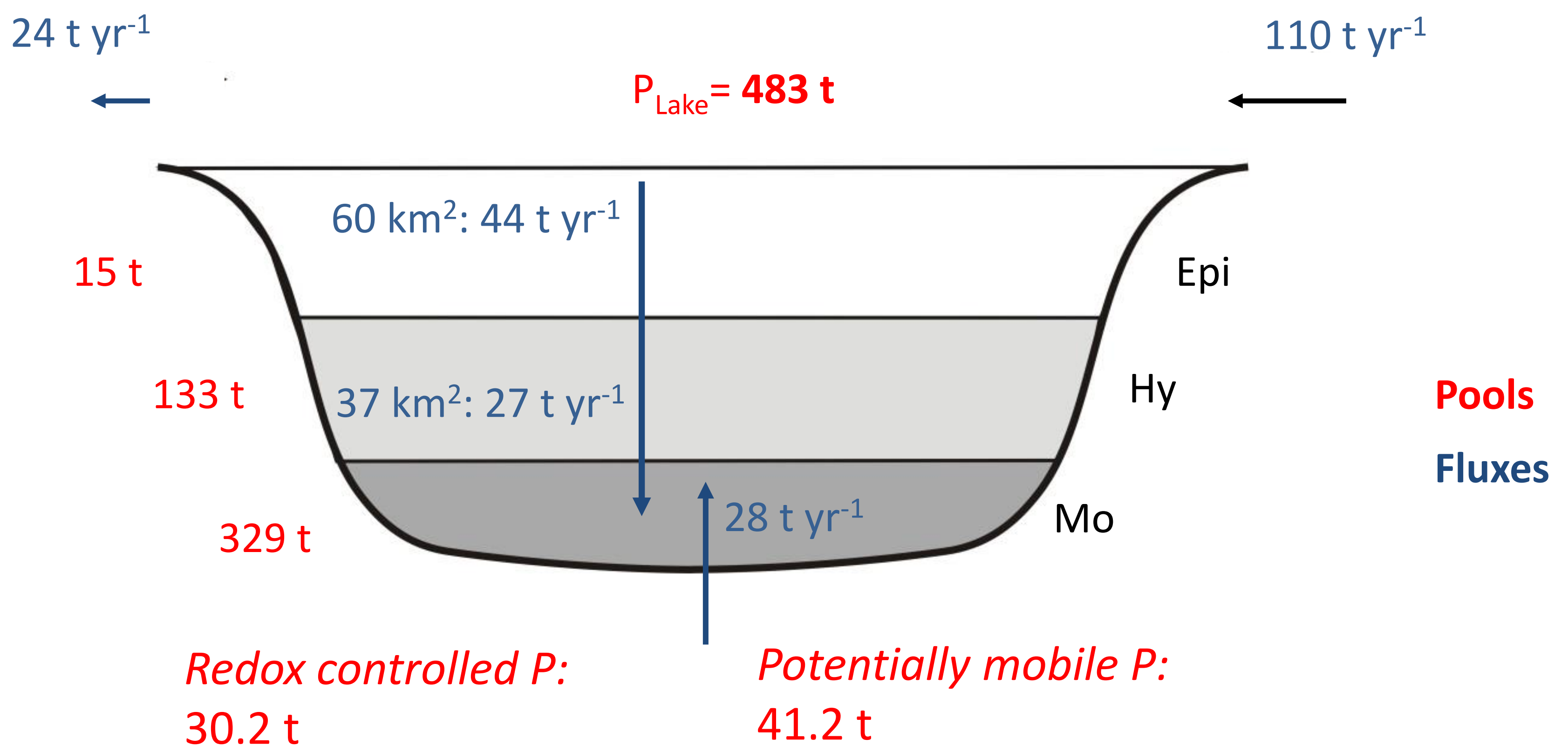
Quantification of redox-controlled P



Additional capacity of P binding under oxic conditions

The higher the reductive potential the higher the impact of re-oxidation.

Phosphorus balance



P net release by a simple mass balance approach (long term):
20 t per year P accumulation since 2005

Phosphorus balance

1. Eutrophication potential of mobile P in sediment is <u>low</u> compared to P_{lake} and P_{import}.

2. P is accumulated in the monimolimnion (less P in the euphotic zone)

3. Anoxic conditions are of low importance for the whole P balance

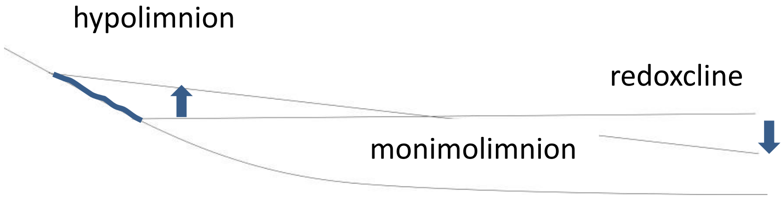
Combining process studies and field measurements with modelling approaches

Lau, M. , Valerio, G., Pilotti, M., Hupfer, M.: Meromictic waters store phosphorus better than sediments (MS draft).

Work in progress: Coupling of hydrophysical conditions with P fluxes

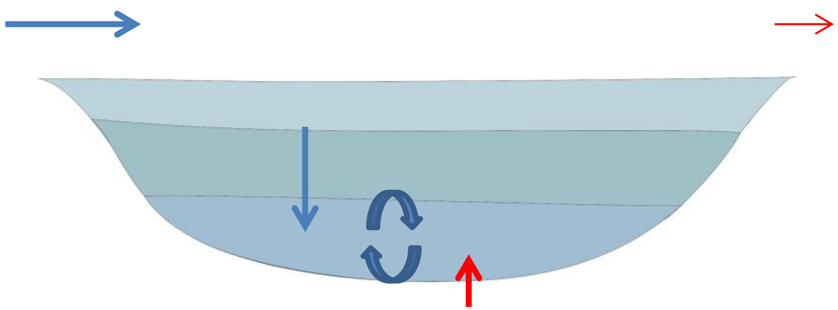
Movements of the redoxcline („seiches“).

Short term redox changes



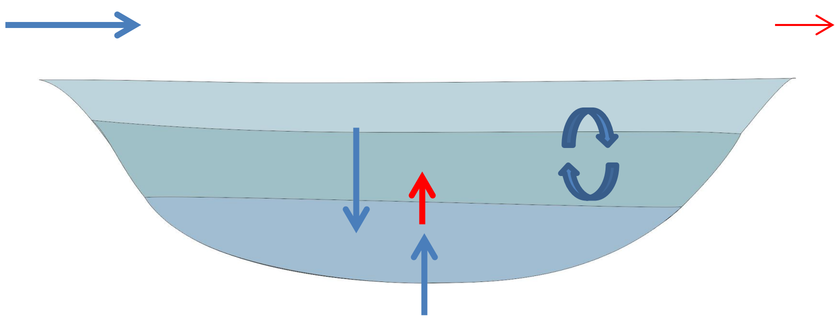
Turbulence in the monimolimnion

Gradients at the sediment surface



Monimolimnion as a trap for phosphorus

Transport across the chemocline



Valerio G., Pilotti, M., Hupfer, M., Lau, M.: Oxycline oscillations induced by internal waves in deep Lake Iseo (MS draft)

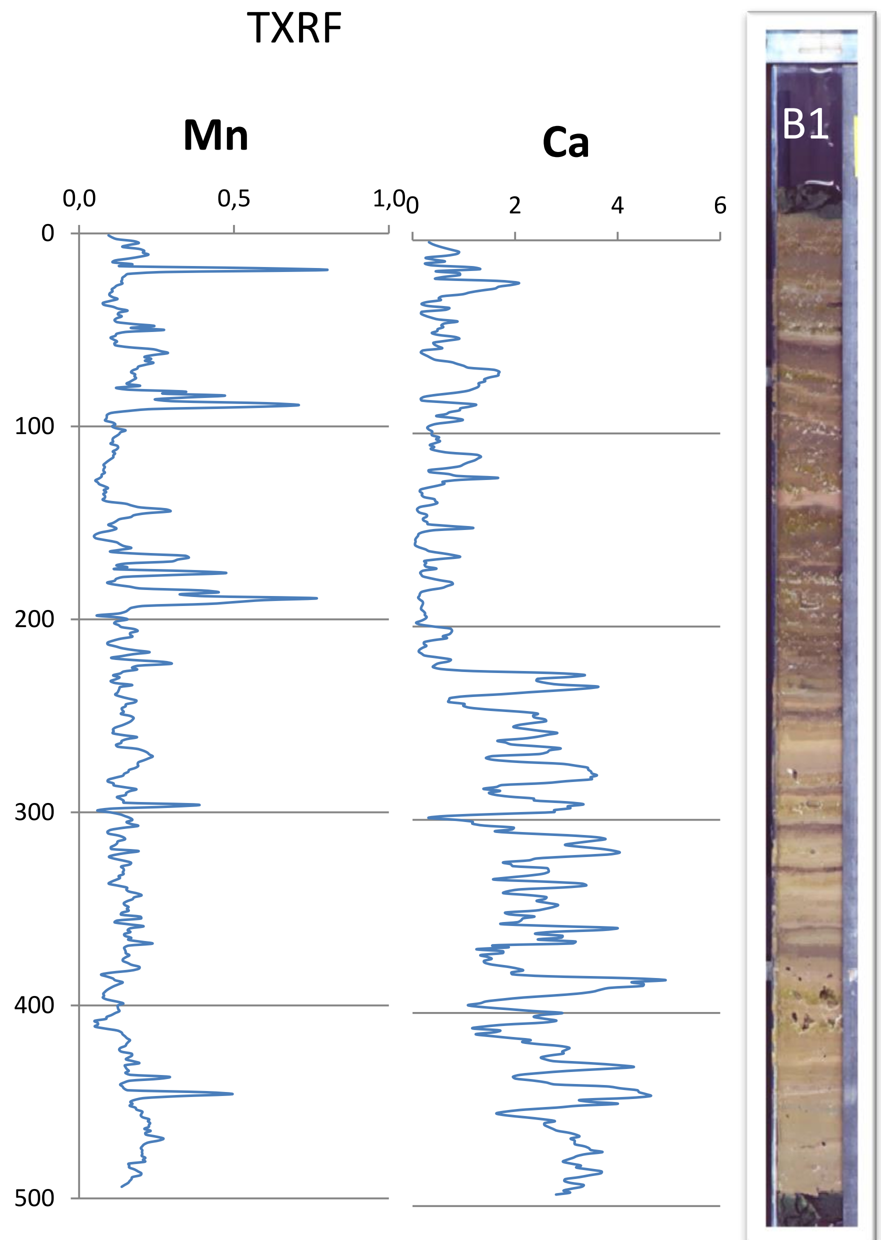
Outlook: Evaluation sediment profiles

Event stratigraphy
(e.g. Ca precipitation)

Estimation of P retention

Proxies for oxygen situation

Pattern of elemental composition



April 2016

Outlook: Evaluation sediment profiles

Chemical Geology 352 (2013) 125–133

Contents lists available at SciVerse ScienceDirect

Chemical Geology

journal homepage: www.elsevier.com/locate/chemgeo

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

Sebastian Naeher [a,b,*], Adrian Gilli [c], Ryan P. North [b,d], Yvonne Hamann [c], Carsten J. Schubert [a]

[a] Eawag, Swiss Federal Institute of Aquatic Science and Technology, Department of Surface Waters — Research and Management, Seestrasse 79, CH-6047 Kastanienbaum, Switzerland
[b] ETH Zurich, Institute for Biogeochemistry and Pollution Dynamics, Universitaetstrasse 16, CH-8092 Zurich, Switzerland
[c] ETH Zurich, Geological Institute, Sonneggstrasse 5, CH-8092 Zurich, Switzerland
[d] Eawag, Swiss Federal Institute of Aquatic Science and Technology, Department of Water Resources and Drinking Water, Ueberlandstrasse 133, CH-8600 Duebendorf, Switzerland

ARTICLE INFO

Article history:
Received 5 August 2012
Received in revised form 3 June 2013
Accepted 4 June 2013
Available online 14 June 2013

Editor: U. Brand

Keywords:
Mn/Fe ratio
Manganese
Oxygen
Redox
XRF core scanning
Lake Zurich

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.

Status WP 1

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

🟢 Completed 🟡 In progress 🔴 To do


Fishfinder 140
GARMIN

Thanks to the IGB team

Sylvia
Jordan

Maximillian
Lau

Juliane
Roth

Thomas
Rossoll

Christiane
Herzog

Tobias
Goldhamme

New in the team

Stefano
Simoncelli

Georgiy
Kirillin

Robert
Ladwig

Thank you!