Phosphorus cycling in a sedimentation pond of a constructed wetland

Santiago Clerici

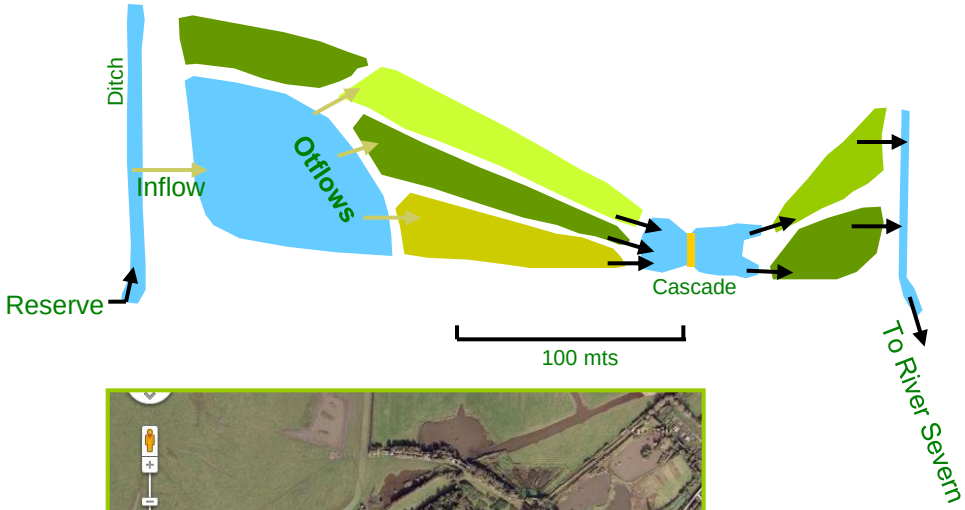
Michael Krom, Robert Mortimer and Sally MacKenzie

WWT Slimbridge

- Effluents high in N, P, Organic Matter and suspended solids

- River Severn estuary downstream

The treatment wetland



- Sedimentation pond to remove suspended matter
- PO_4 and excess suspended matter taken up by reed beds

Failing of the treatment wetland

Excess P is being exported from the system

Palmer Felgate et.al 2011:

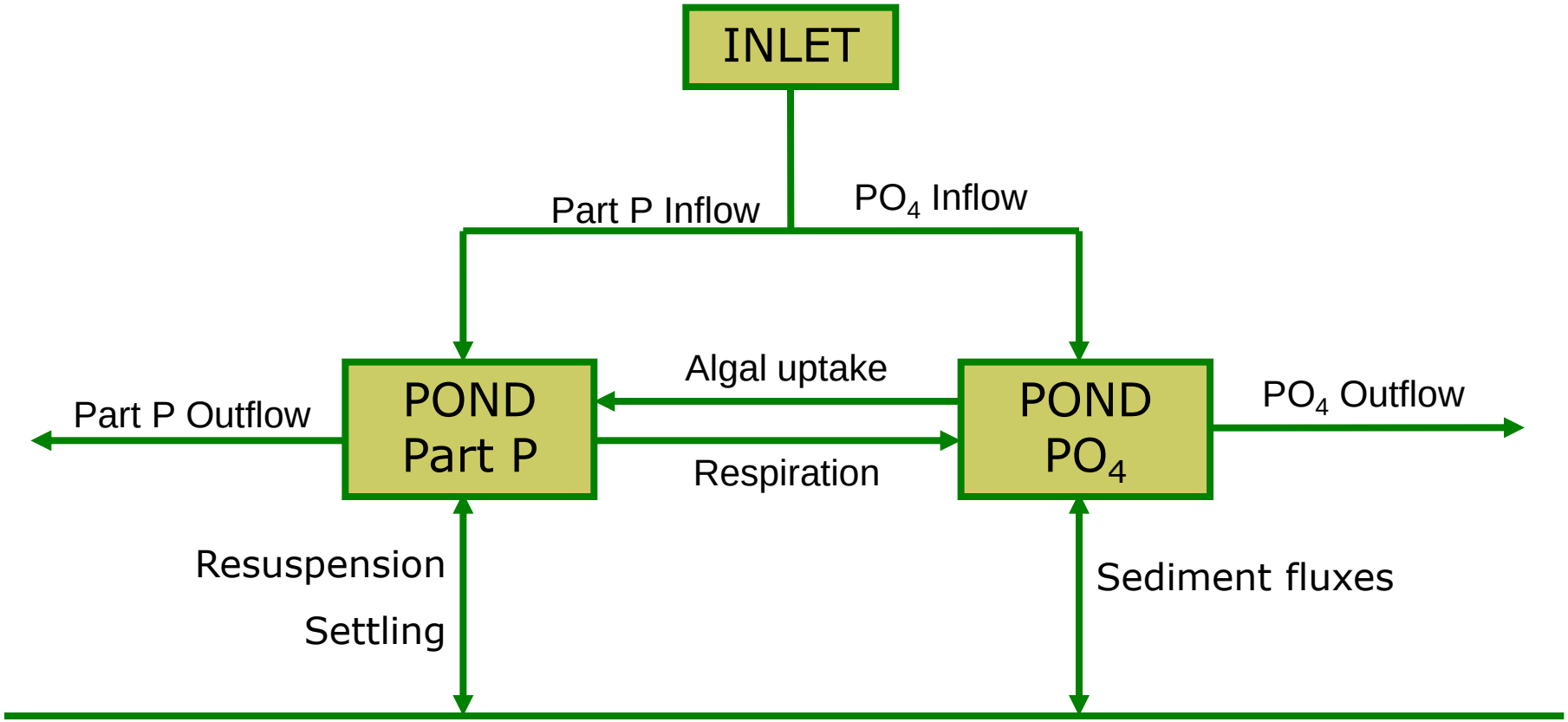
Sedimentation pond becomes source of P in summer

- Collapse of algal blooms in early Summer:
  - P released by redox reactions when oxygen levels go down
  - P released by decomposition of algal matter

Objectives

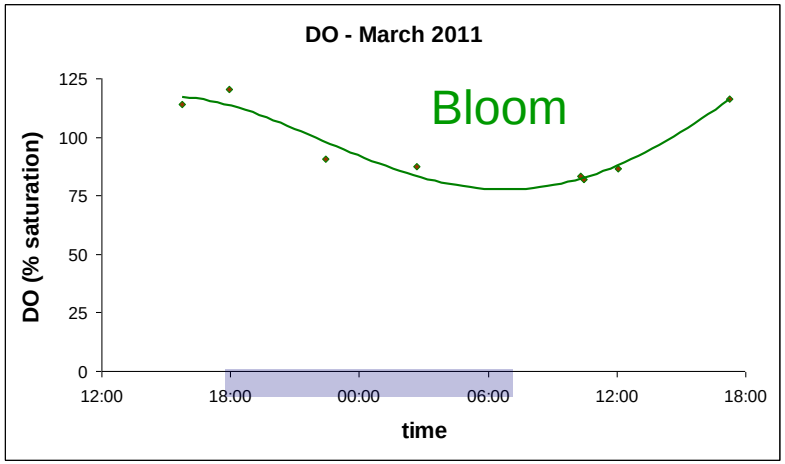
- To find the dominant processes controlling P cycling in the sedimentation pond in Spring and Summer
- To know whether the sediment is a source or a sink of Phosphorus?
- To find the major processes controlling P cycling in the sediment and whether they change seasonally?

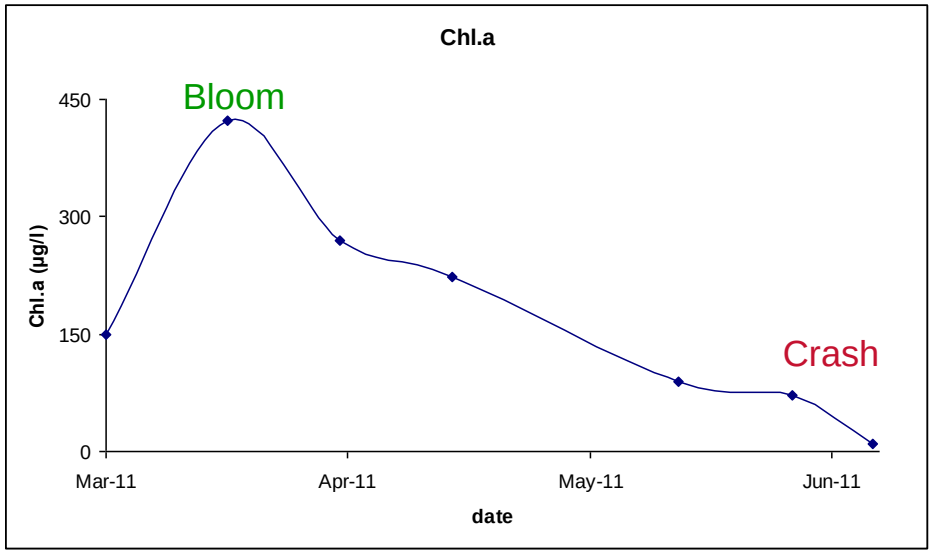
Model of P cycling in the water column

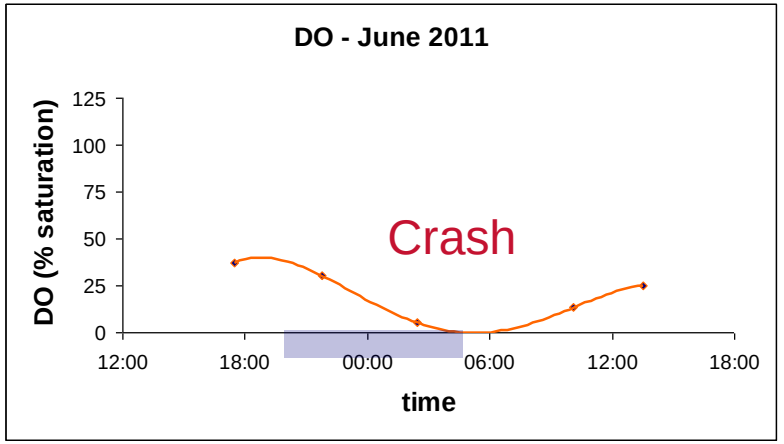


Moles P / day

Chlorophyll and Oxygen levels

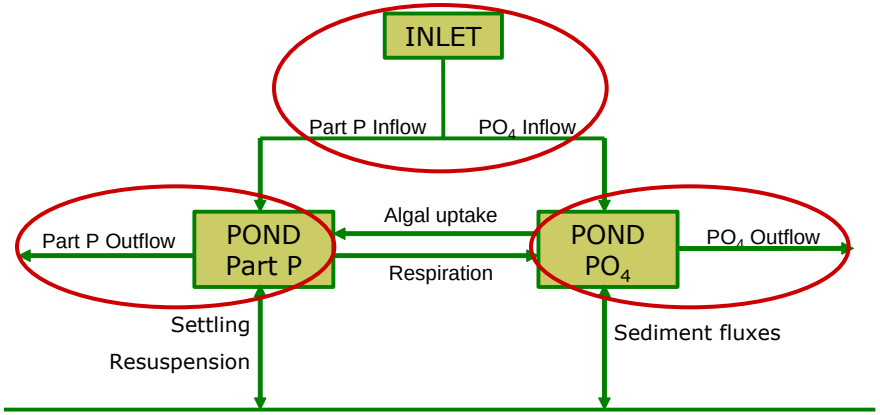




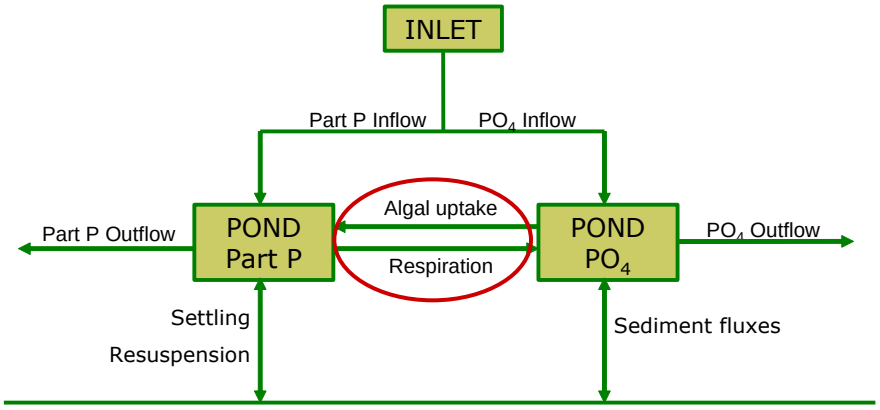


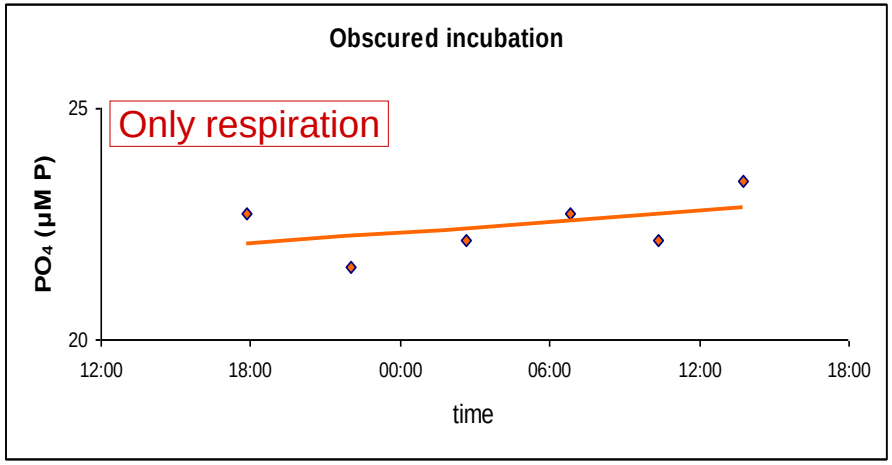
Night hours

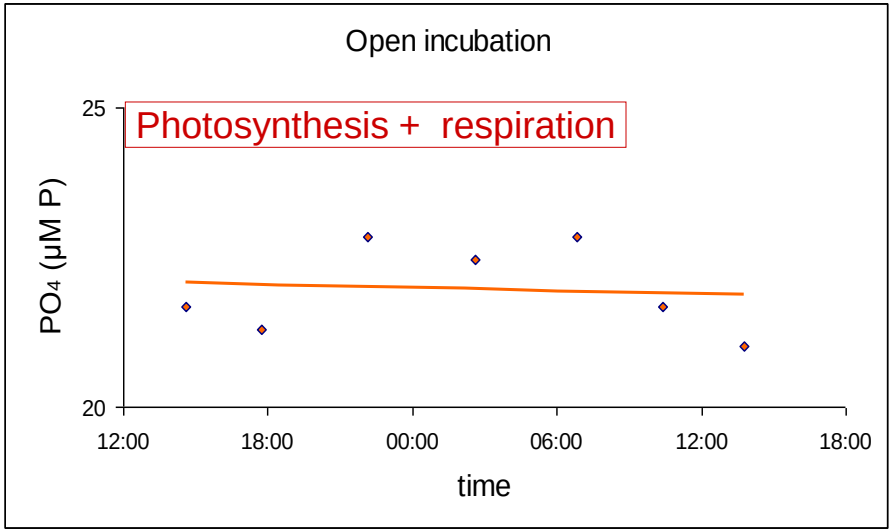
Sampling P at inlet and pond



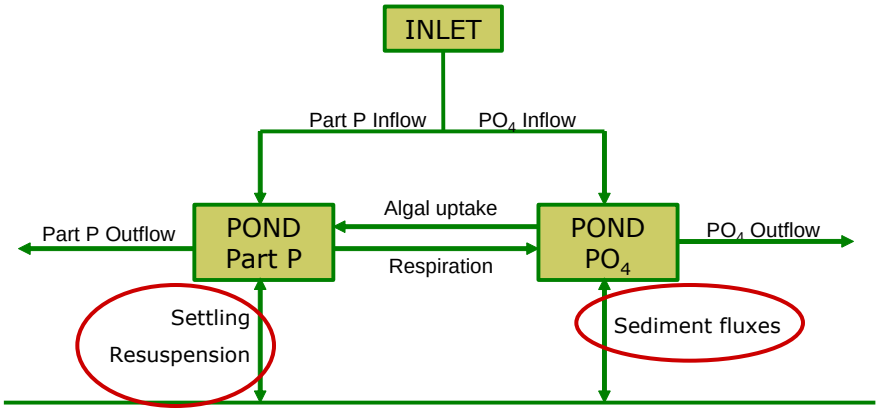
Calculating water column fluxes

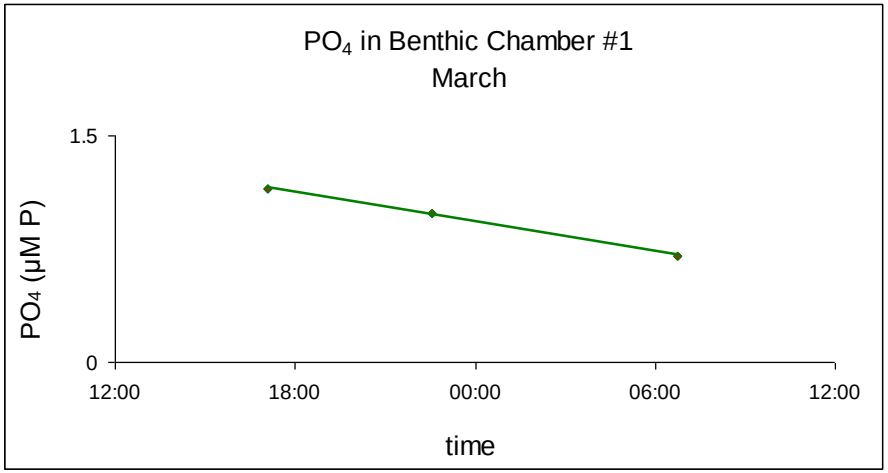


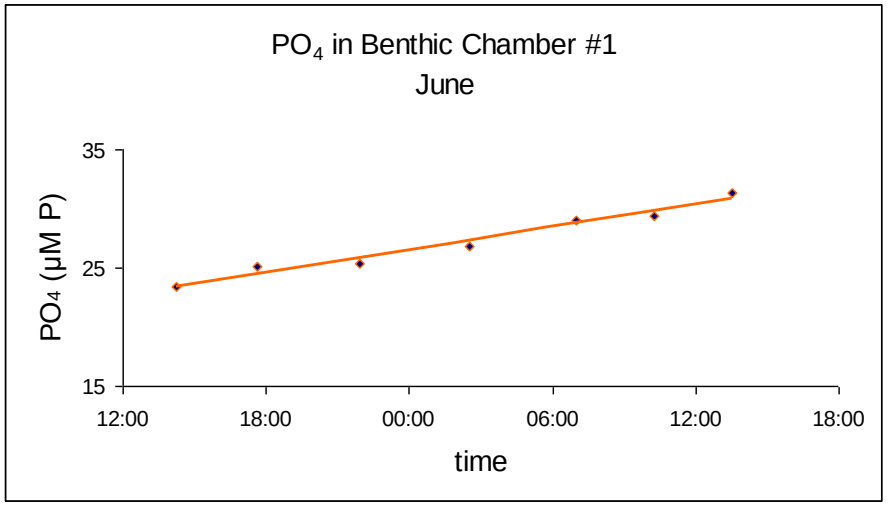




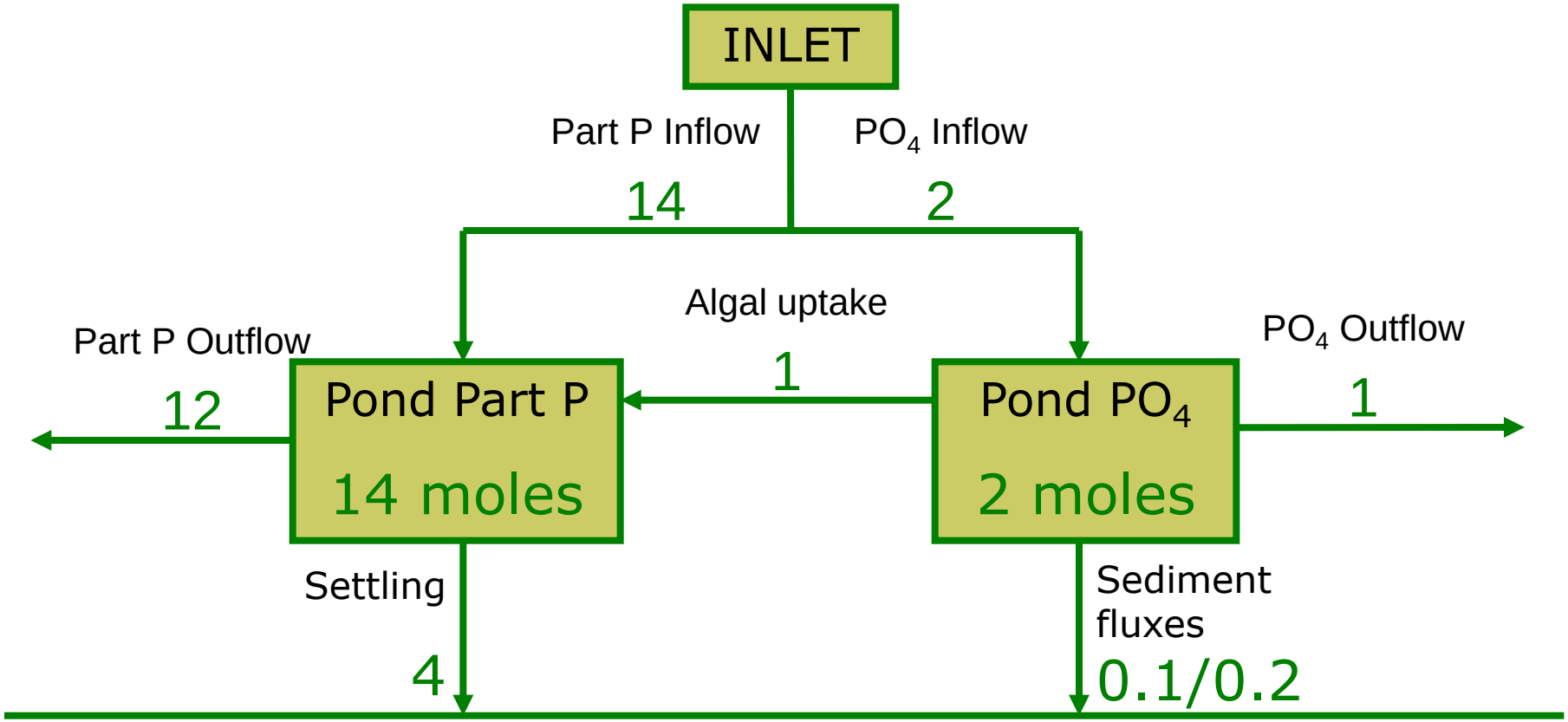
Calculating sediment fluxes





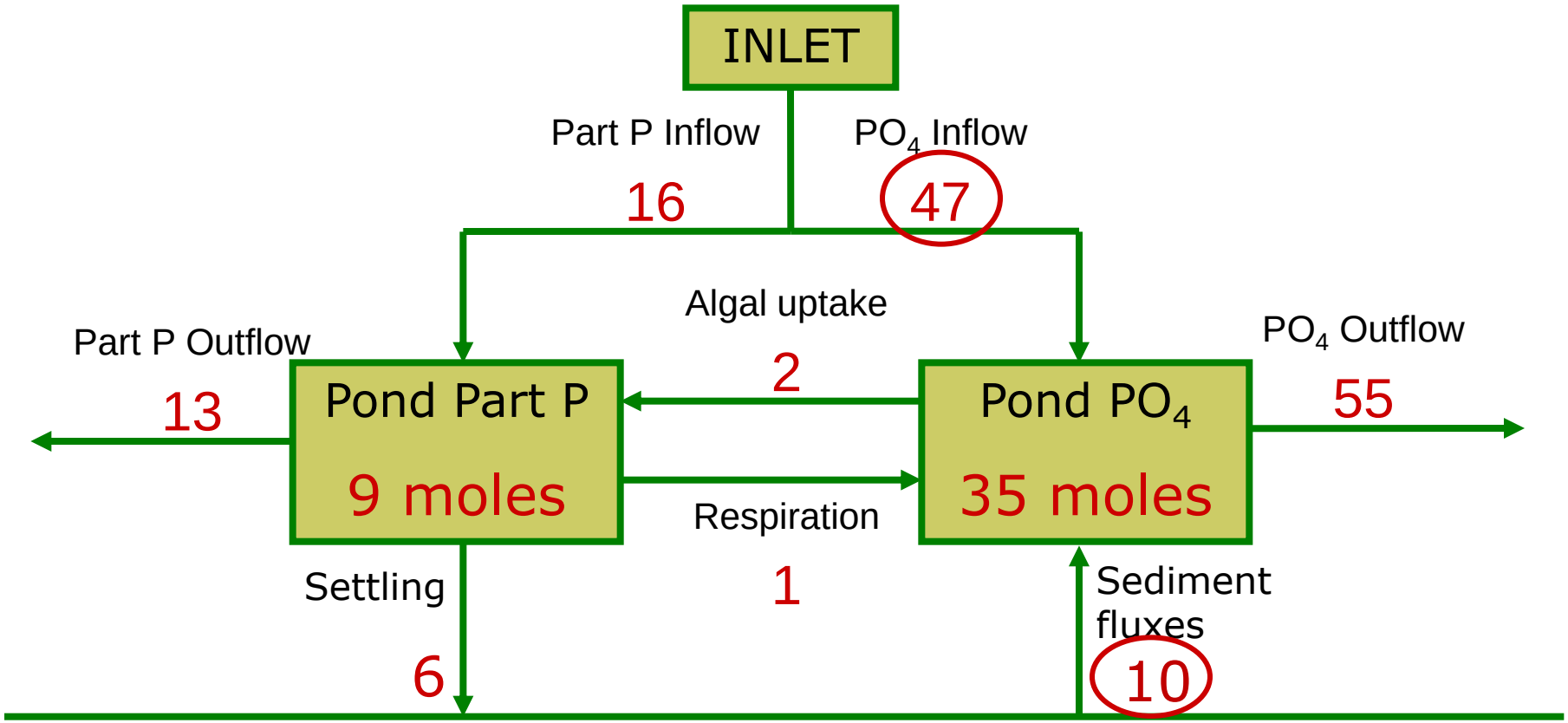


P fluxes **March**



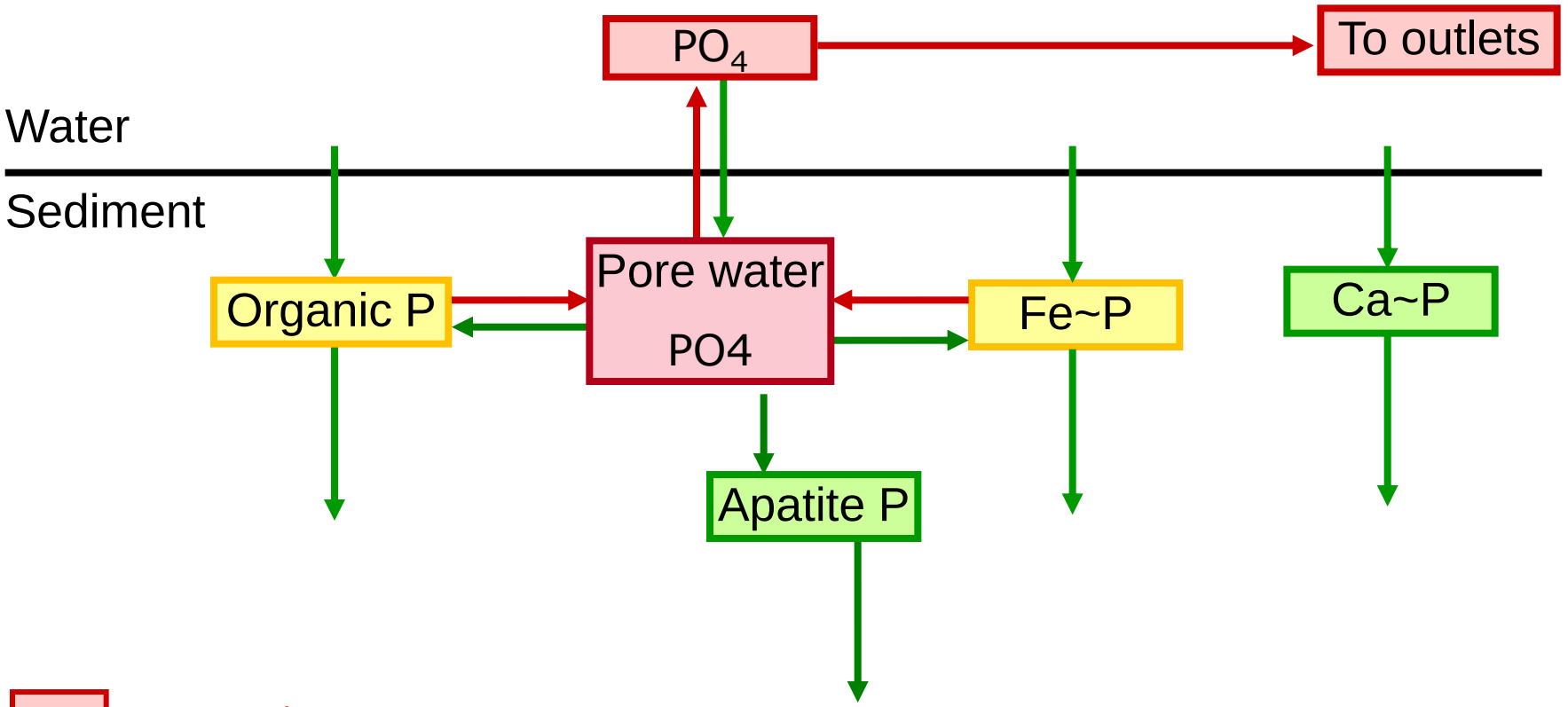
Fluxes in moles P / day

P fluxes **June**



Fluxes in moles P / day

Sediment phosphorus cycle (after Slomp et al 1996)

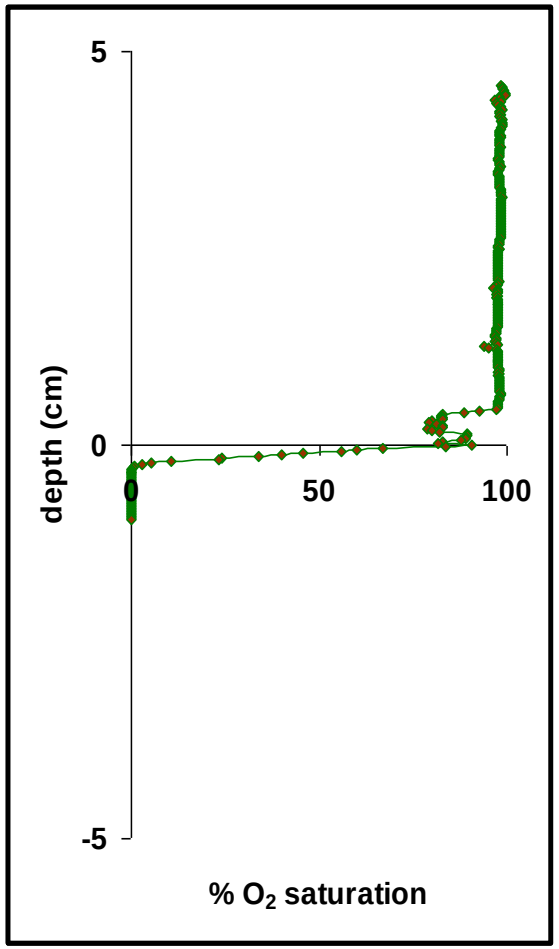


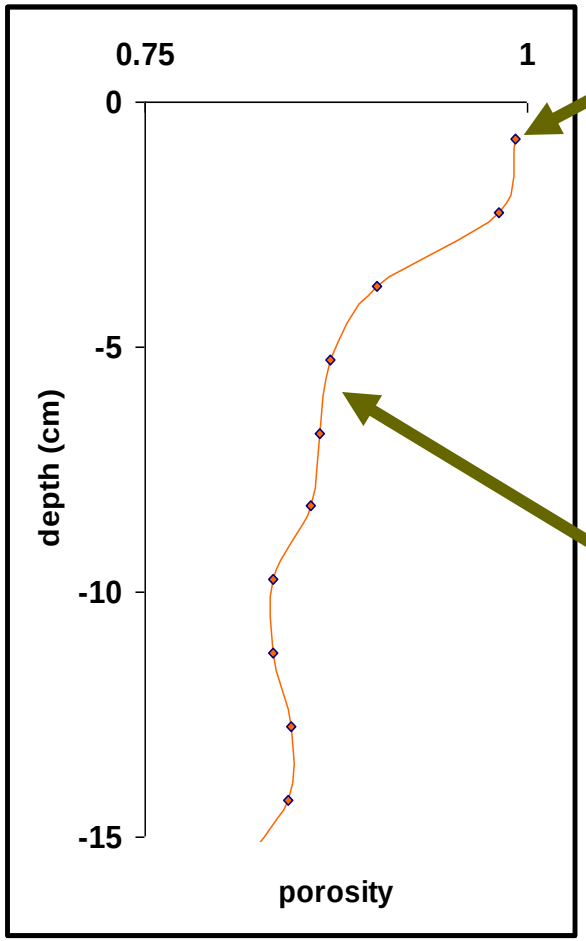
Water: it transports PO_4

Solid: it retains P but it can be released it back into water

Solid: it retains P indefinitely

Description of the solid phase

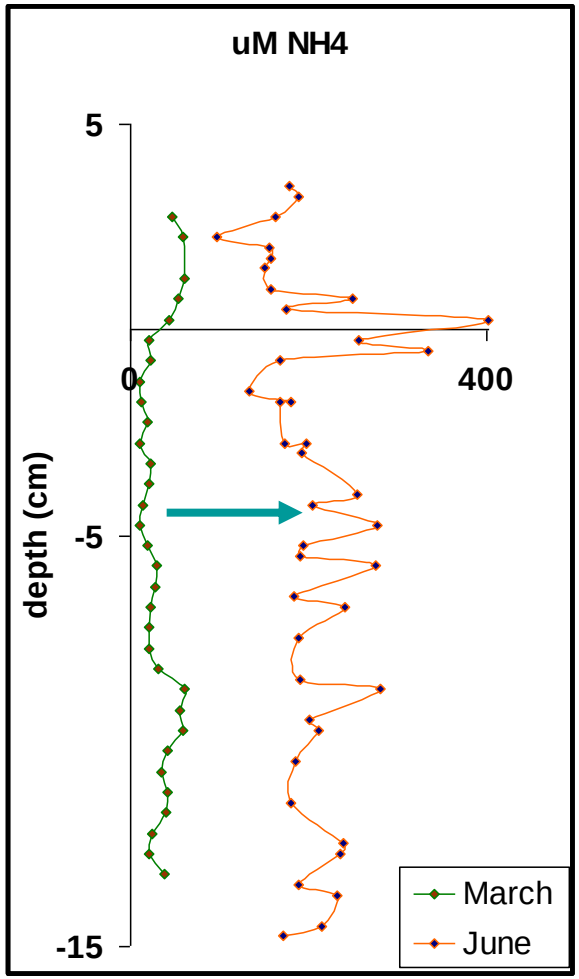


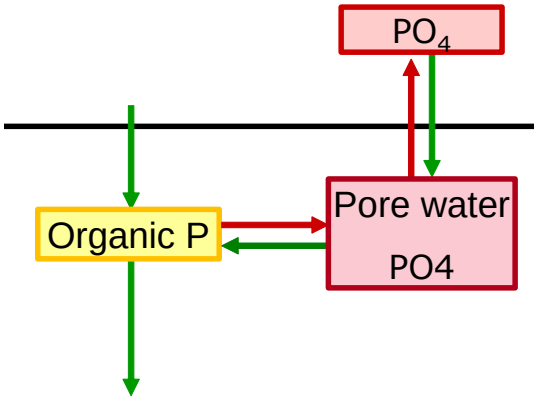


sediment content
20x increase

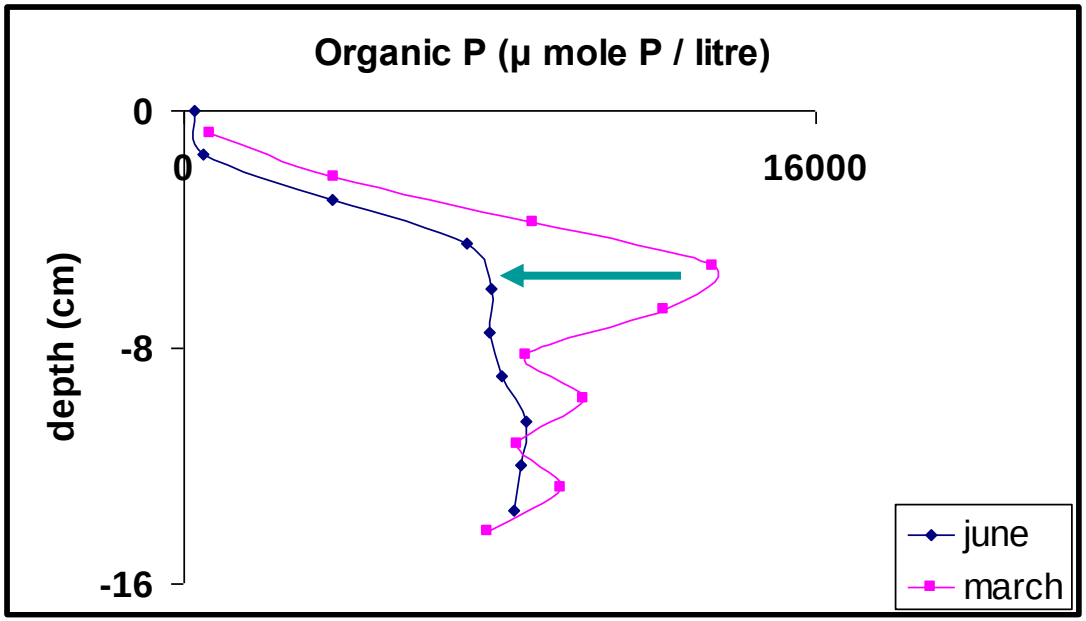
Organic P ↔ Pore water PO_4

Increased respiration in June



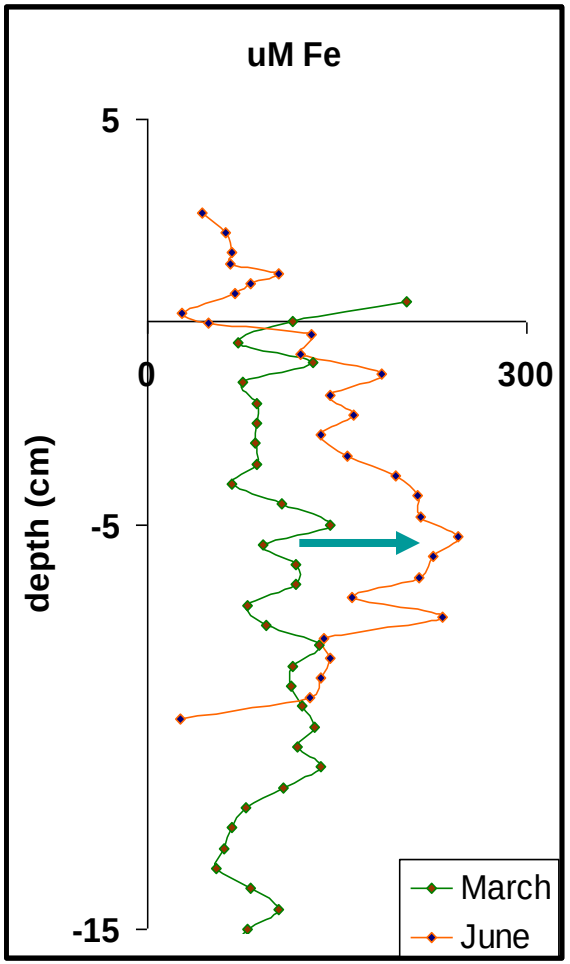


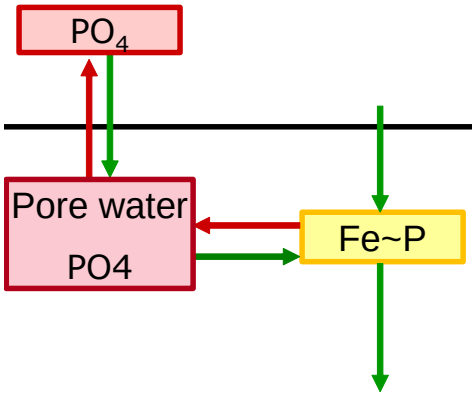
200 moles P released between March and June



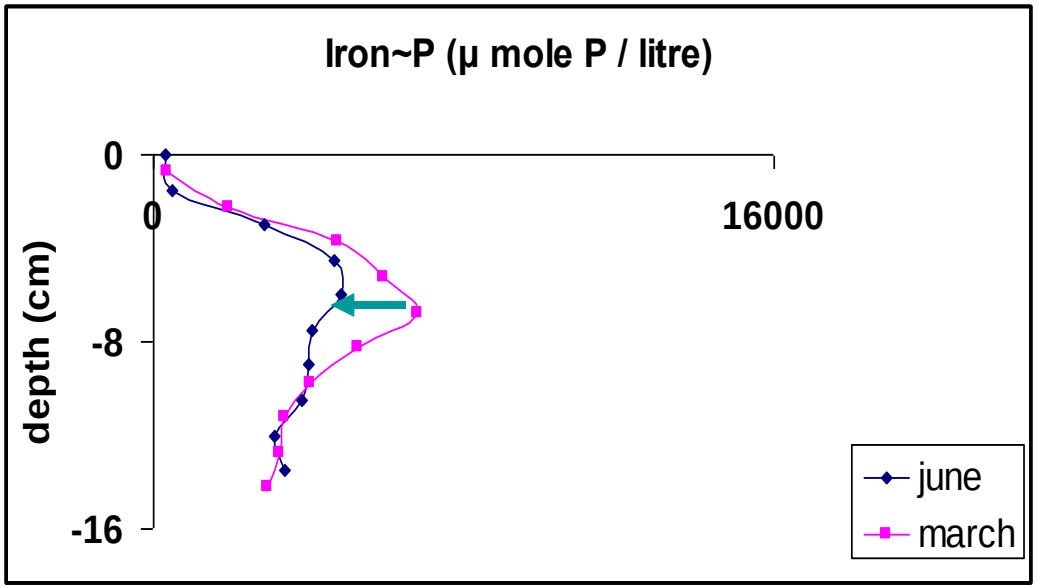
Iron~P ↔ Pore water PO_4

Increased dissolved iron in June



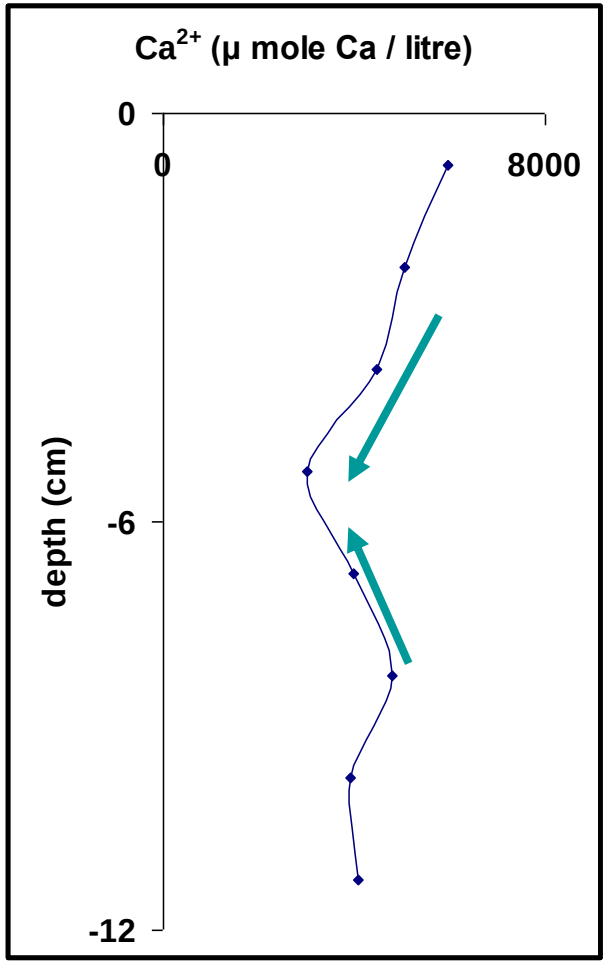


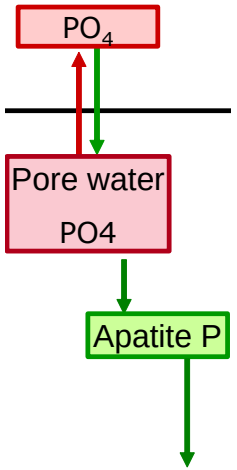
25 moles P released between March and June



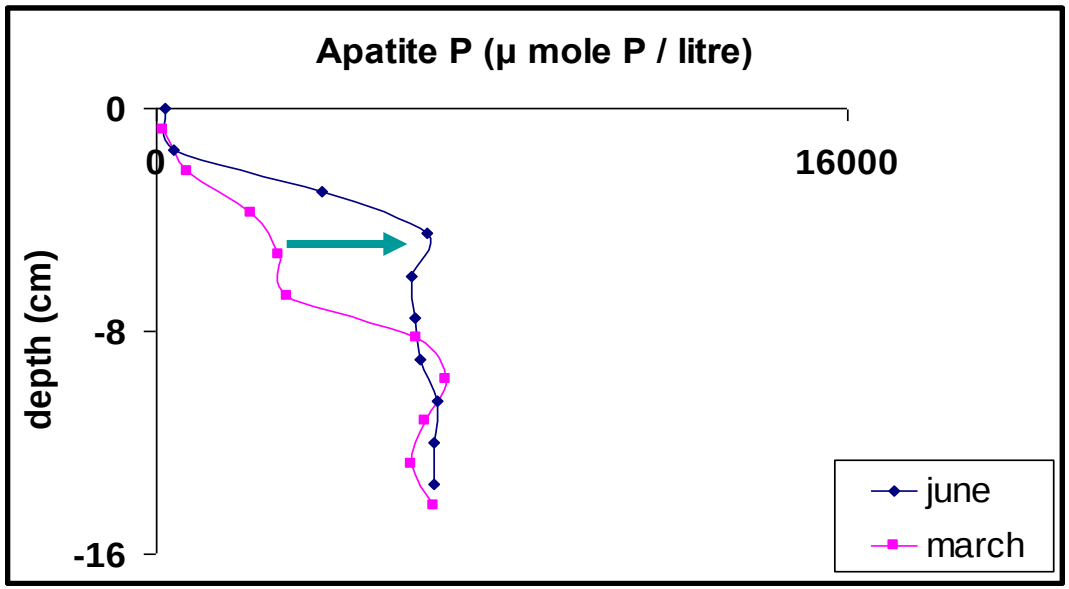
Apatite P ↔ Pore water PO_4

Consumption of calcium in June

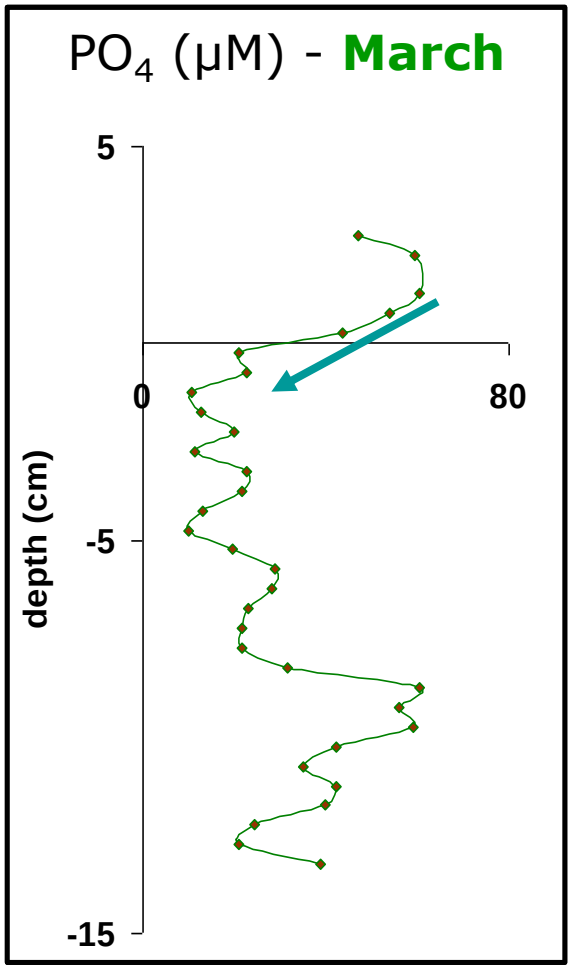




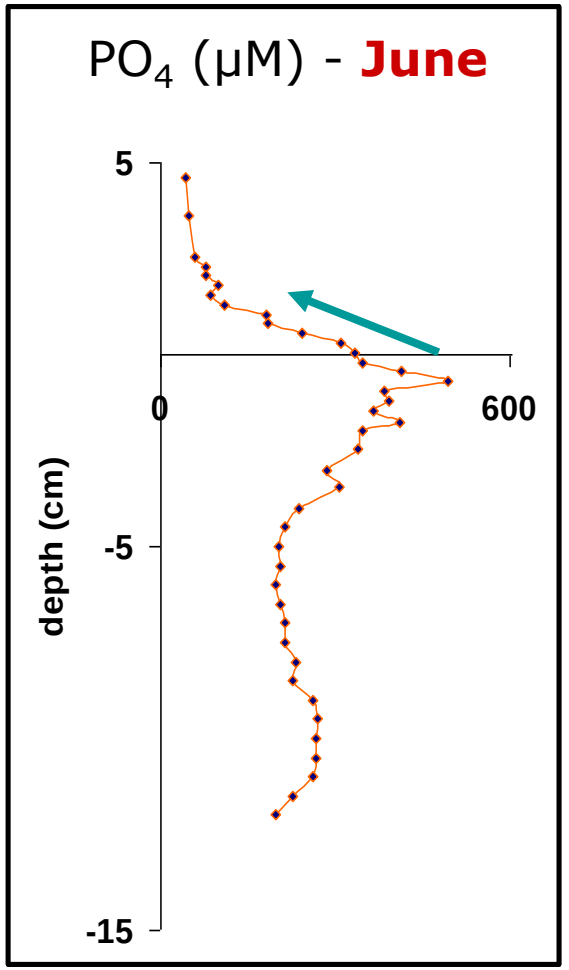
100 moles P consumed between march and June



Pore water PO_4 ↔ Water column PO_4



Calculated: 0.3 mole P / day



Calculated: 7 moles P / day

Summary: control of P in the water column

- Pond retains 15% of Particulate P, both in March and June

- Algal bloom in March
- Oxygen saturation
- Algae and sediments take up SRP in March

- Collapse of algal bloom
- Oxygen levels very low in June
- Large plume of SRP flows in, in June
- Important release of P from sediments in June

Summary: release of P from sediments

- Release of PO_4 mainly by consumption of accumulated organic matter
- Redox related dissolution of Fe also contributes to the release of PO_4
- Precipitation of apatite counteracts, in part, the release of PO_4