Effets de la turbulence sur les cycles biogéochimiques dans les milieux aquatiques

Guilherme Calabró

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(Juan Pedro Mellado, Max Planck Institute for Meteorology)

leesu
laboratoire eau environnement systemes urbains

LABORATOIRE D'HYDRAULIQUE SAINT-VENANT

École des Ponts ParisTech

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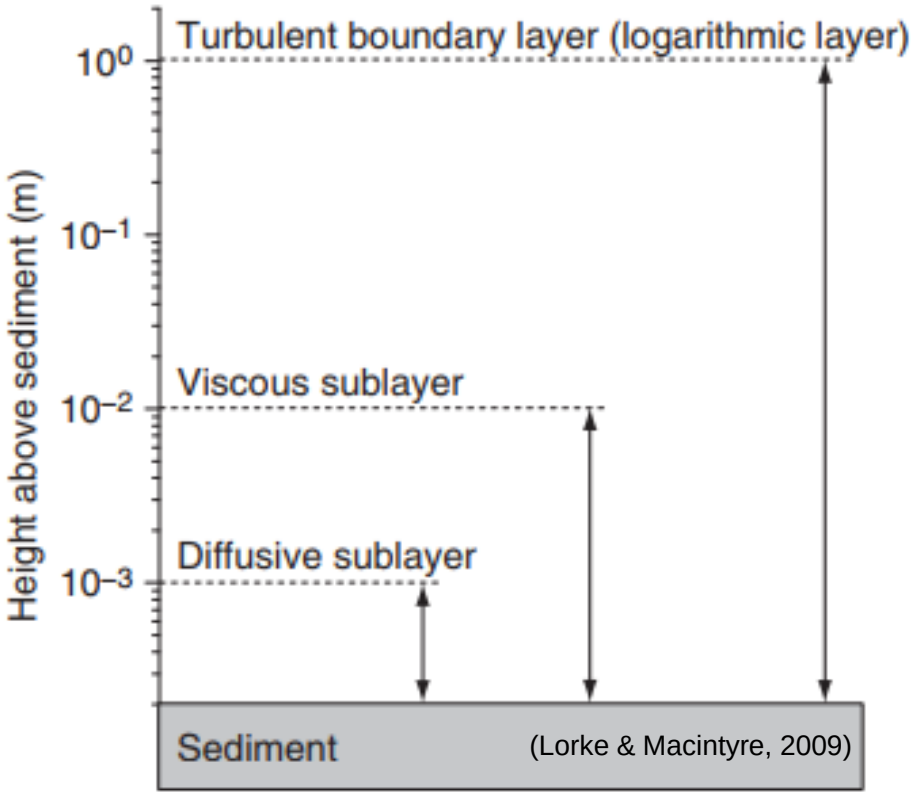
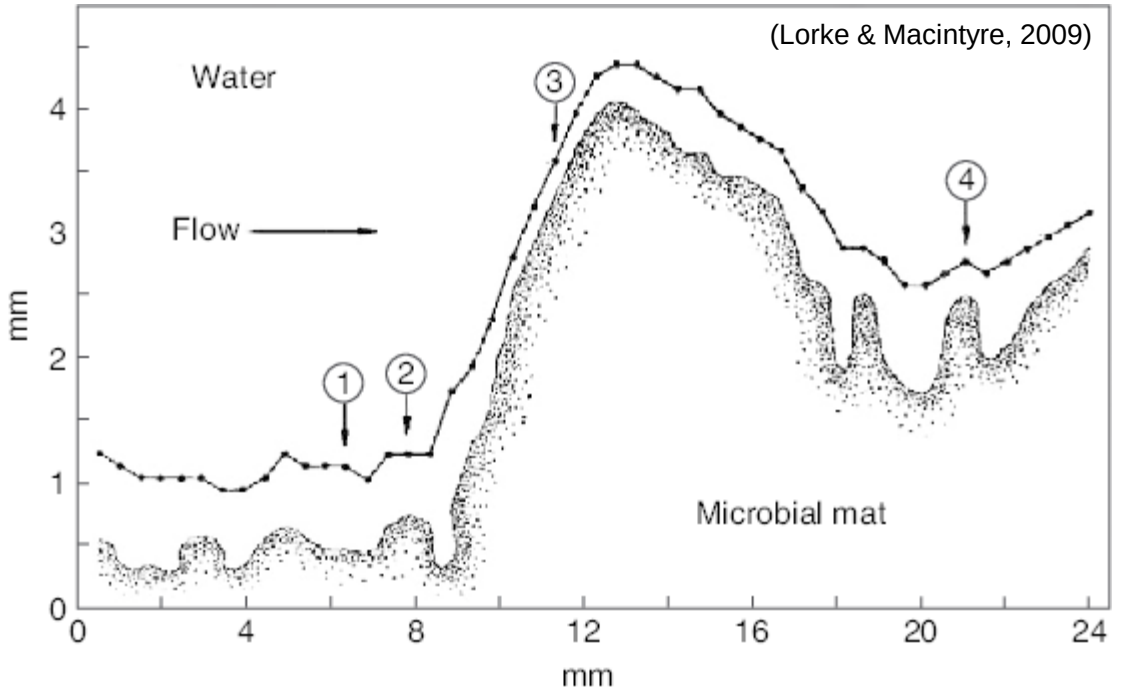
The benthic boundary layer





Thickness of the BBL varies in function of sediment architecture and flow speed

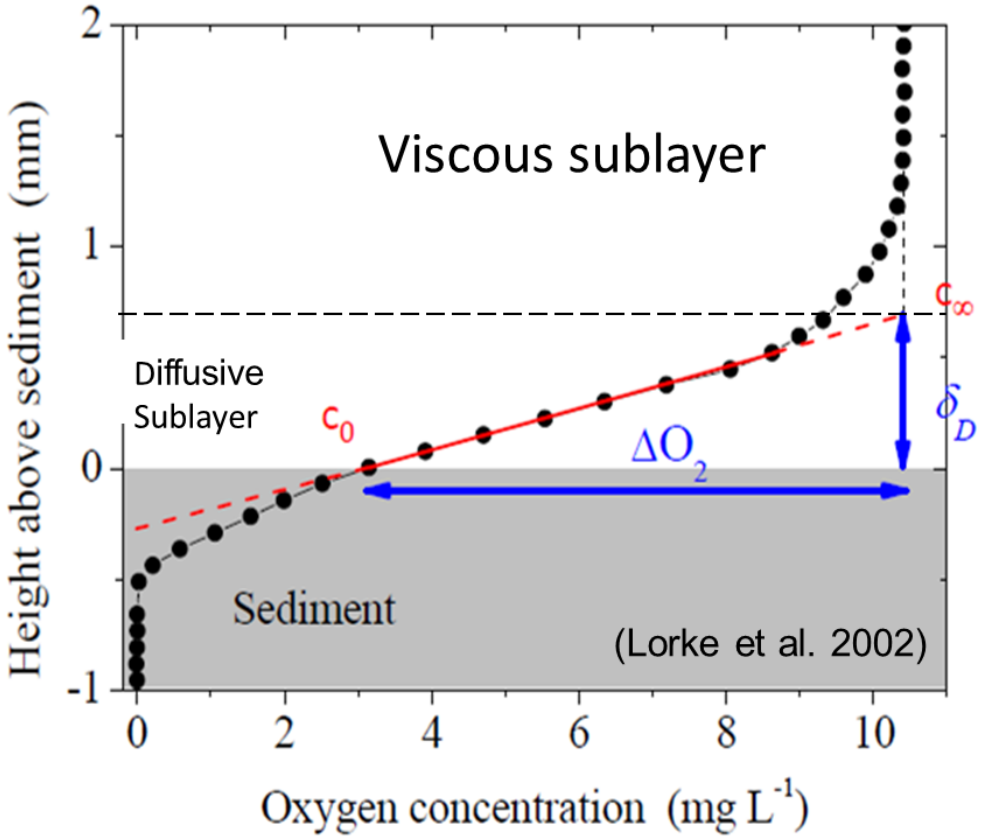
Current speed on BBL thickness

"The diffusive sublayer is the major bottleneck for the transport of mass or heat" (Lorke & Peeters, 2006)

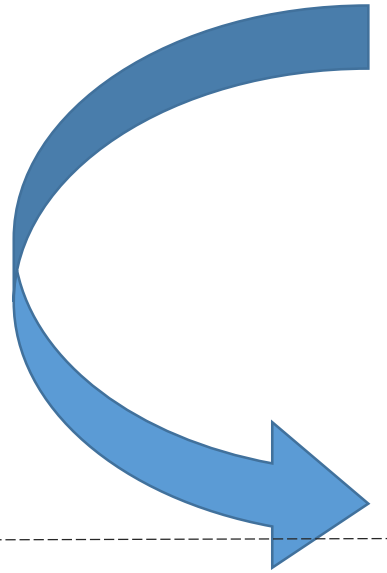
$$F = k(C_\infty - C_0)$$

$$k = \frac{D}{\delta_D} \cong \frac{1}{9} Sc^{-1/2} u_*$$

- k → Transfer coefficient
- C_∞ → Concentration above diffusive sublayer
- C_0 → Concentration above sediment
- Sc → Schmidt number
- u_* → Friction velocity
- δ_D → height diffusive sublayer



Turbulence will instantly and constantly change the thickness of the Diffusive Sublayer



$\downarrow[O_2]$

$\uparrow[O_2]$

$\uparrow[O_2]$

BBL

Sediment

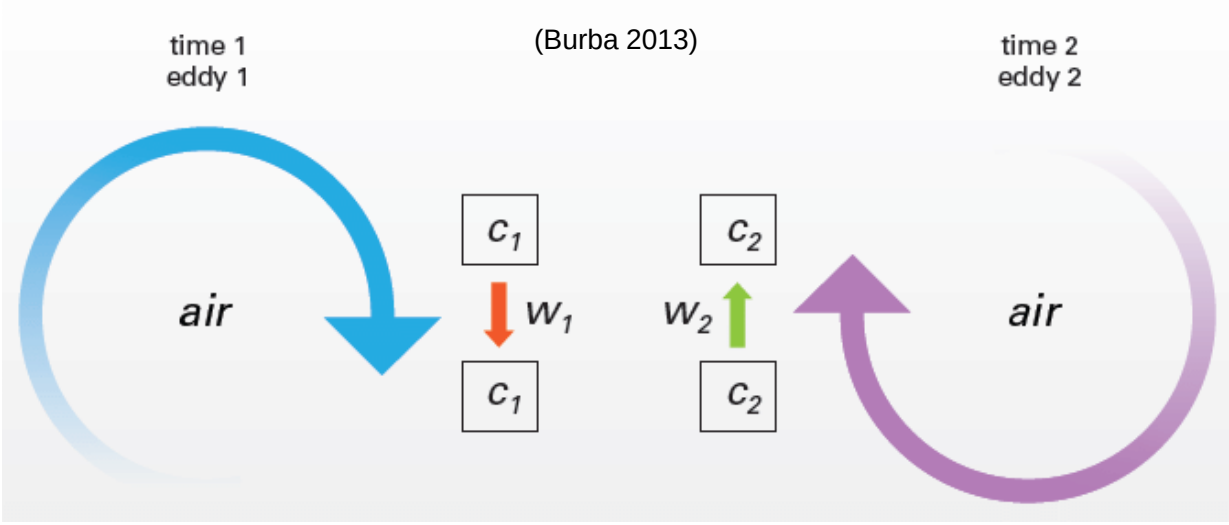
$\downarrow[O_2]$

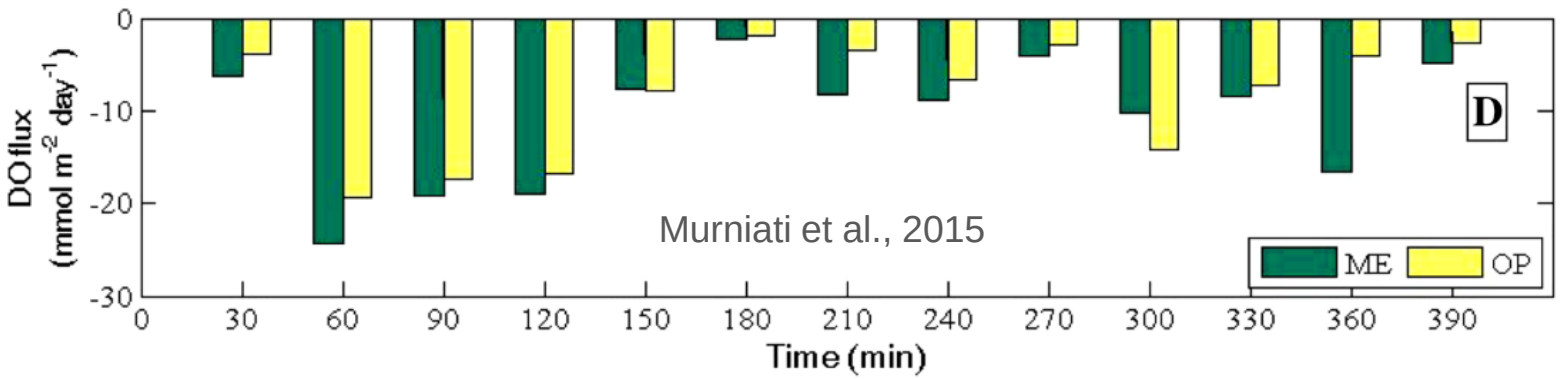
Measuring the flux dynamics

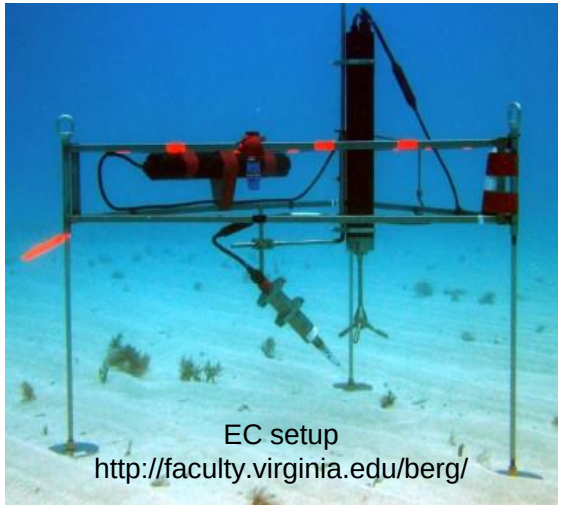
- Eddy Covariance (Berg et. al, 2003)

$$F = \overline{w'c'}$$

w' → Fluctuation of vertical velocity
c' → Fluctuation of the compound concentration







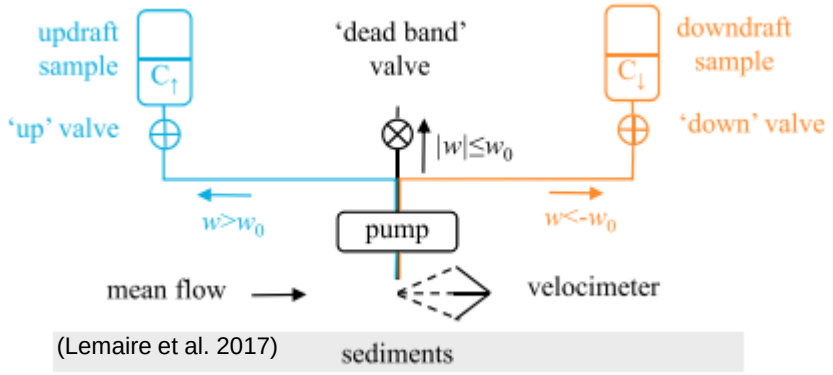
Oxygen flux have a great temporal variability as well as Organic Matter mineralization

Relaxed Eddy Accumulation

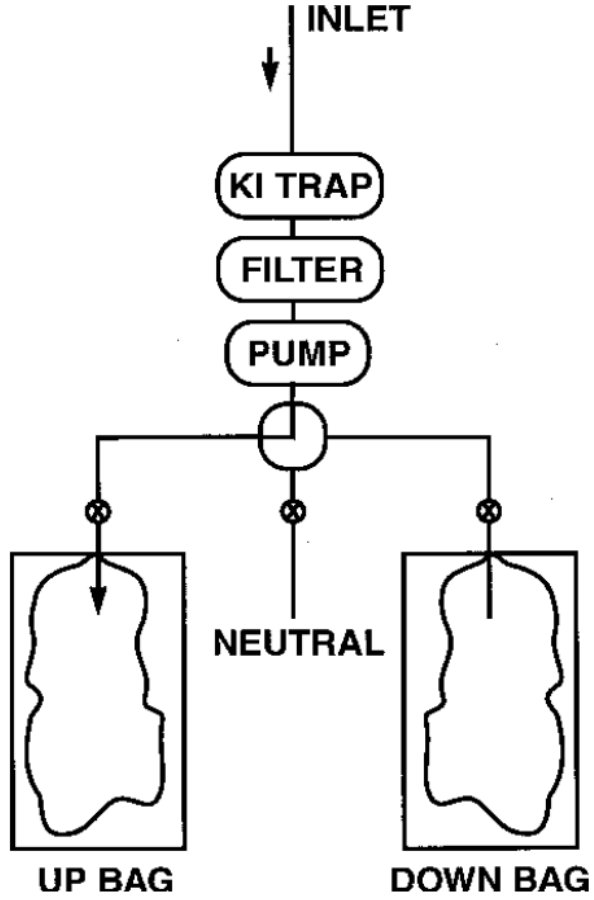
Conditional sampling at constant flow rate (Businger & Oncley, 1990)

$$F_{REA} = b(w_0).\sigma_w.\left(\overline{C_\uparrow} - \overline{C_\downarrow}\right)$$

F REA: Flux
Upward sample: $w>w_0$, concentration $C_\uparrow$
Downward sample: $w<-w_0$, concentration $C_\downarrow$
σ_w standard deviation of vertical speed
$b(w_0)$ empirical coefficient

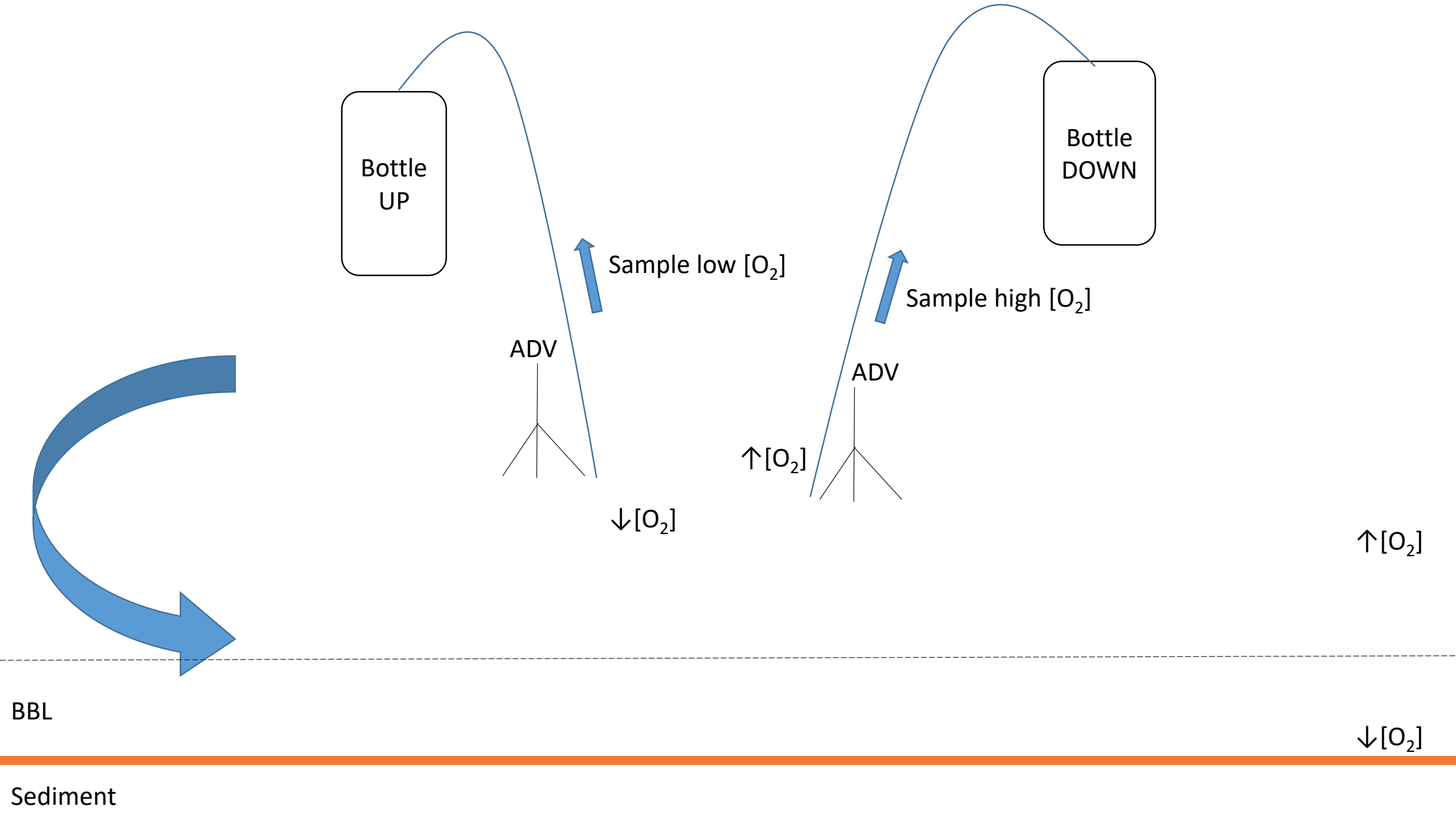


(Lemaire et al. 2017)



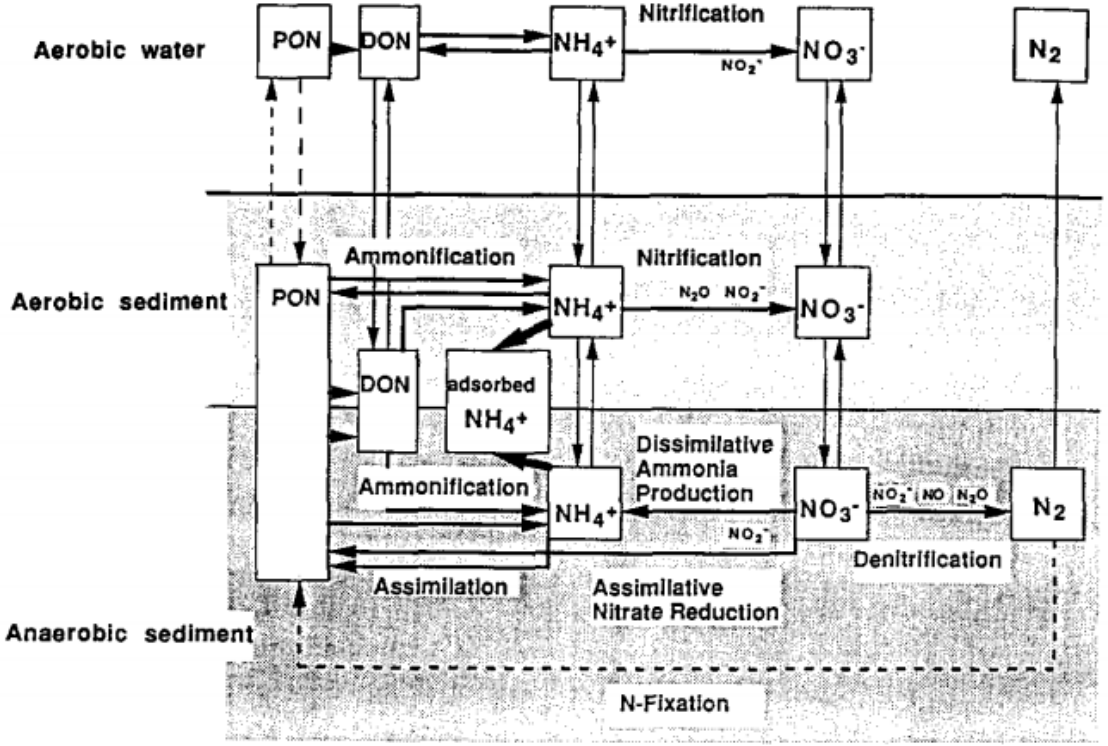
Typical REA measuring principle (Bowling et al. 1998)

Replacing fast probes for fast active sampling to expand the range of measured substances

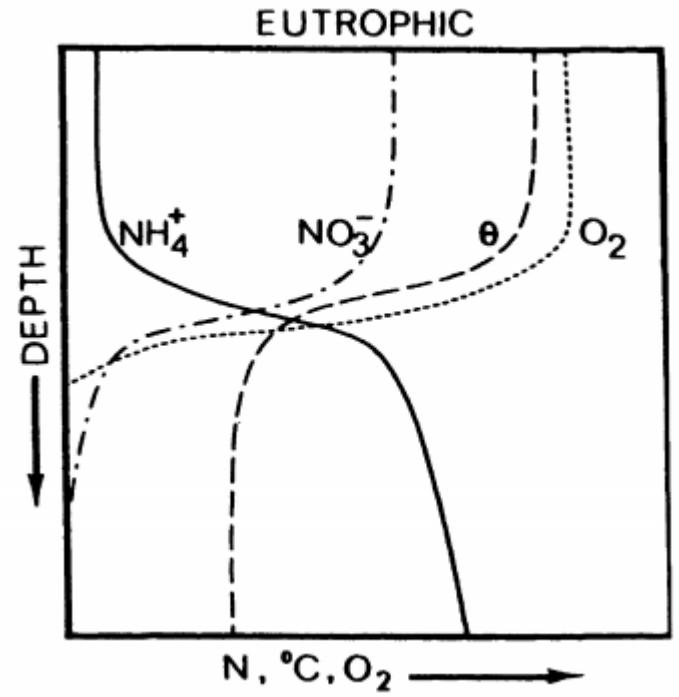

Bottle
UP
Sample low [O2]
ADV
↓[O2]
Bottle
DOWN
Sample high [O2]
ADV
↑[O2]
↑[O2]
BBL
↓[O2]
Sediment

Problematic

What kind of flux can we measure?



(Wetzel, 2001)

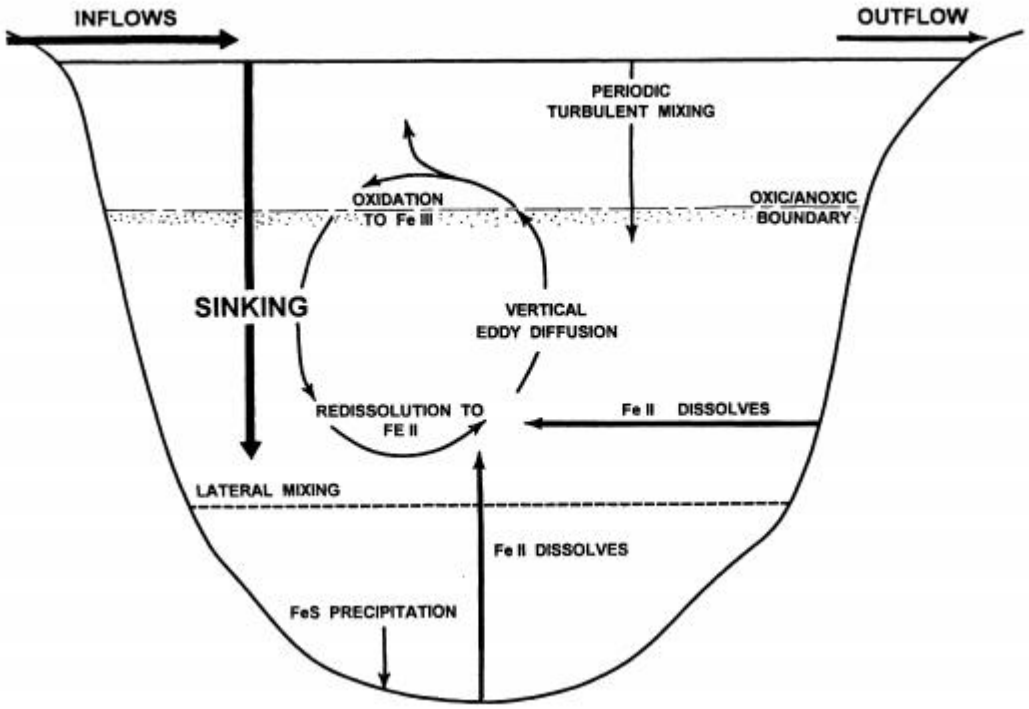


(Wetzel, 2001)

Positive flux of ammonium is expected when negative flux of oxygen is measured. Also ammonium is not rapidly transformed in nitrates

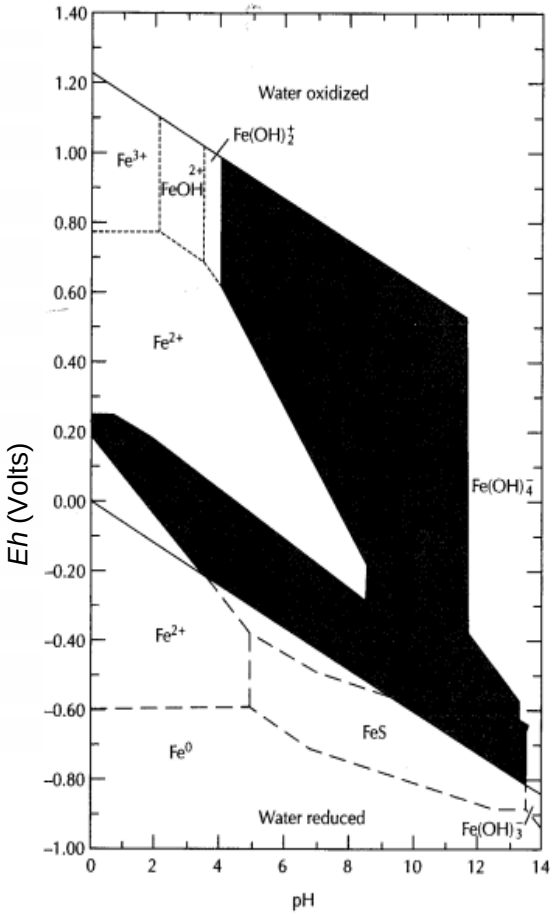
Problematic

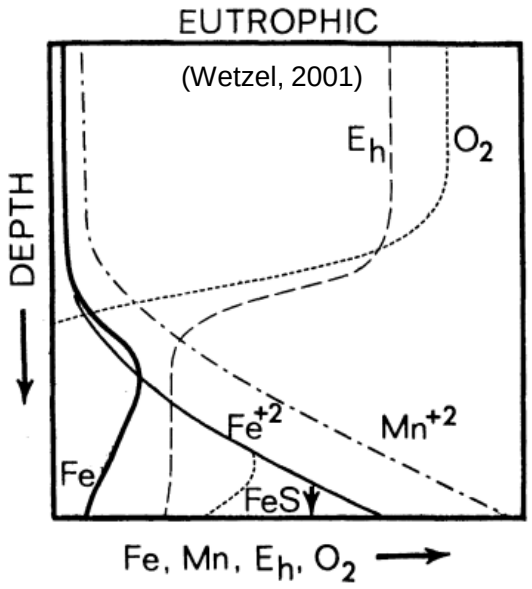
What kind of flux can we measure?



(Wetzel, 2001)

(Stumm and Lee, 1960)





Positive flux of ferrous ions is expected when negative flux of oxygen is measured. But it depends on pH of the waterbody and the Suffer presence