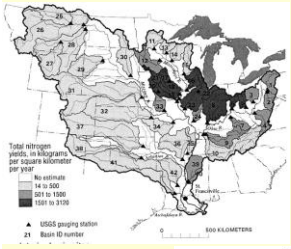
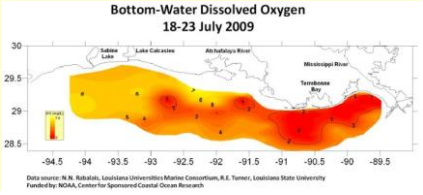
Chemistry, Redox and DO



Controls on nutrients and biota

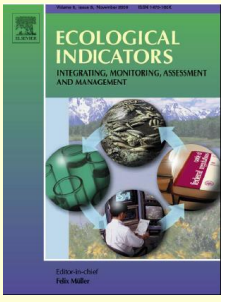


Lecture outline

- Common freshwater chemistry parameters
- Redox
- Photosynthesis
- DO

Ions

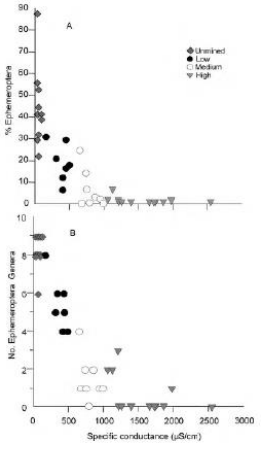
- Total dissolved solids (TDS)
- Salinity
- Conductivity
- Relationships among them?
- More ions means?
  - So, sometimes these variables are useful *indicators*



Conductivity vs. mayflies

- Includes streams draining mountaintop removal and valley fill mining practices

Pond et al. (2008)



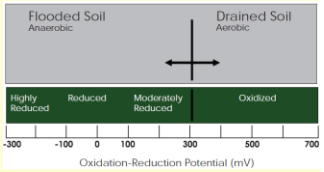
More chemical measures

- **pH**: $-\log_{10}[H^+]$
- **Alkalinity**: ANC; bases; CO_3^{-2} + HCO_3^- + OH-
- **Acidity**: reactivity with bases
- **Hardness**: Mg + Ca ions; indicator of soap precipitation
- **Turbidity**: light absorption from ?
- **Color**: relates to what?

Ohio River

Redox Potential, Potential Energy, and Chemical Transformations

- Redox is a measure of free electron availability
- Measured in mV
  - Low values (< 100 mV): many transferable electrons (reducing environment)
  - High values: few available electrons (oxidizing environment)



- Chemicals have potential energy if they are at a different redox state than the solution that they are in
- So…energy for microbes can be obtained during reactions depending on the redox state

Redox—the order matters

- If we focus on the ecology, then
  - Heterotrophs consuming (i.e., oxidizing) available (reduced) organic matter first use oxygen to accept the electrons that the organic matter is providing
  - As oxygen is depleted, the dominant terminal electron acceptor changes according to what is energetically best/easiest, meaning species that can use these different electron acceptors become important
- However, redox reactions will simply take place in this order without organisms, as well

Chinese buffet?*
- Oxygen
- Nitrate
- Manganese
- Iron
- Sulfate
- Carbon dioxide
- (methanogenesis)

* Thanks Doug Wilcox

Iron and Redox

- Reduced iron (Fe^{2+}), ferrous iron, is soluble
- Oxidized iron (Fe^{3+}), ferric iron, forms an insoluble precipitate
- Low DO leads to high amounts of ferrous iron

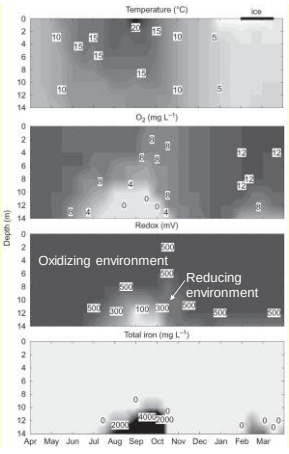
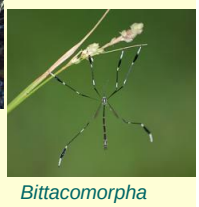


Fig. 12.6

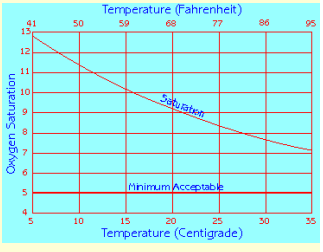
Iron seep



Bittacomorpha
Phantom crane fly

Oxygen: forms and transformations

- 21% of atmosphere is O_2
- Aerobic/anaerobic or oxic/anoxic
- Oxygen often drives redox potential
- Saturation concentration of dissolved O_2 depends on atmospheric pressure and temperature (how?)
- Photosynthesis vs. respiration
- Local considerations…



Photosynthesis

- Net photosynthesis = _____ – _____
  - What about PP?
- Some influential factors: light, temperature, water velocity, and chemicals
- Relationship between photosynthesis and light referred to as P-I relationship

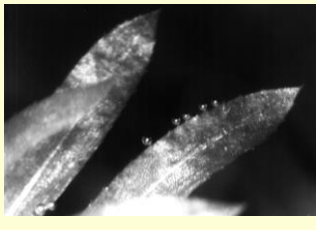


Fig. 12.1

P vs. I

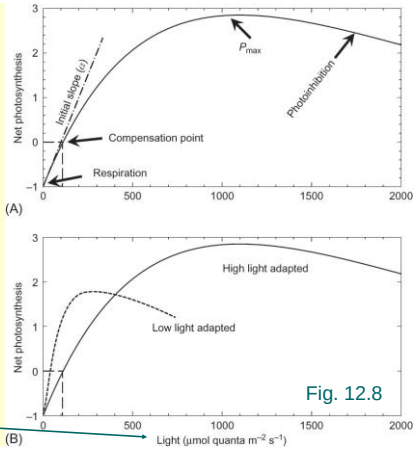


Fig. 12.8

I = PAR?

P-I and Hudson River—Who wins?

Harley & Findlay (1994)

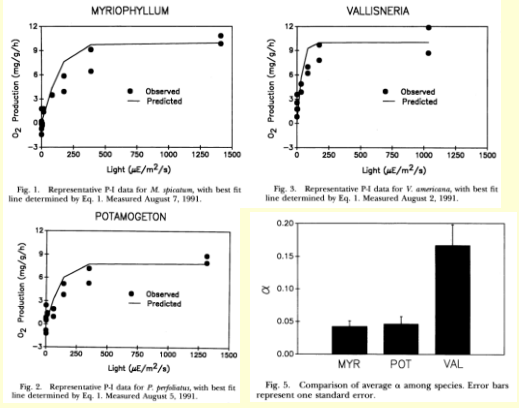


Fig. 1. Representative P-I data for *M. spicatum*, with best fit line determined by Eq. 1. Measured August 7, 1991.

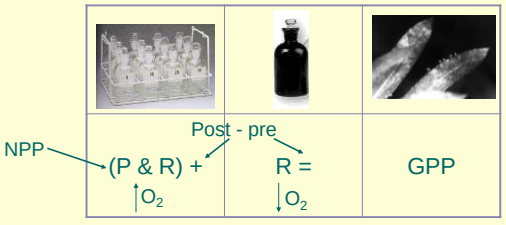
Fig. 3. Representative P-I data for *V. americana*, with best fit line determined by Eq. 1. Measured August 2, 1991.

Fig. 2. Representative P-I data for *P. perfoliatus*, with best fit line determined by Eq. 1. Measured August 5, 1991.

Fig. 5. Comparison of average α among species. Error bars represent one standard error.

How do we measure PP?

- Usually measure changes in DO
  - Light-dark bottles (short incubations; surfaces & nutrient use problematic; what about streams and bottles?)
- Actual carbon uptake
  - $^{14}CO_2$



How do we measure PP? (2)

- Whole system metabolism, but must account for re-aeration

O_2 loggers

Propane injection

P vs. temperature

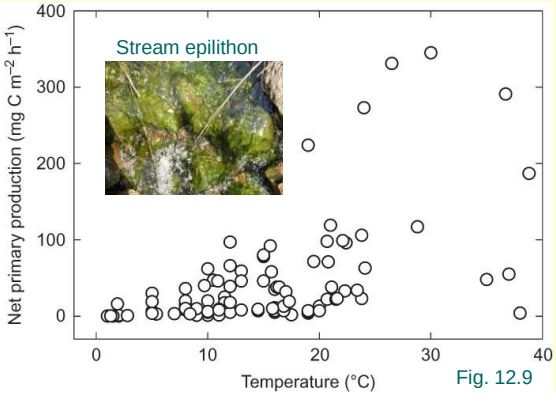


Fig. 12.9

P vs. velocity

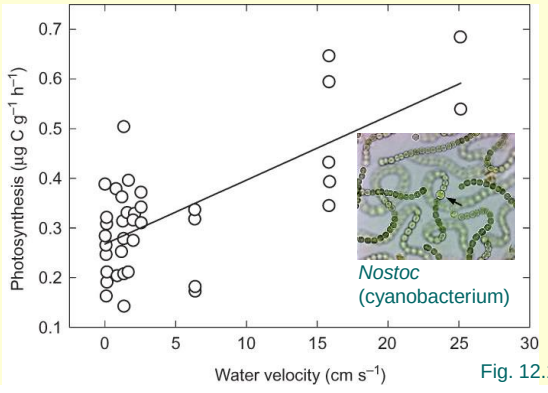


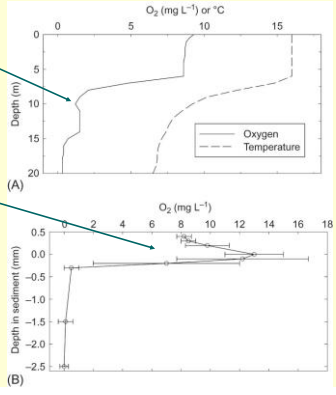
Fig. 12.10

Spatial variation in O_2

Clinograde curve

(vs. orthograde)

Microzone



Temporal variation in O_2

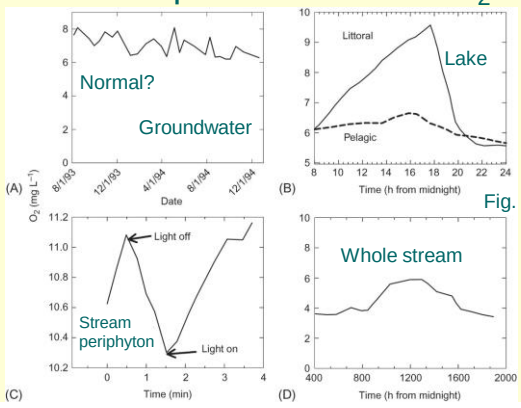


Fig. 12.11