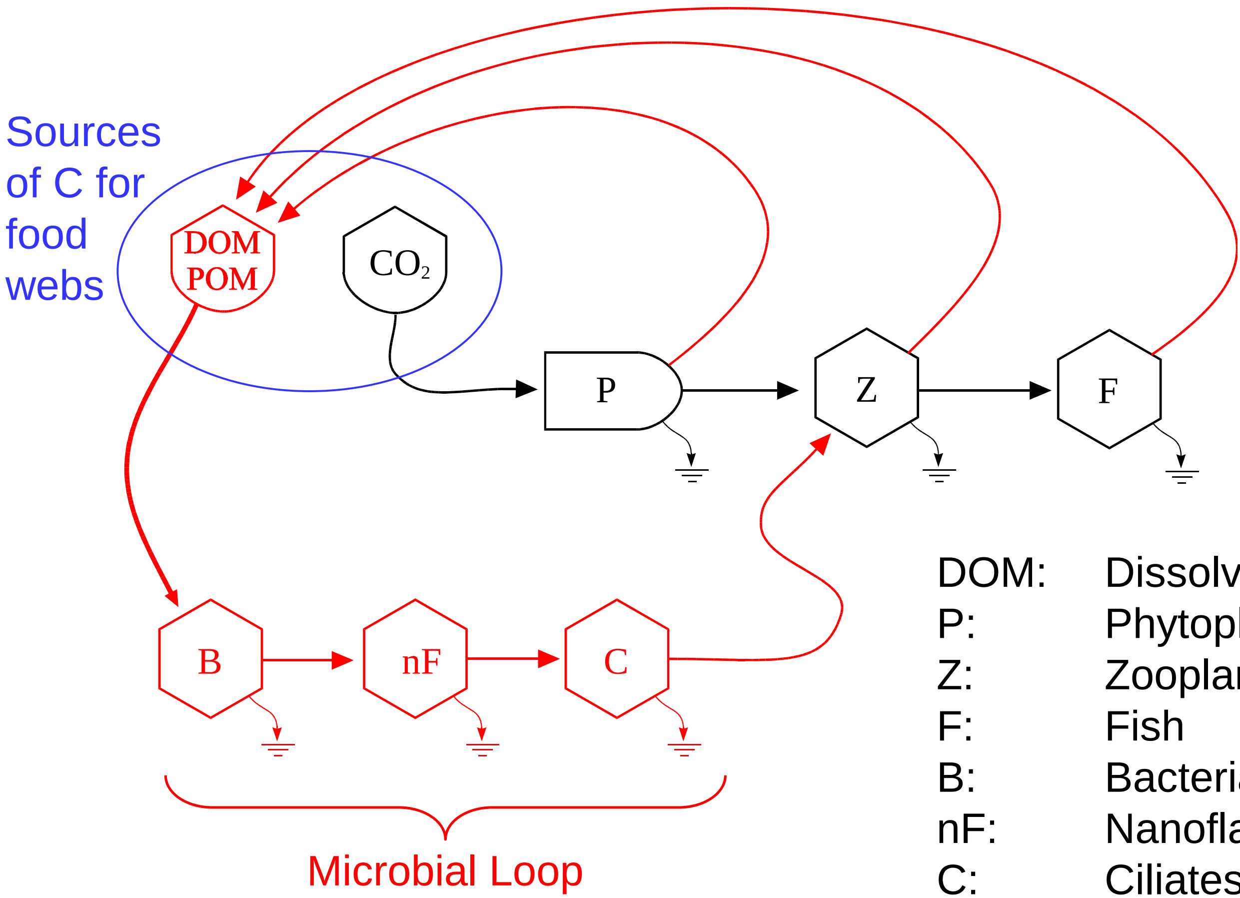
Bacteria-Phytoplankton Competition

Overview:

- Bacterial immobilization or remineralization of N.
- Competition between bacteria and phytoplankton for DIN.
- Experimentally examine how dissolved organic carbon (DOC) affects the competition between bacteria and phytoplankton for limiting nutrients.
- Demonstrate use of microcosms to study microbial dynamics.
- Analysis of time-series and predator-prey dynamics.

Microbial Loop

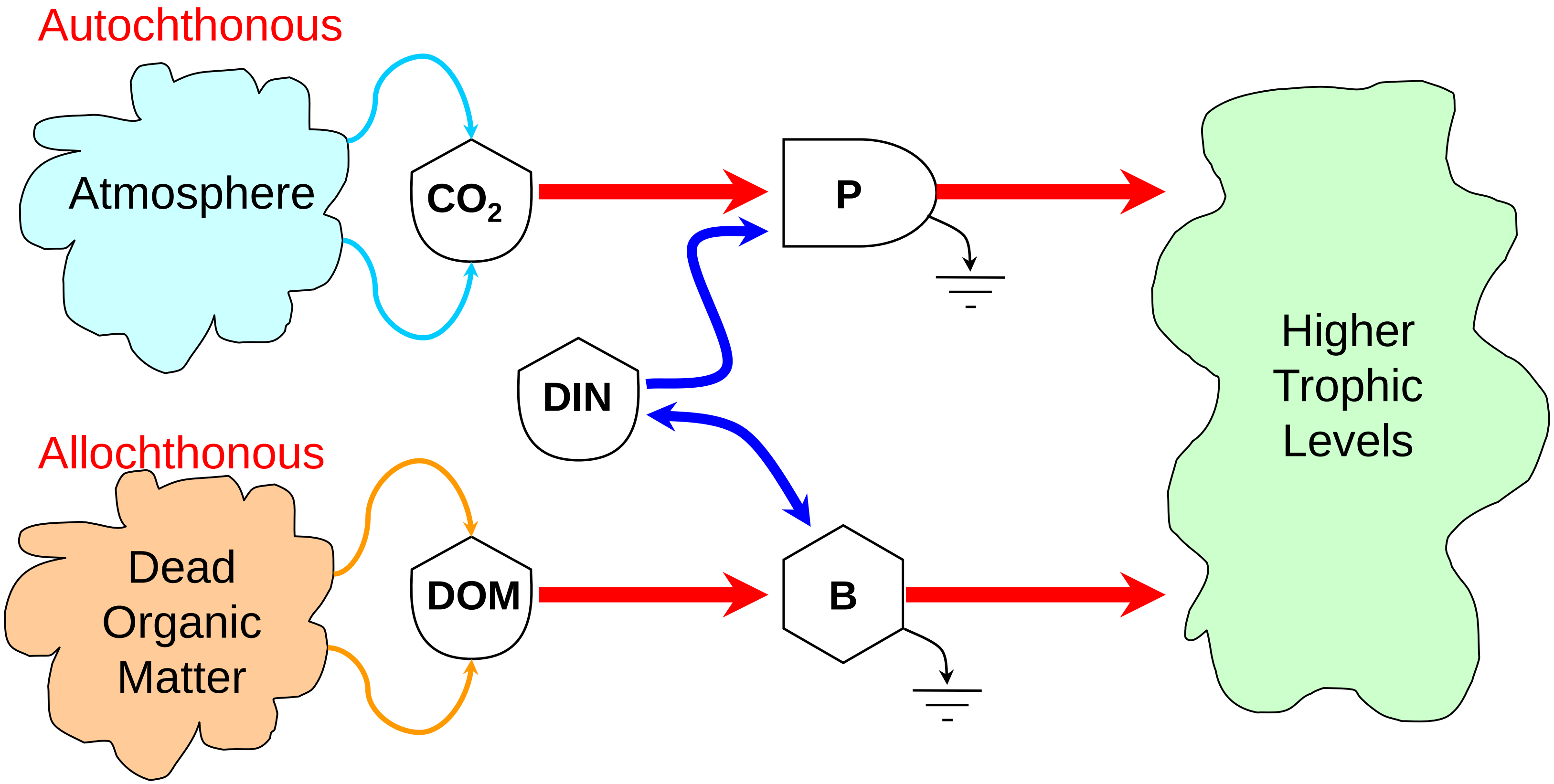
The microbial loop is a conceptualization by which DOM can be routed into the classic food chain via bacteria and their grazers.



DOM: Dissolved organic matter
P: Phytoplankton
Z: Zooplankton
F: Fish
B: Bacteria
nF: Nanoflagellates
C: Ciliates

Primary flow of C and N into *aquatic* food webs

Energy and mass enter the base of the food web via phytoplankton or bacteria.



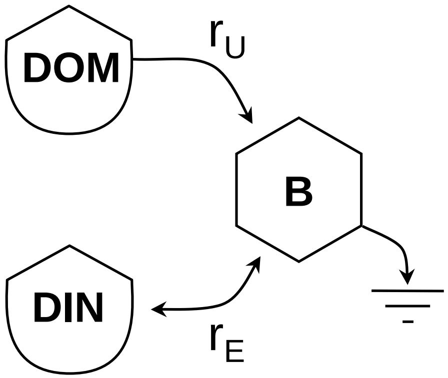
Depending on the C:N composition of DOM, bacteria and phytoplankton can be in competition for DIN (and P).

Organisms with the higher surface area to volume will win.

Carbon and Nitrogen Balances

- **Bacteria**
  - ⇨ Consume DOM
  - ⇨ Use DON over DIN
  - ⇨ Either excrete of consume DIN

- Effect of C:N ratio of DOM on DIN uptake or excretion



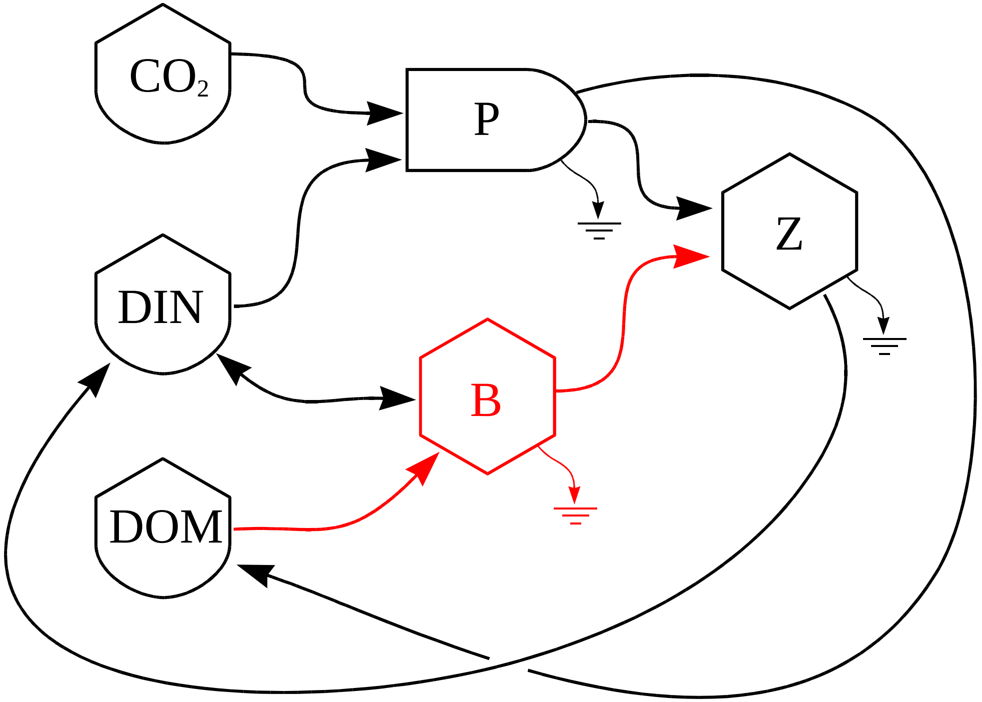
r_U: Rate of DOC uptake (μmol C l^{-1} d^{-1})
r_E: Rate of DIN excretion (μmol N l^{-1} d^{-1})
ρ_B: C:N Ratio of bacteria (atomic)
ρ_D: C:N Ratio of DOM (atomic)

Bacterial N requirement: $\varepsilon r_U \dfrac{1}{\rho_B}$ N associated with DOM uptake: $r_U \dfrac{1}{\rho_D}$

Rate of DIN excretion: $r_E = r_U\left(\dfrac{1}{\rho_D} - \dfrac{\varepsilon}{\rho_B}\right)$

Phytoplankton-Bacteria Competition

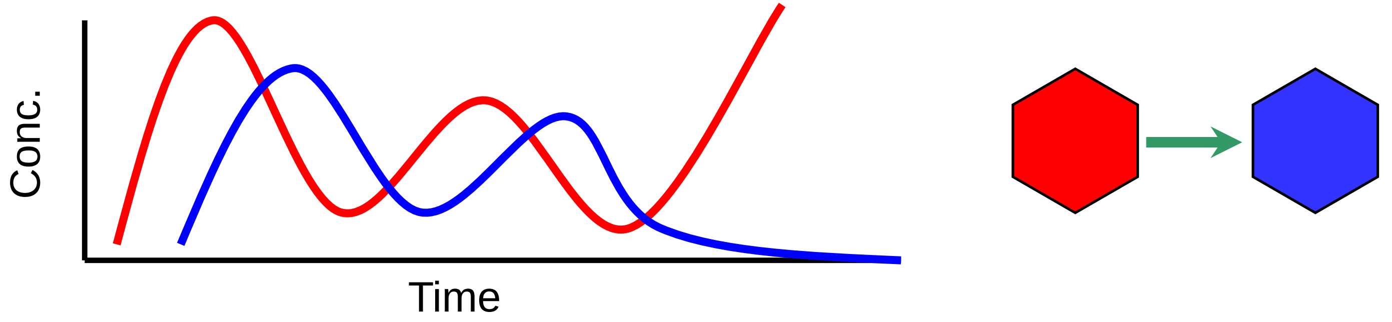
- Consider aggregated conceptualization of lower trophic levels.
- If the C:N ratio of DOM is high, then bacteria will utilize DIN.
- Bacteria should out compete phytoplankton for DIN. Why?
- Dynamics of food web should be dependent on DOM composition



- Paradox: why do phytoplankton excrete DOM?

Value of Time Series Data

- In order to understand ecosystem function, causal relationships need to be determined between organisms and nutrients.



- “Snap shots” can not provide this information. Systems must be followed over time.

- Basic understanding obtained from observations can be used to build models.

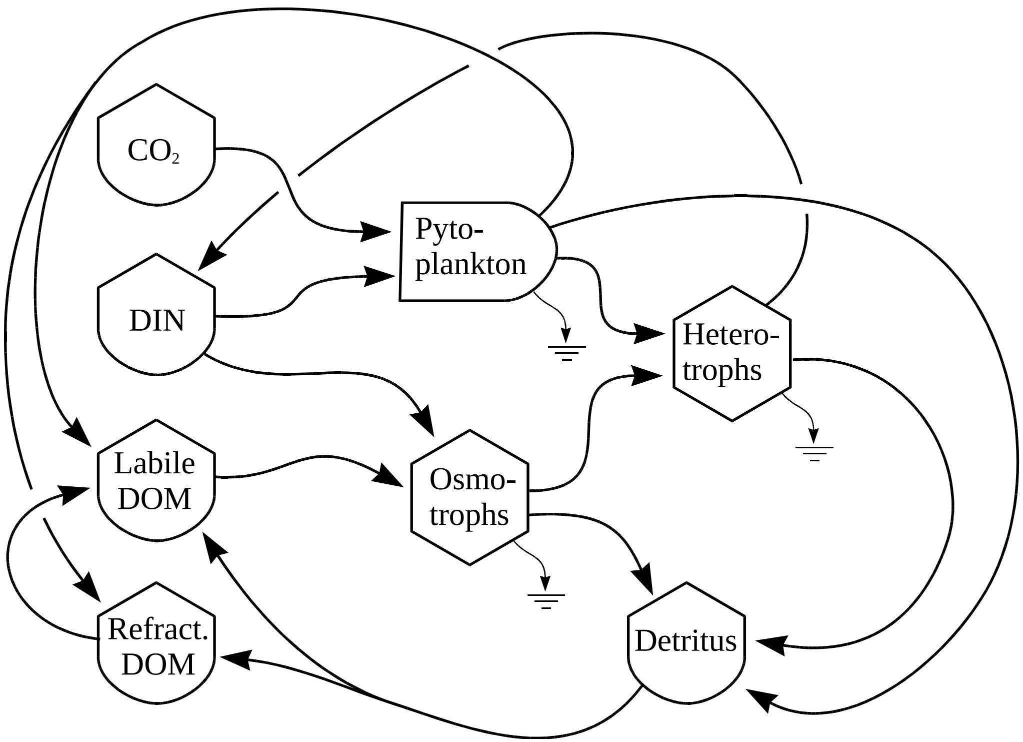
- New time series data can be used to test models.

Example: Mesocosm Experiment

- **Additions:**
  - NO_3 (5 μM), PO_4 (0.5 μM), Si (7 μM)
  - Leaf litter leachate (300 μM DOC)
- **Samples Taken:**
  - NO_3, NH_4, PO_4, Si, O_2 DIC
  - PAR
  - POC, PON, DOC, DON
  - Chl a
  - PP (^{14}C and O_2 incubations)
  - Bacterial No. and productivity
  - Phyto- and zooplankton counts
  - $DI^{13}C$, $DO^{13}C$, $DO^{15}N$
  - Size fractionated $\delta^{13}C$ and $\delta^{15}N$
- **Treatments:**
  - Control: Bag A
  - Organic Matter: Bag B
  - Daily Nutrients: Bag C
  - DOM + Nutrients: Bag D

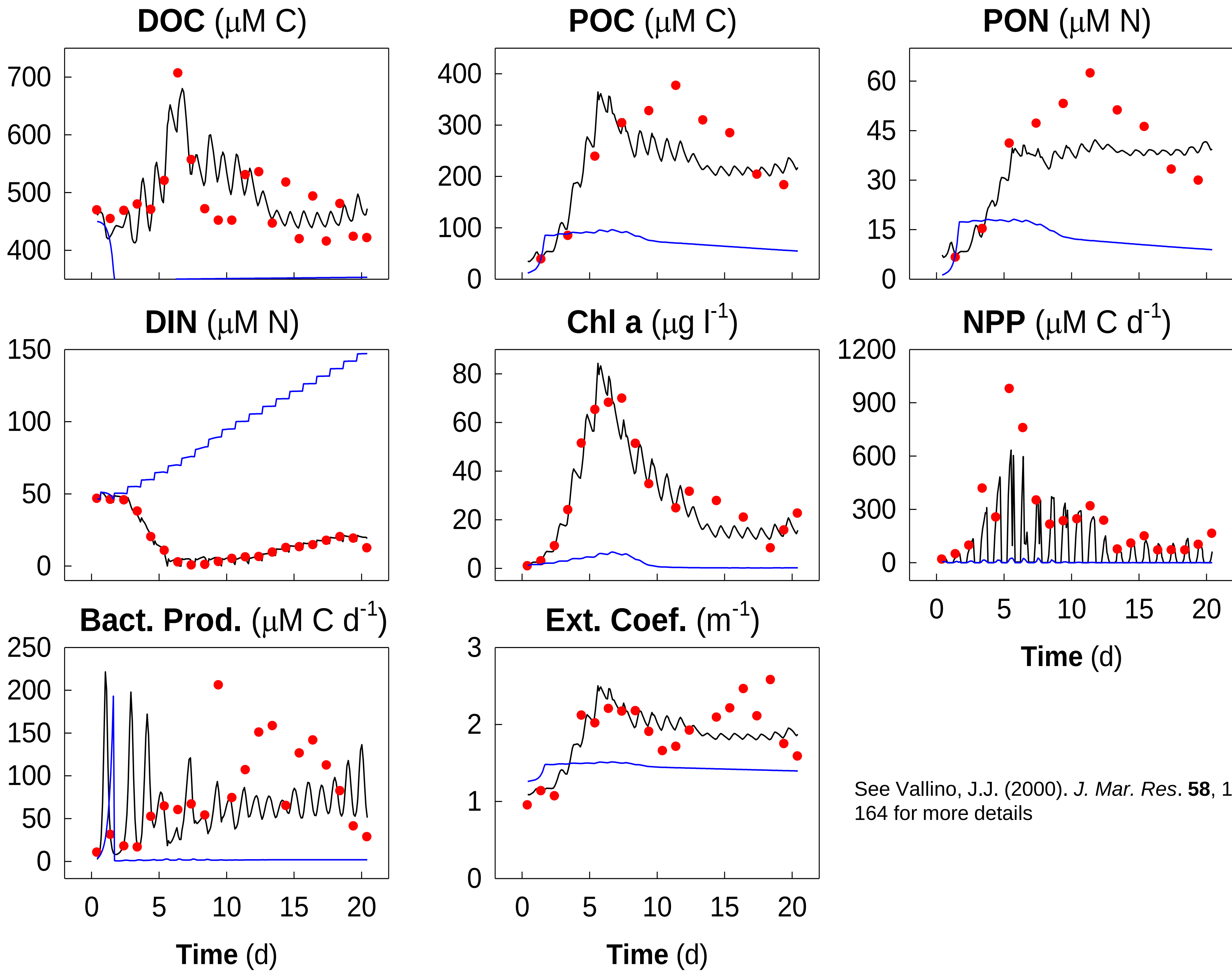
Mesocosm Food Web Model

- Aggregated, coupled C and N model
- Emphasis on OM processing
- Holling type II and III growth kinetics



- State Eqns: 10
  - Auto. C, N
  - Osomo. C, N
  - Hetero. C, N
  - Detritus C
  - Detritus N
  - DIN N
  - DOM-L C
  - DOM-L N
  - DOM-R C
  - DOM-R N
- Parameters
  - 29 Kinetic
  - 10 Initial cond.

Nutrients + Organic Matter (Bag D)



See Vallino, J.J. (2000). *J. Mar. Res*. **58**, 117-164 for more details

Experimental Setup

- Collect Woods Hole seawater into two 20 l carboys
- Prepare two treatments:

	Treatment A	Treatment B
Glucose	0 μM	75 μM (450 μM C)
NO_3^-	36 μM	36 μM
SiO_3	52 μM	52 μM
PO_4	2.3 μM	2.3 μM

- Measure the following constituents over the 7 day incubation
    - DOC (1 person)
    - NO_3^- (1)
    - NH_4^+ (1)
    - PO_4^{3-} (1)
    - Chlorophyll a (by fluorescence and extraction) (1)
    - Bacteria abundances (DAPI) (1)
    - Ciliate and nanoflagellate abundance (DAPI) (1)
    - Phosphatase (2)
    - Bacterial production (2)

What will happen in Treatment A versus Treatment B?

Work clean, as sea water is readily contaminated by hands, etc.