

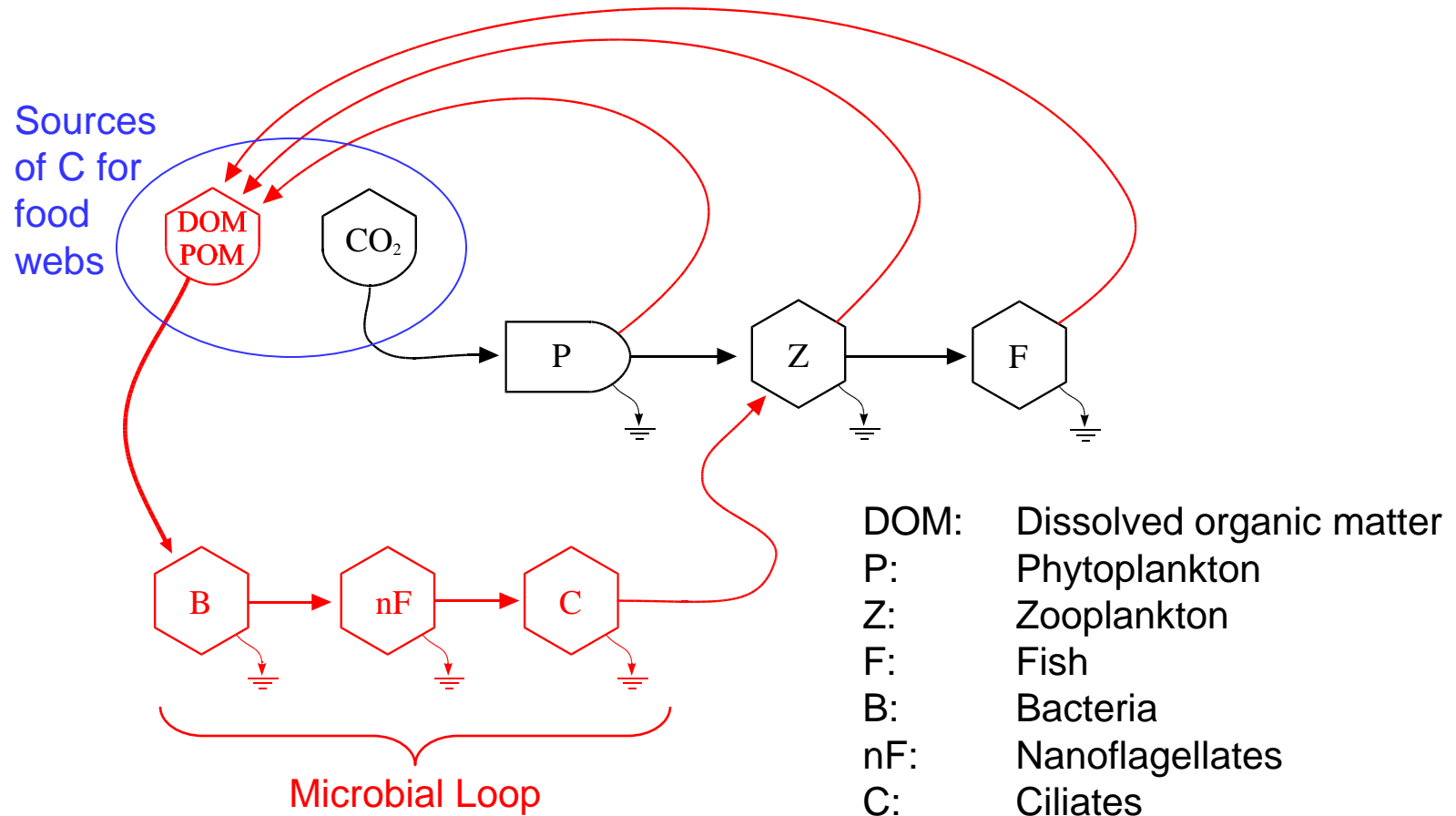
Bacteria-Phytoplankton Competition

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.

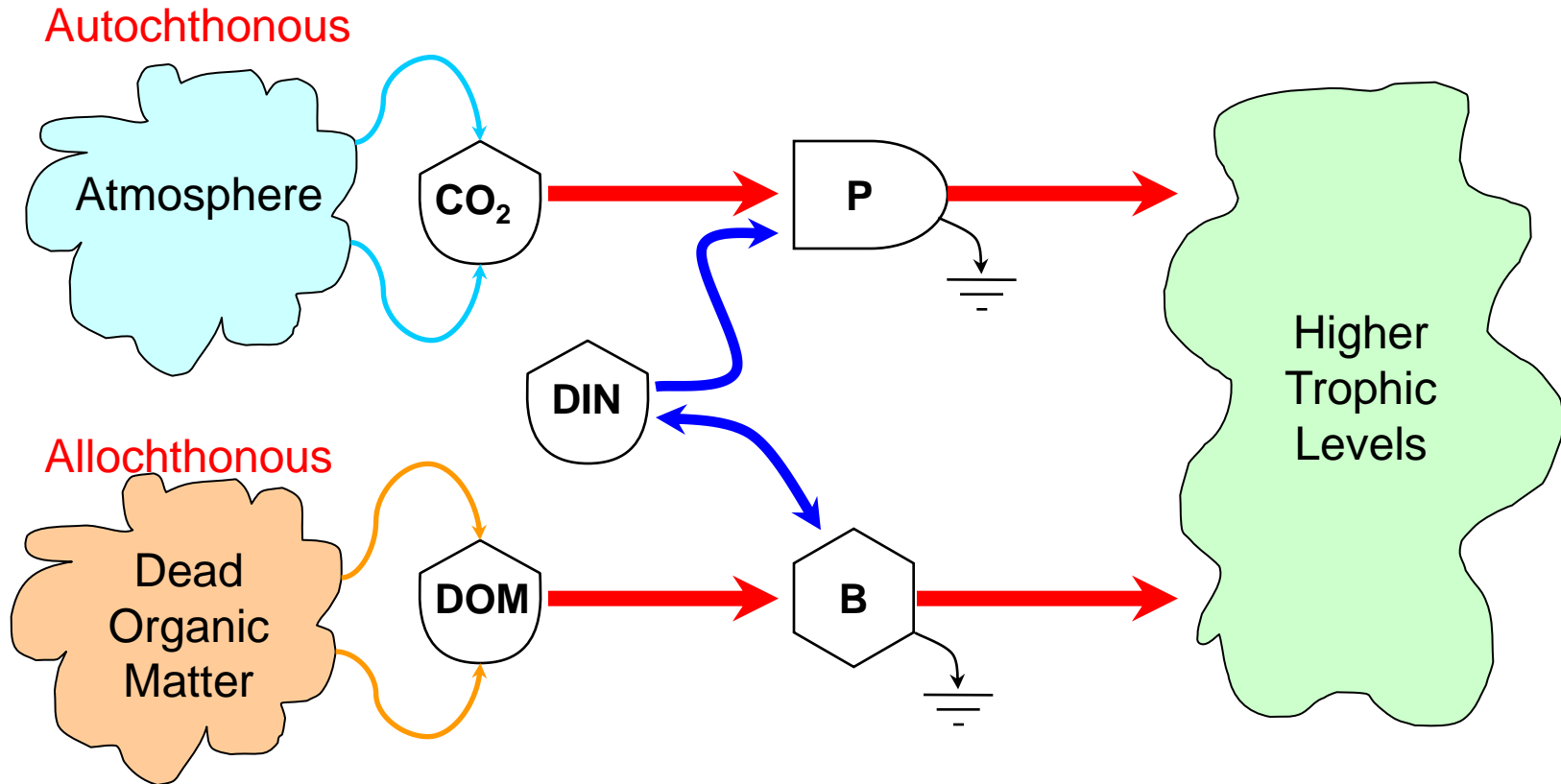
Microbial Loop

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



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).

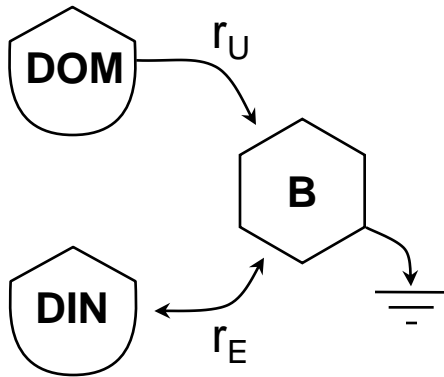
Organisms with the higher surface area to volume will win.

Carbon and Nitrogen Balances

● Bacteria

- ⇒ Consume DOM
- ⇒ Use DON over DIN
- ⇒ Either excrete or consume DIN

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



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

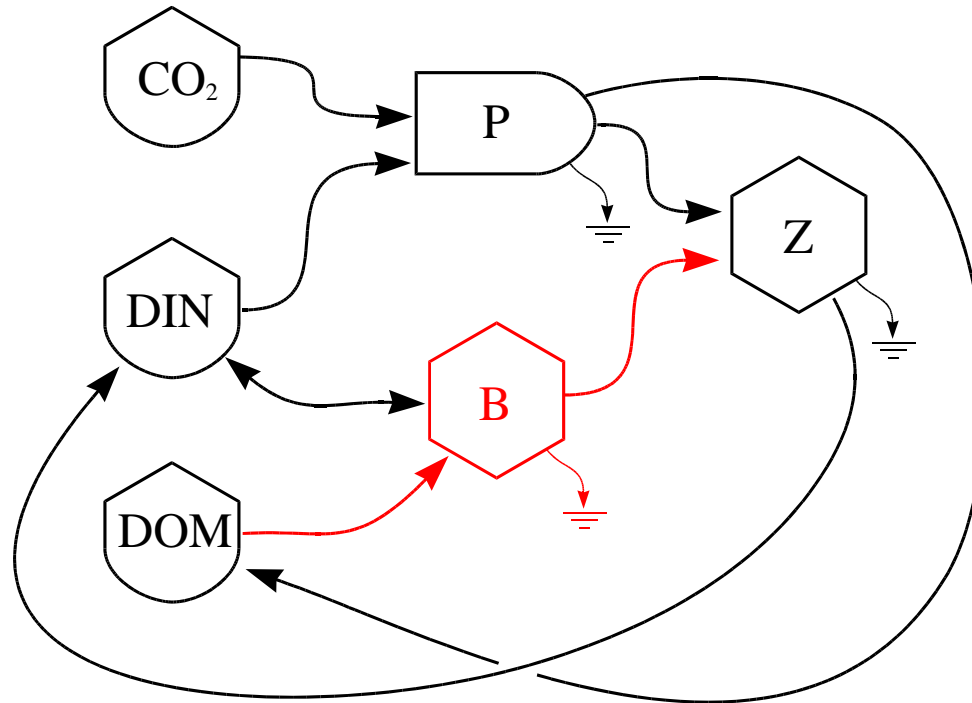
Bacterial N requirement: $\epsilon r_U \frac{1}{\rho_B}$

N associated with DOM uptake: $r_U \frac{1}{\rho_D}$

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

Phytoplankton-Bacteria Competition

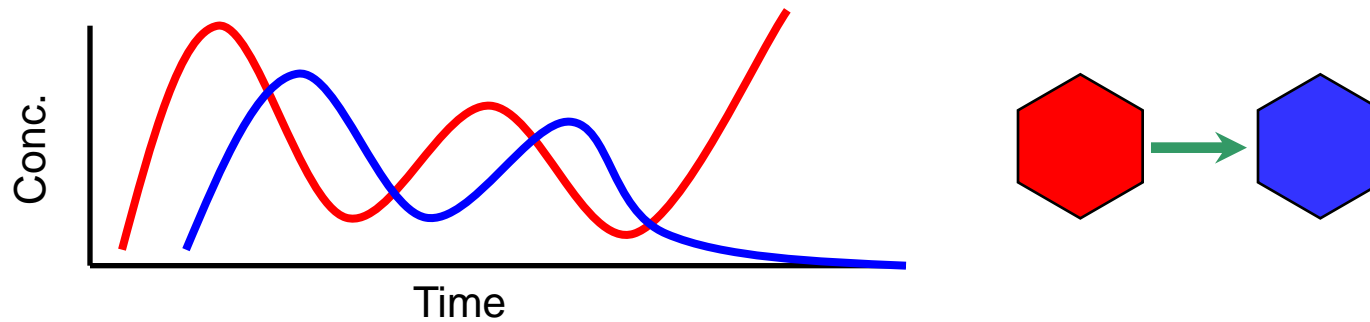
- Consider aggregated conceptualization of lower trophic levels.
- If the C:N ratio of DOM is high, then bacteria will utilize DIN.
- Bacteria should out compete phytoplankton for DIN. Why?
- Dynamics of food web should be dependent on DOM composition



- 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:**

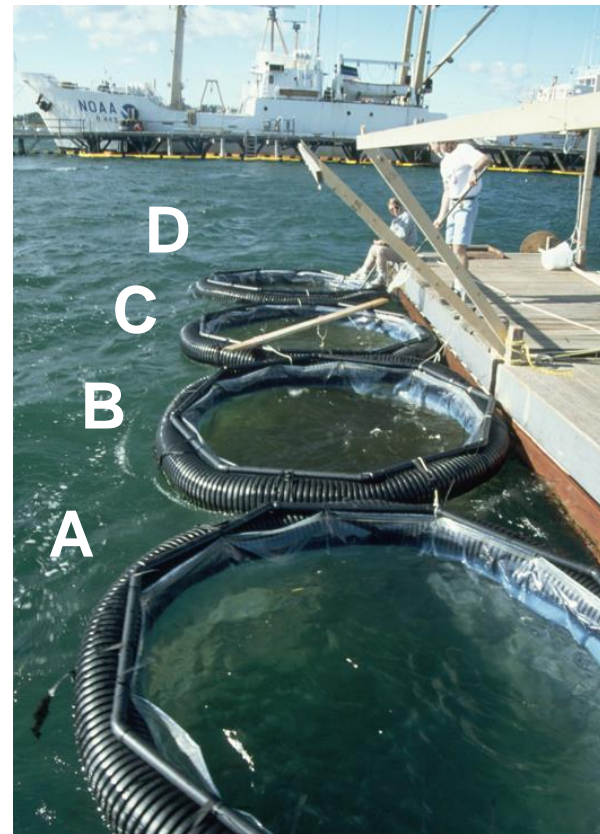
- NO_3 (5 μM), PO_4 (0.5 μM), Si (7 μM)
- Leaf litter leachate (300 μM DOC)

- **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 $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$

- **Treatments:**

- Control: Bag A
- Organic Matter: Bag B
- Daily Nutrients: Bag C
- DOM + Nutrients: Bag D



Mesocosm Food Web Model

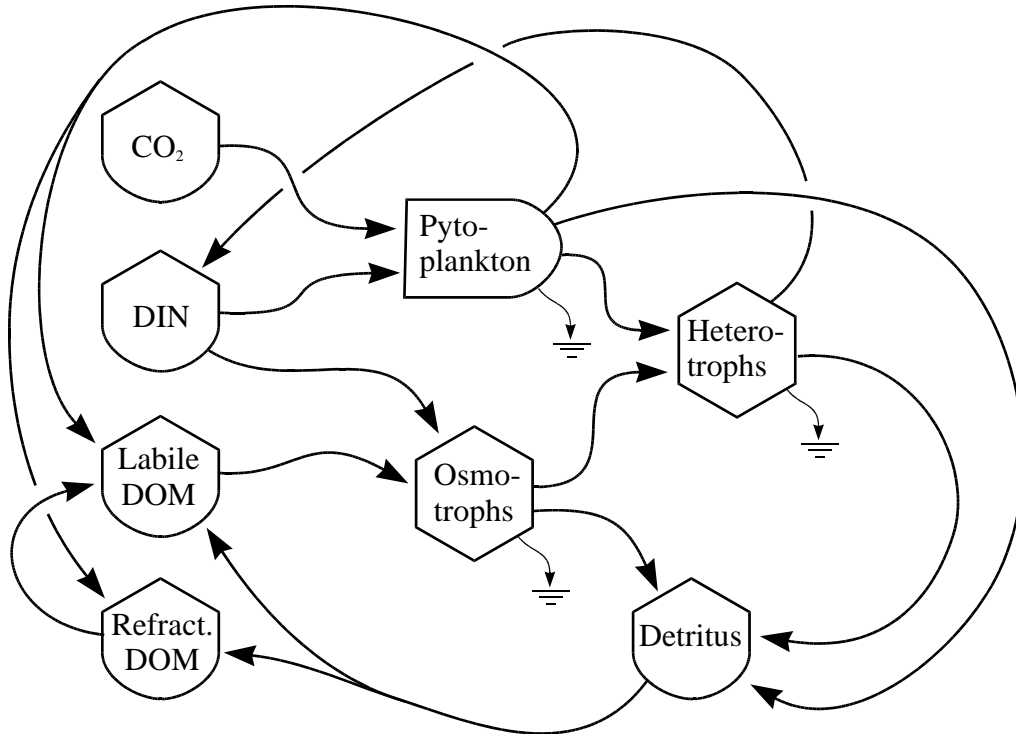
- Aggregated, coupled C and N model
- Emphasis on OM processing
- Holling type II and III growth kinetics

- State Eqns: 10

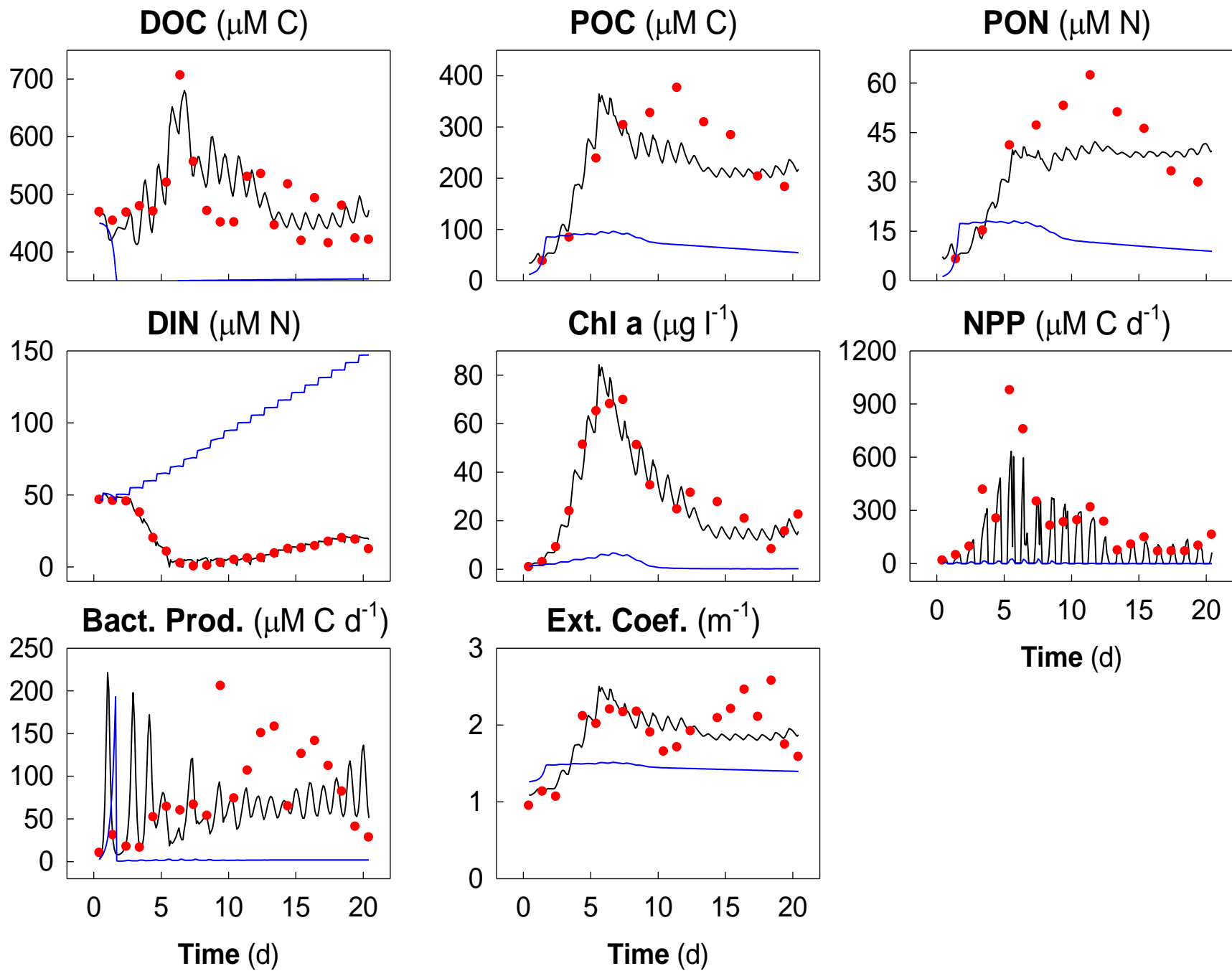
– Auto.	C, N
– Osono.	C, N
– Hetero.	C, N
– Detritus	C
– Detritus	N
– DIN	N
– DOM-L	C
– DOM-L	N
– DOM-R	C
– DOM-R	N

- **Parameters**

- 29 Kinetic
- 10 Initial cond.



Nutrients + Organic Matter (Bag D)



Experimental Setup

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

	Treatment A	Treatment B
Glucose	0 μM	75 μM (450 $\mu\text{M C}$)
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)

What will happen in Treatment A versus Treatment B?

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