

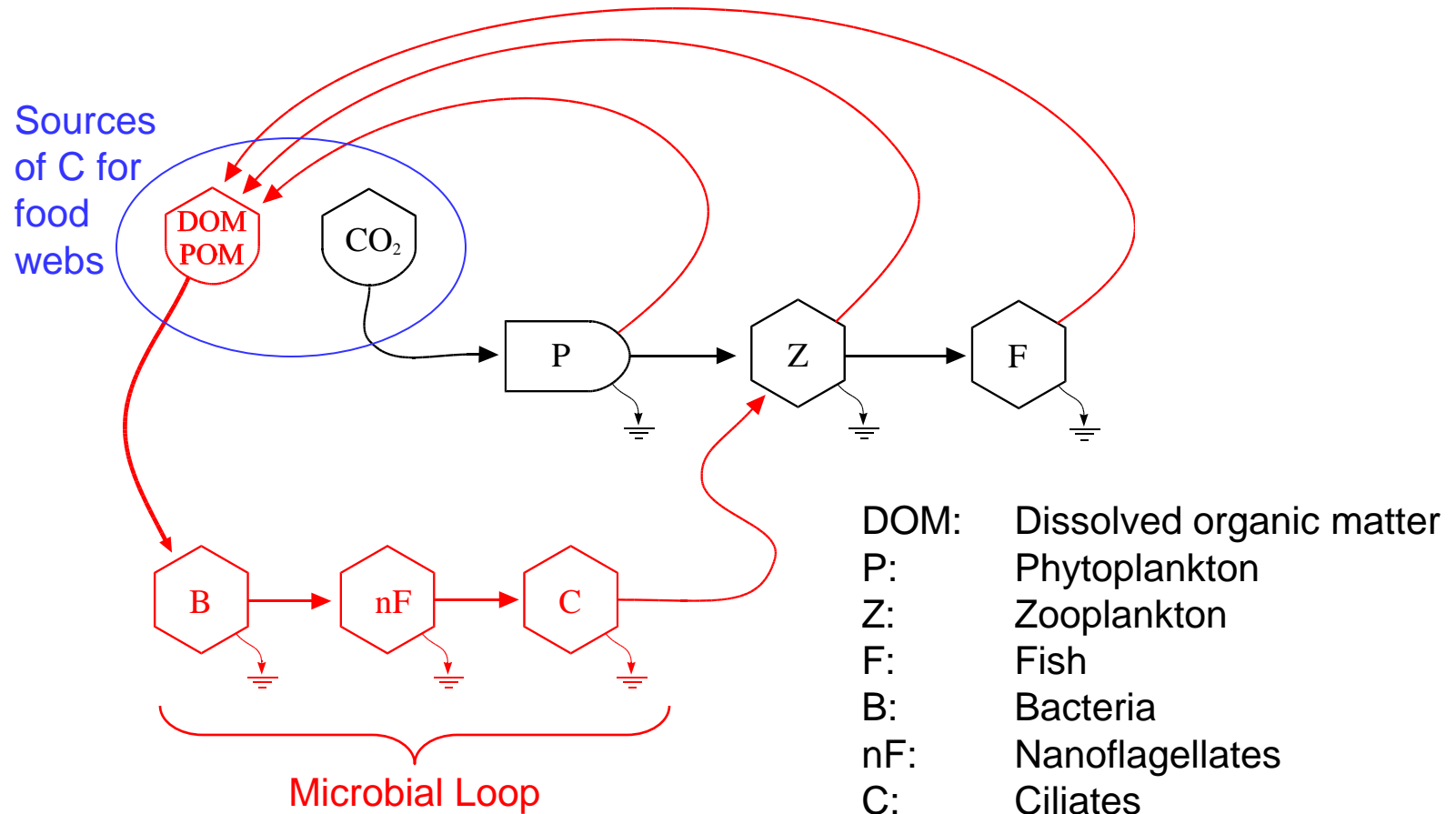
# **Bacteria-Phytoplankton Competition**

## **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.

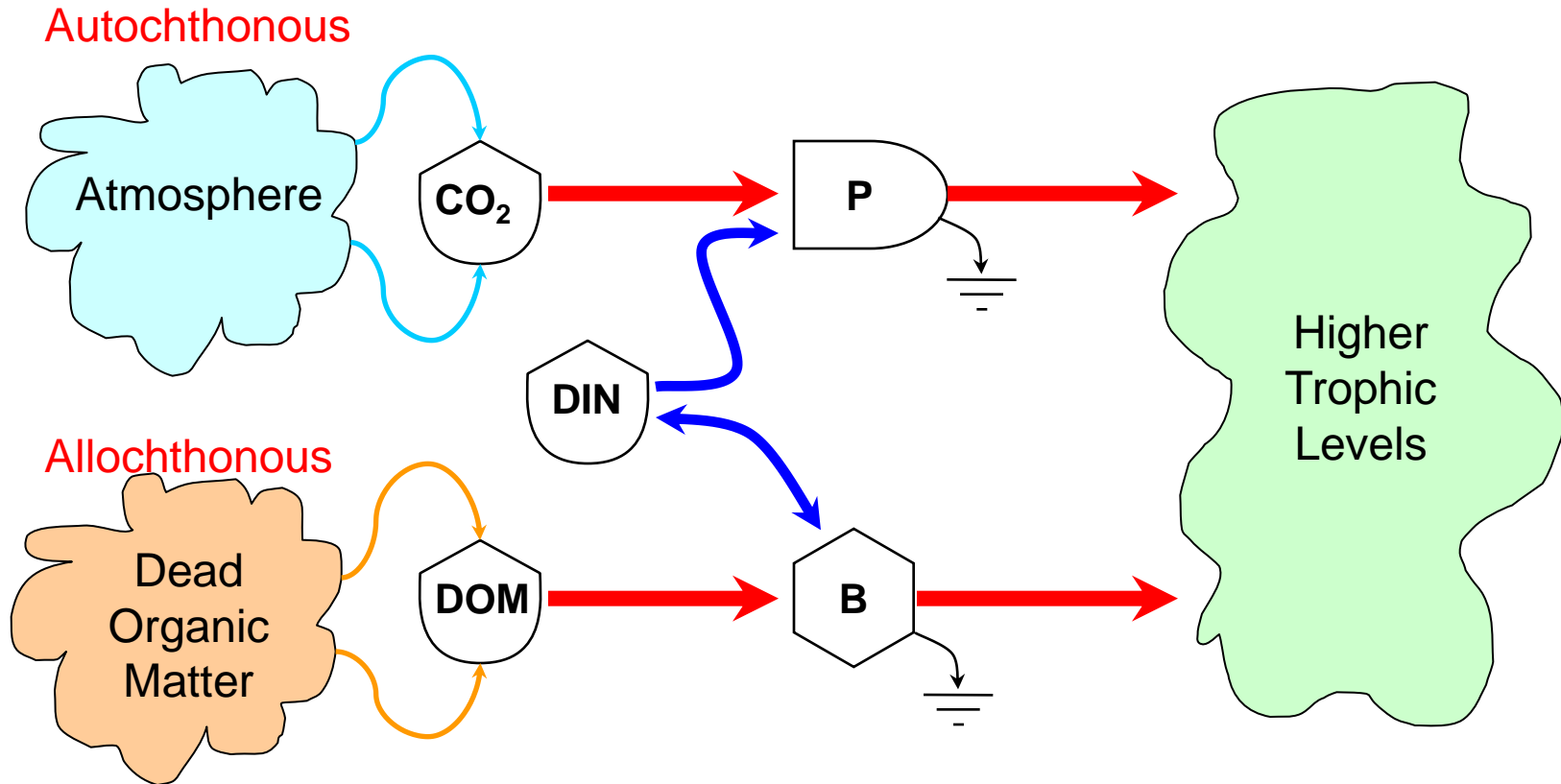
# Microbial Loop

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).

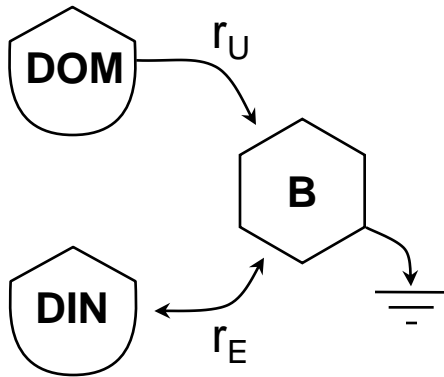
Organisms with the higher surface area to volume will win.

# 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 ( $\mu\text{mol N l}^{-1} \text{d}^{-1}$ )
- $\rho_B$ : C:N Ratio of bacteria (atomic)
- $\rho_D$ : C:N Ratio of DOM (atomic)

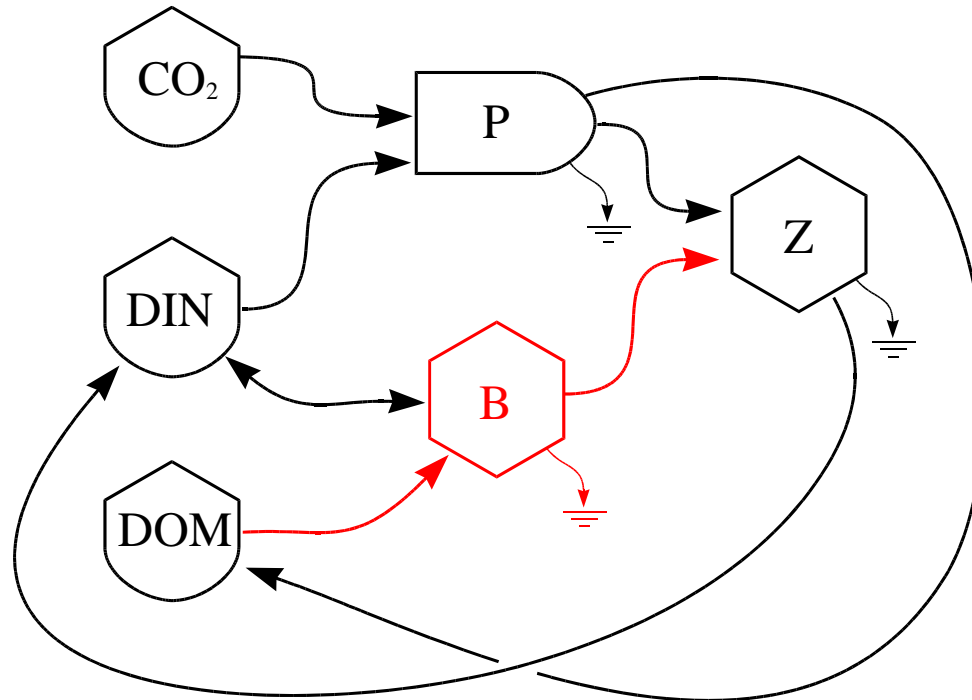
Bacterial N requirement:  $\epsilon r_U \frac{1}{\rho_B}$

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



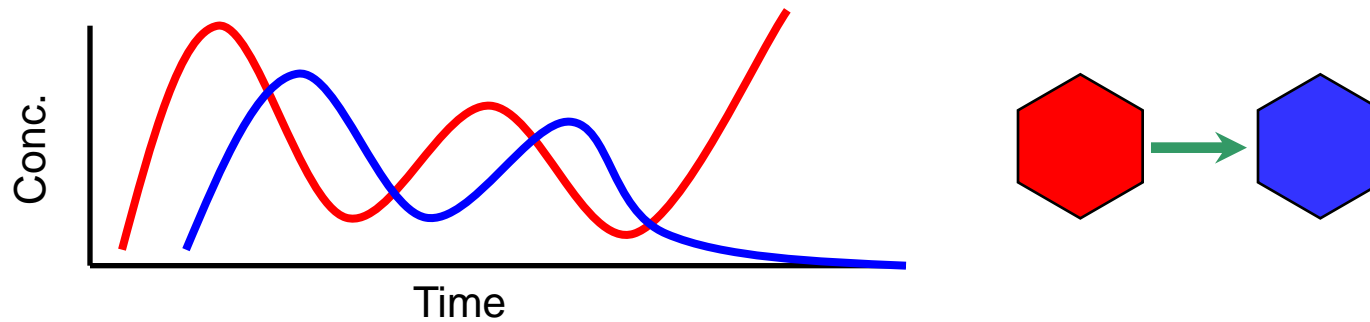
- Paradox: why do phytoplankton excrete DOM?

# Value of Time Series Data

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- 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

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## • Additions:

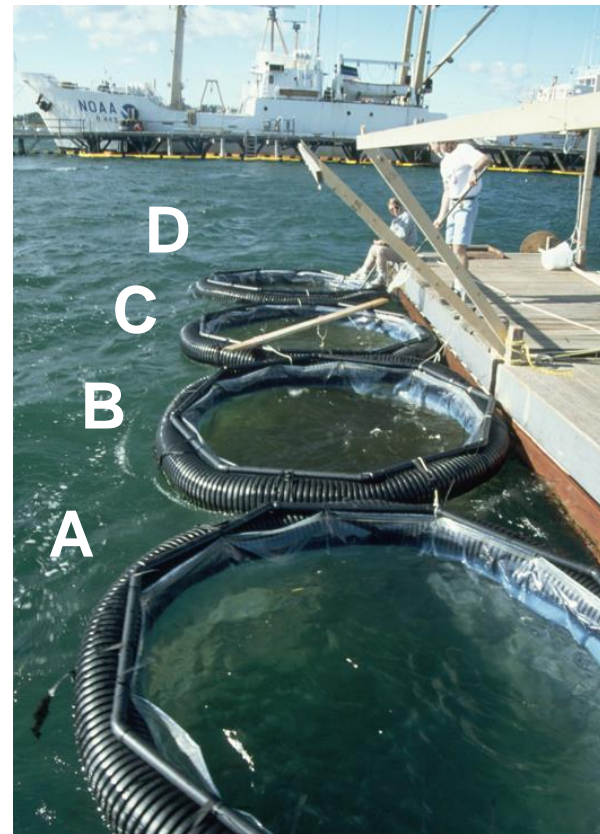
- $\text{NO}_3$  (5  $\mu\text{M}$ ),  $\text{PO}_4$  (0.5  $\mu\text{M}$ ), Si (7  $\mu\text{M}$ )
- Leaf litter leachate (300  $\mu\text{M}$  DOC)

## • Samples Taken:

- $\text{NO}_3$ ,  $\text{NH}_4$ ,  $\text{PO}_4$ , Si,  $\text{O}_2$  DIC
- PAR
- POC, PON, DOC, DON
- Chl a
- PP ( $^{14}\text{C}$  and  $\text{O}_2$  incubations)
- Bacterial No. and productivity
- Phyto- and zooplankton counts
- $\text{DI}^{13}\text{C}$ ,  $\text{DO}^{13}\text{C}$ ,  $\text{DO}^{15}\text{N}$
- 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

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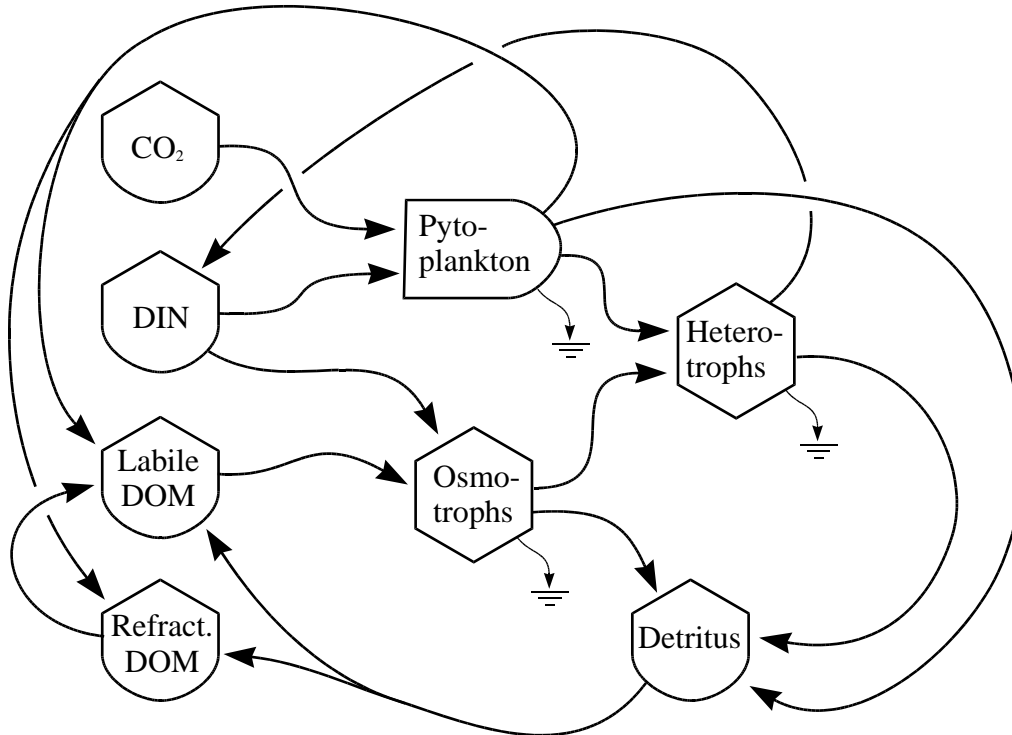
- Aggregated, coupled C and N model
- Emphasis on OM processing
- Holling type II and III growth kinetics

- 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

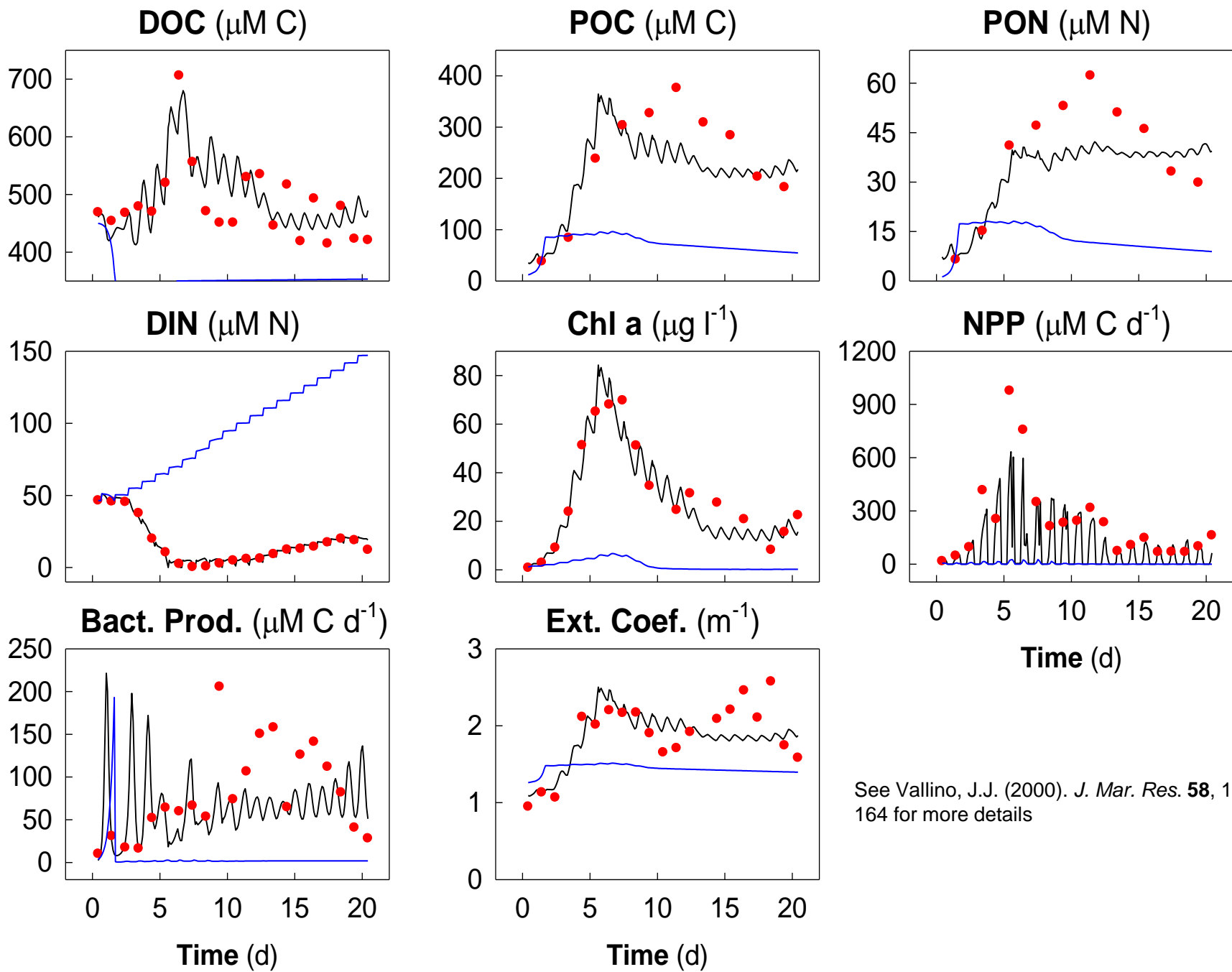
- **Parameters**

- 29 Kinetic
- 10 Initial cond.





# Nutrients + Organic Matter (Bag D)



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 $\mu\text{M}$	75 $\mu\text{M}$ (450 $\mu\text{M C}$ )
$\text{NO}_3^-$	36 $\mu\text{M}$	36 $\mu\text{M}$
$\text{SiO}_3$	52 $\mu\text{M}$	52 $\mu\text{M}$
$\text{PO}_4$	2.3 $\mu\text{M}$	2.3 $\mu\text{M}$

- Measure the following constituents over the 7 day incubation
  - DOC (1 person)
  - $\text{NO}_3^-$  (1)
  - $\text{NH}_4^+$  (1)
  - $\text{PO}_4^{3-}$  (1)
  - Chlorophyll a (by fluorescence and extraction) (1)
  - Bacteria abundances (DAPI) (1)
  - Ciliate and nanoflagellate abundance (DAPI) (1)
  - Phosphatase (2)

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What will happen in Treatment A versus Treatment B?

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