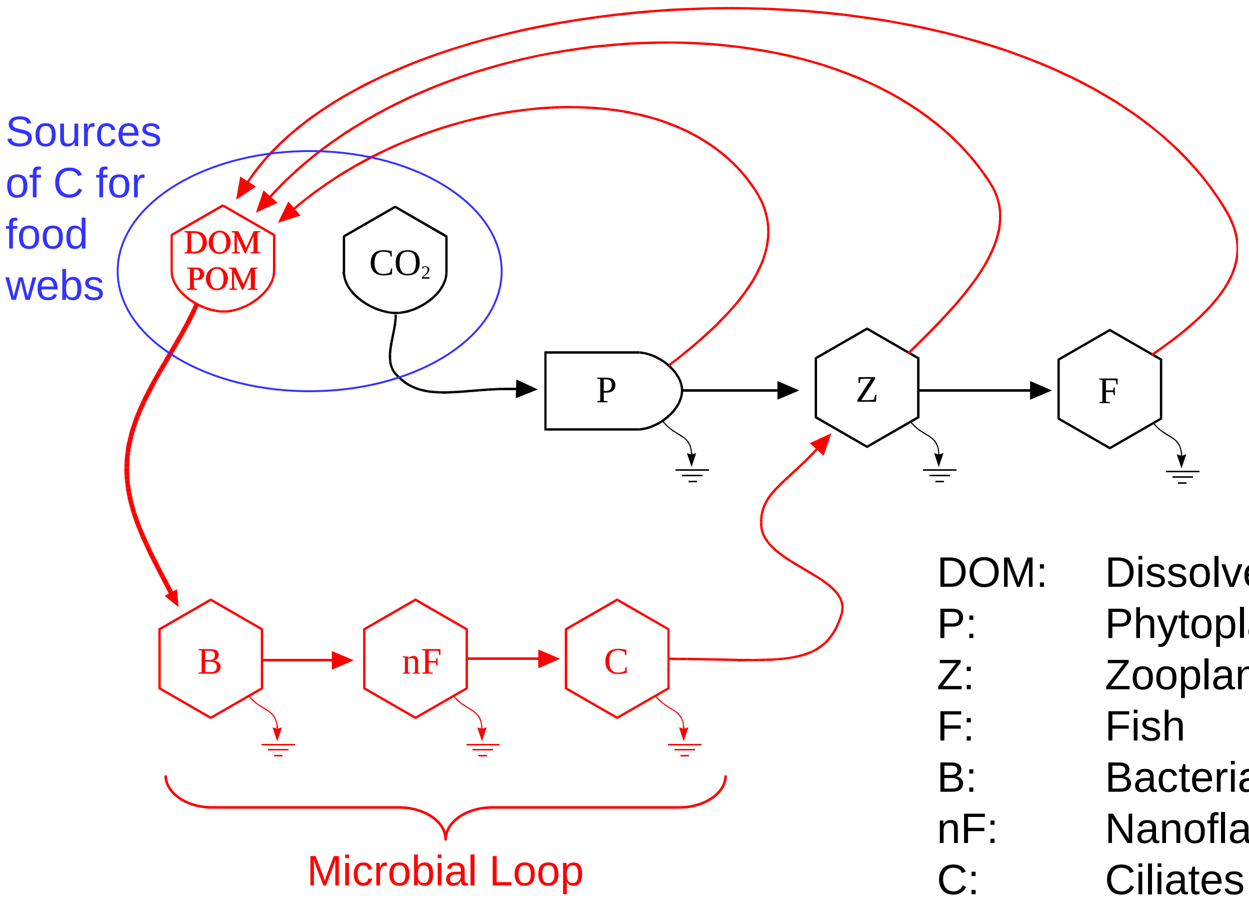
Bacteria-Phytoplankton Competition

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

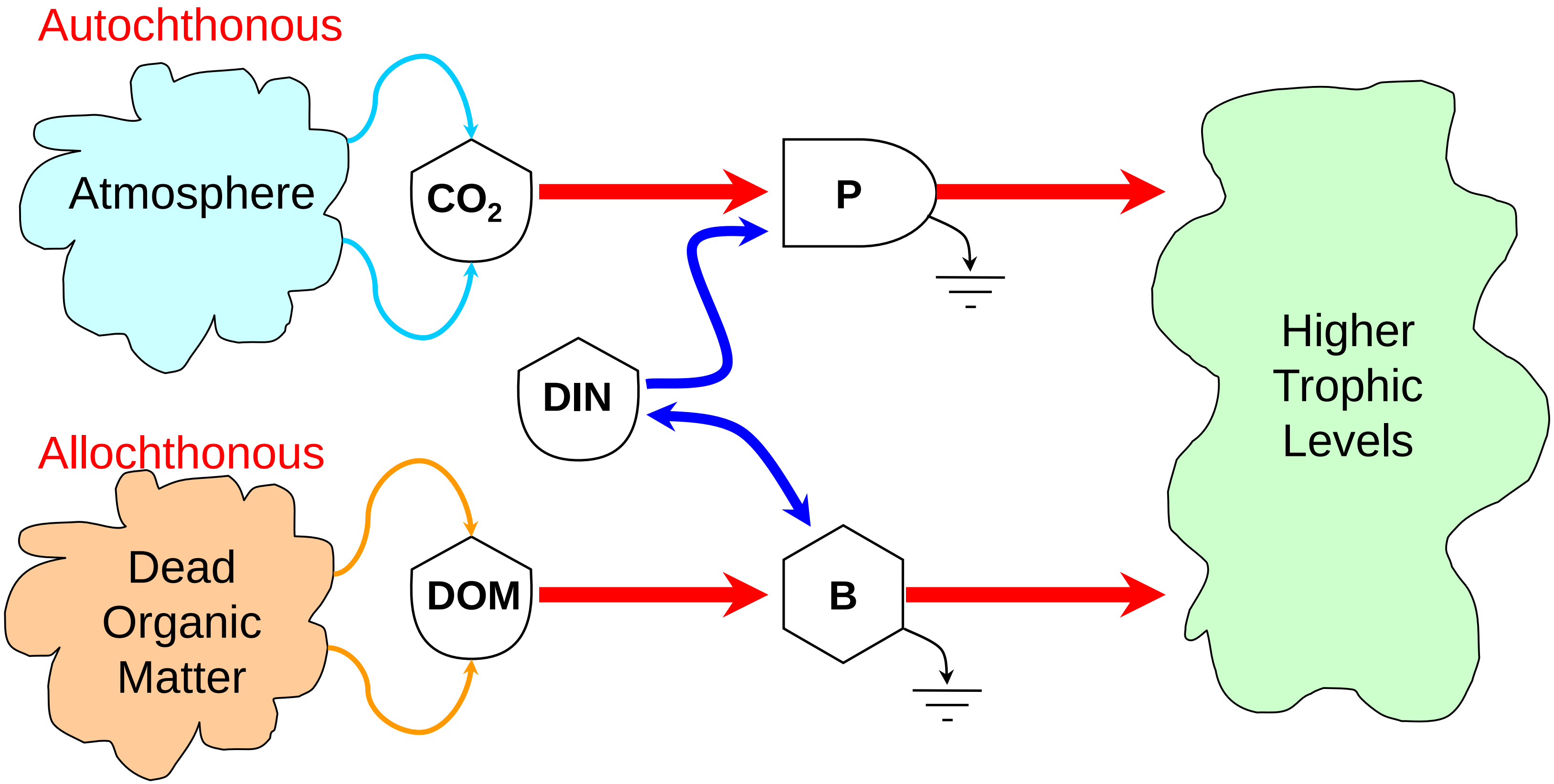
The microbial loop is a conceptualization by which DOM can be routed into the classic food chain via bacteria and their grazers.



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.



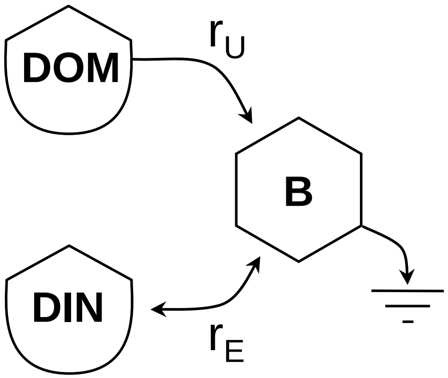
Depending on the C:N composition of DOM, bacteria and phytoplankton can be in competition for DIN (and P).

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)

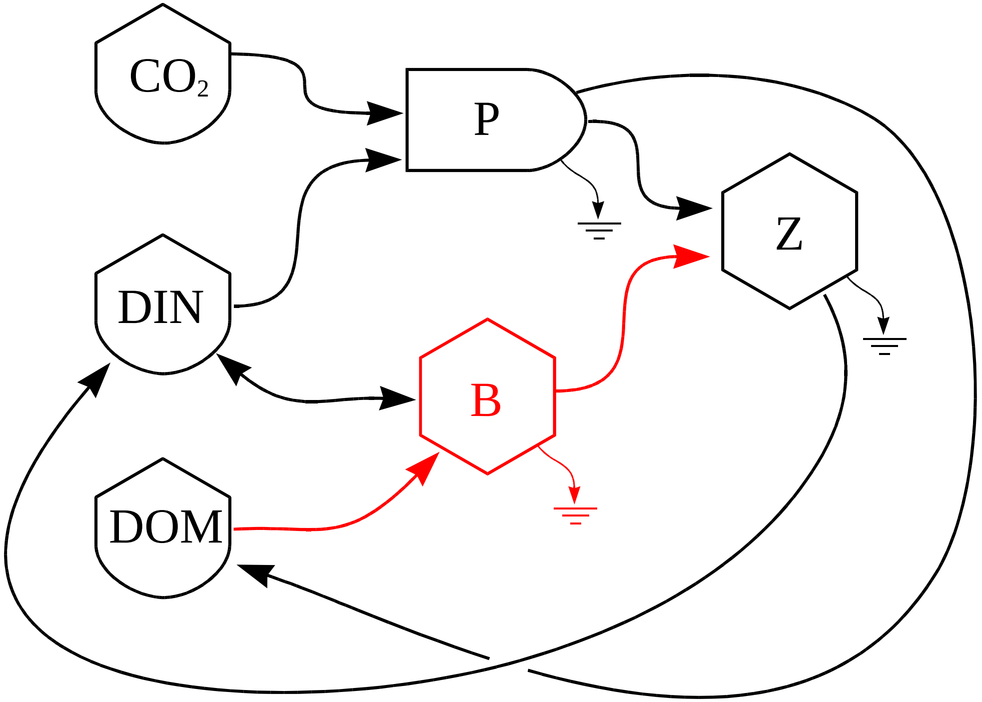
Bacterial N requirement: $\varepsilon r_U \frac{1}{\rho_B}$

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

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

Phytoplankton-Bacteria Competition

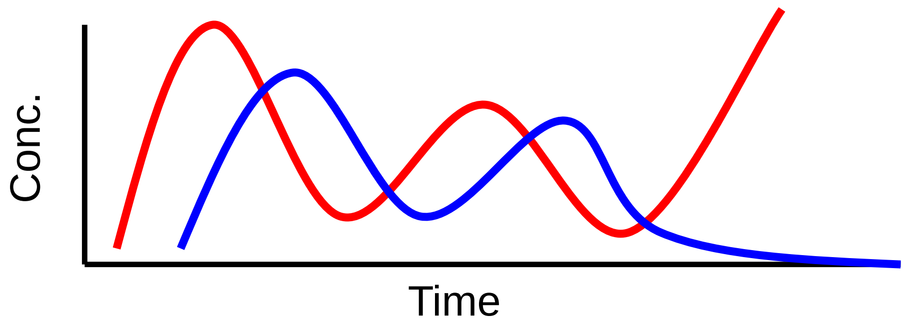
- Consider aggregated conceptualization of lower trophic levels.
- If the C:N ratio of DOM is high, then bacteria will utilize DIN.
- Bacteria should out compete phytoplankton for DIN. Why?
- Dynamics of food web should be dependent on DOM composition

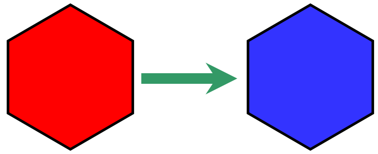


- Paradox: why do phytoplankton excrete DOM?

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)

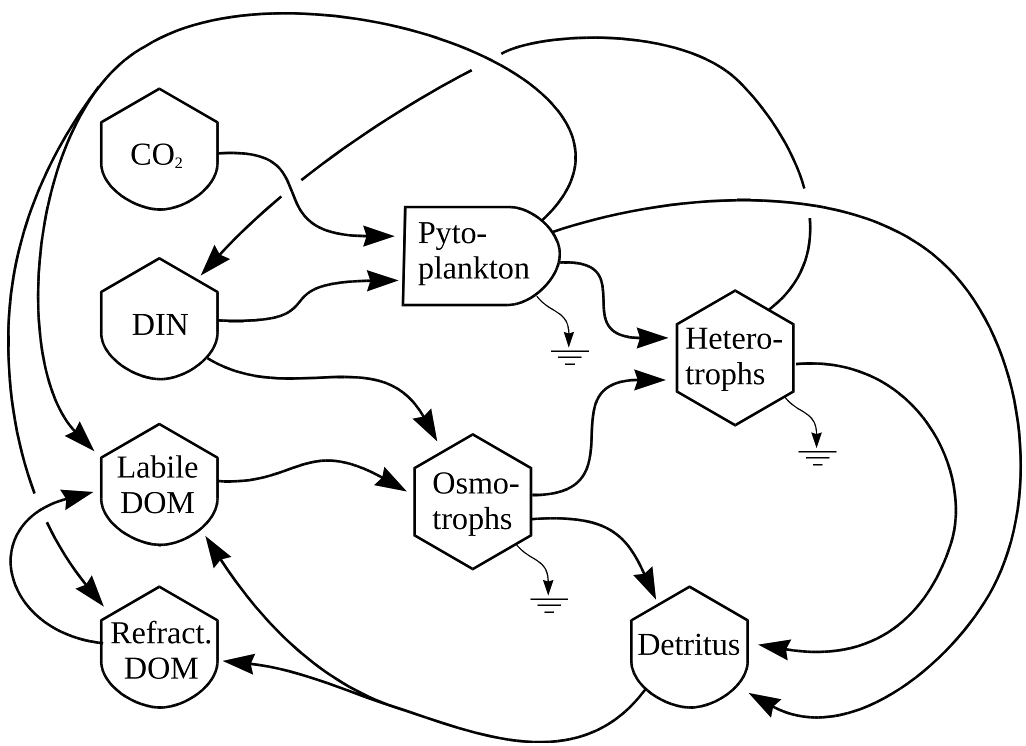
- **Treatments:**

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

- **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 $\delta^{15}N$

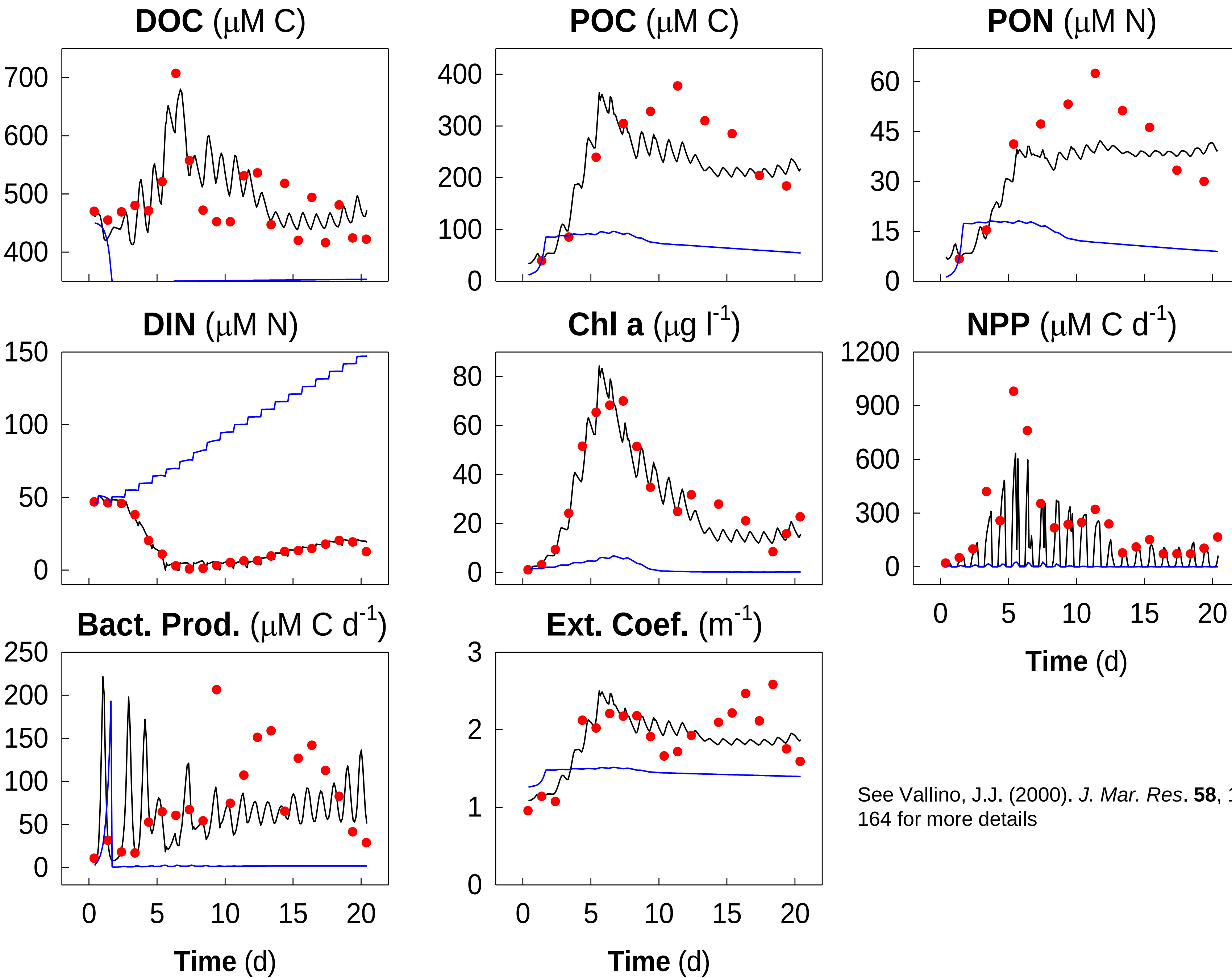
Mesocosm Food Web Model

- 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
    - NO_3^-
    - PO_4^{3-}
    - Chlorophyll a (by fluorescence and extraction)
    - Bacteria abundances (DAPI)
    - Phosphatase

What will happen in Treatment A versus Treatment B?

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

Measurement Assignments

Bacteria:	Olivia B.
DOC:	Kathryn
Chl a:	Olivia S.
Nitrate:	Grayson
Phosphate:	Khashiff
Phosphatase:	Lauren