Nutrient contributions from *Dreissena* spp. to *Lyngbya wollei* and *Cladophora glomerata*

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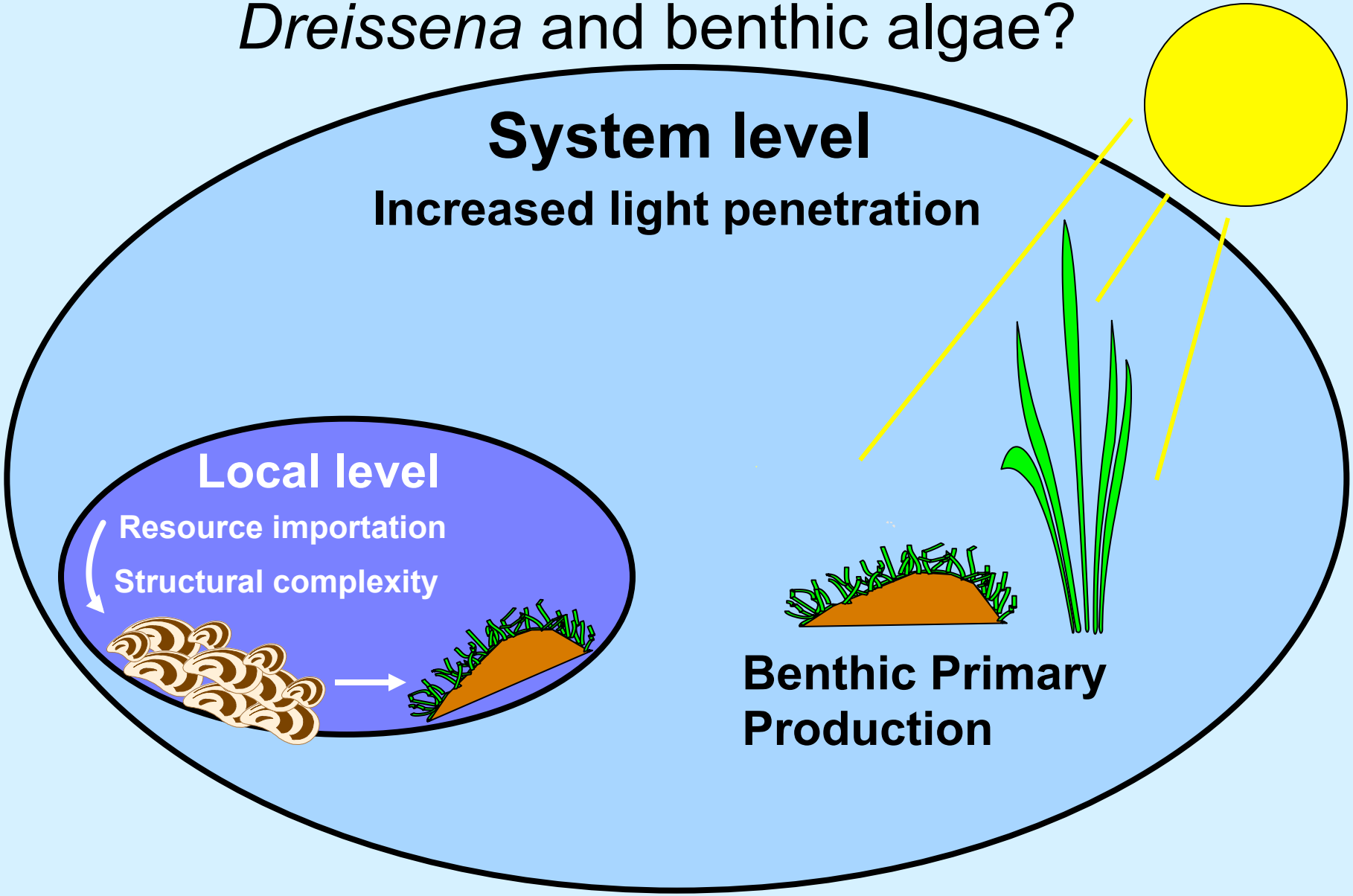
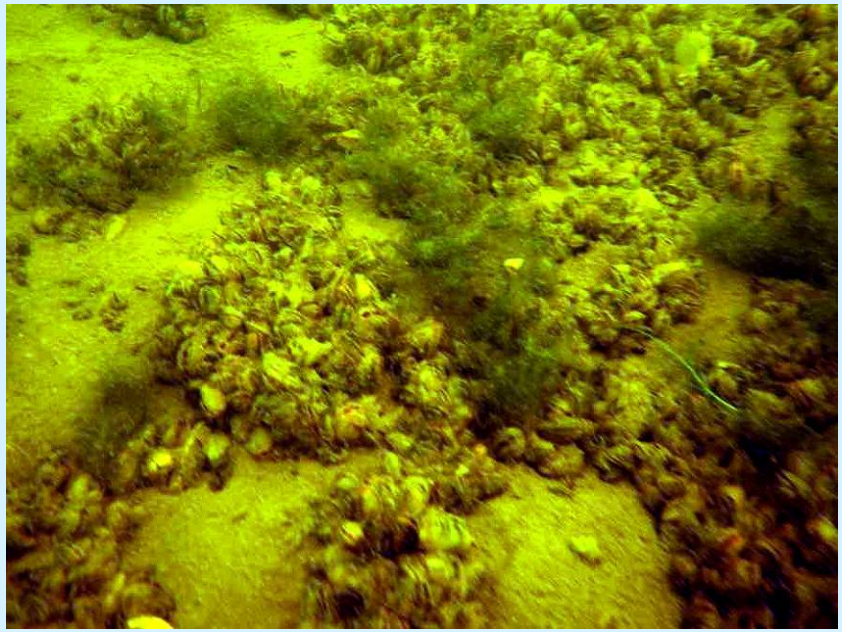
What are local-scale interactions between *Dreissena* and benthic algae?



Contribution to algae

- N & P
  - Ammonium and phosphate
- CO_2
  - Respiration
  - Decomposition
    - Feces and pseudofeces
    - Organic matter
- Other nutrients?
- Structure
  - Hard shells increase surface area



P. Bichier

Do *Dreissena* contribute to benthic algal blooms?

- Not new to Lake Erie
  - Have increased

- Decrease aesthetic value
- Health risks
- Food web structure

- What mechanisms from *Dreissena* facilitate these blooms?

Lyngbya wollei

- Cyanobacterium
- Common in southeastern US
- Recently washed up on shores of Lake Erie
- Requires relatively low light
- Does not attach to hard surfaces
- Toxic?

P. Bichier

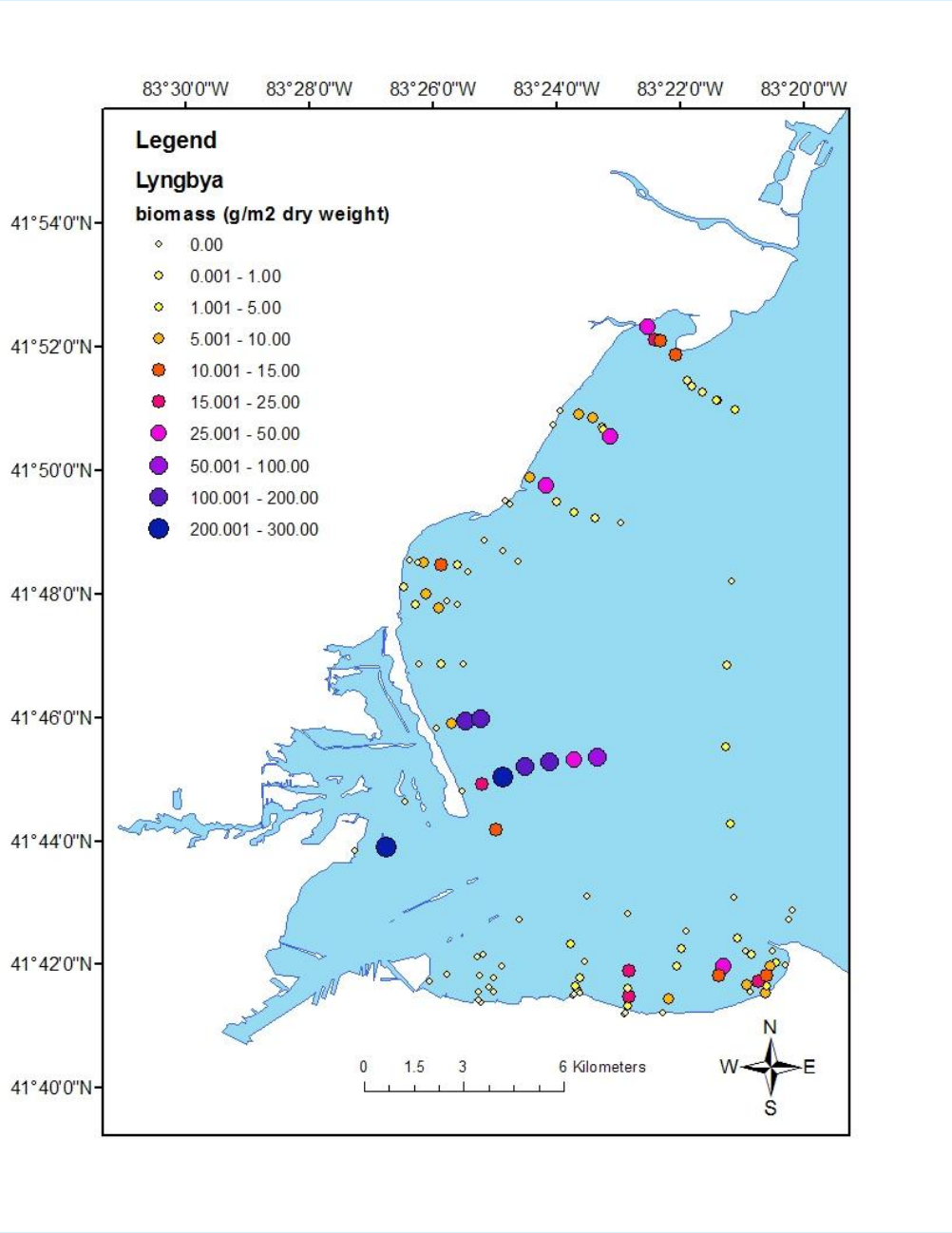
J. Joyner

Cladophora glomerata

- Green alga
- Requires relatively high light and hard substrate
- Blooms common from

  1950s through early 1980s
- Return of blooms since mid- 1990s not associated with P loading
  - *Dreissena*

Higgins et al. 2008



2009 *Lyngbya* survey

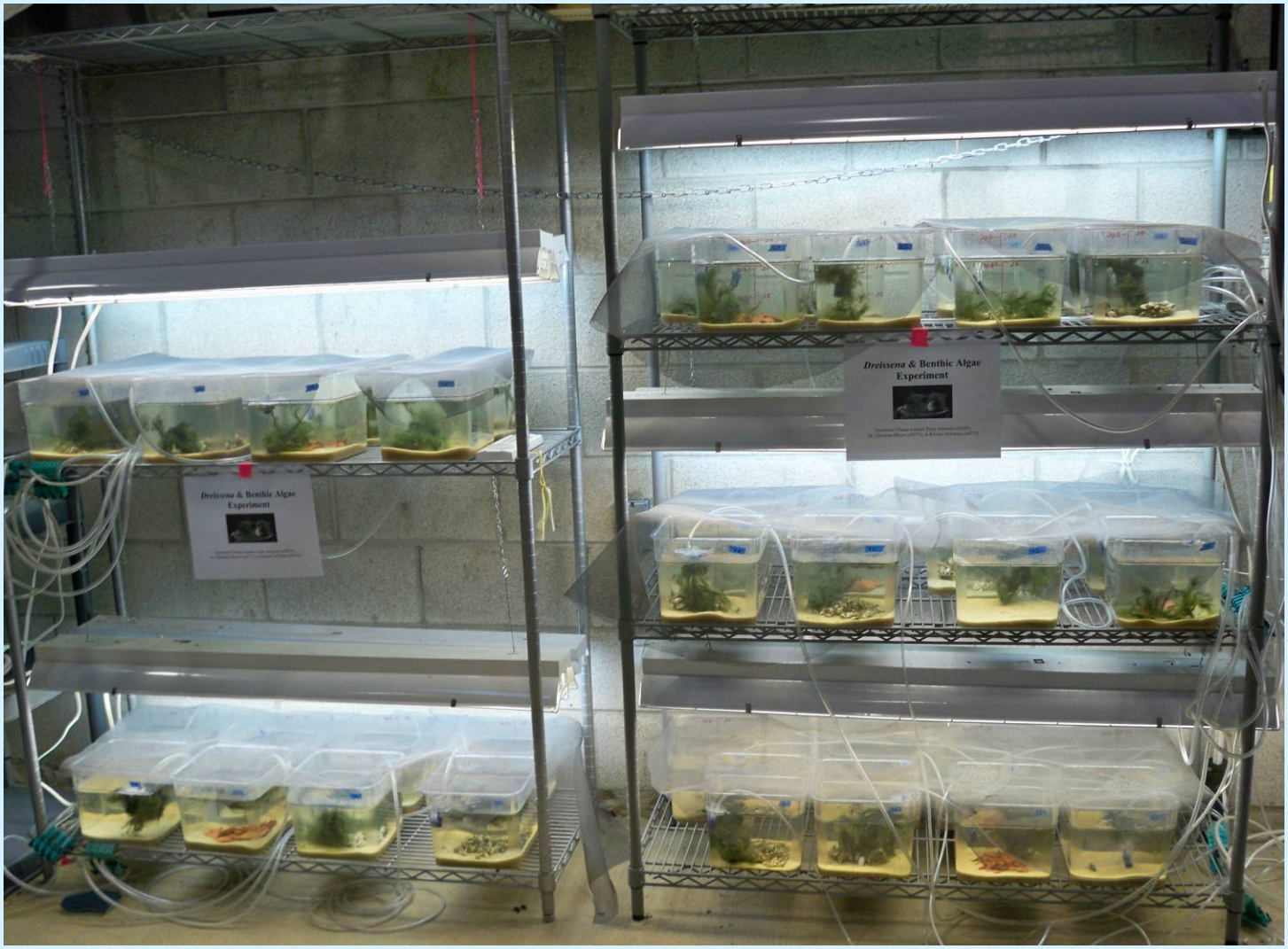
- 140 sites total
  - 113 sites had dreissenid substrate
  - 77 sites had *Lyngbya*
  - 72 sites had both
    - Only 5 sites that had *Lyngbya* did not have dreissenid substrate

Panek et al.

Manipulative Experiments

- Objective: test possible reasons why *Dreissena* may promote the growth of benthic algae and encourage blooms
  - N, P
  - C
  - Other nutrients
    - 10 others quantified
  - Structure

Experimental set-up

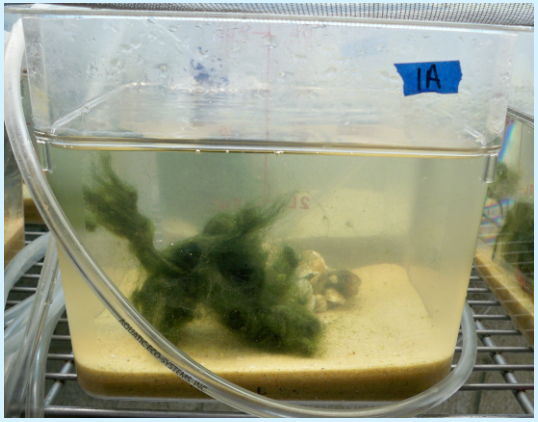


Lyngbya Experiment

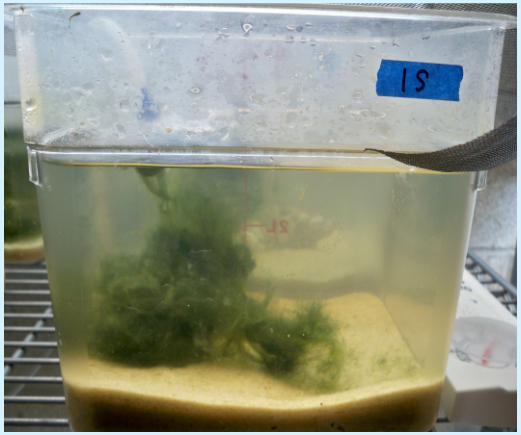
- 4 treatments
- 3400 *Dreissena*/m^2
- 230 g/m^2 *Lyngbya*
- Low-P lake water
- 12 hour photoperiod
- One week
- N=40

Live *Dreissena* (N=10)

Pottery shards (N=10)



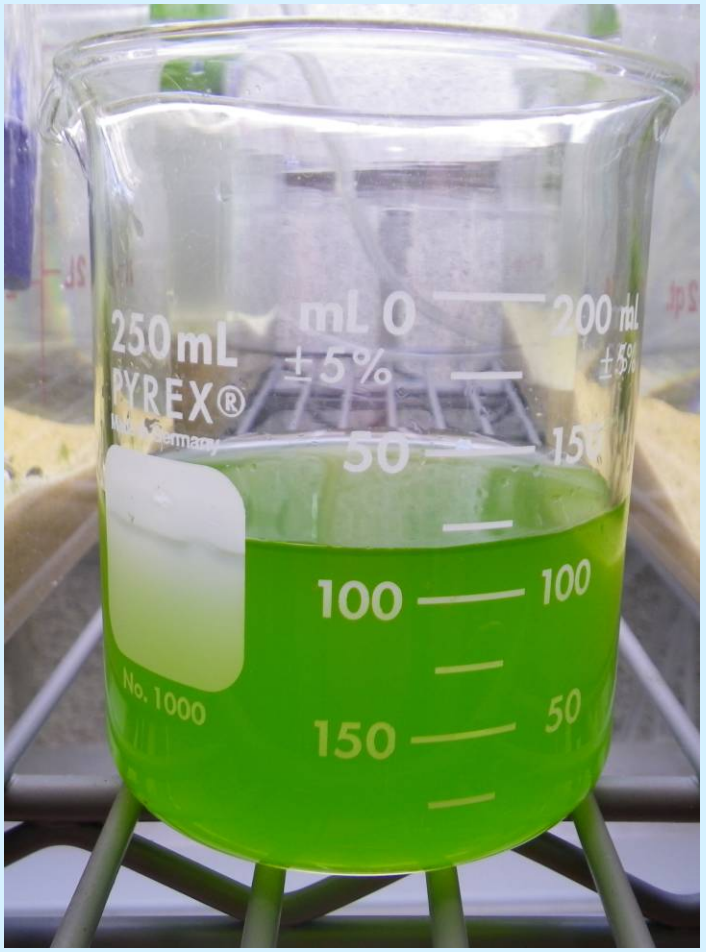
Empty *Dreissena* (N=10)



Sand (N=10)

Fed *Dreissena* throughout experiment

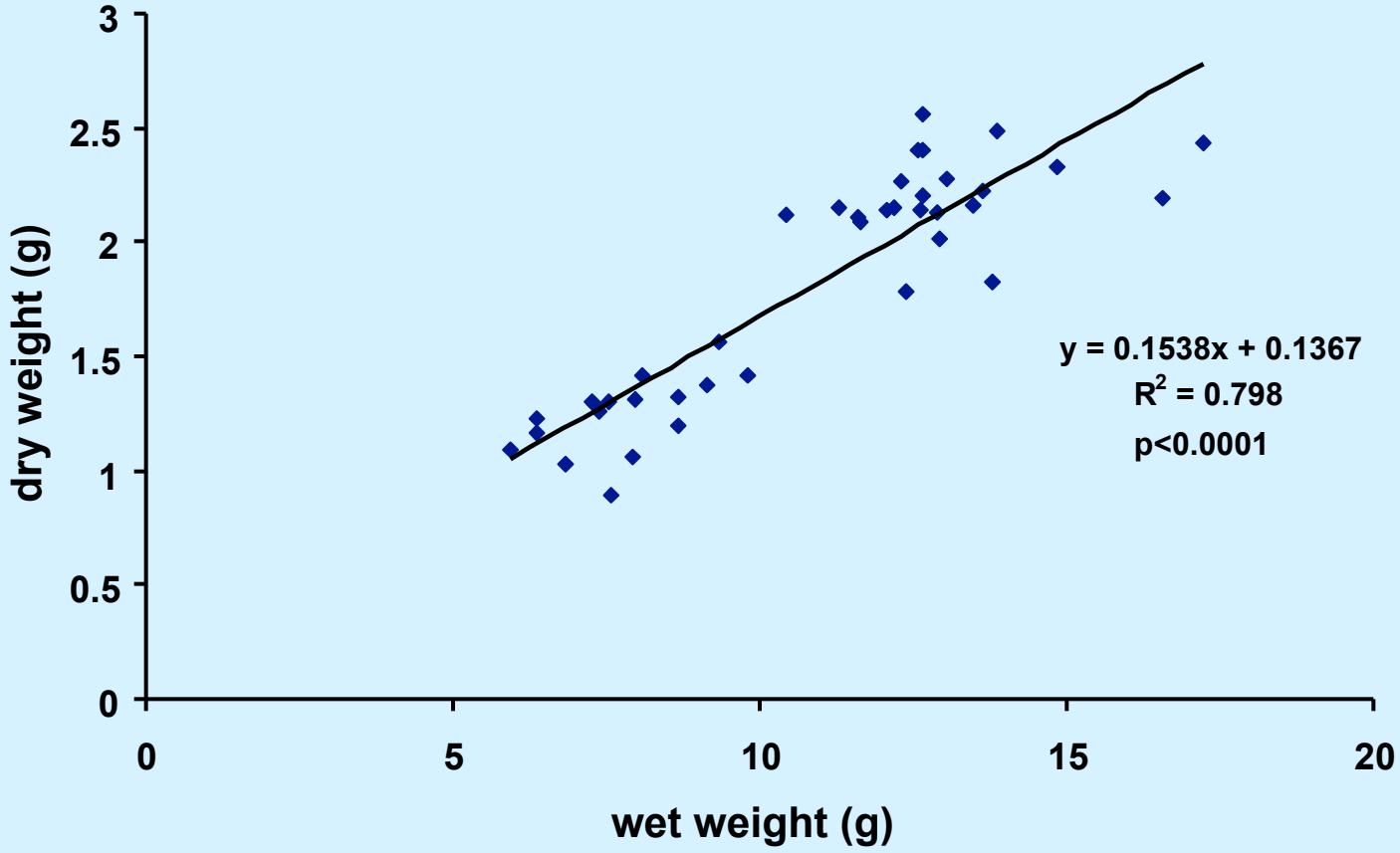
- *Chlamydomonas reinhardtii*
  - Phytoplankton
  - Labeled with stable isotope
    - ^{13}C
    - ^{15}N
  - Given to all tanks



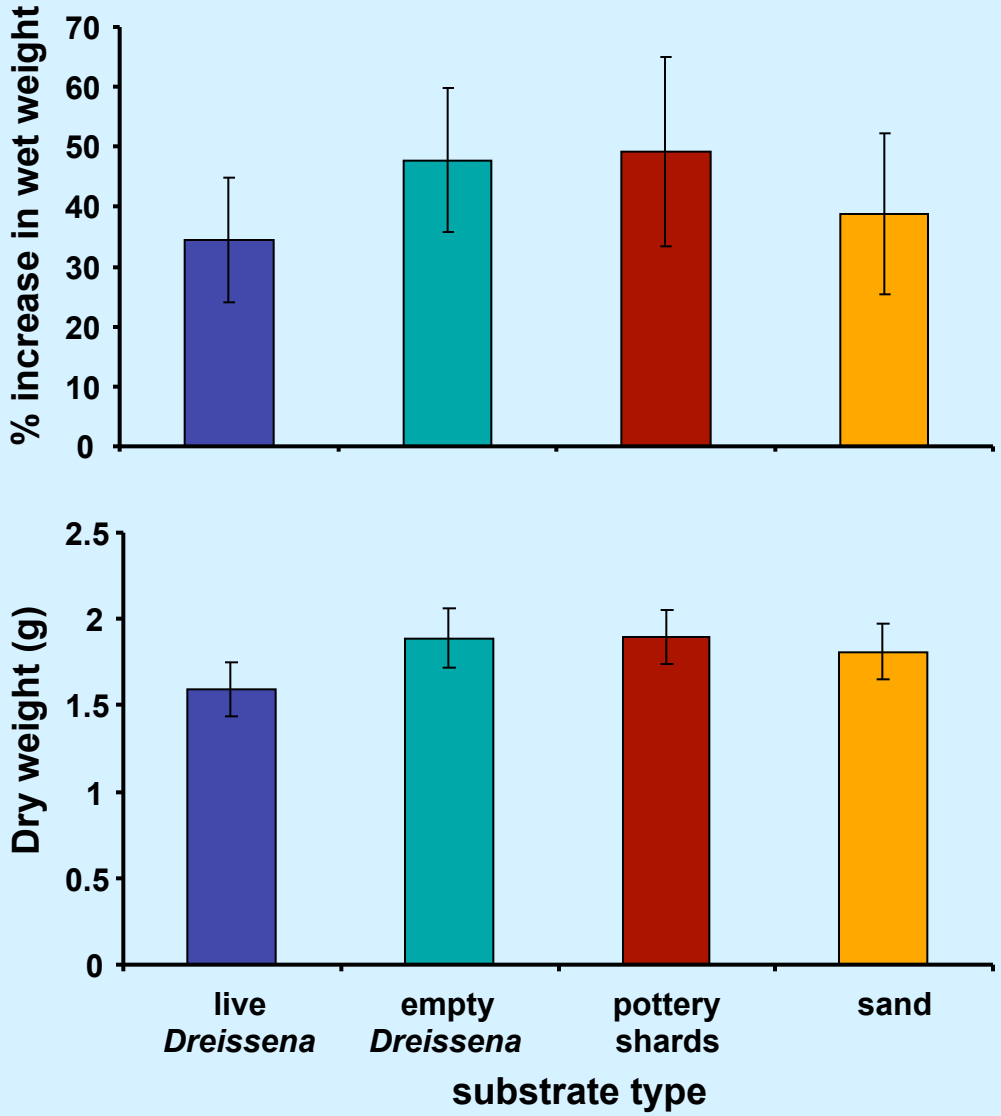
Laboratory Analyses

- C and N
  - CHN analyzer
- P and other nutrients
  - ICP-OES
- Chlorophyll a
  - UV-visible spectrophotometer
- Phycocyanin
  - 10-AU fluorometer
- Photosynthetic efficiency
  - DIVING-PAM fluorometer
- ^{13}C and ^{15}N
  - Samples sent to UC Davis, CA

Positive correlation between wet weight and dry weight



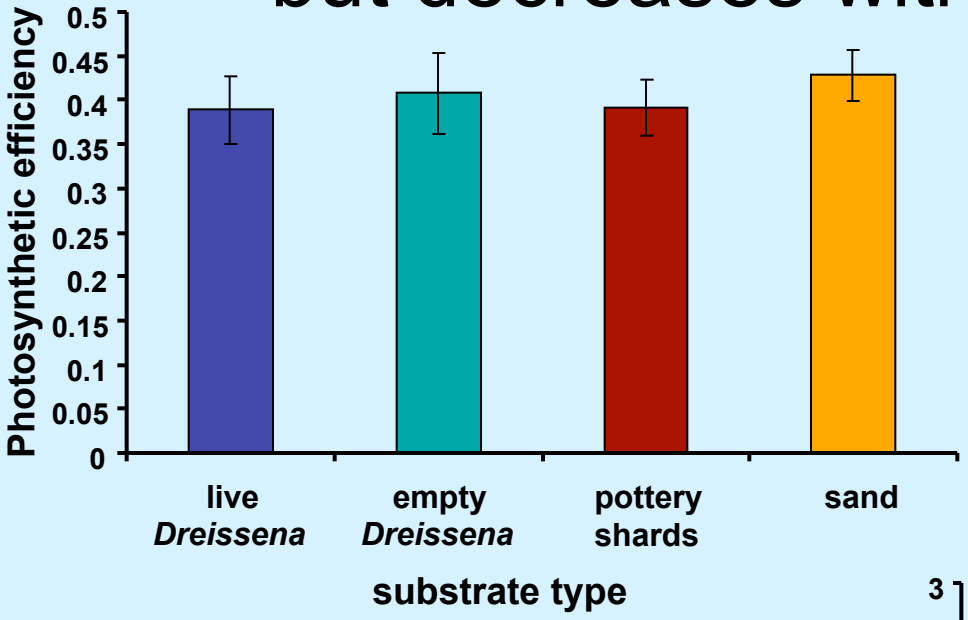
All tanks increase in weight, but no difference among treatments

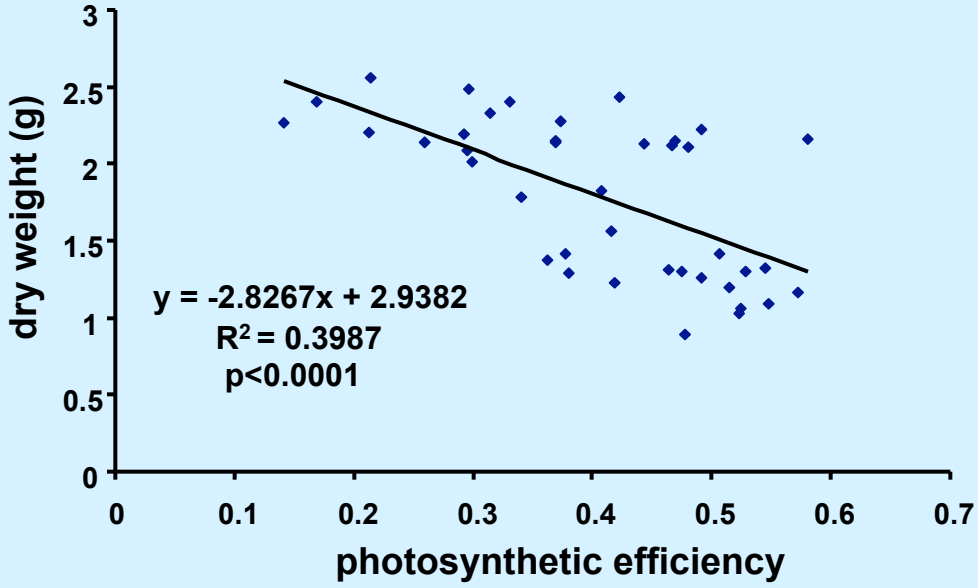


Error bars = SE

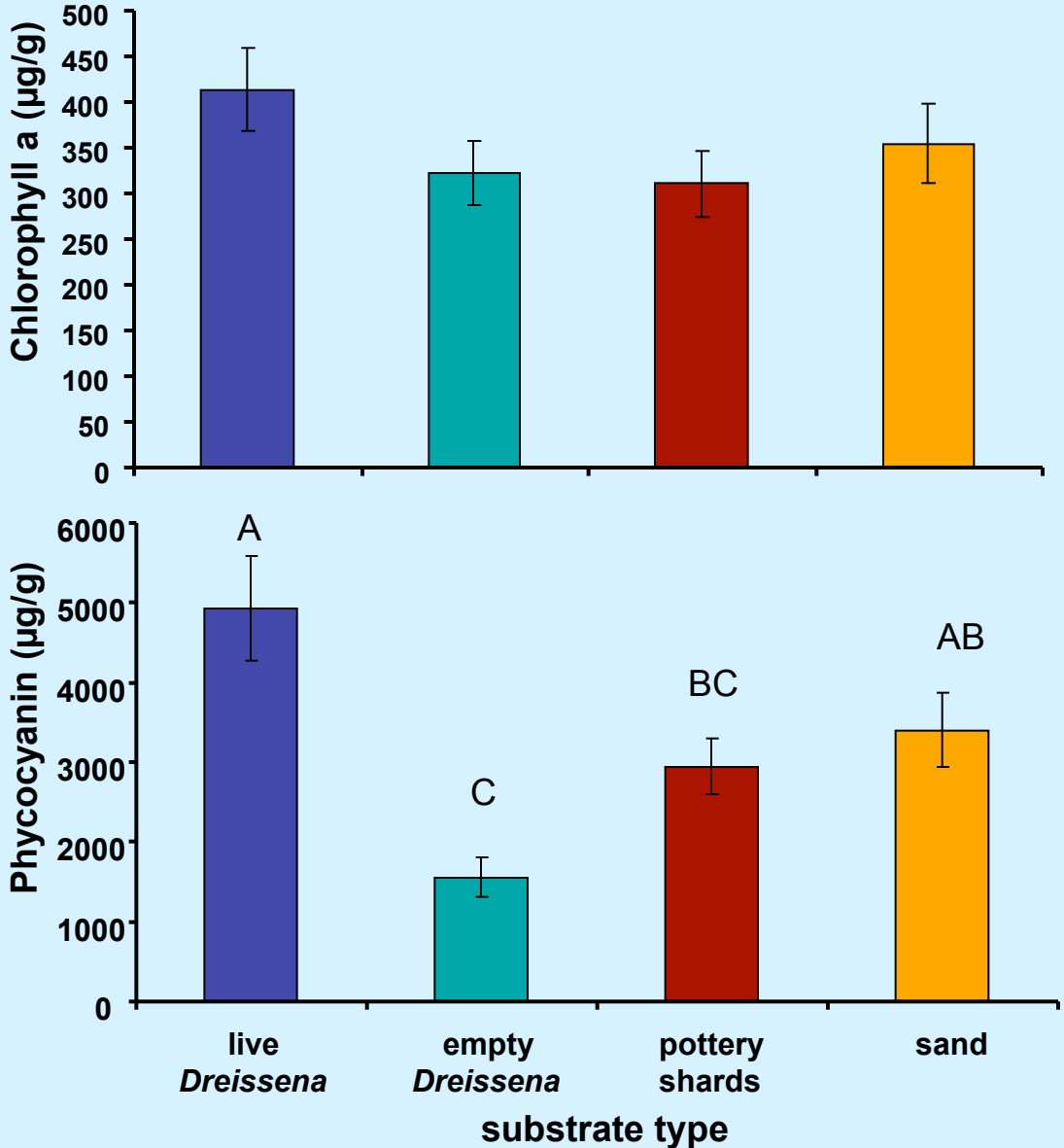
Lyngbya

No difference in photosynthetic efficiency, but decreases with more dry weight

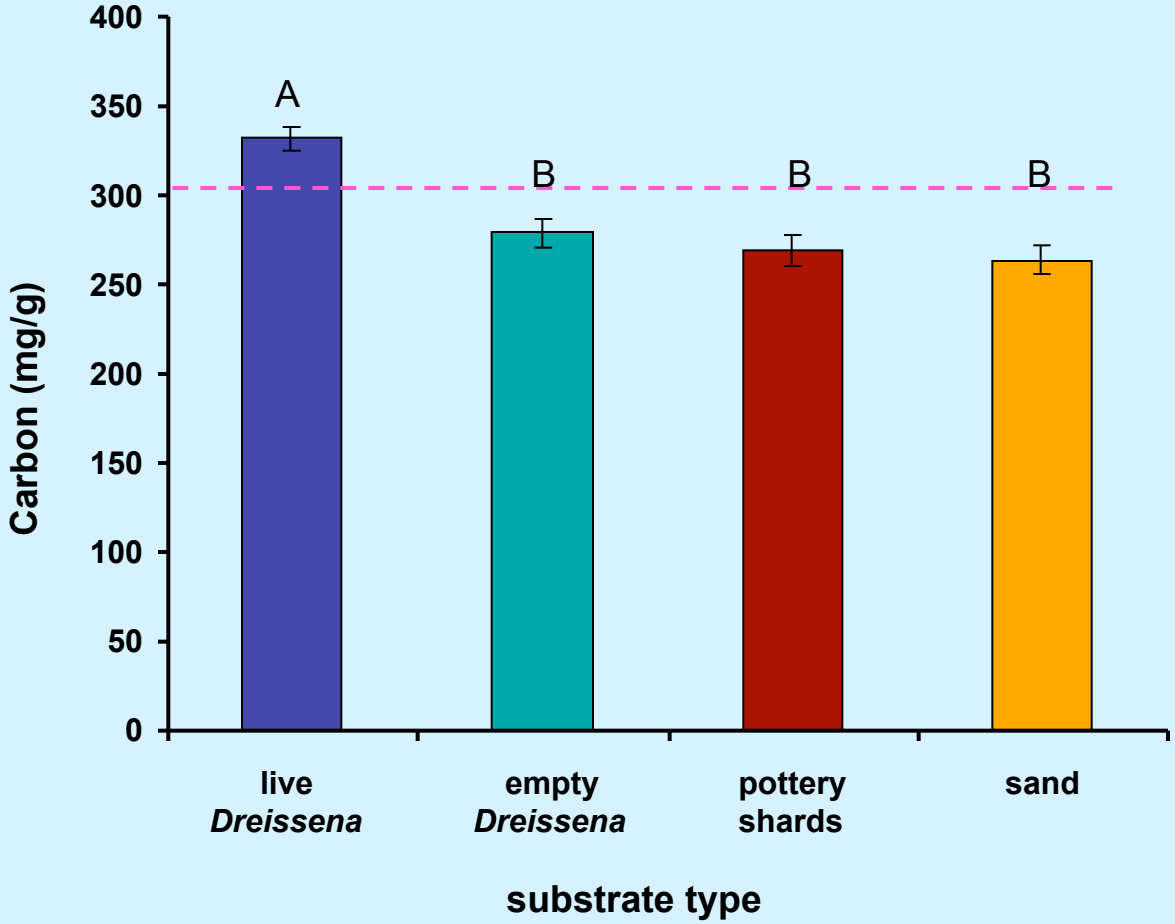




No difference in chlorophyll a, but higher phycocyanin in live *Dreissena* treatment

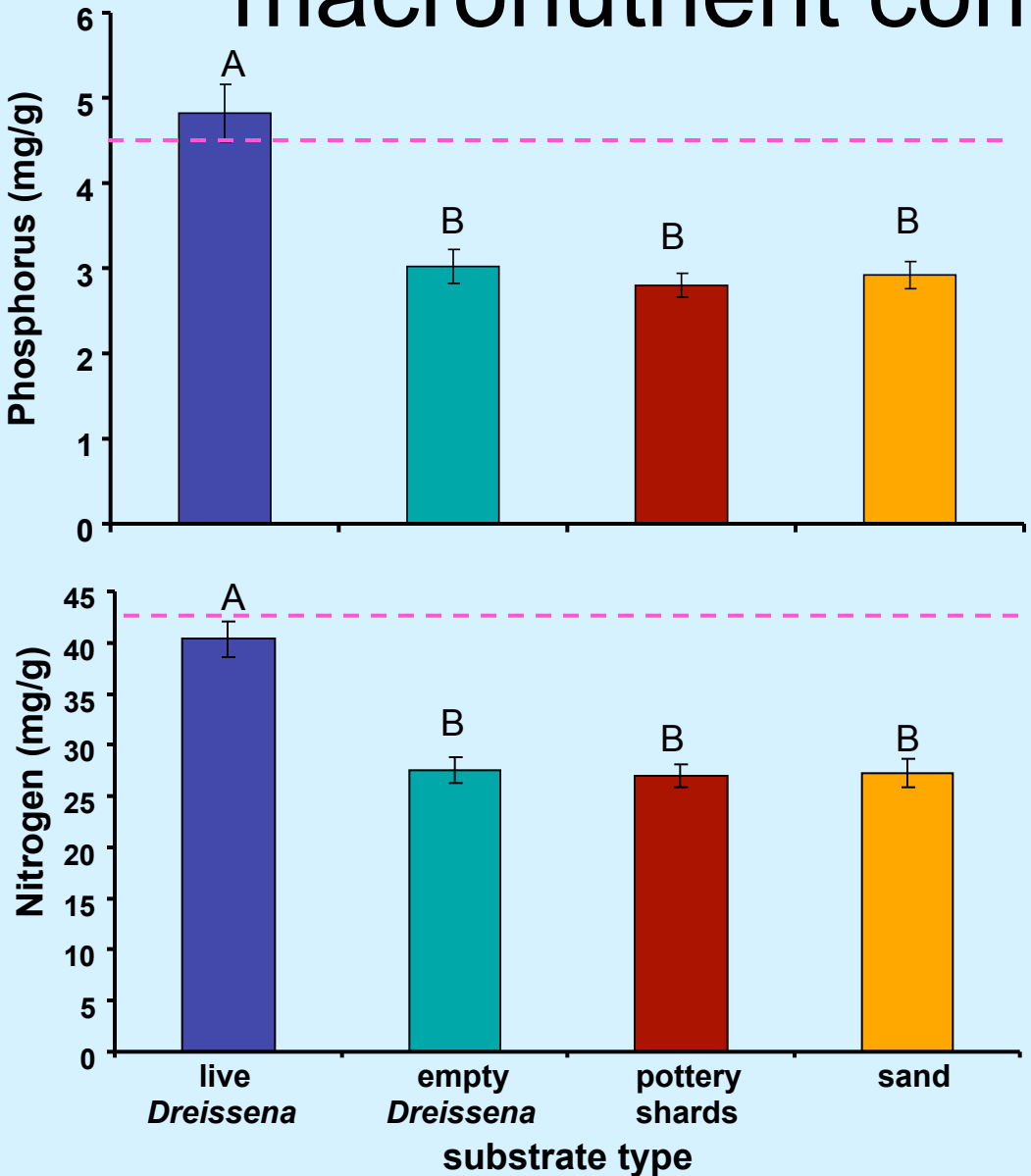


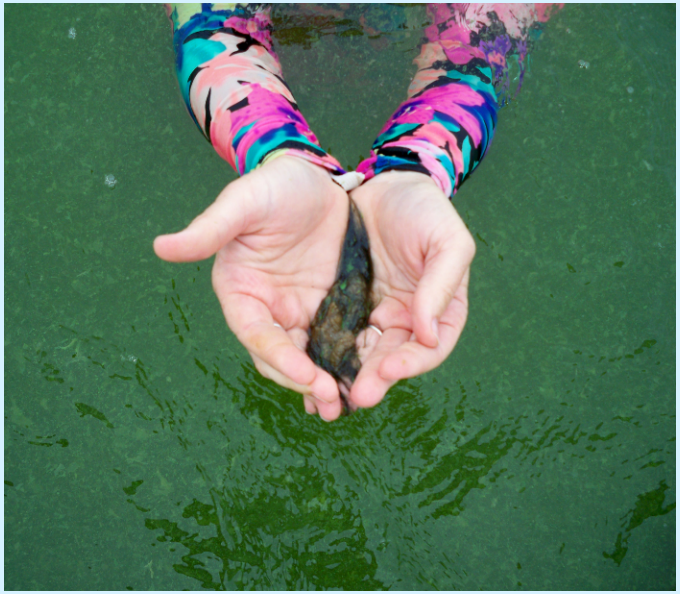
Dreissena increased carbon content in tissue



Lyngbya

Dreissena helped retain macronutrient content in tissue

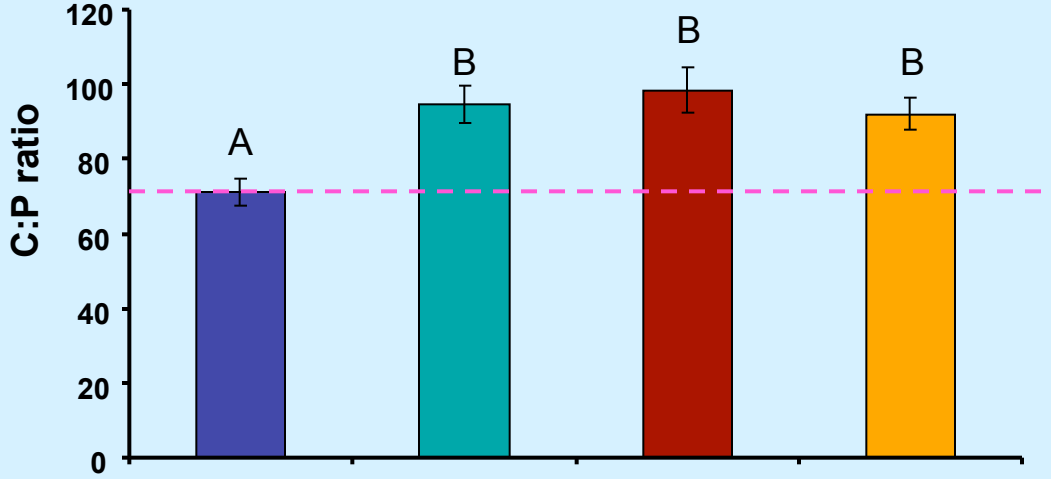


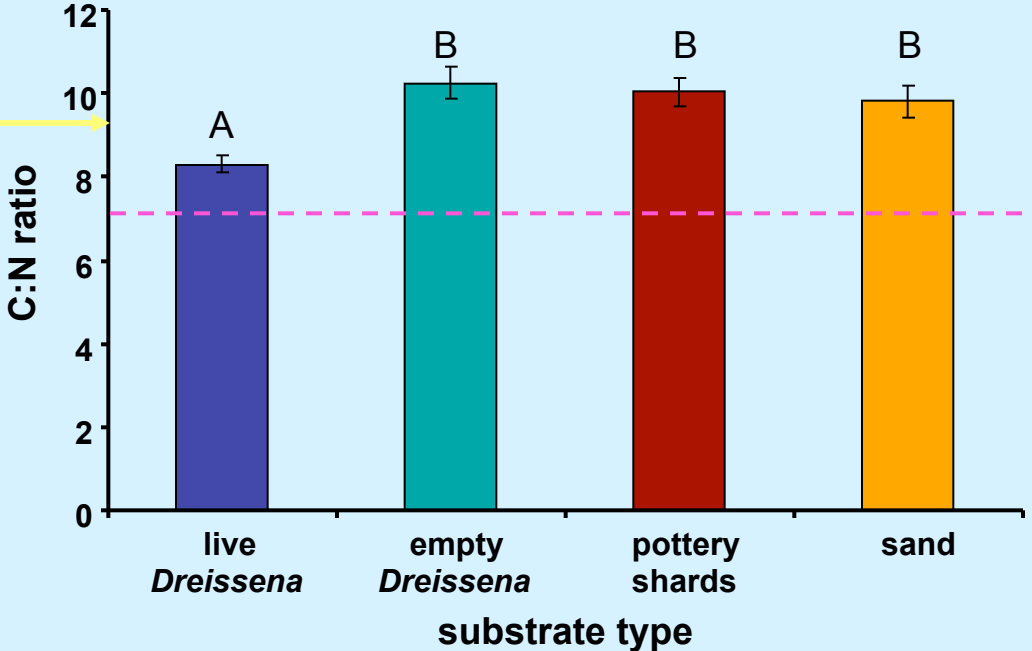


Lyngbya

No P deficiency, but N deficiency in all treatments except live *Dreissena*

- <143 is no P deficiency
- >9.4 C:N is a N deficiency
  - No deficiency in live *Dreissena* treatment

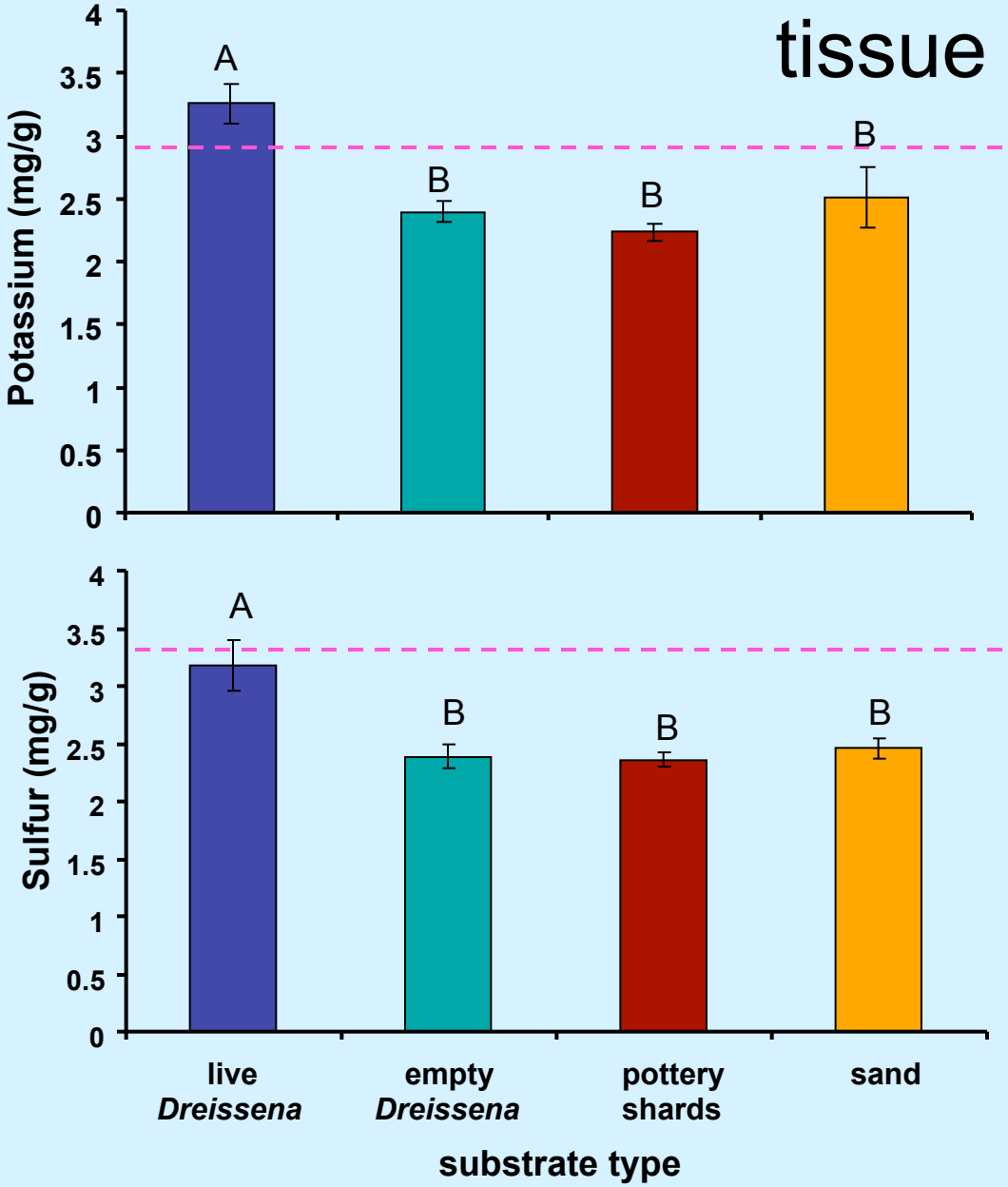




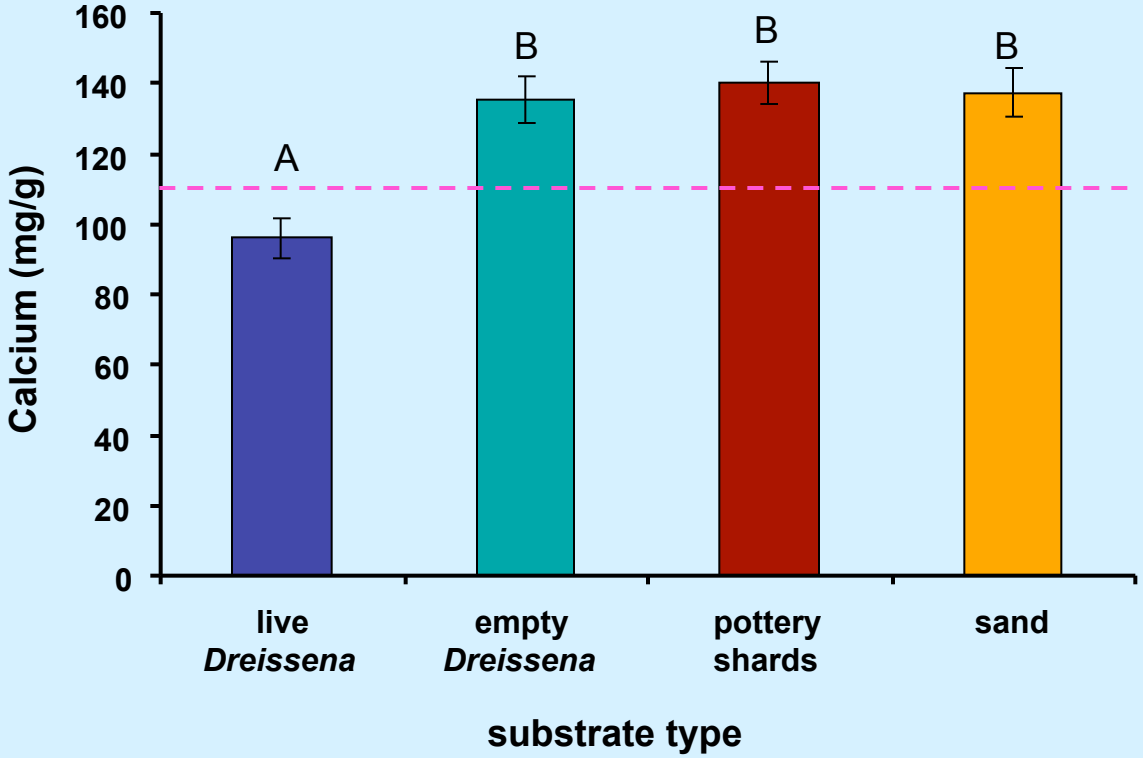
Kahlert 1998

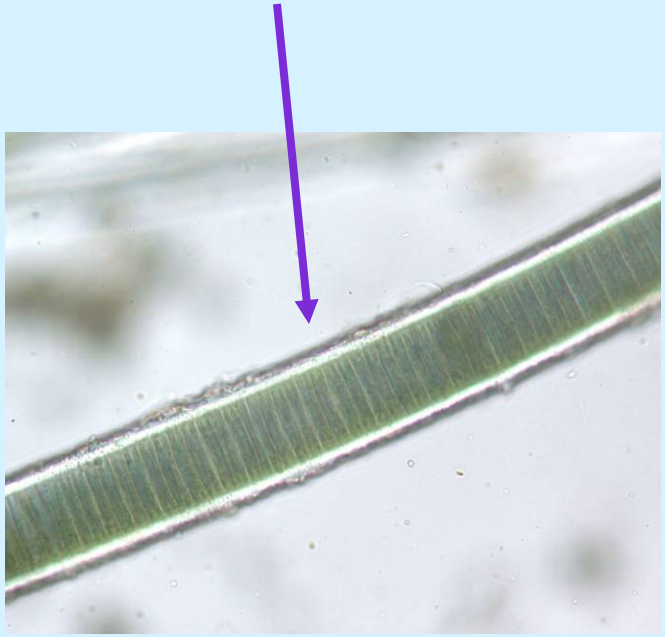
Lyngbya

Dreissena helped retain nutrient content in tissue

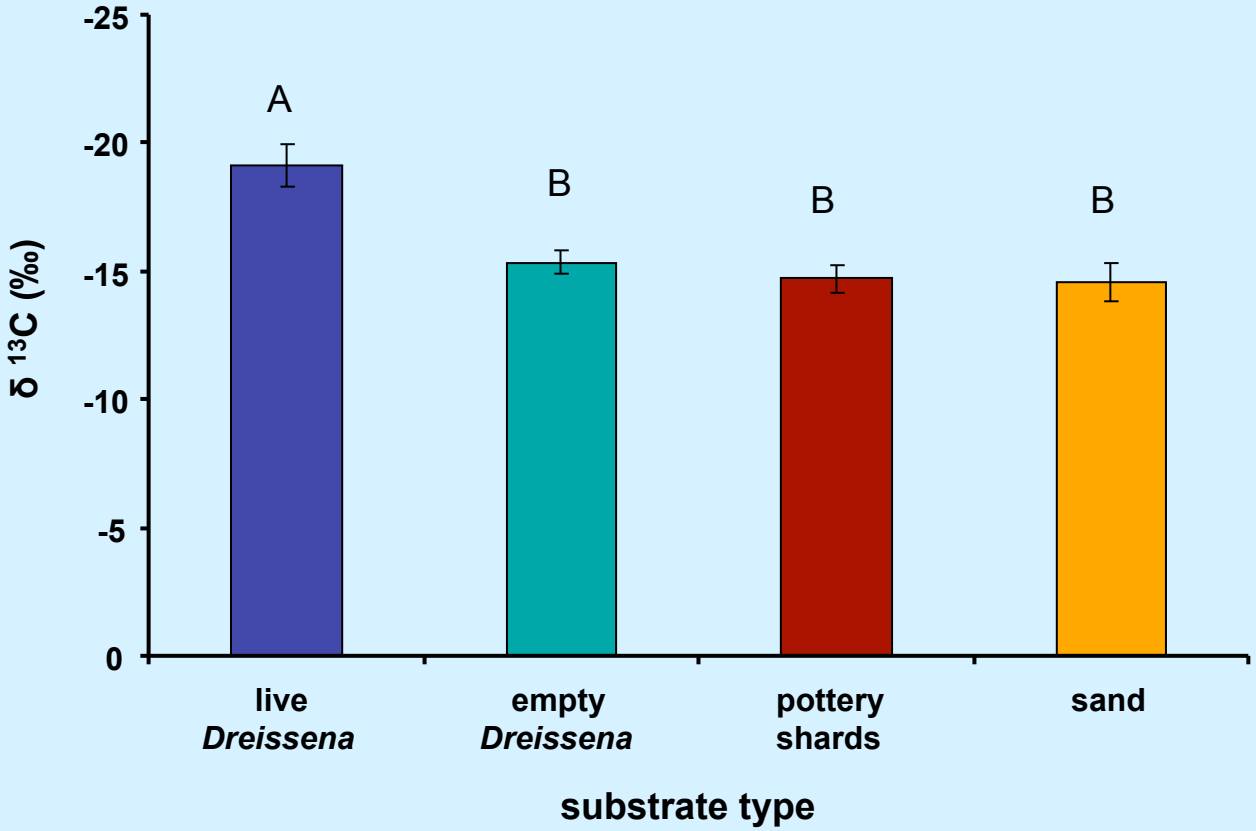


However…

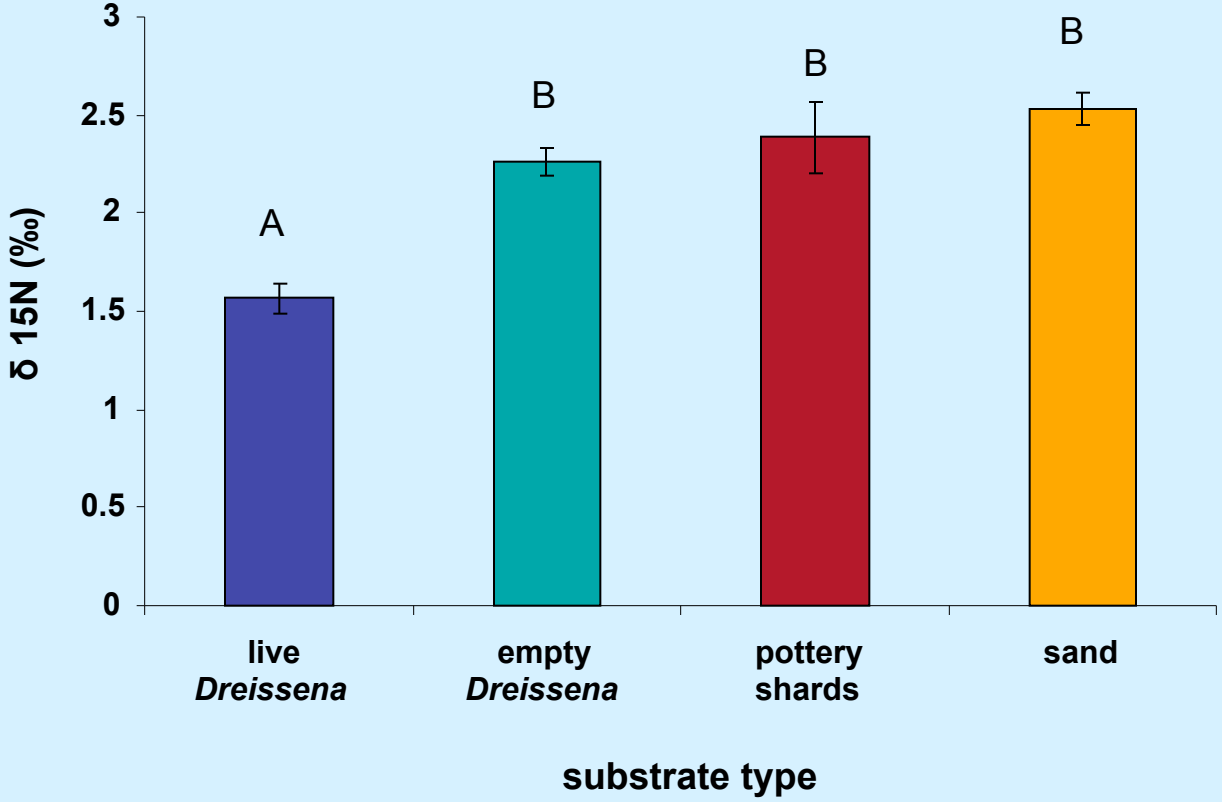

160
140
120
100
80
60
40
20
0
Calcium (mg/g)
A
B
B
B
live *Dreissena*
empty *Dreissena*
pottery shards
sand
substrate type



Stable isotope: less ^{13}C in live *Dreissena* treatment, no significant difference in ^{15}N



Two week preliminary experiment with *Cladophora*: the ^{13}C difference goes away and there becomes a significant difference in ^{15}N

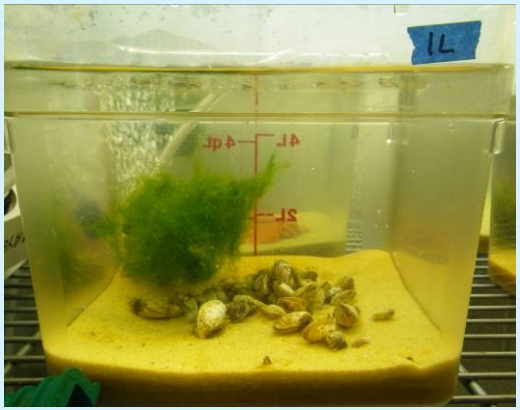


Summary for *Lyngbya*

- *Dreissena* did not increase the biomass of *Lyngbya*
- Increased phycocyanin
- Supplied several nutrients, prevented a decrease in others
- Decreased Ca
- Decreased ^{13}C
- Did not respond to substrates

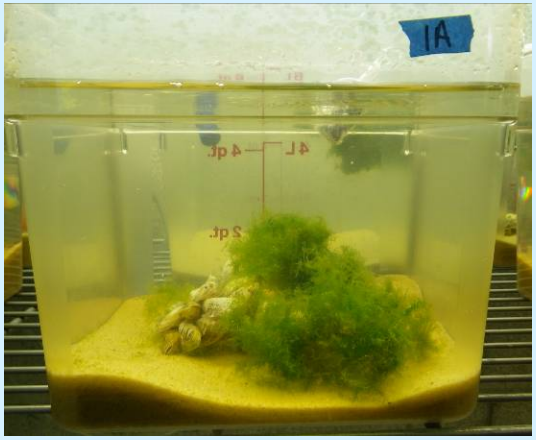
Cladophora Experiment

- 4 treatments
- 3400 *Dreissena*/m^2
- 160 g/m^2 algae
- Low-P lake water
- One week
- 12 hour photoperiod
- N=40
- Fed *Chlamydomonas*



Live *Dreissena* (N=10)

Pottery shards (N=10)



Empty *Dreissena* (N=10)

Sand (N=10)

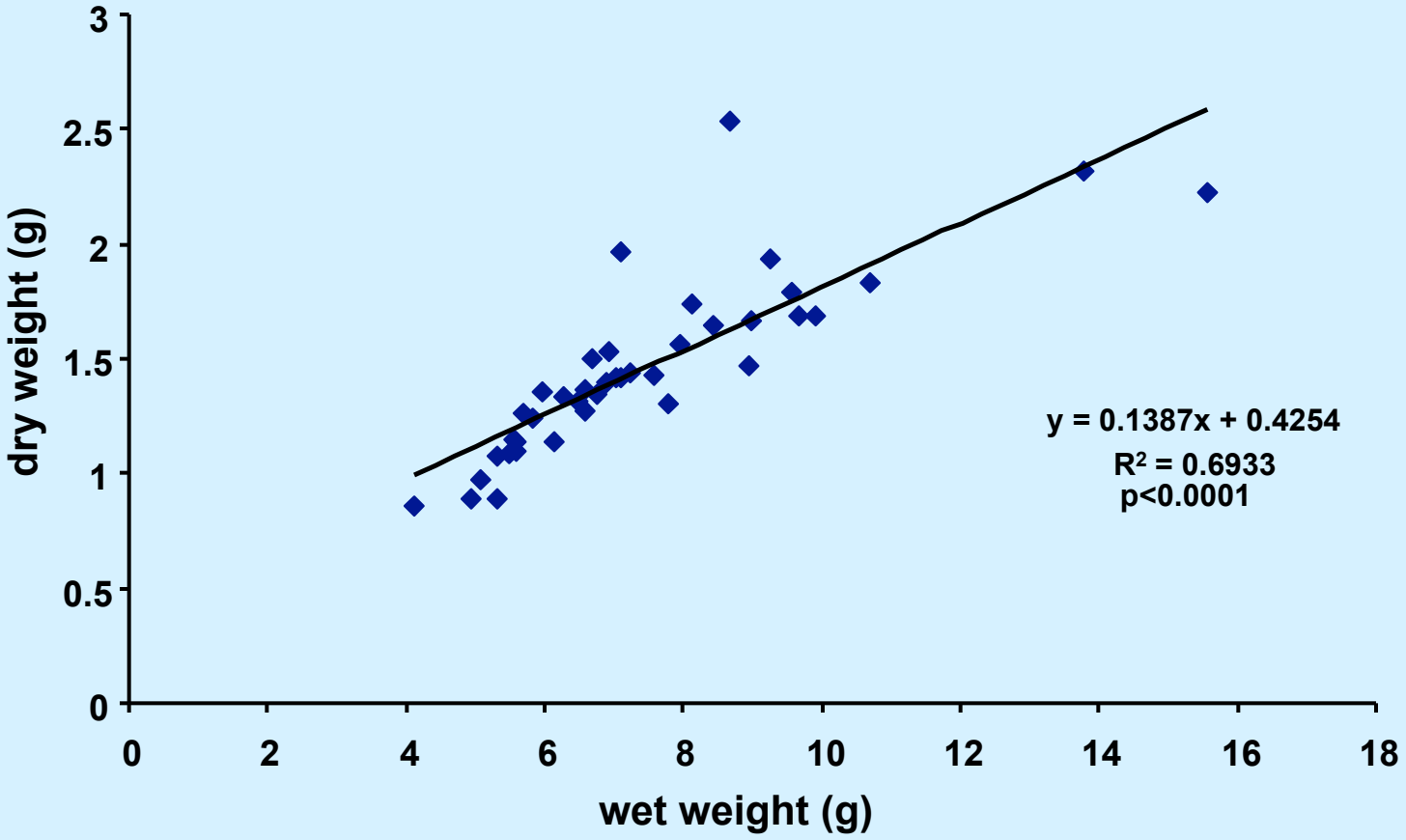
Extra data for *Cladophora*

- Took algal samples after 24 hours and 48 hours
  - Tissue nutrient content
  - Stable isotope

- Water samples from each tank at end of experiment compared to initial water
  - Nutrient

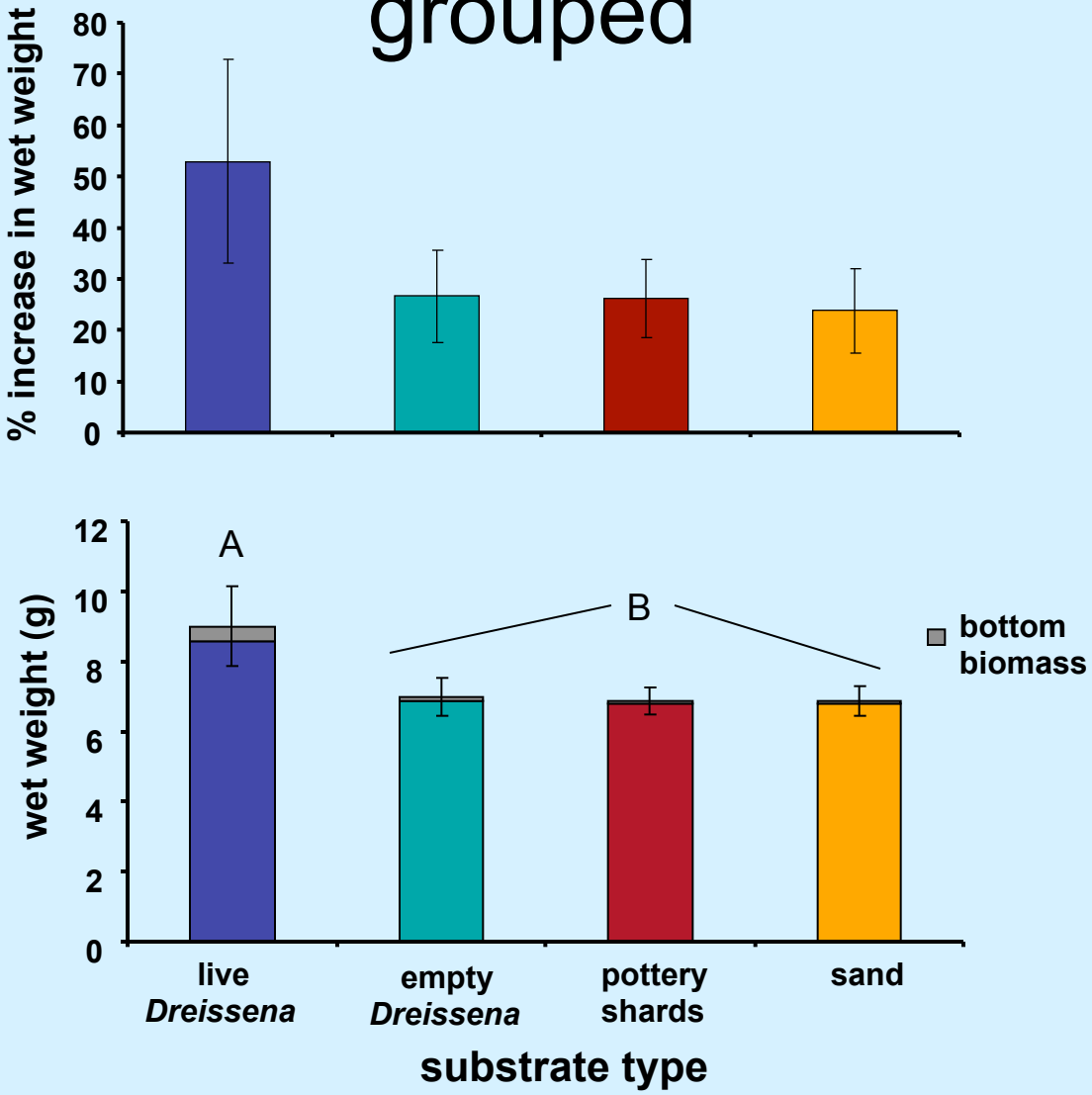
Cladophora

Positive correlation between wet weight and dry weight



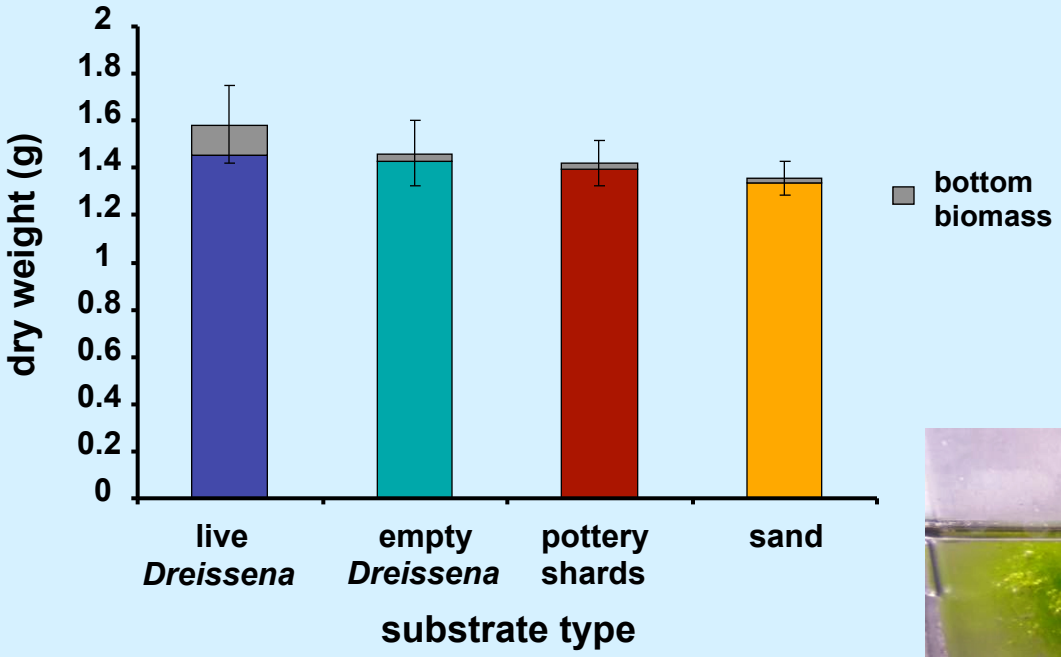
Cladophora

All tanks increase in weight, significant difference when other treatments are grouped



Cladophora

Separation in biomass, more with live *Dreissena*

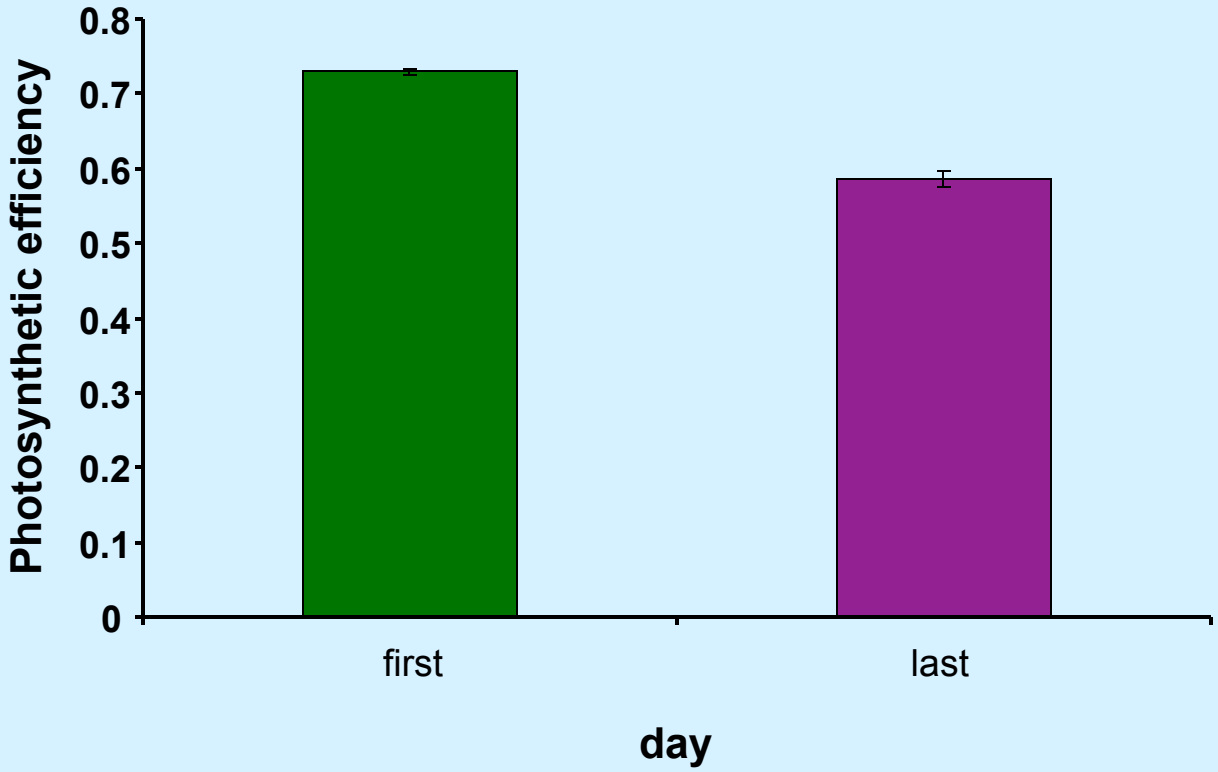


Cladophora Results

- More variability than *Lyngbya*
- No difference in pigments among treatments
  - Chl a or b
- No difference in photosynthetic efficiency among treatments

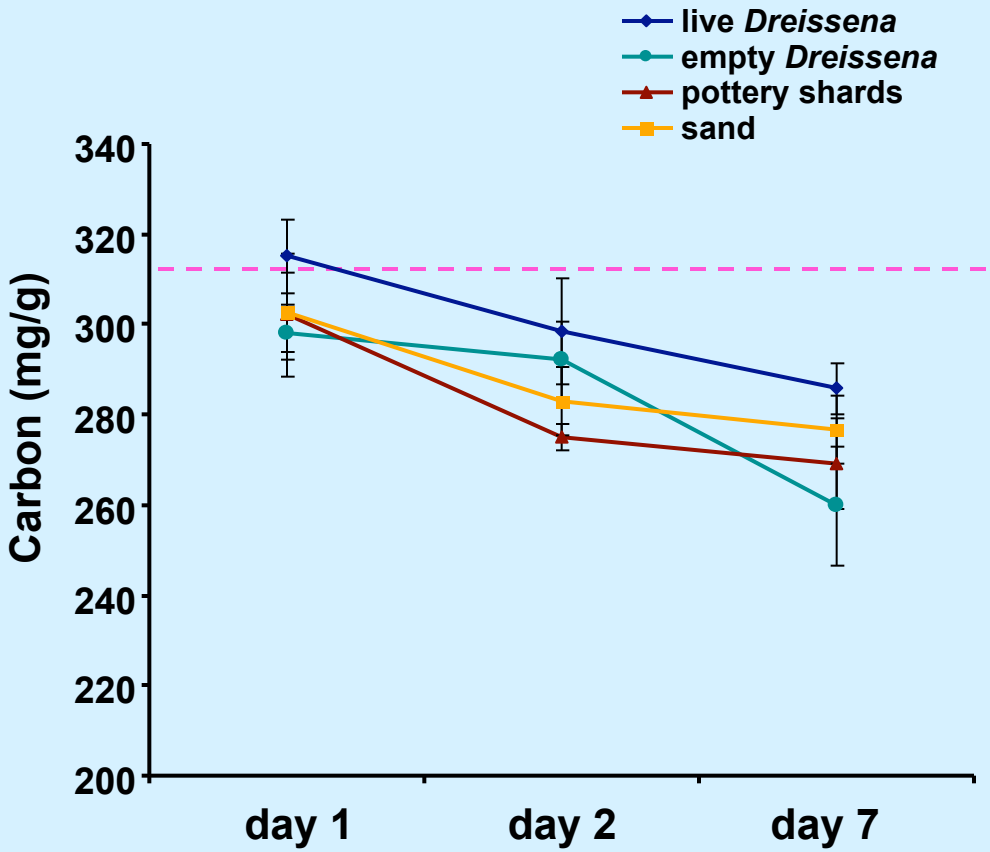
Cladophora

Photosynthetic efficiency significantly decreased at end



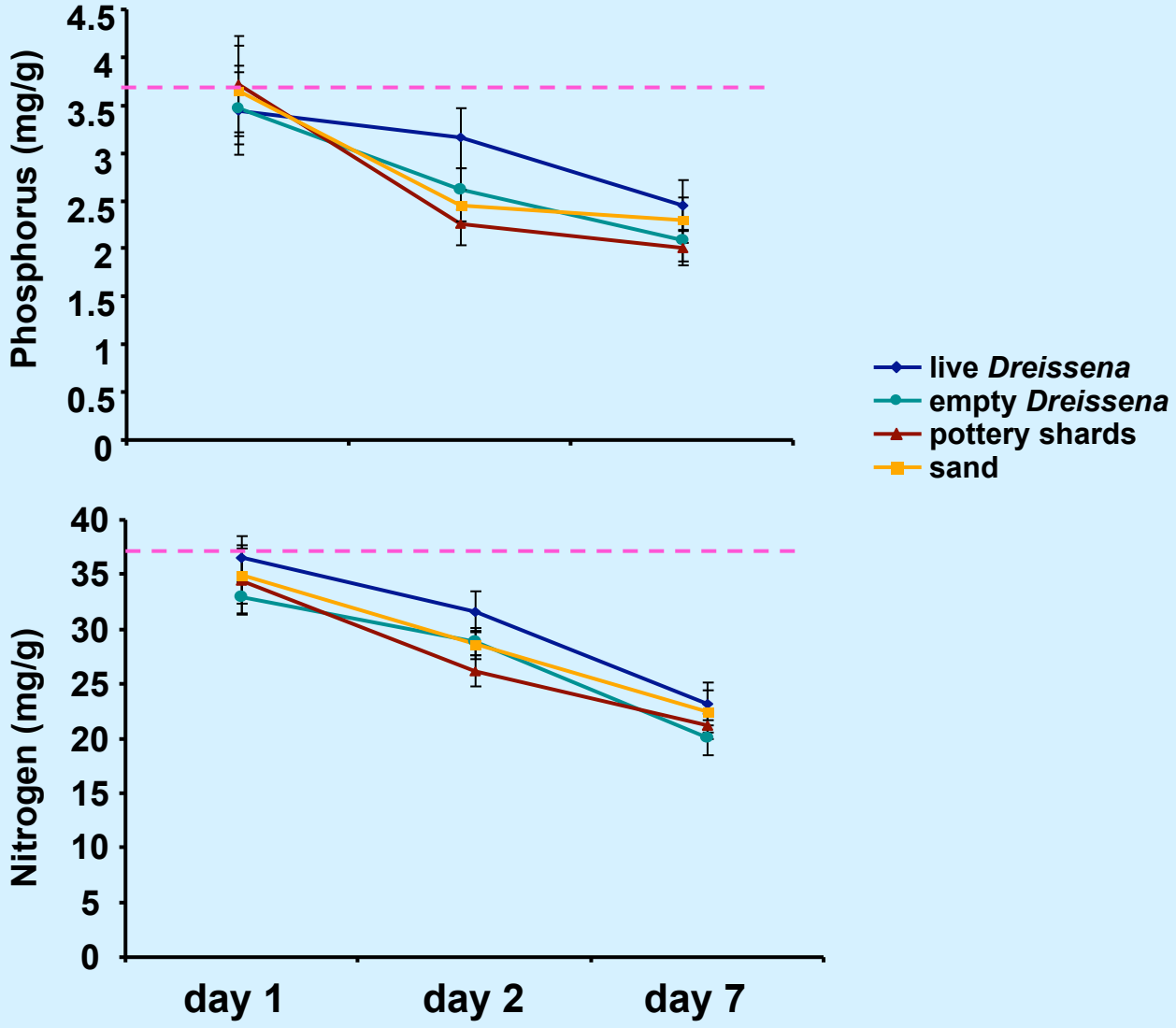
Cladophora

Nutrient tissue was significantly different between days, but not treatments



Cladophora

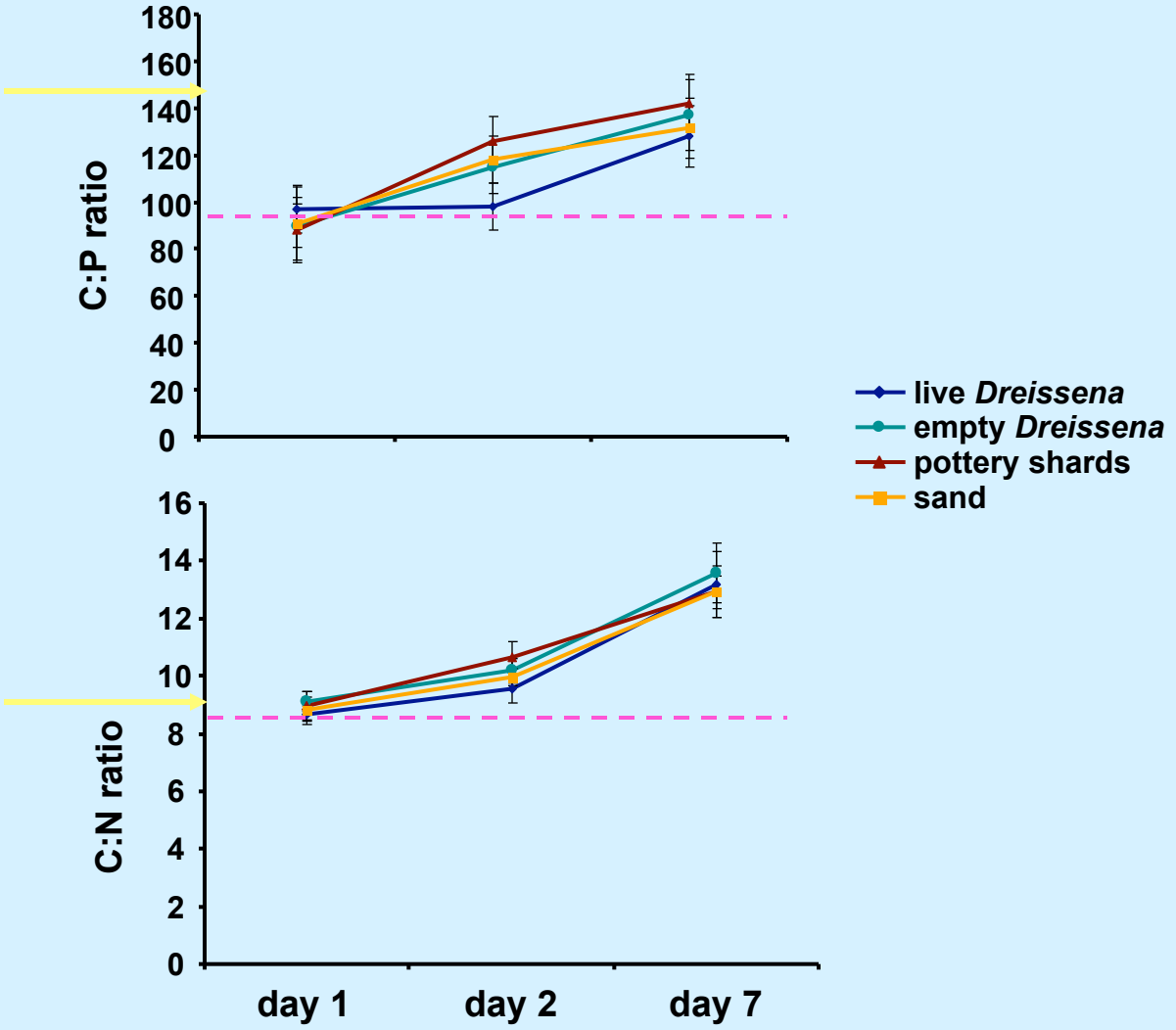
Trend of higher nutrient concentration with live *Dreissena*



Cladophora

No P deficiency, but N deficiency in all treatments

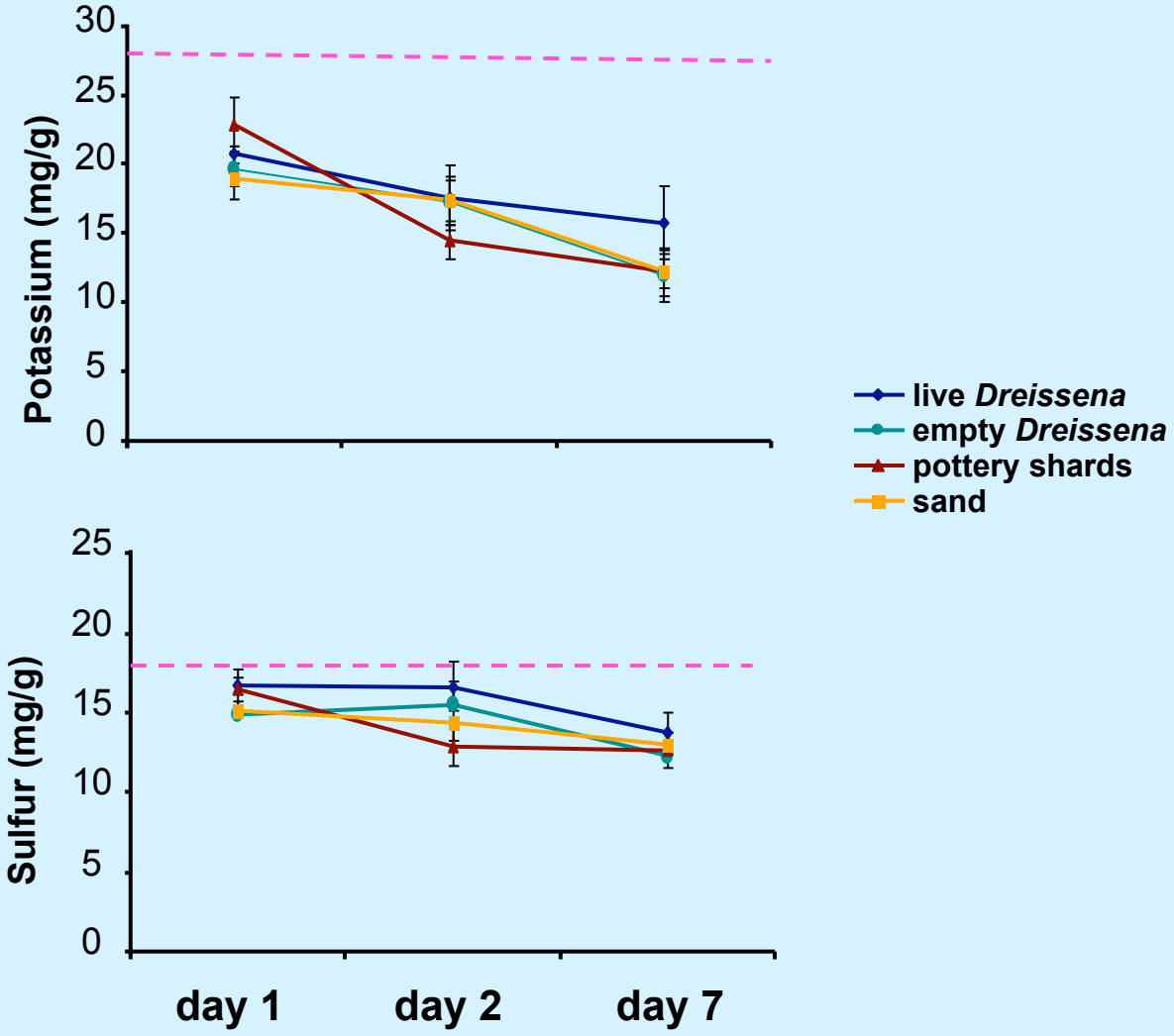
- <143 is no P deficiency
- >9.4 C:N is a N deficiency



Kahlert 1998

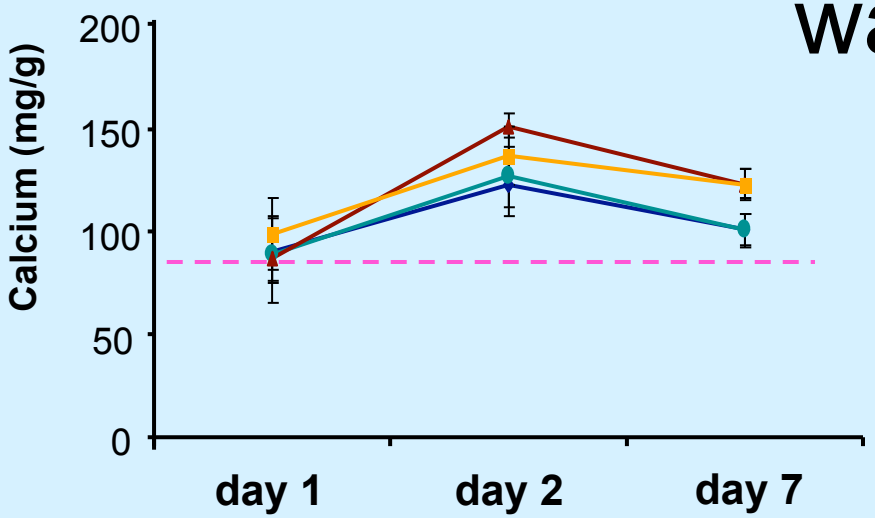
Cladophora

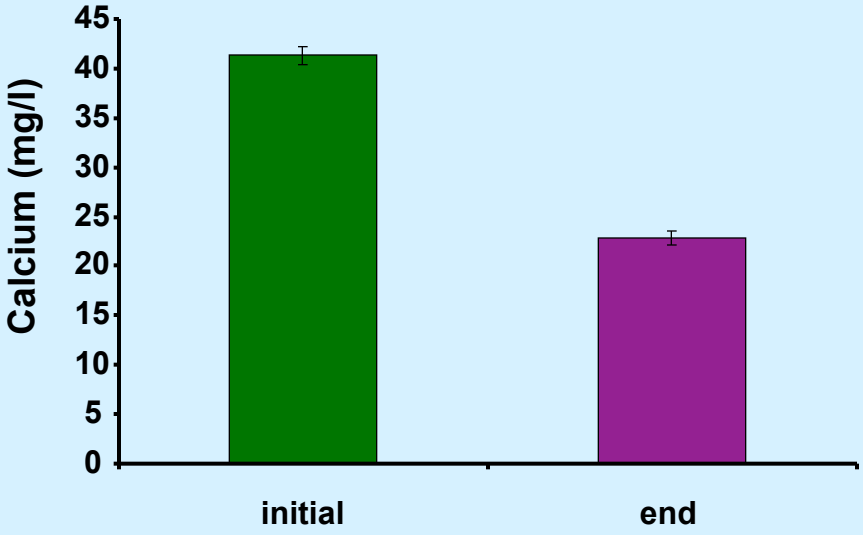
K showed more distinct pattern at end, but was not significantly different



Cladophora

Marginally significantly difference in tissue calcium, significant decrease in water





Summary for *Cladophora*

- Showed a biomass increase in the live *Dreissena* treatment
- No significant difference among pigments
- Showed trends of higher nutrient concentrations in live *Dreissena* treatment
  - C, N, P, K, S
- *Dreissena* decreased Ca concentration
- **Not yet received results for ^{13}C and ^{15}N
- Did not respond to structure

Overall Conclusions: growth

- *Dreissena* increased growth in *Cladophora*, but not Lyngbya
  - Cladophora responded to increased nutrients
    - Dilution
    - Attachment

Overall Conclusions: growth

- *Dreissena* increased growth in *Cladophora*, but not Lyngbya
  - Cladophora responded to increased nutrients
    - Dilution
    - Attachment
  - Not enough time for *Lyngbya*
  - *Lyngbya* growth does not always positively respond to N and P
  - Increased PC and nutrients indicate that *Lyngbya* was photosynthetically healthier with *Dreissena*

Overall Conclusions: nutrients

- *Dreissena* can retain nutrient concentrations in benthic algae
  - Can translate to increase biomass over time
  - More than just C, N, P
  - Higher nutrient content can mean higher quality of algae for grazers
  - Decrease Ca concentration, but unlikely to affect algae in natural system

Overall Conclusions: structure

- Not found to be as important as nutrient contributions
  - No difference among empty shell, pottery shard, or sand alone treatments
  - Algae were floating in the water
  - *Cladophora* bulk biomass was not able to reattach
    - More attachment with live *Dreissena*

Implications

- *Dreissena* increased algal biomass of one species and contributed several important nutrients to benthic algae
  - Supports nearshore shunt hypothesis

Implications

- *Dreissena* increased algal biomass of one species and contributed several important nutrients to benthic algae
- Nutrient reduction policies help control algal blooms, but *Dreissena* aggregate N and P which benefits benthic algae
  - May promote blooms despite reduced loading
  - Target nutrient levels may have to be lower than previously believed
  - Nutrient reductions may be ineffective
    - *Dreissena* help benthic algae acquire C
    - Benthic algae have a low affinity for nutrients in water column

Implications

- *Dreissena* increased algal biomass of one species and contributed several important nutrients to benthic algae
- Nutrient reduction policies help control algal blooms, but *Dreissena* aggregate N and P which benefits benthic algae
- Algae can store nutrients
  - Helpful when nutrient availability is low
    - Create longer presence of algae

Acknowledgements

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