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Is Nitrogen Removal a Shell (or shellfish) Game?

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About Me

- How did you get here?
- What are you interested in?
 - Very different environments but similar interaction between life and chemistry.
- The Interplay between Life and Chemistry
 - Nitrogen
 - Estuaries
 - Waquoit groundwater
 - Oysters
- Can we use this information?
 - Modeling work, future studies.



About

Life/Chemistry



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For most of history, man has had to fight nature to survive; in this century he is beginning to realize that, in order to survive, he must protect it.

Jacques Yves Cousteau

AZQUOTES

Credit:www.azquotes.com

Credit:www.whoi.edu

About

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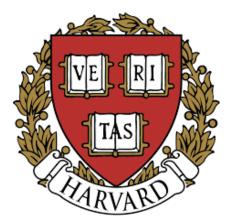
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JOINT PROGRAM IN OCEANOGRAPHY/APPLIED OCEAN SCIENCE & ENGINEERING



Application

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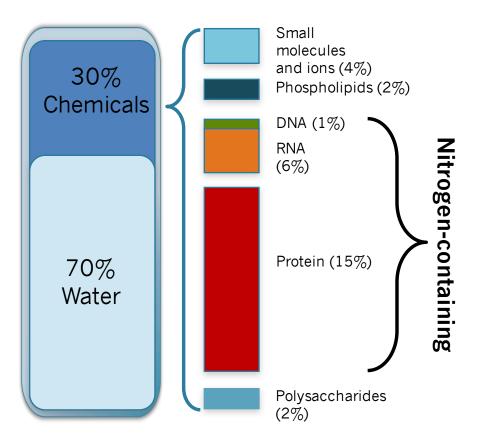
What is the relationship between biological processes and chemical environment?

- How does chemistry influence life?
- How fast are resources moved in an environment?
- What are the mechanisms involved?
- What signatures of life are consistent between environments?





Why do we care about nitrogen?



More than 20% of the cell weight is built with nitrogen.

- One of six elements required for all life (CHONPS).
- Its abundance. Nitrogen is everywhere!
- However, its lack of abundance in a usable form often limits life.
- Humans have gone to great lengths to produce more (anthropogenic) biologically available nitrogen.
- Anthropogenic nitrogen has altered the environment.



Life drives chemistry / Chemistry drives life

- Life
 - Requires energy source
 - In a race to harvest energy
 - In competition for energy

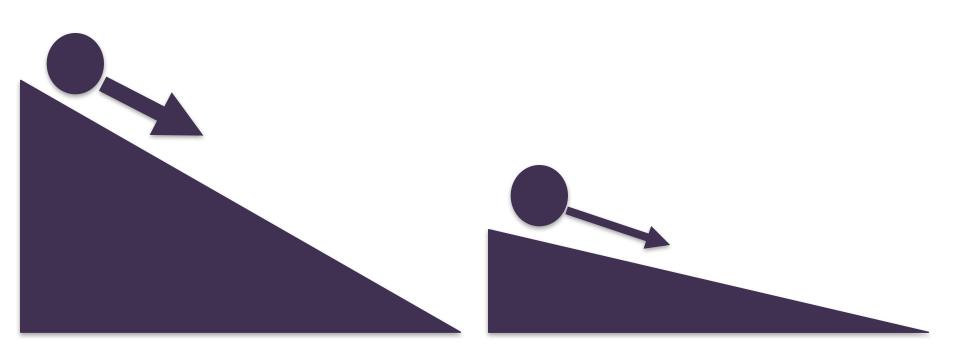
- Chemistry
 - Moves toward balance
 - giving off energy
 - The more out of balance the more energy will be available
 - Tends to move slowly, rates driven by the degree of difference

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Steeper gradient mean more energy



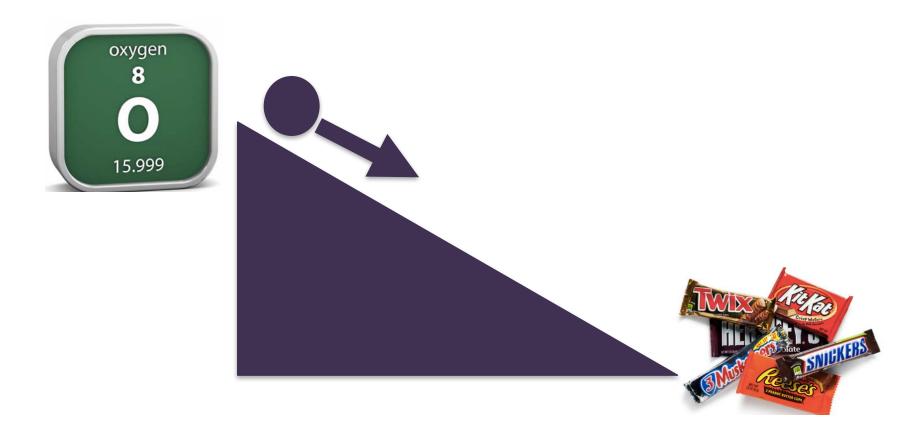
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Steeper gradient mean more energy



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/ Chemistry drives life

Credit:www.elephantfacts.com

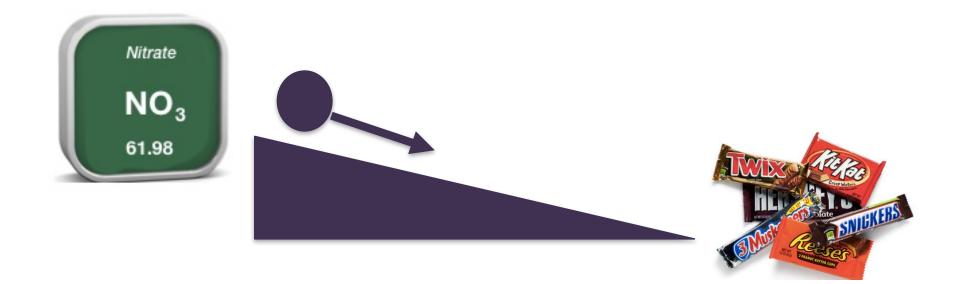
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Steeper gradient mean more energy



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Without oxygen, other chemicals can be used.



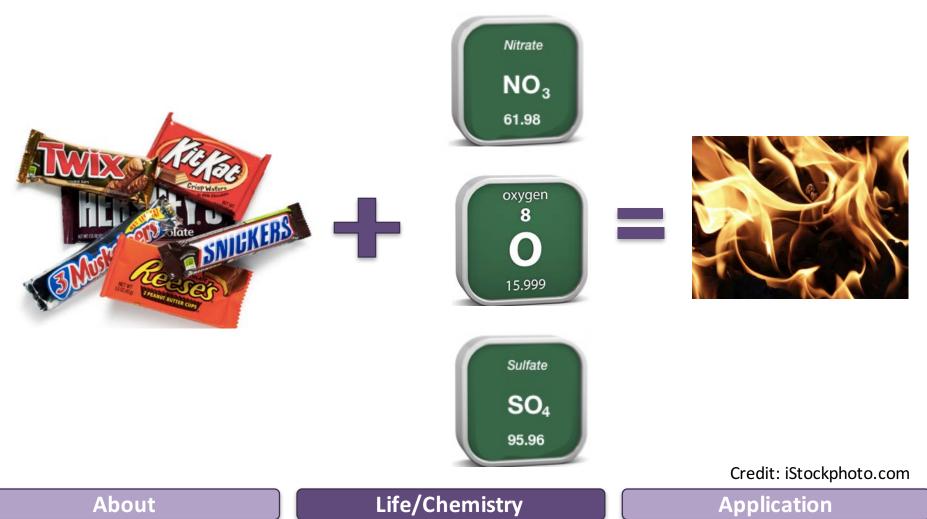
Credit: iStockphoto.com

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Microbes are metabolically diverse.

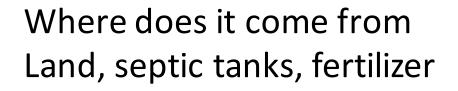








What else does nitrogen do? Stimulates plant growth





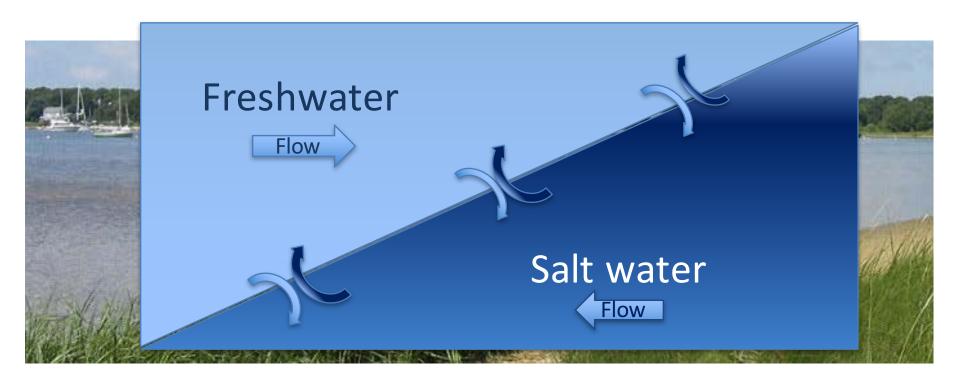
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Estuaries are environments where a chemical gradient persists: freshwater mixing with sea water.



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Estuaries are zones where freshwater and sea water mix.

- Chemically complex lots of energy sources for microbes
- Lots of nutrients for the base of the food chain
- Lots of higher biomass because the base is supported

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Too much nitrogen is bad for the health of the coastal ecosystem

Decrease in available oxygen

Decreased biodiversity

Detrimental to economics

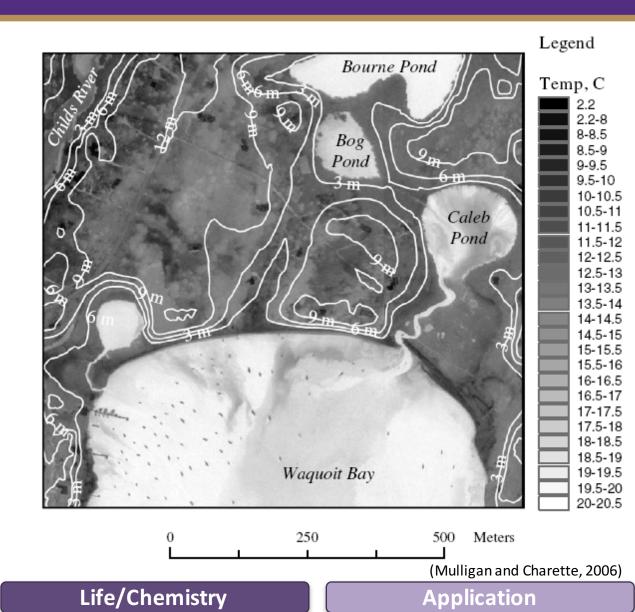
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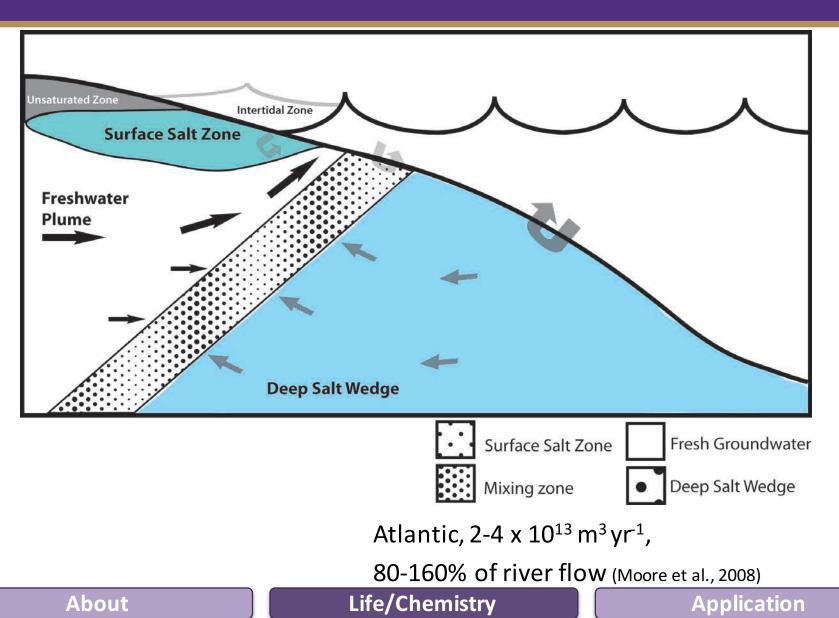
About half of the freshwater entering Waquoit Bay is groundwater



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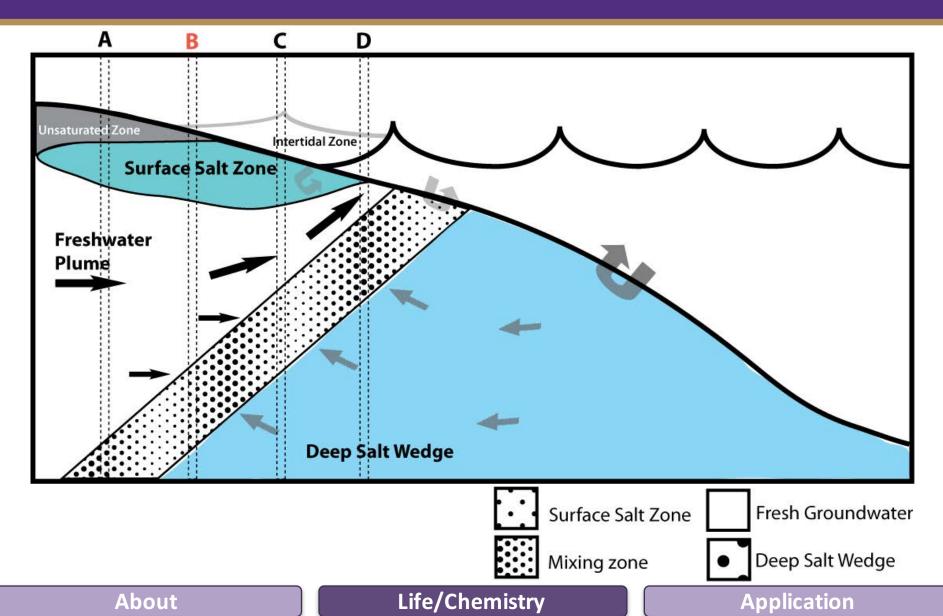


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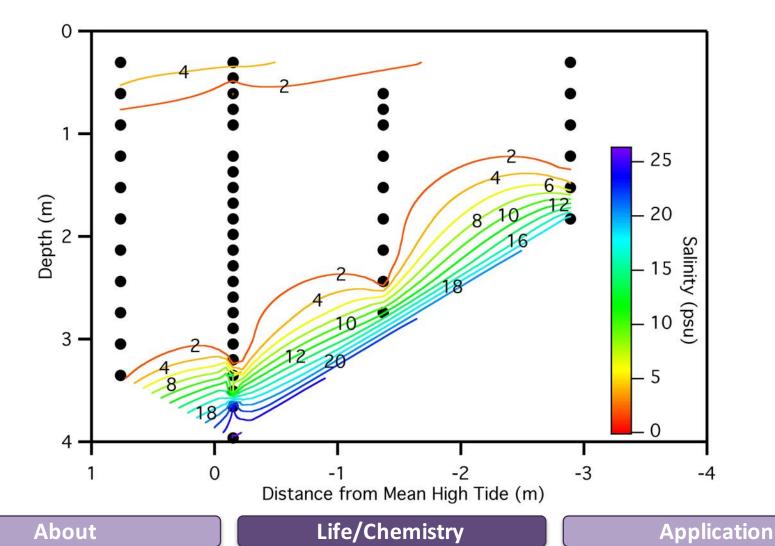


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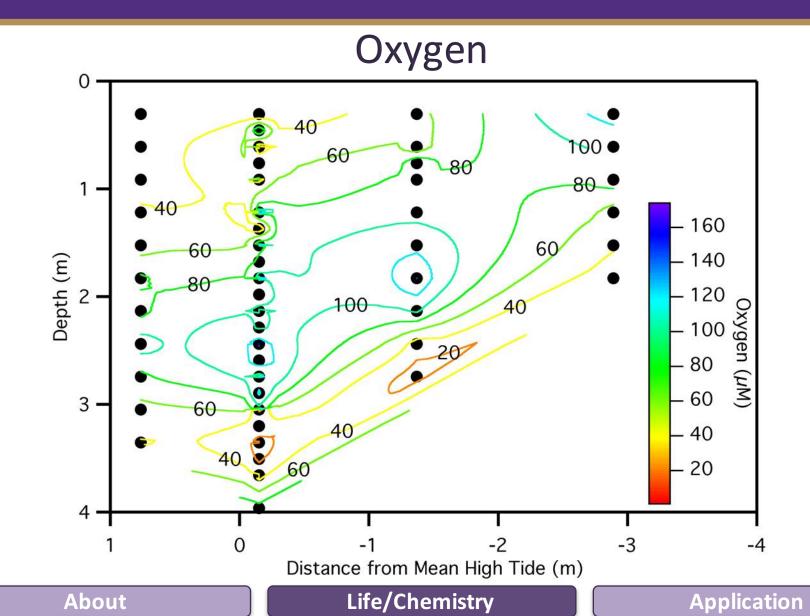


Salinity



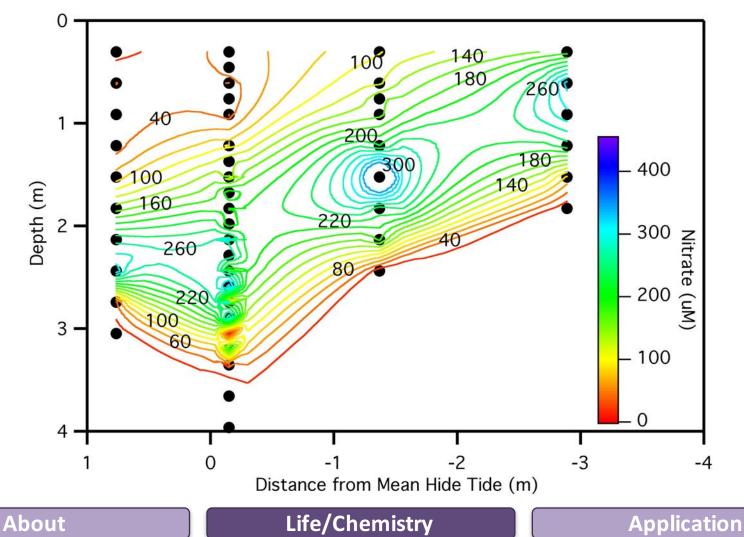


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Nitrate





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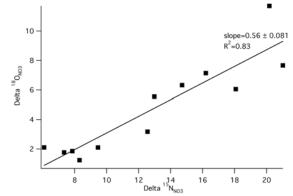
Collect Sediments



Add tracers

Credit: Thomas Kleindinst, WHOI

Look for N-removal



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Why low rates of N-removal in ground water?

- Small zone where oxygen is absent
- Relatively short time for the groundwater to move through that zone
- Sediments in this zone are low in food (carbon)





Why Oysters?

- Economically desirable
- Incorporate nitrogen into biomass
 - ~0.5% of dry weight
 - ~12% of dry weight of tissue
- May move a lot of nitrogen and carbon to the sediments



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Credit:Seafood.maryland.gov

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How valuable are shellfish?

- >\$60M for Barnstable alone in 2013*.
- Shellfish Farming is increasing.
 - ~250 growers on Cape Cod*.
- Little Pond, Falmouth
- Snug Harbor, West Falmouth
- Wellfleet Harbor, Wellfleet
- Floating Bags (3 m), benthic cages or a combination

(*Josh Reitsma and Diane Murphy, Cape Cod Cooperative Extension)

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Little Pond



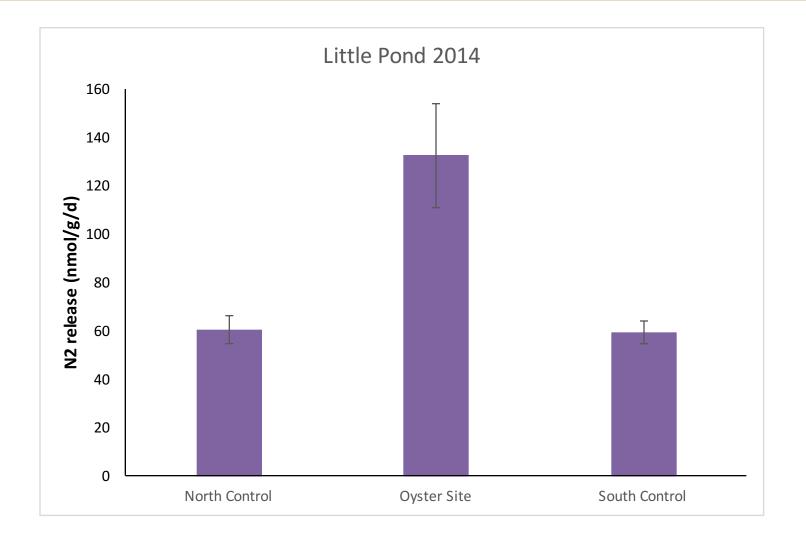


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Wellfleet Nitrogen Removal

About

N2 release (nmol/g/d)

0

Core1

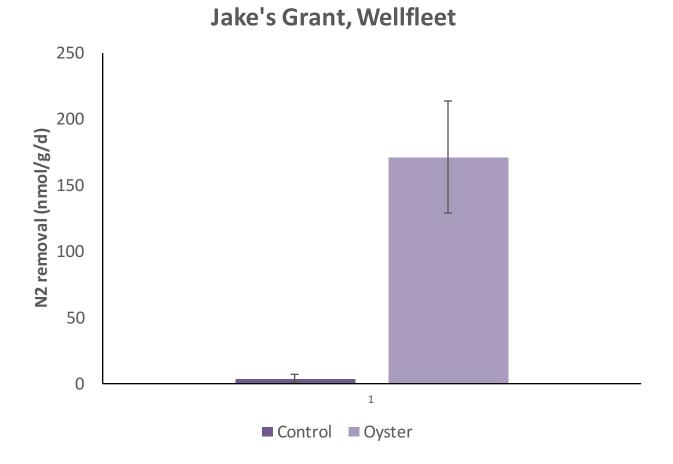
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Core2

Application

Core3





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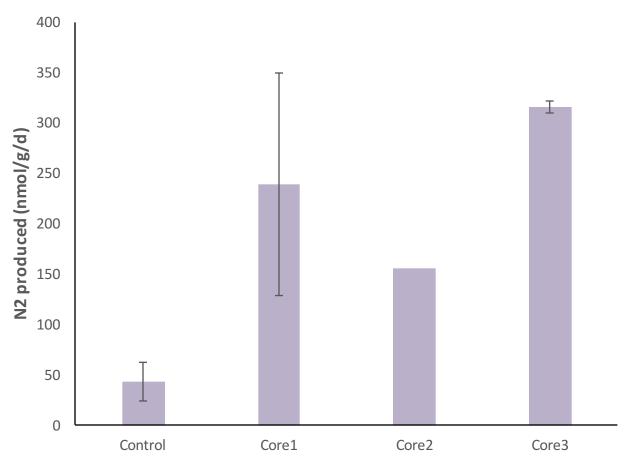
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Snug Harbor, West Falmouth





West Falmouth



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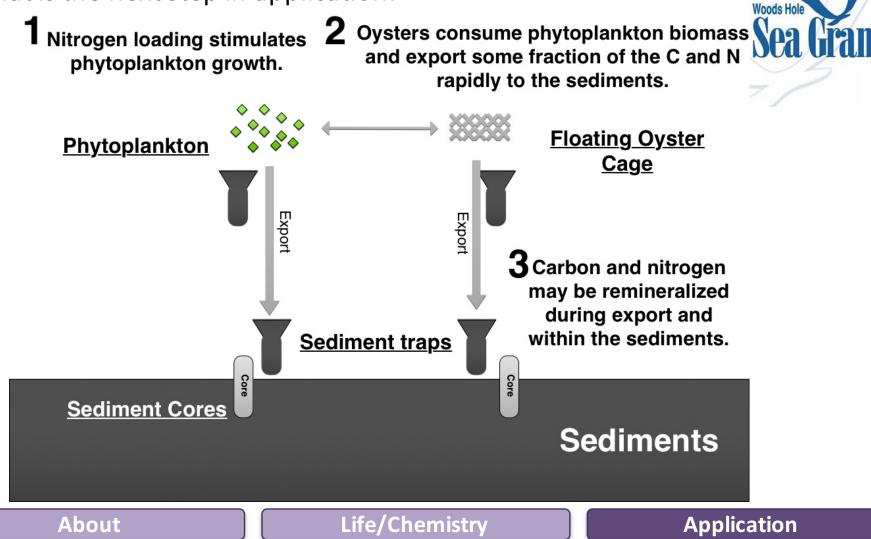


Conclusions:

- Oyster activity does seem to increase removal of nitrogen from the underlying sediments.
 - increase may be more significant in well ventilated environments
- Increase in nitrogen is relatively well coordinated with the presence of the oysters (data not shown)
- Different oyster farming strategies may also influence impact on nitrogen removal



What is the next step in application:





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Model the movement of nitrogen to the sediment, given a particular oyster biomass in Little Pond.

Drive model with oyster biomass, sedimentary C and N content

Extrapolate to similar estuaries on Cape and test the model.

Distribute model to towns to help management of coastal waters

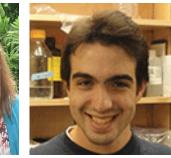
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Acknowledgements:











Charette Lab – WHOI Casciotti Lab – WHOI/Stanford Funding Agencies:





