Waquoit Bay Reserve Coastal Training Program

6TH ANNUAL
CAPE COASTAL CONFERENCE
DECEMBER 4-5, 2018



Working towards an ecosystem level understanding of how different oyster aquaculture practices alter nitrogen cycling.

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WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

TOWN OF FALMOUTH INCORPORATED 1686

WAQUOIT BAY NATIONAL ESTUARINE RESEARCH RESERVE

SCIENCE WARES, INC.

Funding Provided by:

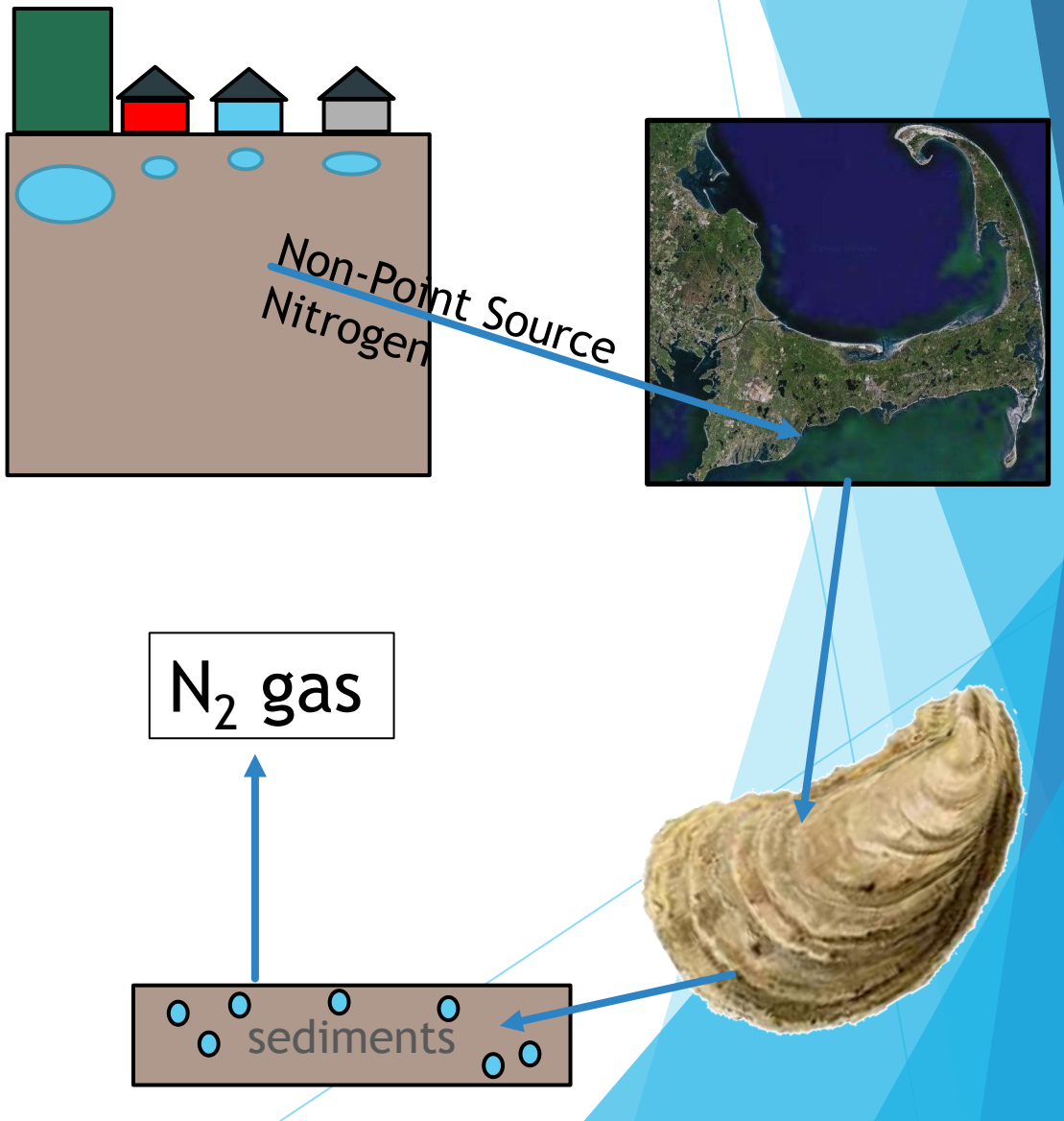
Summer Student Fellowship

The Problem

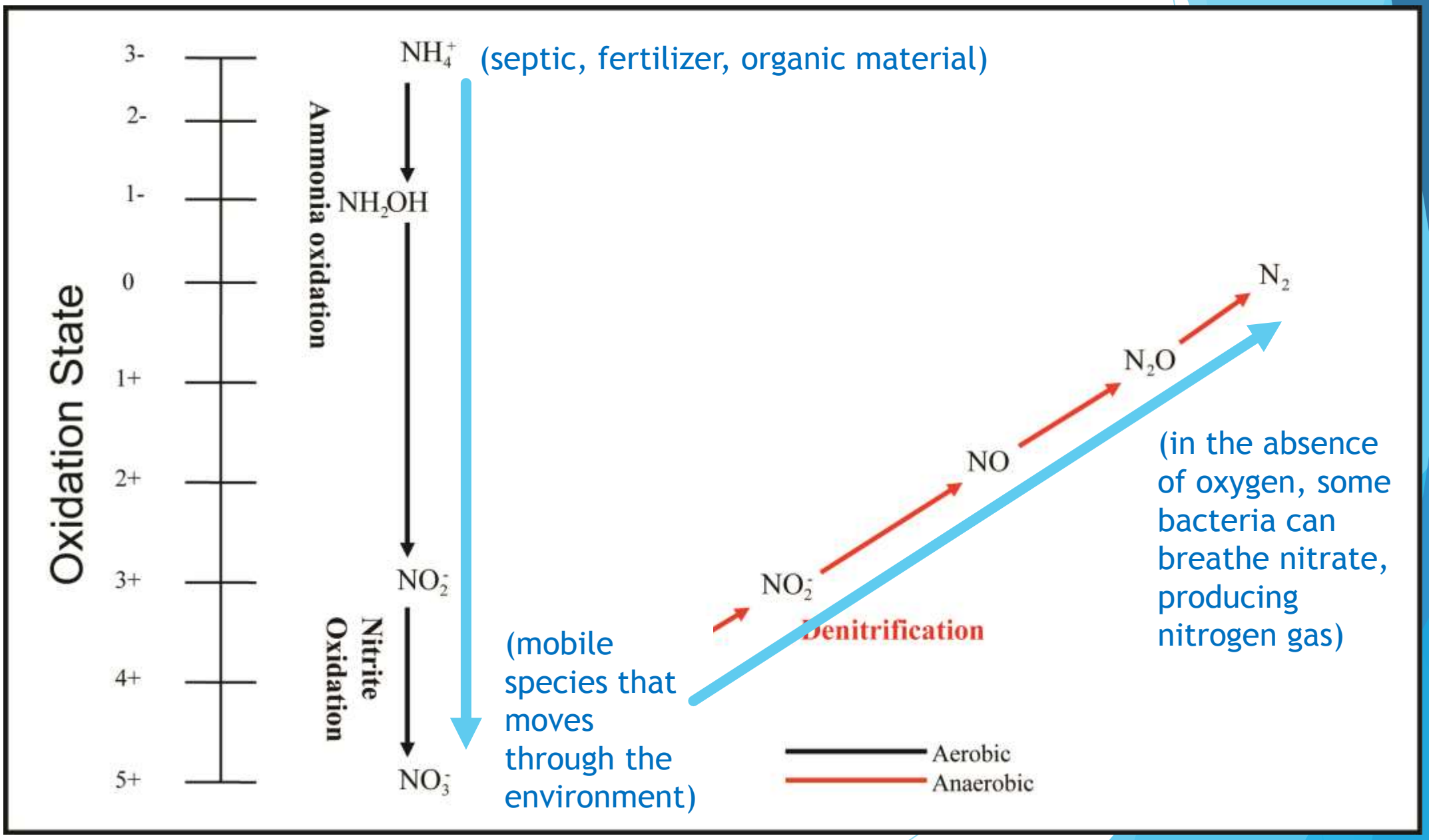
- Populations on septic tanks, fertilizers, etc. introduce a lot of nitrogen (N) into coastal waters
- Many Cape towns are considering shellfish as part of their nitrogen management plan (208 plan)
- We do not fully understand the entire benefits package of shellfish aquaculture
- **Need quantitative data on N-removal** and oyster growth so decision makers can manage resources and meet water quality goals

The Ecology

- Nitrogen is produced through human activity
- Nitrogen act as a fertilizer to plankton in the water driving a production of biomass
- Oysters can eat the plankton and sequester nitrogen in their tissue or export nitrogen to the sediments.
- Once in the sediment the nitrogen may be converted to gas by microbes and leave the ecosystem



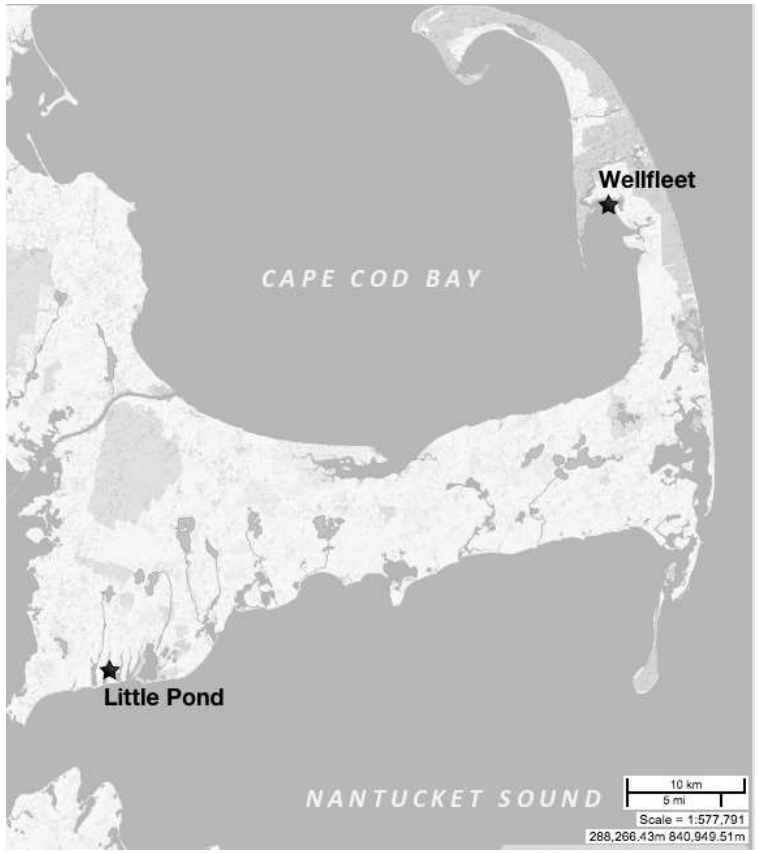
Nitrogen transformations in the environment

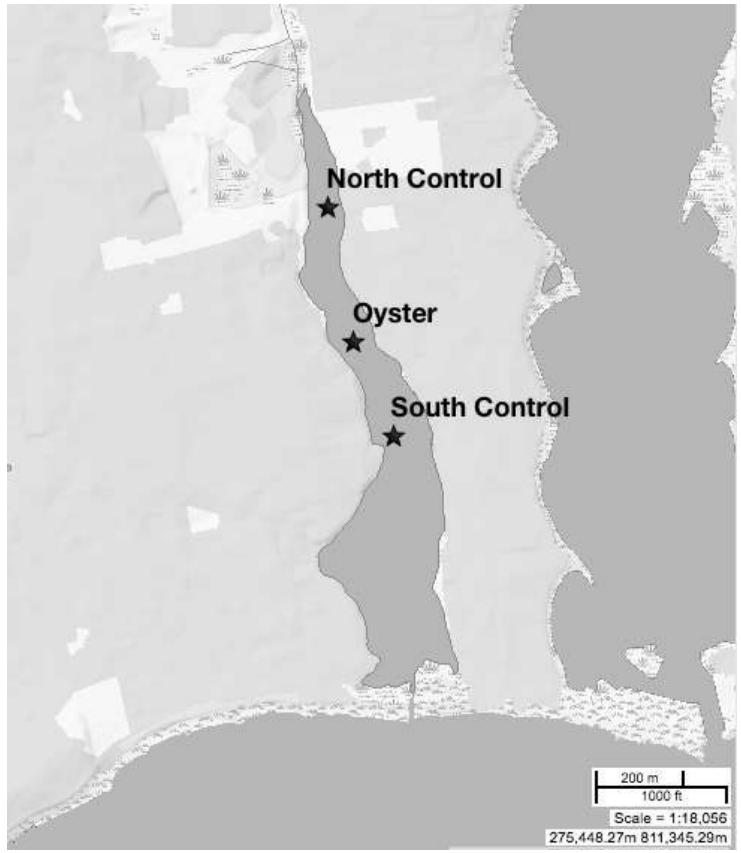


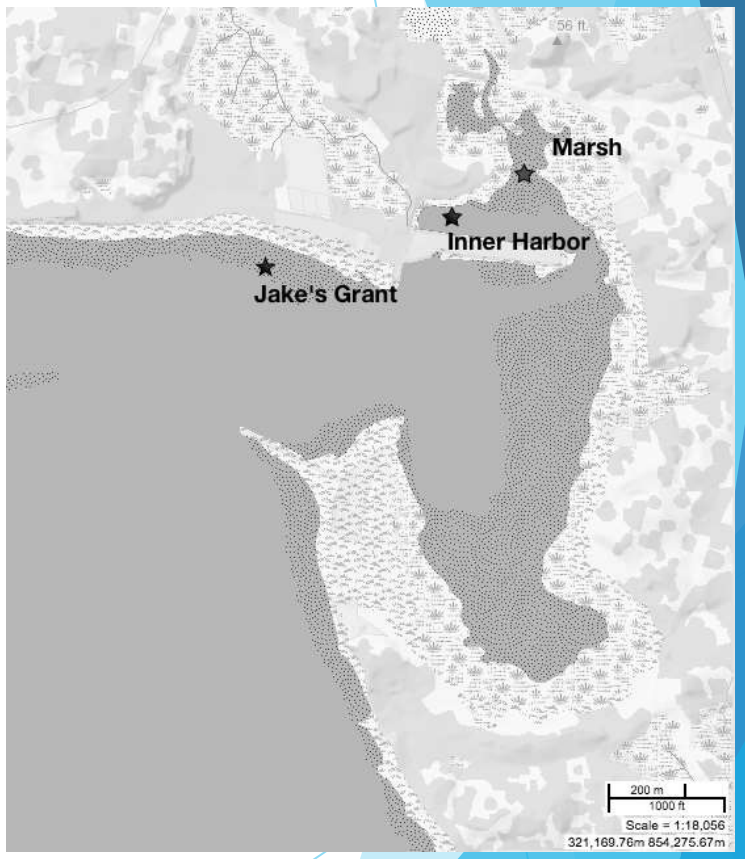
The Big Questions

- Does aquaculture activity change N_2 flux from the sediments?
- Is there enough N_2 generated to be included in the N management planning?
- How are the underlying sediment altered microbiologically or chemically?
- Are there proxy measurements for N-removal estimates that can be utilized by end-users (i.e. a Strep-throat test)

N-removal across environments



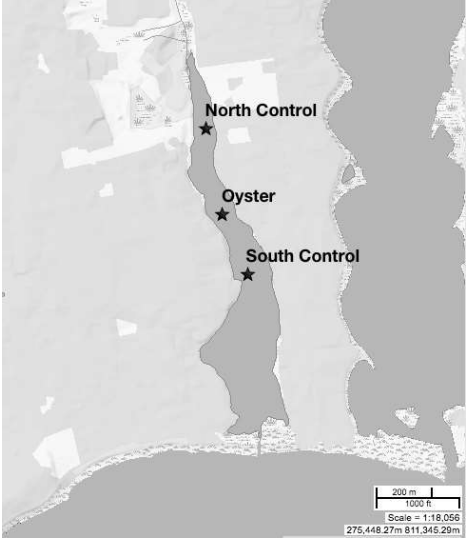


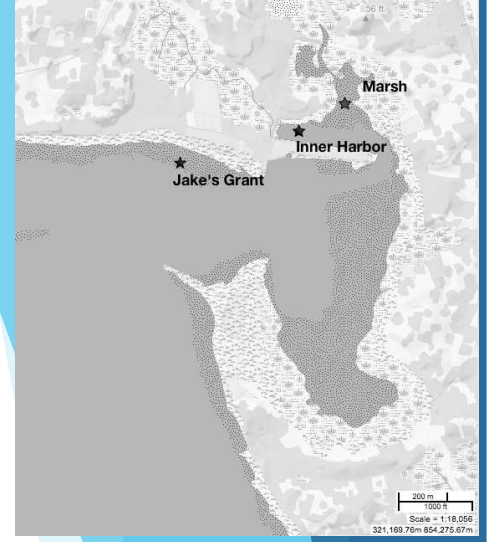


OLIVER MassGIS, http://maps.massgis.state.ma.us/

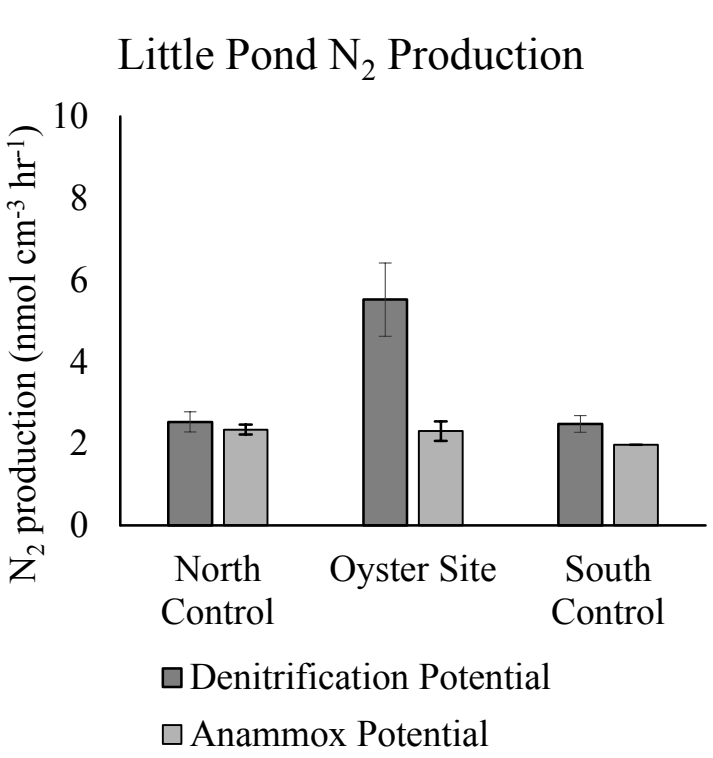
N-removal across environments

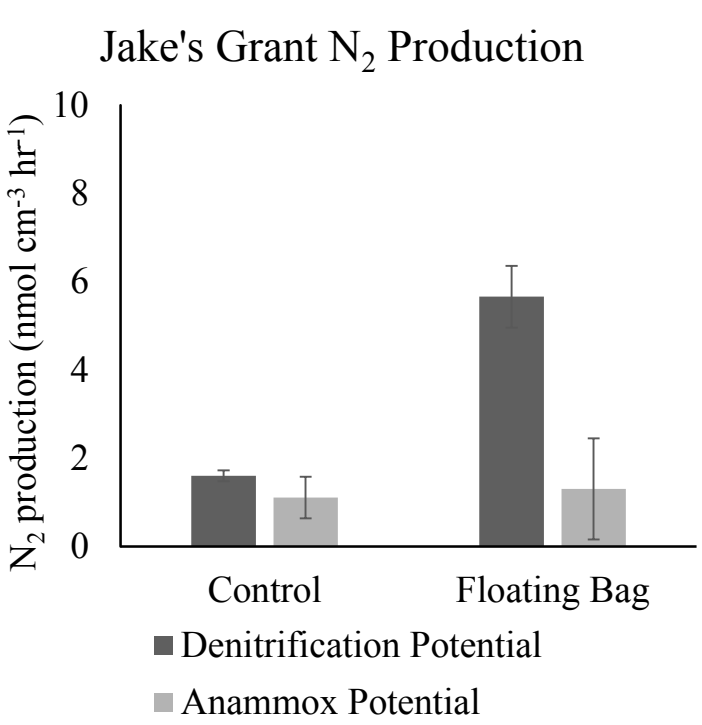
OLIVER MassGIS, http://maps.massgis.state.ma.us/

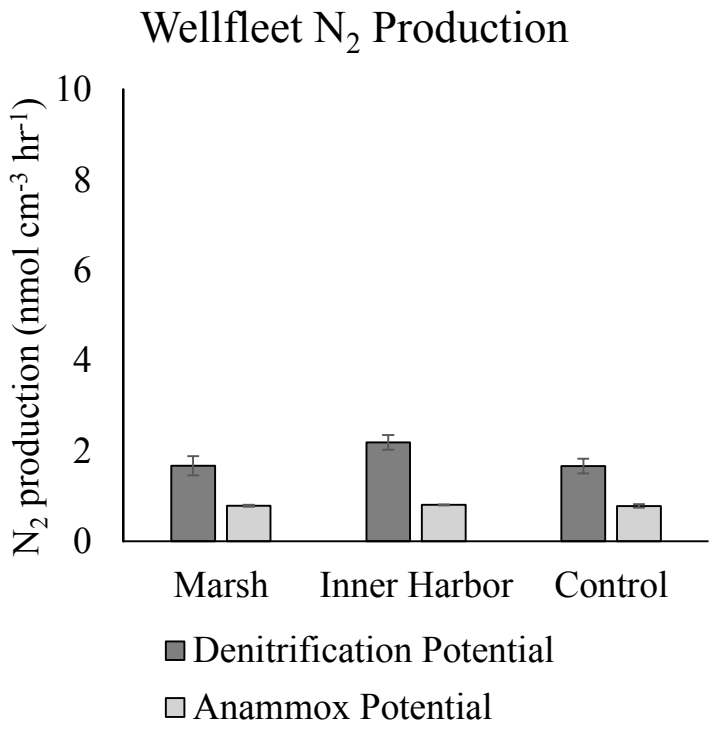


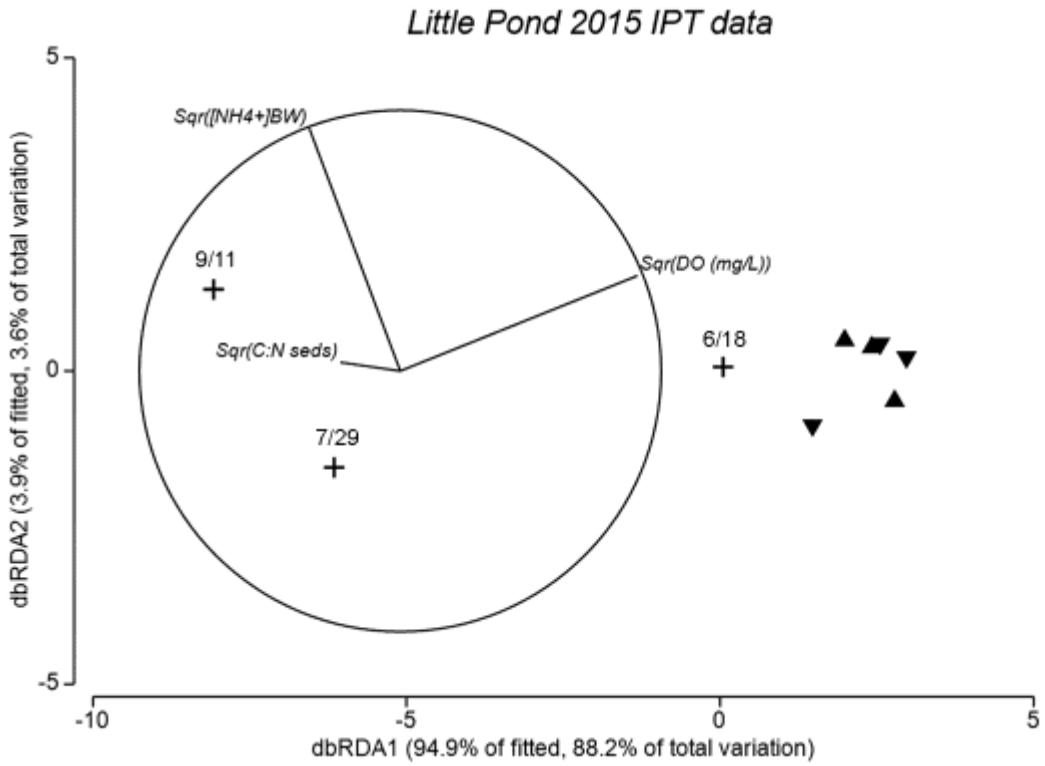


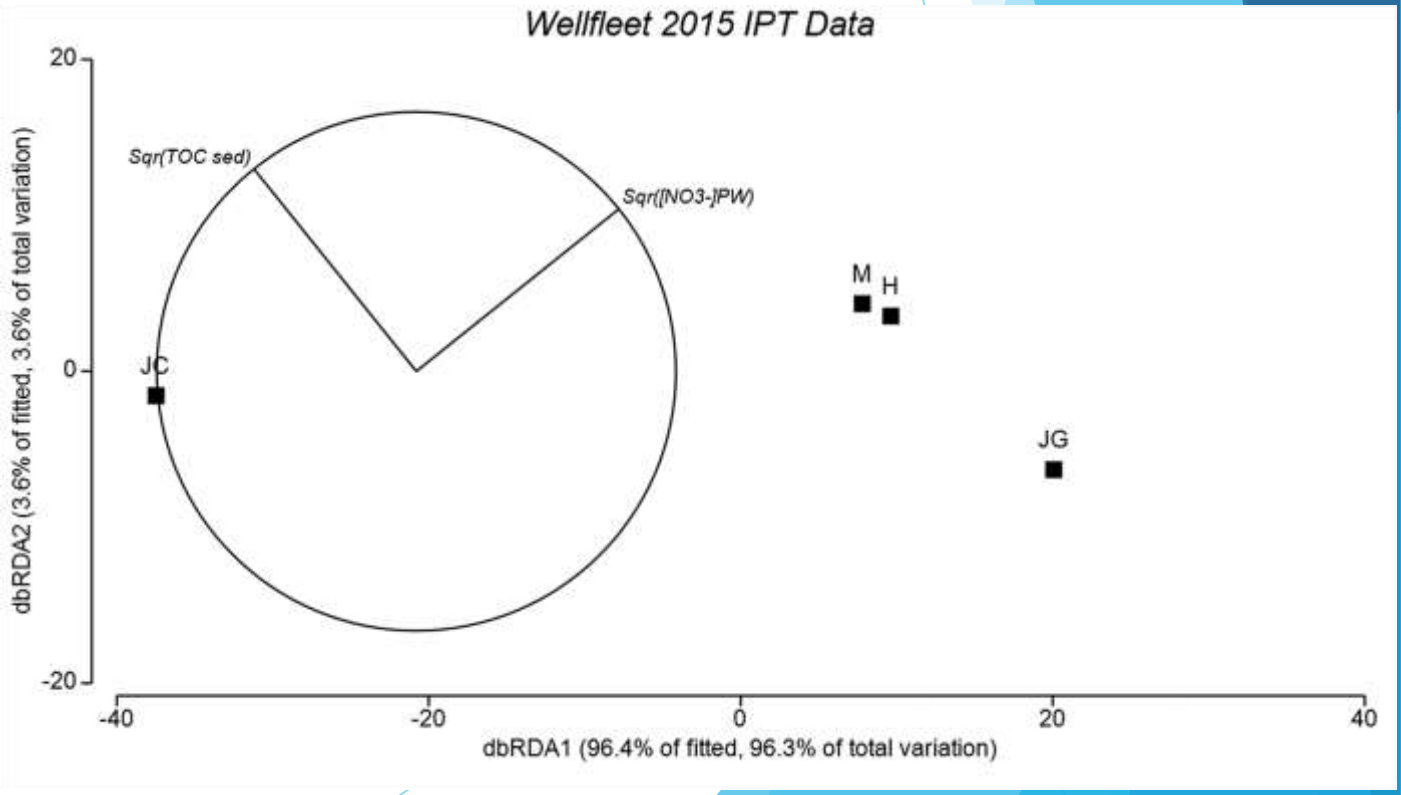
7 to 17% additional N-removal over harvesting oysters








Little Pond 2015 IPT data
site
LP_NC
LP
LP_SC
Sqr([NH4+]BW)
Sqr(DO (mg/L))
Sqr(C:N seds)
9/11
6/18
7/29
dbRDA2 (3.9% of fitted, 3.6% of total variation)
dbRDA1 (94.9% of fitted, 88.2% of total variation)
5
0
-5
-10
-5
0
5

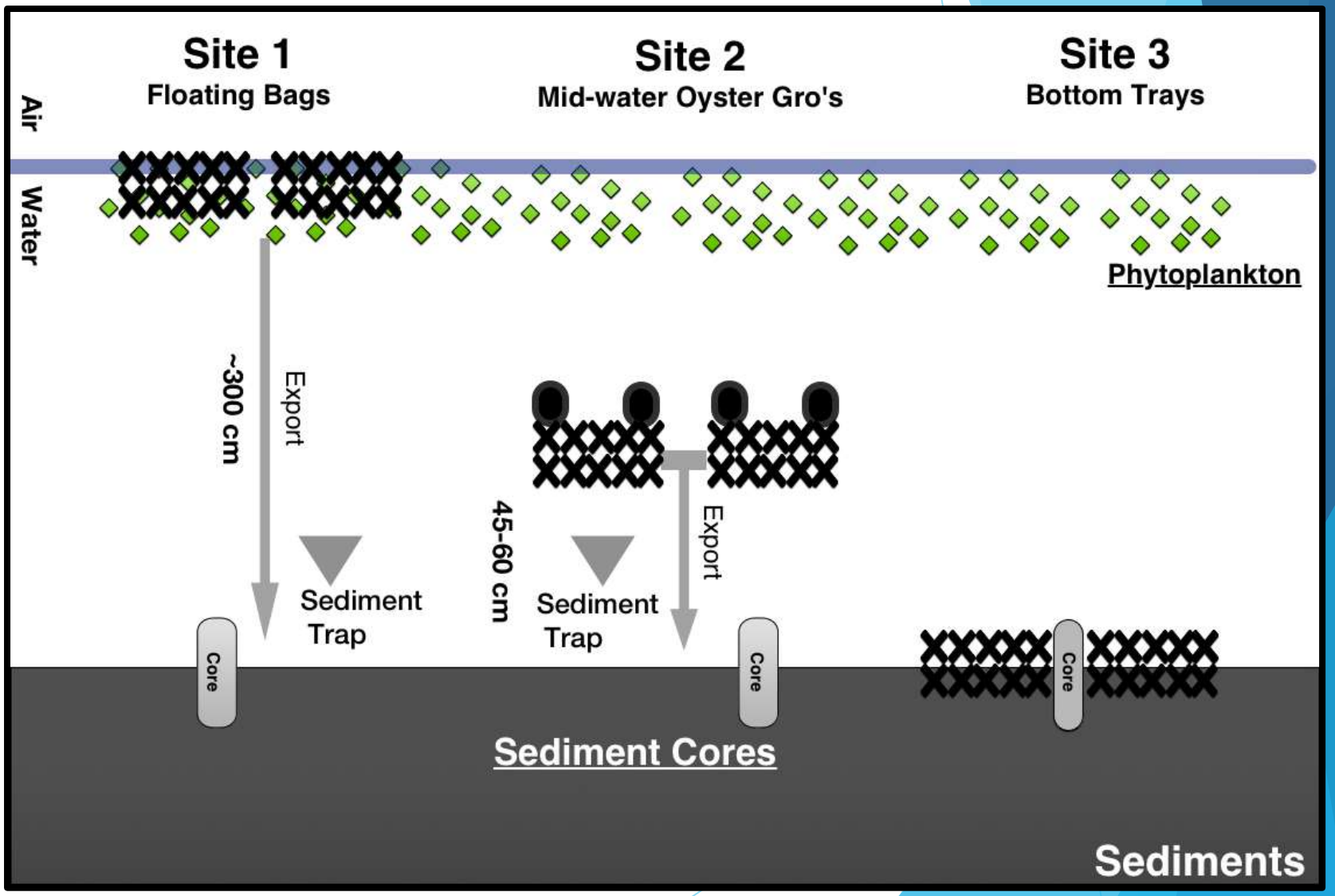

Wellfleet 2015 IPT Data
Sqr(TOC sed)
Sqr([NO3-]PW)
M
H
JC
JG
dbRDA2 (3.6% of fitted, 3.6% of total variation)
dbRDA1 (96.4% of fitted, 96.3% of total variation)
20
0
-20
-40
-20
0
20
40

Project Overview:

Objective: *evaluate oyster growth and the sedimentary N-removal efficiencies, for a standard oyster biomass, of three aquaculture systems*

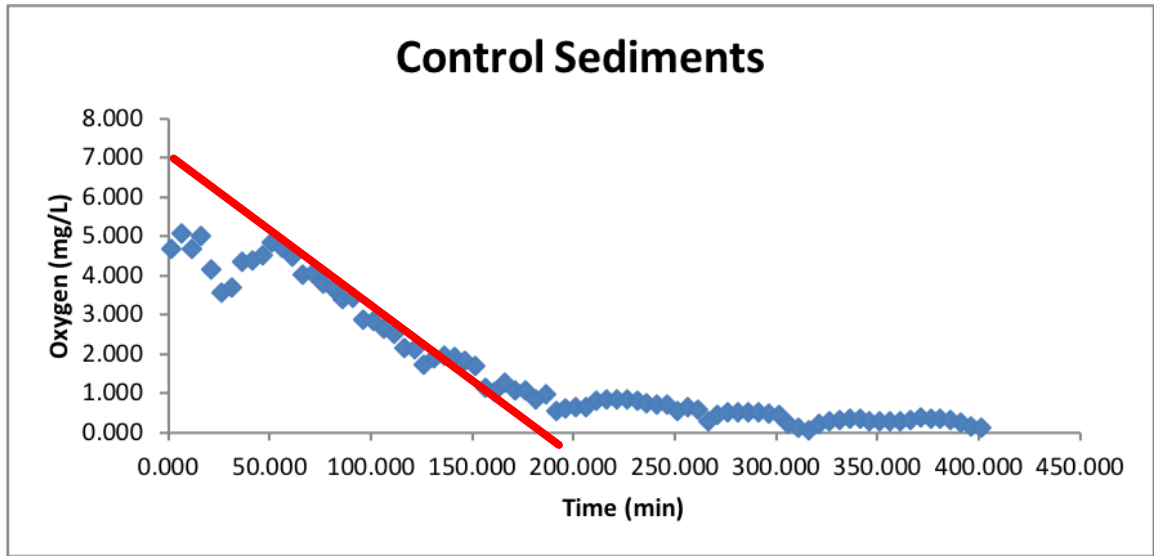
Approach:

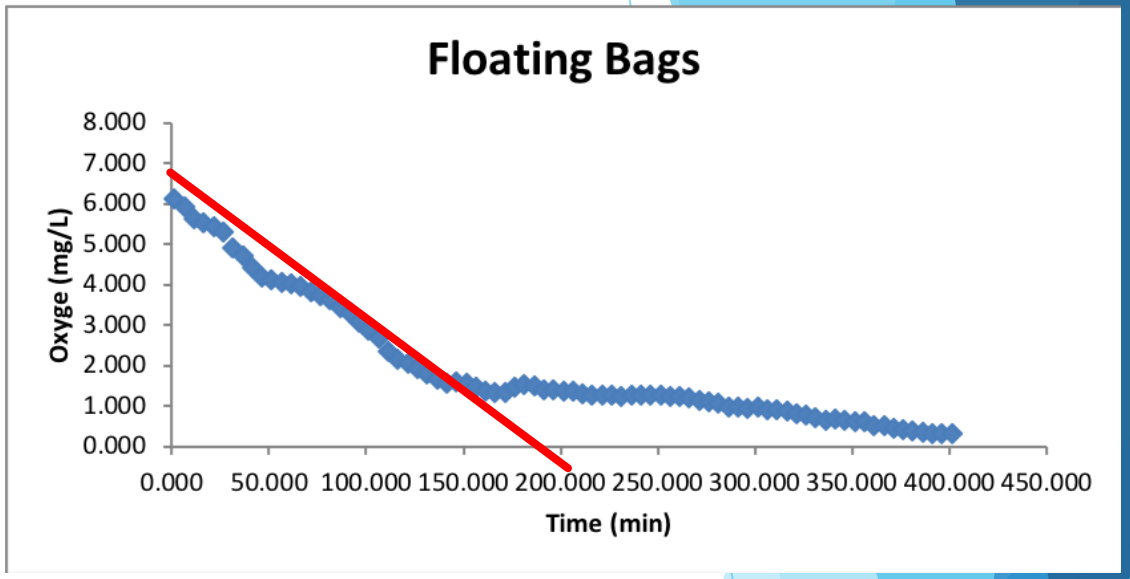
- *Assess the growth of the oysters*
- *Quantify geochemical fluxes across the sediment/water interface*
- *Monitor the microbial activity and composition in the underlying sediments.*

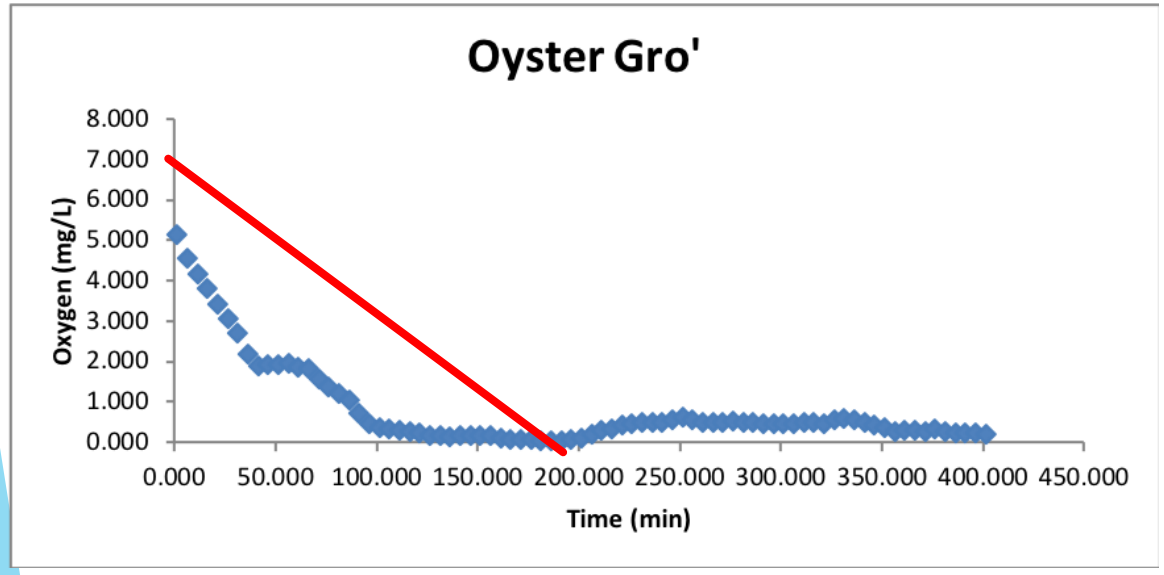


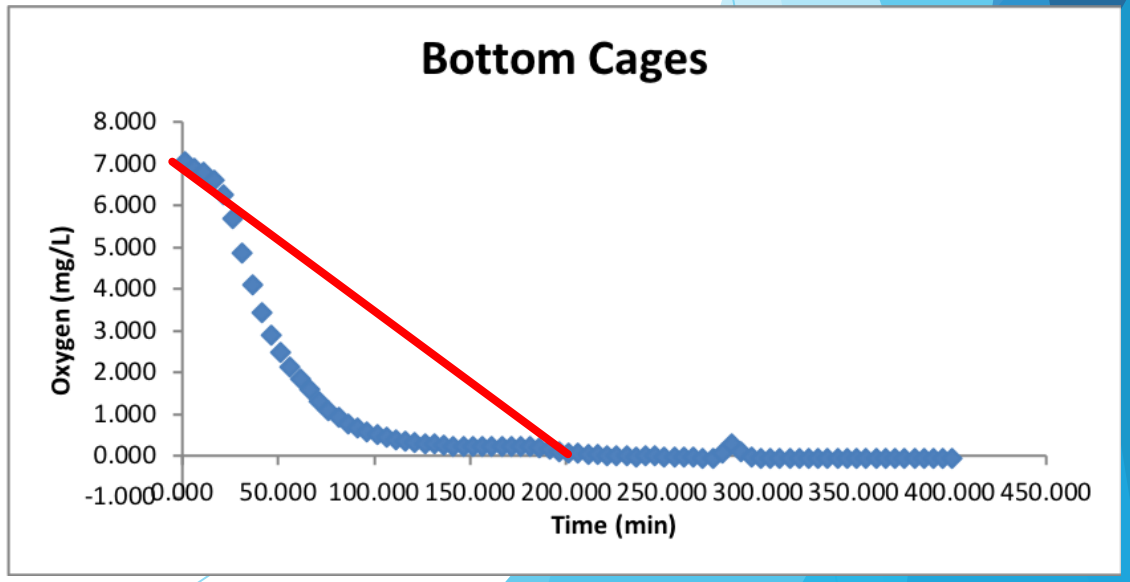
Flux core measurements:

- Sediment oxygen demand

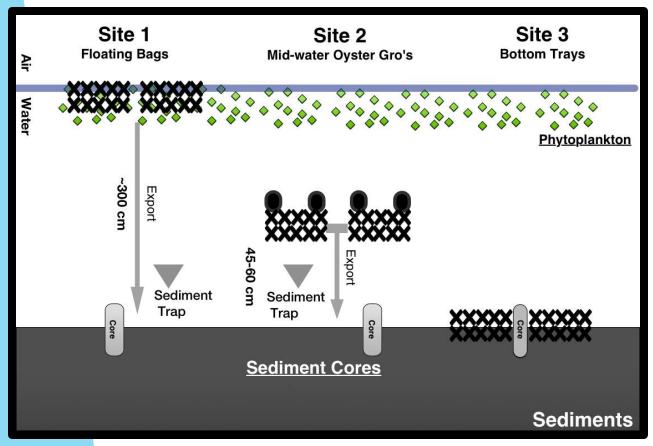


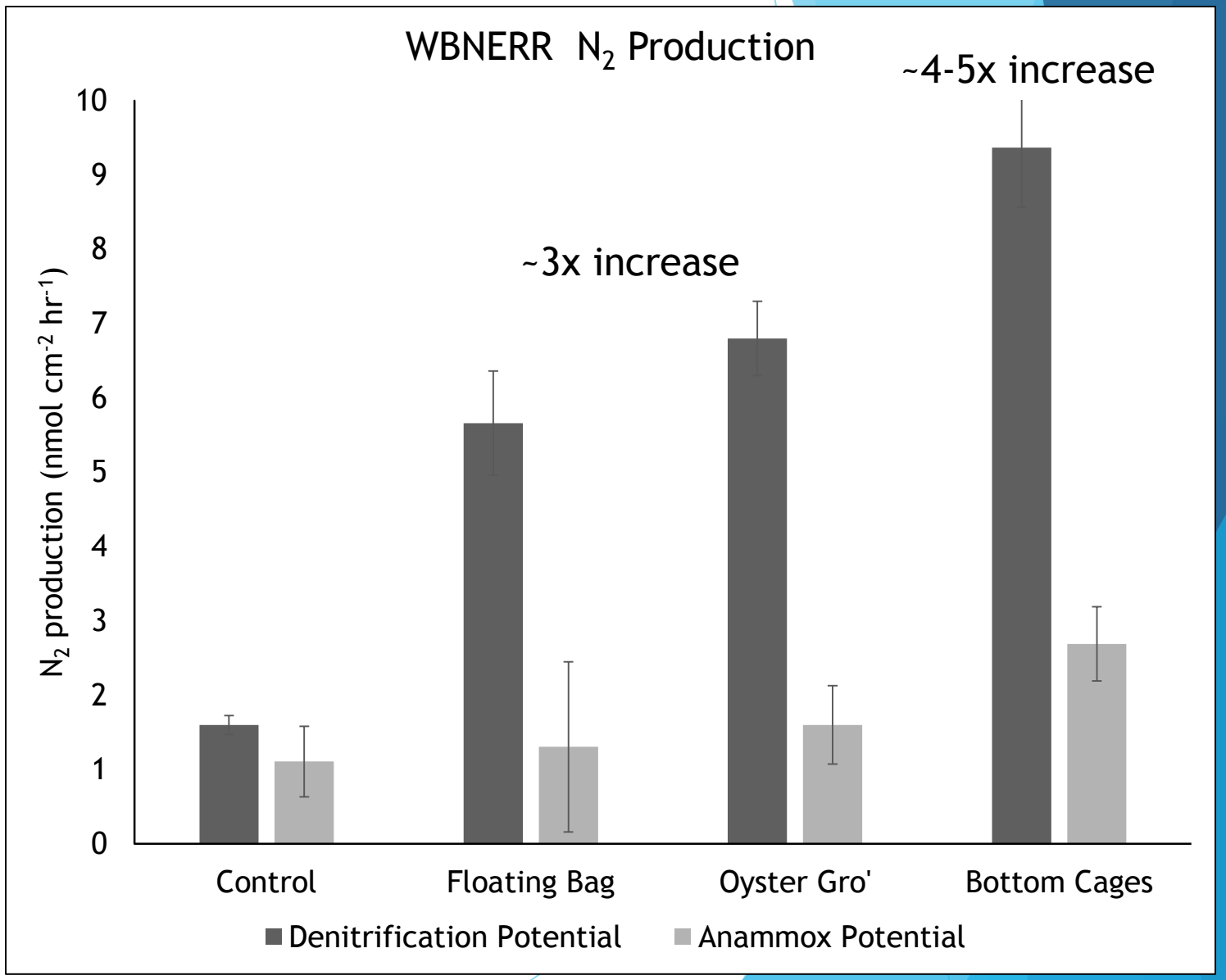






- N_2-removal (denitrification) is highest in sediments underlying bottom cages
- N_2-removal (denitrification) is higher under all the aquaculture systems than under in control sediments.





- Potential rates from isotope or flux incubations are limited
  - Snapshot in time
  - Altered by sampling

- Mass balance approach
  - Requires measurements of every pool
  - Integrates over longer time periods
  - Does not specifically tell you rates of processes
  - Algorithms may apply to other systems

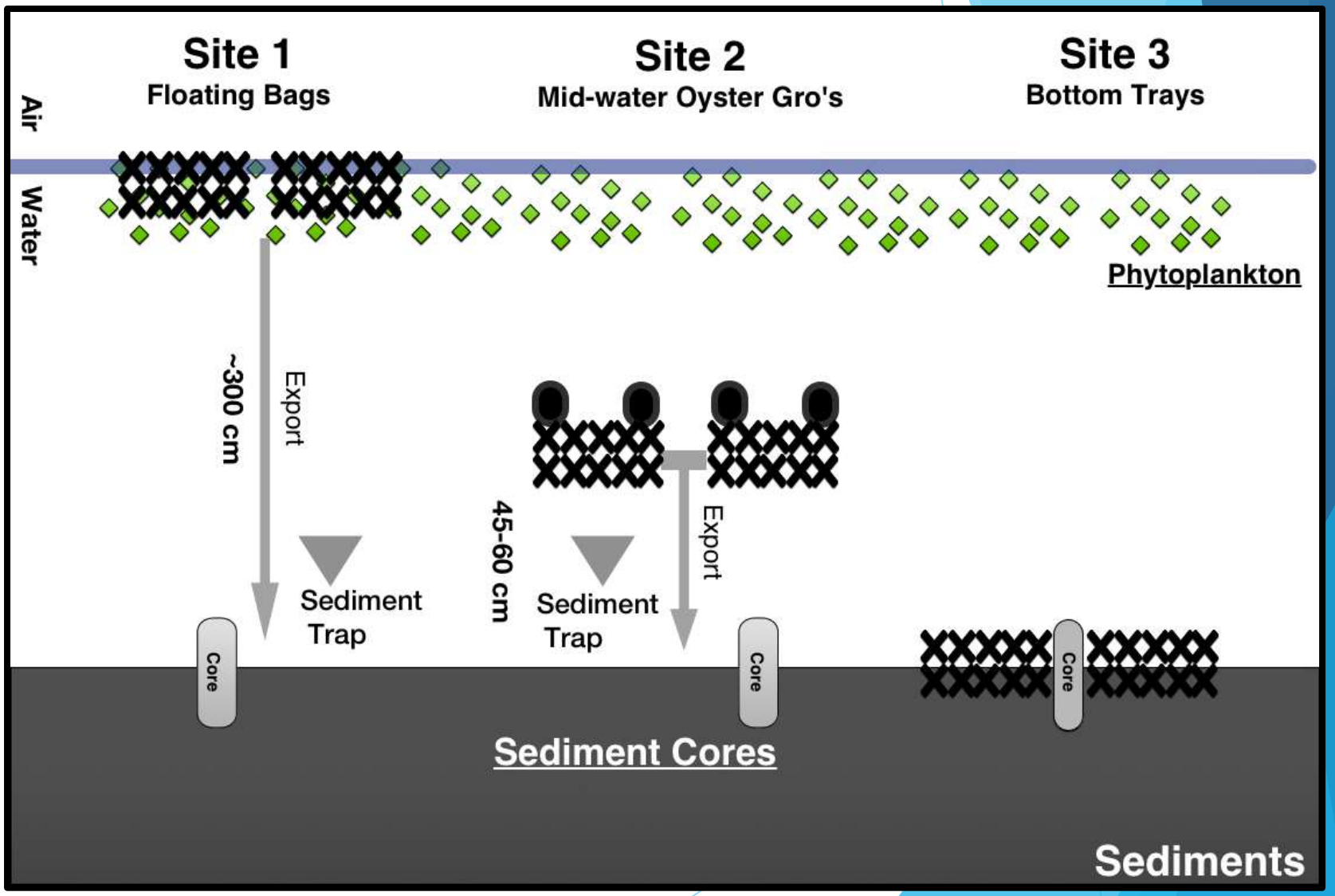


Table 1. Data Collection and Analysis Matrix

Field Measurements	Geochemistry	Molecular
Year 1 and Year 2: **Water Quality Measurements**: Conductivity, DO, pH, temperature, turbidity, oyster mass **Flux measurements**: SOD, N_2, NO_3^-, NO_2^-, NH_4^+, $\delta^{15}NO_3^-$, $\delta^{15}NO_2^-$, $\delta^{15}NH_4$	Year 1 and Year 2: **Sediment cores**: Total C, inorganic C, organic C, total N, total sulfur, C:N, %C, %N, $\delta^{13}C$, $\delta^{15}N$ **Sediment Traps**: Total C, inorganic C, organic C, total N, total sulfur, C:N, %C, %N, $\delta^{13}C$, $\delta^{15}N$ **Water column**: NO_3^-, NO_2^-, NH_4^+, $\delta^{15}NO_3^-$, $\delta^{15}NO_2^-$, $\delta^{15}NH_4^+$, POC, PON **Porewater**: NO_3^-, NO_2^-, NH_4^+, DO, $\delta^{15}NO_3^-$, $\delta^{15}NO_2^-$, $\delta^{15}NH_4^+$ **Oyster Tissue**: Total N , C:N, %C, %N, $\delta^{13}C$, $\delta^{15}N$	Year 1: **Sediment cores**: RNA and DNA extraction for RT-qPCR, metatranscriptome library preparation, and iTag sequencing **Water Column**: Chlorophyll A Year 2: **Sediment cores**: DNA extraction, iTag sequencing **Water Column**: Chlorophyll A

Mass Balance

- How much of the ambient N moves into the oyster tissue?

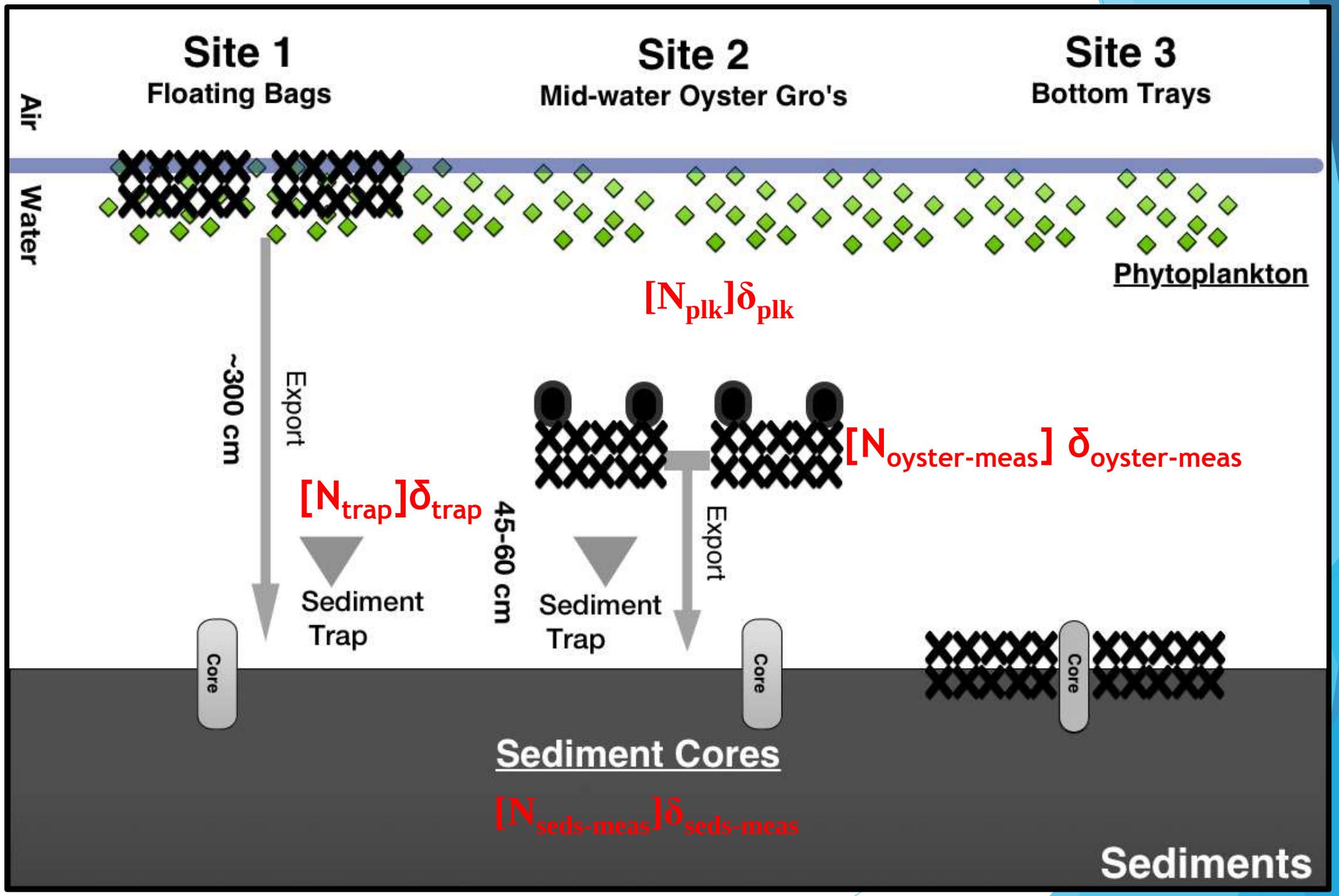
$$[N_{oyster\text{-}meas}]\,\delta_{oyster\text{-}meas} = [N_{oyster\text{-}initial}]\delta_{oyster\text{-}initial} + \varepsilon[N_{plk}]\delta_{plk}$$

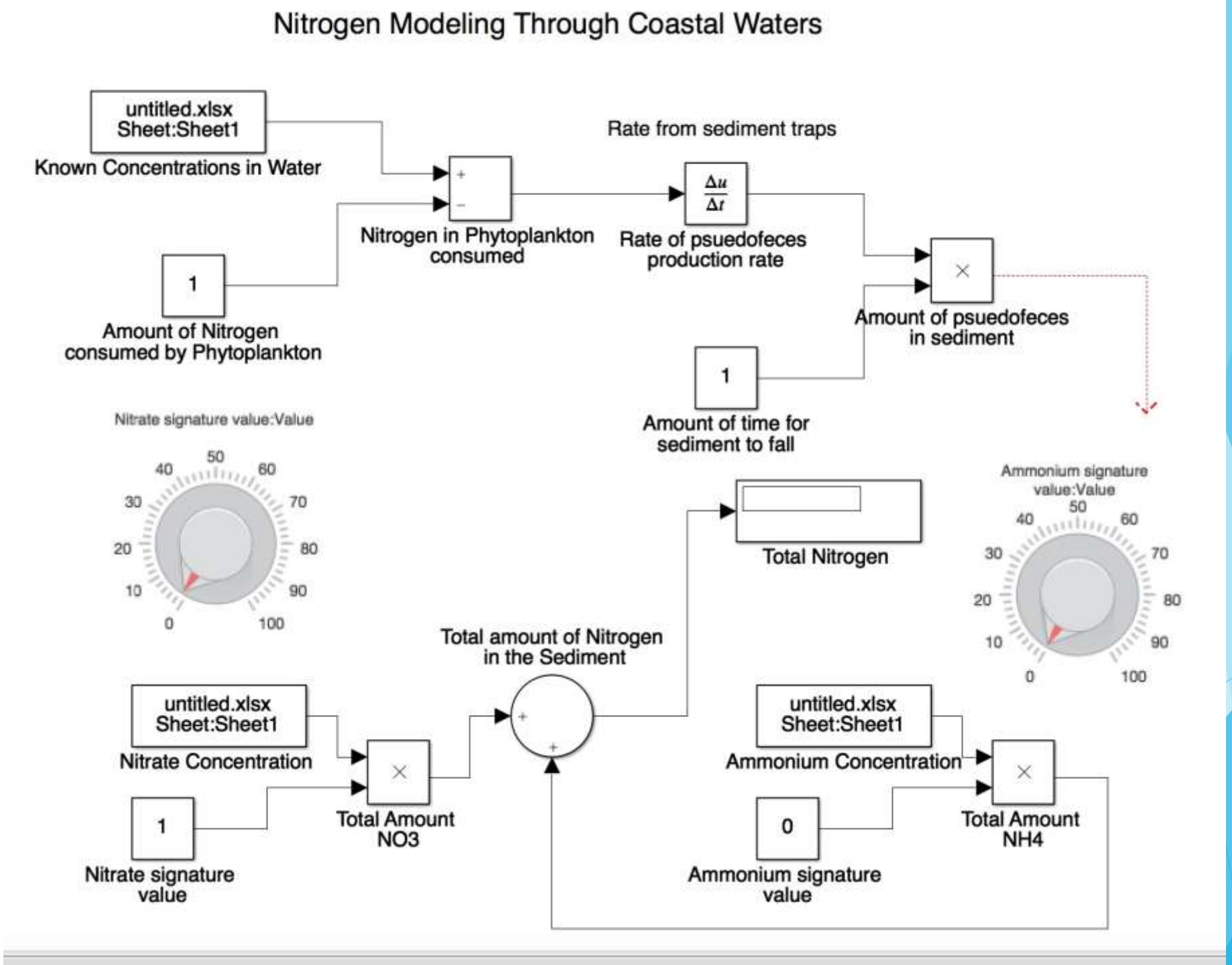
- How much N makes it to the sediments (export N)

$$[N_{trap}]\delta_{trap} = [N_{plk}]\delta_{plk} + [N_{psuedofeces}]\delta_{puesdofeces} - \varepsilon[N_{respiration}]\delta_{respiration}$$

- How much N is removed (missing) from the sediments

$$[N_{seds\text{-}meas}]\delta_{seds\text{-}meas} = [N_{seds}]\delta_{seds} + [N_{trap}]\delta_{trap} - \varepsilon_{remove}[N_{loss}]\delta_{loss}$$


Site 1
Floating Bags
Site 2
Mid-water Oyster Gro's
Site 3
Bottom Trays
Air
Water
Phytoplankton
$[N_{plk}]\delta_{plk}$
~300 cm
Export
$[N_{trap}]\delta_{trap}$
45-60 cm
$[N_{oyster\text{-}meas}]\ \delta_{oyster\text{-}meas}$
Export
Sediment Trap
Sediment Trap
Core
Core
Core
Sediment Cores
$[N_{seds\text{-}meas}]\delta_{seds\text{-}meas}$
Sediments


Nitrogen Modeling Through Coastal Waters
untitled.xlsx
Sheet:Sheet1
Known Concentrations in Water
Rate from sediment traps
Nitrogen in Phytoplankton consumed
Rate of psuedofeces production rate
1
Amount of Nitrogen consumed by Phytoplankton
Amount of psuedofeces in sediment
1
Amount of time for sediment to fall
Nitrate signature value:Value
Ammonium signature value:Value
Total Nitrogen
Total amount of Nitrogen in the Sediment
untitled.xlsx
Sheet:Sheet1
Nitrate Concentration
Total Amount NO3
1
Nitrate signature value
untitled.xlsx
Sheet:Sheet1
Ammonium Concentration
Total Amount NH4
0
Ammonium signature value

Acknowledgements

- Stonehill
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  - Anna Pickney
  - Pete Giannini
  - Everton Pacheco
- WHOI
  - Vivian Mara
  - Alec Cobban
  - Claudia Mazur
  - Becka Bense
  - Emma Keeler
  - Sarah Lott
  - Becka Cox
  - David Beaudoin
  - Taylor Sehein
- Falmouth
  - Chuck Martinsen
  - Christina Lovely
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- WBNERR
  - Tonna-Marie Rogers
  - Joan Muller
  - Jim Rassman

Undergraduates
High school students