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Annie E. Murphy
Virginia Institute of Marine Science

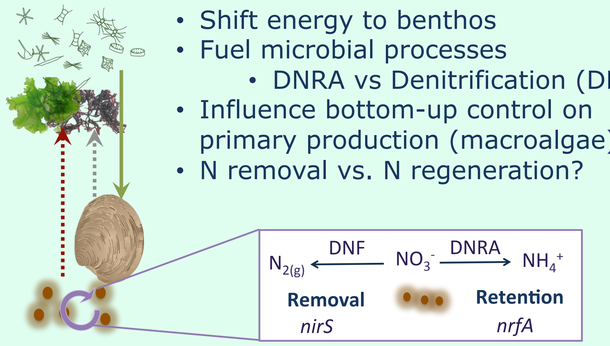
Iris C. Anderson
Virginia Institute of Marine Science

Mark W. Luckenbach
Virginia Institute of Marine Science

Effects of Commercial Clam Aquaculture on Biogeochemical Cycling in Shallow Coastal Ecosystems

Anna E. Murphy[1], Iris C. Anderson[1], Ashley R. Smyth[1], B.K. Song[1], Mark W. Luckenbach[1]
Kyle A. Emery[2], Mike L. Pace[2], Daniele Nizzoli[3], Marco Bartoli[3]
[1]Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, VA
[2]University of Virginia, Charlottesville, VA; [3]Università degli Studi di Parma, Parma, Italy

Benthic-Pelagic Coupling



- Shift energy to benthos
- Fuel microbial processes
  - DNRA vs Denitrification (DNF)
- Influence bottom-up control on primary production (macroalgae)
- N removal vs. N regeneration?

Objectives

- Determine the role clam aquaculture plays in C and N cycling, by quantifying:
  - Nutrient regeneration
  - Benthic metabolism
  - Denitrification vs. DNRA
- Determine environmental factors that influence these rates; multiple sites
- Assess effects on an ecosystem scale
  - Is clam aquaculture a net sink for N?

Study Sites

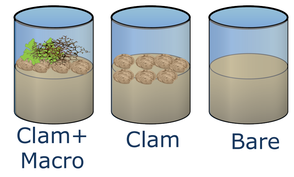
Cherrystone Inlet, VA
Smith Island Bay, VA

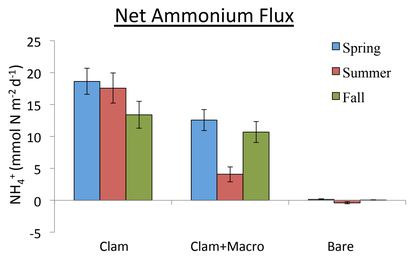
Sacca di Goro, Italy

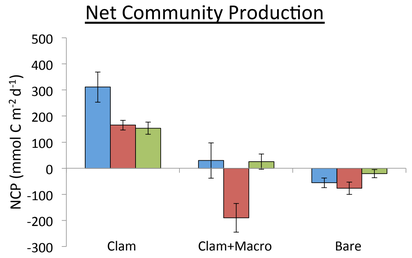
Nutrient Regeneration at Clam Beds Fuels Macroalgae

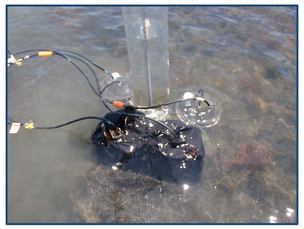
Seasonal *in situ* flux measurements in Cherrystone Inlet

Treatments:





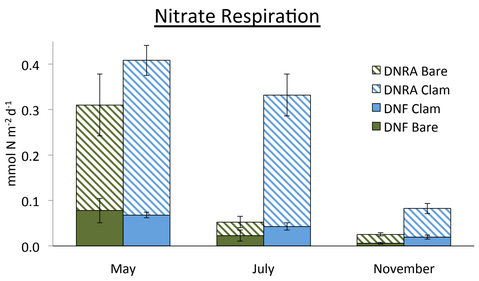


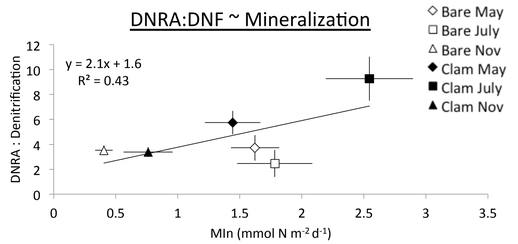


- Significantly higher NH_4^+ effluxes at clam beds due to clam excretion and microbial mineralization of biodeposits
- NH_4^+regeneration at the clam beds ~37-98% of the N input from the watershed
- Macroalgae sequester a significant portion of NH_4^+; flux reduced by 20-77% in the presence of macroalgae
- Clam sediments provide 58-122% of the macroalgal N demand

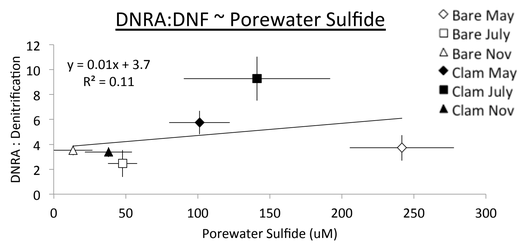
DNRA Favored over Denitrification - Cherrystone Inlet

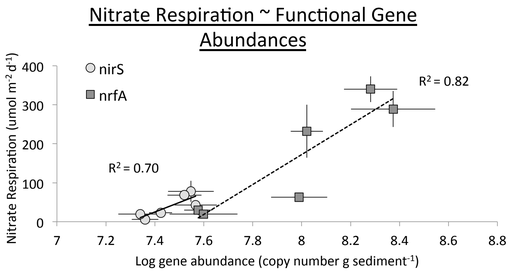
Isotope pairing technique ($^{15}NO_3$ added) to measure denitrification (DNF) and DNRA
Isotope pool dilution ($^{15}NH_4$ added) to measure gross mineralization (Min) rates





- DNRA and DNF significantly enhanced at clam beds compared to uncultivated sediments
- Clam sediments had significantly higher *nrfA* (DNRA) than uncultivated; *nirS* (DNF) similar across seasons and sediment type





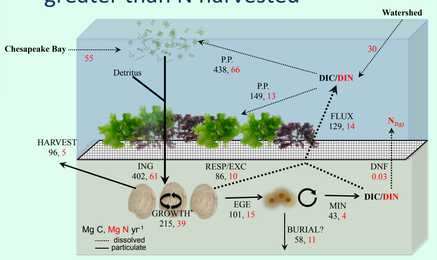
- DNRA : DNF significantly higher at the clam beds
- DNRA favored due to supply of labile organic carbon, low water column nitrate, and sulfidic conditions
- *nrfA* (DNRA) and *nirS* (DNF) correlated with rates

Ecosystem Scale Changes

- Scaled clam bioenergetics to Cherrystone Inlet
- Created C and N budget for the system

- Clam beds occupy 3% of the Inlet
- Clams filter entire system in 2-15 days
- N regenerated at clam beds ~3-fold greater than N harvested

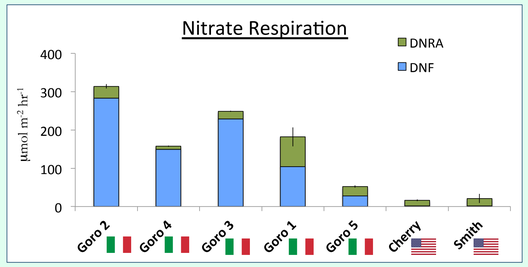
% of Filtered Particulate N	
Clam Excretion	16%
Clam Egestion	25%
Microbial Min	7%
Harvested	8%
Denitrification	0.05%



- Based on clearance time relative to water residence time (2-3 days), and location of clams near mouth, food source is likely from Chesapeake Bay (external subsidy)
- Thus, N regenerated by clam cultivation is allochthonous N and may lead local eutrophication

But, Location Matters!

- DNF and DNRA rates are higher in Italy compared to US
- DNF > DNFA in Italy; DNF < DNRA in US



Low salinity
High NO_3^-
→
High Salinity
Low NO_3^-

- Relative availability of labile carbon to nitrate dictates dominant pathway:
  - DNF exceeds DNRA when NO_x is high (up-estuary, Italy)
  - DNRA exceeds DNF when NO_x is low (US sites, coupled to nitrification)

Acknowledgements

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