Effects of human-facilitated bivalve populations on energy and nitrogen flow in coastal and marine ecosystems

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February 22, 2022

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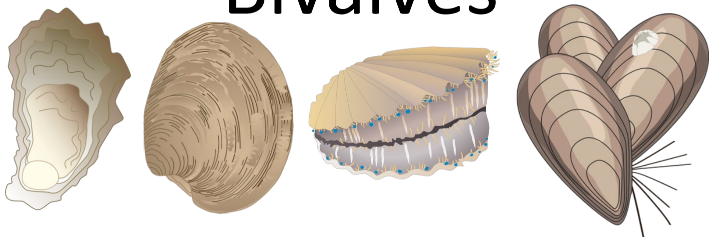
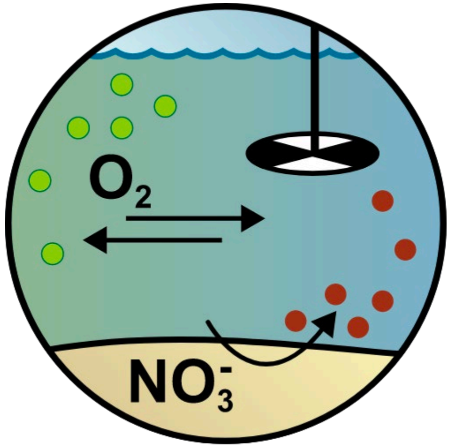
Energy Flow is Important

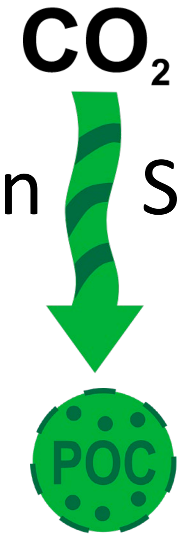
Bivalves



Water Quality

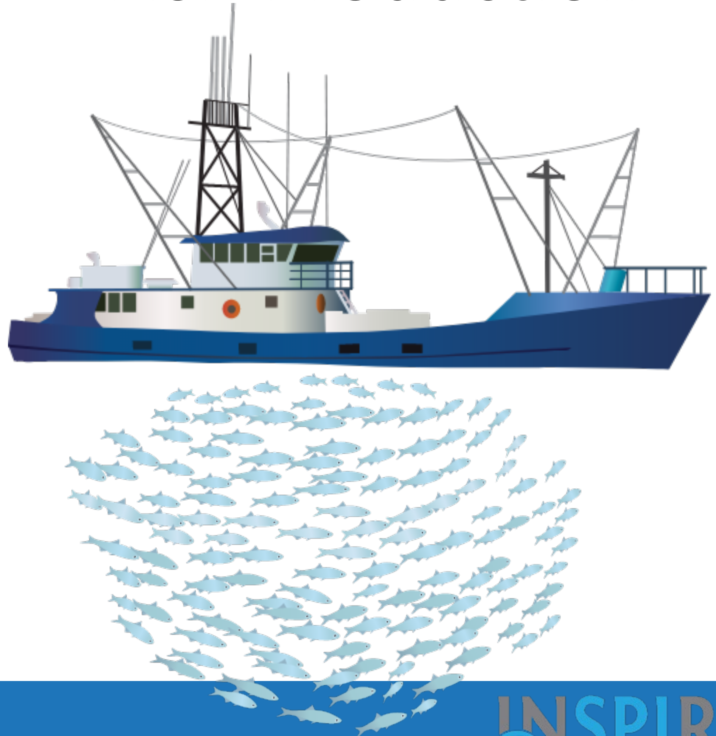


Nitrogen Removal

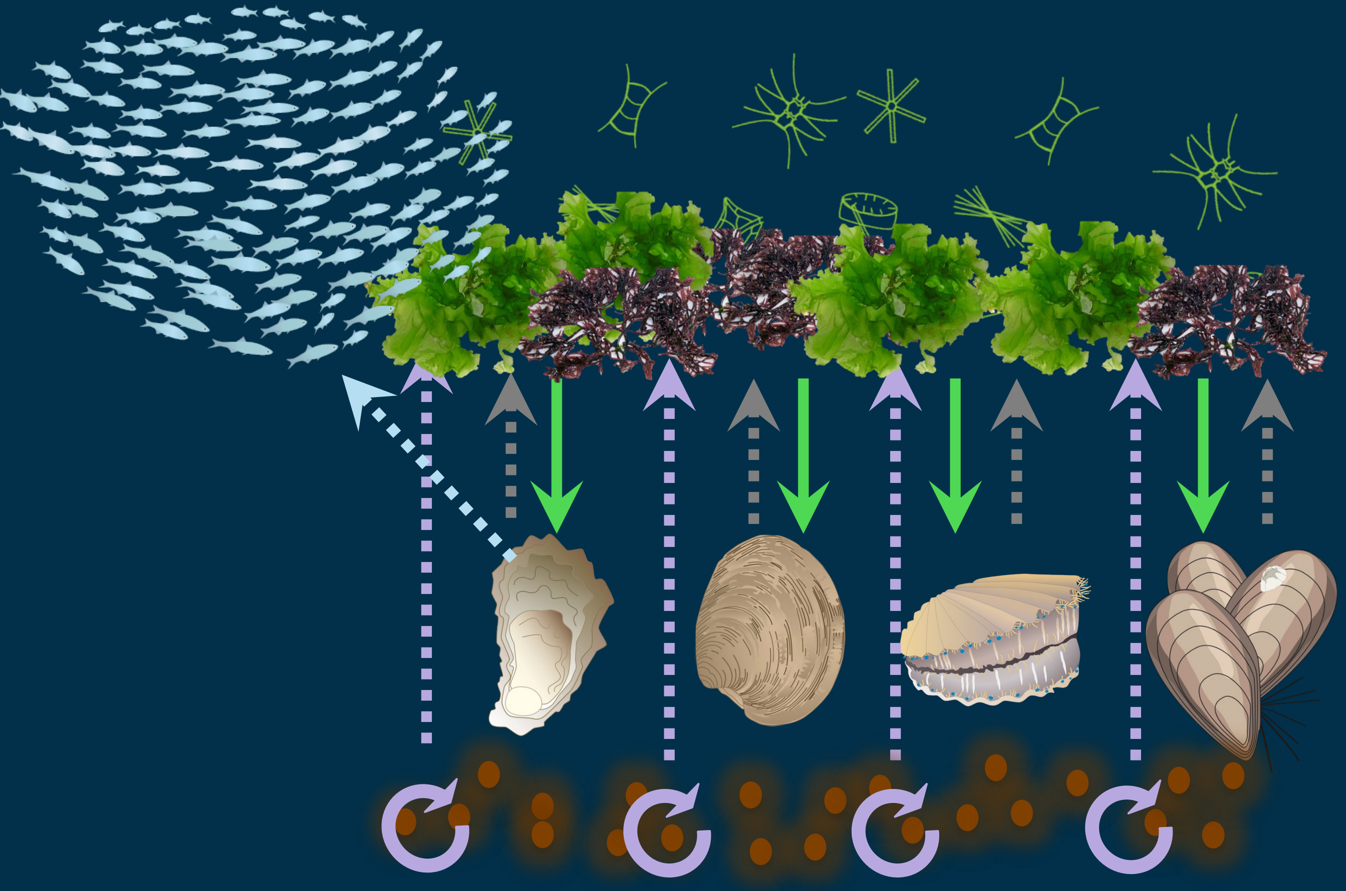


Carbon Sequestration

Fish Production



Bivalves and Benthic-Pelagic Coupling



Top-down vs. Bottom-up depends on:

- Environmental context
- Bivalve physiology, density
- Microbial community

Nitrogen and Carbon Transformers

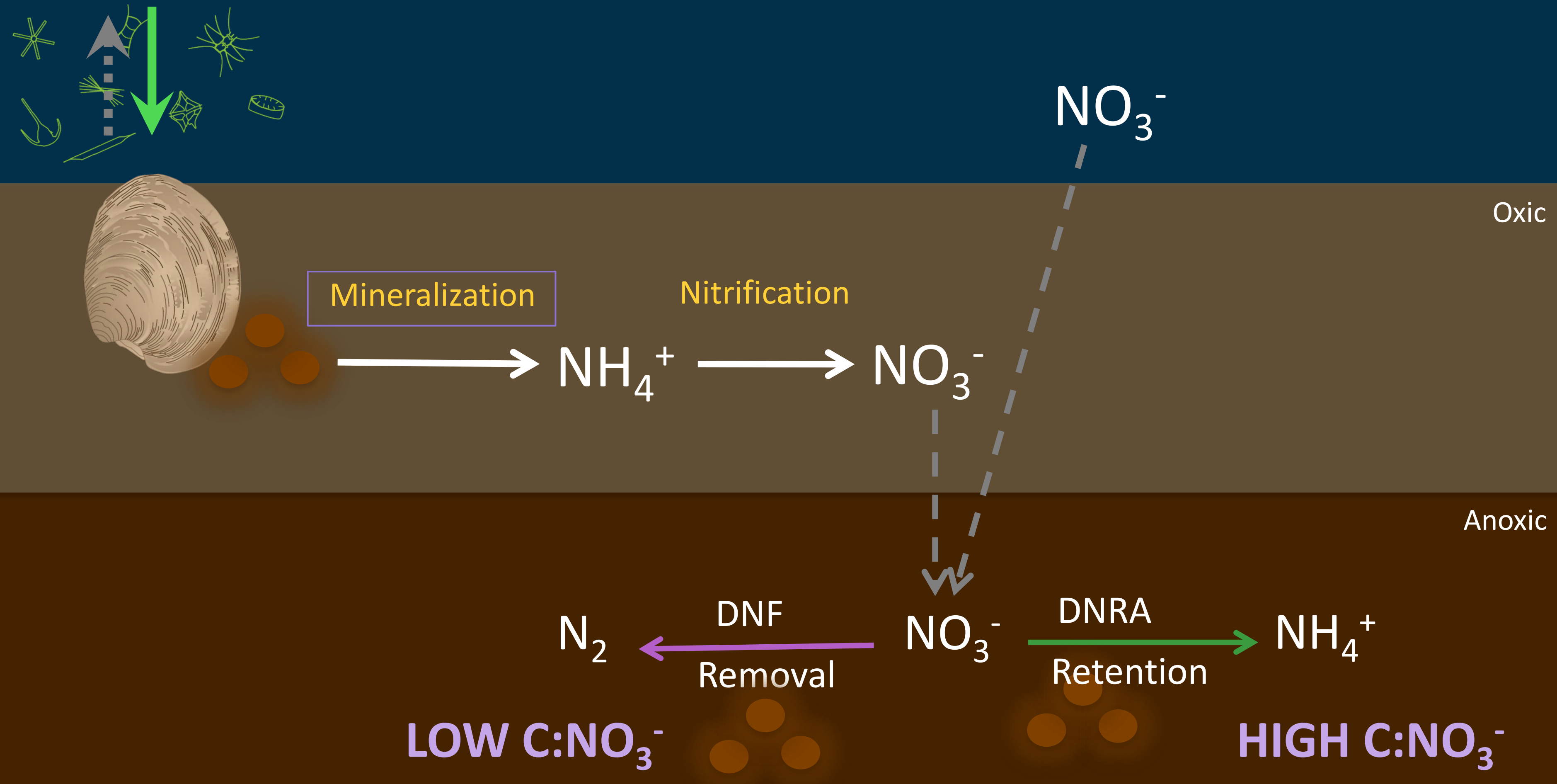
Human-Facilitated Bivalve Populations

Human-Facilitated Bivalve Populations

- How does clam aquaculture influence nitrogen cycling and microbial N removal?
- Can clam aquaculture influence ecosystem-scale energy flow?

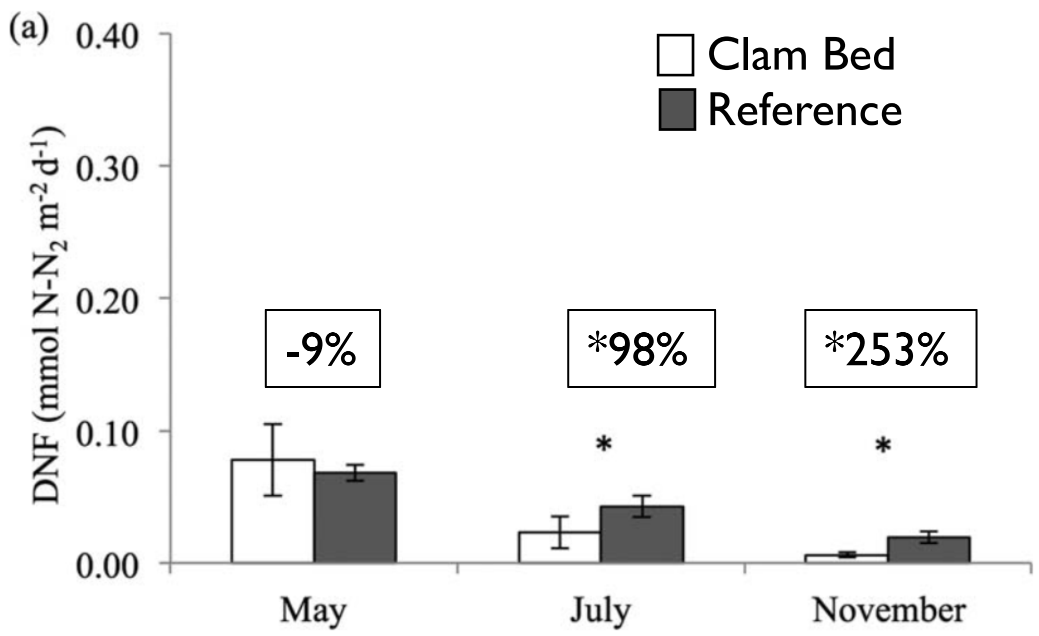
- How may epifaunal growth on novel surfaces associated with offshore wind development influence ecosystem-scale energy flow?

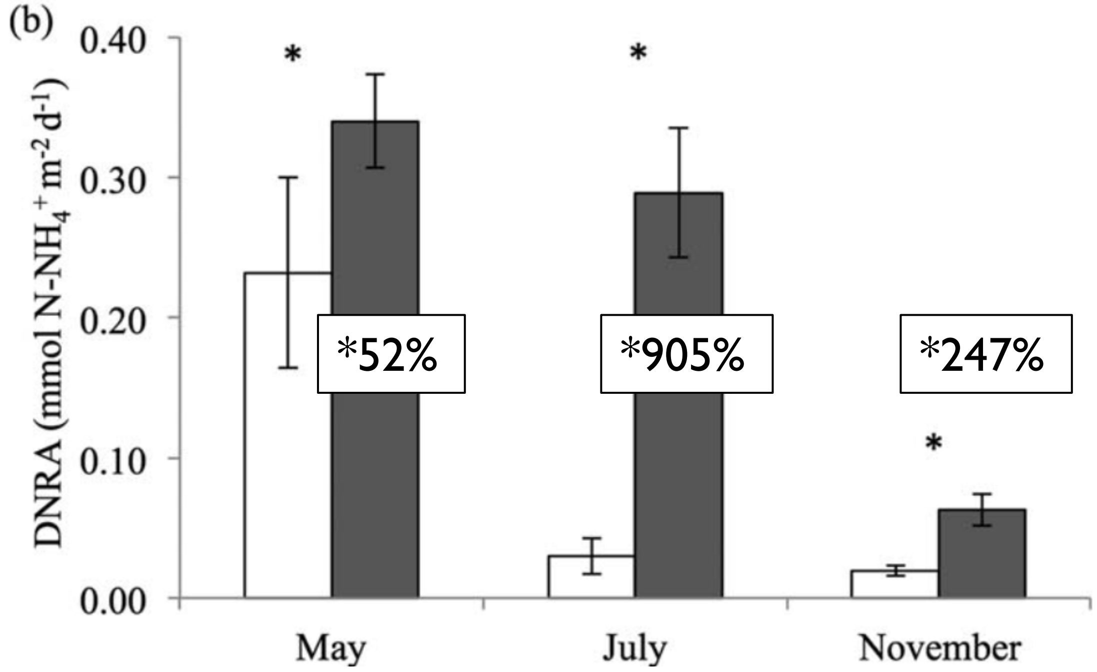
Which pathway is dominant?



Hard Clam Aquaculture

Chesapeake Bay, Virginia





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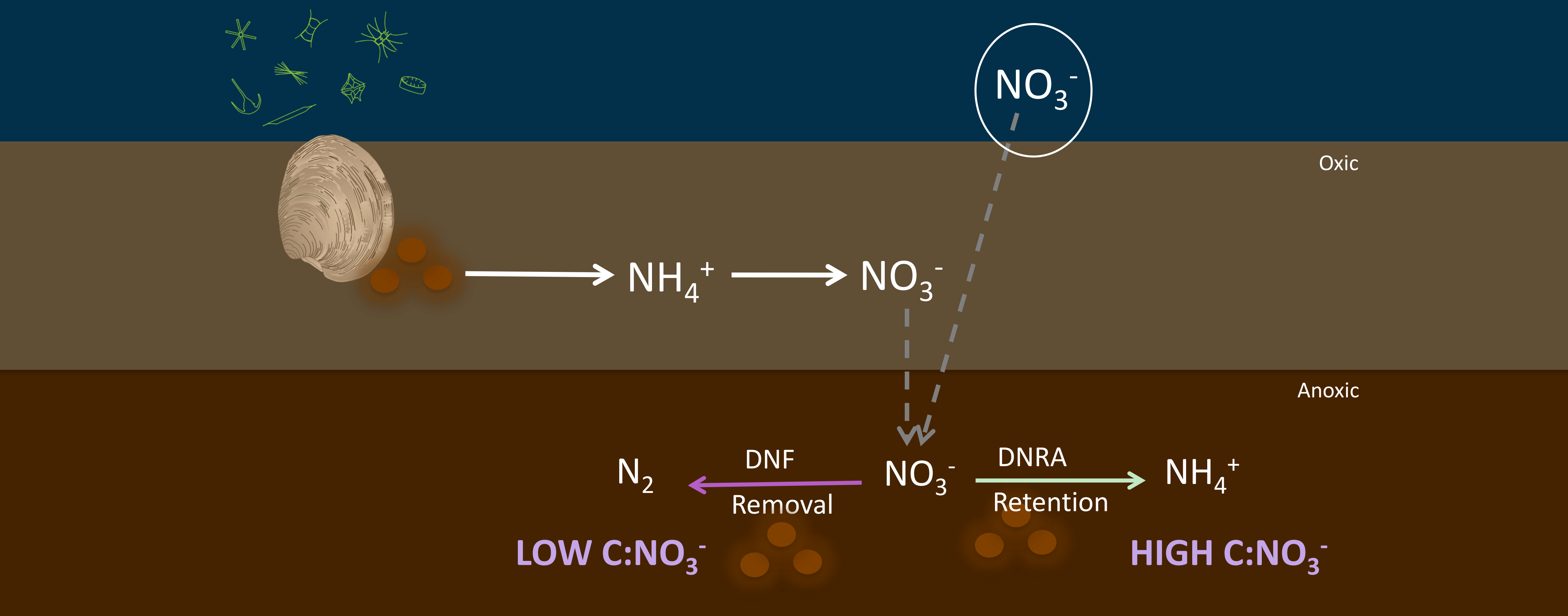
Why do clam beds in Cherrystone favor DNRA over DNF?

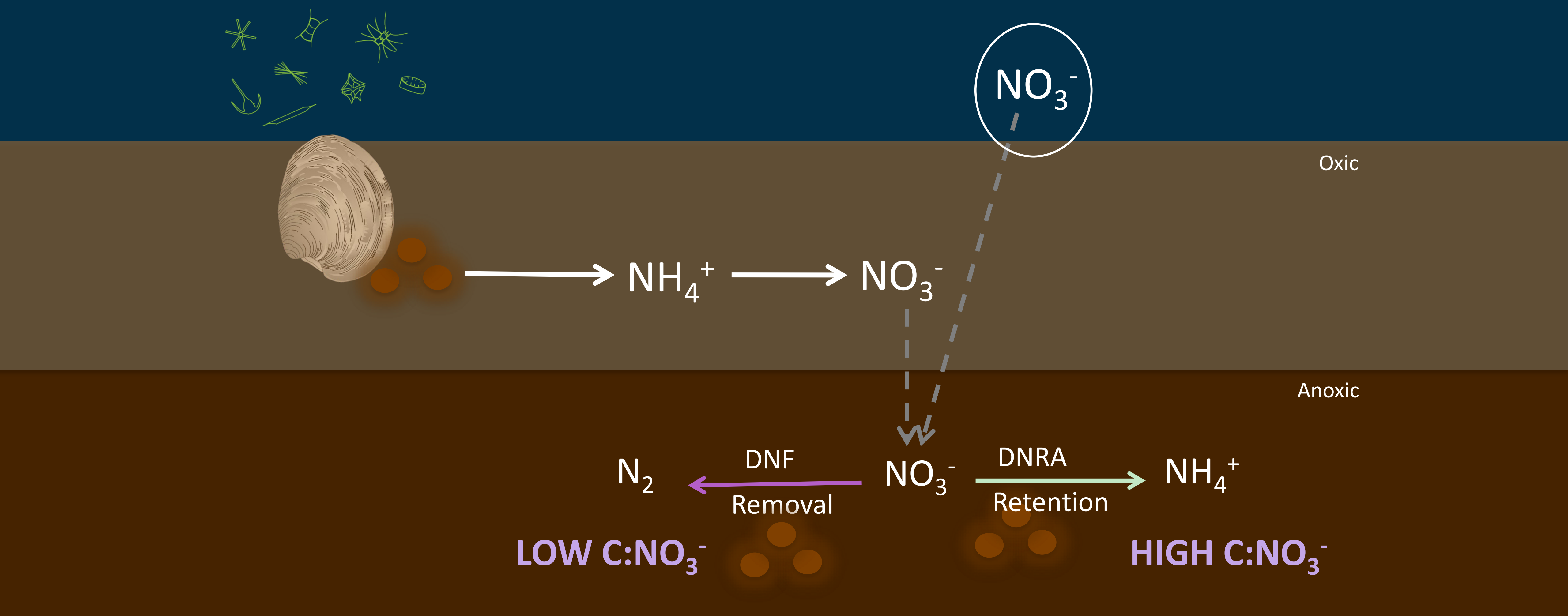
Controls:



Why do clam beds in Cherrystone favor DNRA over DNF?

Controls:

- [NO_3^-] water column: 0 – 0.5 µM

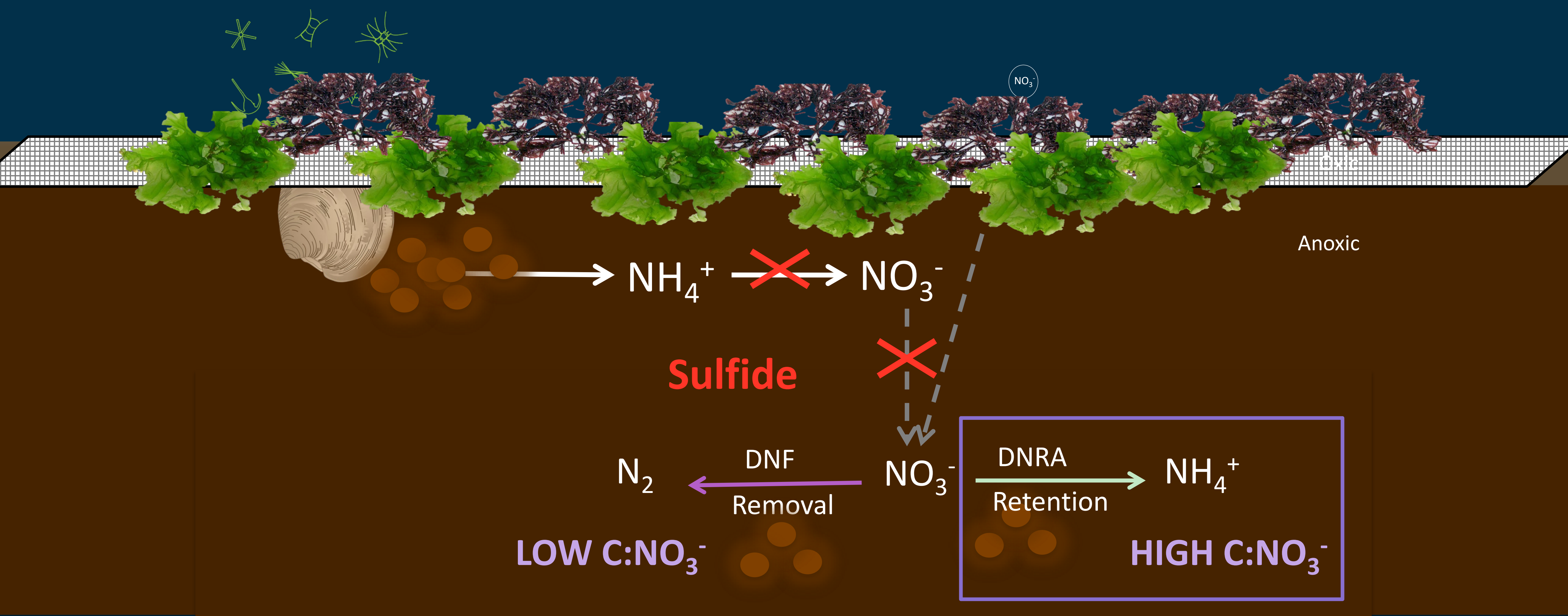


Why do clam beds in Cherrystone favor DNRA over DNF?

Dependent on environment

Controls:

- $[NO_3^-]$ water column: 0 – 0.5 µM
- Low O_2 and High Sulfide
- Carbon – quality and quantity



Human-Facilitated Bivalve Populations

- How does clam aquaculture influence nitrogen cycling and microbial N removal?

Increase NO_3^- respiration; DNRA > DNF

- Can clam aquaculture influence ecosystem-scale energy flow?

- How may epifaunal growth on novel surfaces associated with offshore wind development influence ecosystem-scale energy flow?

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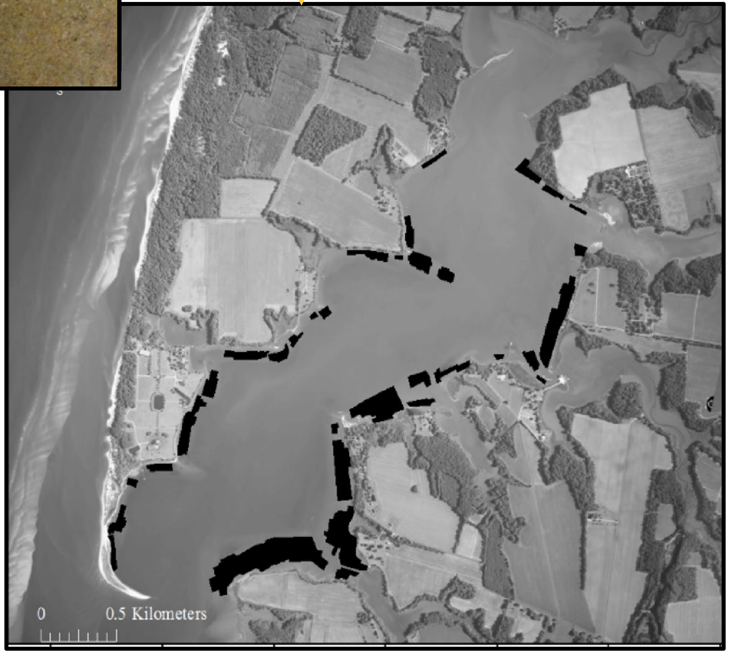
Ecosystem-scale Energy Flow

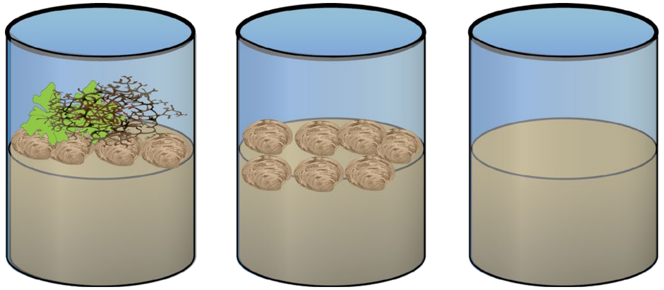
Cherrystone Inlet, VA

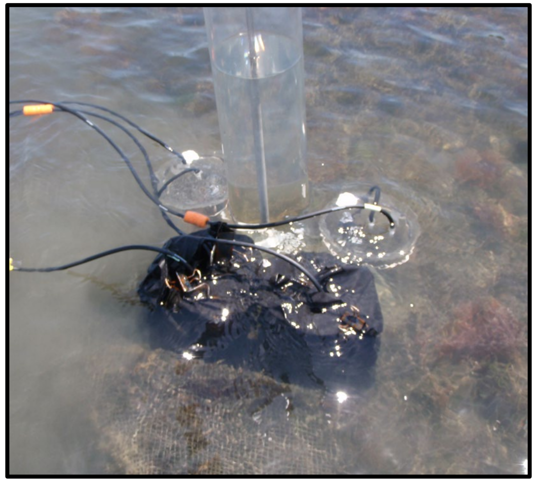


1. Estimate the clam population and size distribution

2. Model clam physiological rates

3. Scale seasonal benthic rates (direct measurements)





Murphy et al. 2016

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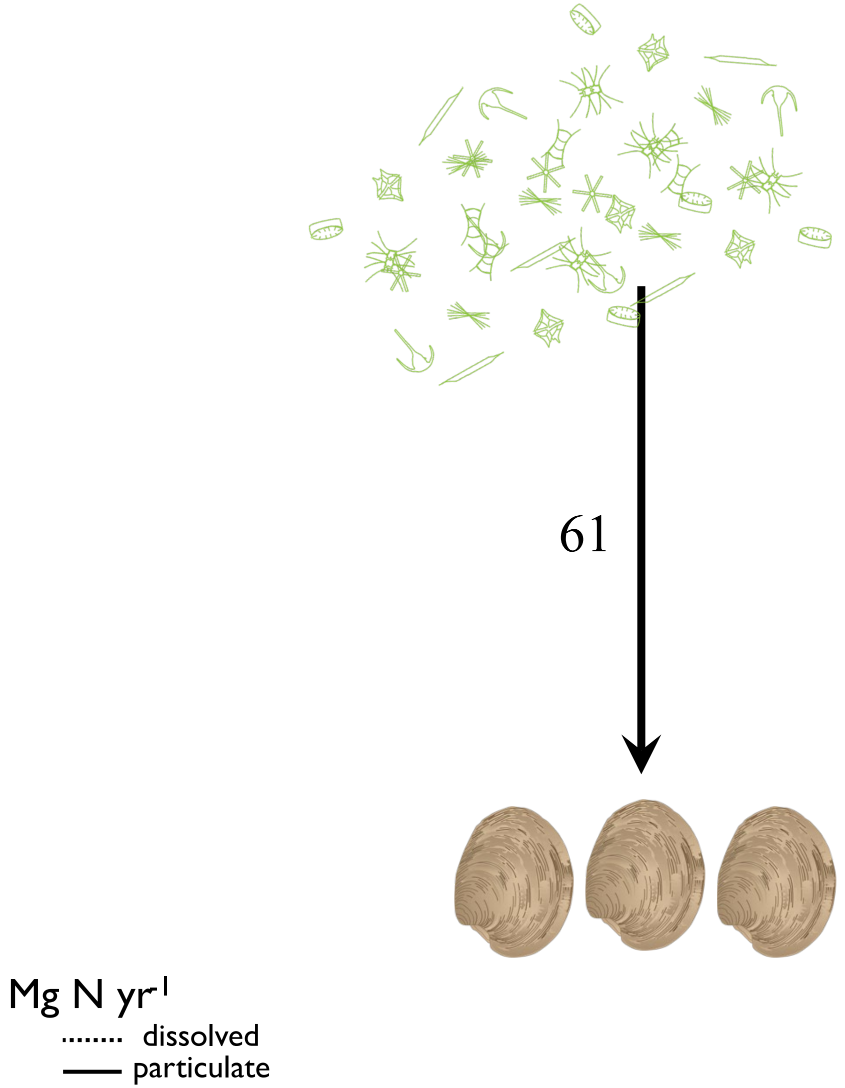
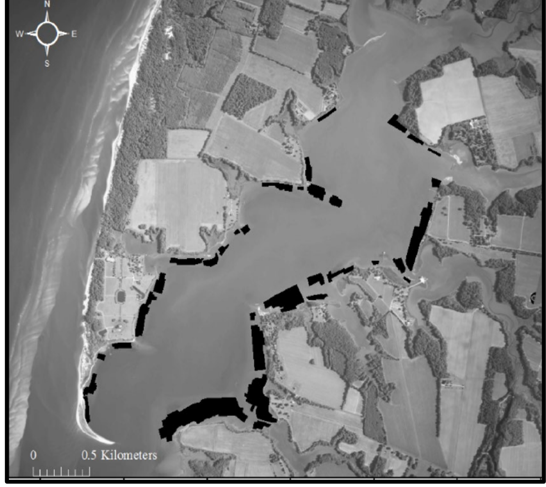
Top-Down Effects

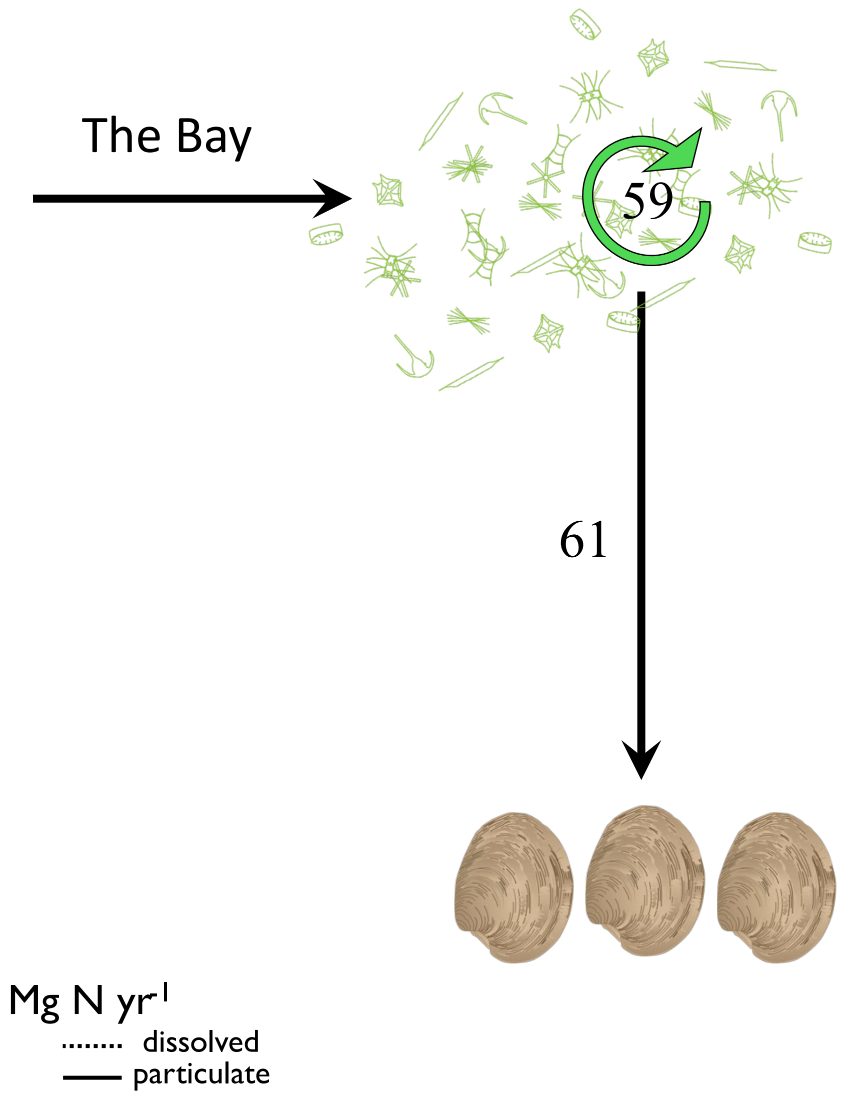


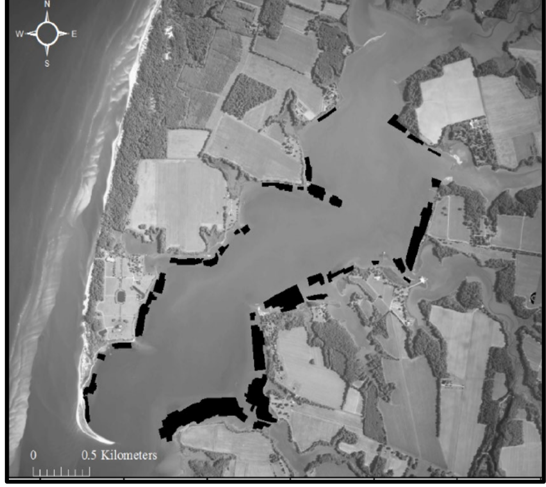


- 7 – 44% of the total Inlet volume daily
- ~2 – 15 days to filter entire Inlet

Murphy et al. 2016

Top-Down Effects

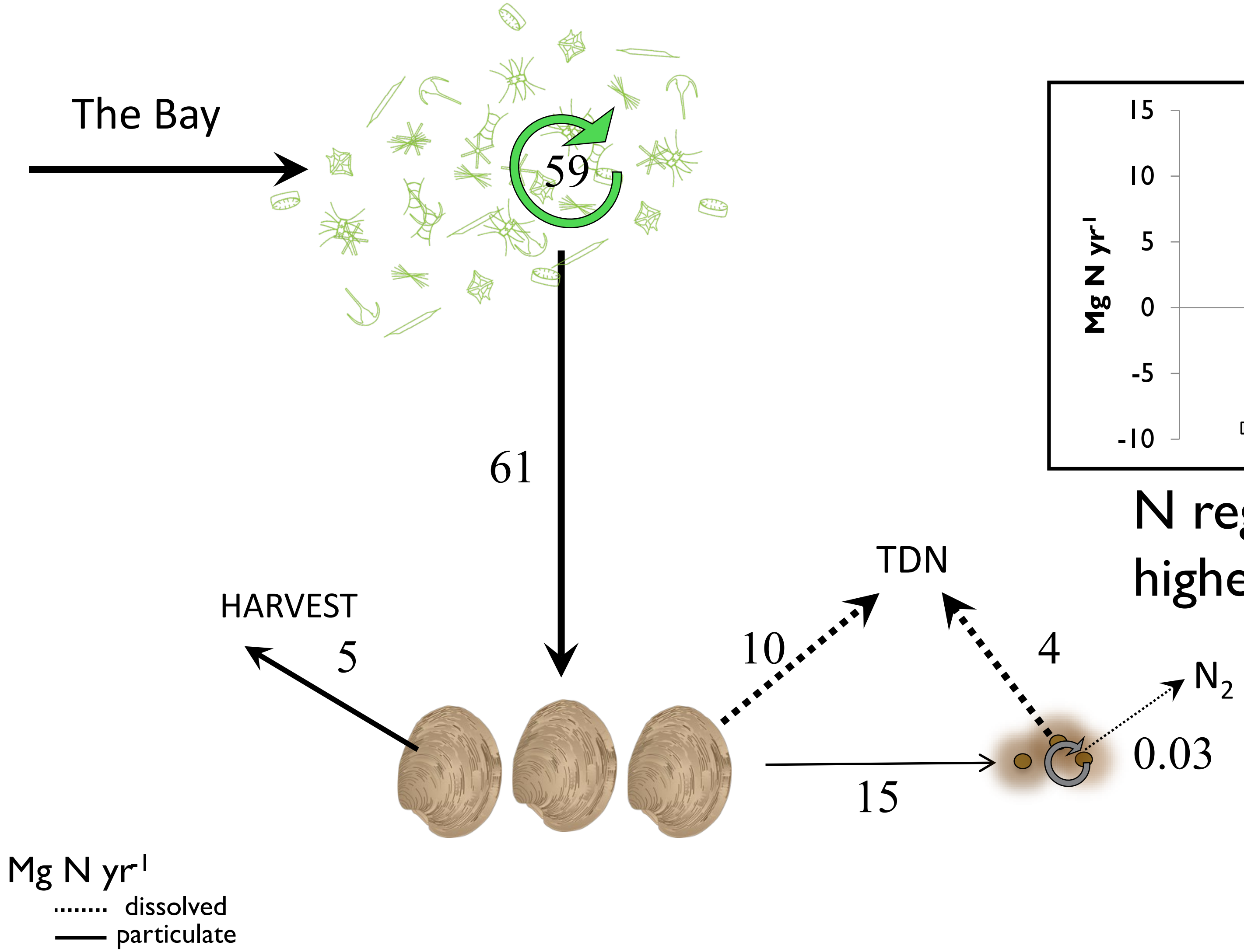


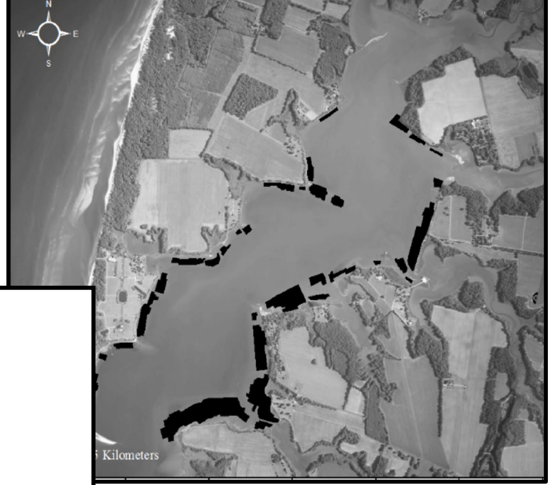


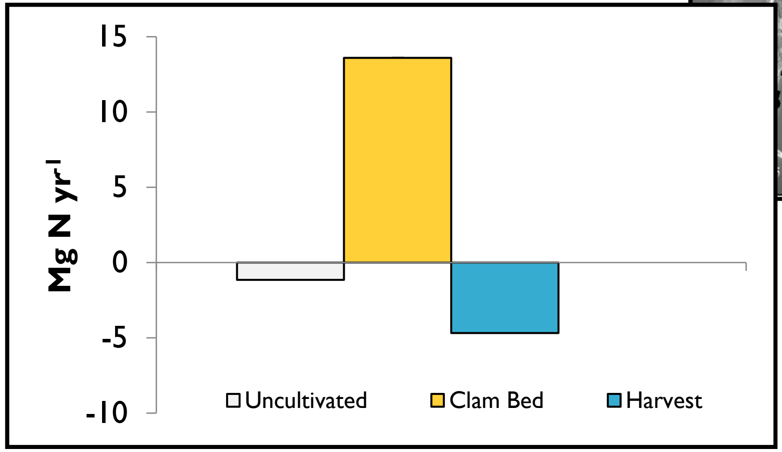
- 7 – 44% of the total Inlet volume daily
- ~2 – 15 days to filter entire Inlet
- Capacity to ingest >100% of internal phytoplankton production
    - Not entirely accessible

Murphy et al. 2016

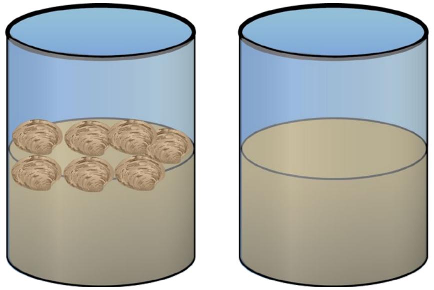
Enhanced Mineralization





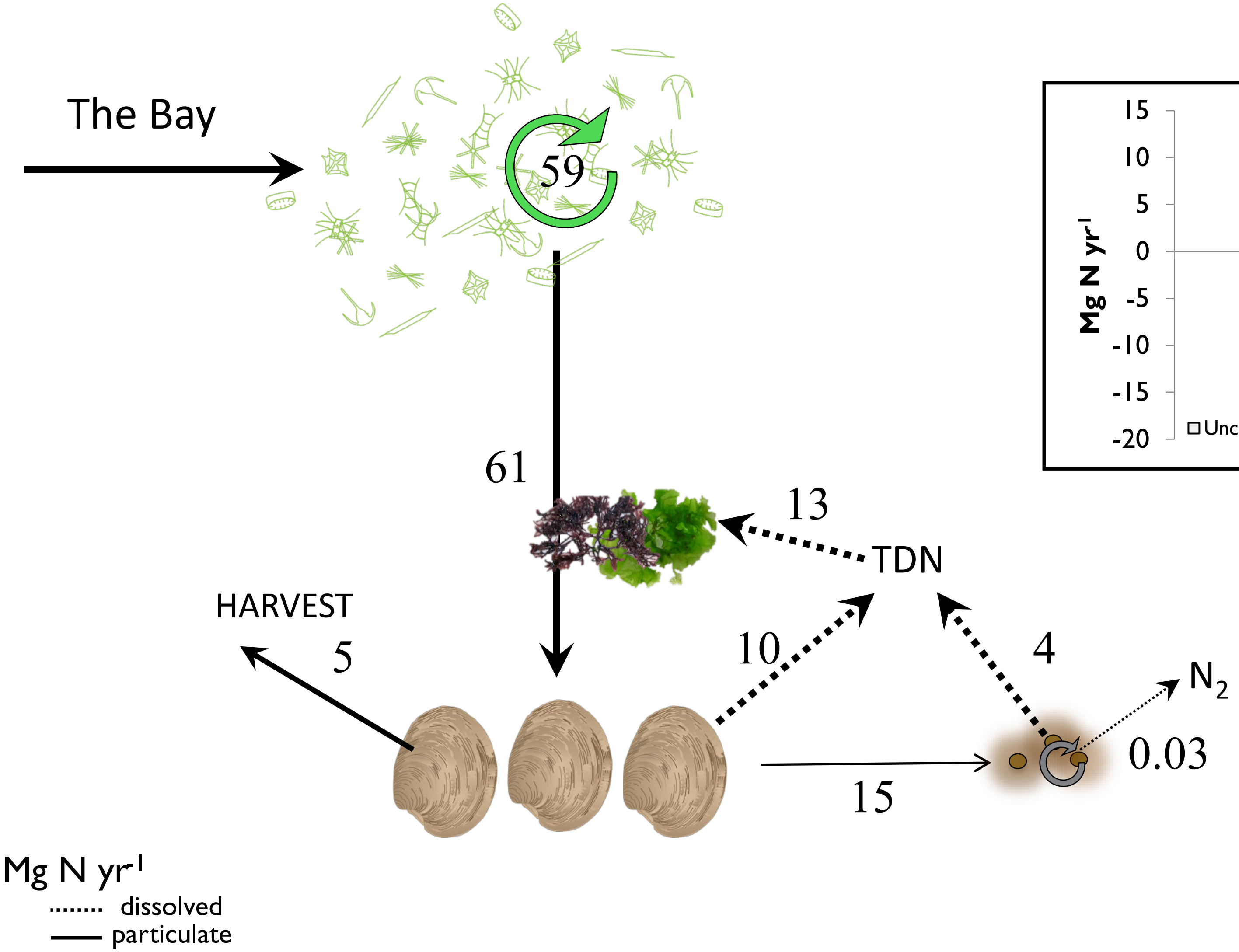


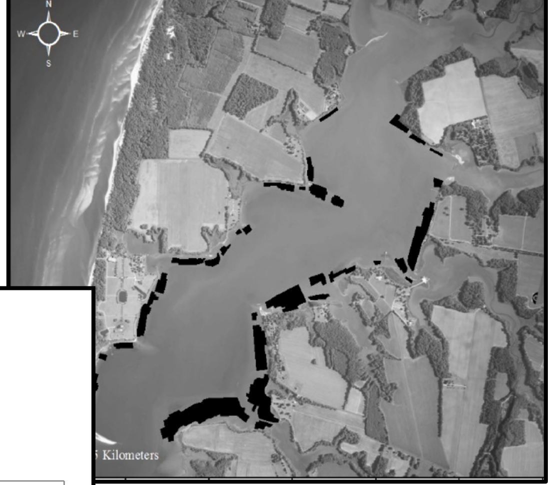
N regeneration is ~ 3-fold higher than N harvested

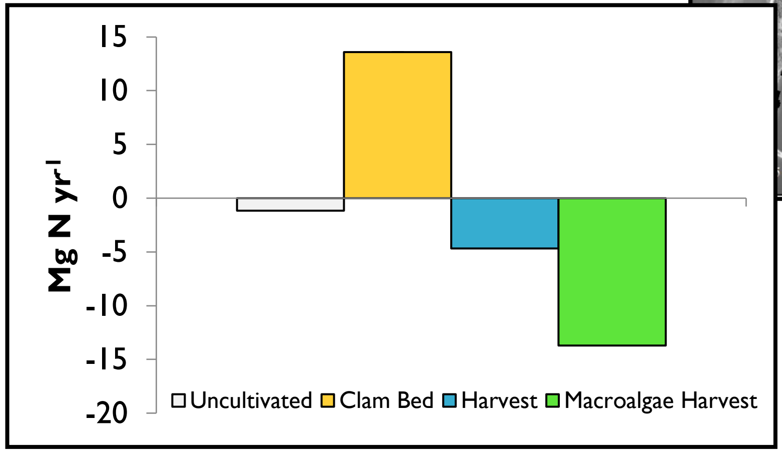


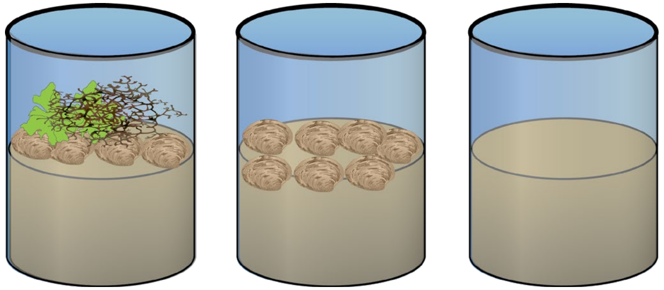
Murphy et al. 2016

Bottom-up Effects

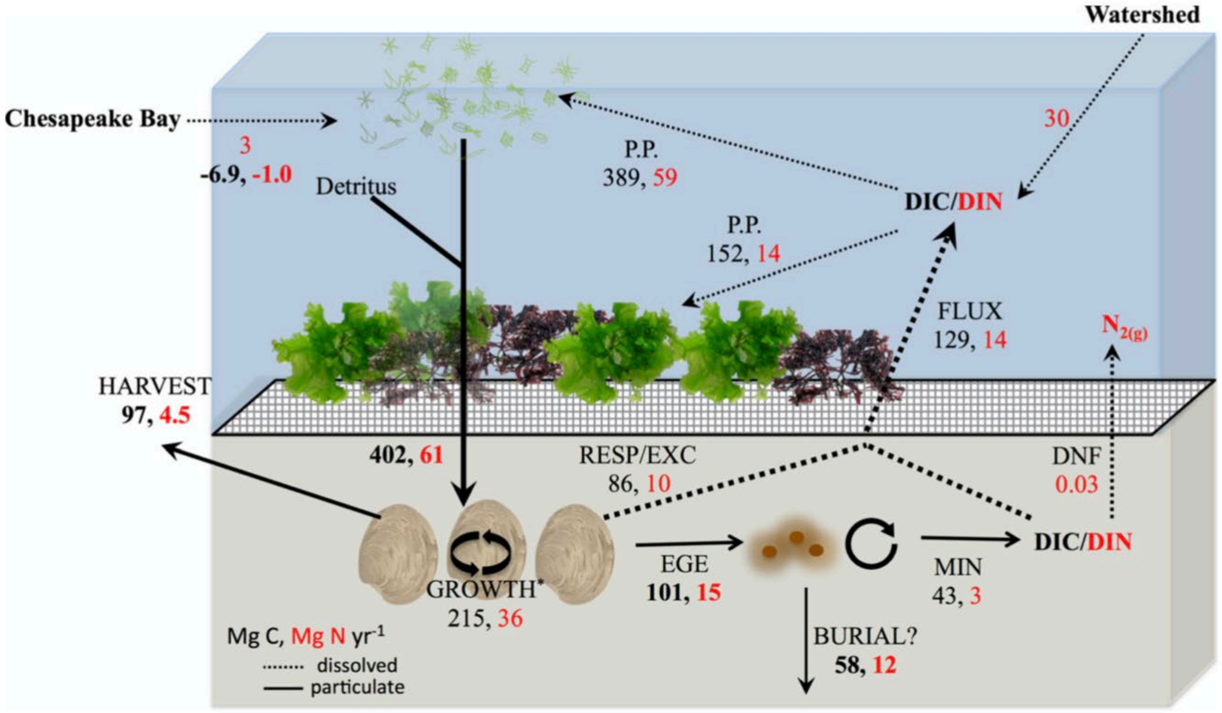








Murphy et al. 2016



- Clams filter C and N from a wide area and deliver it to Cherrystone sediments
- N regeneration > N harvested
- Clams support macroalgal production
- Macroalgal harvest would remove a large amount of N

Murphy et al. 2016

Human-Facilitated Bivalve Populations

- How does clam aquaculture influence nitrogen cycling and microbial N removal?

  Increase NO_3^- respiration; DNRA > DNF

- Can clam aquaculture influence ecosystem-scale energy flow?

  Potential for bottom-up control; (phytoplankton to macroalgae)

- How may epifaunal growth on novel surfaces associated with offshore wind development influence ecosystem-scale energy flow?

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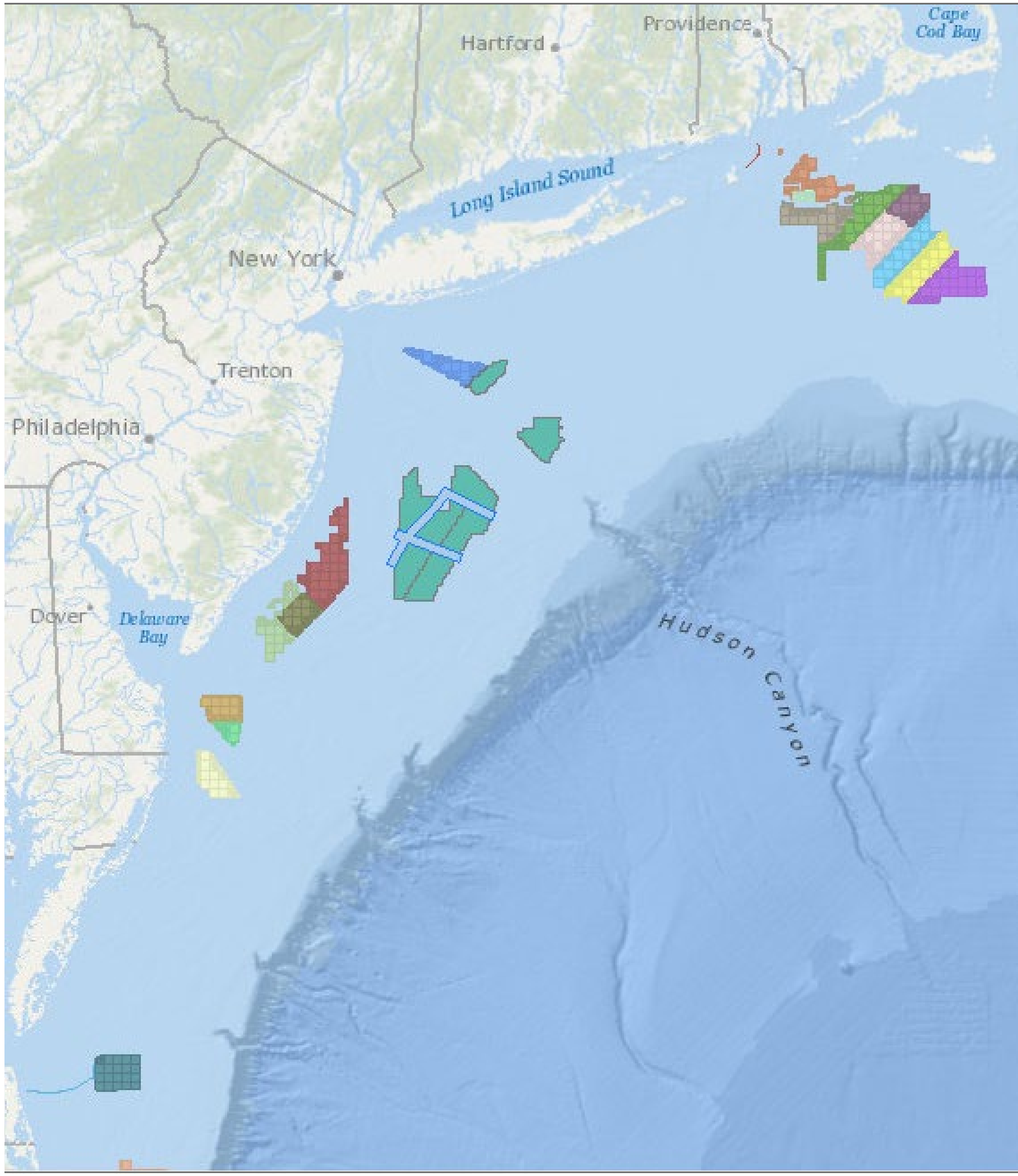
Offshore Wind Development

30 gigawatts by 2030 = 2,500 turbines (12MW)

= 3,750,000 m^2 of introduced novel habitat
[~525 football fields]



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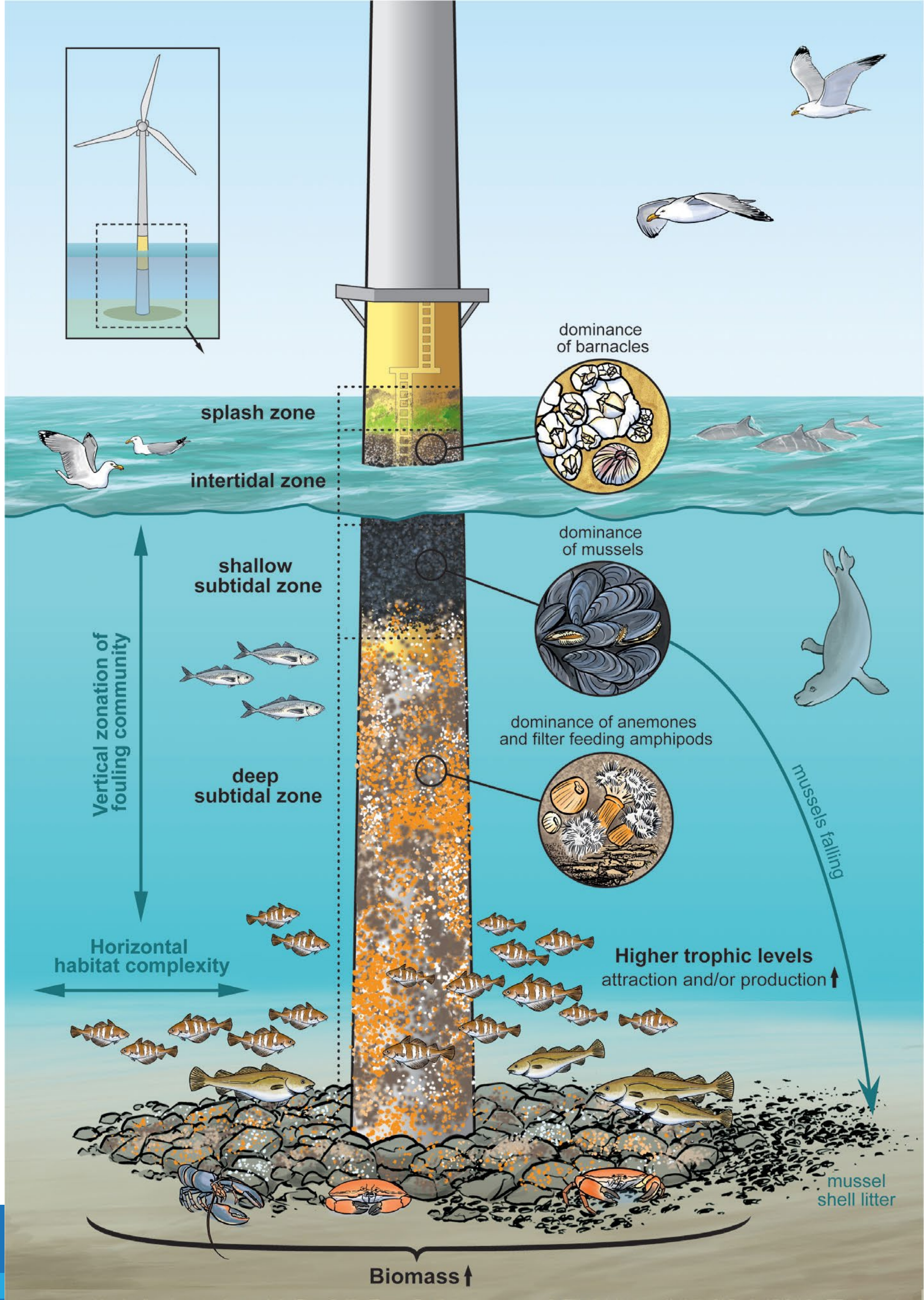
Artificial Reef Effect

Novel structures
increase basal trophic level production

Shifts in energy flow

Organic enrichment of surrounding sediments

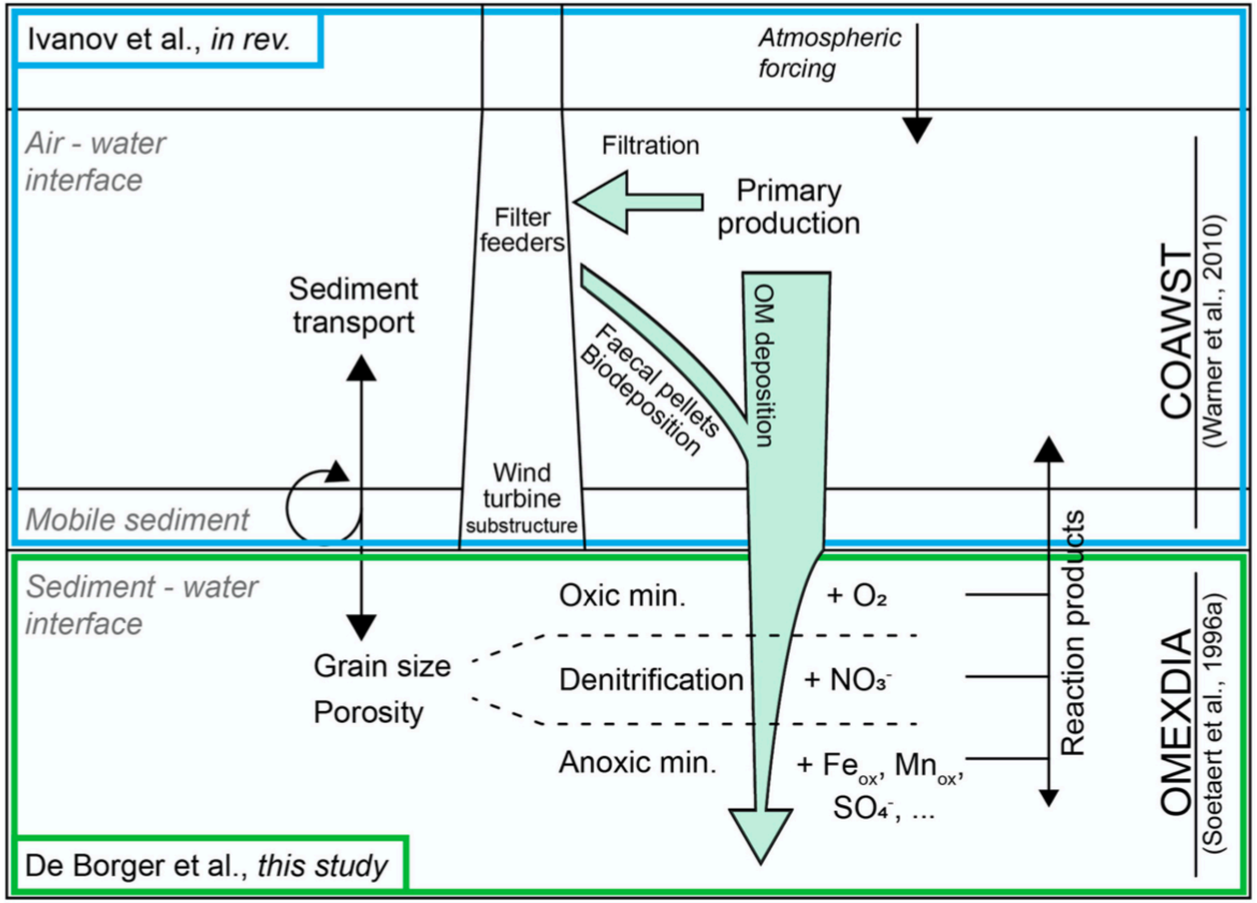
Higher trophic levels (fisheries) connectivity



Organic enrichment

Modelling studies

- TOC flux to the sediments increased (50% within 5 km)
- TOC flux decreases further away from the monopiles
- Increased total mineralization rates (~30%)
- Buildup of OC in sediments (increase by ~10%)
- Increase in anoxic metabolic rates
- DNF increase by ~2-3%



frontiers in Marine Science

ORIGINAL RESEARCH
published: 02 June 2021
doi: 10.3389/fmars.2021.631799

Check for updates

Offshore Wind Farm Footprint on Organic and Mineral Particle Flux to the Bottom

Evgeny Ivanov[1], Arthur Capet[1], Emil De Borger[2,3], Steven Degraer[3], Eric J. M. Delhez[4], Karline Soetaert[2], Jan Vanaverbeke[5] and Marilaure Grégoire[1]*

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published: 17 June 2021
doi: 10.3389/fmars.2021.632243

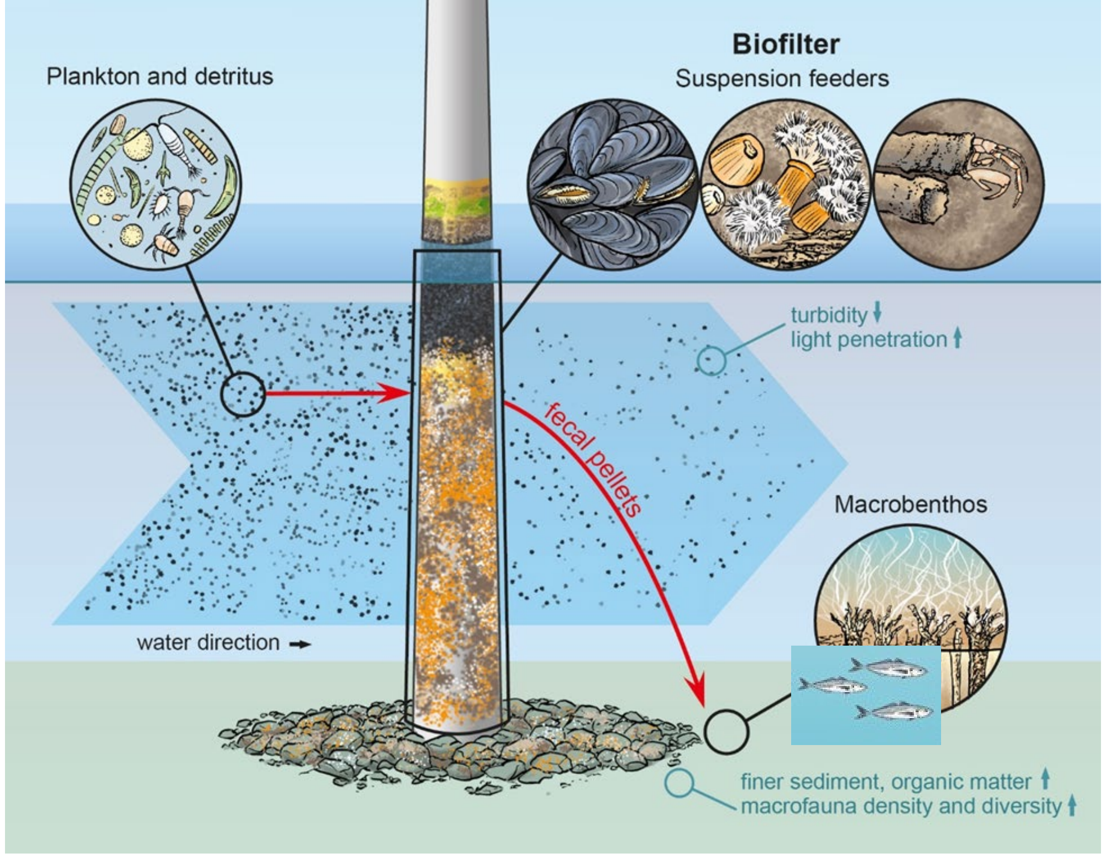
Check for updates

Offshore Windfarm Footprint of Sediment Organic Matter Mineralization Processes

Emil De Borger[1,2], Evgeny Ivanov[3], Arthur Capet[3], Ulrike Braeckman[1], Jan Vanaverbeke[1,4], Marilaure Grégoire[3] and Karline Soetaert[1,2]*

[1] Department of Biology, Marine Biology Research Group, Ghent University, Ghent, Belgium, [2] Department of Estuarine and Delta Systems, Royal Netherlands Institute of Sea Research (NIOZ), Yerseke, Netherlands, [3] Modeling for Aquatic SysTems (MAST), University of Liège, Liège, Belgium, [4] Operational Directorate Natural Environment, Marine Ecology and Management, Royal Belgian Institute of Natural Sciences, Brussels, Belgium

Future Work



- High resolution underwater imagery ⟶ Photogrammetric models to estimate biomass
- Measure changes in benthic functioning of the soft sediments at the base of the turbines
- Link with fish data to explore ecosystem connectivity shifts (trophic dynamics)

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