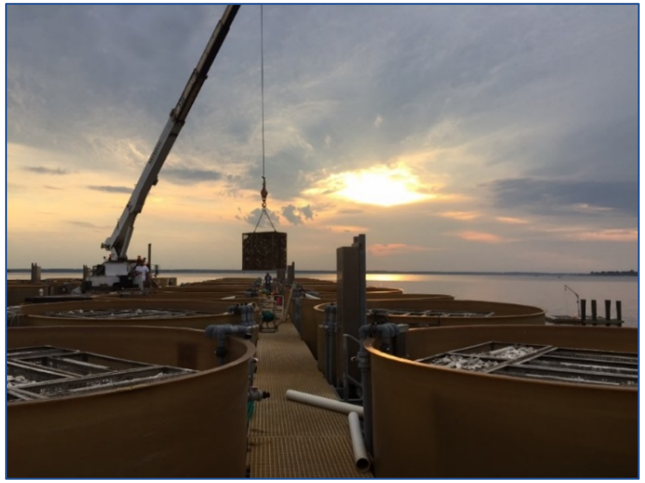
Oyster Best Management Practices (BMP) in the Chesapeake Bay: Management and Scientific Considerations



Fisheries GIT Meeting

January 8, 2019

Presenters: Ward Slacum (ORP) and

Jeffrey Cornwell (UMCES)

Acknowledgements

Role	Oyster BMP Expert Panel
Panelists	Larry Sanford (UMCES) Suzanne Bricker and Julie Rose (NOAA) Lynn Fegley and Frank Marenghi (MDNR) Karen Hudson, Lisa Kellogg, and Mark Luckenbach (VIMS) Andrew Lacatell (TNC) Chris Moore (CBF) Matt Parker (Sea Grant at U. of MD) and Ken Paynter (U. of MD) Bill Wolinski (Talbot County of Public Works)
Chesapeake Bay Program/US EPA Advisors	Lucinda Power, Rich Batiuk, Lew Linker, Matt Johnston, Ralph Spagnolo, Ed Ambrogio, Jeff Sweeney, Jeremy Hanson, Julie Reichert-Nguyen
Panel Support	Ward Slacum and Emily French (ORP), Carl Cerco (US Army Corps of Engineers), Paige Hobaugh, Emilie Franke, and Kyle Runion (CBP)
Data	Colleen Higgins, Kurt Stephenson, Bonnie Brown, Peter Kingsley-Smith, Steve Allen, Paige Ross, Roger Mann, and Melissa Southworth
Stakeholder Review	Citizen Advisory Committee, Chesapeake Bay Foundation, Chesapeake Bay Commission, Lynnhaven River Now, Southern Environmental Law Center and partners, Oyster Company of Virginia, and Norfolk Public Works

Decision Framework: Incremental BMP Recommendations

	Private Oyster Aquaculture					Licensed Oyster Harvest				Oyster Reef Restoration		
Oyster Practice Category x Crediting Protocol	**A. Off-bottom private oyster aquaculture using hatchery-produced oysters**	**B. On-bottom private oyster aquaculture using hatchery-produced oysters**	**C. On-bottom private oyster aquaculture using transplanted wild oysters**	**D. On-bottom private oyster aquaculture using substrate addition**	**E. Private oyster aquaculture with no activity**	**F. Licensed oyster harvest using hatchery-produced oysters**	**G. Licensed oyster harvest using transplanted wild oysters**	**H. Licensed oyster harvest using substrate addition**	**I. Licensed oyster harvest with no activity**	**J. Oyster reef restoration using hatchery-produced oysters**	**K. Oyster reef restoration using substrate addition**	**L. Oyster reef restoration using no harvest area designation only**
1. Nitrogen Assimilation in Oyster Tissue	1st **Approved**	1st **Approved**	1st Not Endorsed	1st **Approved**	1st Not Endorsed	2nd **Complete**	2nd Not Endorsed	Later	2nd Not Endorsed	2nd **Complete**	2nd **Complete**	2nd Policy Issue
2. Nitrogen Assimilation in Oyster Shell	2nd Research Gap	2nd Research Gap	2nd Not Endorsed	2nd Research Gap	2nd Not Endorsed	2nd Research Gap	2nd Not Endorsed	Later	2nd Not Endorsed	2nd **Complete**	2nd **Complete**	2nd Policy Issue
3. Enhanced Denitrification Associated with Oysters	2nd Research Gap	2nd Research Gap	2nd Not Endorsed	2nd Research Gap	2nd Not Endorsed	2nd Research Gap	2nd Not Endorsed	Later	2nd Not Endorsed	2nd **Complete**	2nd **Complete**	2nd Policy Issue
4. Phosphorus Assimilation in Oyster Tissue	1st **Approved**	1st **Approved**	1st Not Endorsed	1st **Approved**	1st Not Endorsed	2nd **Complete**	2nd Not Endorsed	Later	2nd Not Endorsed	2nd **Complete**	2nd **Complete**	2nd Policy Issue
5. Phosphorus Assimilation in Oyster Shell	2nd Research Gap	2nd Research Gap	2nd Not Endorsed	2nd Research Gap	2nd Not Endorsed	2nd Not Endorsed	2nd Not Endorsed	Later	2nd Not Endorsed	2nd **Complete**	2nd **Complete**	2nd Policy Issue
6. Suspended Sediment Reduction Associated with Oysters	Later	Later	Later	Later	Later	Later	Later	Later	Later	Later	Later	Later
7. Enhanced Nitrogen Burial Associated with Oysters	Later	Later	Later	Later	Later	Later	Later	Later	Later	Later	Later	Later
8. Enhanced Phosphorus Burial Associated with Oysters	Later	Later	Later	Later	Later	Later	Later	Later	Later	Later	Later	Later

1st Report (approved) 2nd Report (in draft) Later = Future Report

Endorsed Licensed Oyster Harvest-Definition

Endorsed Oyster Practice-Protocol Combinations for BMP Approval

This chapter describes the Panel's recommendations on the nitrogen and phosphorus reduction effectiveness determination concerning assimilation in tissue of harvested oysters for the below oyster practice:

Endorsed Oyster Practice Title	Reduction Protocol	Practice Definition
F. Licensed oyster harvest using hatchery-produced oysters	1. Nitrogen assimilation in oyster tissue 4. Phosphorus assimilation in oyster tissue	Planting oysters (e.g., spat-on-shell, single oysters) produced from hatchery techniques directly on the bottom to enhance the stock in State-designated fishing areas (e.g., public shellfish fishing grounds) for eventual removal (harvest) from the water by individuals holding the proper licenses.

Licensed Oyster Harvest-Qualifying Conditions

- **Max Oyster Harvest Allowance for Reduction Credit**—Harvest claimed for reduction credit can be at maximum no more than 15% of hatchery-produced oyster spat planted per planting.
- **Oyster Harvest Allowance Timeframe**—Maximum of five years from the planting of hatchery-produced oysters.
- **Reduction Credit Time Lag**—Oyster harvest becomes eligible for reduction credit two years after a planting of hatchery-produced oysters (single oysters or spat-on-shell less than 2 inches) unless an assessment is done demonstrating a timeframe less than two years is appropriate.
- **Harvest Reduction Crediting Timeframe**—Oyster harvest allowance timeframe minus the reduction credit time lag equals the timeframe the nitrogen and phosphorus reduction from the oyster harvest allowance can be credited.
- **Lifespan of BMP**—Treatments (i.e., plantings) must occur within five years for the BMP to remain active. Inactivity will cause the BMP to expire until another treatment occurs.

Approved Oyster Reef Restoration Practices for Interim BMP Use (Pending Approval for Crediting)

Endorsed Oyster Practice-Protocol Combinations for BMP Approval

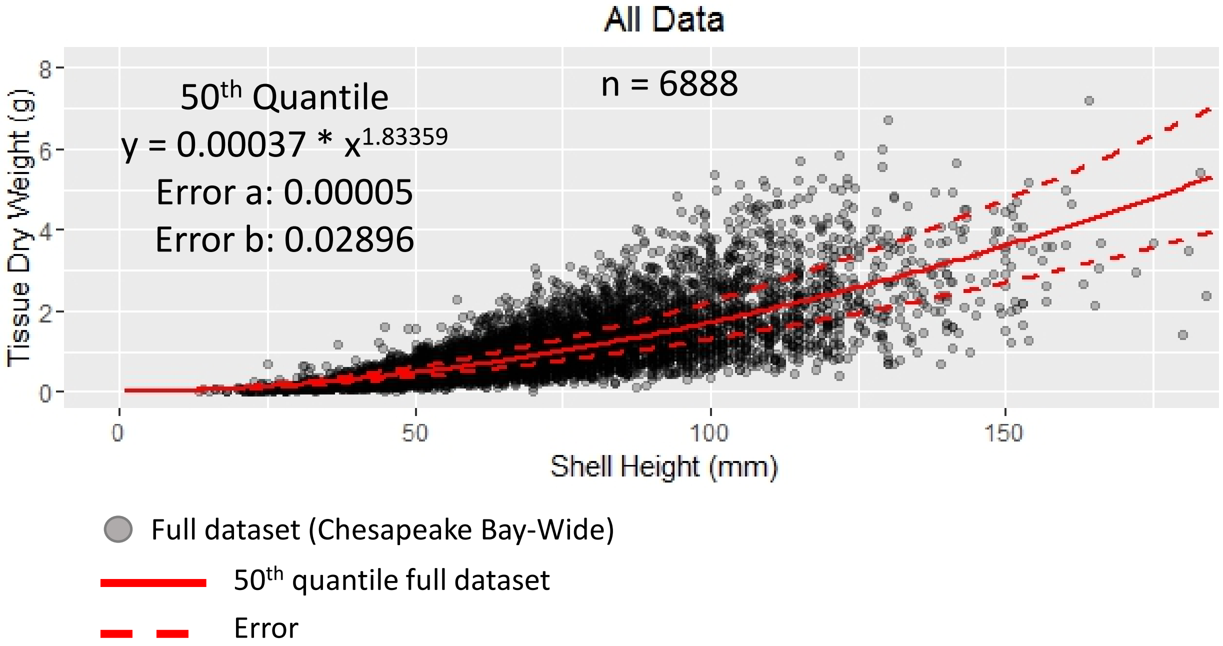
This chapter describes the Panel's recommendations on the nitrogen and phosphorus reduction effectiveness determination concerning assimilation (sequestration) in tissue and shell for the below oyster practices:

Endorsed Oyster Practice Title	Reduction Protocols	Practice Definition
J. Oyster reef restoration using hatchery-produced oysters	1. Nitrogen assimilation in oyster tissue 2. Nitrogen assimilation in oyster shell 4. Phosphorus assimilation in oyster tissue 5. Phosphorus assimilation in oyster shell	Planting oysters (e.g., spat-on-shell, single oysters) produced from hatchery techniques directly on the bottom or raised substrate to enhance oyster biomass in areas where removal is not permitted.
K. Oyster reef restoration using substrate addition		Planting oyster shells and/or alternative substrate directly on the bottom to attract recruitment of naturally occurring (wild) oyster larvae to enhance oyster biomass in areas where removal is not permitted.

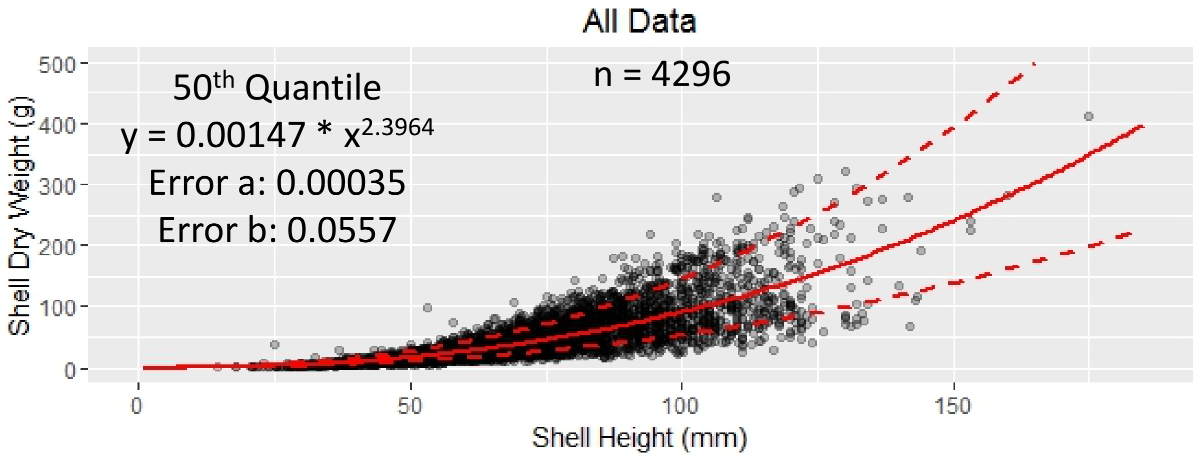
Oyster Reef Restoration: Calculating N & P Assimilation In Tissue & Shell

- Uses Chesapeake Bay-wide <u>shell height</u> to tissue and shell dry weight regression equations

Chesapeake Bay Oyster Tissue Reef Data



Chesapeake Bay Oyster Shell Reef Data



- The average nitrogen (tissue: 8.2%, shell: 0.2%) and phosphorus (tissue: 0.9%, shell: 0.04%) percent contents were used to calculate the amount sequestered in the live oyster tissue and shell biomass (tissue percent contents approved by CBP, Cornwell et al. 2016; shell percent contents in draft).

N & P Assimilation Interim BMPs—Combined Tissue & Shell
Based on 2017/2018 Harris Creek Data (Shell-Base Sites)

Oyster Reef Restoration-Assimilation Estimates for Planning		
Live Oyster Tissue + Shell Reduction Effectiveness	lbs $acre^{-1}$ $year^{-1}$ (max duration = 3 years)	
Treatment Category	Nitrogen	Phosphorus
Shell-Base + SOS n = 7 sites Mean Live Density = 42 oysters m^{-2}	24	4

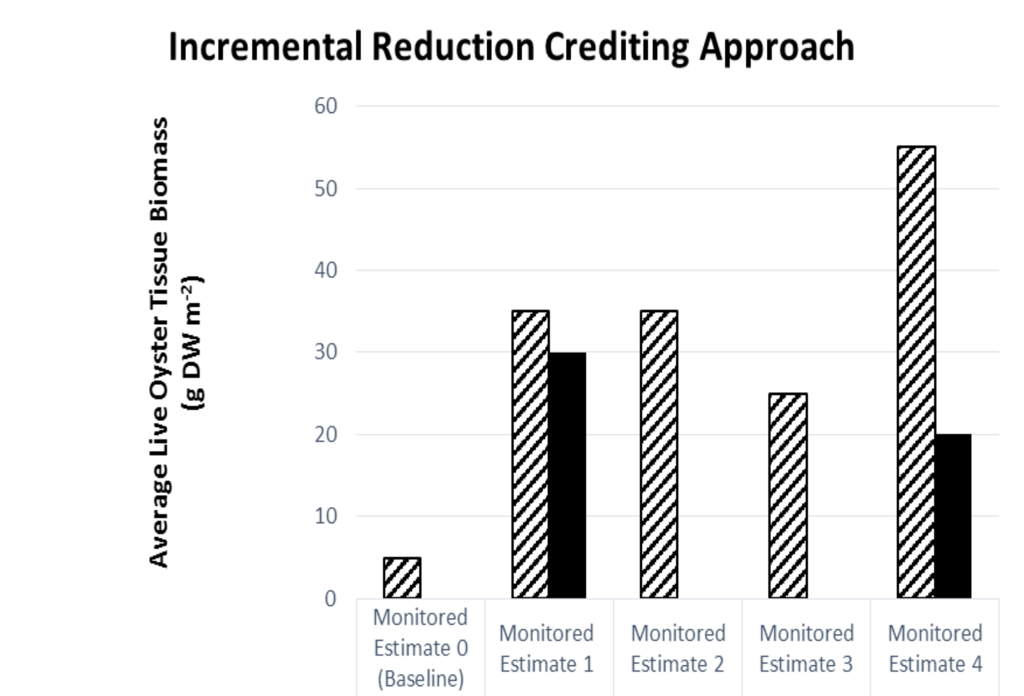
- Planning estimates are one time credits expressed as annual rates. Can be applied for a total of three years on acres where substrate (shell or alternative substrate, such as granite or stone) and/or hatchery-produced SOS were planted.
- The total N and P reduction (tissue plus shell) ~ 74 lbs $acre^{-1}$ and 12 lbs $acre^{-1}$, respectively.
- Represents a mean live oyster tissue and shell biomass of ~ 45 and 2300 g m^{-2}, respectively, three years post-restoration.

Site-Specific Oyster Reef Restoration BMP for Crediting: Assimilation Reduction Effectiveness Strategy

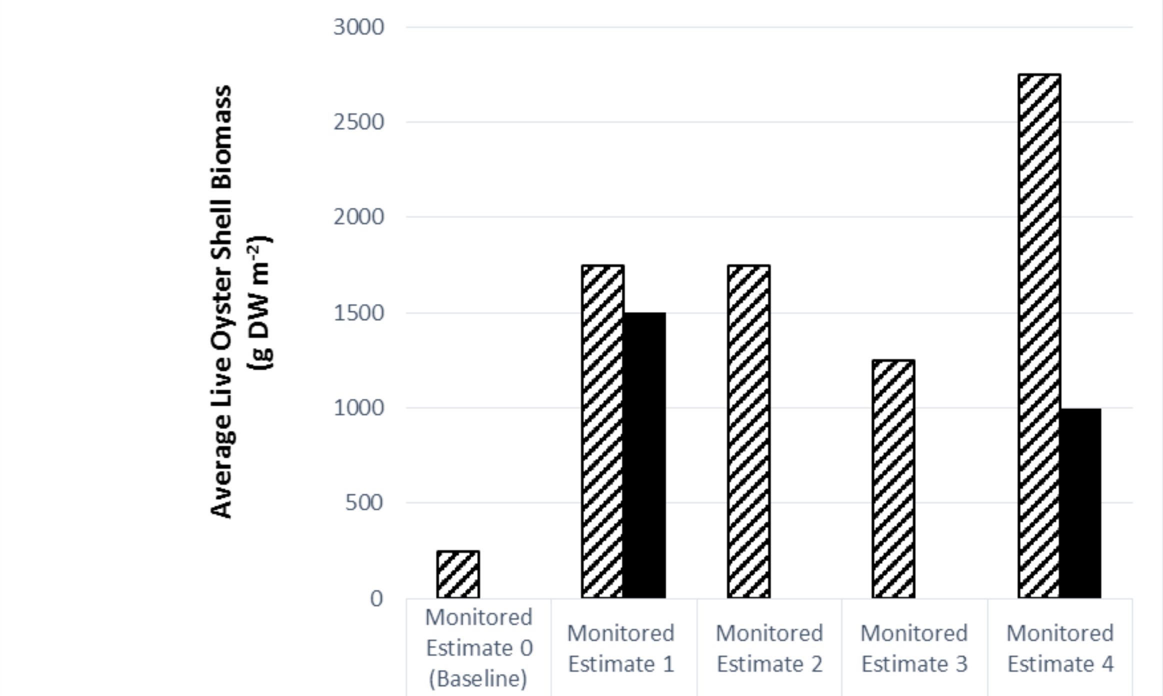
- **Type of reduction:** One-time credit that can be credited incrementally based on appreciated tissue and shell biomass from live oysters during the monitoring timeframe of at least every three years established by the implementing program.

- **Useful life of the BMP:** No reduction credit is given if monitored oyster biomass is below the established pre-restoration baseline value, does not increase from the previously credited post-restoration amount, or decreases.

Site-Specific Oyster Reef Restoration BMP: Assimilation Reduction Effectiveness Strategy Example



	Monitored Estimate 0 (Baseline)	Monitored Estimate 1	Monitored Estimate 2	Monitored Estimate 3	Monitored Estimate 4
Determined Biomass	5	35	35	25	55
Eligible Appreciated Biomass for Reduction Credit	0	30	0	0	20

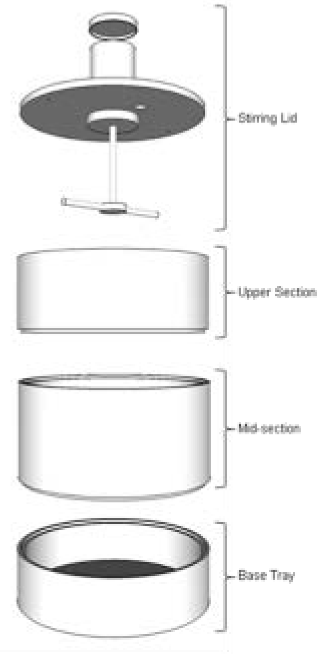


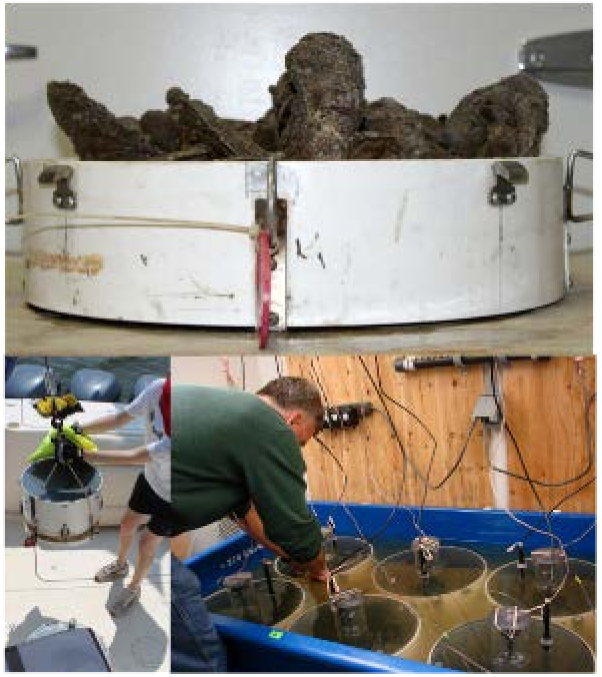
	Monitored Estimate 0 (Baseline)	Monitored Estimate 1	Monitored Estimate 2	Monitored Estimate 3	Monitored Estimate 4
Determined Biomass	250	1750	1750	1250	2750
Eligible Appreciated Biomass for Reduction Credit	0	1500	0	0	1000

Total N Sequestered: Tissue + Shell

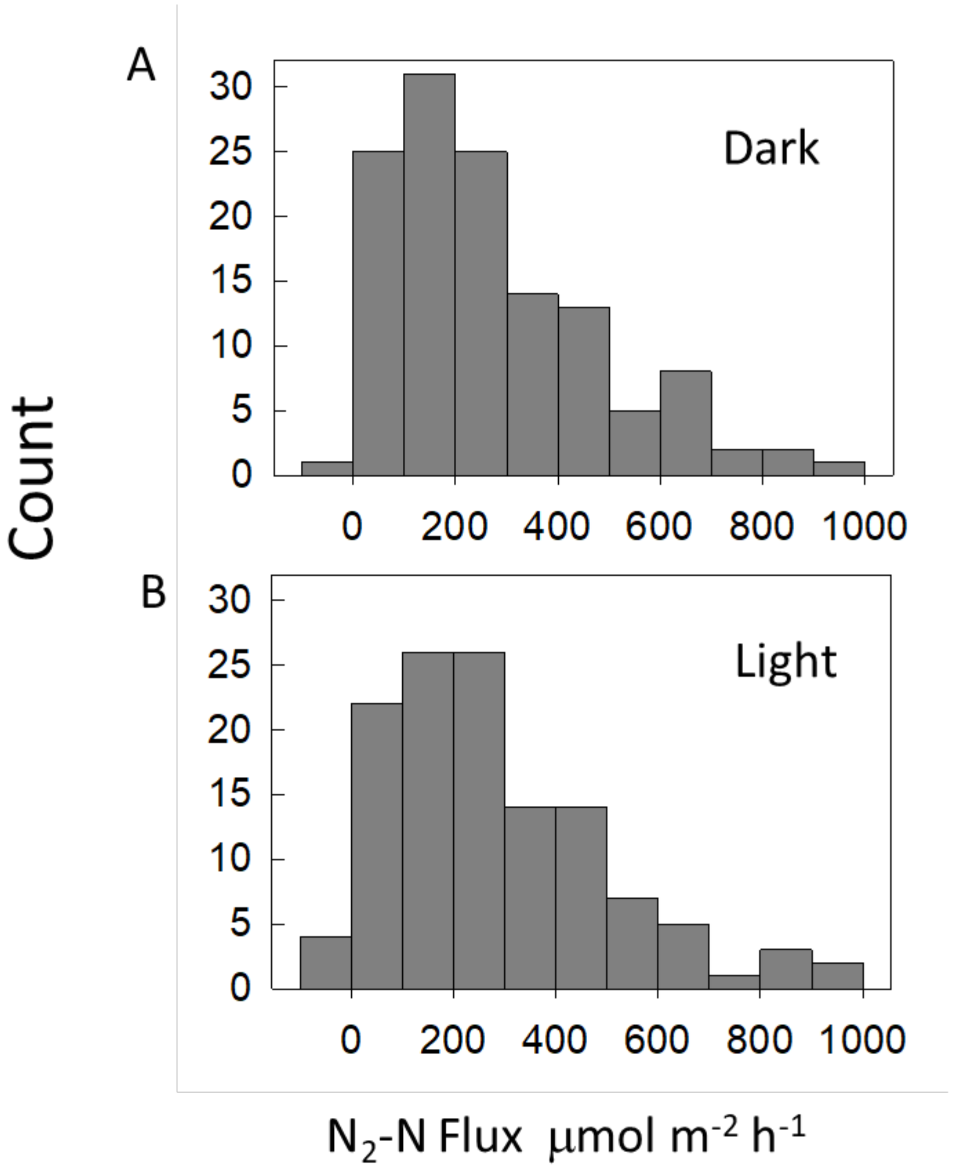
Enhanced Denitrification Protocol Goal:

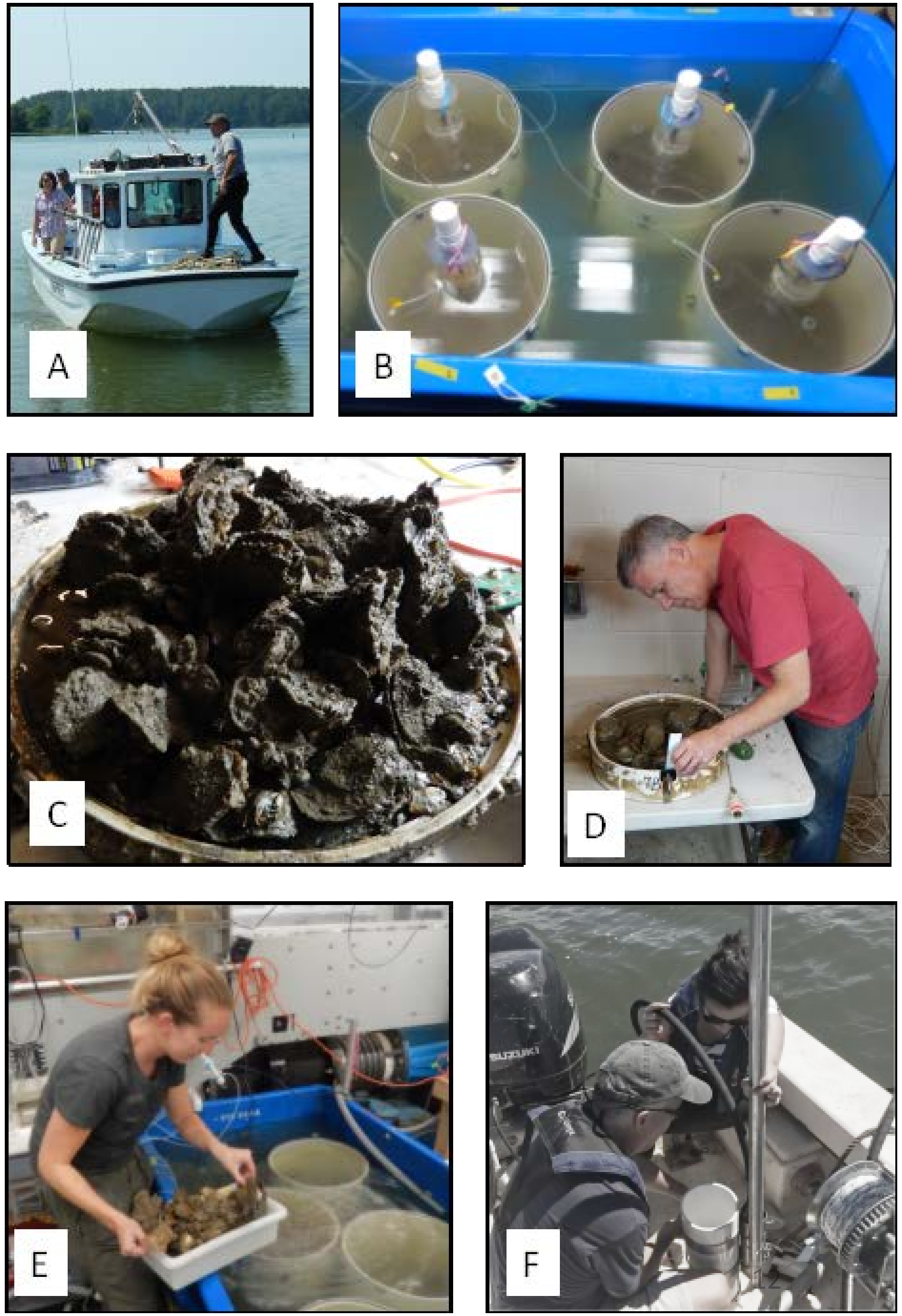
Provide defensible, verifiable estimates of N reduction from enhanced denitrification associated with oyster reefs





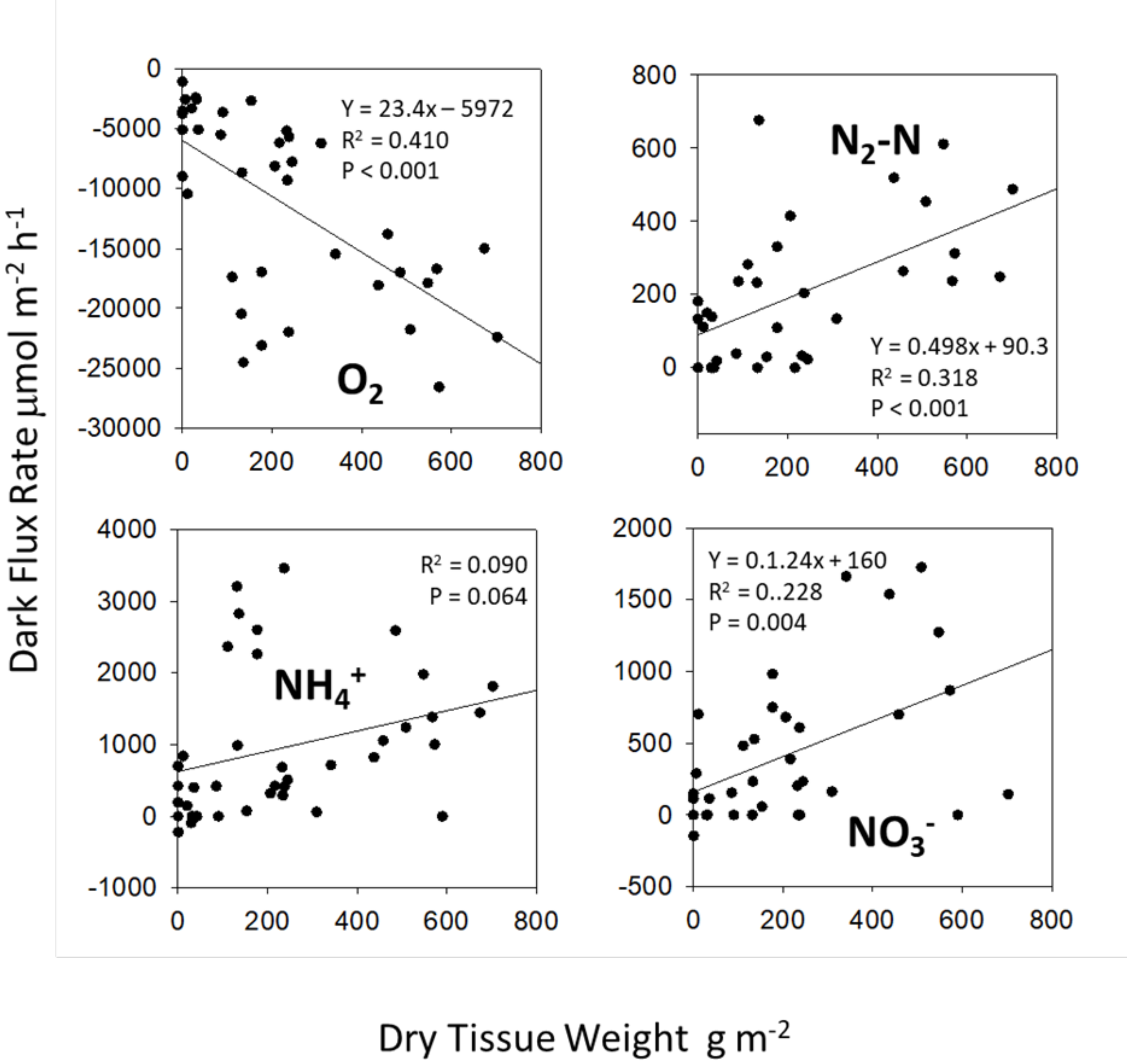
ORES Summary





Harris Creek Observations/Conclusions

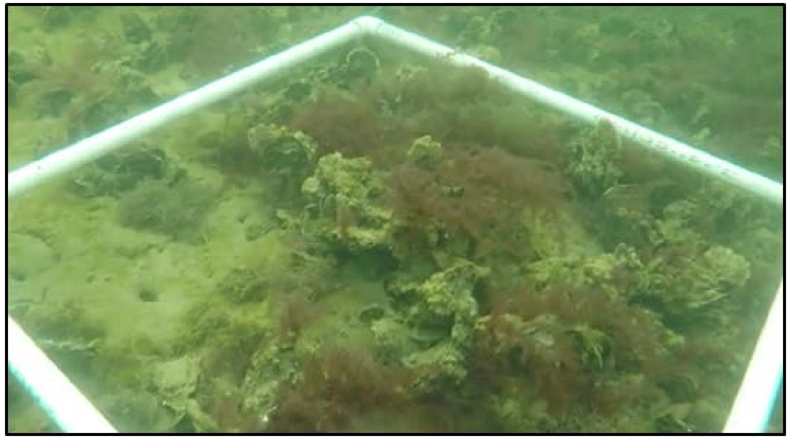
- Harris Creek rates are all "community" rates – sediments + animals
- Rates are generally high and >> control rates
- Much of the overall nutrient processing and denitrification closely associated with oyster "clumps"
- Nutrient cycling enhanced by higher oyster biomass
- Denitrification best predicted by some non-oyster biomass – see Lisa!



Verification of Denitrification Rates using Oyster Tissue Biomass

- Research demonstrates positive relationship between denitrification rates and oyster tissue biomass

- For restoration reefs, maintenance of oyster biomass is key to maintaining the reef as a BMP



Enhanced Denitrification-Oyster Reef Restoration
Components of Site-Specific DNF Rate

- **Reference Rate (Baseline Determination)**
  - Measure denitrification (DNF) rates at oyster site and nearby reference site
    - Consult with expert to determine <u>appropriate number of sampling points</u> for size of BMP designated area
  - Enhanced Rate = Oyster Site – Reference Rate

- **Light and/or Dark Incubation**
  - If bottom gets sufficient light for photosynthesis (≥ 2% of incident sunlight):
    - Light incubations are needed to incorporate daylight hours for DNF rate
    - If only have dark incubations, then only dark hours can be incorporated for DNF rate
  - If no light reaches bottom then dark DNF rate can apply to full 24 hours

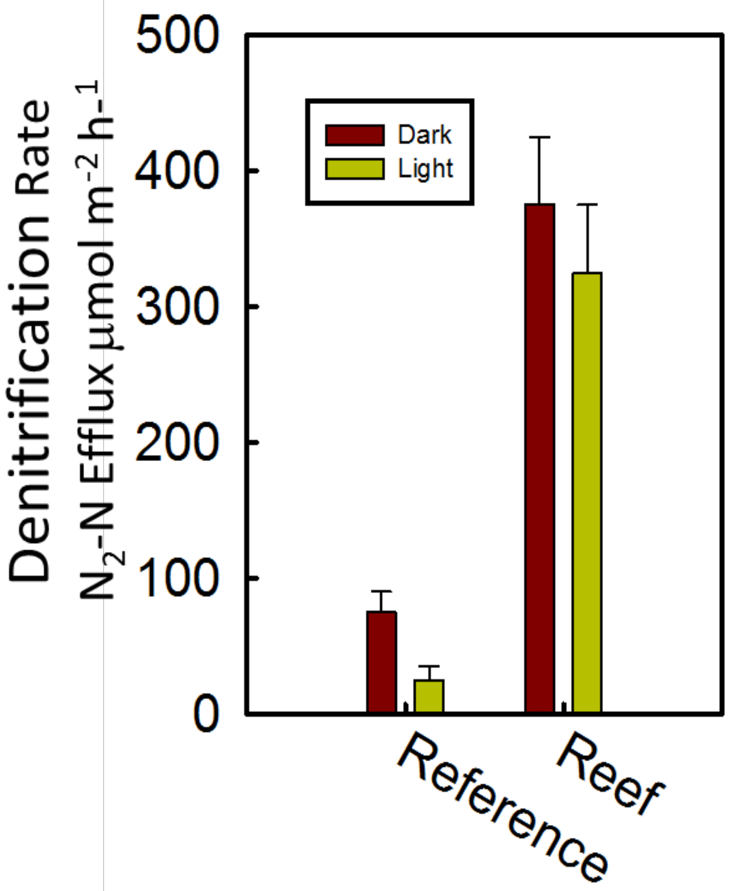
- **QA/QC of DNF Rate**
  - Total nitrogen (TN) fluxes should scale linearly—as O_2 decreases, TN increases

Enhanced Denitrification-Oyster Reef Restoration Components of Site-Specific DNF Rate

- **Seasonality**
  - Used defined time periods to address seasonal variability
    - Spring—Mar-May (92 days total)
    - Summer—Jun-Aug (92 days total)
    - Fall—Sep-Nov (91 days total)
    - Winter—Dec-Feb (90 days total)
  - Can receive partial annual credit for seasons with measured DNF rates; full annual credit if there are DNF rates for all seasons

- **Oyster Tissue Biomass Associated with DNF Rate**
  - Define “oyster presence” for verification later
    - Chamber Method: Measure oyster tissue biomass in chamber
    - Core Method: Determine average tissue biomass of designated BMP site

Enhanced Denitrification-Oyster Reef Restoration
DNF Rate Calculation Example: Light & Dark Rates (Light Reaches Bottom)



Mean Reference Rate: Dark = 60 ± 15 µmol N m^{-2} h^{-1}
± SD Light = 20 ± 5 µmol N m^{-2} h^{-1}

Mean Reef Rate: Dark = 375 ± 75 µmol N m^{-2} h^{-1}
± SD Light = 325 ± 75 µmol N m^{-2} h^{-1}

Daily rate if location and date is 14 hours light, 10 hours dark

Reference = (60*10 + 20*14) = 880 µmol m^{-2} d^{-1}
Reef = (375*10+ 325* 14) = 8,300 µmol m^{-2} d^{-1}

Daily Enhanced Denitrification Rate:
Reef – Reference = 7,420 µmol N m^{-2} d^{-1}
= 0.10388 g N m^{-2} d^{-1}
= 0.93 lbs N acre-^{1} d^{-1}

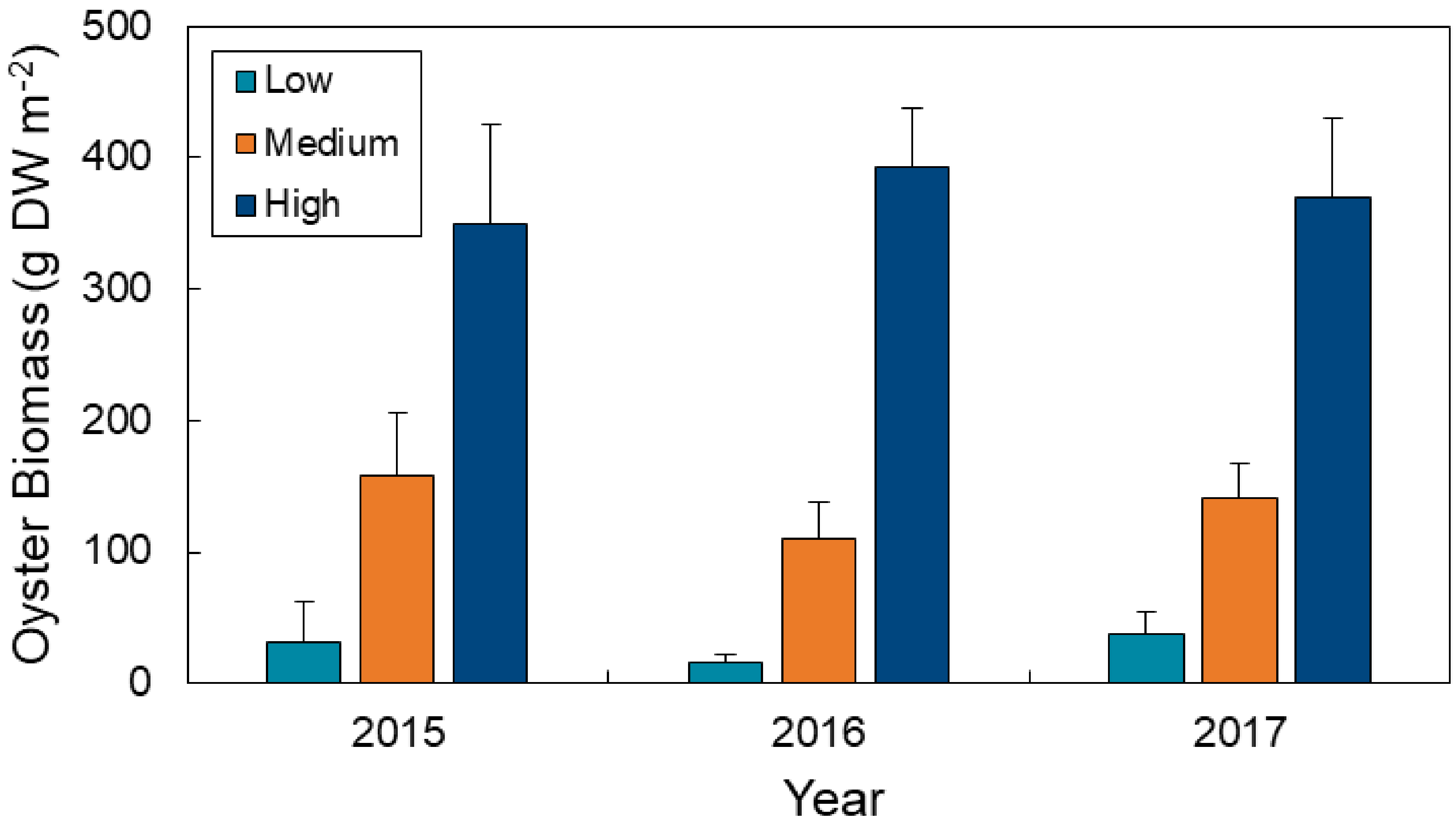
Example Assumptions:

- **Light reaches the bottom and light and dark rates assessed**
- Rates are typical warm season rates that can be observed in the summer season (e.g., July)
- Mean reference oyster tissue biomass = 0 g m^{-2}
- Mean reef oyster tissue biomass = 50 g m^{-2}

Summer Season
Jun-Aug (92 days total)

"Annual" Rate
= 0.93 lbs N $acre^{-1}$ d^{-1} * 92 days
= **86 lbs N $acre^{-1}$ y^{-1}**

Oyster Tissue Biomass (Harris Creek, MD)



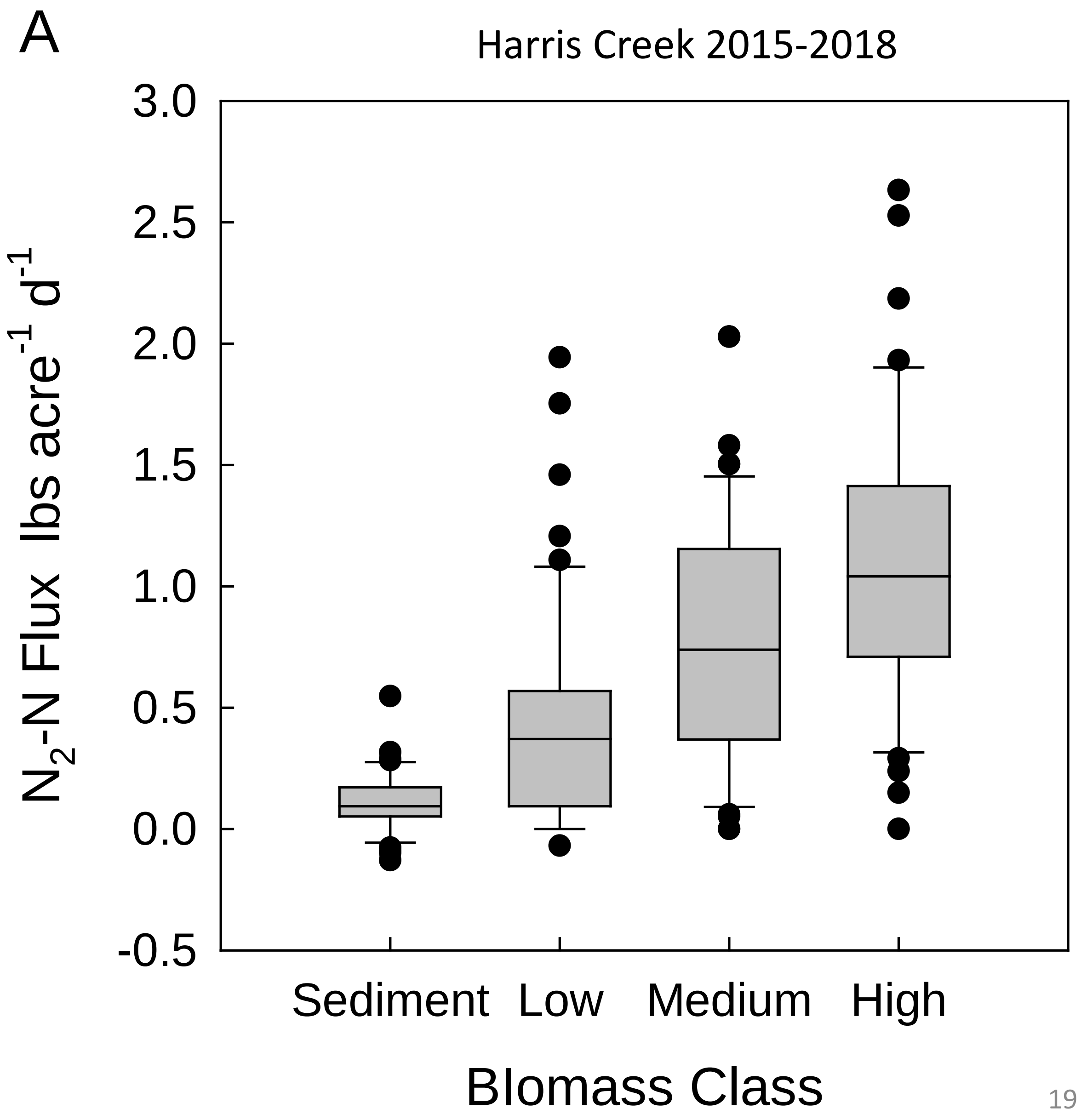
Low: <75 g DW m^{-2}

Medium: 75 - 225 g DW m^{-2}

High: > 225 g DW m^{-2}

Oyster tissue biomass class definition for denitrification analysis. The data used here are from summer (June-August) tray incubations and do not include the accumulation of shell and organisms other than oysters.

Importance of Biomass



Site-Specific Best Management Practice – Oyster Reef Restoration

- Indexed to oyster biomass. Must stay relatively constant or increase to keep BMP
- BMP (*in final development*) is prescriptive, as much as possible, regarding approaches for assessment
- Implementation will not be simple, but we believe for medium to large restoration projects it could enhance the value of restoration
- Key need: sufficient oyster biomass data sets
- Key need: affordable assessment of denitrification; data beyond Harris Creek

Future Considerations – Oyster Denitrification

On-Bottom Aquaculture - Issues

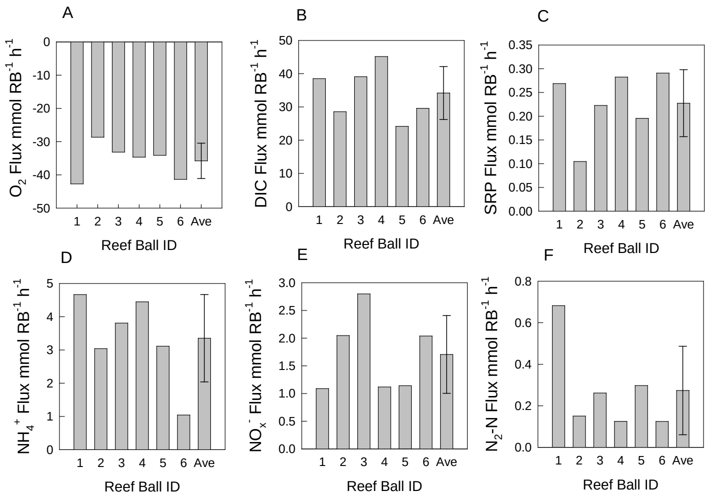
- Biomass determination
- Oysters are moved around
- Harvest effects (multiple year classes?)
- Denitrification enhancement seems likely

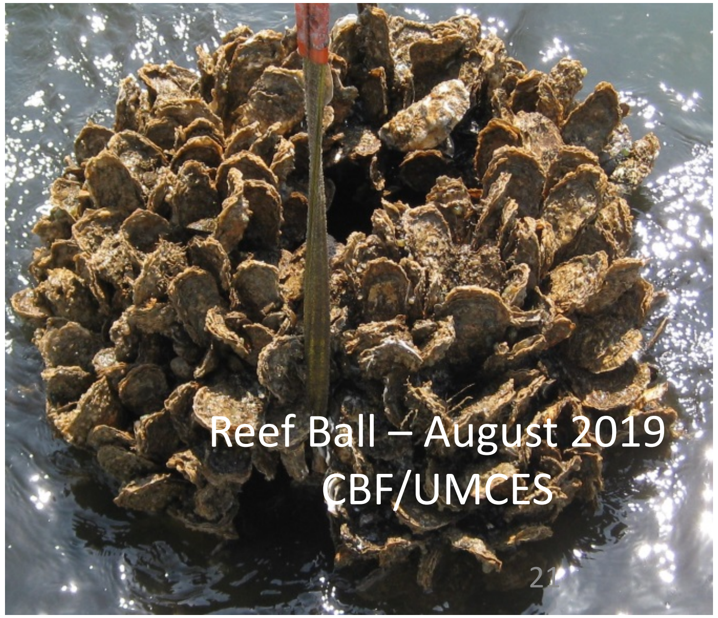
Water Column Aquaculture - Issues

- Poor sediment quality in footprint – sometimes
- Likely need model to explain transport/fate of biodeposits… Data to calibrate models?
- Denitrification enhancement is likely in many locations – denitrification outside of footprint

Engineered Structures

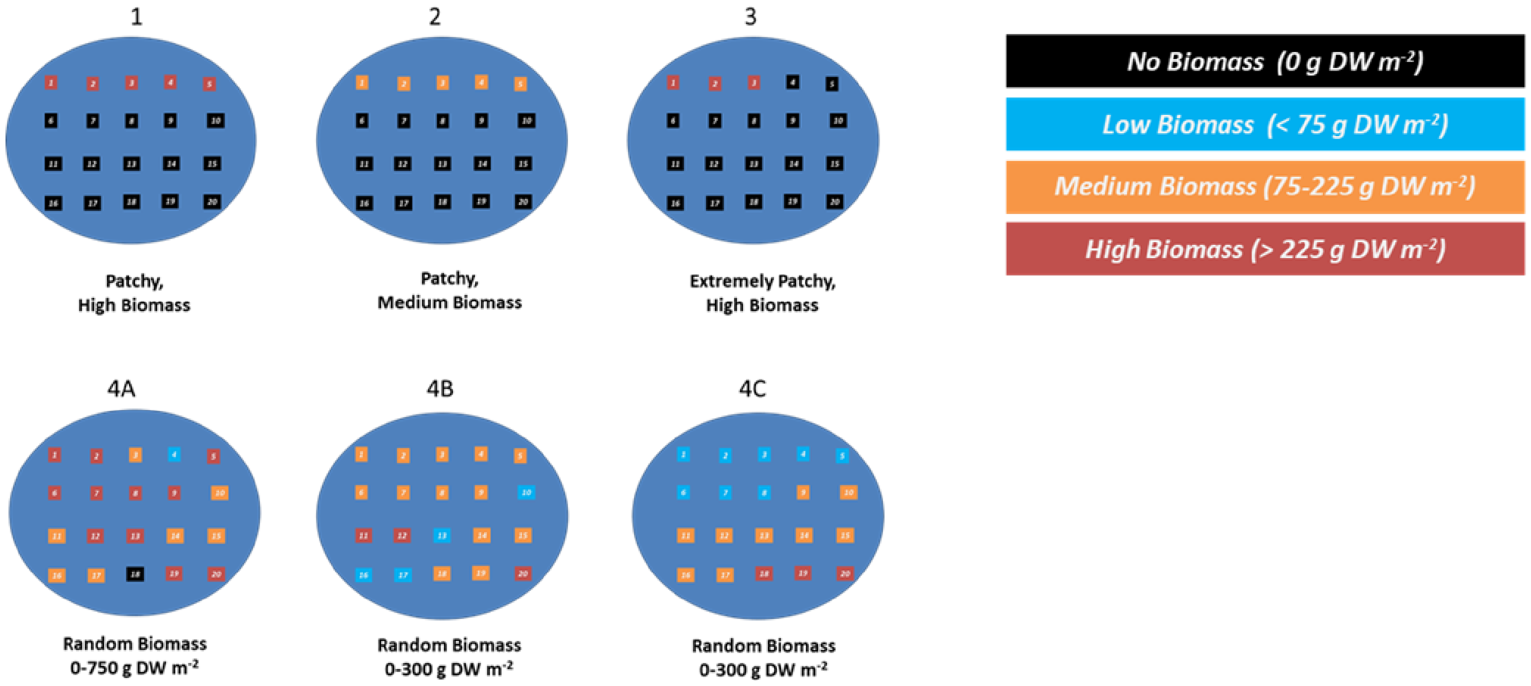
- Minimal data
- Relationship to biomass?
- Need site specific Information





Wrapping Up

Extreme patchiness could lead to whole reef estimates that could give results at variance with the “correct” amount of denitrification in a given reef. The key remaining part of this is to incorporate understandable language that ensures that common sense is applied when extrapolating data to the whole reef.



Report done in January 2020

The key challenge of this panel has been developing a plan that:

1. Captures the necessary scientific rigor required for a very new type of BMP
2. Can be implemented – agencies can develop suitable regulations and it is tractable (not excessively complicated)