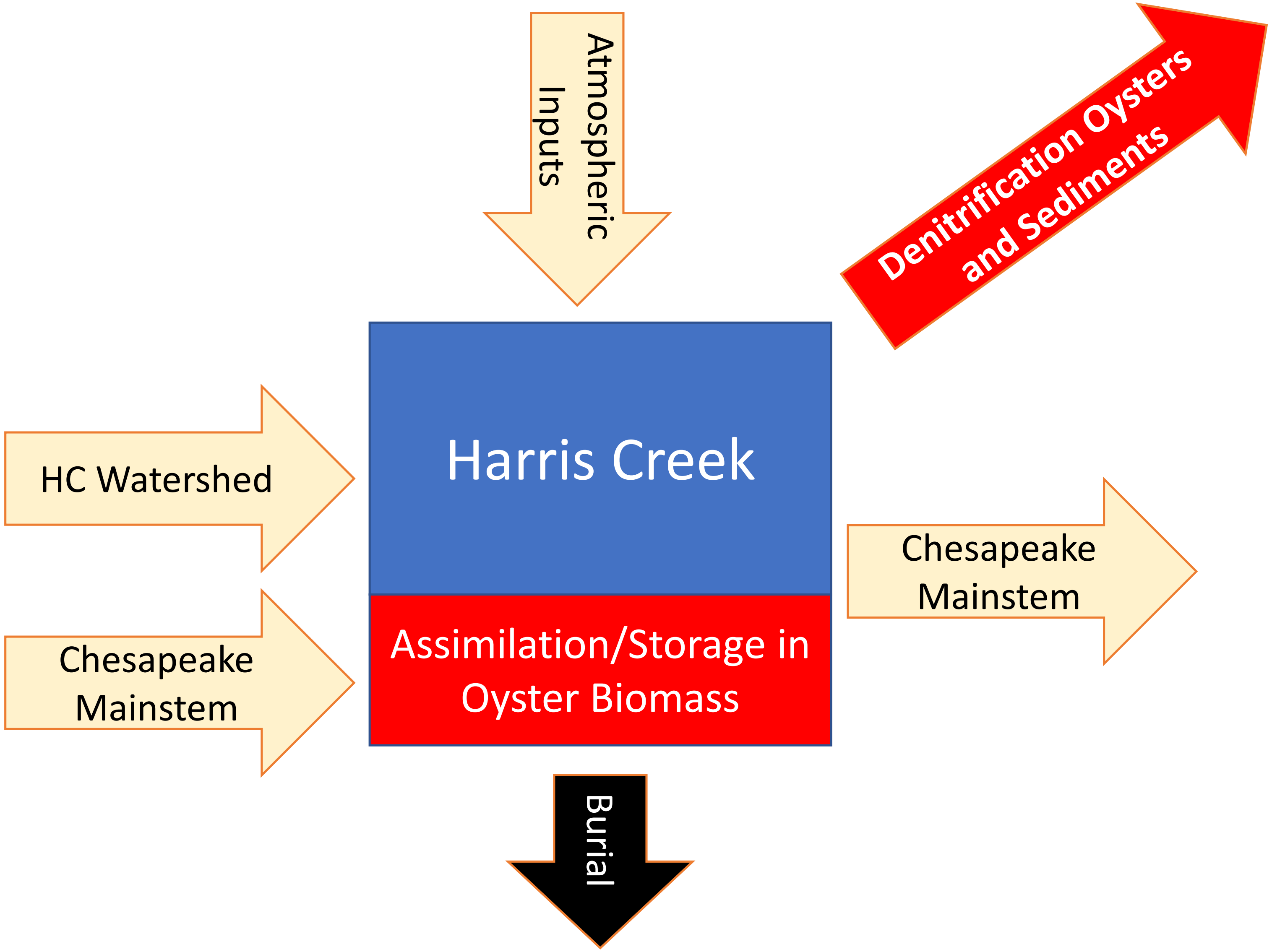
# Oyster Expert Panel – Planning Estimates N and P Removal

June 26, 2019

Presenter: Jeffrey Cornwell, Panel Chair
Representing many colleagues….

# Nitrogen and Phosphorus Mass Balance

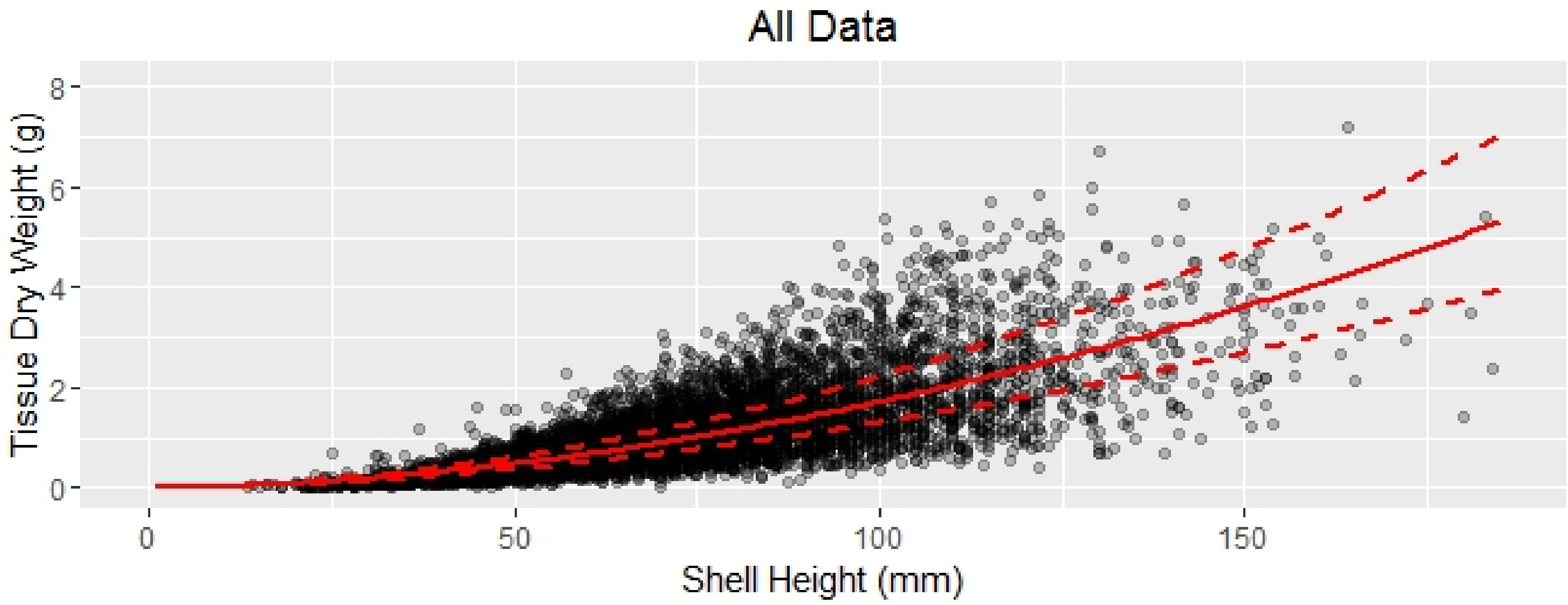


# Nutrient Ecosystem Services With Bivalves?

- A complete analysis of "removal" considers harvest of assimilated N or P, as well as the net effect of all biogeochemical processes
- Harvest of oyster tissue is considered a net removal of N and P from the Chesapeake Bay ecosystem – certified as a "best management practice" or BMP[1]
- Microbial denitrification is under consideration as a BMP for oyster restoration
- The assimilation/retention of N and P in living oyster biomass is under consideration as a BMP
- **Certification as a BMP requires a clear scientific consensus and hard data, not platitudes. This panel has taken exception care meshing science with management.**

[1]Cornwell, J. C. and others 2016. Panel Recommendations on the Oyster BMP Nutrient and Suspended Sediment Reduction Effectiveness Determination Decision Framework and Nitrogen and Phosphorus Assimilation in Oyster Tissue Reduction Effectiveness for Oyster Aquaculture Practices

# Oyster Tissue Reef Data




n = 6888

Equation for 50th quantile of the full data set

$y = 0.00037 * x^{1.83359}$

# A Planning Estimate for an Oyster Reef Restoration Enhanced Denitrification Rate Based on Harris Creek Data

**Jeffrey Cornwell, UMCES**

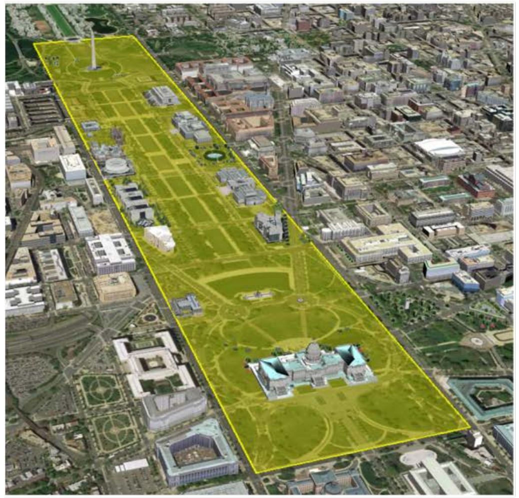
**M. Lisa Kellogg, VIMS**

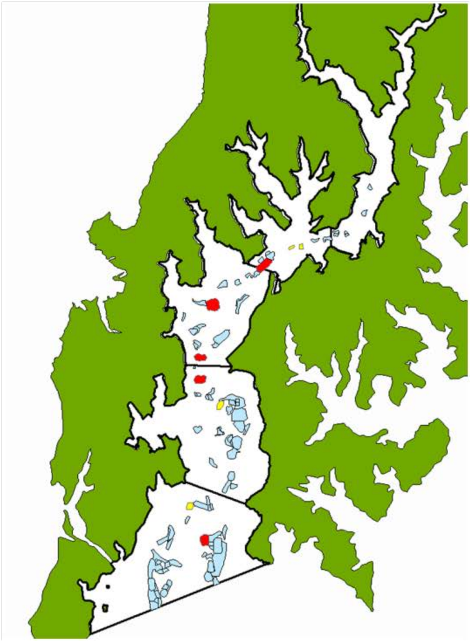
**Michael S. Owens, UMCES**

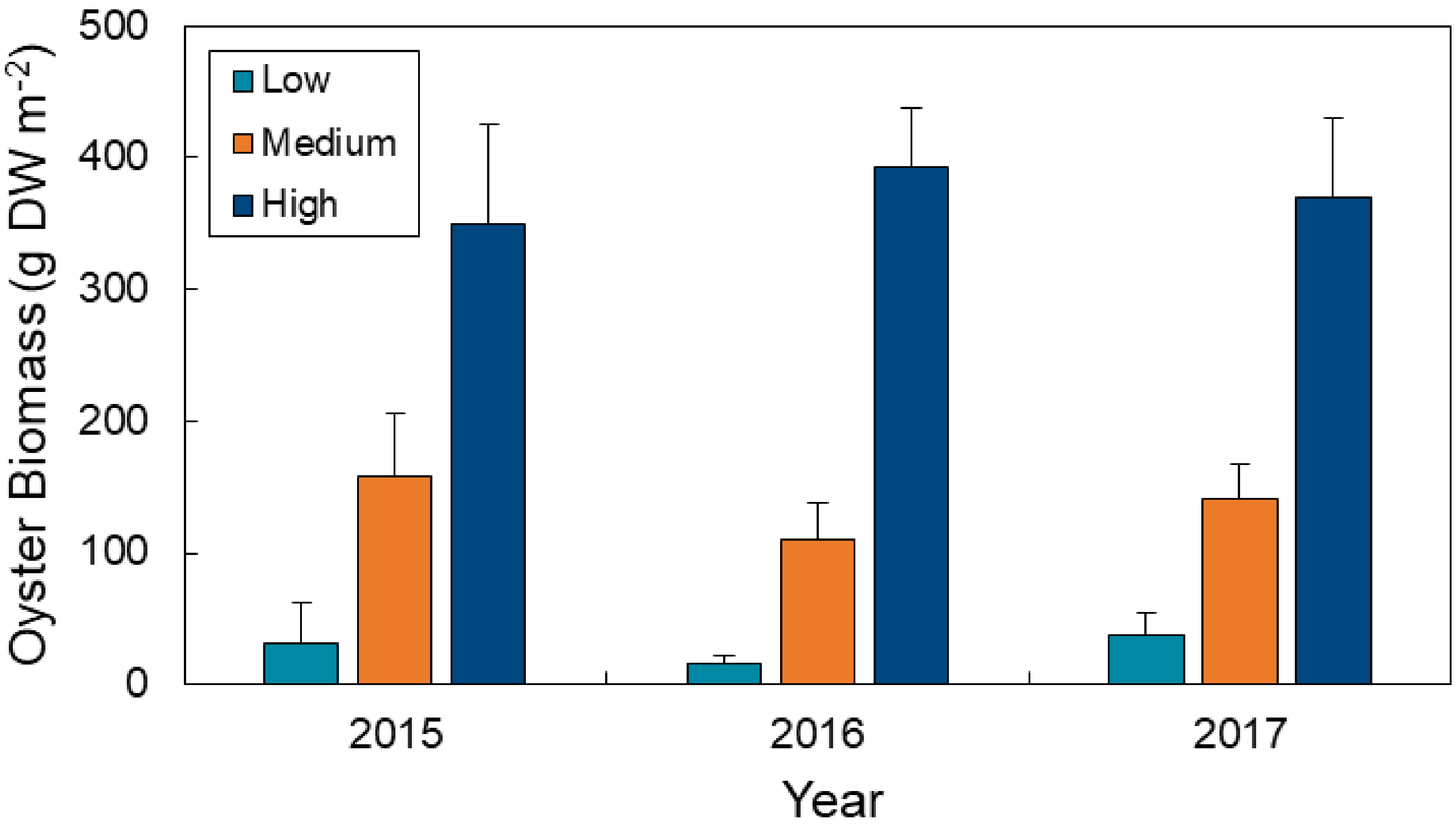
**Julie Reichert-Nguyen, Oyster Recovery Partnership**

# Harris Creek, MD

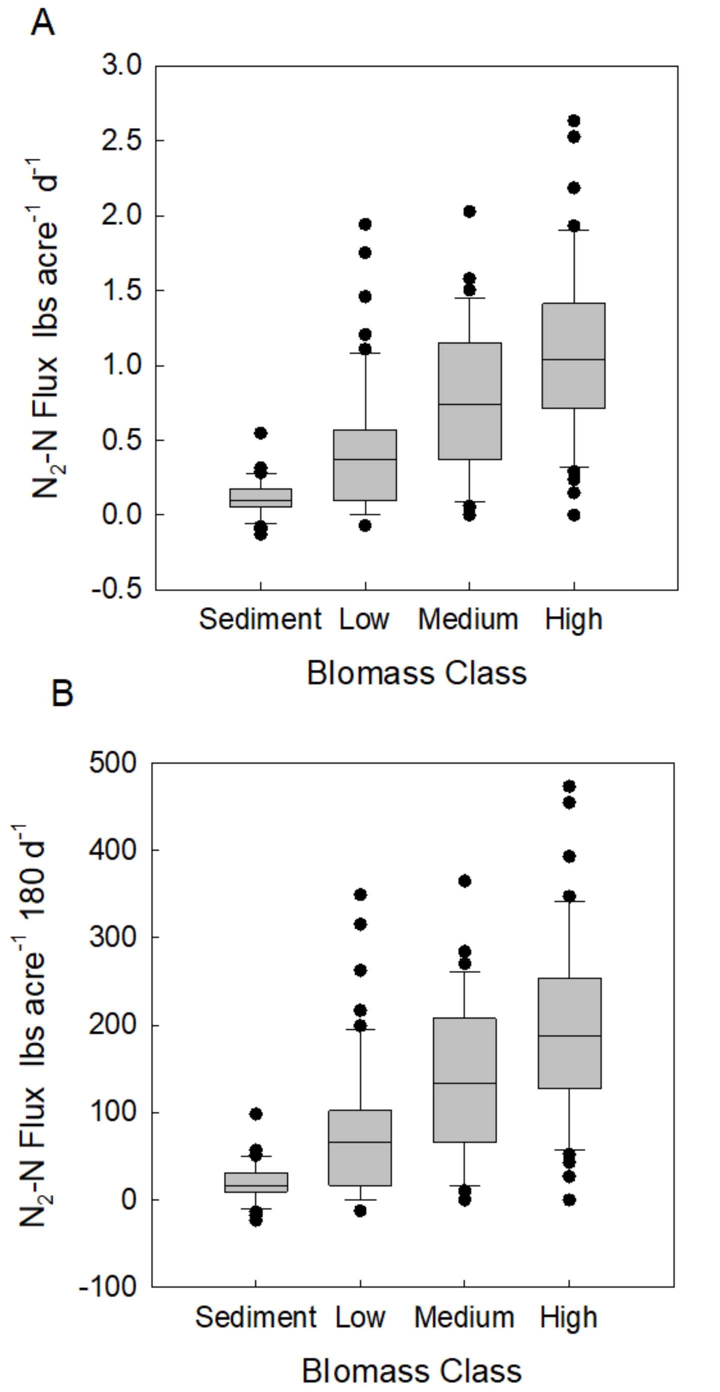
- ~350 acres planted with juvenile oysters set on oyster shell
- Cost ≈ $28 million
- What are the benefits?




Biomass class definition for denitrification analysis. The data used here are from summer tray incubations used for the determination of oyster biomass and do not include the accumulation of shell and organisms other than oysters. Categories used were low (<75 g DW $m^{-2}$), medium (75 - 225 g DW $m^{-2}$), and high (> 225 g DW $m^{-2}$) based on summer data (June-August).




| | | | Dark Reef Denitrification Rates | | | | Light Reef Denitrification Rates | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oyster Tissue Biomass Category | Sampling Season | Sampling Year | n | Average $N_2$-N Flux witin Year (µmol $m^{-2}$ $h^{-1}$) | StdDev of Average $N_2$-N Flux within Year (µmol $m^{-2}$ $h^{-1}$) | Seasonal Average $N_2$-N Flux Across Years (µmol $m^{-2}$ $h^{-1}$) | n | Average of $N_2$-N Flux (µmol $m^{-2}$ $h^{-1}$) | StdDev of N2-N Flux (µmol $m^{-2}$ $h^{-1}$) | Seasonal Average $N_2$-N Flux Across Years (µmol $m^{-2}$ $h^{-1}$) |
| Low | Spring | 2015 | 2 | 84 | 93 | 84 | 2 | 142 | 102 | 142 |
| | Summer | 2015 | 16 | 202 | 182 | 210 | 12 | 235 | 265 | 227 |
| | | 2016 | 6 | 152 | 99 | | 6 | 156 | 73 | |
| | | 2017 | 12 | 275 | 182 | | 12 | 290 | 224 | |
| | Fall | 2015 | 2 | 0 | 0 | 42 | 2 | 1 | 75 | 38 |
| | | 2016 | 7 | 84 | 87 | | 7 | 74 | 75 | |
| Medium | Summer | 2015 | 6 | 373 | 252 | 336 | 7 | 278 | 144 | 276 |
| | | 2016 | 6 | 230 | 83 | | 6 | 182 | 46 | |
| | | 2017 | 12 | 407 | 222 | | 12 | 368 | 109 | |
| | Fall | 2015 | 4 | 18 | 21 | 96 | 3 | 83 | 79 | 89 |
| | | 2016 | 6 | 175 | 113 | | 6 | 95 | 120 | |
| High | Spring | 2015 | 4 | 396 | 184 | 396 | 6 | 676 | 225 | 676 |
| | Summer | 2015 | 14 | 361 | 162 | 384 | 15 | 320 | 128 | 384 |
| | | 2016 | 6 | 267 | 81 | | 6 | 299 | 61 | |
| | | 2017 | 12 | 525 | 254 | | 12 | 532 | 178 | |
| | Fall | 2015 | 1 | 23 | | 122 | 1 | 82 | | 137 |
| | | 2016 | 5 | 221 | 165 | | 5 | 192 | 80 | |
| Sediment (Background) | Spring | 2015 | 10 | 26 | 24 | 26 | 12 | 2 | 65 | 2 |
| | Summer | 2015 | 12 | 88 | 74 | 88 | 11 | 17 | 37 | 17 |
| | Fall | 2014 | 12 | 43 | 27 | 55 | 12 | 23 | 20 | 38 |
| | | 2016 | 12 | 66 | 36 | | 12 | 54 | 39 | |

| | Enhanced Dark Denitrification Reef Rate ($\mu mol\ m^{-2}\ h^{-1}$) | | | Enhanced Light Denitrification Reef Rate ($\mu mol\ m^{-2}\ h^{-1}$) | | |
|---|---|---|---|---|---|---|
| **Oyster Tissue Biomass Category** | ***Spring*** | ***Summer*** | ***Fall*** | ***Spring*** | ***Summer*** | ***Fall*** |
| Low | 58 | 122 | -13 | 140 | 210 | 0 |
| Medium | | 248 | 41 | | 259 | 51 |
| High | 370 | 296 | 67 | 674 | 367 | 99 |
| | | | | | | |
| Mean hours per day | 9.7 | 9.7 | 12.2 | 14.3 | 14.3 | 11.8 |

| | Daily Denitrification Reef Enhancement ($\mu mol\ m^{-2}\ d^{-1}$) | | | Denitrification Reef Enhancement during Measured Timeframe ($\mu mol\ m^{-2}\ 184\ d^{-1}$) |
|---|---|---|---|---|
| **Oyster Tissue Biomass Category** | ***Spring*** | ***Summer*** | ***Fall*** | ***Sum of Season x Eligible Crediting Days*** |
| Low | 2,558 | 4,183 | -160 | 454,425 |
| Medium | | 6,112 | 1,096 | 629,202 |
| High | 13,218 | 8,115 | 1,980 | 1,277,154 |
| | | | | |
| Eligible Crediting Days | 31 | 92 | 61 | 184 |

| | Net Denitrification Reef Enhancement ($lbs\ acre^{-1}\ y^{-1}$) | | | |
|---|---|---|---|---|
| **Oyster Tissue Biomass Category** | ***Spring*** | ***Summer*** | ***Fall*** | ***Annual Total Based on 184 Eligible Crediting Days*** |
| Low | 10 | 48 | -1 | **57** |
| Medium | | 70 | 8 | 79 |
| High | 51 | 93 | 15 | 160 |

# The estimate of N removal is 57 lbs $acre^{-1}$ $y^{-1}$

**The Calculation**

- Seasonally explicit rates are identical to a broad average, both for the "warm season".
- The separate incubation of reef communities under dark and illuminated conditions yields similar data. Sediment illumination appear more important.

**Our Next Steps**

- Finalize BMP report. Big challenge – keep it tractable!
- Approval – site specific BMP
- How do we get site-specific numbers at an affordable cost?

# Planning Estimates for Oyster Reef Restoration BMPs Related to Nitrogen and Phosphorus Assimilation Based on Harris Creek Data and Draft Recommendations from the Oyster BMP Expert Panel

Julie Reichert-Nguyen and Ward Slacum, Oyster Recovery Partnership

# Goal:

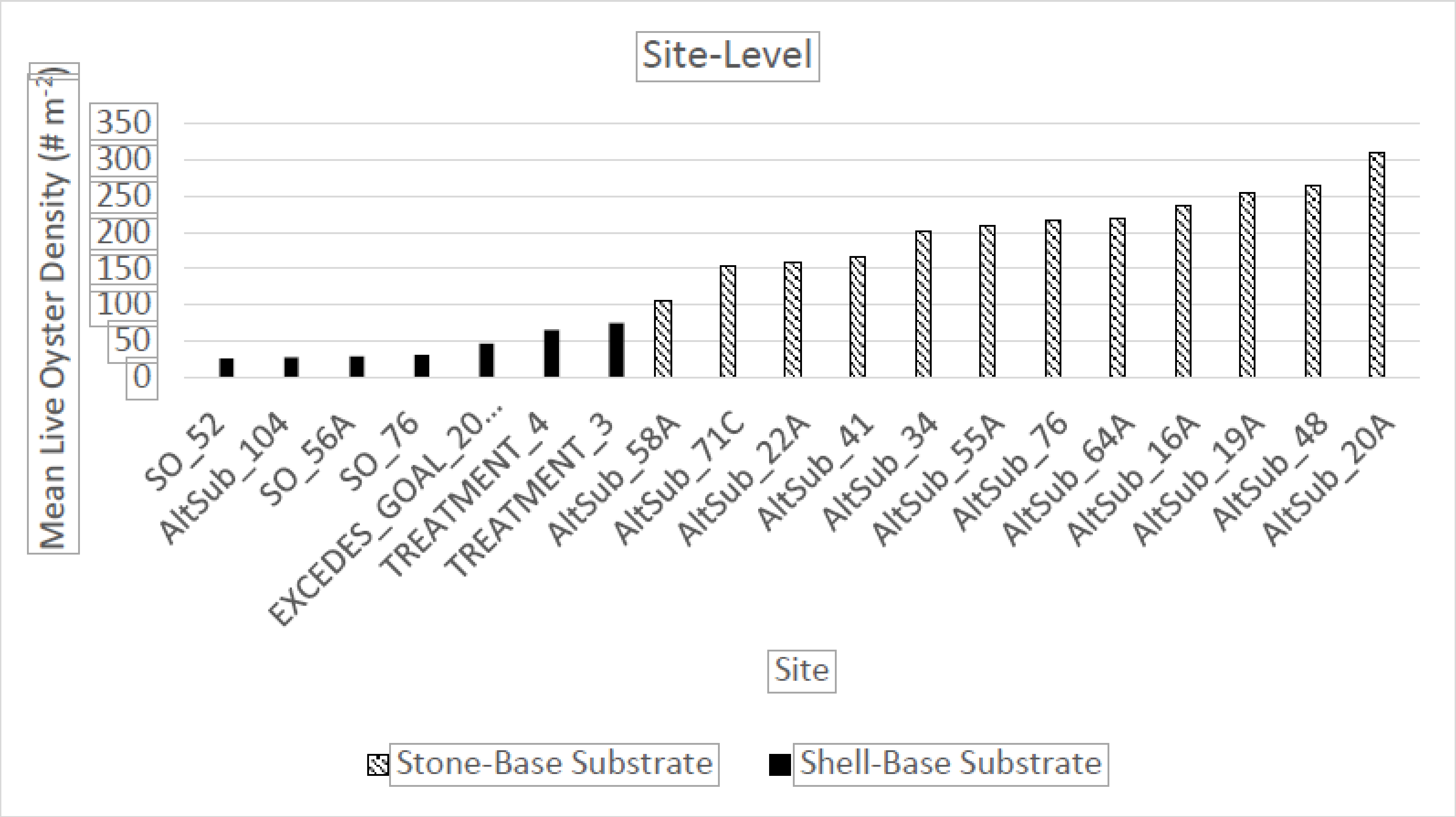
Provide defensible and conservative estimates of live oyster tissue and shell biomass and corresponding N and P reduction effectiveness that would be representative of expected levels post-restoration after three years based on real data

# Assimilation Into Both Tissue & Shell

## Based on Harris Creek Data

| 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<br>n = 7 sites<br>Mean Live Density = 42 oysters $m^{-2}$ | 24 | 4 |

The oyster reef restoration-assimilation estimates for BMP planning purposes. The restoration activity (i.e., treatment) involved creating a shell-base by planting spat-on-shell (SOS) on mixed shell or planting SOS only. For the SOS only sites, oyster shell was used as the shell base. Estimates include the amount of nitrogen or phosphorus assimilated (sequestered) in the combined tissue and shell biomass of live oysters based on oyster size measurements (i.e., shell heights) and oyster densities from 2017/2018 Harris Creek data three years post-restoration. The Oyster BMP Expert Panel's recommended Chesapeake Bay-wide regression equations (in draft) were used to convert measured shell heights to tissue and shell dry weight biomass. 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). Estimates 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.




We are taking a conservative approach….

# Conclusions

- The N and P reduction effectiveness for the oyster reef restoration-assimilation BMPs are driven by oyster tissue and shell biomass. Data from Harris Creek provided the largest dataset to determine conservative planning estimates that reflect potential oyster tissue and shell biomass three years post restoration.
- While these planning estimates can be applied more broadly for other restoration projects in the Chesapeake Bay, they should not be used to calculate the N and P reduction for crediting purposes. Oyster densities, and consequently, tissue and shell biomass, can vary quite significantly depending on the restoration activity and location. Therefore, for crediting purposes, site-specific data should be acquired to determine the oyster tissue and shell biomass following the Oyster BMP Expert Panel's recommendations.
- These planning estimates can apply for a max duration of three years since it is unknown at this time whether there are additional increases in oyster tissue and shell biomass beyond three years post restoration.

# Assimilation – Next Steps

**We're working on**

- Dealing with increased or decreased biomass of oysters over time
- Timing of crediting. After reef maturation, credit then?

**Challenges**

- Finalizing report. This summer
- Implementation. Getting this BMP into a form that can actually be applied in model world