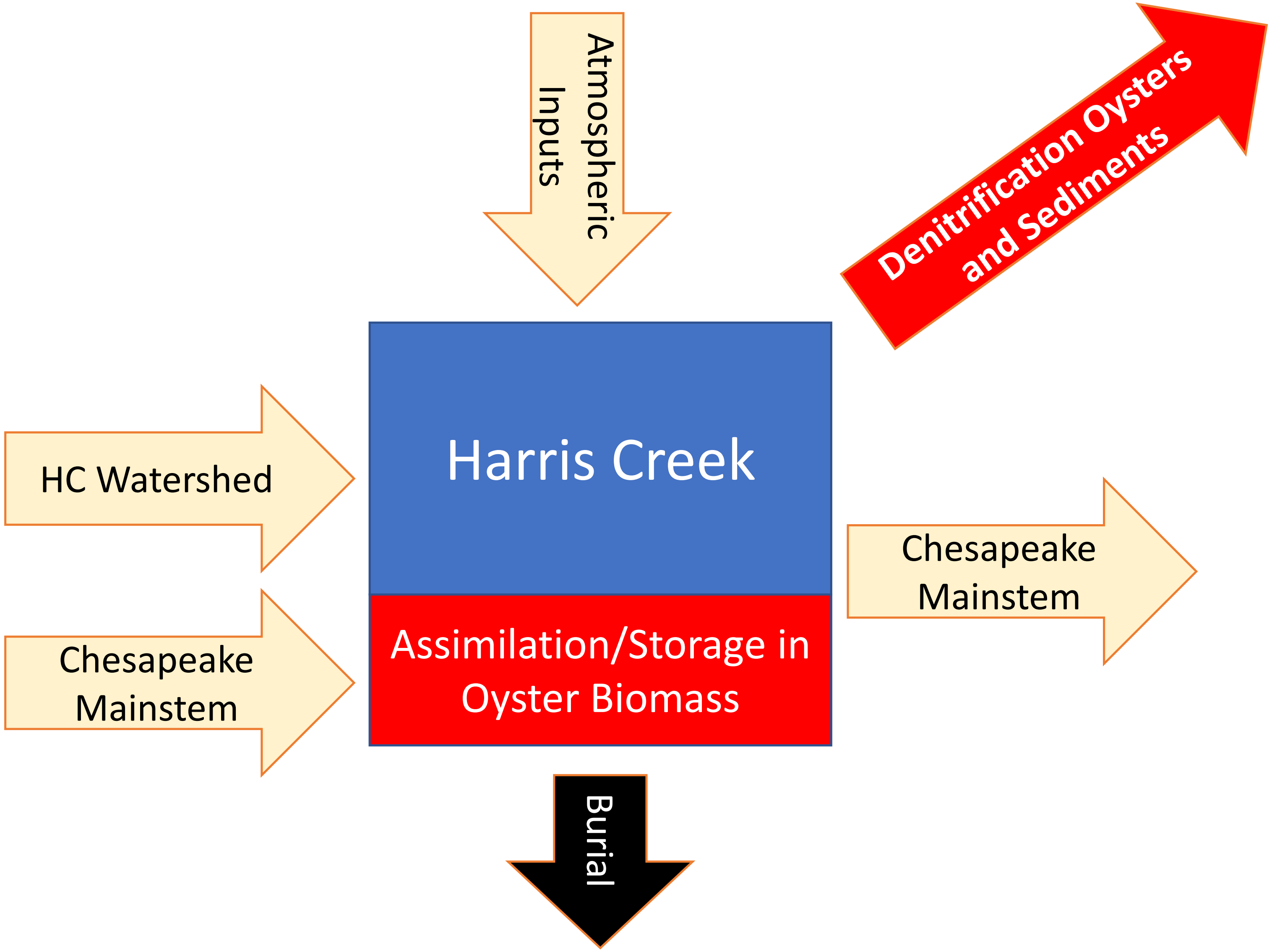
Oyster BMP Expert Panel – Oyster Reef Restoration Planning Estimates N and P Removal

July 8, 2019

Presenters: Jeffrey Cornwell, Panel Chair,
Julie Reichert-Nguyen, Panel Coordinator
Representing many colleagues….

Nitrogen and Phosphorus Mass Balance

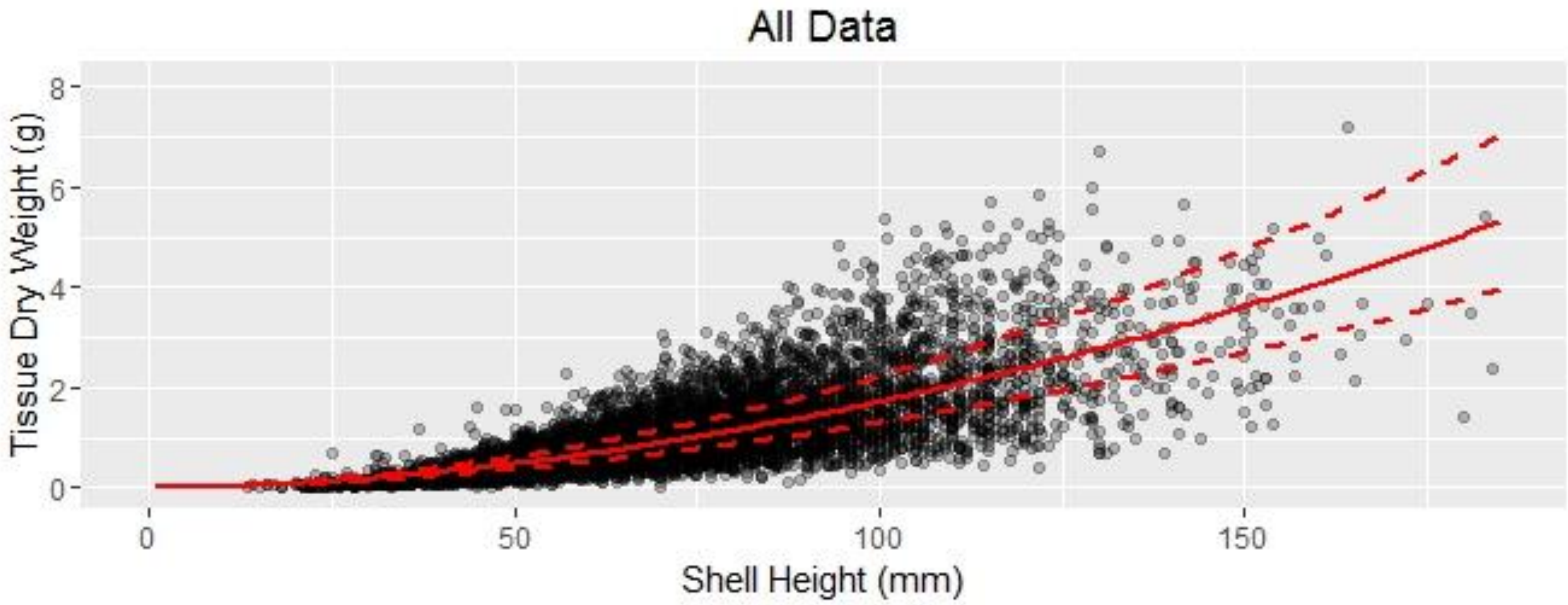


Nutrient Ecosystem Services With Bivalves?

- 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

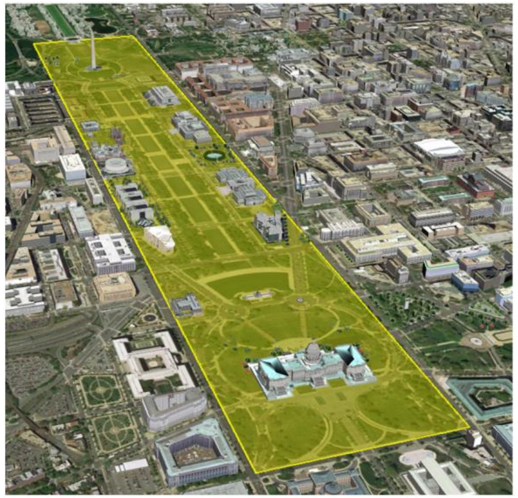
$y = 0.00037 * x^{1.83359}$

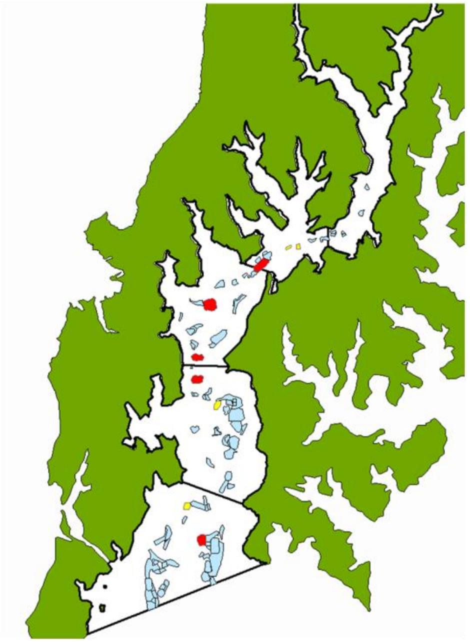
A Planning Estimate for an Oyster Reef Restoration Enhanced Denitrification Rate Based on Harris Creek Data

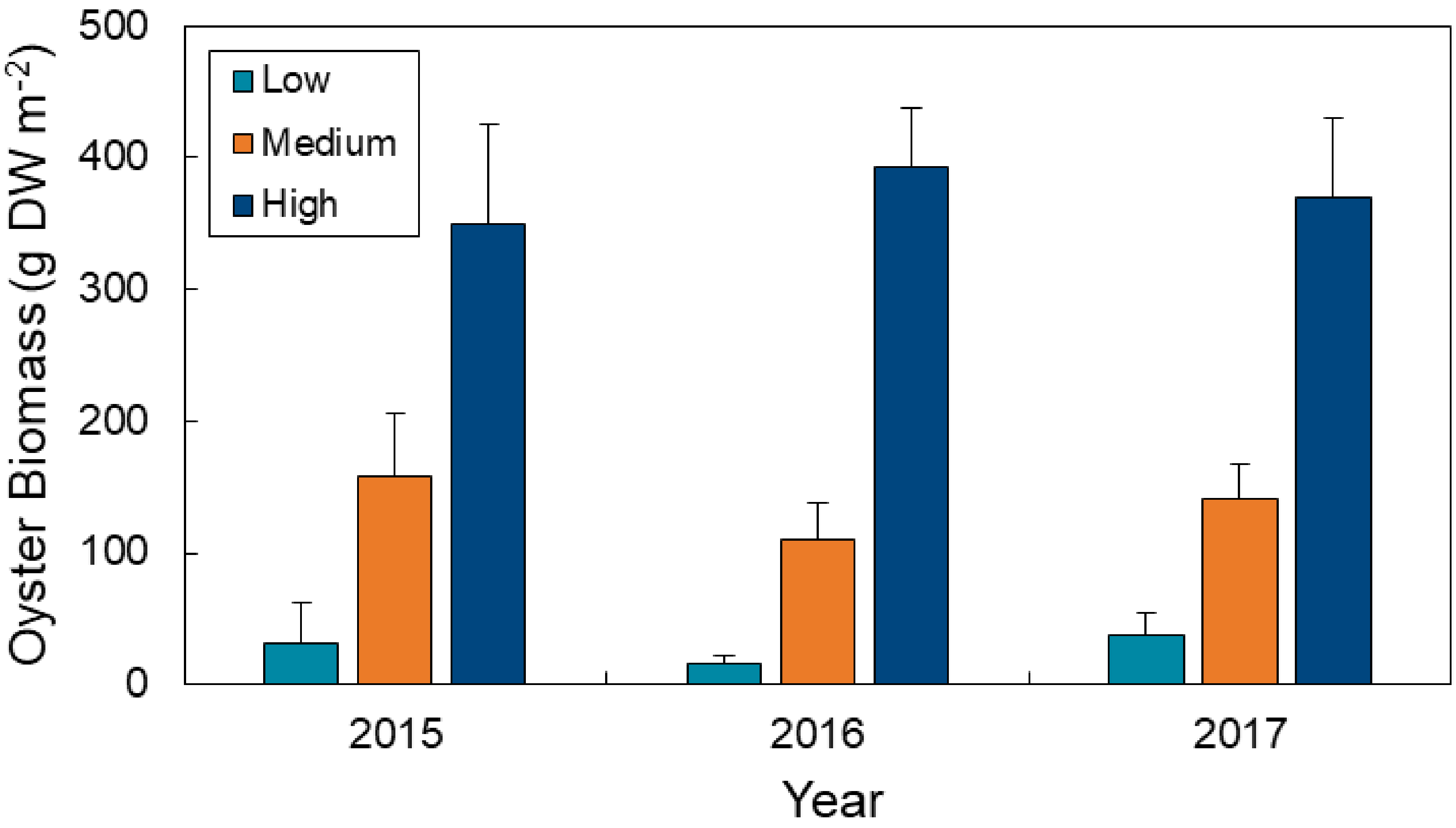
Jeffrey Cornwell, UMCES
M. Lisa Kellogg, VIMS
Michael S. Owens, UMCES
Julie Reichert-Nguyen, Oyster Recovery Partnership

Harris Creek, MD

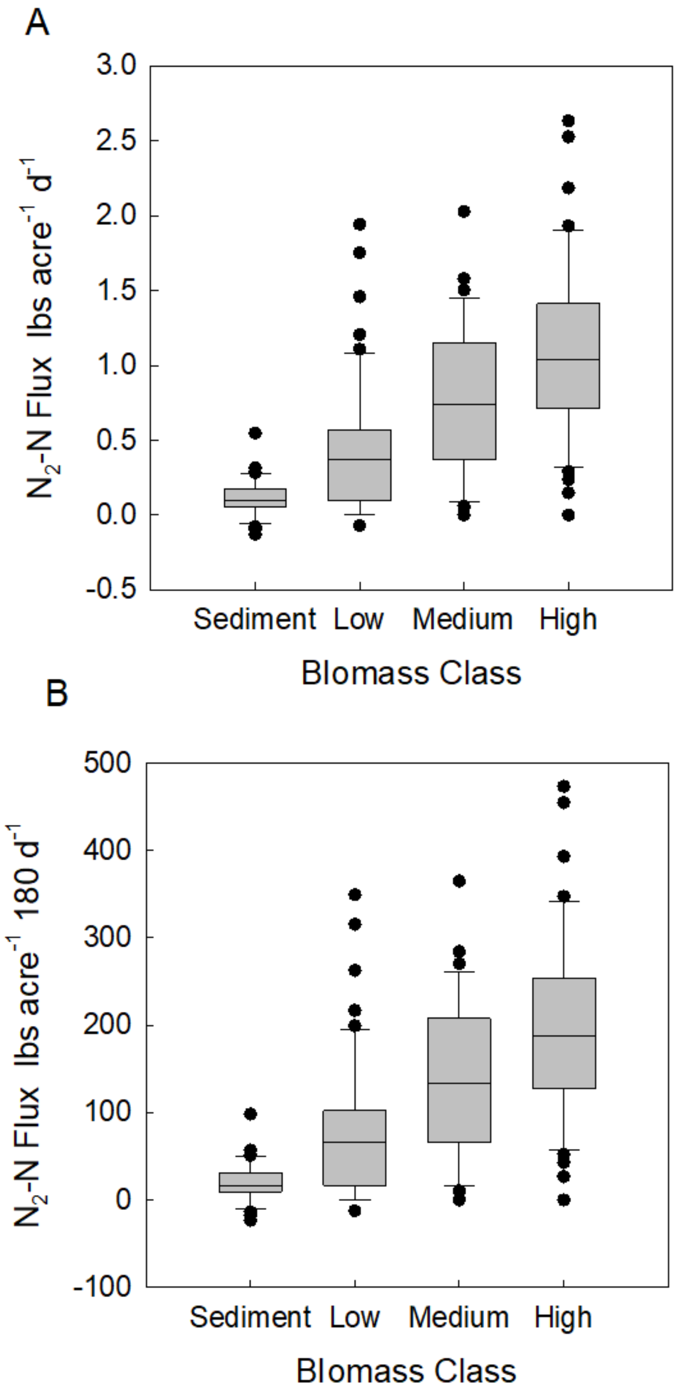
- ~350 acres planted with juvenile oysters set on oyster shell
- Cost ≈ $28 million
- What are the benefits?







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 (µmol m^{-2} h^{-1})			Enhanced Light Denitrification Reef Rate (µmol 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 (µmol m^{-2} d^{-1})			Denitrification Reef Enhancement during Measured Timeframe (µmol 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

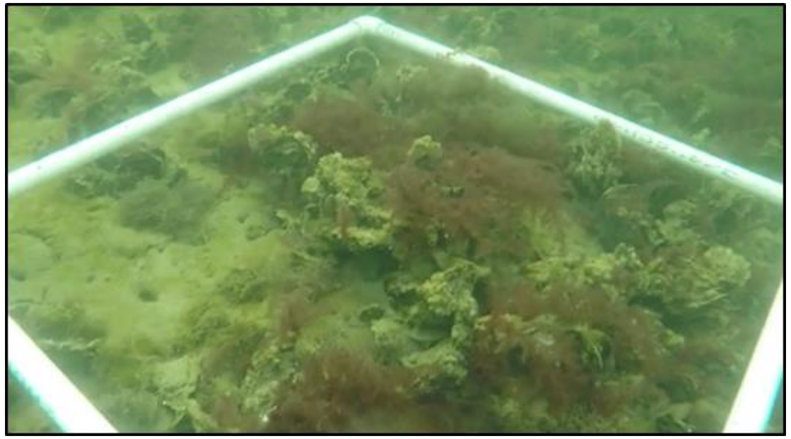
- Finalize BMP report. Big challenge – keep it tractable!
- Approval – site specific BMP
- How do we get site-specific numbers at an affordable cost?

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

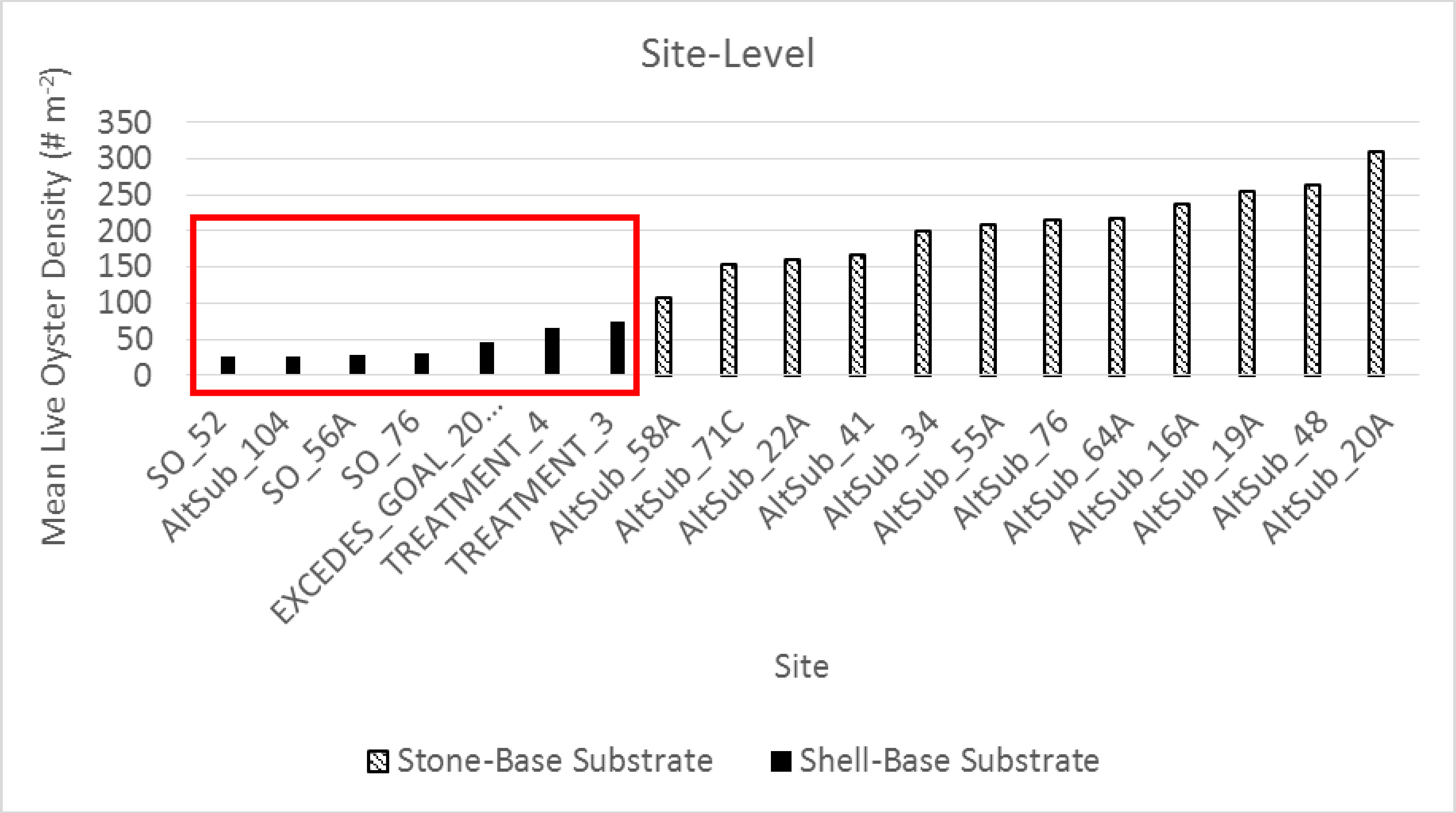
Goal:

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



Harris Creek Data Three Years Post Restoration Activities

2017/2018 Sampling

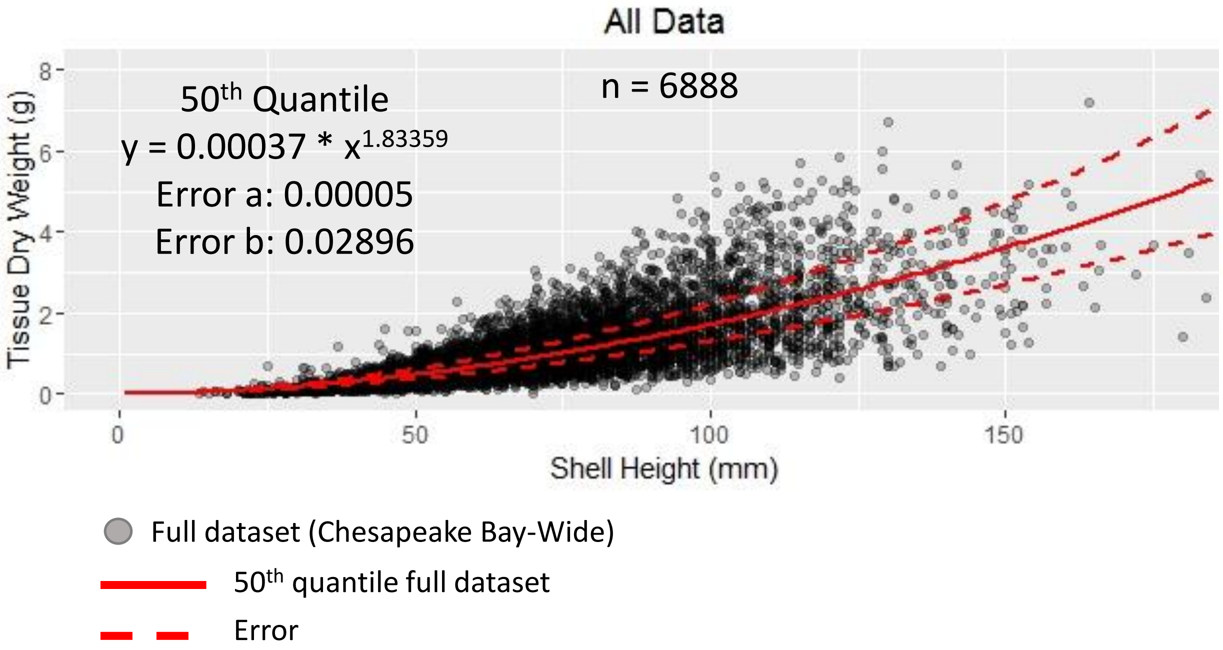


We are taking a conservative approach….

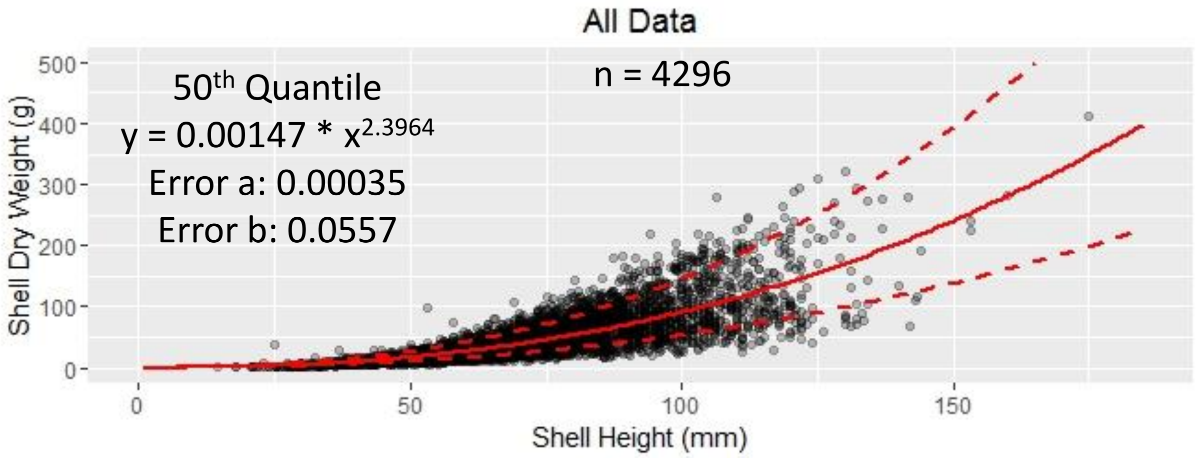
Calculating N & P Assimilation In Tissue & Shell

- Used the Oyster BMP Expert Panel's recommended Chesapeake Bay-wide shell height to dry weight regression equations (in draft).

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.

N & P Assimilation 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.
  - Reflects potential oyster tissue and shell biomass three years post restoration.

- Planning estimates can be applied more broadly for other restoration projects in the Chesapeake Bay for planning purposes.

- 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.
  - 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.

- Planning estimates can apply for a max duration of three years
  - It is unknown at this time whether there are additional increases in oyster tissue and shell biomass beyond three years post restoration.

N & P 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.