Update on the Oyster BMP Expert Panel's Draft Recommendations for the Second Incremental Report

WQGIT

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Julie Reichert-Nguyen, Oyster BMP Expert Panel Coordinator
Jeff Cornwell, Panel Chair

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CENTER FOR ENVIRONMENTAL SCIENCE

OYSTER RECOVERY PARTNERSHIP | ORP

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In Today's Update

Recommendations the Panel has been working on:

- A framework to determine the potential nitrogen and phosphorus reduction effectiveness associated with shell from harvested oysters for BMP consideration.

- Rationale for site-specific estimates to determine the nitrogen reduction effectiveness related to the enhanced denitrification protocol for oyster reef restoration and private oyster aquaculture practices.

Panel Meetings

- The Panel has met ~ once per month since December 2016 to discuss recommendations for the 2nd report (no meeting in July 2017). There were 2 panel meetings in May and November 2017.

- The Panel hosted a stakeholder meeting on May 22, 2017. Meeting summary can be found at www.chesapeakebay.net/what/event/oyster_bmp_expert_panel_open_feedback_meeting

Oyster BMP Expert Panel Charge

- **Panel convened on September 22, 2015; charged with:**
  - Establishing a nutrient and suspended sediment reduction effectiveness determination decision framework for oyster BMPs.
  - Determining the nutrient and suspended sediment reduction effectiveness of oyster practices using available science and established framework.

Questions Related to Using Oysters as a Tidal In-Water BMP

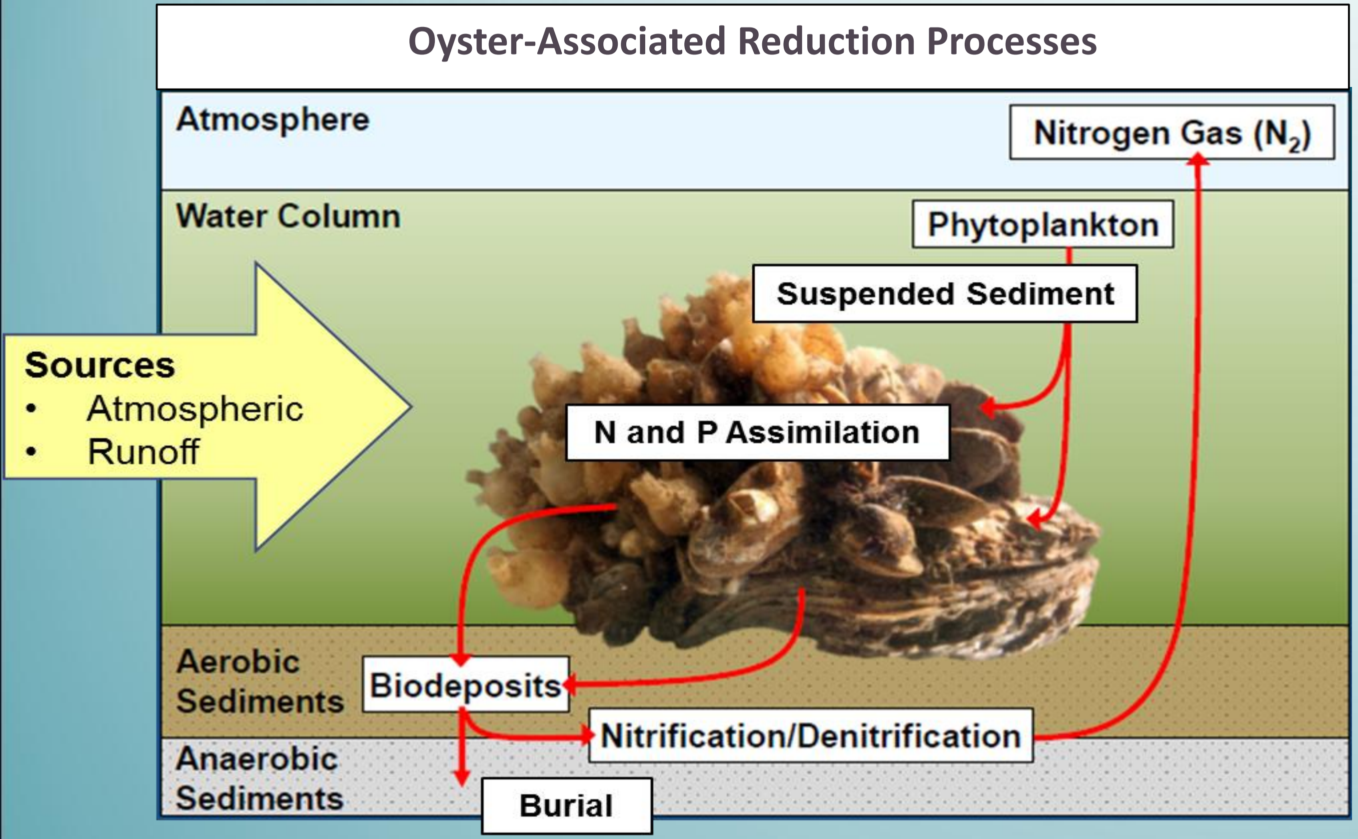
- **Science-Related: Reduction Effectiveness Determination**
  - Does existing data support nitrogen and phosphorus reduction estimates for the various oyster practices occurring in Chesapeake Bay?
  - How can the reduction be quantified and verified given the variability in oyster growth and survival?

- **Policy-Related: Removal Versus Sequestration**
  - Should reduction credit only be given when N and P is <u>removed</u> from the waterbody (e.g., tissue from harvested oysters, denitrification)?
  - Can <u>buried biodeposits</u> or <u>sequestered</u> nitrogen and phosphorus in oysters receive credit (e.g., oyster reef restoration practices)?
  - How to handle crediting N and P stored in shells given that shells should be returned to the Bay? Can credit be given for <u>temporary removal</u>?

Decision Points from the Oyster BMP Reduction Effectiveness Decision Determination Framework

Step	Decision Points	Description
1	Identify practices and oyster-associated reduction processes suitable for BMP Consideration	Practice must include an enhancement activity that could result in the overall production of new oysters and reduction process must occur with practice
2	Sufficient science exists to determine reduction	Quality and scope of data can generate a reasonably constrained estimate
3	Estimate is verifiable	Practical method exists, or could be developed, to track reduction effectiveness
4	Identified unintended consequences are manageable	Negative effects can be addressed so they don't outweigh environmental benefits

Reduction Effectiveness Protocols based on Oyster-Associated Nutrient/Suspended Sediment Reduction Processes



Reduction Effectiveness Protocols
1. Nitrogen Assimilation in Oyster Tissue
2. Nitrogen Assimilation in Oyster Shell
3. Enhanced Denitrification Associated with Oysters
4. Phosphorus Assimilation in Oyster Tissue
5. Phosphorus Assimilation in Oyster Shell
6. Sediment Reduction Associated with Oysters
7. Enhanced Nitrogen Burial Associated with Oysters
8. Enhanced Phosphorus Burial Associated with Oysters

Chesapeake Bay Oyster Practice Categories Identified

Chesapeake Bay Oyster Practices												
Oyster Fate	Oysters removed (harvested) from Bay									Oysters remain in Bay		
Fisheries Management Approach	Private oyster aquaculture (State-issued water column and bottom leases to individuals)					Public fishery (State-designated fishing areas for individuals with proper licences)				Oyster reef restoration (sanctuaries - no harvest)		
Oyster Culture Type	Hatchery-produced oysters (Diploid and Triploid)		Wild oysters (Diploid)			Hatchery-produced oysters (Diploid)	Wild oysters (Diploid)			Hatchery-produced oysters (Diploid)	Wild oysters (Diploid)	
Activity	Hatchery-produced oysters grown off the bottom using some sort of gear (e.g., floating rafts near the surface or cages near the bottom)	Hatchery-produced oysters grown on the bottom using no gear	Moving wild oysters from one location to another	Addition of substrate to the bottom to enhance recruitment of wild oyster larvae	None	Addition of hatchery-produced oysters (e.g. spat-on-shell)	Moving wild oysters from one location to another	Addition of substrate to enhance recruitment of wild larvae	None	Sanctuary creation followed by addition of hatchery-produced oysters	Sanctuary creation followed by addition of substrate	Sanctuary creation
Oyster Practice Title	Off-bottom private oyster aquaculture using hatchery-produced oysters	On-bottom private oyster aquaculture using hatchery-produced oysters	On-bottom private oyster aquaculture using transplanted wild oysters	On-bottom private oyster aquaculture using substrate addition	Private oyster aquaculture with no activity	On-bottom public fishery oyster production using hatchery-produced oysters	On-bottom public fishery oyster production using transplanted wild oysters	On-bottom public fishery oyster production using substrate addition	Public fishery with no activity	Oyster reef restoration using hatchery-produced oysters	Oyster reef restoration using substrate addition	Designated Oyster reef No harvest Area

Incremental Recommendations

- Approved (red outline)
- 1st Report (approved)
- 2nd Report (in draft)
- 3rd Report (planned)

D - Default estimate recommended

S – Method for site-specific estimate recommended

? – Estimate determination pending until gaps are filled

R - Research gap

P - Policy gap

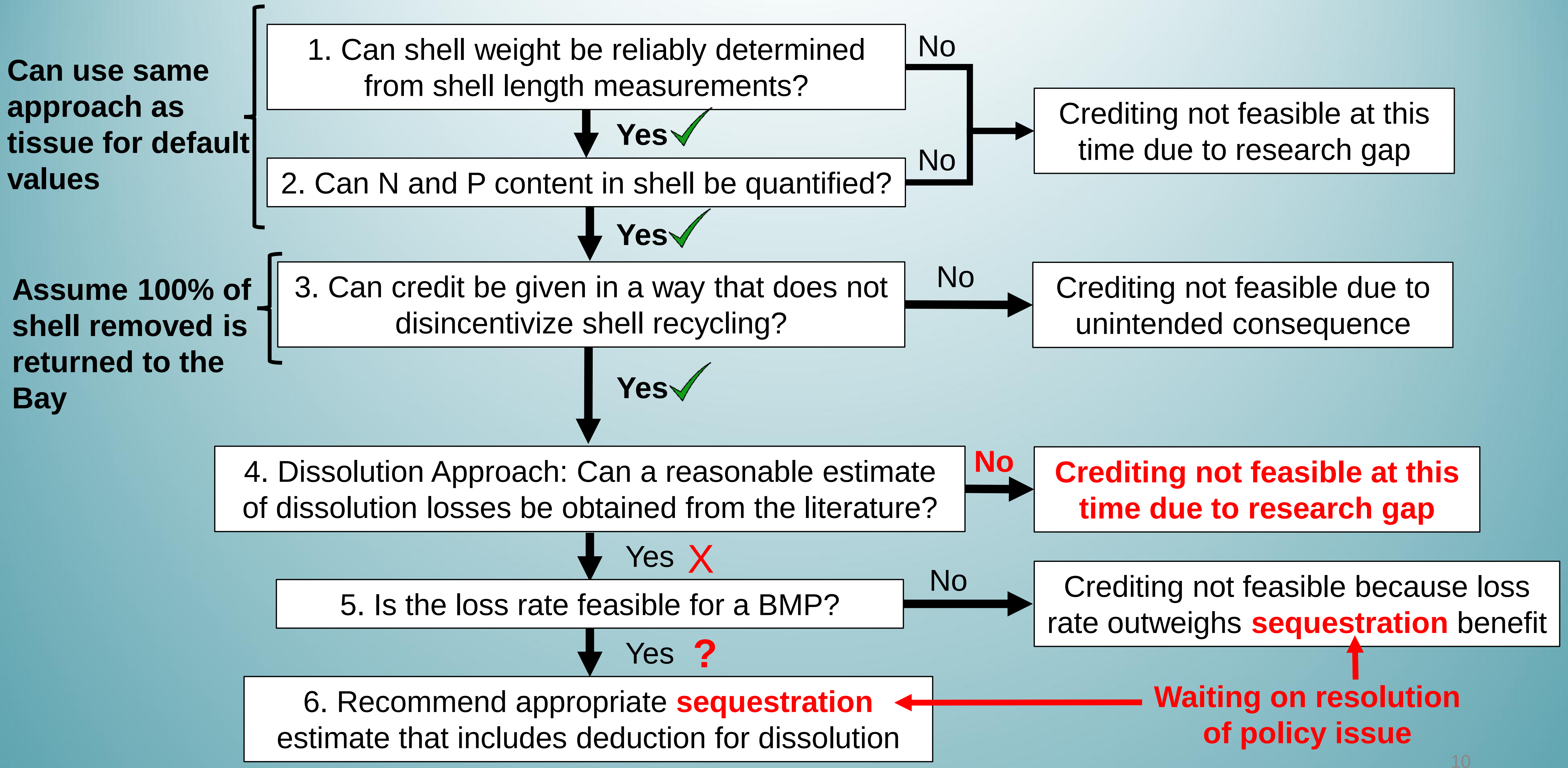
TBD - To be decided whether to undergo BMP consideration

X - Practice not endorsed for BMP consideration

On hold - Sequestration policy/legal issue

	Chesapeake Bay Oyster Practices											
	Private Oyster Aquaculture					Public Fishery				Oyster Reef Restoration		
Oyster Practice Category-Reduction Effectiveness Protocol Combination	**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. On-bottom public fishery oyster production using hatchery-produced oysters**	**G. On-bottom public fishery oyster production using transplanted wild oysters**	**H. On-bottom public fishery oyster production using substrate addition**	**I. Public fishery with no activity**	**J. Oyster reef restoration using hatchery-produced oysters**	**K. Oyster reef restoration using substrate addition**	**L. Designated oyster reef no harvest area**
1. Nitrogen Assimilation in Oyster Tissue	**D/S**	**D/S**	X	**D/S**	X	TBD	TBD	TBD	TBD	On hold	On hold	On hold
2. Nitrogen Assimilation in Oyster Shell	? R/P Gap	? R/P Gap	X	? R/P Gap	X	TBD	TBD	TBD	TBD	On hold	On hold	On hold
3. Enhanced Denitrification Associated with Oysters	S	S	X	S	X	TBD	TBD	TBD	TBD	S	S	S / X consensus not met
4. Phosphorus Assimilation in Oyster Tissue	**D/S**	**D/S**	X	**D/S**	X	TBD	TBD	TBD	TBD	On hold	On hold	On hold
5. Phosphorus Assimilation in Oyster Shell	? R/P Gap	? R/P Gap	X	? R/P Gap	X	TBD	TBD	TBD	TBD	On hold	On hold	On hold
6. Suspended Sediment Reduction Associated with Oysters	On hold	On hold	On hold	On hold	On hold	On hold	On hold	On hold	On hold	On hold	On hold	On hold
7. Enhanced Nitrogen Burial Associated with Oysters	On hold	On hold	On hold	On hold	On hold	On hold	On hold	On hold	On hold	On hold	On hold	On hold
8. Enhanced Phosphorus Burial Associated with Oysters	On hold	On hold	On hold	On hold	On hold	On hold	On hold	On hold	On hold	On hold	On hold	On hold

N and P Assimilation in Oyster Shell: Strategy to Determine the Reduction Effectiveness for Private Oyster Aquaculture Practices (DRAFT)



Method to Determine Conservative Default Values for the Amount of Nitrogen and Phosphorus Stored in Oyster Shell

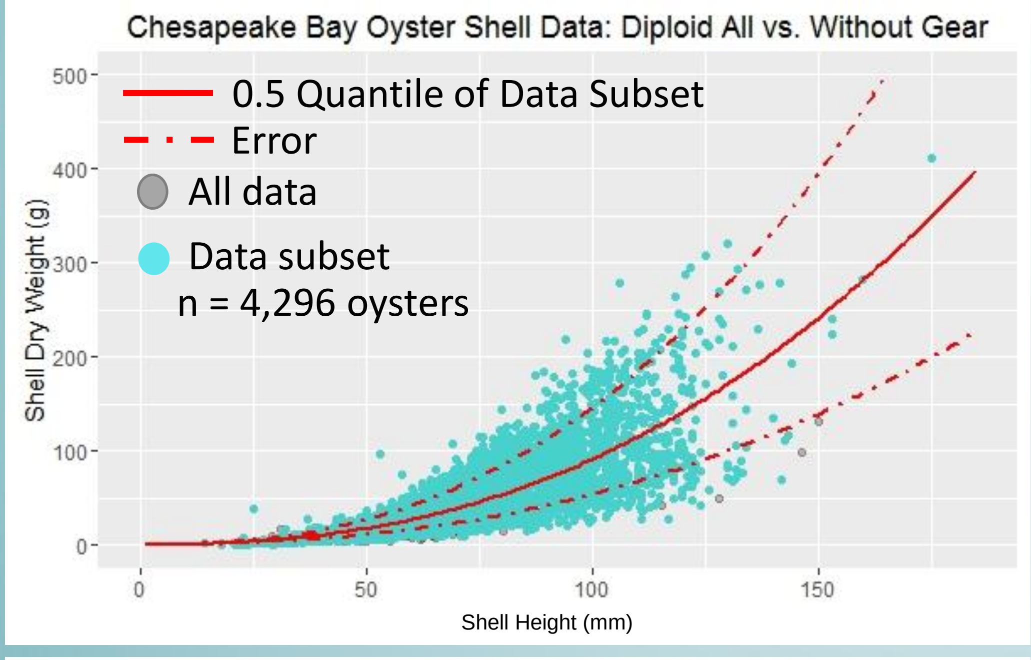
Step 1: Determine the oyster shell height to shell dry weight relationship using quantile regression.

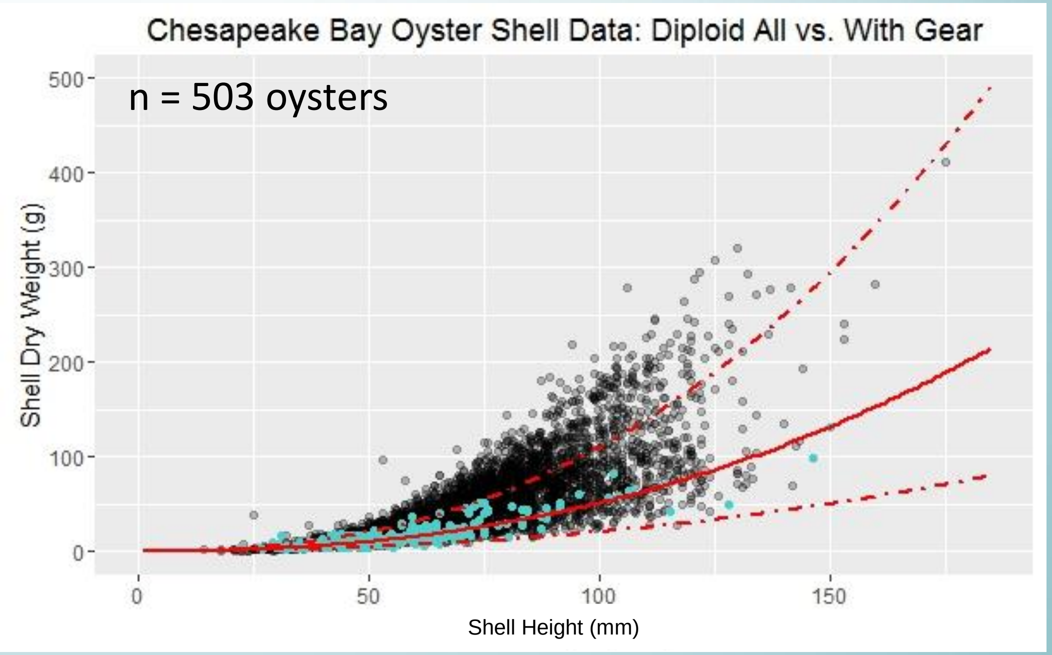
- Quantile regression uses the median of the data—less influenced by extremes (good statistical approach to use with highly variable data).
- Allows for consideration of various oyster growth influencing factors: ploidy, culture method and type, location/environment, and season.
- Shell dry weight needed to determine the amount of N and P stored in shell.

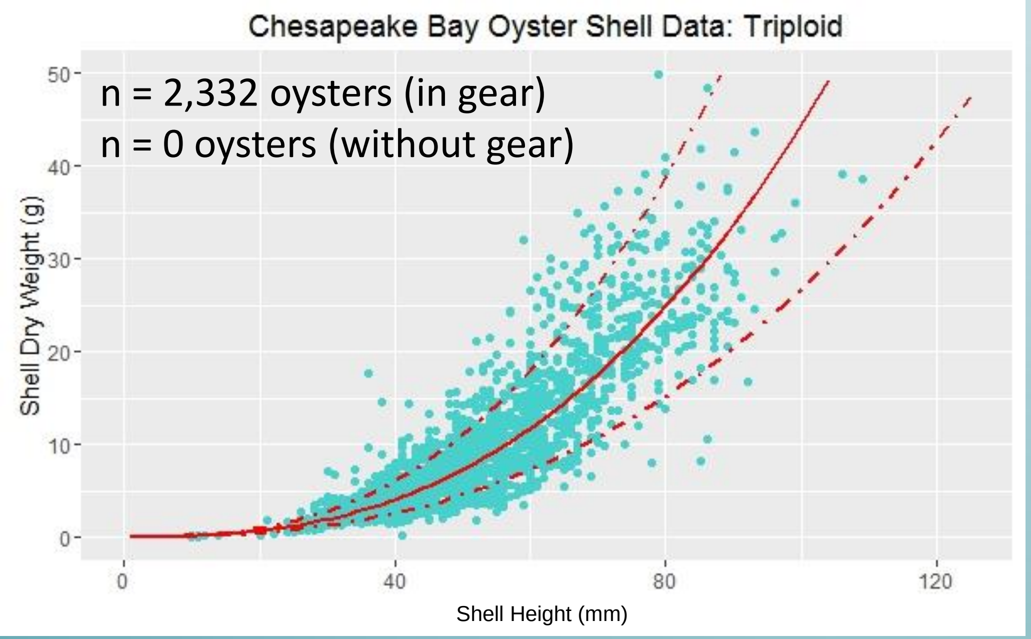
Step 2: Use shell height midpoints of determined oyster size class ranges to calculate the oyster shell dry weight with regression equations from Step 1.

Step 3: Determine and multiply the percent nitrogen and phosphorus content in oyster shell to oyster shell weights from Step 2 to determine the amount of N and P sequestered for the different size classes.

Method to Determine Amount of N and P Stored in Shell







Panel conclusions so far:

- Agreed that there is sufficient data to reliably determine shell weights from shell height data.
- Agreed that ploidy (diploid and triploid) and culture methods (with and without gear) should have separate estimates.
- Season and location effects currently being evaluated
- Literature review showed that **average N content in shell = 0.20% and P = 0.04%**

Shell Assimilation: Evaluation of Dissolution Literature to Account for Shell being Returned to the Bay

- **Three types of studies found:**
  - Annual shell loss rates from field studies:
    - Delaware Bay: Average shell loss rate per year ranged from 5-37% (Powell et al. 2007)
    - James River: Shell loss rate >20% per year for reefs (Mann et al. 2009).
  - Instantaneous shell decay rates based on field studies:
    - Rate of 0.5-0.9 per year (Smith et al. 2005)
    - Rate of 0.45 per year for market size oysters (Christmas et al. 1997)
  - Shell dissolution rates based on lab study:
    - Weathered shell degraded from 0.06-0.15% per day depending on pH (Waldbusser et al. 2011)

- **Panel's conclusions:**
  - Studies only evaluated loss of carbonate shell structure and not the loss of N and P; some studies did not differentiate shell loss due to dissolution from burial.
  - Waldbusser et al. 2011 study most relevant, but may not adequately account for what is happening in the field.
  - With existing science, the Panel is not confident in assigning a default deduction to account for N and P that may dissolve back into the water when shells are returned to the Bay.

Conclusions So Far: N and P Assimilated in Oyster Shell Protocol for Private Oyster Aquaculture

- There is a potential reduction associated with the amount of N and P sequestered in harvested shell, but the reduction effectiveness can't be determined at this time due to lack of information on dissolution rates for shells returned to the Bay.
- Panel recommends separate shell height to shell weight regression equations for diploid with gear and diploid without gear.
- Panel recommends a separate triploid regression equation using available triploid with gear data.
  - Panel agrees that the triploid with gear regression equation can be used for the triploids without gear because they would likely have heavier shells based on diploid analysis; therefore, sequestered N and P would be under-estimated.
- Literature review showed that **average N content in shell = 0.20% and P = 0.04%**

Enhanced Denitrification Associated with Oysters – Concept

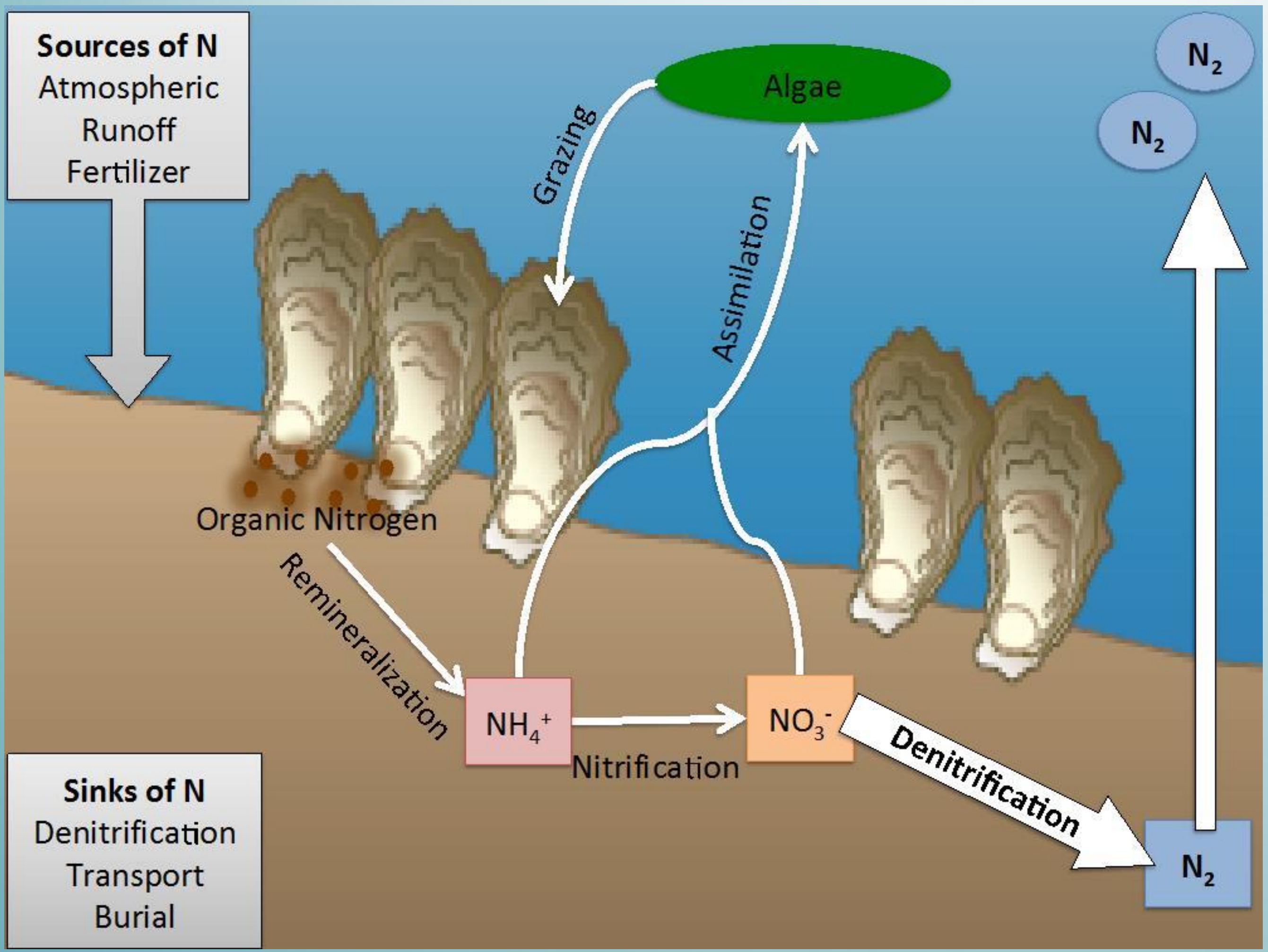


Image Credit: Ashely Smyth, jappliedecologyblog.wordpress.com/2015/05/20/location-matters-for-oyster-reef-ecosystem-services/

- Oysters take away remineralization (production of inorganic N) from the water column and transfer the process to the sediments.
- 100% of remineralized N in the water column is bioavailable to grow more algae.
- Oysters moving organic N to the sediments (i.e., oyster biodeposits) could allow more denitrification to intercept some of this remineralized N (releases N_2 gas; not bioavailable).
- Enhanced denitrification is the amount of new denitrification that occurs because of the presence of oysters.

Enhanced Denitrification Associated with Oysters – Data Availability and Challenges

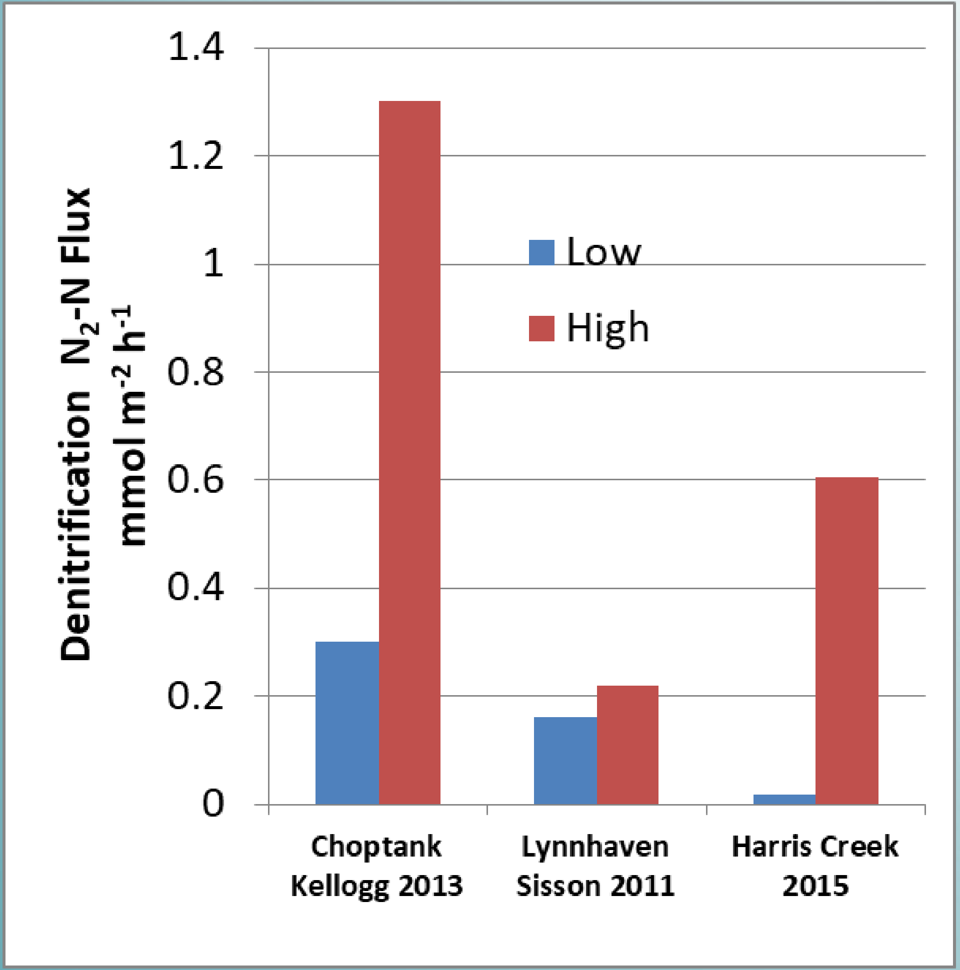
- In the Chesapeake Bay, we have more (valid) data on denitrification associated with oyster restoration and aquaculture than any other region.
  - There are still a relatively few studies.
  - Direct measurement of net flux of N_2-N per unit area would be needed (potential rates from gene copies and proxies such as sediment oxygen demand, biodeposit production or filtration would not be appropriate).
  - Given variability in data, site-specific estimates are recommended at this time until adequate data become available to determine a default rate.

- A measured denitrification approach (site with oysters minus a control site without oysters) could be used now to calculate the nitrogen reduction potential from enhanced denitrification at the site level.
  - Panel currently evaluating approaches to ensure that the methodology for the site-specific estimates would be conservative.

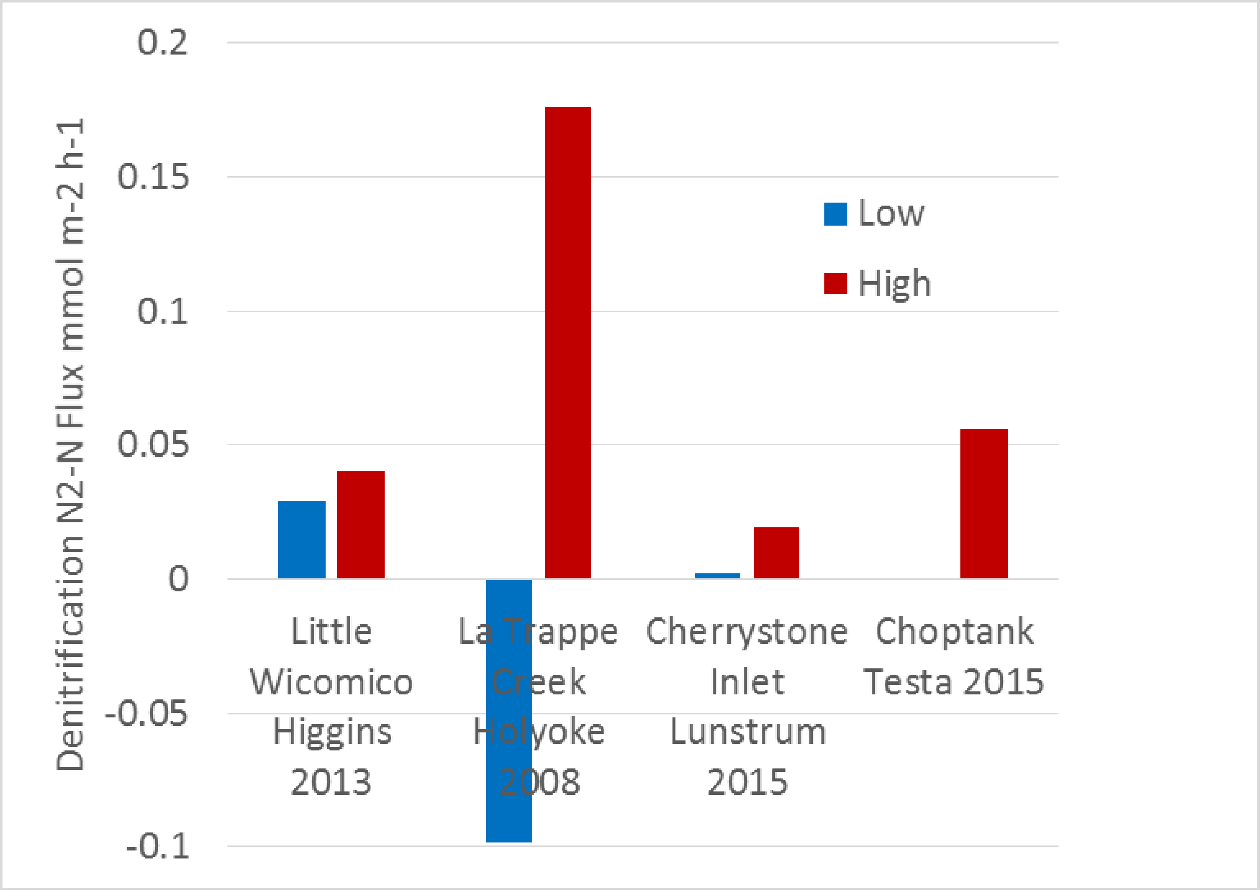
- Determining the total nitrogen reduction potential from enhanced denitrification requires knowing the fate of biodeposits.
  - Biodeposits could be denitrified elsewhere (few data exist for this parameter—research gap); measured denitrification likely underestimates the reduction.

Denitrification Literature Review – High Variability

Chesapeake Bay, Restoration-Related



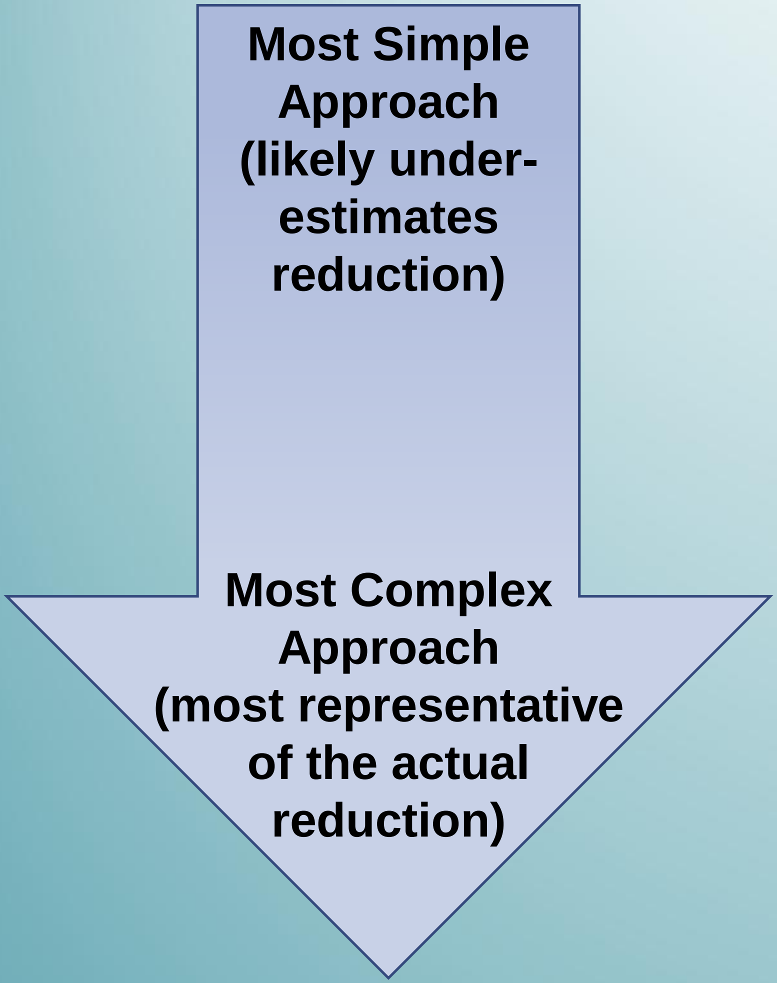
Chesapeake Bay, Aquaculture-Related



Low = minimum rate observed
High = maximum rate observed

Conclusion: Minimal available data and high variability supports the need for site-specific estimates at this time.

Enhanced Denitrification Associated with Oysters – Reduction Effectiveness Determination Strategy



Simple: Apply appropriate method that would capture the minimum enhanced denitrification rate (method exists; oyster site minus control site).

Complex: Apply method that would also take into consideration the fate of biodeposits (method does not exist; research gap).

Enhanced Denitrification Associated with Oysters – Measurements Needed for Simple Approach

- Oyster site and nearby control site (suitable for oyster growth/restoration and outside the area of expected oyster practice impact).
  - Enhancement = measured oyster site N_2-N flux – average control site flux
- Different seasons to capture seasonal variability.
- A minimum number of replicates at oyster and control sites during each season to allow estimation of variability.
- All measurements should include dark incubation; if area gets sufficient light for photosynthesis, then light incubations should also be done or daylight hours should not be credited.
- Measurement to define “oyster presence” (e.g., oyster biomass).

Conclusions So Far: Enhanced Denitrification Associated with Oysters

- At present, site-specific estimates of enhanced denitrification are needed because few studies have directly measured net flux of N_2-N per unit area and resulting data are highly variable.

- If future studies identify significant relationships between oyster site characteristics and denitrification rates, default enhanced denitrification estimates could be developed.

- Accurately estimating total denitrification enhancement requires knowing the fate of all biodeposits produced, an assessment that is beyond the scope of current measurement techniques. However, the Panel believes comparison of oyster sites to control sites likely underestimates total enhancement, making this a conservative approach.
    - Panel currently working on strategies to incorporate data variance to ensure estimates are conservative.

Panel Next Steps

- **January/February 2018—Planned release of Panel's 2nd incremental draft report for 30-day review**
  - Opportunity for the Chesapeake Bay Program Partnership and public/stakeholders to provide comments on the Panel's recommendations.

- **December 2017—Tentative timeframe to resolve sequestration/biodeposition policy/legal question for in-water BMPs**
  - BMP consideration for shell assimilation, burial, and suspended sediment reduction protocols would depend on these conclusions.

How to Keep Informed of Panel Efforts

ORP webpage summarizing Panel effort

oysterrecovery.org/water-quality-improvement

First report available at

oysterrecovery.org/oyster-bmp-first-report/

Contact Information: jreichert@oysterrecovery.org

QUESTIONS?