Oyster Best Management Practice Expert Panel—Recommendations on the Oyster BMP Reduction Effectiveness Decision Framework and Nitrogen and Phosphorus Assimilation in Oyster Tissue Reduction Effectiveness for Oyster Aquaculture Practices

Webinar to Kickstart CBP Partnership and Public Review of Draft Report

September 22, 2016

Jeff Cornwell, University of Maryland Center for Environmental Science, Panel Chair

Julie Reichert-Nguyen and Ward Slacum, Oyster Recovery Partnership, Panel Coordinators

Acknowledgements

Role	Oyster BMP Expert Panel
Panelists	Suzanne Bricker and Julie Rose (NOAA) Lynn Fegley (MDNR) Karen Hudson, Lisa Kellogg, and Mark Luckenbach (VIMS) Andy Lacatell (TNC) Chris Moore (CBF), Matt Parker (Sea Grant at U. of MD) and Ken Paynter (U. of MD) Larry Sanford (UMCES) Bill Wolinski (Talbot County of Public Works)

Role	Panel Support
Chesapeake Bay Program/U.S. EPA Advisors	Lucinda Power, Rich Batiuk, Lew Linker, Ed Ambrogio, Carl Cerco, Matt Johnston, and policy group led by Peyton Robertson and Emilie Franke
Coordination	Emily French (ORP)
Stakeholder Feedback	Delegate Anthony J. O'Donnell, Sue Kriebel, Steve McLaughlin, Russ Baxter, Tolar Nolley, Brad Rodgers, Johnny Shockley, and John Klein for their input during the public stakeholder meeting and the Citizen Advisory Committee, Chesapeake Bay Commission, Chesapeake Bay Foundation, Lynnhaven River Now, Southern Environmental Law Center and partners, Norfolk Public Works, and OCVA, LLC for their comments on initial drafts
Data Sharing	Colleen Higgins, Kurt Stephenson, Bonnie Brown, Peter Kingsley-Smith, Steve Allen, and Paige Ross

Interest in Using Oysters to Improve Water Quality in the Chesapeake Bay

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Evaluation of the Use of Shellfish as a Method of Nutrient Reduction in the Chesapeake Bay (2013)

Recommendation: Oysters harvested from aquaculture cages could receive nutrient reduction benefit

City of Virginia Beach Virginia — A Community for a Lifetime

Formal request proposing the Chesapeake Bay Program to consider denitrification rates for a “sanctuary oyster reef” BMP

Oyster Company of Virginia

Formal request for *in situ* nutrient remediation pilot between oyster farm and stormwater permittee

Clean Water Act/Chesapeake Bay Partnership Strategy

Water Quality Assessment
Chesapeake Bay not meeting various WQS

Chesapeake Bay TMDL
Developed in 2010 as a plan to reduce nitrogen, phosphorus, and sediment loads.

Watershed Implementation Plans
Jurisdictions (States and local partners) develop WIPs to show how they will achieve pollutant reductions.

BMPs
CBP-approved practices or technologies are selected by jurisdictions for credit towards achieving their respective WIP commitments

End Goal: Meet WQS

BMP Expert Panel
Determine pollutant reduction effectiveness of proposed BMPs following the CBP BMP Review Protocol

Oyster BMP Expert Panel Background Information:
http://oysterrecovery.org/water-quality-improvement-2/

CBP = Chesapeake Bay Program
BMP = Best Management Practices
TMDL = Total Maximum Daily Load
WIP = Watershed Implementation Plan
WQS = Water Quality Standards

1st Incremental Recommendation Report

The Panel's recommendations found in this first incremental report include:

- A decision framework to determine the nutrient (nitrogen and phosphorus) and suspended sediment reduction effectiveness of oyster practices for BMP application.
- The default reduction effectiveness estimates for the "Nitrogen Assimilated in Oyster Tissue" and "Phosphorus Assimilated in Oyster Tissue" reduction effectiveness protocols for oyster practices in the following oyster practice categories:
    - Off-bottom private oyster aquaculture using hatchery-produced oysters
    - On-bottom private oyster aquaculture using hatchery-produced oysters
    - On-bottom private oyster aquaculture using substrate addition

Main Steps of Decision Framework

Step 1: Determine oyster practice categories and individual oyster-associated nutrient and suspended sediment reduction effectiveness crediting protocols for evaluation.

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Step 2: For each suitable oyster practice category and reduction effectiveness crediting protocol combination, determine the reduction effectiveness estimate (e.g., number/rate, equation/method to calculate estimate) based on current scientific understanding.

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Step 3: Decide if the estimate would be verifiable (i.e., a practical method and the information needed to apply the method exists) and if so, provide verification guidelines.

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Step 4: Identify any unintended consequences and decide if negative effects could be addressed so they don't outweigh environmental benefits.

Panel Decision Criteria

Recommended for BMP Consideration: In the Panel’s best professional judgement, the practice will enhance the overall production of new oysters.

Suitable for Reduction Effectiveness Consideration: In the Panel's best professional judgement, the reduction process could occur in association with a particular oyster practice category.

Sufficient Science: In the Panel's best professional judgement, data of sufficient quality and scope exist and can be used to generate a reasonably constrained estimate of the reduction associated with a particular oyster practice category.

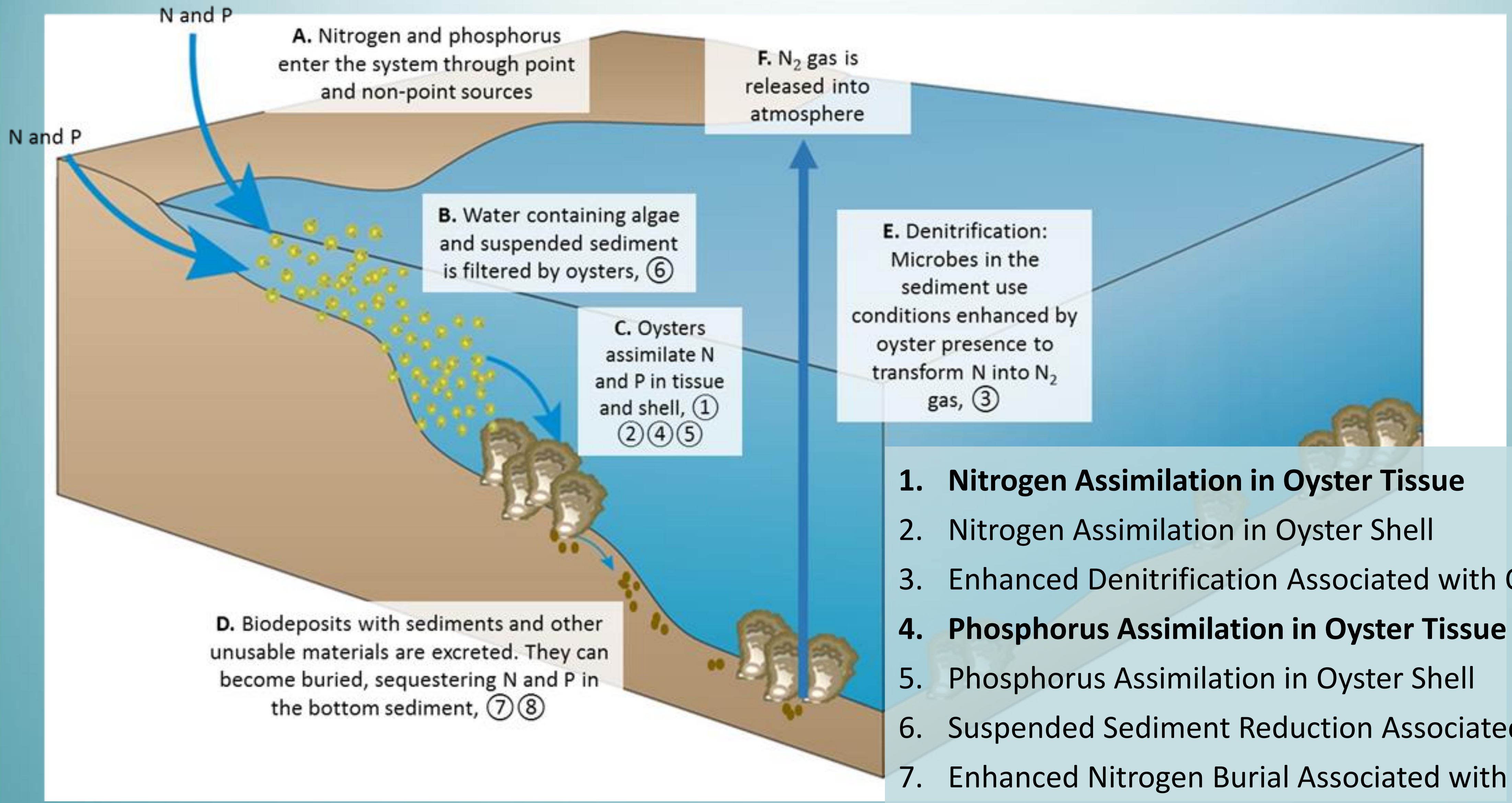
Verifiable: In the Panel's best professional judgement, a practical method exists, or could be created, to track reduction effectiveness if the BMP is implemented.

Unintended Consequence: Identification of potential unexpected negative or positive effects on the environment resulting from the practice. If there are any negative effects, can they be addressed so they do not outweigh environmental benefits? Positive unintended consequences are referred to as “ancillary benefits” to match the terminology found in the BMP Review Protocol (CBP 2015).

Chesapeake Bay Oyster Practices

Oyster Fate	Oysters removed (harvested) from Bay									Oysters remain in Bay		
Fisheries Management Approach	Private oyster aquaculture (water column and bottom leases)					Public fishery				Oyster reef restoration (sanctuaries)		
Oyster Culture Type	Hatchery-produced oysters		Wild oysters			Hatchery-produced oysters	Wild oysters			Hatchery-produced oysters	Wild oysters	
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 oyster 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	Active oyster reef restoration using hatchery-produced oysters	Active oyster reef restoration using wild oysters	Passive oyster reef restoration
***Panel Recommends for BMP Consideration**	**Yes**	**Yes**	No	**Yes**	No	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Oyster Practice Category	A	B	C	D	E	F	G	H	I	J	K	L

Oyster-Associated 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. Suspended Sediment Reduction Associated with Oysters
7. Enhanced Nitrogen Burial Associated with Oysters
8. Enhanced Phosphorus Burial Associated with Oysters

Decision Outcomes to Date for Oyster Aquaculture Practices

	Private Oyster Aquaculture				
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**
1. Nitrogen Assimilation in Oyster Tissue	**#**	**#**	X-Practice	**#**	X-Practice
2. Nitrogen Assimilation in Oyster Shell	D	D	X-Practice	D	X-Practice
3. Enhanced Denitrification Associated with Oysters	D	D	X-Practice	D	X-Practice
4. Phosphorus Assimilation in Oyster Tissue	**#**	**#**	X-Practice	**#**	X-Practice
5. Phosphorus Assimilation in Oyster Shell	D	D	X-Practice	D	X-Practice
6. Suspended Sediment Reduction Associated with Oysters	? - Policy	? - Policy	X-Practice	? - Policy	X-Practice
7. Enhanced Nitrogen Burial Associated with Oysters	? - Policy	? - Policy	X-Practice	? - Policy	X-Practice
8. Enhanced Phosphorus Burial Associated with Oysters	? - Policy	? - Policy	X-Practice	? - Policy	X-Practice

= recommended reduction effectiveness estimates are available for BMP application; D = ongoing Panel deliberations; X-Practice = not recommended by Panel for BMP consideration; ? - Policy = ongoing policy deliberations

Oyster Practice Categories Defined

Category	Oyster Practice	Description
A	Off-bottom private oyster aquaculture using hatchery-produced oysters	Hatchery-produced oysters grown off the bottom in the water column using sort of gear (e.g., floating rafts near the surface or cages near the bottom) in a private oyster aquaculture designated area where public fishing does not occur (e.g., water column leases) for eventual removal from the water.
B	On-bottom private oyster aquaculture using hatchery-produced oysters	Hatchery-produced oysters (e.g., spat-on-shell) grown directly on bottom using no gear in a private oyster aquaculture designated area where public fishing does not occur (e.g., bottom leases) for eventual removal from the water.
D	On-bottom private oyster aquaculture using substrate addition	Planting oyster shells or alternative substrate, such as granite, directly on the bottom to attract recruitment of natural (wild) oysters in private oyster aquaculture designated areas where public fishing does not occur (e.g., bottom leases) for eventual removal from the water.

Two Recommended Approaches for Determining Nitrogen and Phosphorus Reduction Effectiveness Assimilated in Oyster Tissue of Removed (Harvested) Oysters for Aquaculture Practices

1. Default estimates for recommended practices regardless of location.

2. Site-specific estimates developed by the BMP implementer, in coordination with the State and CBP, using the Panel’s recommended methodology

Reduction Effectiveness Qualifying Conditions

The Panel agreed that the qualifying conditions described below would apply to both the default and the site-specific estimates:

- Only includes oysters that are removed moving forward from the time the BMP is approved/implemented for reduction effectiveness credit in the TMDL. This baseline condition was proposed by the CBP Partnership Management Board and the Panel concurs with their decision.
- Oysters had to have been grown from initial sizes < 2.0 inches shell height.
- Oysters have to be alive when removed to count toward the reduction effectiveness.

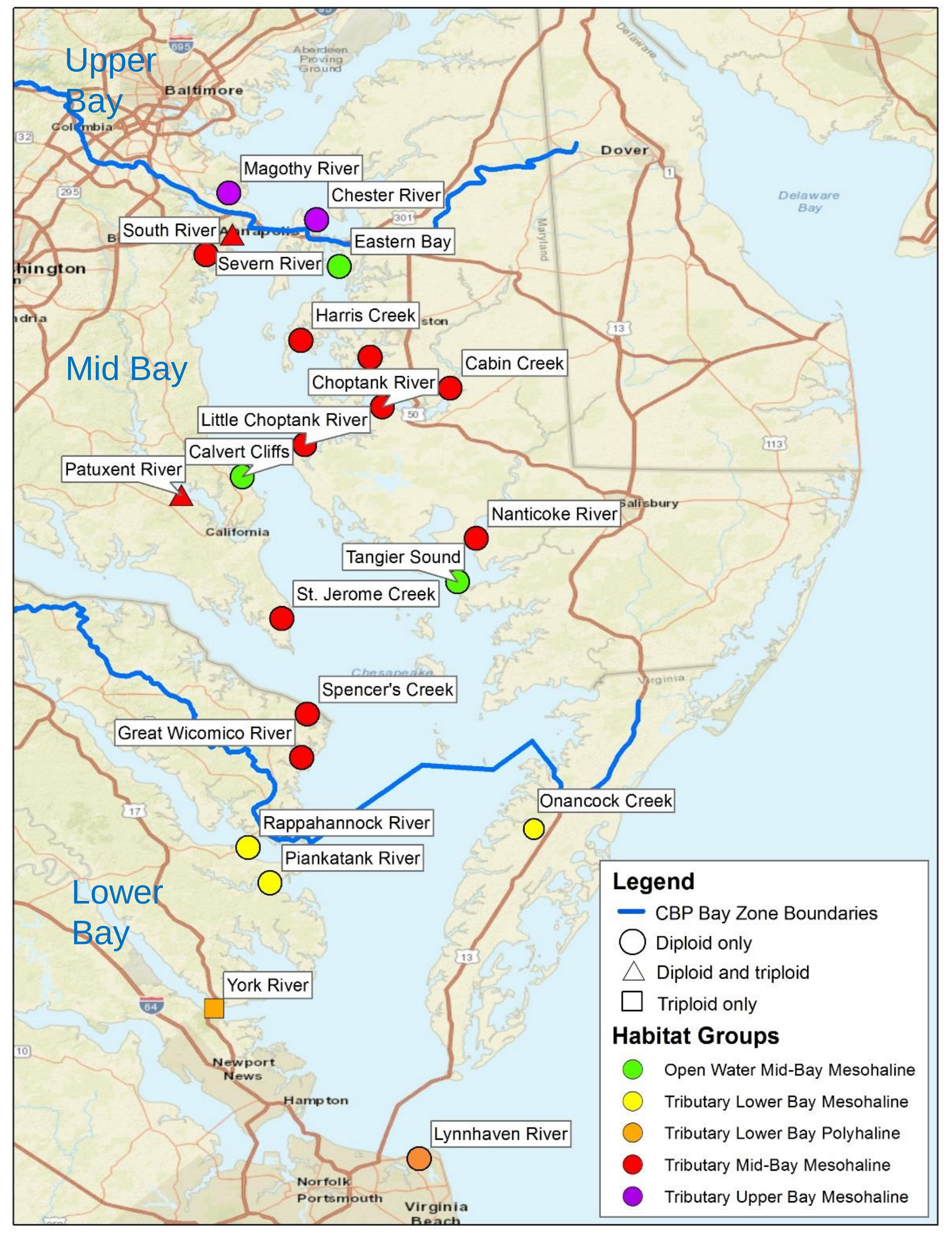
Method to Determine the Default N and P Reduction Effectiveness Estimates

The default reduction effectiveness estimates are based on using a regression equation to convert oyster shell height to tissue dry weight, applying the regression equation with the midpoints from recommended oyster size classes to determine the tissue dry weight, and then multiplying the tissue dry weight by the recommended % nitrogen and % phosphorus content in oyster tissue.

Step 1: Determine the oyster shell height to tissue dry weight regression equations for diploid and triploid oysters

Step 2: Establish oyster size class ranges for the shell height midpoints that will be used to calculate the oyster soft tissue dry weight

Step 3: Establish and apply the percent nitrogen and phosphorus content in oyster tissue to determine the reduction effectiveness estimates



Step 1: Data Locations Used for Regression Equations

- 22 general locations (1 triploid only site, 19 diploid only sites, and 2 sites with triploid and diploid oyster data).

- To look at the potential influence of site and environmental condition on the oyster shell height to tissue dry weight regression, the oyster data was also grouped by where the location fell in the Chesapeake Bay Program Bay zones (Upper, Mid, and Lower) and by the its salinity characteristic (mesohaline or polyhaline).

Step 2: Shell Height to Dry Tissue Weight Regression Equations for Diploids and Triploids

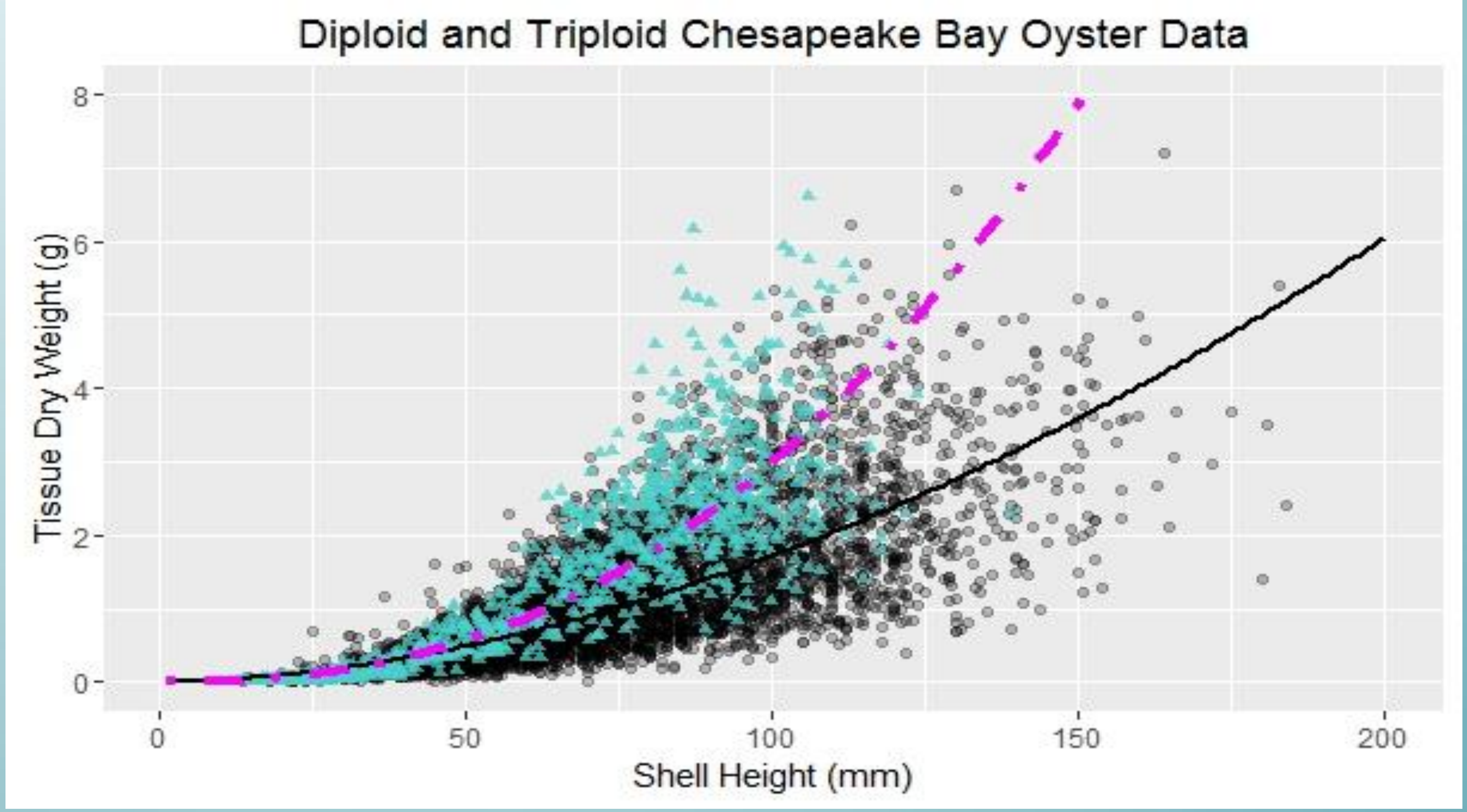
Regression Equation: $y = ax^b$
y = Tissue Dry Weight (g)
x = Shell Height (mm)

Regression equations based on 50th quantile using quantile regression statistical approach

Diploid Error:
a = ± 0.00006
b = ± 0.03427

Triploid Error:
a = ± 0.00002
b = ± 0.08846

Conclusion: Differences in biomass between diploid and triploid oysters warranted the use of separate regression equations.



Diploid 0.5 Quantile Curve, $y = 0.0004x^{1.82}$ (n = 5,750 oysters)

Triploid 0.5 Quantile Curve, $y = 0.00005x^{2.39}$ (n = 1,066 oysters)

Other Factors Considered

Factor	Conclusion
Culture Method (on-bottom, without gear and off-bottom with gear)	Oyster data for the different culture methods either skewed about the 50th quantile curve or were very similar, suggesting that the equations will more likely underestimate tissue dry weight, and hence reduction effectiveness.
Season	Fall, winter, and spring data skewed above the 50th quantile curve, while summer skewed slightly below. Given that the equations would more likely underestimate the reduction effectiveness for three of the four seasons and growers harvest year round, the Panel felt any instances for potential overestimation would be negated by instances of underestimation.
Location/Environmental Condition	Oyster data for four of the five habitat groups skewed above or were similar to the 0.5 quantile curve of the entire dataset, suggesting a greater chance to underestimate the reduction effectiveness. The remaining habitat group was only slightly below the 0.5 quantile curve of the entire dataset.

Step 2: Oyster Size Classes and Midpoints to Apply with Regression Equations

	Oyster Size Class Range (Shell Height in inches)	Oyster Size Class Range (Shell Height in mm)	Approximate Shell Height Midpoint (in inches)	Shell Height Midpoint to Use with Regression Equation (Shell Height in mm)
a.	**2.0 - 2.49**	~50 - 63	2.25	57
b.	**2.5 - 3.49**	~64 - 88	3.0	76
c.	**3.5 - 4.49**	~89 - 114	4.0	102
d.	**4.5 - 5.49**	~115 - 139	5.0	127
e.	**≥ 5.5***	≥ 140	6.0	152

*Midpoint based on 5.5-6.49 range

Step 3: Average Percent N and P Content in Oyster Tissue

- Average % Nitrogen Content in Oyster Tissue = **8.2%**
  - Based on 5 published studies and 1 unpublished study on diploid oysters in waterbodies along the Atlantic Coast

- Average % Phosphorus Content in Oyster Tissue = **0.9%**
  - Based on 2 published studies and 1 unpublished study on diploid oysters in waterbodies along the Atlantic Coast

Recommendation: The Panel is recommending that the above percent N and P contents be applied to both diploid and triploid oysters.

Default Reduction Effectiveness Estimates for N and P Assimilated in Oyster Tissue

Oyster Size Class Range	Diploid Tissue Dry Weight (g/oyster)*	Default Diploid N Content (g/oyster)***	Default Diploid P Content (g/oyster)****
a. 2.0 - 2.49	0.63	0.05	0.01
b. 2.5 - 3.49	1.06	0.09	0.01
c. 3.5 - 4.49	1.81	0.15	0.02
d. 4.5 - 5.49	2.70	0.22	0.02
e. ≥ 5.5	3.74	0.31	0.03

Oyster Size Class Range	Triploid Tissue Dry Weight (g/oyster)**	Default Triploid N Content (g/oyster)***	Default Triploid P Content (g/oyster)****
a. 2.0 - 2.49	0.79	0.06	0.01
b. 2.5 - 3.49	1.56	0.13	0.01
c. 3.5 - 4.49	3.16	0.26	0.03
d. 4.5 - 5.49	5.33	0.44	0.05
e. ≥ 5.5	8.20	0.67	0.07

*Diploid: tissue dry weight (g) = 0.0004 * Shell Height (mm)$^{1.82}$

**Triploid: tissue dry weight (g) = 0.00005 * Shell Height (mm)$^{2.39}$

*** 8.2% average nitrogen content in oyster tissue dry weight (based seven studies in waterbodies along the Atlantic Coast; used the average of the site means for studies outside of Chesapeake Bay; site-specific averages were used for studies within Chesapeake Bay)

****0.9% average phosphorus content in oyster tissue dry weight (based on three studies in Chesapeake Bay; same averaging approach as N, but only studies in Chesapeake Bay were found).

Methodology for Site-Specific Estimates

The Panel is recommending an option where the BMP implementer can apply for a site-specific estimate.

- The oyster BMP implementer works with the State and CBP to define:
  - Practice-specific oyster size class categories if using different categories than the default estimate
  - Two timeframes set by the State to reflect seasonal differences.
- Once approved by the State and CBP, the operation will have 50 random oysters per size class per season analyzed to determine the average tissue dry weight.
  - Samples are sent to a lab that uses standardized methods to acquire the tissue dry weight in grams (e.g., tissue heated at 60°C until samples reach constant weight).
- The average tissue dry weight for each size class is multiplied by the default 8.2% N content and 0.9% P content in oyster tissue to determine the site-specific reduction effectiveness estimates.
- The site-specific reduction effectiveness estimates are reviewed by at least two experts selected by either the State or CBP before making an approval decision.
- Once approved, the estimate is good for 5 years and then should be re-evaluated.

Recommended Application and Verification Guidelines

The Panel identified 3 types of data that would be needed to apply the nutrient reduction effectiveness estimates:

1. *Type and total # of containers*- The type (bushel, box,) and total # of containers used to package oysters.

2. *Average # of oysters in each container type*- Needed to figure out the total # of removed oysters to apply the reduction effectiveness estimates to on an annual basis.
   - **Verification Guideline:** The Panel recommends that the average # of oysters in a container is quantified by counting and documenting the total # of oysters in 10 containers. Oyster counts should be conducted during the two times a year when oysters are measured (see below).

3. *The average size of oysters in each container type*- Needed to figure out which oyster size class estimate to use
   - Verification Guideline: The average size of oysters in containers is quantified by measuring the shell heights of 50 randomly selected oysters from representative containers. The Panel recommends that shell heights be measured two times a year to address any seasonal variability in biomass for similar shell heights. The Panel suggests that measurements are taken 6 months apart based on timeframes set by the State to reflect any changes in minimum harvest sizes.

Reporting and Unit of Measure

- In Chesapeake Bay commercial fishermen and aquaculturists are required to quantify and report monthly oyster harvest to state management agency. Harvest is reported according to how oysters are packaged and sold which includes units of bushels, counts of oysters in boxes, or individual oysters.

- The Panel identified two different ways in which aquaculturists currently package their oysters for reporting:

1. **Oysters of variable shell heights are packaged together in the same container**
   - **Verification Guideline:** Twice a year, 50 oysters are randomly selected from at least 10 containers for shell height measurements. The average shell height of all measurements is used to verify which oyster size class range estimate to use to determine the nutrient reduction effectiveness.
   - Only can report in one oyster size class.
   - Typical approach used by on-bottom growers.

2. **Oysters of uniform size are packaged in separate containers**
   - **Verification Guideline:** Twice a year, 50 random oysters' shell heights are measured from at least 10 containers for each oyster size class range that the implementer is reporting. The average shell height of all measurements for that particular size class is used to verify which oyster size class range estimate(s) to use to determine the nutrient reduction effectiveness.
   - Can report in multiple oyster size classes.
   - Typical approach used by off-bottom growers.

Recommended Reporting Components

If oysters are grown at one location:

Reporting Component	Information From Grower
Ploidy	Diploid or triploid
Practice Title	Off-bottom Private Oyster Aquaculture Using Hatchery-Produced Oysters, On-Bottom Private Oyster Aquaculture using Hatchery-Produced Oysters, or On-Bottom Private Oyster Aquaculture Using Substrate Addition
Reporting Unit	Bushels, boxes, other container (indicate what type), or individuals
Packaging Type	Variable oyster sizes or uniform oyster sizes
Central coordinates of initial grow-out location	Latitude and Longitude
Month/year removed from final grow-out location	Month and Year
Number of containers of live oysters or individual oysters	# (count)
Oyster count average for unit verification check	# (10 representative containers per two time periods from final grow-out location)
Shell height average(s) for oyster size verification check	# (50 random oysters from 10 containers per two time periods from final grow-out location)

Off-Bottom Example (Oysters Grown in One Location)

Off-Bottom Private Oyster Aquaculture-Uniform Oyster Sizes per Packaged Container	
Reporting Component	**Information provided by grower**
Ploidy	Triploid
Practice Title	Off-bottom Private Oyster Aquaculture Using Hatchery-Produced Oysters
Reporting unit	Boxes
Packaging type	Uniform oyster sizes
Central coordinates of initial grow-out location	37° 36.444, -76° 25.411
Central coordinates of final grow-out location	37° 36.444, -76° 25.411
Month/Year removed from final grow-out location*	January-December 2016

Number of Containers with live oysters

Oyster Size Class (inches)	Container Count
2.0 - 2.49	0
2.5 - 3.49	5,000
3.5 - 4.49	5,000
4.5 - 5.49	0
≥ 5.5	0

Verification Checks

Oyster Size Class (inches)	Average Oyster Count per Container	Average Shell Height
2.5 - 3.49	100	3.33
3.5 - 4.49	100	4.25

Oyster Size Class (inches)	Total # of harvested oysters (# of containers x average oyster count)
2.5 - 3.49	500,000
3.5 - 4.49	500,000

Oyster Size Class (inches)	Default Triploid N Content Estimate (g/oyster)	Default Triploid P Content Estimate (g/oyster)
2.5 - 3.49	0.13	0.01
3.5 - 4.49	0.26	0.03

Nitrogen (N)	g N Removed
500,000 x 0.13 g N $oyster^{-1}$	65,000
500,000 x 0.26 g N $oyster^{-1}$	130,000
Total	195,000 = 195 kg N removed (429 lbs)

Phosphorus (P)	g P Removed
500,000 x 0.01 g P $oyster^{-1}$	5,000
500,000 x 0.03 g P $oyster^{-1}$	15,000
Total	20,000 = 20 kg P removed (44 lbs)

Movement of Oysters

The Panel identified instances where oysters are moved from their initial grow-out location to another location in the Bay or elsewhere. Reasons for moving the oysters include:

- Changing the taste by moving oysters to an area with higher salinity
- Water quality problems in the initial grow-out location.

Panel Recommendation: If locations are in different water segments, partition the credit by their size class when removed from each grow-out location based on the surviving oysters from the final grow-out location.

Verification Guideline: When moved, 50 random oysters are measured following the same guidelines described above based on how they're packaged. The average shell height from the measured oysters is used to determine what size class they are in before being transplanted into the new location.

Additional reporting if oysters are grown at multiple locations:

- Central coordinates (latitude and longitude) of any grow-out locations oysters are transferred to (if applicable)
- Month/year oysters are transferred
- Oyster size class category when placed at transfer location

Movement of Oysters-Example

- Diploid oysters are removed from Location 1 and moved to Location 2—50 random oysters are measured and the average shell height = 2.3 inches

- 1,000,000 diploid oysters are removed from Location 2 for harvest—50 random oysters are measured and the average shell height = 3.5 inches

- **Location 1 N reduction credit** = 1,000,000*0.05 grams = **50,000 grams**

- **Location 2 N reduction credit** = 1,000,000*0.15 grams = 150,000 grams minus the 50,000 grams partitioned to Location 1 = **100,000 grams**

- If oysters end up in the same size class for the multiple locations, then the 1st location will receive the credit.

Default Approach to Deal with Missing Information

Missing Verification Measurements

Panel Recommendation: If average oyster shell heights and average numbers of oysters in containers are not known then a default approach where the minimum legal size of oysters and State documented information specifying the average number of minimum legal sized oysters can be packaged in a specific container is used.

Example: State minimum legal harvestable size is 3 inches and they define bushels as 300 individual oysters. If verification measurements are missing, then all bushels would be multiplied by 300 and individual oysters assigned to the 2.5-3.49 inch oyster size class reduction effectiveness estimate for diploids.

Missing Ploidy Designation

Panel Recommendation: If ploidy is missing, then apply the diploid estimates.

Identified Unintended Consequences

Issue	Select Relevant Studies
Biodeposition by bivalves leads to increased nutrient releases from sediment	Choptank River: (Testa et al. 2015) St. Jerome Cr., Spencer’s Cr., Chesapeake Bay: (Higgins et al. 2013)
Loss or change of benthic biota through excessive organic matter loading	Puget Sound fish farm: (Weston 1990) New Zealand mussel farm: (Christensen et al. 2003)

Panel concluded that these consequences were relevant to off-bottom aquaculture. No negative consequences were identified for on-bottom aquaculture.

The Panel felt these consequences could be managed by monitoring the sediment via sediment core samples (heavily loaded sediments are jet black).

Ancillary Benefits

- Increases in seagrasses from enhanced water clarity by oysters.
- Connection between oyster reefs on the bottom and more abundant and rich marine life.
- Diverse and abundant marine species associated with rack-and-bag and floating gear.
- Finfish habitat provided by bottom aquaculture cages near the bottom.

Recommended Future Research to Refine Estimates

- Studies that work directly with aquaculturists to understand how aquaculture techniques influence oyster growth.
- Studies that evaluate seasonal differences for off bottom aquaculture.
- Studies that evaluate the % nitrogen and phosphorus contents in tissue for triploid oysters.
- Studies that evaluate potential differences in the % nitrogen and % phosphorus content between different oyster size classes.
- Studies that evaluate the amount of nitrogen and phosphorus removal resulting from removal of bio-fouling materials from aquaculture cages.

Conclusions

- Sufficient science was available to determine default N and P reduction effectiveness estimates based on N and P assimilated in oyster tissue of harvested diploid and triploid oysters for application with the following private oyster aquaculture practice categories:
  - Off-bottom Private Oyster Aquaculture Using Hatchery-Produced Oysters
  - On-Bottom Private Oyster Aquaculture using Hatchery-Produced Oysters
  - On-Bottom Private Oyster Aquaculture Using Substrate Addition categories.

- The Panel agreed that the estimates could be verifiable by counting the number of oysters in a subsample of containers and measuring a subsample of oyster shell heights using the Panel's recommended guidelines.

- Potential unintended negative consequences were identified for Off-bottom Private Oyster Aquaculture Using Hatchery-Produced Oysters, but the Panel felt these would be manageable by monitoring the condition of the sediment.

Request for CBP Partnership and Public Review

CBP Partnership and Public comment period on draft report

September 22 to October 22, 2016 (by midnight)

Send comments to jreichert@oysterrecovery.org

QUESTIONS?

Oyster BMP Expert Panel Timeline

Sep 22, 2016
Webinar on 1st set of draft recommendations for CBP Partnership and public 30-day review

Oct 22, 2016
Partnership and public comments due on 1st incremental draft report

Oct 2016
Review and revise report based on comments; update WTWG on Technical Appendix describing how recommendations will be applied in TMDL modeling tools

Nov 2016
Target month for WQGIT approval, in coordination with other GITs, of panel's 1st set of recommendations

Jan-May 2017
2nd set of recommendations (draft, review and approval)

Panel's Planned Report Schedule

	Private Oyster Aquaculture					Public Fishery				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. 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. Active oyster reef restoration using hatchery-produced oysters	K. Active oyster reef restoration using wild oysters	L. Passive oyster reef restoration
1. Nitrogen Assimilation in Oyster Tissue	**1st**	**1st**	**1st**	**1st**	**1st**	2nd	2nd	2nd	2nd	On hold	On hold	On hold
2. Nitrogen Assimilation in Oyster Shell	2nd	2nd	2nd	2nd	2nd	2nd	2nd	2nd	2nd	On hold	On hold	On hold
3. Enhanced Denitrification Associated with Oysters	2nd	2nd	2nd	2nd	2nd	2nd	2nd	2nd	2nd	2nd	2nd	2nd
4. Phosphorus Assimilation in Oyster Tissue	**1st**	**1st**	**1st**	**1st**	**1st**	2nd	2nd	2nd	2nd	On hold	On hold	On hold
5. Phosphorus Assimilation in Oyster Shell	2nd	2nd	2nd	2nd	2nd	2nd	2nd	2nd	2nd	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

Nitrogen Example
(Oysters Grown in One Location)

Diploid Example	g N Removed	kg N Removed	lbs N removed
1,000,000 size a oysters x 0.05 g N $oyster^{-1}$	50,000	50	110
2,000,000 size b oysters x 0.09 g N $oyster^{-1}$	180,000	180	397
1,000,000 size c oysters x 0.15 g N $oyster^{-1}$	150,000	150	330
Total	380,000	380	**837**

Triploid Example	g N Removed	kg N Removed	lbs N removed
1,000,000 size a oysters x 0.06 g N $oyster^{-1}$	60,000	60	132
2,000,000 size b oysters x 0.13 g N $oyster^{-1}$	260,000	260	573
1,000,000 size c oysters x 0.26 g N $oyster^{-1}$	260,000	260	573
Total	580,000	580	**1,278**

Triploid oysters have more biomass than same size diploid oysters resulting in more N removed