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

Update to the WQGIT on Panel's Responses to Comments

November 28, 2016

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Comments on Draft of First Report

- The Panel received written comments from 5 groups during the 30-day open comment period (September 22 to October 22, 2016) on the draft of the first report: Oyster Company of Virginia (OCVA), Chesapeake Bay Commission (CBC), Chesapeake Bay Foundation (CBF), Southern Environmental Law Center (SELC), and Dr. Lynton Land.
  - Summary of comments and Panel responses can be found in the supplemental document titled, "Oyster BMP 1st report response to comments.pdf."
  - The Panel organized comments by those related to:
    1. Panel's recommendations in the 1st report
    2. Policy/implementation
    3. Practice-protocol combinations that will be addressed in a future report
  - This presentation covers the Panel's changes to the report related to # 1
  - Policy/implementation-related comments were shared with the CBP Partnership to address as these were outside the purview of the Panel's charge (i.e., review existing science, and if sufficient, determine the reduction effectiveness estimates) and should not affect approval of the report.

Recommendations in the First Report

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

- A decision framework to incrementally determine the nutrient (nitrogen and phosphorus) and suspended sediment reduction effectiveness of oyster practices for BMP application.

- 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

- Methodology to establish site-specific estimates.

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

Chesapeake Bay Oyster Practices

Oyster Fate	Oysters removed (harvested)									Oysters remain		
Fisheries Management Approach	Private oyster aquaculture (water column and bottom leases)					Public fishery				Oyster reef restoration (sanctuaries)		
Oyster Culture Type	Hatchery-produced **diploid or triploid** oysters		Wild oysters **(diploid)**			Hatchery-produced **diploid** oysters	Wild oysters **(diploid)**			Hatchery-produced **diploid** oysters	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							
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

Comment # 4 and 5: Clarification on which estimates (diploid or triploid) should be used with the oyster practice category.

The Panel added clarification text throughout the report, including in the practice definitions.

Clarification on Steps of Decision Framework

Comment #1, #14, #26, and #27: Related to procedures involving expert review of estimates using recommended methodology, timeframe for re-evaluation of estimates, and detailed protocols for unintended consequences.

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

↓

1 and 14

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.

↓

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.

↓

26 and 27

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

Step 2 of Decision Framework: Expert Review of Estimates and Timeframe (Comment # 1 and 14)

(2.f) Does a methodology exist now that can be used to address knowledge gaps so that an estimate could be determined in the near future (within 5 years)?

yes

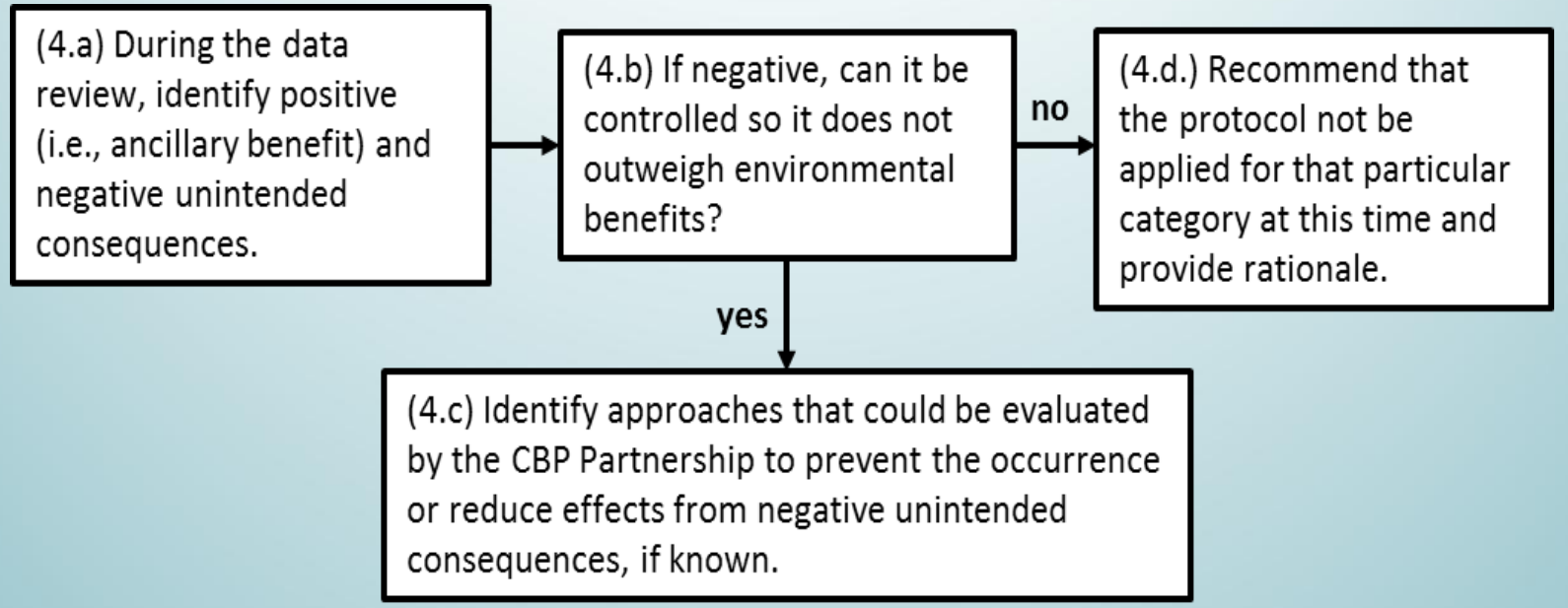
*(2.g) Panel recommends a methodology to determine the estimate, including the consideration of applicable environmental and implementation factors that would influence the estimate.

Revised language in bold:

* If the recommended method is used to determine what the estimate would be within the 5 year timeframe, then the Panel recommends that the **estimate is reviewed and approved using a similar approach as the re-evaluation procedures for existing estimates described in the CBP Partnership Expert Review Protocol (CBP 2015). The Panel encourages the CBP Partnership to incorporate opportunities for stakeholder involvement and input concerning these reduction effectiveness estimate determinations.**

Panel agreed that existing CBP Partnership-approved procedures should be used to review these estimates. Also agreed that these procedures should be used when re-evaluating all estimates. Panel recommends a 5-year timeframe for re-evaluation consideration of estimates, if new science is available, following procedures in the CBP Partnership Expert Review Protocol: "[review] can be conducted within a source Workgroup in consultation with the WTWG…follow guidelines listed in IIA [Review Process for New Estimates] except that a separate Panel is not convened and the information generated is added to the existing support documentation for the estimates."

Step 4 of Decision Framework: Clarification on Unintended Consequences (Comment # 26 and 27)



The Panel revised text in Step 4 of the Decision Framework and the unintended consequences section of the report so that it is clear that the Panel are presenting options that could be evaluated by the jurisdiction/CBP Partnership. It was never the intent of this step to provide detailed protocols. Detailed implementation procedures for BMPs are developed by the jurisdiction/CBP Partnership. The Panel felt that negative biogeochemical and hydrodynamic effects could be controlled (e.g., incorporate relevant sediment, water quality, and flow metrics in existing oyster aquaculture regulations).

Recommended Reduction Effectiveness Estimates

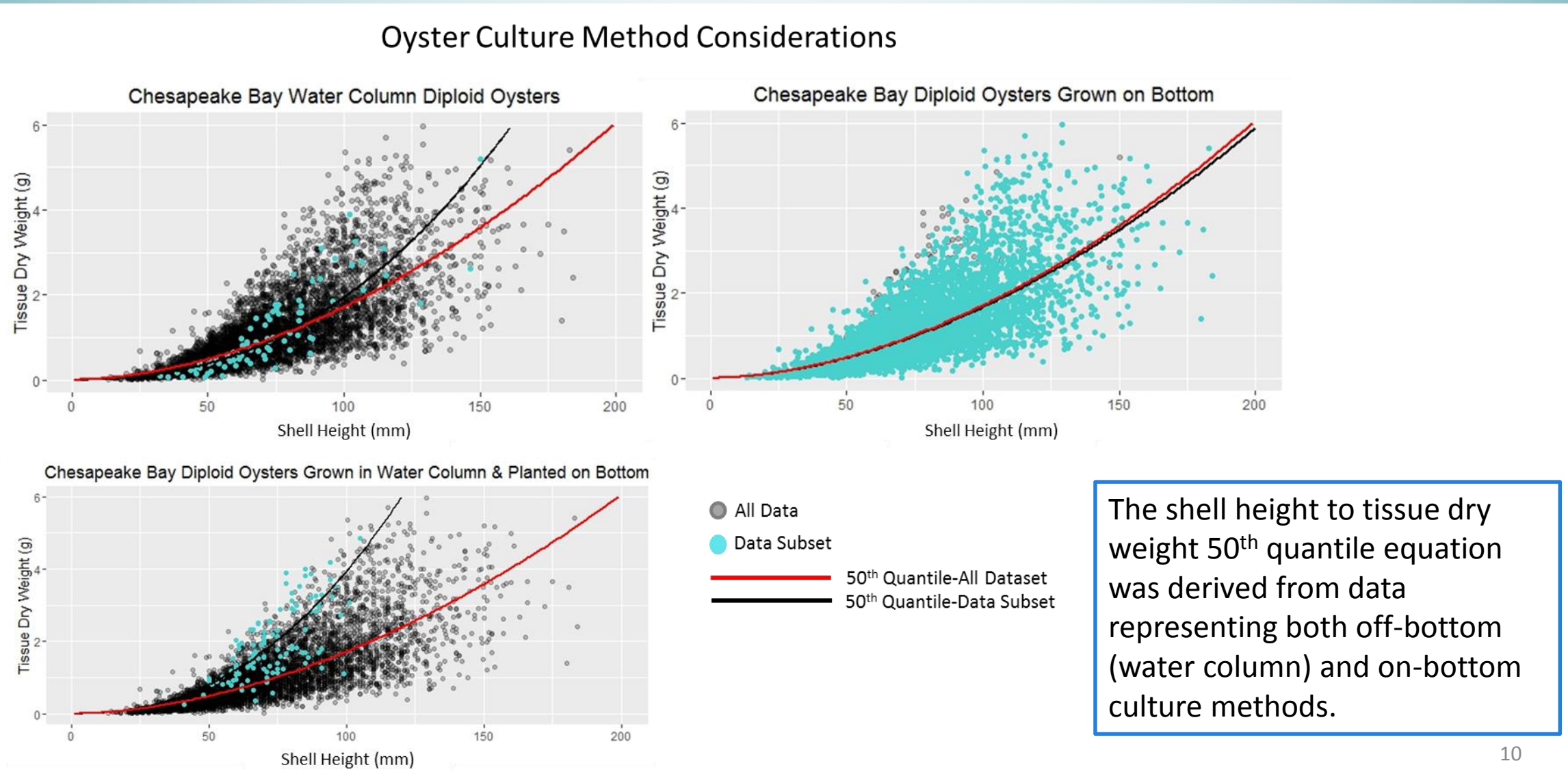
1. Default estimates for recommended practices regardless of location.

2. Site-specific estimates determined by the BMP implementer, in coordination with the CBP Partnership and reporting jurisdiction, using the Panel's recommended methodology.

Commenters had minor clarification questions concerning the science. Most comments were related to policy/implementation procedures.

Comments on Reduction Effectiveness

- **Comment # 15:** How do default estimates consider differences between off-bottom and on-bottom culture methods?



The shell height to tissue dry weight 50th quantile equation was derived from data representing both off-bottom (water column) and on-bottom culture methods.

Comments on Reduction Effectiveness Cont.

- **Comment # 16:** Too many oyster size class categories
  - **Panel Response:** The data available allowed the Panel to recommend estimates for five size class categories; it was not the Panel's intent that a practice must report in all five, but instead they would only report in the size classes that is relevant to their practice.

- **Comment # 17:** Expertise to review site-specific estimates
  - **Panel Response:** The Panel agreed it would be more appropriate for these procedures to be sorted out by the CBP Partnership; recommend they consider the re-evaluation procedures of existing estimates in the BMP Expert Review Protocol as a potential model to follow; also encourage them to incorporate opportunities for stakeholder involvement during procedure-related determinations.

- **Comment # 20:** If encouraging crediting of hatchery-produced diploid oysters and discouraging crediting of wild diploid oysters, need mechanism that will be transparent/validated/enforceable
  - **Panel Response:** Crediting of which culture type is ultimately the decision of the jurisdiction/CBP Partnership. The recommended default reduction effectiveness estimates could be applied to both hatchery-produced diploid and wild oysters. Panel added text in report concerning culture type consideration in deriving the default estimates.

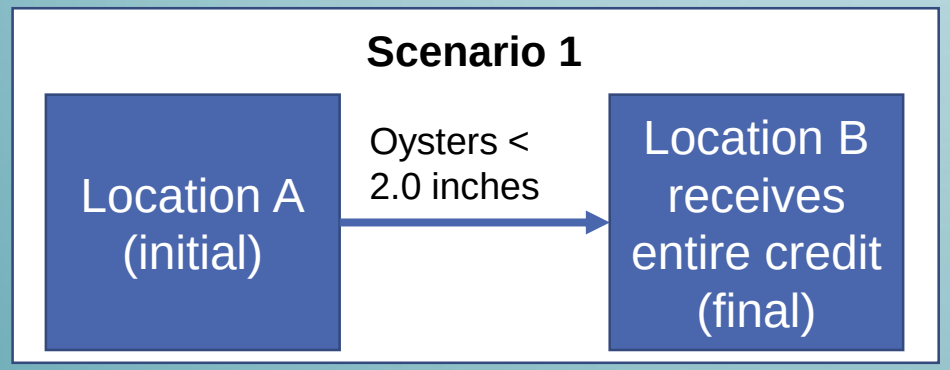
Comments on Application and Verification Guidelines: Substrate Addition

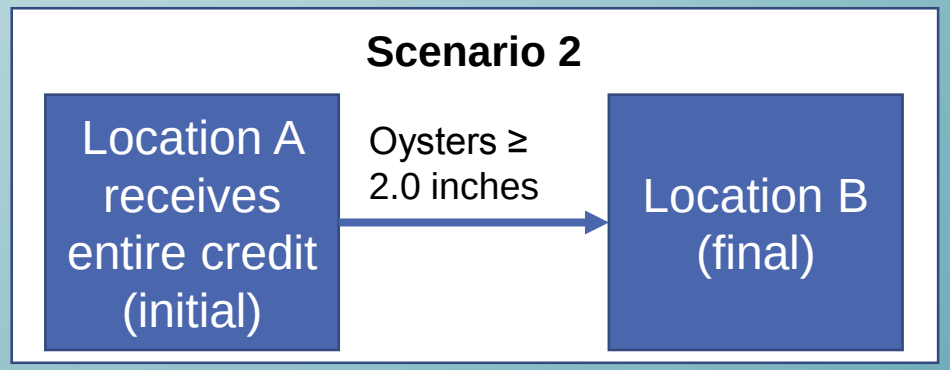
- **Comment # 18:** Clarification on how much substrate is sufficient to establish an "on-bottom private oyster aquaculture using substrate addition" practice.
  - **Panel Response:**
    - A baseline guideline on the amount of substrate would not be appropriate because substrate requirements would vary greatly based on the site characteristics (e.g., type and existing condition of the bottom), type of substrate used (e.g., shell, granite, cement, etc.), and requirements to maintain the site.
    - This issue is more related to implementation and should be sorted out when the jurisdiction, in coordination with the CBP Partnership, develops implementation and verification procedures for this practice. However, agreed that requirements related to substrate addition is integral to this practice operating as a BMP and should be determined before allowing application of the reduction effectiveness credit.

Comments on Application and Verification Guidelines: Movement of Oysters

- **Comment # 19**: Don't allow crediting when oysters are moved
  - **Panel Response:** The Panel felt it was important to include recommended guidelines on how to apply the reduction effectiveness in situations where the oysters are moved from one location to another in a scientifically defensible manner because this does occur. The decision on whether the movement of oysters will be allowed for crediting purposes would ultimately be made by CBP Partnership as they develop policy/implementation procedures.

  - **Recommendation Re-evaluated:** The Panel decided that partitioning the credit wouldn't be necessary because oysters are either moved when they are less than 2 inches (entire credit would be applied to the final grow-out location) or they are moved for only a short period of time to the final grow-out location (entire credit would go to the initial grow-out location). The Panel removed the partitioning recommendation and recommended these scenarios instead, including average shell height verification check of 50 random oysters when oysters are moved.





Comments on Application and Verification Guidelines: Reporting

- **Comment # 21:** Policy procedures should not use boxes, bushels, or general acreage as reporting unit
  - **Panel Response:** Individuals would be the preferred reporting unit (added text to indicate this), but since reporting occurs in boxes and bushels, the Panel felt it was important to also provide verification guidelines related to these units. Which reporting unit to allow is ultimately the decision of the jurisdiction/CBP Partnership.

- **Comment # 22:** Panel should discourage incomplete reporting
  - **Panel Response:** The Panel supports the recommended method to deal with missing ploidy or verification measurements because only the minimum credit would be allowed based on State harvest regulations.

- **Comment # 23:** Clarify that reduction credits are only applicable the year oysters are harvested.
  - **Panel Response:** The Panel agrees that the reduction effectiveness is based on the annual reporting timeframe during which the live oysters are harvested and added clarification text in the report.

- **Comment # 24:** Reports should mirror certification reports
  - **Panel Response:** Recommended reporting components are based on what is needed to calculate and validate the recommended reduction effectiveness for the nitrogen and phosphorus assimilation in oyster tissue protocols. The Panel agrees that these components should be built into existing reports where possible.

Comments on Application and Verification Guidelines: Reporting Cont.

- **Comment # 25:** Add reporting field to document where larval/seed/young oysters come from (e.g., hatchery name, wild recruitment, etc.)
  - **Panel Response:** The Panel did not feel that the report form needed to include a field indicating where the oysters came from since it is not needed to calculate the reduction effectiveness. However, they did feel it would be appropriate to include in the recommended reporting guidelines suggestions on how the initial oyster planting size could be verified. The Panel added the following suggestions:
    - For hatchery-produced oysters from off-bottom and on-bottom oyster practices, receipts could be used to demonstrate that larvae or spat were purchased by the practice (these life stages are < 2.0 inches).
    - For wild oysters harvested under the substrate addition category, initial site assessments of current oyster populations during the bottom leasing process could be used to establish if there were oysters greater than two inches present. These oysters could then be estimated and subtracted from the total harvested oyster count of the first BMP reporting year.

Comments on Recommended Future Research

- **Comment # 28:** Additional study of N and P content of triploid oysters to include seasonal analysis
  - **Panel Response:** Current diploid data suggests low seasonal effect. Triploid oysters less likely influenced by season since they do not spawn. Since there isn't data on this, study could be useful, but should first prioritize studies on age/size and site/environmental differences.

- **Comment # 29:** Unclear how research on N and P sequestration related to biofouling could be translated into policy
  - **Panel Response:** The Panel feels that this should remain in the future research section because it's related to potential N and P removal. It is difficult to discern whether this is a viable option without future research on this topic.

Comments on Model Application

- **Comment # 30:** Fuller explanation of model application and guidance on the extent of local water quality influenced by oyster aquaculture
  - **Panel Response:**
    - The technical appendix is written by the CBP Modeling Team, in coordination with the Watershed Technical Workgroup based on Panel's recommendations. Since this information is not from the Panel, it is not included in the main body of the report. The Panel's Watershed Technical Workgroup representative added additional clarification text in Appendix F.

    - The extent of local water quality influenced by an aquaculture practice is ultimately determined from model runs that CBP uses to inform whether the TMDL goals are being met after approval of the reduction effectiveness estimates.

Misc. Comments (No Change to Report)

- **Comment # 2:** Other GITs involvement with approval of report
  - Joint meeting with the Water Quality Goal Implementation Team and the Sustainable Fisheries and Habitat Goal Implementation Teams. If consensus is not reached, then it will be elevated to the CBP Management Board for an approval decision.

- **Comment # 3:** Supported Panel's incremental approach and opportunities for public involvement.

- **Comment # 7 and 8:** Supported Panel's recommendation to not endorse the use of the reduction effectiveness estimates for practices involving transplanted wild oysters or practices where there is no enhancement activity.

- **Comment # 11:** What constitutes "high density?"
  - "High density" is dependent on the environmental and bottom conditions of the site (i.e., there isn't one value that would fit all circumstances). The Panel is assuming the commenter is concerned about potential unintended consequences from over-enrichment of the sediments and provided information on this unintended consequence in Section 10 of the report.

Upcoming Meetings

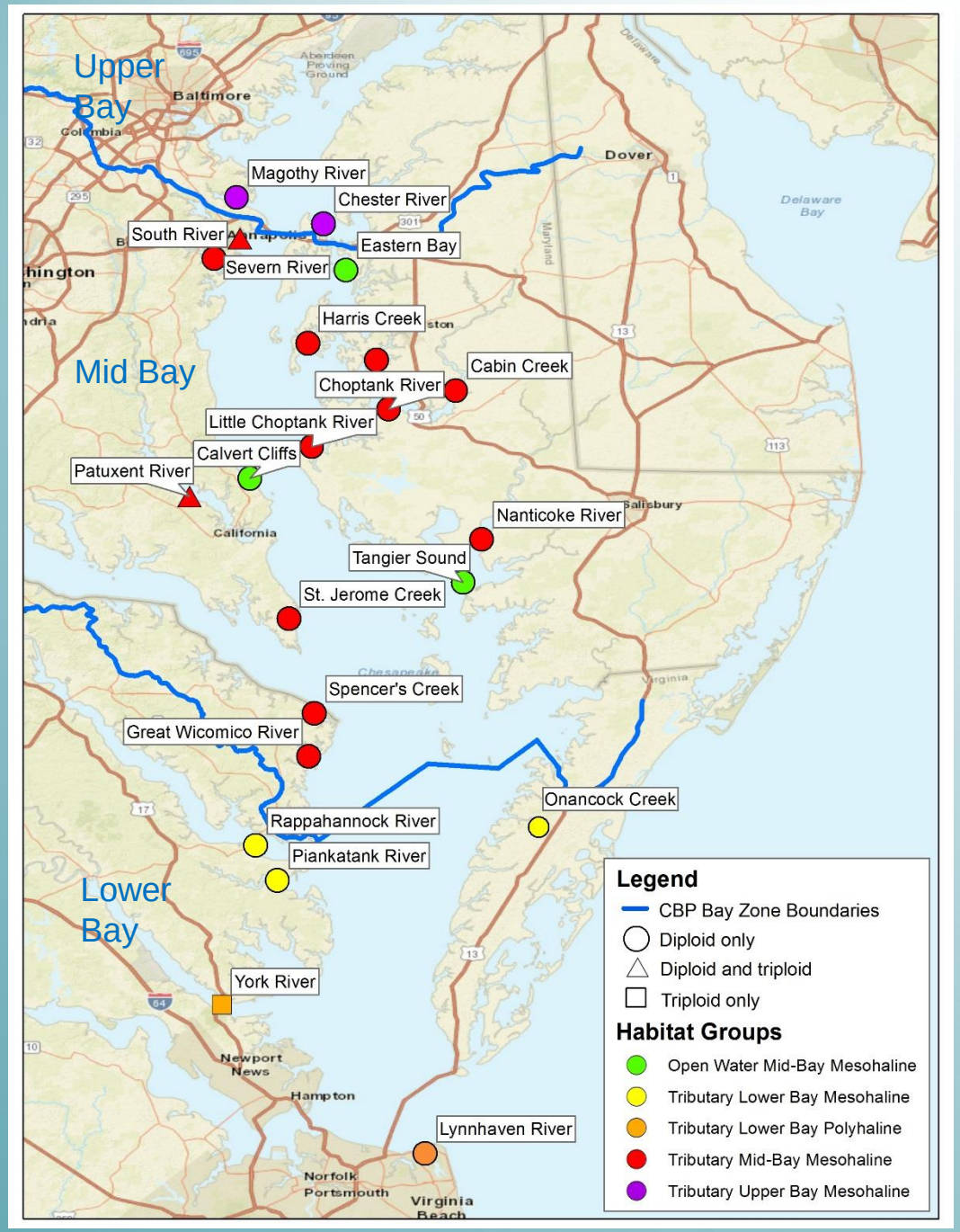
- **December 1, 2016**—The Panel will present their revised technical appendix on model application to the Watershed Technical Workgroup (WTWG). This is an open meeting. The agenda and materials will be posted HERE.

- **December 19, 2016 (tentative)**—Panel will present their revised 1st incremental report to the WQGIT, in coordination with the Fisheries and Habitat GITs and CBP Partnership, for approval. This is an open meeting. The agenda and materials will be posted HERE.

QUESTIONS?

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



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

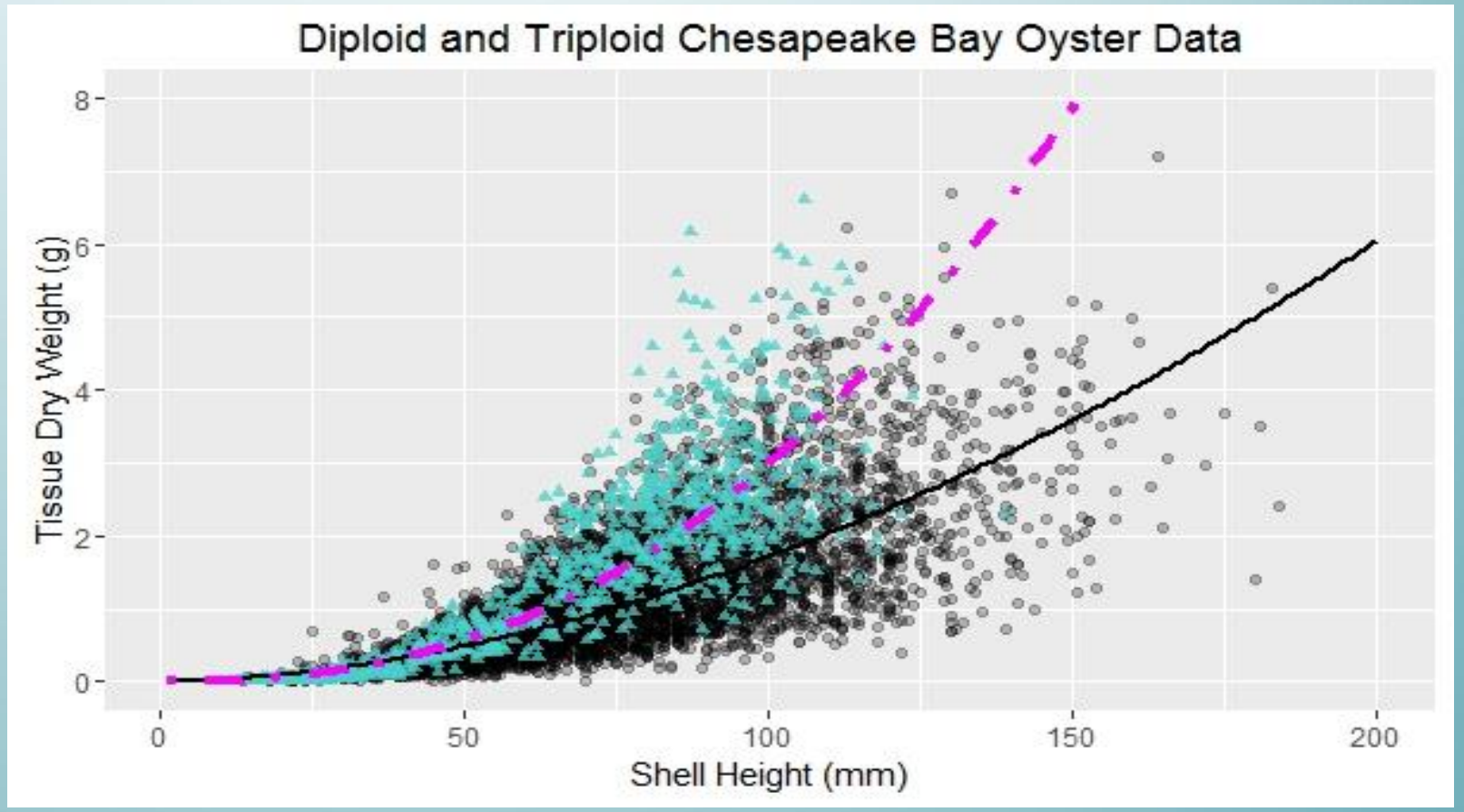
Regression Equation: $y = ax^b$
y = Tissue Dry Weight (g)
x = Shell Height (mm)

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.



Other Factors Considered

Factor	Conclusion
Culture Method and Type	Oyster data for the culture methods that were evaluated (i.e., off-bottom, on-bottom, and combination of both) and type (i.e., hatchery-produced, wild) either skewed above or were similar to the 0.5 quantile curve of the entire dataset, suggesting that the recommended equations will more likely underestimate the tissue dry weight and hence, the 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.

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).

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

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 reporting jurisdiction and CBP Partnership 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 ~ 6 months apart.

- Once approved by the CBP Partnership, 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.

- Review and approval of site-specific estimates follow a similar approach as the re-evaluation procedure of existing estimates described in the CBP Partnership BMP Expert Review Protocol. Same goes for re-evaluation of the site-specific estimates.

- Once approved by the CBP Partnership, the estimate would be applicable for that practice as long as they continue growing oysters under the same conditions when the reduction effectiveness evaluation was made.

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.