Oyster Best Management Practice 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

Watershed Technical Workgroup Approval Decision Meeting

December 1, 2016

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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. (Please refer to report for details of future work.)

- 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.

Reduction Effectiveness Estimates for N and P Assimilated in Oyster Tissue (Summarized for use in Model from Panel's Findings)

BMP Name	Lbs N Reduced/1,000,000 Oysters Harvested	Lbs P Reduced/1,000,000 Oysters Harvested
Diploid Oyster Aquaculture 2.25 Inches	110	22
Diploid Oyster Aquaculture 3.0 Inches	198	22
Diploid Oyster Aquaculture 4.0 Inches	331	44
Diploid Oyster Aquaculture 5.0 Inches	485	44
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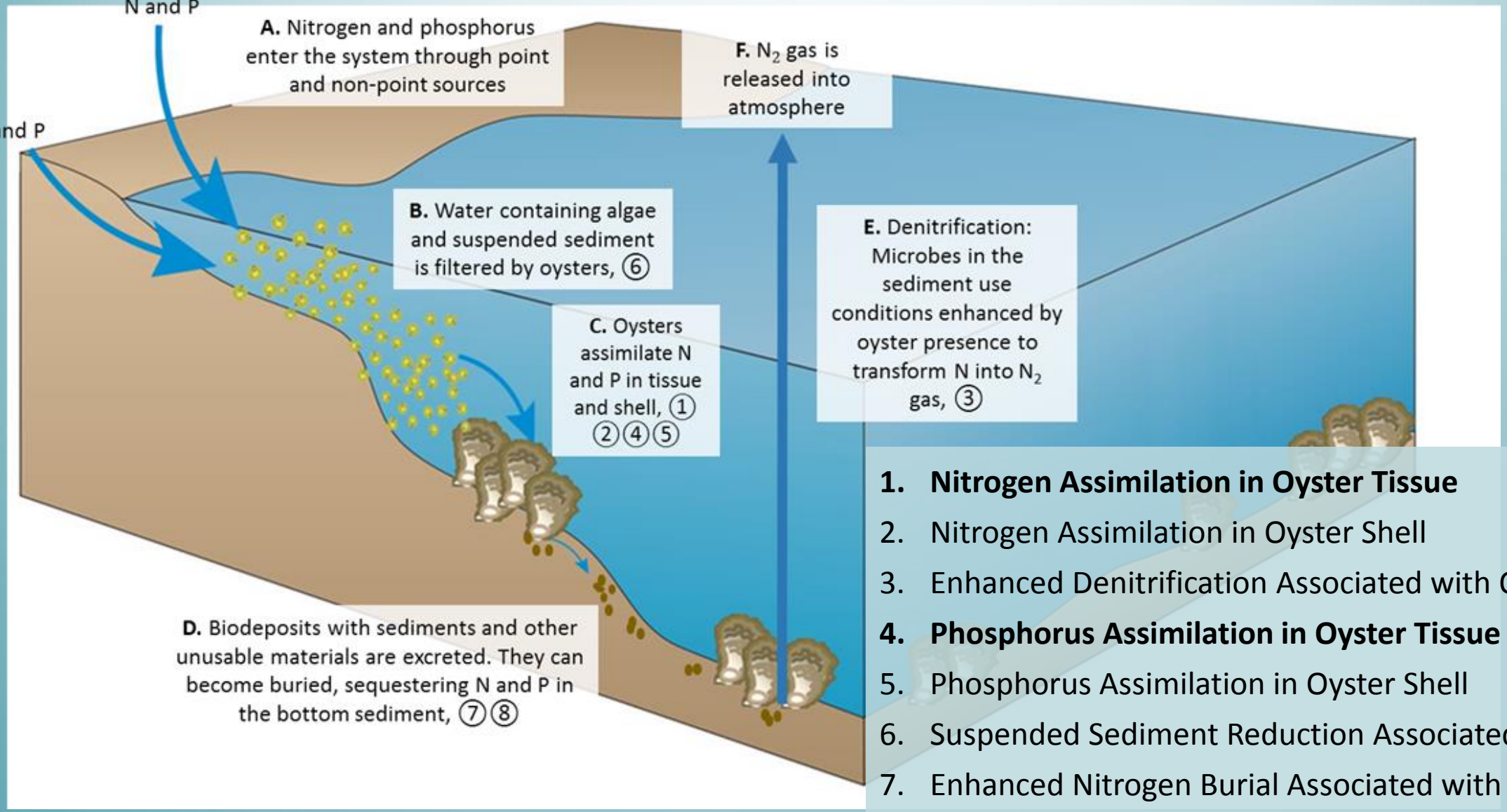
Triploid Oyster Aquaculture 5.0 Inches	970	110
Triploid Oyster Aquaculture Greater than 6.0 Inches	1,477	154
Site-Specific Monitored Oyster Aquaculture	NA	NA

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	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

Oyster Practice Categories Defined

Category	Oyster Practice	Description
A	Off-bottom private oyster aquaculture using hatchery-produced oysters	Hatchery-produced diploid or triploid oysters grown off the bottom in the water column using some sort of gear (e.g., floating rafts near the surface or cages near the bottom) in an area designated for oyster aquaculture where public fishing is not allowed (e.g., State-permitted oyster aquaculture leases to private oyster aquaculturists) for eventual removal from the water.
B	On-bottom private oyster aquaculture using hatchery-produced oysters	Hatchery-produced diploid or triploid oysters (e.g., spat-on-shell) grown directly on bottom using no gear in an area designated for oyster aquaculture where public fishing is not allowed (e.g., State-permitted oyster aquaculture leases to private oyster aquaculturists) for eventual removal from the water.
D	On-bottom private oyster aquaculture using substrate addition	Placing oyster shell or alternative hard substrate, such as granite, at the bottom sediment surface to attract recruitment of wild (diploid) oysters in an area designated for oyster aquaculture where public fishing is not allowed (e.g., State-permitted oyster aquaculture leases to private oyster aquaculturists) for eventual removal from the water.

Note: Definitions were slightly modified after comments from WQGIT during November 28, 2016 meeting to clarify what is meant by "private oyster aquaculture." Private refers to designated oyster aquaculture areas where public fishing is not allowed, such as State-permitted oyster aquaculture leases to private oyster aquaculturists.

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.

Panel's 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

Default Calculation: Shell Height to Dry Tissue Weight Regression Equations for Diploids and Triploids

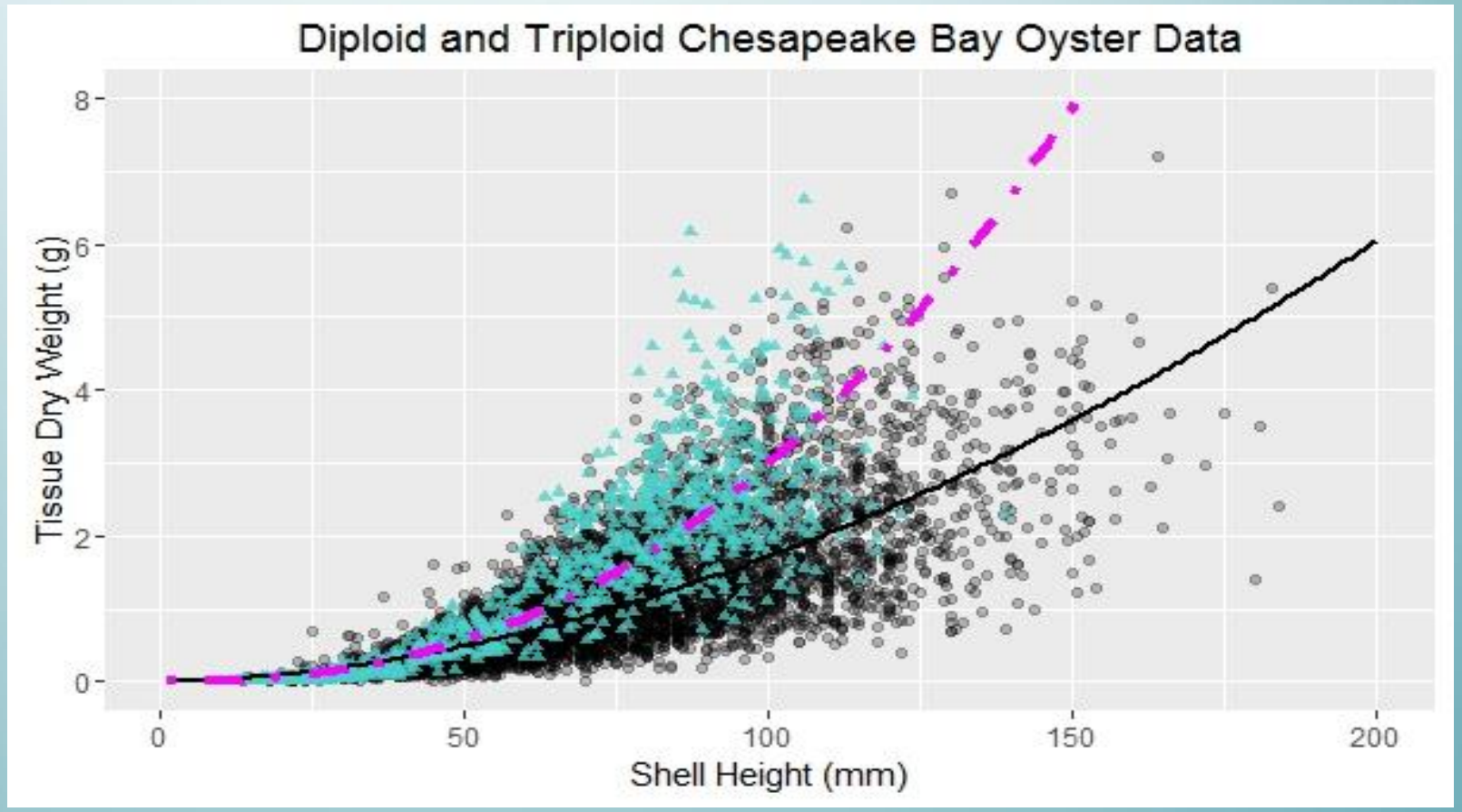
Regression Equation: $y = ax^b$
y = Tissue Dry Weight (g)
x = Shell Height (mm)

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)

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

Oyster Size Class Range (Shell Height in Inches)	Oyster Size Class Midpoint in Inches (mm)	Diploid Tissue Dry Weight (g/oyster)*	Default Diploid N Content (g/oyster)***	Default Diploid P Content (g/oyster)****
a. 2.0 - 2.49	2.25 (57)	0.63	0.05	0.01
b. 2.5 - 3.49	3.0 (76)	1.06	0.09	0.01
c. 3.5 - 4.49	4.0 (102)	1.81	0.15	0.02
d. 4.5 - 5.49	5.0 (127)	2.70	0.22	0.02
e. ≥ 5.5	6.0 (152)	3.74	0.31	0.03

Oyster Size Class Range (Shell Height in Inches)	Oyster Size Class Midpoint in Inches (mm)	Triploid Tissue Dry Weight (g/oyster)**	Default Triploid N Content (g/oyster)***	Default Triploid P Content (g/oyster)****
a. 2.0 - 2.49	2.25 (57)	0.79	0.06	0.01
b. 2.5 - 3.49	3.0 (76)	1.56	0.13	0.01
c. 3.5 - 4.49	4.0 (102)	3.16	0.26	0.03
d. 4.5 - 5.49	5.0 (127)	5.33	0.44	0.05
e. ≥ 5.5	6.0 (152)	8.20	0.67	0.07

*Diploid 50th quantile regression equation: tissue dry weight (g) = 0.0004 * Shell Height (mm)$^{1.82}$

**Triploid 50th quantile regression equation: 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).

Reduction Effectiveness Estimates for N and P Assimilated in Oyster Tissue (Summarized for use in Model from Panel's Findings)

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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.

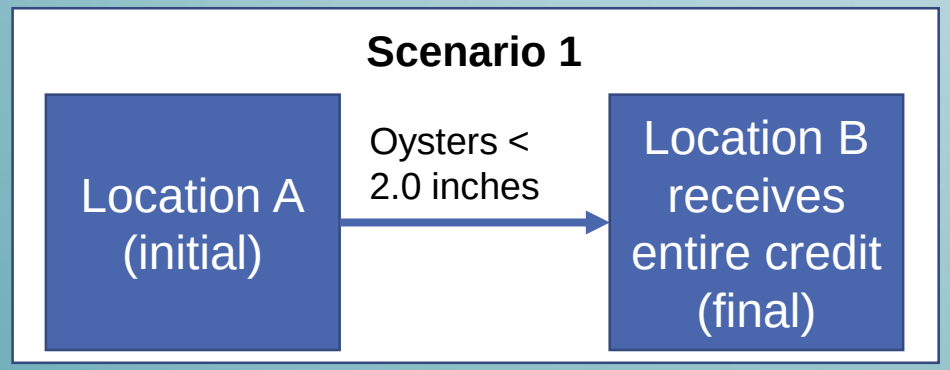
- Once approved by the CBP Partnership, the estimate would be applicable for that practice as long as they continue growing oysters under the same conditions when the reduction effectiveness evaluation was made.

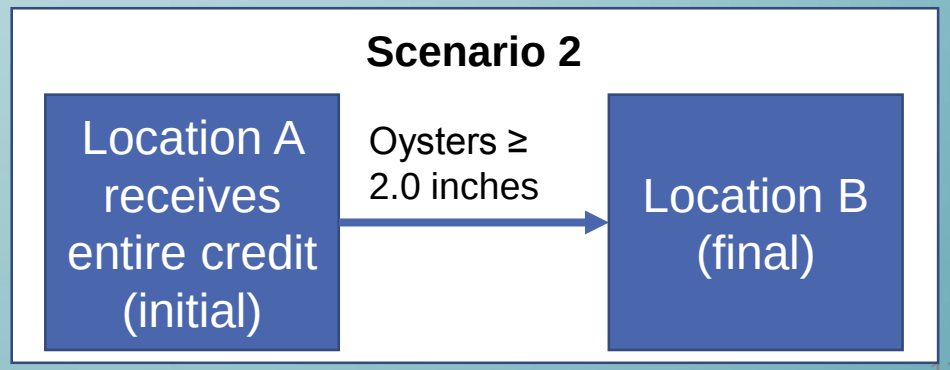
Recommended Application Guideline—Movement of Oysters

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:

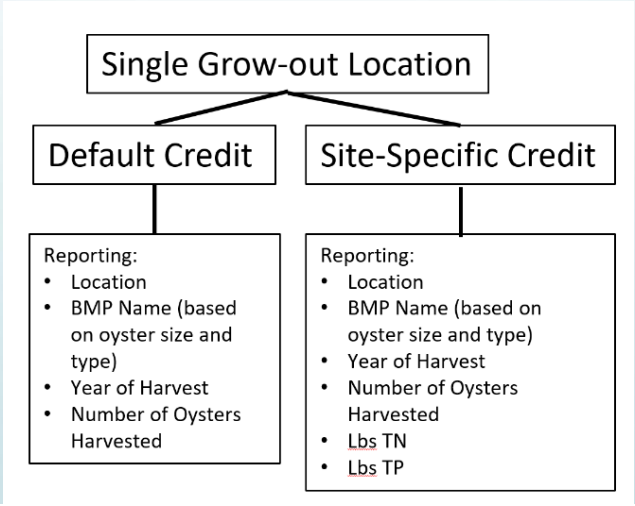
- Changing the taste by moving oysters to an area with higher salinity
- Water quality problems in the initial grow-out location.

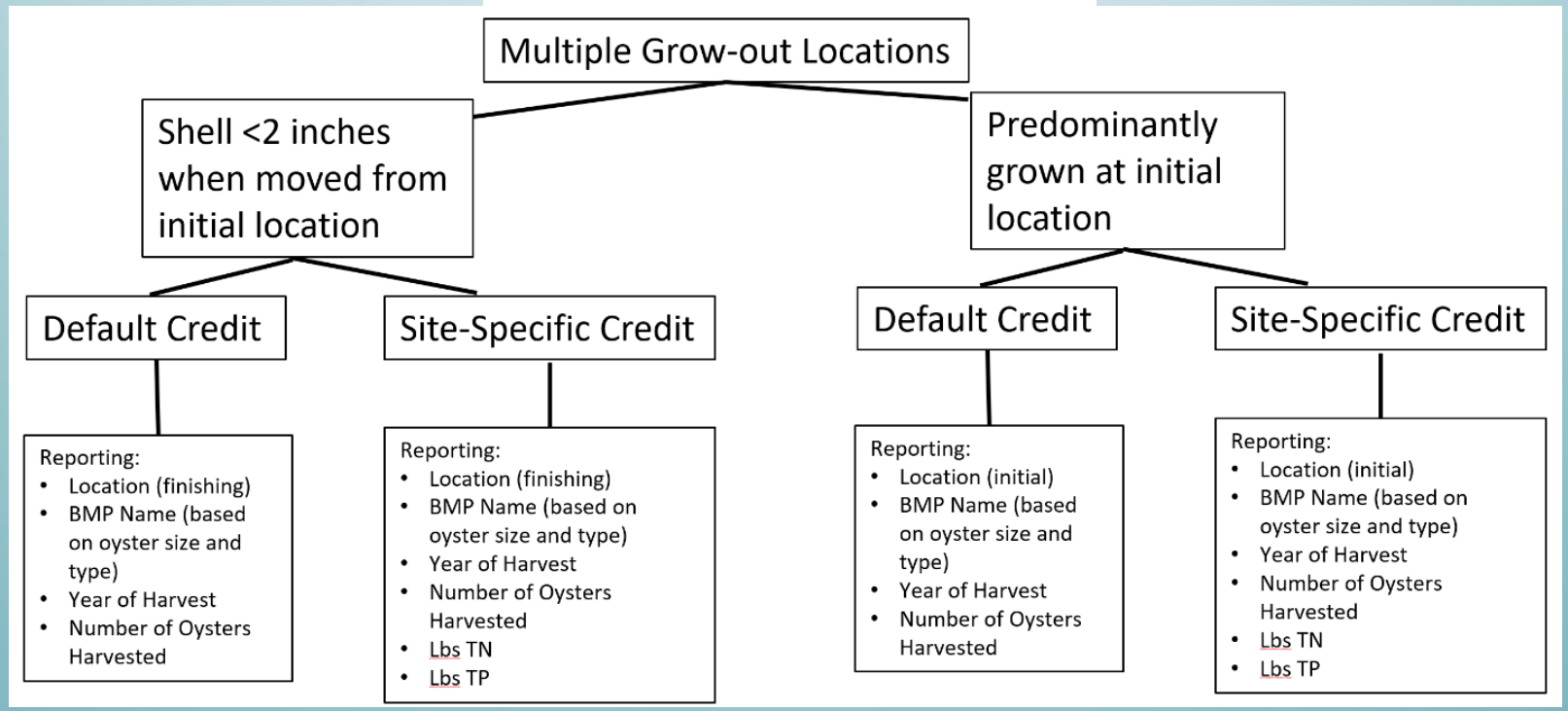
Panel Recommendation: The Panel decided that partitioning the credit wouldn't be necessary because oysters are either moved when they are less than 2 inches (entire credit would be applied to the final grow-out location) or they are moved for only a short period of time to the final grow-out location (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 to determine whether the credit is applied to the initial or final grow-out location.





Reporting Requirements





Recommended Reporting Guidelines

Individual oysters would be the preferred reporting unit. However, since there are varying units (e.g., bushels, boxes) currently being used to report oyster harvest, the Panel recommends that the following information be reported to account for this in order to offer flexibility to reporting jurisdictions (i.e., State agencies) in verifying the reduction effectiveness in a scientifically-defensible manner.

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.

Recommended Default Approach to Deal with Missing Verification and Ploidy 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.

Upcoming Meetings

- **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.

Matt Johnston will now discuss how these recommendations were incorporated into the Technical Appendix