BMPs for Nutrient Reduction

Updates from the Expert Panel and Modeling based on real world data

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Expert Panel

- Nutrient reduction effectiveness from aquaculture oyster tissue approved by Chesapeake Bay Program in Dec 2016.
- Panel continues to examine nutrient reduction effectiveness for aquaculture oyster shell, enhanced denitrification, and restoration practices

Chesapeake Bay Program Approved Harvested Oyster Tissue for Nutrient BMP Credits

- Derived from oyster growth data from Chesapeake Bay locations.
- Determined five size class ranges based on shell height.

BMP Name	Lbs N Reduced/ million Oysters Harvested	Lbs P Reduced/ million Oysters Harvested
Diploid Oyster Aquaculture 2.25 Inch	110	22
Diploid Oyster Aquaculture 3.0 Inch	**198**	**22**
Diploid Oyster Aquaculture 4.0 Inch	331	44
Diploid Oyster Aquaculture 5.0 Inch	485	44
Diploid Oyster Aquaculture ≥ 5.5 Inch	683	66
Triploid Oyster Aquaculture 2.25 Inch	132	22
Triploid Oyster Aquaculture 3.0 Inch	**287**	**22**
Triploid Oyster Aquaculture 4.0 Inch	573	66
Triploid Oyster Aquaculture 5.0 Inch	970	110
Triploid Oyster Aquaculture ≥ 5.5 Inch	1,477	154

- Chesapeake - Harvested tissue now used to fulfil required nutrient reductions.
- Mashpee MA oysters used for nutrient reduction (Mashpee CCMP, 2015)

What is the value of the nutrient removal service? How do we estimate that?

Estimated as an avoided or replacement cost using costs of alternative nutrient management measures as estimate of value

	$/kg N removed
Waste Water Treatment Plant*	$32-99
Ag BMP	$13
Urban BMP	$350
Va Nutrient Credit Exch. Assoc. 2018 Sales Price	$8.33

*range based on three effluent levels – 8, 5, 3 mg N/L
values from Bricker et al. 2017
http://www.deq.virginia.gov/Portals/0/DEQ/Water/PollutionDischargeElimination/2017%20Exchange%20Annual%20Compliance%20Plan%20Update.pdf?ver=2017-10-26-153954-917

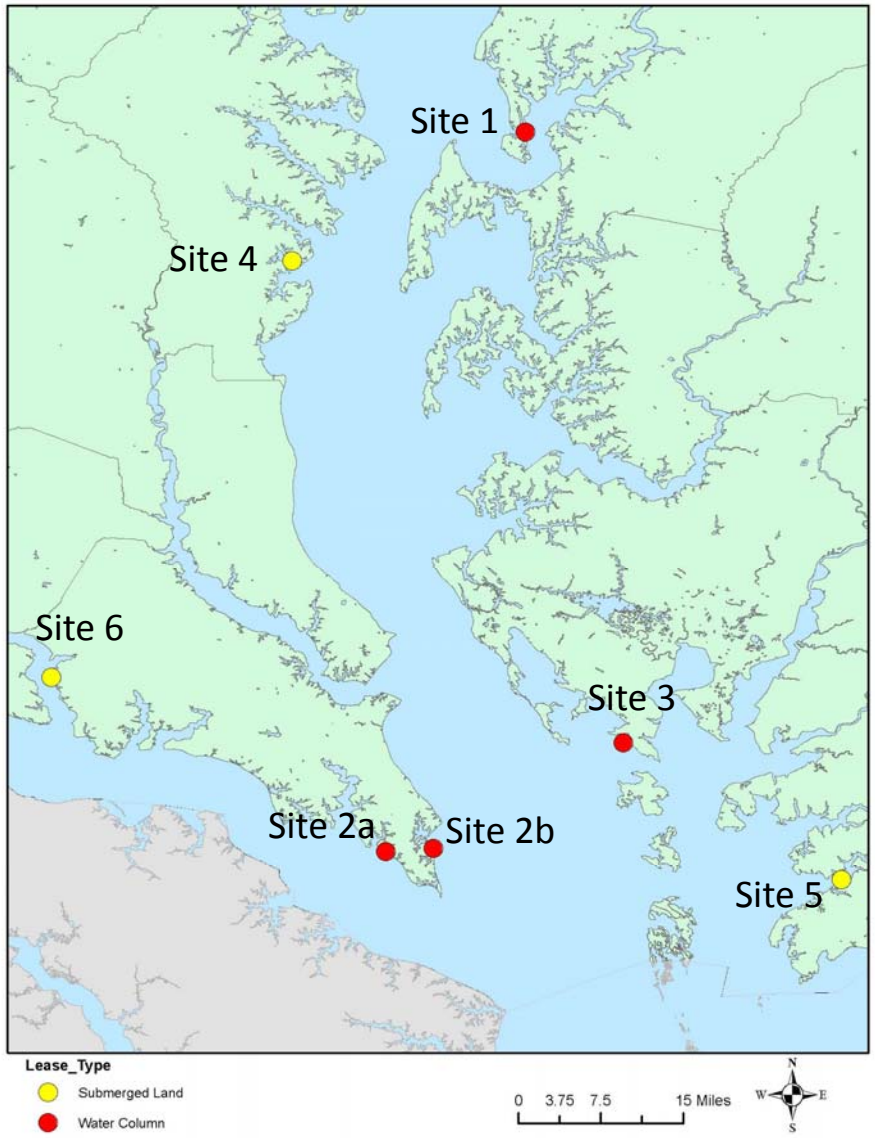
Range of $ values possible

BMP Name	Lbs N Reduced/ million Oysters Harvested	Value Based on WWTP		Value Based on Ag BMP	Value Based on Urban BMP	Va Nutrient Credit Exchange Assoc. 2018 N Sales Price*
Diploid Oyster Aquaculture 2.25 Inch	110	$ 1,597	$ 4,940	$ 649	$ 17,463	$ 416
Diploid Oyster Aquaculture 3.0 Inch	198	$ 2,874	$ 8,891	$ 1,168	$ 31,434	$ 748
Diploid Oyster Aquaculture 4.0 Inch	331	$ 4,804	$ 14,864	$ 1,952	$ 52,549	$ 1,251
Diploid Oyster Aquaculture 5.0 Inch	485	$ 7,040	$ 21,779	$ 2,860	$ 76,997	$ 1,833
Diploid Oyster Aquaculture ≥ 5.5 Inch	683	$ 9,914	$ 30,671	$ 4,027	$ 108,431	$ 2,581
Triploid Oyster Aquaculture 2.25 Inch	132	$ 1,916	$ 5,928	$ 778	$ 20,956	$ 499
Triploid Oyster Aquaculture 3.0 Inch	287	$ 4,166	$ 12,888	$ 1,692	$ 45,563	$ 1,085
Triploid Oyster Aquaculture 4.0 Inch	573	$ 8,317	$ 25,731	$ 3,379	$ 90,968	$ 2,165
Triploid Oyster Aquaculture 5.0 Inch	970	$ 14,079	$ 43,558	$ 5,720	$ 153,994	$ 3,666
Triploid Oyster Aquaculture ≥ 5.5 Inch	1477	$ 21,439	$ 66,326	$ 8,709	$ 234,484	$ 5,581

* http://www.deq.virginia.gov/Portals/0/DEQ/Water/PollutionDischargeElimination/2017%20Exchange%20Annual%20Compliance%20Plan%20Update.pdf?ver=2017-10-26-153954-917

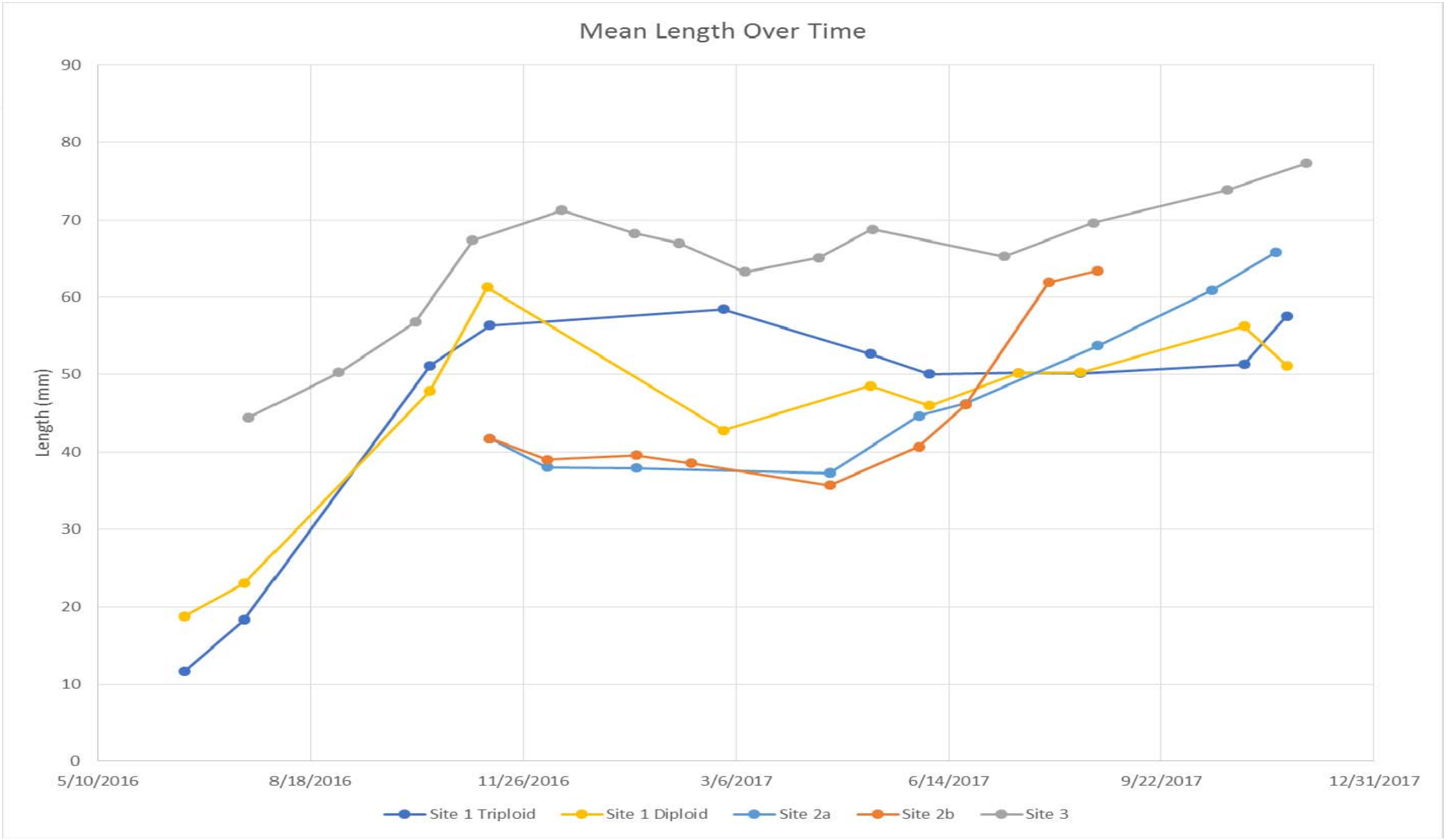
Field work and FARM Model Estimate of Nutrient Reduction

- Collected water and oyster samples May 2016 -Nov 2017
- Input data into FARM Model
- Estimate nutrient reduction due to oyster feeding
- Includes tissue and shell



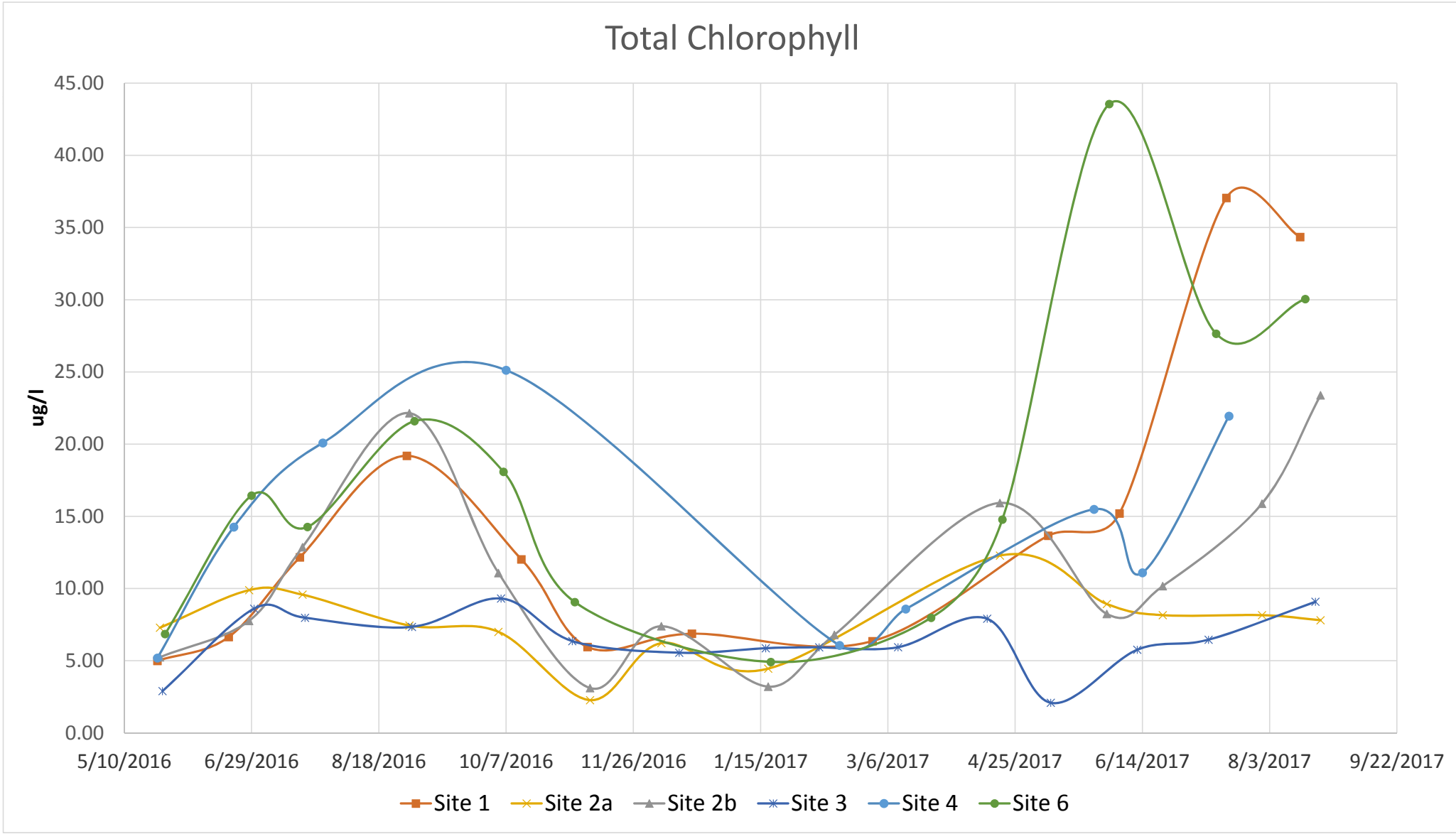
Oyster Measurements

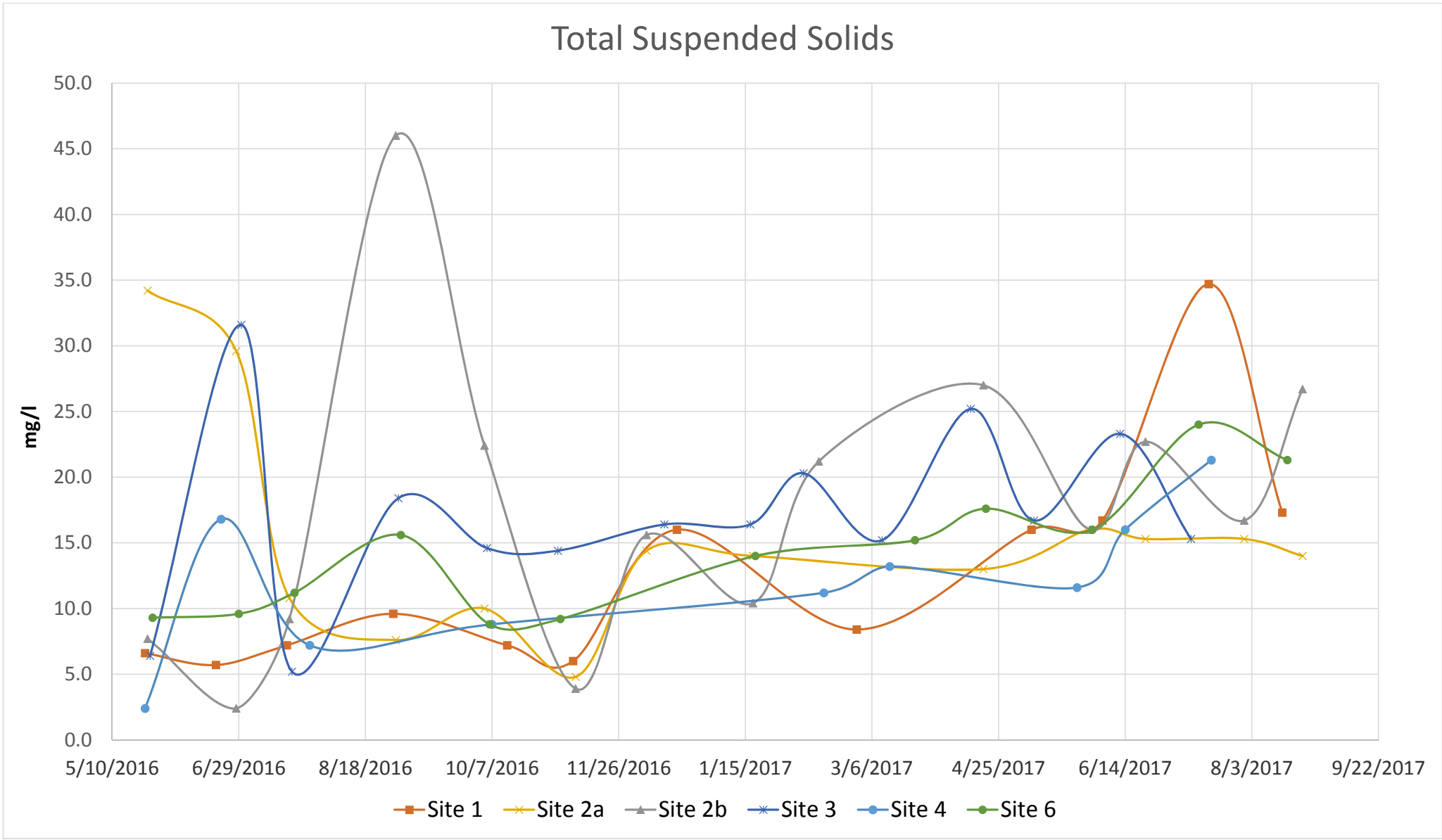
- Fresh weight
- Wet tissue weight
- Wet shell weight
- Volume of liquid in oyster
- Dry tissue weight
- Dry shell weight

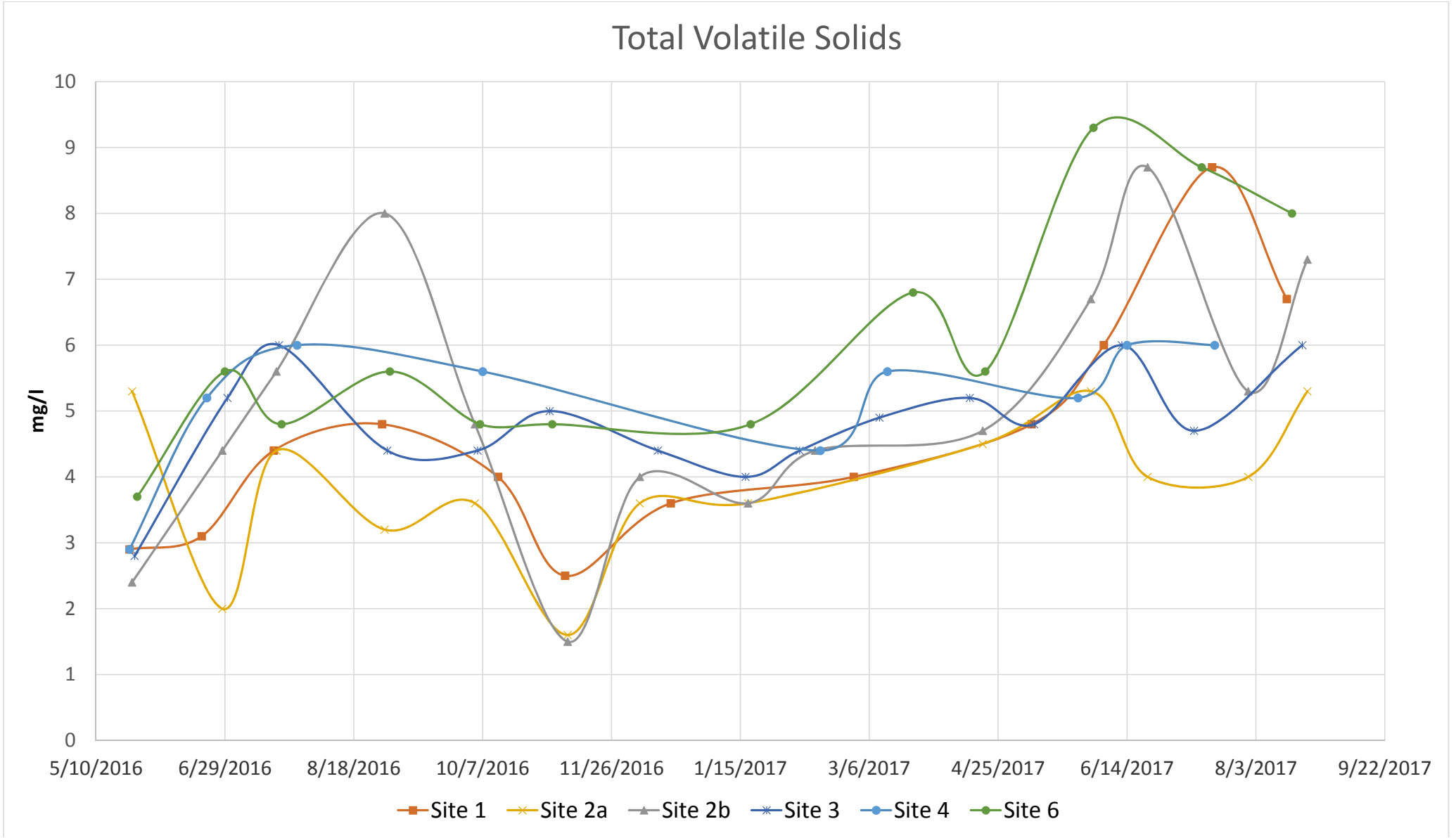

Mean Length Over Time
Length (mm)
90
80
70
60
50
40
30
20
10
0
5/10/2016
8/18/2016
11/26/2016
3/6/2017
6/14/2017
9/22/2017
12/31/2017
Site 1 Triploid
Site 1 Diploid
Site 2a
Site 2b
Site 3

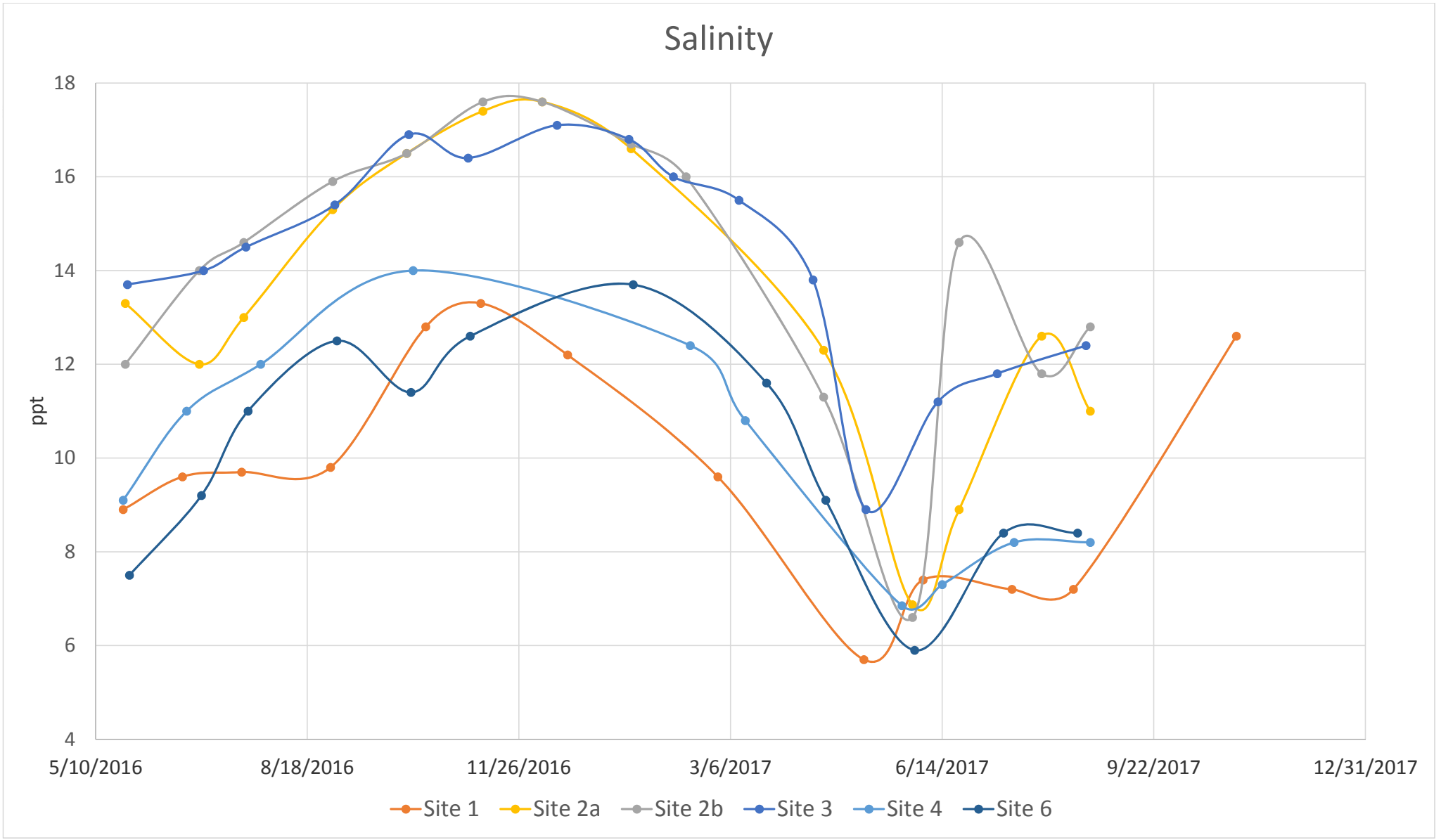
Water Parameters Measured

- Lat/Long
- Dissolved Oxygen
- Salinity
- Chlorophyll
- Total Suspended Solids
- Total Volatile Solids
- Ammonia
- Nitrate/Nitrite


Total Chlorophyll
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
ug/l
5/10/2016
6/29/2016
8/18/2016
10/7/2016
11/26/2016
1/15/2017
3/6/2017
4/25/2017
6/14/2017
8/3/2017
9/22/2017
Site 1
Site 2a
Site 2b
Site 3
Site 4
Site 6


Total Suspended Solids
mg/l
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
5/10/2016
6/29/2016
8/18/2016
10/7/2016
11/26/2016
1/15/2017
3/6/2017
4/25/2017
6/14/2017
8/3/2017
9/22/2017
Site 1
Site 2a
Site 2b
Site 3
Site 4
Site 6


Total Volatile Solids
mg/l
10
9
8
7
6
5
4
3
2
1
0
5/10/2016
6/29/2016
8/18/2016
10/7/2016
11/26/2016
1/15/2017
3/6/2017
4/25/2017
6/14/2017
8/3/2017
9/22/2017
Site 1
Site 2a
Site 2b
Site 3
Site 4
Site 6

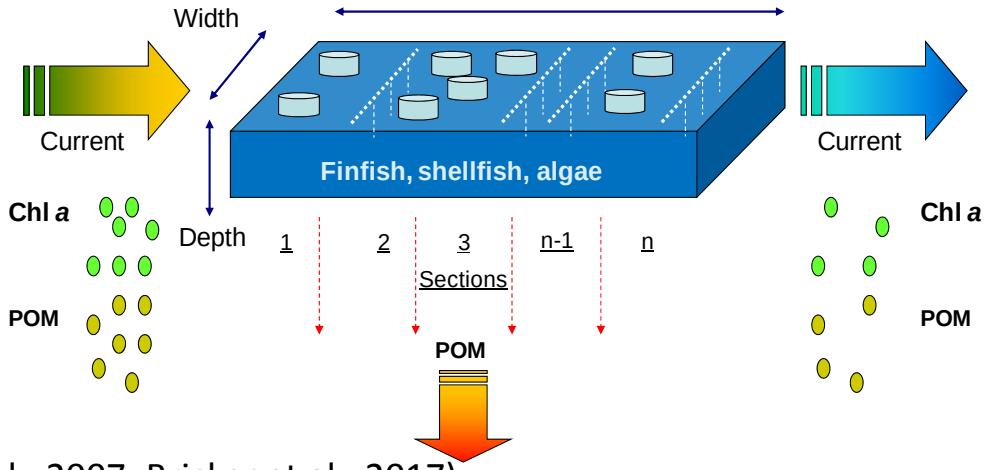

Salinity
18
16
14
12
10
8
6
4
ppt
5/10/2016
8/18/2016
11/26/2016
3/6/2017
6/14/2017
9/22/2017
12/31/2017
Site 1
Site 2a
Site 2b
Site 3
Site 4
Site 6

Farm Aquaculture Resource Management (FARM) Model

A local-scale carrying capacity and environmental effects model.

Accounts for food conditions, shellfish eco-physiological characteristics, and farming practices.

Estimates production potential, farm optimization (configuration, stocking density), environmental effects (i.e. nitrogen removal).



(Ferreira et al., 2007; Bricker et al., 2017)

FARM model results for MD Chesapeake Bay farms
Nitrogen removal (as tissue and shell from 3 inch oyster)

Location	Culture Type	N removed (kg/acre/yr)	Total N removed (kg/yr)
Site 1	bottom cage triploid	**64**	**314**
Site 2b	floating cage triploid	**56**	**1215**
Site 4	bottom culture	**531**	**2124**
Site 6	bottom culture	**301**	**2107**

Expert BMP Panel results for MD Chesapeake Bay farms
Annual nitrogen removal (as tissue) for 3 inch oyster using FARM Model Production Estimate

Location	Culture Type	N removed (kg/acre/yr)	Total N removed (kg/acre/yr)
Site 1	bottom cage triploid	**48**	**238**
Site 2b	floating cage triploid	**45**	**985**
Site 4	bottom culture	**62**	**248**
Site 6	bottom culture	**88**	**616**

Nutrient Reduction Comparison: FARM Model and Expert BMP Panel

Location	Culture Type	Farm Model Estimate of Nitrogen Removal (kg/yr)	BMP Estimate of Nitrogen Removal (kg/yr)
Site 1	bottom cage triploid	**314**	**238**
Site 2b	floating cage triploid	**1215**	**985**
Site 4	bottom culture	**2124**	**248**
Site 6	bottom culture	**2107**	**616**

Comparison of Potential Revenue for Nutrient Reduction: Farm Model and Expert BMP Panel

Potential Revenue based on avoided costs for select farms					
BMP Method		3 inch Triploid Oysters		3 inch Diploid Oysters	
		Site 1	Site 2b	Site 4	Site 6
Farm Model Estimate	WWTP Minimum	$ 10,035	$ 38,886	$ 67,968	$ 67,424
	WWTP Maximum	$ 31,046	$ 120,305	$ 210,276	$ 208,593
	Ag BMP	$ 4,077	$ 15,798	$ 27,612	$ 27,391
	Urban BMP	$ 109,760	$ 425,320	$ 743,400	$ 737,450
	VNCEA 2018	$ 2,613	$ 10,124	$ 17,695	$ 17,554
BMP Estimate	WWTP Minimum	$ 3,448	$ 14,304	$ 3,592	$ 8,937
	WWTP Maximum	$ 10,668	$ 44,252	$ 11,114	$ 27,650
	Ag BMP	$ 1,401	$ 5,811	$ 1,459	$ 3,631
	Urban BMP	$ 37,716	$ 156,445	$ 39,292	$ 97,752
	VNCEA 2018	$ 898	$ 3,724	$ 935	$ 2,327

Conclusions

- Depending on a sales price, there could be potential revenue for oyster farms for nutrient reductions.
  - Dependent on changes in policy to allow for compensation
  - Dependent on type of compensation
- FARM Model is a useful tool, but needs continued refinement for Chesapeake Bay.

Next steps

- Continue to refine model for Chesapeake Bay
- Evaluate what it would take to compensate farms for nutrient reductions (complete in 2018)
- Economic Evaluation of MD Oyster Industry (complete in 2018)
- BMP Expert Panel to continue to review science for additional BMP's
  - Shell, denitrification, etc

Questions

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