Sustainable Oyster Aquaculture, Water Quality Improvement and Ecosystem Service Potential in Maryland, Chesapeake Bay

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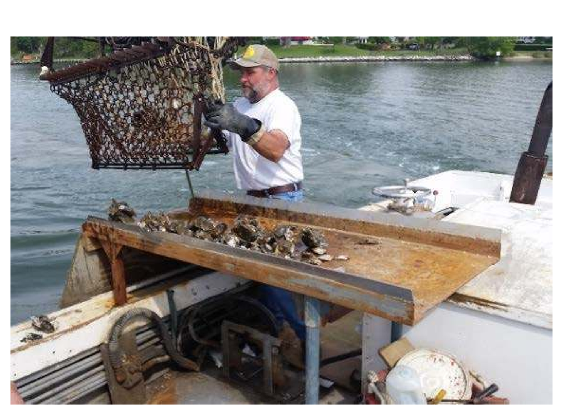
Introduction

The United States had a $16 billion seafood trade deficit in 2016[1]. NOAA is targeting expanded shellfish aquaculture to close this gap while also recognizing water quality benefits of increased oyster populations[2]. The number of oysters harvested by aquaculture in Maryland, Chesapeake Bay has increased tenfold since 2010[3]. Oysters are well known for their ability to effectively remove nutrients from the water column through filtration and assimilation into tissue and shell[4], as well as through oyster related denitrification[4]. This recognition has led to approval of harvested oyster tissue for use as a nutrient Best Management Practice (BMP) in Chesapeake Bay[6] to help jurisdictions meet mandated nutrient reductions. There has been interest in compensating oyster growers for the nutrients removed through the Maryland Nutrient Trading Program established in 2010[7]. With the approval of the oyster tissue BMP, payment to growers is possible once approved by the trading program pending development of a payment mechanism.

This study is designed to evaluate: 1) potential nutrient removal via sustainable oyster aquaculture, 2) the value of the removed nutrients, and 3) potential payment to growers within a nutrient credit trading program for the nutrient removal service their oysters provide.

Methods

- Water and oysters samples were taken monthly at 6 Maryland oyster farms since May 2016 (Figure 1).
- Analyses included: Temperature, Salinity, Chlorophyll, Total Suspended Solids, Total Volatile Solids, Dissolved Oxygen, Dissolved Inorganic Nitrogen. (Figure 2)
- Oyster length and weights were measured to develop growth curves used to calibrate the Farm Aquaculture Resource Management (FARM[8]) oyster production/nutrient removal model.
- A range of values was estimated in an avoided costs approach using 3 alternative removal measures (wastewater treatment, agricultural and urban best management practices[4]) and based on the VA Nutrient Credit Exchange Association[9] 2018 nutrient sales value (Table 1).
- The FARM model[8] was applied to data from each farm for estimation of potential nutrient removal based on oyster filtration and sequestration into tissue and shell for harvested oysters and on the approved BMP (Tables 2a & 2b).
- Based on FARM[8] model estimates and published avoided costs, potential value of nitrogen removed was estimated (Table 3).



Preliminary Results

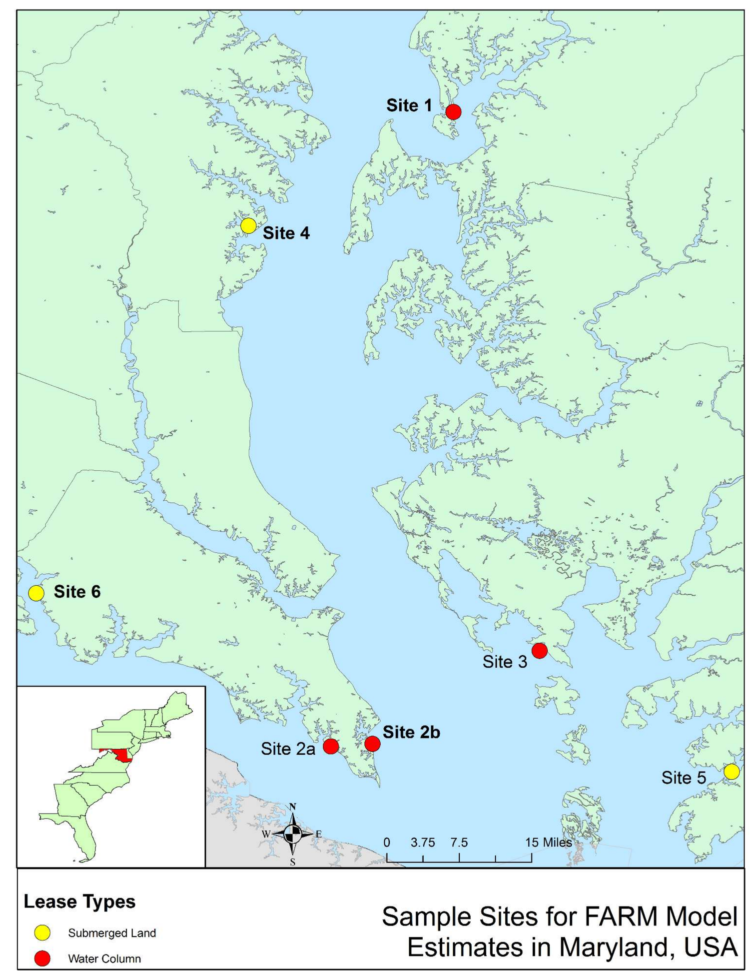


Figure 1. Information from sites 1, 2b, 4 and 6 (in bold above) were used to calculate estimates of nitrogen removal associated with oyster farms using the FARM Model for this exercise. These estimates were used to calculate the value of avoided/replacements costs for oyster aquaculture.

Figure 2 shows Salinity, Chlorophyll, Total Suspended Solids, Total Volatile Solids at MD oyster farm locations since May 2016. Note that Chlorophyll and Total Volatile Solids are oyster food. Note that in June 2017 increased flows from the Conowingo Dam lowered salinity to abnormally low levels across the sample sites.

	$/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

Table 1: Estimated value of nitrogen removal as an avoided or replacement cost using costs of alternative nutrient management measures as estimate of value[4, 9].

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 diploid	477	1908
Site 6	bottom culture diploid	254	1778

Table 2a shows nitrogen removal (as tissue and shell from 3 inch oyster) estimated from FARM model results based on filtration and assimilation into tissue and shell for MD Chesapeake Bay farms (note that seeding densities are different among the farms)

Location	Culture Type	N removed (kg/acre/yr)	Total N removed (kg/yr)
Site 1	bottom cage triploid	48	238
Site 2b	floating cage triploid	45	985
Site 4	bottom culture diploid	62	248
Site 6	bottom culture diploid	88	617

Table 2b shows nitrogen removal (as tissue from 3 inch oyster) estimated from FARM model production estimates (as tissue) with BMP Panel results for MD Chesapeake Bay farms (note that seeding densities are different).

Potential Revenue Based Of 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	$ 61,056	$ 56,896
	WWTP Maximum	$ 31,046	$ 120,305	$ 188,892	$ 176,022
	Ag BMP	$ 4,077	$ 15,798	$ 24,804	$ 23,114
	Urban BMP	$ 109,760	$ 425,320	$ 667,800	$ 622,300
	VNCEA 2018	$ 2,613	$ 10,124	$ 15,896	$ 14,813
BMP Estimate	WWTP Minimum	$ 3,322	$ 21,442	$ 7,113	$ 9,023
	WWTP Maximum	$ 10,277	$ 66,337	$ 22,006	$ 27,914
	Ag BMP	$ 1,349	$ 8,711	$ 2,890	$ 3,666
	Urban BMP	$ 36,332	$ 234,525	$ 77,799	$ 98,687
	VNCEA 2018	$ 865	$ 5,582	$ 1,852	$ 2,349

Table 3 shows value of removed nitrogen based on avoided costs[8] and VA Nutrient Credit Exchange[9] for removal based on FARM model estimated nutrient removal (via filtration and sequestration into tissue and shell) and based on BMP based nutrient in tissue of harvested oysters.

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Conclusions, Implications, Next Steps

- Oyster aquaculture is an effective nitrogen removal method that could/ should be used in combination with traditional measures in comprehensive nutrient management program.
- Depending on a sales price for removed nitrogen, there could be potential revenue for oyster farms for nutrient reductions.
- This is dependent on changes in policy to allow for compensation and dependent on type of compensation.
- Evaluation of policy barriers to compensating oyster farmers.
- Economic Evaluation of MD Oyster Industry
- BMP Expert Panel will continue review of science for additional BMP's including removal in shell, and by denitrification.
- FARM Model is a useful tool, but needs continued refinement for use in Chesapeake Bay.

Citations

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