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 2016¹. NOAA is targeting expanded shellfish aquaculture to close this gap while also recognizing water quality benefits of increased oyster populations². The number of oysters harvested by aquaculture in Maryland, Chesapeake Bay has increased tenfold since 2010³. Oysters are well known for their ability to effectively remove nutrients from the water column through filtration and assimilation into tissue and shell⁴, as well as through oyster-related denitrification⁵. This recognition has led to increased interest in using oysters to remove nitrogen and phosphorus from wastewater treatment, agricultural and urban best management practices. There has been interest in compensating oyster growers for the nutrients removed through the Maryland Nutrient Trading Program established in 2010⁶. With the approval of the oyster 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 oyster samples were taken monthly at 6 Maryland oyster farms since May 2016 (Figure 1).
• Analyses included: Temperature, Salinity, Chlorophyll, Dissolved Oxygen, Dissolved Inorganic Nitrogen. (Figure 2)
• Oyster length and weights were measured to develop analyses included: Temperature, Salinity, Chlorophyll, Dissolved Oxygen, Dissolved Inorganic Nitrogen. (Figure 2)
• The FARM model 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 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/replace costs for oyster aquaculture.

<table>
<thead>
<tr>
<th>Location</th>
<th>Culture Type</th>
<th>N removed (kg/acreyr)</th>
<th>Total N removed (kg/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>bottom cage triploid</td>
<td>64</td>
<td>314</td>
</tr>
<tr>
<td>Site 2b</td>
<td>floating cage triploid</td>
<td>56</td>
<td>122</td>
</tr>
<tr>
<td>Site 6</td>
<td>bottom culture diploid</td>
<td>214</td>
<td>1778</td>
</tr>
</tbody>
</table>

Table 2a 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). Figure 2 shows salinity, Chlorophyll, Total Suspended Solids, Total Volatile Solids and dissolved oxygen 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 near basin levels across the sample area.

Figure 2. Details of the Chesapeake Bay aquaculture sites used in the study. The number of sites is shown in parentheses. Each site had a different culture type and BMP to measure nutrient removal.

Table 3 shows value of nitrogen removed based on avoided costs and VA Nutrient Credit Exchange. The number of sites is shown in parentheses. Each site had a different culture type and BMP to measure nutrient removal.

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<tbody>
<tr>
<td>Site 1</td>
<td>bottom cage triploid</td>
<td>48</td>
<td>236</td>
</tr>
<tr>
<td>Site 2b</td>
<td>floating cage triploid</td>
<td>45</td>
<td>985</td>
</tr>
<tr>
<td>Site 4</td>
<td>bottom culture diploid</td>
<td>82</td>
<td>248</td>
</tr>
<tr>
<td>Site 6</td>
<td>bottom culture diploid</td>
<td>46</td>
<td>617</td>
</tr>
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Table 3 shows value of nitrogen removed based on avoided costs and VA Nutrient Credit Exchange. The number of sites is shown in parentheses. Each site had a different culture type and BMP to measure nutrient removal.

Conclusions, Implications, Next Steps

• Oyster aquaculture is an effective nitrogen removal method that could 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

policies
Kellogg et al. 2013. Denitrification and nutrient assimilation on a restored oyster reef. Environmental Science & Technology
Bricker et al. 2017. The role of shellfish aquaculture in reduction of eutrophication in an urban estuary, Environmental Science & Technology 52: 173-183

Acknowledgments

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