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Use of viral indicators to assess public health risk to shellfish growing areas: A case study from Blaine, Washington

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Viral Indicators in Shellfish Growing Areas: Assessing Public Health Risk

Mark Toy
Office of Shellfish & Water Protection

Salish Sea Conference, May 1, 2014
Introduction

- Norovirus (NoV) and other enteric viruses responsible for majority of shellfish consumption related viral disease worldwide
- Current NPDES requirements use fecal coliforms (FC) as pathogen indicator
- Many pathogenic viruses more resistant to disinfection and persistent in environment than FC
- NoV hard to measure (not culturable)
Culturable bacteriophage ‘virus’ of E. coli bacteria

High numbers in raw sewage $10^5$ PFU/100gm

Resistant to chlorination

RNA virus similar in size and shape to norovirus

Much studied viral indicator of sewage
NoV Positivity versus MSC

from Ireland
Temperature Dependent MSC Depuration Rate (Maine studies)
MSC Reduction Efficiency Verses Flow at Yarmouth, Maine WTP
(data collected after 3" rain event during flood closure)
In summary

- MSC levels correlated with NoV
- Seasonal patterns: 1–3 log between summer and winter
- MSC levels in effluent increase with wet weather flows through WWTP
- Different species of shellfish have different uptake and depuration rates
- Viral indicator research basis for FDA 1000:1 dilution guidance
FDA guidance on growing area classification around sewage outfalls
Conducted November 4–8, 2012

DOH, FDA, Lummi Tribe, City of Blaine

First FDA study of membrane filtration facility

Dye study to measure dilution from outfall

Microbial study to correlate dilution with contamination
Oyster Cage Sites

(Seasonal winter closure due to nonpoint sources (California and Dakota Creeks))
<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Date Collected</th>
<th>Time</th>
<th>FC/ 100 ml</th>
<th>MSC / 100 ml</th>
<th>GI MPN/ 100 ml (95% CL)</th>
<th>GII MPN/ 100 ml (95% CL)</th>
<th>AdV MPN/ 100 ml (95% CL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grab</td>
<td>3-Nov-12</td>
<td>12:00</td>
<td>3550000</td>
<td>286000</td>
<td>&lt;86 CI(10-720)</td>
<td>93 CI(12-730)</td>
<td>&lt;310 CI(37-2600)</td>
</tr>
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<td>4-Nov-12</td>
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<td>2600000</td>
<td>364000</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<td>3100000</td>
<td>166000</td>
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<td>&lt;86 CI(10-720)</td>
<td>1300 CI(290-6200)</td>
</tr>
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<td>6h comp</td>
<td>4-Nov-12</td>
<td>21:00</td>
<td>3350000</td>
<td>142000</td>
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<td>&lt;86 CI(10-720)</td>
<td>&lt;310 CI(37-2600)</td>
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<td>4:00</td>
<td>1550000</td>
<td>150000</td>
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<td>&lt;86 CI(10-720)</td>
<td>1300 CI(290-6200)</td>
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<tr>
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<td>5-Nov-12</td>
<td>10:00</td>
<td>2850000</td>
<td>194000</td>
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<td>&lt;86 CI(10-720)</td>
<td>750 CI(150-3800)</td>
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<td>2450000</td>
<td>326000</td>
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<td>ND</td>
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<tr>
<td>5h comp</td>
<td>5-Nov-12</td>
<td>21:00</td>
<td>1050000</td>
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<td>ND</td>
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<tr>
<td>6h comp</td>
<td>6-Nov-12</td>
<td>3:00</td>
<td>2450000</td>
<td>276000</td>
<td>&lt;86 CI(10-720)</td>
<td>&lt;86 CI(10-720)</td>
<td>1300 CI(290-6200)</td>
</tr>
</tbody>
</table>

ND – Not Determined
### Table 4: Unchlorinated Effluent - Indicator Microorganism and Human Virus Levels

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Date Collected</th>
<th>Time</th>
<th>FC/ 100 ml</th>
<th>MSC / 100 ml</th>
<th>GI MPN/ 100 ml (95% CL)</th>
<th>GII MPN/ 100 ml (95% CL)</th>
<th>AdV MPN/ 100 ml (95% CL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grab</td>
<td>3-Nov-12</td>
<td>12:00</td>
<td>2</td>
<td>170</td>
<td>&lt;86 CI(10-720)</td>
<td>&lt;86 CI(10-720)</td>
<td>&lt;310 CI(37-2600)</td>
</tr>
<tr>
<td>Grab</td>
<td>4-Nov-12</td>
<td>10:50</td>
<td>3.0015</td>
<td>6400</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>5h comp</td>
<td>4-Nov-12</td>
<td>22:00</td>
<td>1.5</td>
<td>200</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>6h comp</td>
<td>5-Nov-12</td>
<td>10:00</td>
<td>1</td>
<td>800</td>
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<td>&lt;86 CI(10-720)</td>
<td>420 CI(64-2800)</td>
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<tr>
<td>6h comp</td>
<td>5-Nov-12</td>
<td>14:00</td>
<td>3</td>
<td>120</td>
<td>93 CI(12-730)</td>
<td>&lt;86 CI(10-720)</td>
<td>&lt;310 CI(37-2600)</td>
</tr>
<tr>
<td>5h comp</td>
<td>5-Nov-12</td>
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<td>0.5</td>
<td>240</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>6h comp</td>
<td>6-Nov-12</td>
<td>3:00</td>
<td>2</td>
<td>150</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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</tbody>
</table>

### Table 6: Final Effluent - Indicator Microorganism and Human Virus Levels

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Date Collected</th>
<th>Time</th>
<th>FC/ 100 ml</th>
<th>MSC / 100 ml</th>
<th>GI MPN/ 100 ml (95% CL)</th>
<th>GII MPN/ 100 ml (95% CL)</th>
<th>AdV MPN/ 100 ml (95% CL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grab</td>
<td>3-Nov-12</td>
<td>11:15</td>
<td>0.49</td>
<td>4040</td>
<td>&lt;86 CI(10-720)</td>
<td>&lt;86 CI(10-720)</td>
<td>&lt;310 CI(37-2600)</td>
</tr>
<tr>
<td>Grab</td>
<td>4-Nov-12</td>
<td>11:45</td>
<td>9.0045</td>
<td>11200</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<tr>
<td>6h comp</td>
<td>5-Nov-12</td>
<td>6:00</td>
<td>1.5</td>
<td>400</td>
<td>&lt;86 CI(10-720)</td>
<td>&lt;86 CI(10-720)</td>
<td>&lt;310 CI(37-2600)</td>
</tr>
<tr>
<td>6h comp</td>
<td>5-Nov-12</td>
<td>12:00</td>
<td>0.5</td>
<td>600</td>
<td>&lt;86 CI(10-720)</td>
<td>&lt;86 CI(10-720)</td>
<td>&lt;310 CI(37-2600)</td>
</tr>
<tr>
<td>5h comp</td>
<td>4-Nov-12</td>
<td>22:00</td>
<td>3</td>
<td>400</td>
<td>&lt;86 CI(10-720)</td>
<td>&lt;86 CI(10-720)</td>
<td>&lt;310 CI(37-2600)</td>
</tr>
</tbody>
</table>
Travel Times of Dye Excursion

<table>
<thead>
<tr>
<th>Location</th>
<th>Start Time</th>
<th>End Time</th>
<th>Elapsed Time</th>
<th>Distance</th>
<th>Estimated Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Concentration</td>
<td>11/5/2012 8:36:50 AM</td>
<td>11/6/2012 7:53:08 AM</td>
<td>25.27 hours</td>
<td>1.52 km</td>
<td>0.06 km/hr</td>
</tr>
<tr>
<td>Yellow Concentration</td>
<td>11/5/2012 6:36:50 AM</td>
<td>11/6/2012 8:04:15 AM</td>
<td>25.46 hours</td>
<td>3.06 km</td>
<td>0.12 km/hr</td>
</tr>
<tr>
<td>Growing Area</td>
<td>11/5/2012 6:36:50 AM</td>
<td>11/6/2012 6:48:33 AM</td>
<td>24.2 hours</td>
<td>3.73 km</td>
<td>0.13 km/hr</td>
</tr>
<tr>
<td>End of Detectable Dye</td>
<td>11/5/2012 6:36:50 AM</td>
<td>11/6/2012 11:04:50 AM</td>
<td>28.47 hours</td>
<td>3.96 km</td>
<td>0.21 km/hr</td>
</tr>
</tbody>
</table>

Legend
- WTP: LPWRF Diffuser
- Shellfish Stations

Concentration (ppb)
- <= 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.50
- 0.50 to 1.0
- 1.0 to 5.0
- 5.0 to 10.0
- 10.0 to 50.0
- >= 50.0

Semiahmoo Bay
1000:1 Dilution Line

Travel Time to Growing Area: 24.20 hours

Sources: Esri, DeLorme, NPS, NRCAN, GeoBase, IGN, Kappa NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community
Shellfish Viral Concentrations at Oyster Cages (per 100 grams)
Table 4: Oyster Sentinels – Indicator Microorganism and Human Virus Levels

<table>
<thead>
<tr>
<th>Station</th>
<th>MSC/100 g</th>
<th>FC/100 g</th>
<th>EC/100 g</th>
<th>GI MPN/100 g (95% CL)</th>
<th>GII MPN/100 g (95% CL)</th>
<th>AdV MPN/100 g (95% CL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20970</td>
<td>5400</td>
<td>1700</td>
<td>1400 (600-3300)</td>
<td>180 (26-1300)</td>
<td>&lt;620 (92-4500)</td>
</tr>
<tr>
<td>2</td>
<td>5092</td>
<td>3500</td>
<td>1100</td>
<td>880 (330-2300)</td>
<td>590 (19-1900)</td>
<td>&lt;620 (92-4500)</td>
</tr>
<tr>
<td>3</td>
<td>4859</td>
<td>5400</td>
<td>560</td>
<td>&lt;170 (26-1300)</td>
<td>590 (19-1900)</td>
<td>2200 (700-6800)</td>
</tr>
<tr>
<td>4</td>
<td>828</td>
<td>700</td>
<td>700</td>
<td>&lt;170 (26-1300)</td>
<td>960 (370-2500)</td>
<td>&lt;620 (92-4500)</td>
</tr>
<tr>
<td>5</td>
<td>1882</td>
<td>330</td>
<td>68</td>
<td>&lt;170 (26-1300)</td>
<td>740 (260-2100)</td>
<td>1300 (300-5300)</td>
</tr>
<tr>
<td>6</td>
<td>1187</td>
<td>330</td>
<td>17.9</td>
<td>&lt;170 (26-1300)</td>
<td>350 (85-1500)</td>
<td>&lt;620 (92-4500)</td>
</tr>
</tbody>
</table>
**Major Findings**

- Membrane filter removal rates much higher for FC than for MSC (6 log vs. 3 log)
- Low chlorine residual had minimal effect on MSC levels in final effluent
- Significant levels of FC, MSC in all cages
- Norovirus, Adenovirus detected in cages and not in WRF effluent (and higher away from outfall diffuser)
- >24 hours travel time from diffuser to Conditionally Approved area
Next Steps

- Additional microbial testing to look for seasonal patterns, other pollution sources
- Advocate for increased chlorine residual in final effluent at Blaine WRF
- Conduct similar studies in other areas of concern (Penn Cove, Dyes Inlet, Richmond Beach, Poverty Bay, etc.)
- Microbial testing of wastewater effluent under adverse conditions (including flow blending)
- Participate in work group on development of FDA dilution guidance
Thank You

Mark Toy
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Mark.Toy@doh.wa.gov
Website: www.doh.wa.gov/CommunityandEnvironment/Shellfish.aspx