May 1st, 1:30 PM - 3:00 PM

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

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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 resistent to disinfection and persistent in environment than FC

▸ NoV hard to measure (not culturable)

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Male Specific Coliphage (MSC)

- 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 verses MSC
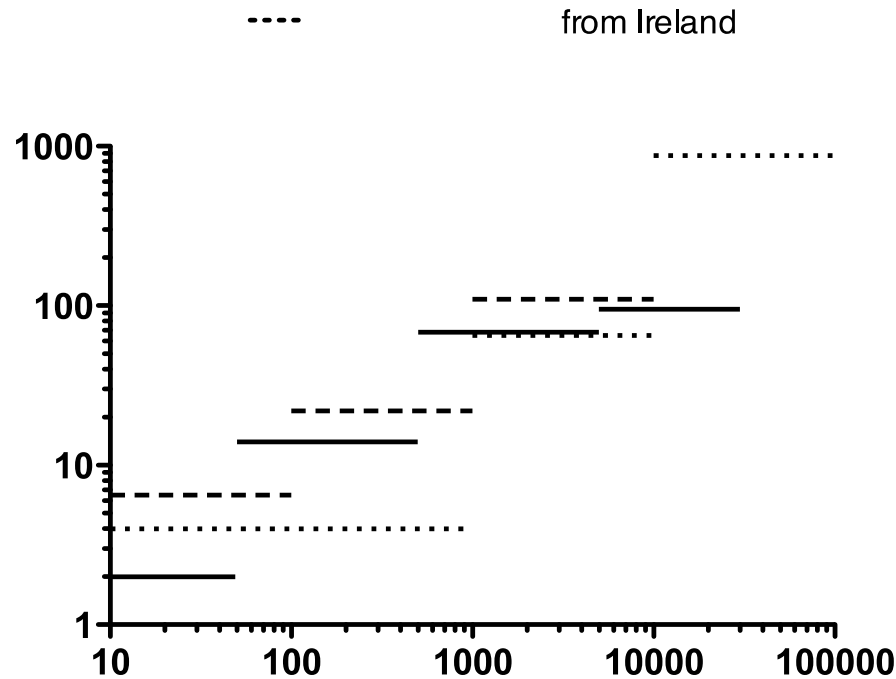
Temperature Dependent MSC Depuration Rate (Maine studies)

Legend: Fore River Trials (○), Royal River Trials (●), Presumpscot River (grey ●). Y-axis: Single Log Reduction in Days. X-axis: Average Water T °C. Dashed line labeled "Log Reduction in 2 Days".
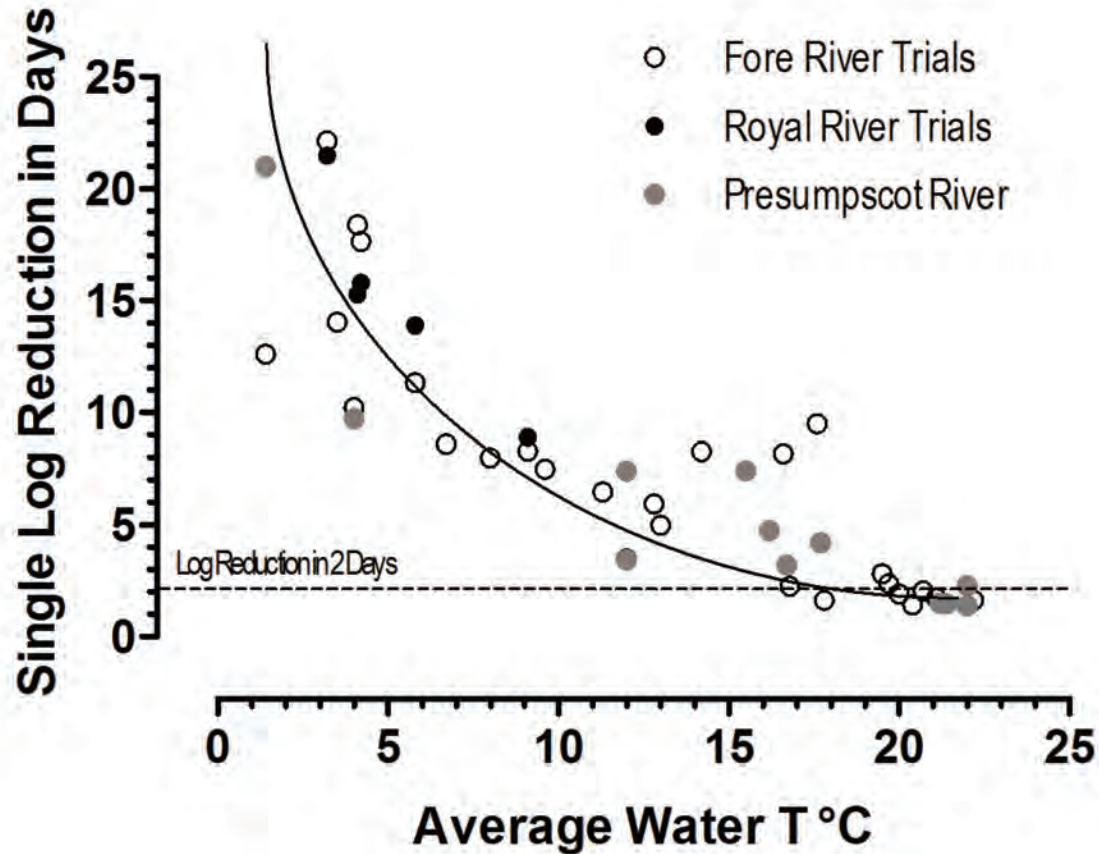
MSC Reduction Efficiency Verses Flow
at Yarmouth, Maine WTP
(data collected after 3" rain event during flood closure)

Normal Plant Operation

eduction of MSC
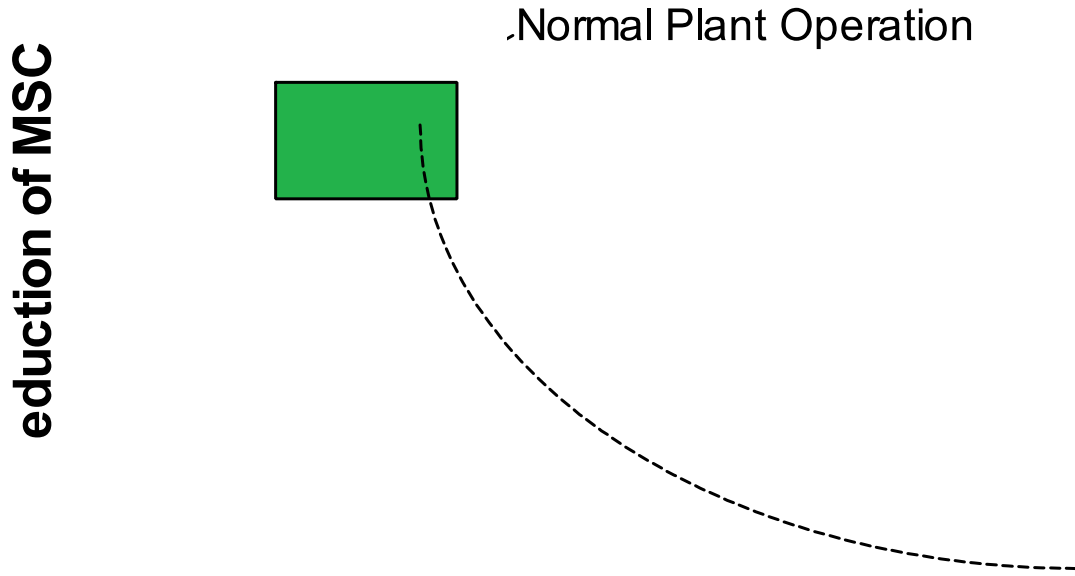
In summary

- 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

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FDA guidance on growing area classification around sewage outfalls

1000:1 DILUTION LINE POLICY IMPACT

River or Stream wt/ High FC

Head of Tide

Bay

Prohibited (Permanently Closed)

WTP

Conditionally Approved or Restricted

Approved

Ocean

1000:1 Dilution Line or Travel Time Line

Line of No Impact from WTP failure
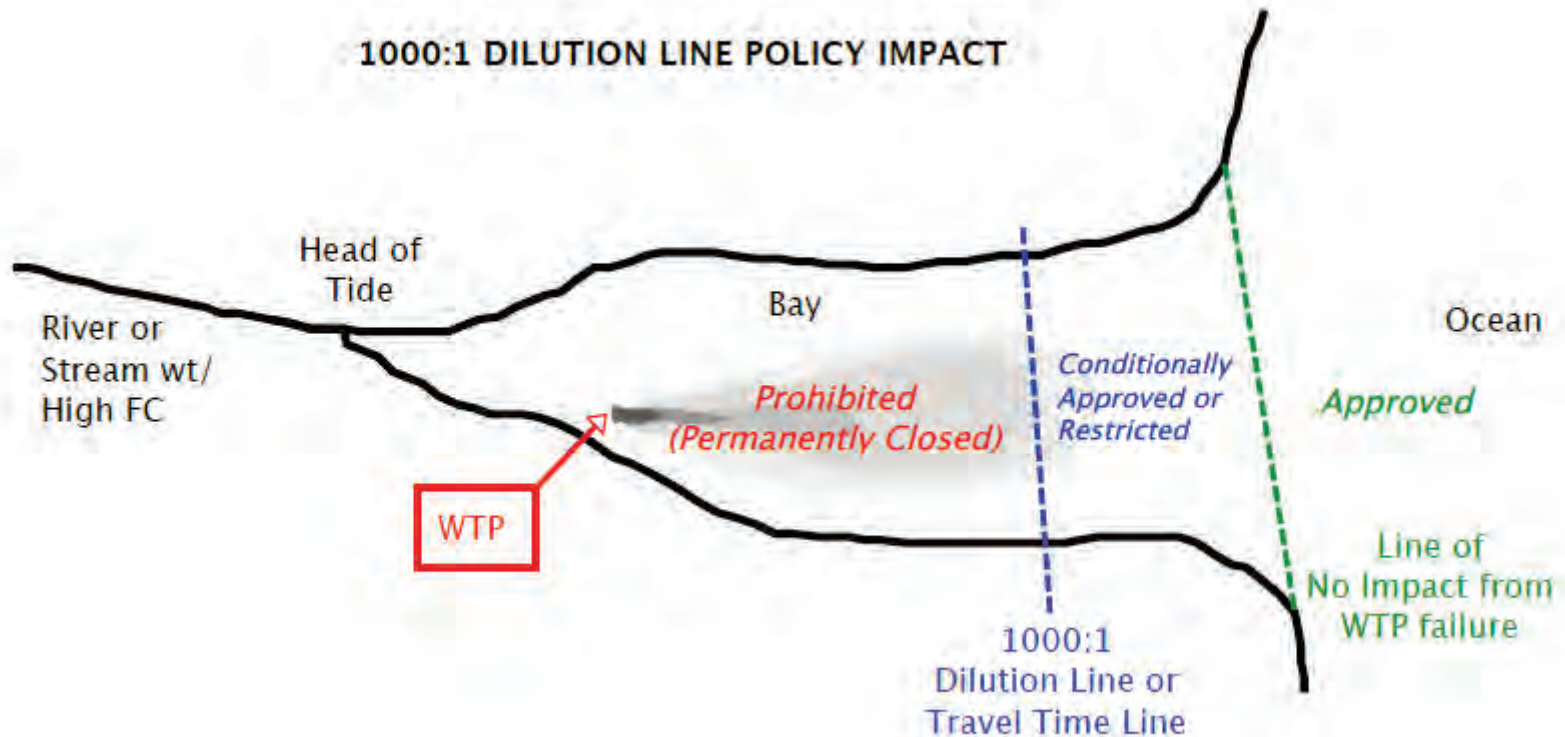
Blaine Dye and Microbial Study

- 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

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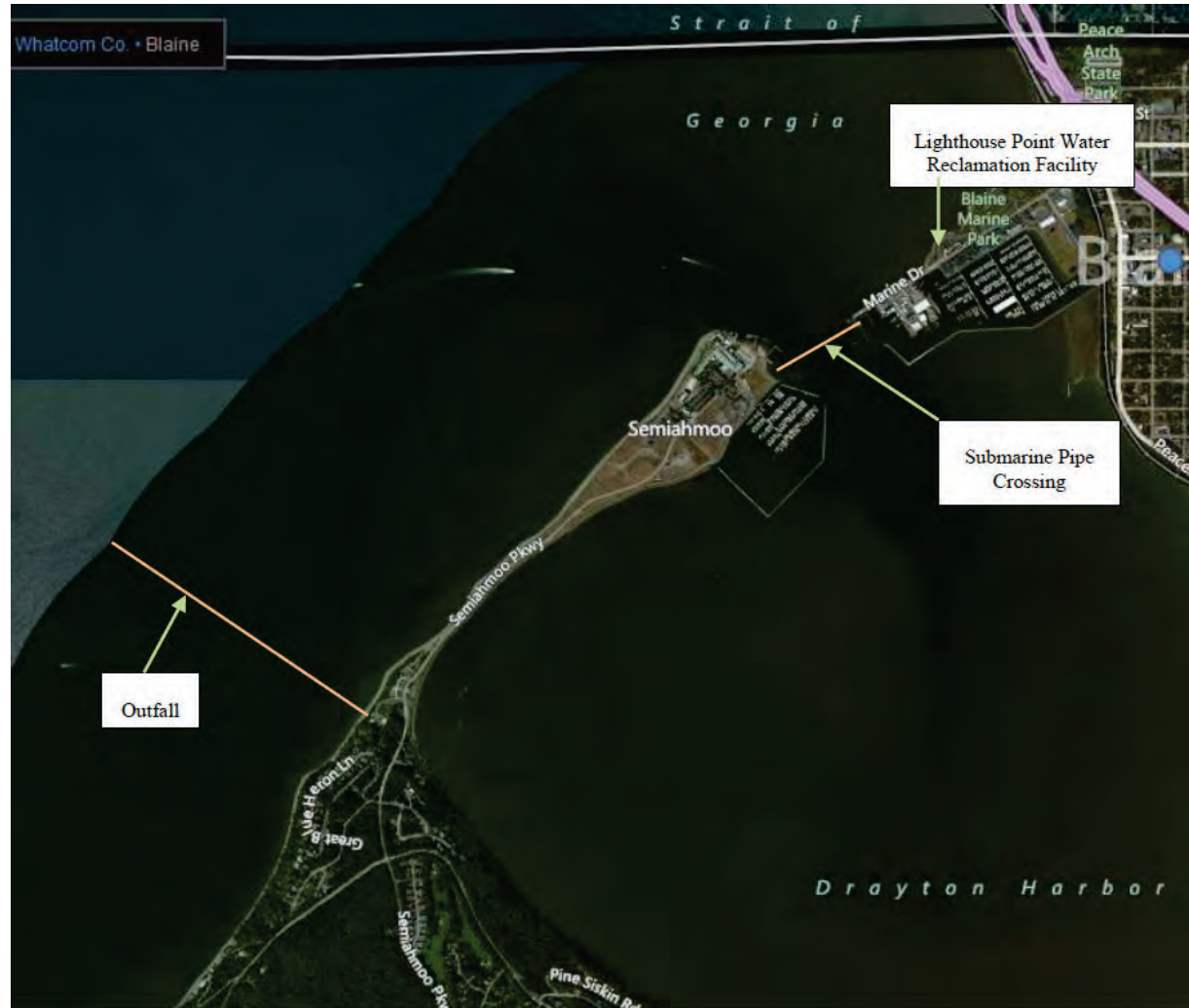
Oyster Cage Sites

(Seasonal winter closure due to nonpoint sources (California and Dakota Creeks))

Table 1: Influent - Indicator Microorganism and Human Virus Levels

Sample Type	Date Collected	Time	FC/ 100 ml	MSC / 100 ml	GI MPN/ 100 ml (95% CL)	GII MPN/ 100 ml (95% CL)	AdV MPN/ 100 ml (95% CL)
Grab	3-Nov-12	12:00	3550000	286000	<86 CI(10-720)	93 CI(12-730)	<310 CI(37-2600)
Grab	4-Nov-12	10:44	2600000	364000	ND	ND	ND
5h comp	4-Nov-12	10:00	3100000	166000	<86 CI(10-720)	<86 CI(10-720)	1300 CI(290-6200)
6h comp	4-Nov-12	21:00	3350000	142000	<86 CI(10-720)	<86 CI(10-720)	<310 CI(37-2600)
6h comp	5-Nov-12	4:00	1550000	150000	<86 CI(10-720)	<86 CI(10-720)	1300 CI(290-6200)
6h comp	5-Nov-12	10:00	2850000	194000	<86 CI(10-720)	<86 CI(10-720)	750 CI(150-3800)
4h comp	5-Nov-12	16:00	2450000	326000	ND	ND	ND
5h comp	5-Nov-12	21:00	1050000	142000	ND	ND	ND
6h comp	6-Nov-12	3:00	2450000	276000	<86 CI(10-720)	<86 CI(10-720)	1300 CI(290-6200)

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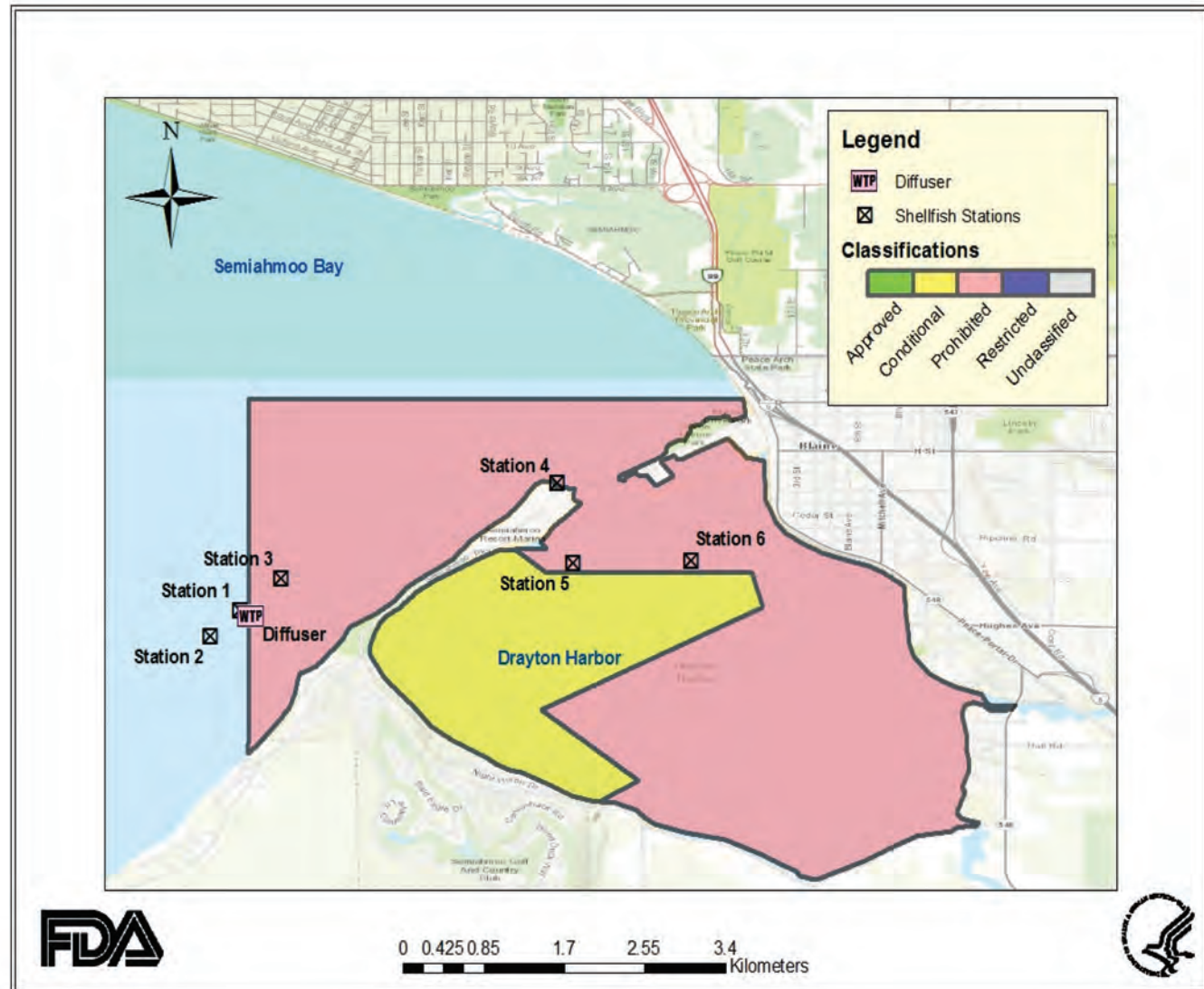
Table 4: Unchlorinated Effluent - Indicator Microorganism and Human Virus Levels

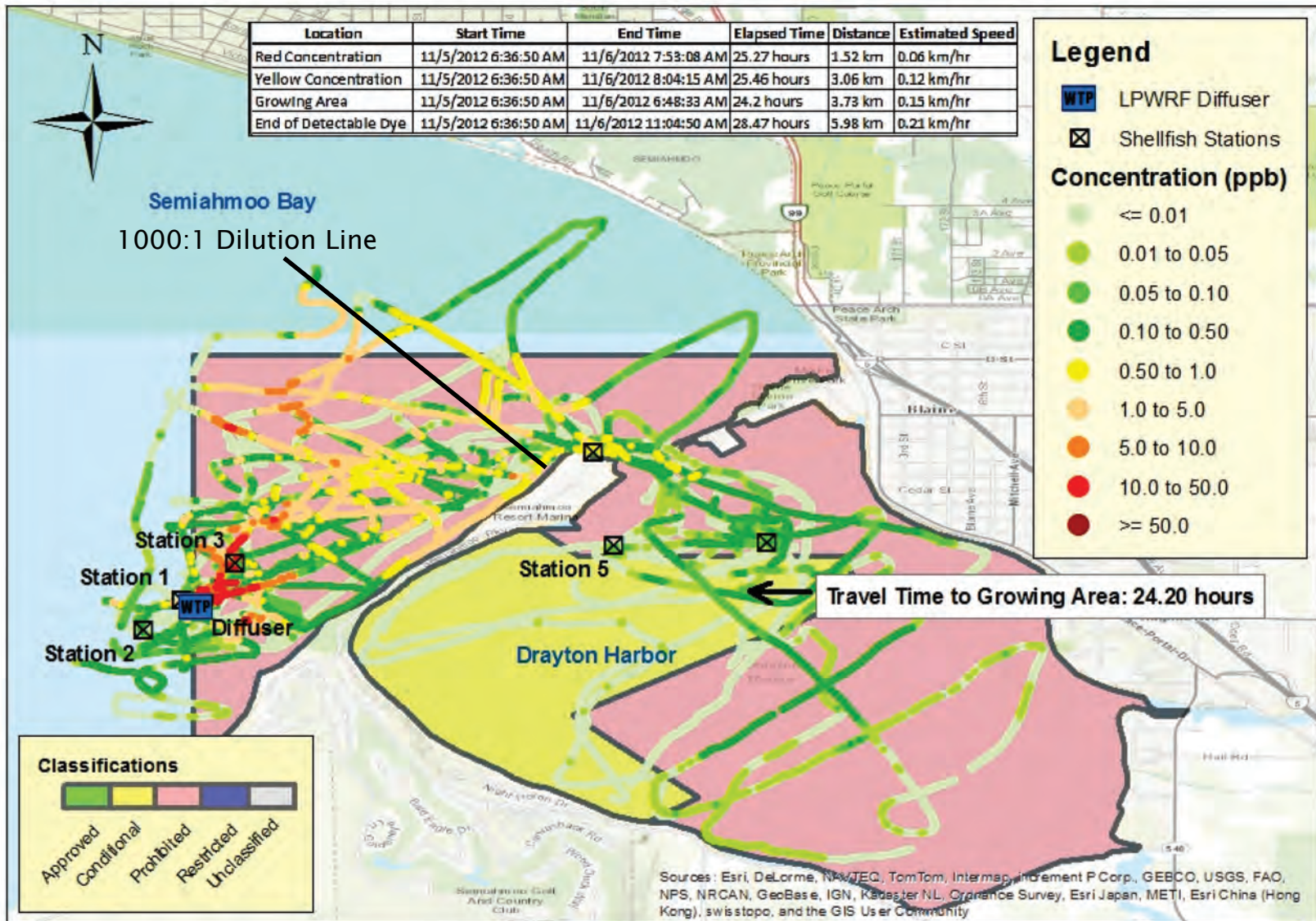| Sample Type	Date Collected	Time	FC/ 100 ml	MSC / 100 ml	GI MPN/ 100 ml (95% CL)	GII MPN/ 100 ml (95% CL)	AdV MPN/ 100 ml (95% CL)
Grab	3-Nov-12	12:00	2	170	<86 CI(10-720)	<86 CI(10-720)	<310 CI(37-2600)
Grab	4-Nov-12	10:50	3.0015	6400	ND	ND	ND
5h comp	4-Nov-12	22:00	1.5	200	ND	ND	ND
6h comp	5-Nov-12	10:00	1	800	<86 CI(10-720)	<86 CI(10-720)	420 CI(64-2800)
6h comp	5-Nov-12	14:00	3	120	93 CI(12-730)	<86 CI(10-720)	<310 CI(37-2600)
5h comp	5-Nov-12	21:00	0.5	240	ND	ND	ND
6h comp	6-Nov-12	3:00	2	150	ND	ND	ND

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

Sample Type	Date Collected	Time	FC/ 100 ml	MSC / 100 ml	GI MPN/ 100 ml (95% CL)	GII MPN/ 100 ml (95% CL)	AdV MPN/ 100 ml (95% CL)
Grab	3-Nov-12	11:15	0.49	4040	<86 CI(10-720)	<86 CI(10-720)	<310 CI(37-2600)
Grab	4-Nov-12	11:45	9.0045	11200	ND	ND	ND
6h comp	5-Nov-12	6:00	1.5	400	<86 CI(10-720)	<86 CI(10-720)	<310 CI(37-2600)
6h comp	5-Nov-12	12:00	0.5	600	<86 CI(10-720)	<86 CI(10-720)	<310 CI(37-2600)
5h comp	4-Nov-12	22:00	3	400	<86 CI(10-720)	<86 CI(10-720)	<310 CI(37-2600)

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Travel Times of Dye Excursion

Location	Start Time	End Time	Elapsed Time	Distance	Estimated Speed
Red Concentration	11/5/2012 6:36:50 AM	11/6/2012 7:53:08 AM	25.27 hours	1.52 km	0.06 km/hr
Yellow Concentration	11/5/2012 6:36:50 AM	11/6/2012 8:04:15 AM	25.46 hours	3.06 km	0.12 km/hr
Growing Area	11/5/2012 6:36:50 AM	11/6/2012 6:48:33 AM	24.2 hours	3.73 km	0.15 km/hr
End of Detectable Dye	11/5/2012 6:36:50 AM	11/6/2012 11:04:50 AM	28.47 hours	5.98 km	0.21 km/hr

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

Station 3
Station 1
Station 2
Diffuser
Station 5

Travel Time to Growing Area: 24.20 hours

Drayton Harbor

Classifications
Approved | Conditional | Prohibited | Restricted | Unclassified

Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, Increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

FDA

0 0.425 0.85 1.7 2.55 3.4
Kilometers

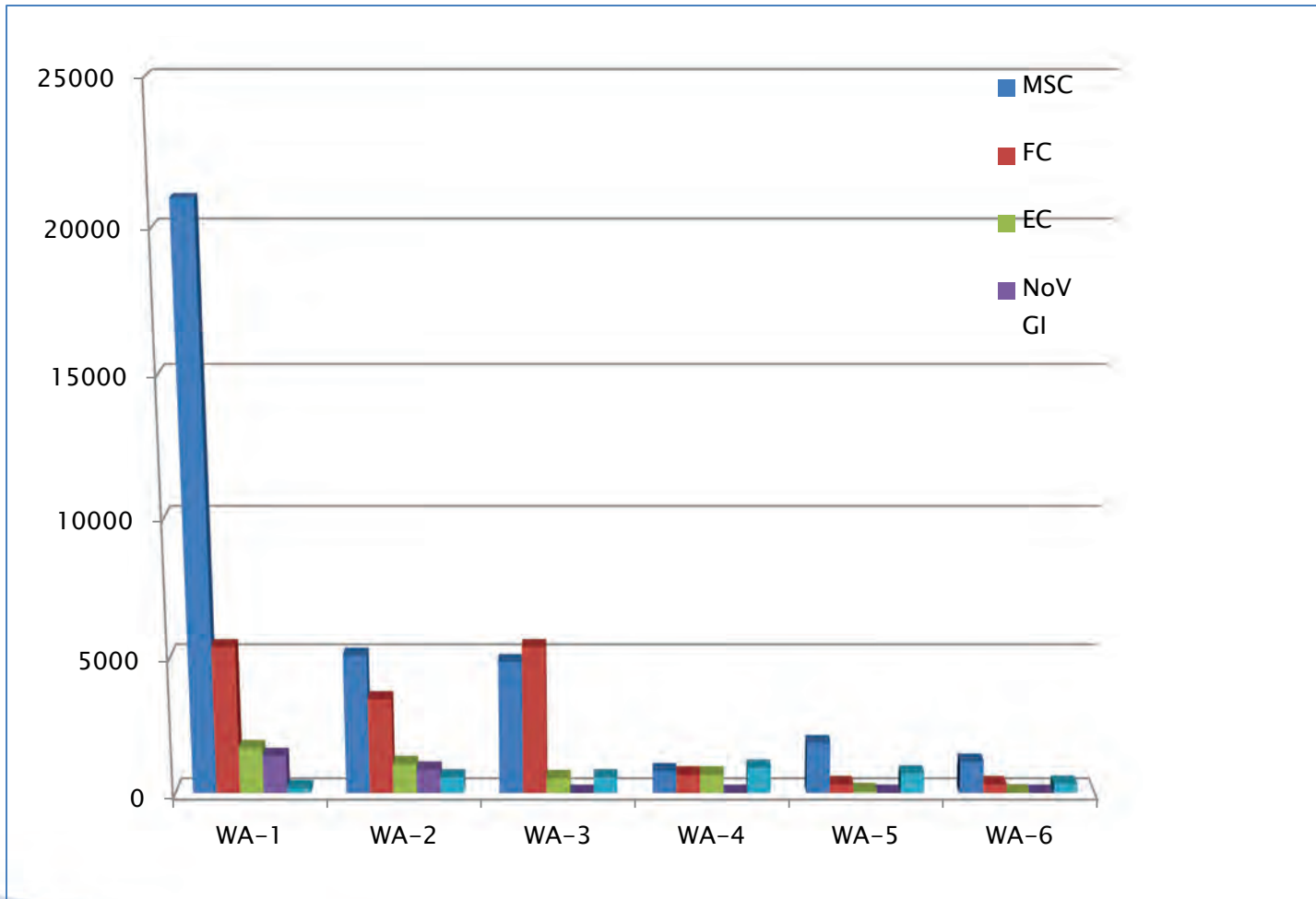# Shellfish Viral Concentrations at Oyster Cages (per 100 grams)

## Table 4: Oyster Sentinels – Indicator Microorganism and Human Virus Levels

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

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

Drayton Harbor 04/12/12
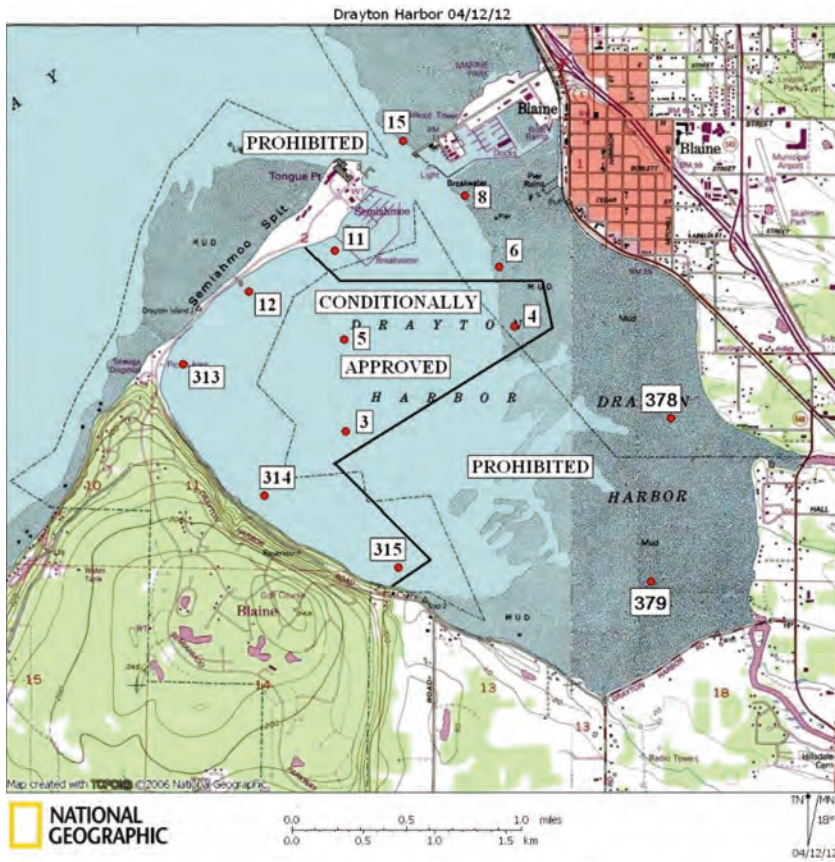
Thank You

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