Use of MSC in Sanitary Wastewater System Assessments of Canadian Shellfish Areas

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Canadian Shellfish Sanitation Program 101

- Food safety assurance for Canadian domestic and export markets
- Supports 1948 Canada-US Agreement on Shellfish Sanitation
- Delivered at federal level:
  - Canadian Food Inspection Agency (Plant Sanitation, Biotoxins, Vibrio)
  - Environment Canada (Growing Area Classification, Sanitary Surveys)
  - Fisheries and Oceans Canada (Patrol, Resource Management)
- The CSSP shares same principles, approaches and key criteria as the NSSP

Wastewater Systems in Canada

- Approximately 3800 sanitary systems in Canada
- Some 320 discharge in the vicinity of shellfish growing areas on Pacific and Atlantic coasts
- Operation and effluent quality traditionally regulated by Provincial ministries
- Federal regulations promulgated in 2012, compliance of priority systems by 2020
- Summary of systems near shellfish areas:

Treatment Level	
Primary	7%
Secondary	84%
Tertiary	1%
Other	8%

Treatment Type	
Mechanical	41%
Lagoon	45%
Other	14%

MSC Sampling

- Sampling EC: 2012 – present (CFIA - HC: 2009 – 2011)
- 685 samples collected
  - raw influent
  - post-treatment/pre-disinfection
  - final effluent
- 17 systems
  - 2 primary (1 UV, 1 Cl) 7300 – 10,200 m^3/d | 1.9 – 2.7 mgd
  - 7 secondary mechanical (2 UV, 5 Cl) 600 – 6700 m^3/d | 0.2 – 1.8 mgd
  - 7 secondary lagoon (3 UV, 1 Nat. UV, 3 Cl) 450 – 1520 m^3/d | 0.1 – 0.4 mgd
  - 1 tertiary mechanical (UV) 10,200 m^3/d | 2.7 mgd
- Mechanical: extended aeration, activated sludge, SBR, RBC, oxidation ditch
- Lagoons: all multi-cell aerated (retention time: 15 – 80 days; avg. 23)
- One sampled lagoon uses natural UV disinfection – shallow pond

MSC Results

	n	Log *[95% CI]*
Raw Influent *(0.1 – 7.5 mgd)*	370	4.91 *[4.83, 4.99]*

Treatment	n *(pairs)*	LRV *[95% CI]*
Primary	33	– 1.10 *[–0.59, –1.61]*
Secondary (Mechanical)	84	– 2.28 *[–2.08, –2.48]*
Secondary (Lagoon)	60	– 3.15 *[–2.92, –3.38]*
Tertiary	3	– 2.45

Disinfection *(where final conc. > LoQ)*	n *(pairs)*	LRV *[95% CI]*
Chlorine	39	– 0.48 *[–0.25, –0.71]*
UV	94	– 1.60 *[–1.48, –1.72]*
Natural UV	5	– 0.90

MSC Results vs FC Results

	MSC		Fecal Coliform	
Treatment	n	LRV *[95% CI]*	n	LRV *[95% CI]*
Primary	33	– 1.10 *[–0.59, –1.61]*	45	**– 3.18** *[–2.54, –3.82]*
Secondary (Mechanical)	84	– 2.28 *[–2.08, –2.48]*	182	– 2.19 *[–2.08, –2.30]*
Secondary (Lagoon)	60	– 3.15 *[–2.92, –3.38]*	296	**– 3.62** *[–3.53, –3.71]*
Tertiary	3	– 2.45	4	– 2.24

Assessing Wastewater Impacts - Canada

- Under CSSP, all wastewater system outfalls (WWTP, lift stations, CSOs) have minimum 300m (1000 ft) prohibited area
- Normal operation at WWTP: prohibited area expanded to achieve viral reduction performance objective at outer boundary
- Wastewater system failure scenarios (P_{90} or max. flow):
  - Conditional zone meets viral PO at outer boundary
  - WWTP – by-pass, inadequate treatment
  - Lift Stations, CSOs – overflow or raw or diluted sewage
  - Cond. Approved or Cond. Restricted meets 14 or 88 FC/100mL at boundary
- Use NoV data for WWTP LRV (if available), MSC (more likely), LRV credit
- Prohibited zone sized based on hydrologic modelling (DHI MIKE and others) complemented by dye and drogue studies

Log Reduction Value (LRV)

$LRV_{total} = LRV_{treatment} + LRV_{disinfection} + LRV_{inactivation} + LRV_{dilution}$

Set $LRV_{disinfection} = 0$ (safety factor)

If t_{90} = 500 hrs then $LRV_{inactivation}$ is <0.05 for 24hr $\longrightarrow$ 0

$LRV_{total} = LRV_{treatment} + LRV_{dilution}$

$LRV_{dilution} = LRV_{total} - LRV_{treatment}$

Example:

LRV_{total} (performance objective) = 5.0

$LRV_{treatment}$ (normal operation) = 2.25

$LRV_{dilution} = 5.0 - 2.3$

$LRV_{dilution}$ = 2.7 : normal ops. prohibited area achieves min. 2.7 reduction

For failure (raw discharge) $LRV_{dilution}$ conditional area would be 5.0

LRV Treatment 'Credit'

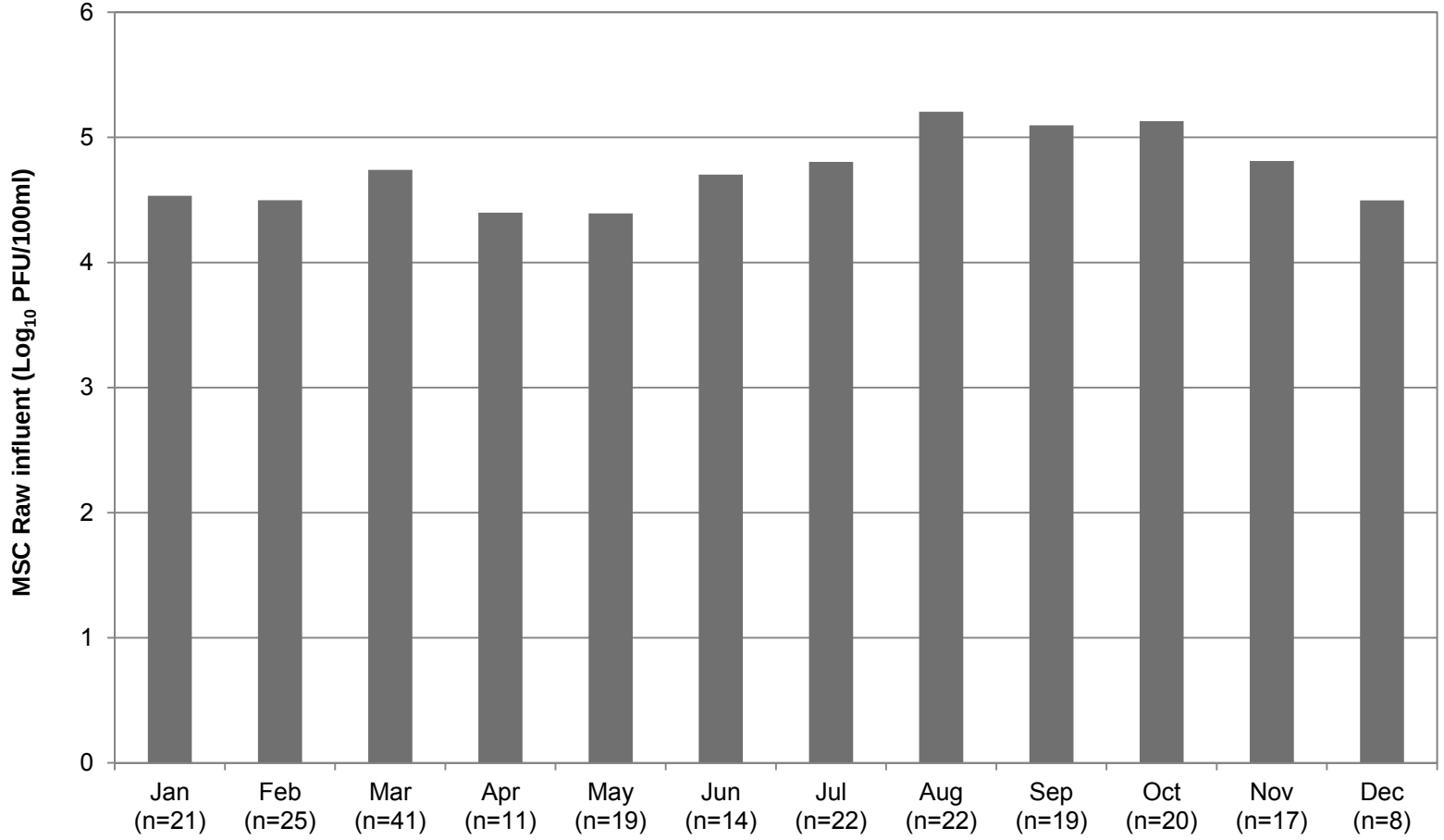
Treatment	LRV credit	MSC LRV *[95% CI]*
Primary	0	– 1.10 *[–0.59, –1.61]*
Secondary (Mechanical)	– 1	– 2.28 *[–2.08, –2.48]*
Secondary (Lagoon)	– 2	– 3.15 *[–2.92, –3.38]*

- Used for systems where neither MSC nor NoV has been measured
- Credit is at least one-log lower than mean and below lower 95% CI

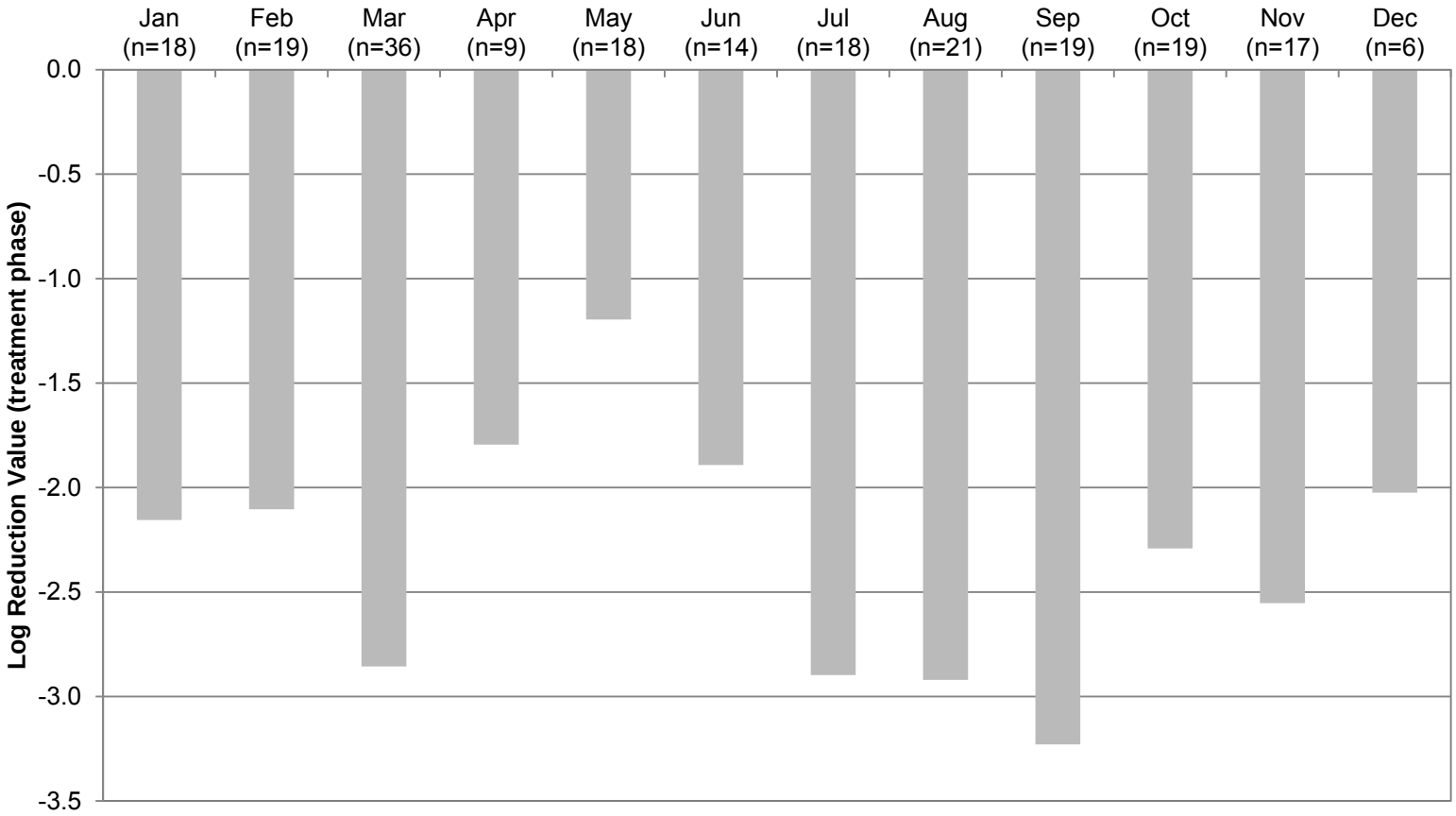
Modelling output

Growing Area Classification

Seasonality – Raw Influent



Seasonality – LRV Treatment Stage



Seasonality – LRV Treatment

Treatment	Warm (Jun-Sep)	Cold (Jan-Apr)
Primary	– 1.7	– –
Secondary (Mechanical)	– 2.3	– 2.0
Secondary (Lagoon)	– 3.9	– 2.1
All	– 3.0	– 2.0

Water temperatures:

- Warm season: 15 – 28°C (60 – 82°F)
- Cold season: 0 – 8°C (32 – 45°F)

Summary

- MSC appears to be a useful indicator of log reduction, particularly in WWTP treatment stage
- More conservative than estimating reduction via fecal coliforms (Primary and lagoon systems)
- Limit of Detection/Quantification/Enumeration is often limiting for determining reduction through disinfection
- LoQ also limiting for MSC results in overlay waters
- Some seasonality in raw influent and in treatment efficacy
- Performance objective and credit values are current [interim] Canadian Approach pending conclusions of *US – Canada Joint Health Risk Assessment on Noroviruses in Shellfish*
- MSC has not yet been incorporated in CSSP for water or shellstock.
- Some Provinces are including LRV based on MSC into regulatory permits
- 2014: NoV + MSC sampling to bolster data for correlation

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Thank you for your attention

Merci de votre attention