Spatial and temporal variation in the water quality of four marshes adjacent to the nearshore of Western Durham, Lake Ontario

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# Durham Region Coastal Wetland Monitoring Project

- Long term monitoring program that assesses the conditions of 15 wetlands in the region
  - Water quality
  - Sediment quality
  - Watersheds and landuse
  - Submerged aquatic vegetation
  - Aquatic macroinvertebrates
  - Fish
  - Breeding amphibians and birds

<table>
<thead>
<tr>
<th></th>
<th>Rouge (ha)</th>
<th>Frenchmans (ha)</th>
<th>Duffins (ha)</th>
<th>Carruthers (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Drowned River Mouth</td>
<td>Barrier Beach Lagoon</td>
<td>Drowned River Mouth</td>
<td>Drowned River Mouth</td>
</tr>
<tr>
<td>Size (ha)</td>
<td>56</td>
<td>39</td>
<td>78</td>
<td>116</td>
</tr>
<tr>
<td>Watershed (ha)</td>
<td>33,289</td>
<td>1,652</td>
<td>28,653</td>
<td>3,812</td>
</tr>
<tr>
<td>Vegetation type</td>
<td>Marsh 64% Swamp 36%</td>
<td>Marsh 99% Swamp 1%</td>
<td>Marsh 88%</td>
<td>Marsh 24% Swamp 76%</td>
</tr>
<tr>
<td>Water Quality</td>
<td>Fair</td>
<td>Fair</td>
<td>Fair</td>
<td>Poor</td>
</tr>
<tr>
<td>Trending</td>
<td>Improving</td>
<td>Mixed</td>
<td>Improving</td>
<td>Mixed</td>
</tr>
</tbody>
</table>

- Rouge and Duffins undergoing Restoration Efforts

Includes complexes
Western Durham Monitoring Program

- The public was upset with beach closures; community unhappy with algal growth
- TRCA completed preliminary lake investigations in 2006
- Began more intensive sampling in 2007; concurrently, looked at the adjacent marshes
- Rotary Park:
  - no longer sampled by the Health Department
  - not physically safe to swim due to shoreline protection
  - Provincially significant marsh
This program differs from the DRCWM Project

- Sampling occurred concurrently with lake monitoring program
- 3 to 6 locations sampled in each marsh
- 2007 to 2009, generally monthly between April and November
  - Frenchmans Bay Marsh not sampled until 2008

- Water quality
  - York-Durham Regional Environmental Lab
  - TP, SRP
  - NO₂, NO₃, TKN, NH₃
  - E. coli
  - pH, alkalinity, conductivity
  - Suspended solids

- Seasonal differences

- Spatial differences

- Water quality in relation to lake levels
The data is online…


Friday morning 9:50 Rm 1008: Outreach and Education Session
Marsh water quality is often better than the creeks.
We have local watershed loads too:

- TRCA and Environment Canada have been working together to estimate land-based nutrient and suspended loadings from creeks/rivers
- Malkin et al. loads are on the low end using PWQMN data
2008 Loads based on PWQMN and EMC for dry and wet weather respectively

- Majority of Load in 2008 came in April and December

- In order to avoid backwater effects from the lake, loads are based on river/creek samples well upstream of the marshes

- Similar to other studies, these values are used in models and considered as inputs to the nearshore; nuances: e.g. only main branch of Rouge sampled, not close to lake

- Our work examines the continuum and how these inputs are processed in the marshes prior entering the lake
Precipitation and Discharge

- 2007 to 2009 has “Wet” and “Dry” years
  - 2007 to 2008: record low to record high
  - During high flows, creek water likely bypasses the marshes and are a good indicator of what enters the lake
  - During low flows, what is exiting the marshes is likely different than what is observed upstream
  - More work is required to understand the relationships
- Dry year: elevated discharge in January and spring
- Wet years: elevated discharge in January, spring, sometimes in fall
  - 2008 is particularly wet in the summer!
Median concentrations in DRY years are different than WET years for...

**SRP**: Rouge, Duffins, and Carruthers (the 3 Drowned River Mouth Marshes)

**NH$_3$ + NH$_4^+$**: Rouge and Duffins
- Also a difference in Carruthers for NH$_3$ and SS, but the Dunn’s posthoc test (which is very conservative) does not show a difference.

**TP**: Carruthers

**Nitrate+Nitrite**: Carruthers
Total Phosphorus (mg/L)

Variability:
- Dry years: Spring and Summer
- Wet years: Spring and Fall
- no statistical difference between median seasonal concentrations (spring is not different than summer or fall)

Between years in each marsh, seasonal median concentrations are not statistically different
(e.g. Spring of 2007 is not different than Spring of 2008 is not different than Spring 2009)
Rouge Marsh

Duffins Marsh – highest [SRP] and variability

Carruthers Marsh

Frenchmans Bay Marsh

SRP (mg/L)

Variability:
- Dry years: Spring and Summer
- Wet years: Fall
- no statistical difference between median seasonal concentrations (spring is not different than summer or fall) except FMBM (spring fall)

Between years in each marsh, spring and summer median concentrations are statistically different for Rouge, Duffins, and Carruthers
(e.g. Spring of 2007 is different than Spring of 2008/2009)
Nitrate + Nitrite (mg/L)

Variability:
- Dry years: Spring
- Wet years: Spring
- Median concentrations tend to be highest in Spring
- In general, statistical difference between median seasonal concentrations (e.g. spring is different than summer)

In general, between DRY and WET years, summer median concentrations are statistically different for Rouge, and Duffins. (e.g. Summer of 2007 is different than Summer of 2008)

Rouge Marsh – highest [NO₃+NO₂] and variability

Duffins Marsh

Carruthers Marsh

Frenchmans Bay Marsh
Ammonia + Ammonium (mg/L)

Variability:
- Dry years: Fall
- Wet years: Fall – especially in wet years!
- Tends to be lower when Nitrate is higher
- In general, statistical difference between median seasonal concentrations (e.g. spring is different than summer/fall, except in Rouge)

In general, between DRY and WET years, spring median concentrations are statistically different for Rouge, and Duffins; Fall median concentrations are different for Carruthers. (e.g. Spring of 2007 is different than Spring of 2008/2009)

Between years in individual marshes, median concentrations:
- Rouge Marsh:
  - Spring: 2007 is statistically different than 2008 and 2009
  - Summer: no statistical difference
  - Fall: no statistical difference

- Duffins Marsh:
  - Spring: none
  - Summer: none
  - Fall: 2007 is statistically different than 2008 and 2009 for Carruthers only

- Carruthers Marsh:
  - Spring: none
  - Summer: none
  - Fall: 2007 is statistically different than 2008 and 2009

- Frenchmans Bay Marsh:
  - Spring: none
  - Summer: none
  - Fall: none

In general, statistical difference between median seasonal concentrations (e.g. spring is different than summer/fall, except in Rouge)
Suspended Solids (mg/L)

Not surprising as SS patterns likely reflect precipitation events, and in the Rouge, Duffins, and Carruthers marshes - the influence of carp

NO Statistical Differences

- Frenchmans Bay Marsh
- Carruthers Marsh
- Duffins Marsh
- Rouge Marsh
In the public eye, aesthetics are important...

- Suspended solids and turbidity are evident in many of the marshes.
- Carp stir up sediments in all marshes except Frenchmans.
SS are often transferred to the lake.

Alongshore transport keeps these sediments close to the shore and nutrients associated with the sediments.
Suspended Solids – settle in Duffins and Frenchmans

- generally greater in the spring and fall in Carruthers and Rouge
- generally greater in the spring and summer in Duffins and Frenchmans

Rouge Marsh

- Spring
- Summer
- Fall

Frenchmans Marsh

- Spring
- Summer
- Fall

Duffins Marsh

- Spring
- Summer
- Fall

Carruthers Marsh

- Spring
- Summer
- Fall

General decline with a couple exceptions

Intervention to keep carp out

Declines towards mouth
Eurasian Water Milfoil

- Aquatic invasive in Frenchman’s Bay; underwater stands and dense floating mats
- Grows in up to 10 m water depth, commonly in depths 1-3 m
- Die off could contribute to nutrients in region
- Why is it growing?
Spatial marsh water quality

- generally greater in the summer and fall
- TP declines in Frenchmans Bay and Duffins
- Eurasian Milfoil an issue in Frenchmans Bay, lower TP observed here…water clarity?

Concentrations highest in Duffins
- general decline towards mouth

Declines towards Mouth

Exceptions
What about processing?

Top of Marsh vs. Marsh Mouth

- Nutrients are introduced to the marsh between the top and the mouth
- Concentrations are increasing, but unclear why with available data; possibilities include:
  - Sources with higher concentrations
  - Resuspension
  - Runoff

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1:1 line

Possible Denitrification or Dilution?

- Top of marsh has higher concentrations than mouth
- Concentrations are decreasing, but unclear why; possibilities include:
  - nutrient processing
  - dilution from sources with lower concentrations (e.g. lake, groundwater, etc)

Hard to interpret due to exchange with lake and varying lake levels and concentrations
TP and SRP

- **Duffins and Rouge Marshes**
  - Appears to be a mix between loss of nutrients and introduction of nutrients

- **Carruthers Marsh**
  - TP source between top and mouth of marsh, but SRP is decreasing (consumption? dilution?)

- **Frenchman's Bay Marsh**
  - Is phosphorus being processed?
  - Is there dilution from the Lake?
  - Note the “line” Frenchmans marsh samples at the mouth of the marsh
The same holds for Suspended Solids!

• Duffins and Rouge Marshes
  - Appears to be a mix between loss of solids and introduction of solids (resuspension?)

• Carruthers Marsh
  - Suspended solids source between top and mouth of marsh

• Frenchman's Bay Marsh
  - Settling?
  - Dilution from Lake?
  - Still in a line like P

In all cases,
• Carruthers behaves differently
• Frenchmans behaves differently
• Duffins and Rouge behave similarly
Take Home Messages

• **Temporal variability is observed between wet and dry years**
  – Drowned river mouths: SRP, NH$_3$; TP and SS only in Carruthers
  – Barrier beach lagoon: no significant temporal differences

• **Seasonal variability is observed in the marshes for some nutrients**
  – Sometimes there are significant differences for different seasons in wet/dry years (e.g. SRP, NO$_3$, NH$_3$ + NH$_4^+$), and sometimes there are no significant differences (e.g. TP)
  – Significant seasonal differences exist (e.g. NO$_3$ and NH$_3$ + NH$_4^+$)

• Frenchmans Bay Marsh exhibits a decline in nutrients from top to mouth for all nutrients!
• Duffins Creek and Rouge Marsh: mix of nutrient inputs and loss
• Carruthers tends to be different from the other marshes

• Depending on what lies between the creek and the lake could affect the loadings calculated

• This is a work in progress!
  – Efforts to date have focused on the lake
  – Preliminary look at the marshes with the intent to resample the marshes and to start looking at how loads are affected by processing, mixing/dilution
  – the data is available; always looking for collaborators interested in studying the area
Acknowledgements

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