Developing an Environmental Monitoring Program for the Saint John Harbour

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Saint John Harbour Funding and Partnerships

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Overview of Saint John Harbour

Activities in the harbour include:
• Discharges from oil refinery, pulp and paper mills, brewery, municipal wastewaters
• Busy port (including cruise ships)
• Dredging of shipping channel and disposal of sediments at marine disposal site
Historical Data on Sediment Contamination

Previous studies showed:
- Spatial variability in sediment contaminants
- Elevated metals, PCBs, and PAHs closer to dredge disposal and industrial discharges
- Some exceedences of CCME sediment quality guidelines

• from report by Land & Sea Environmental Consultants, 2001
Main Overall Objective

To work with SJH Environmental Monitoring Partnership to:

• Design optimal program for long term monitoring:
  – Location and number of reference and impacted sites
  – Methods (timing and frequency of sampling, sampling and analytical methods)
  – Thresholds for assessing change for:
    • Sediment contaminants
    • Benthic invertebrate communities
Contaminants and Invertebrates in Sediments

Phase 1 – **Characterize Baseline** (Years 1-3, 2011-14)
- What is the range of contaminant concentrations and invertebrate populations at reference sites?
- What season is the best to sample in?
- How much variability is there within sites across years?

Phase 2 – **Characterize “hotspots”** (Years 2-3, 2012-14)
- Extensive sampling of known or potential hotspots (Year 2)
- Intensive sampling of a few hotspots (Year 3)

Use results to establish warning levels and critical thresholds against which to assess change
Phase 1: Reference sites for contaminants and benthic invertebrates –

Historical data used to choose sites

Reference sites historically low in metals and PAHs
Phase 2: “Hotspot” sites for contaminants and benthic invertebrates (Oct 2012; Jun and Nov 2013)

Sites also selected based on historical data
Sediment Sampling

- Used grab sampler
- Grab split for invertebrates and contaminants (n=5-10/site/date)
- Top 5 cm used for contaminants, frozen
- Sieved using 0.5 mm mesh for invertebrates, preserved
Sediment Contaminants

- Samples analyzed for grain size and organic carbon
- Metals - aluminum, arsenic, cadmium, copper, chromium, iron, mercury, nickel, lead, rubidium, selenium, silver, strontium, thallium, vanadium, zinc (CCME guidelines exist for ones underlined; bolded ones previously monitored)
- Polyaromatic hydrocarbons (PAHs) – sediments analyzed for 16 priority compounds (CCME guidelines exist for 12)
- PCBs – 38 individual congeners, Oct, 2011 samples only (results not shown)
% Grain Size Composition of Inner and Outer Harbour Samples from 2011-2013

- Granules_Pebbles
- Coarse_Sand
- Fine_Medium_Sand
- Silt_Clay

Sampling Date and Site:
- Site 01: Aug 2011
- Site 02: Oct 2011
- Site 03: Apr 2012
- Site 04: Jun 2012
- Site 05: Oct 2012
Zinc in Sediments from the Inner Saint John Harbour

<table>
<thead>
<tr>
<th>Date</th>
<th>Site 01</th>
<th>Site 02</th>
<th>Site 03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug 2011</td>
<td>30 ± 10</td>
<td>40 ± 10</td>
<td>35 ± 10</td>
</tr>
<tr>
<td>Oct 2011</td>
<td>35 ± 10</td>
<td>45 ± 10</td>
<td>35 ± 10</td>
</tr>
<tr>
<td>Apr 2012</td>
<td>40 ± 10</td>
<td>50 ± 10</td>
<td>40 ± 10</td>
</tr>
<tr>
<td>Jun 2012</td>
<td>45 ± 10</td>
<td>55 ± 10</td>
<td>45 ± 10</td>
</tr>
</tbody>
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Historical range: 9 – 442 mg/kg
CCME ISQG = 124 mg/kg
Arsenic in Sediments from the Inner Harbour

Historical – 5.3 – 14.8 mg/kg
CCME ISQG = 7.24 mg/kg

Almost all outer harbour reference sites fall below CCME guideline
Total PAHs in Sediments from the Inner Harbour

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<th>Date</th>
<th>Site 01</th>
<th>Site 02</th>
<th>Site 03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug 2011</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Oct 2011</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Apr 2012</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Jun 2012</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Historical – 0 – 46.5 mg/kg

NOAA Guideline = 1.6 mg/kg
Arsenic in Sediments from the Inner Harbour – Proposed Threshold

3x SDp = 3.9-11.3 mg/kg-dw
Phase I – Summary of sediment contaminants at reference sites

- Metals concentrations typically well below guidelines (lead, cadmium, copper, zinc, mercury)
  - Arsenic exceeds ISQG at all inner harbour sites and one outer harbour site
  - Chromium exceeds ISQG mainly at inner harbour sites
  - Aluminum above NOAA guidelines at all sites
- Total PAHs also well below effects thresholds for all six dates
- Total PCBs ranged from 2.2 to 17.5 ng/g dw, many individual PCBs below detection limits (<0.2 ng/g), sites well below ISQG of 21.5 ng/g
What species do we find in grab samples?

- Polychaete worms most abundant at all sites
- Bivalves more common in outer than inner harbour
Seasonal Variation of Invertebrate Abundance at Reference Sites (2011-2012)

Abundance of organisms per 1/2 grab

- Site 1
- Site 2
- Site 3
- Site 4
- Site 6
- Site 13

Number of organisms per 1/2 grab

- August 2011
- October 2011
- April 2012
- June 2012

Sampling dates
Interannual Variation in Invertebrate Species Richness at Reference Sites (2011-2013)
Phase 1 - Summary of benthic invertebrate results

- Consistent differences in infaunal invertebrate community between inner and outer harbour.

- Seasonal variation observed at all sites.


- Low abundance in April and June but less variability.

- October considered to be best time to sample. Higher variability but higher abundance and richness.
Phase 2 – Contaminants and invertebrates in sediments at “hotspots”

- “Hotspots” selected using historical data
  - Characterized metals, PAHs, benthic macroinvertebrates
  - Assessed their variability over time
  - Sediments collected
    - 2012 – Oct at 3 sites
    - 2013 – June and Nov at 9 sites
Zinc in Sediments from the Inner Saint John Harbour

CCME PEL = 271 mg/kg-dw

CCME ISQG = 124 mg/kg-dw

SDp = 16.79-73.4 mg/kg-dw

Site 01
Site 02
Site 03
Site 14
Site 18
Site 19
Site 20
Site 21
Site 22
Site 23

“hotspots” reference
Phase II – Are the “hotspots” really hot?

Approaching threshold for PAHs

Copper above CCME ISQG

Lead, copper and zinc above CCME ISQG
Species Richness of Benthic Invertebrates
- Oct 2012

Species richness per 1/2 grab

Blue: Reference sites
Red: Potentially contaminated sites

Number of species (all taxa combined) per 1/2 grab

Sampling sites

1 2 3 4 6 13 14 15 16

Hotspot
Abundance of Benthic Invertebrates - Oct 2012

Abundance of organisms per 1/2 grab

Blue: Reference sites
Red: Potentially contaminated sites

Sampling sites

Hotspot
Phase II – “Hotspots” summary

- Metals concentrations typically well below guidelines
  - Exceptions copper, lead and zinc elevated at 1-2 sites
- Total PAHs mainly below effects thresholds but approaching thresholds at a few sites
- Abundance and richness of invertebrates low at one “hotspot” in Oct 2012 and Jun 2013
- More invertebrate analyses to be done for Jun and Nov 2013 to assess sediment contaminants and macroinvertebrates at 12 potential “hotspots”
Conclusions

• Little seasonal or interannual variability in sediment contaminants at reference sites (no best time to sample)

• Considerable seasonal and spatial variability in sediment macroinvertebrates
  – Inner harbour community different than outer harbour
  – Lower abundance and richness in April and June but less variability
  – Higher richness and abundance in Aug and Oct but more variability
  – October chosen as best time to sample

• Thresholds for contaminants tentatively set at 3 SD

• Thresholds for macroinvertebrate changes under discussion
How will research feed into design of the monitoring program

Current program will identify appropriate:

- Sampling sites
- Sampling times
- Methods (field, lab and data analyses)
- Triggers to identify changes of concern for invertebrate abundance and community composition, metals, PAHs, and sentinel species (invertebrate and “fish” populations)

Results are being regularly presented to end users
Data will provide baseline against which future changes can be assessed
Thank you