What’s in a Hazard Quotient?

Validating Ecological Risk Estimates at DFO Light Stations

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Agenda

- Background to DFO Maritimes and Gulf Region Assessment Program
- Ecological Risk Assessments (ERAs) at DFO sites
- Validation Study
  - Approach
  - Point Lepreau
  - Soil and soil invertebrates
  - Birds
  - Shrews
- Conclusions
DFO Site Assessment Program

- DFO owns over 1,000 properties in Maritimes and Gulf Region
- Prior to 2000, the extent of DFO’s potential environmental liabilities was not quantified
- ESA program was initiated in Fall of 2000, and has been ongoing annually, to respond to the need to quantify these potential liabilities
  - Phase I/II/III ESAs
  - Human health SSCs in 2007
  - ERA program initiated in 2010
DFO Site Assessment Program

### Common Environmental Issues

<table>
<thead>
<tr>
<th>Property Type</th>
<th>Lead-Based Paint</th>
<th>Mercury Baths</th>
<th>Discarded Batteries</th>
<th>Creosote Timbers</th>
<th>Fuel Storage</th>
<th>Burn Pits</th>
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</thead>
<tbody>
<tr>
<td>Light Stations</td>
<td>Lead and selected other metals</td>
<td>Mercury</td>
<td>Lead, Zinc</td>
<td></td>
<td>PHC</td>
<td>PAHs, metals</td>
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<td>Wooden Range Lights</td>
<td>Lead and selected other metals</td>
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<td>Lead, Zinc</td>
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<td>Small Craft Harbours</td>
<td>Lead and selected other metals</td>
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<td></td>
<td>PAHs</td>
<td>PHC</td>
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<tr>
<td>Mile Beacons and Skeletal Tower Range Lights</td>
<td>Lead and selected other metals</td>
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<td>Lead, Zinc</td>
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</table>
Until recently, potential ecological risks had not been directly addressed in Maritimes and Gulf Region.

In Fall 2010, an ERA program was initiated using a template and approach developed by a team of four consultants (Stantec, AMEC, CRA, Dillon) working with PWGSC.

Standard approach of benchmark comparisons and food chain models to calculate Ecological Hazard Quotients (EHQs).

Interpretation of risk, and need for remedial action, centered around EHQs >1
Elevated EHQs (>1) have been routinely predicted at sites ranging from larger light stations to small range lights.

These EHQs are interpreted in light of field observations and assumed conservatisms and uncertainties in the food chain models, including:

- Positive bias in the soil EPC due to sampling design
- Dietary assumptions
- Bioaccessibility
- Home range assumptions

Remedial action has yet to be recommended based on the ERA results.
Risk drivers in the ERAs are bird and mammal species that rely upon soil invertebrates, particularly earthworms, as a key component of their diet. Key components of the study include:

- Mist netting of songbirds and collection of blood and feather samples for laboratory analysis of lead;
- Trapping and dissection of shrews for laboratory analysis of liver, kidney, and femur;
- Collection of soil invertebrates including earthworms, slugs, and grasshoppers for laboratory analysis of metals;
- Grid-based soil sampling to determine representative exposure point concentrations (EPCs); and
- Habitat surveys and field observations on foraging preferences.
Point Lepreau Light Station

- Maces Bay, Saint John County, NB
- Antimony, arsenic, beryllium, chromium, copper, lead, selenium, thallium, and zinc exceed the CCME Commercial SQGs.
- Exceedances of the CCME SQG were most frequently encountered for lead.
- The highest soil metal concentrations are associated with the location of current or former buildings.
- EHQs >1 for American robin and masked shrew.
- Discounted based on bias in the soil EPC, limited area of impact, and bioaccessibility assumptions.
- No remedial action recommended.
Soil Sampling Approach
Collection of a cross-section of soil invertebrates that comprise the diet of invertivorous birds and mammals.

Pathway included in standard food chain models
Pathway ignored in standard food chain models
Mist Netting

- After 8 days of effort, 8 individual birds which were suitable surrogates, had been captured at the Point Lepreau light station.

- Six blood samples and seven feather samples were collected.

- No birds were captured at a reference location due to time constraints (Fall migration).

- Species sampled:
  - Common yellow throat warbler
  - Hermit thrush
  - Savannah sparrow
  - Song sparrow
Shrew Sampling

- Shrews were captured using snap traps in a grid pattern where the traps were set 10 m apart for a total of 80 traps.

- The work required five nights of surveying to capture 10 Shrews from Point Lepreau.

- Traps were set at the reference site until 5 Shrews were captured.

- Collected mammals were identified to genus and sent to RPC where they were weighed, measured for length, sexed, dissected and liver, kidney and bone (femur) samples were analysed separately for lead concentration.
Soil Sampling Results

- EPC can be calculated by:
  - Sampling of contaminant sources (biased high)
  - Site-wide grid (biased low?)
  - Habitat preferences and foraging ranges
Soil Sampling Results

- Range of soil lead EPCs
  - 4,520 mg/kg based on Phased ESA data (used in original ERA)
  - 150 – 3860 mg/kg based on habitat areas
  - 326 mg/kg based on site wide grid

- Significant uncertainty and range in possible soil EPCs
  - This value drives the food chain model and over-estimation here causes a knock-on effect in all ROC risk estimates.
Soil Invertebrate Sampling Results

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<tr>
<th></th>
<th>Point Lepreau</th>
<th>Reference Site</th>
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<tr>
<td>Worms</td>
<td>1000</td>
<td>1000</td>
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<tr>
<td>Slugs</td>
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<td>10</td>
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<tr>
<td>Grasshoppers</td>
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<td>0.01</td>
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## Avian Blood/Feather Sampling Results

<table>
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<tr>
<th>Sample ID</th>
<th>Date Sampled</th>
<th>RL</th>
<th>Blood (µg/mL)</th>
<th>Benchmark (µg/mL)</th>
<th>Benchmark (mg/kg)</th>
<th>Feather (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL-COYE-5</td>
<td>19-Aug-13</td>
<td>0.005</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.349</td>
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<tr>
<td>PL-HETH-3</td>
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<td>0.007</td>
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<tr>
<td>PL-SAVS-4</td>
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<td>0.015</td>
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<td>5</td>
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<td>PL-SAVS-6</td>
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<td>PL-SOSP-1</td>
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<td>0.055</td>
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<td>PL-SOSP-2</td>
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</table>

**Notes:**
- COYE – common yellow throat warbler
- HETH – Hermit thrush
- SAVS – Savannah sparrow
- SOSP – Song Sparrow
## Shrew Tissue Sampling Results

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Lead Concentrations (mg/kg)</th>
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<tr>
<td></td>
<td>Kidney</td>
<td>Bone</td>
<td>Liver</td>
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<tr>
<td>PL-Shrew-1</td>
<td>0.716</td>
<td>4.15</td>
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<td>PL-Shrew-2</td>
<td>31.5</td>
<td>83.5</td>
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<td>PL-Shrew-3</td>
<td>52.1</td>
<td>90.7</td>
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<tr>
<td>PL-Shrew-4</td>
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<td>PL-Shrew-5</td>
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<td>675</td>
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<td>PL-Shrew-9</td>
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<td>LR-Shrew-3</td>
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<td>LR6-Shrew-5</td>
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<td>0.92</td>
<td>0.063</td>
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</tr>
</tbody>
</table>
Shrew Morphology Results

Mean and SEM of Weight

Mean and SEM Total Length

Mean and SEM Tail Length

Mean and SEM Hind Foot Length
Conclusions

- Use of soil data from investigations designed to characterize contaminant sources (e.g., the light tower) are likely to significantly bias ERA results high.
- Food chain models based solely on earthworm uptake and ingestion will significantly overestimate contaminant uptake in an invertivore diet.
- ERAs conducted at DFO light stations in Maritimes and Gulf Region have likely overestimated potential risks.
- Biological effects to avian receptors at light station sites are unlikely.
- Biological effects to insectivorous small mammals are uncertain
  - Lead accumulation in kidney and femur
  - No morphological effects
  - No qualitative difference in abundance