Potential use for fish and fish habitat modelling in assessments of a changing Huron-Erie Corridor

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Funding Support: CCIAP & IJC
Fish & Fish Habitat Modelling Examples

- Static Weighted Suitable Area Assessments by Fish Guild of Climate Change-Induced Habitat Changes
- Deterministic Long-term Trends in Population Dynamics based on Water Level Fluctuations
- Short-term Spatially Explicit Trends in First Year Dynamics for Select Fish Species
Fish Habitat Supply Model Layers

<table>
<thead>
<tr>
<th>DM_ZVEGSUB_UNQ</th>
<th>SUM_AREA(m2)</th>
<th>DepthRange</th>
<th>VegDensity_DM</th>
<th>Substrate_DM</th>
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<tbody>
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<td>480006.0</td>
<td>1-2</td>
<td>0.0,100</td>
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<tr>
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<td>0-1</td>
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## Lake St. Clair - Water Level Scenarios

<table>
<thead>
<tr>
<th></th>
<th>BASE CASE</th>
<th>WARM &amp; DRY</th>
<th>NOT-AS Warm &amp; Dry</th>
<th>WARM &amp; WET</th>
<th>NOT-AS Warm &amp; Wet</th>
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<tbody>
<tr>
<td><strong>LAKE STATISTICS</strong></td>
<td></td>
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</tr>
<tr>
<td>Mean</td>
<td>175.38</td>
<td>174.40</td>
<td>174.75</td>
<td>174.57</td>
<td>175.18</td>
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<tr>
<td>Maximum</td>
<td>176.11</td>
<td>175.12</td>
<td>175.43</td>
<td>175.36</td>
<td>175.95</td>
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<tr>
<td>Minimum</td>
<td>174.38</td>
<td>173.37</td>
<td>173.72</td>
<td>173.46</td>
<td>174.05</td>
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<tr>
<td>Annual Range</td>
<td>1.73</td>
<td>1.75</td>
<td>1.71</td>
<td>1.90</td>
<td>1.90</td>
</tr>
<tr>
<td><strong>CHANGE FROM BASE CASE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Annual</td>
<td>-0.98</td>
<td>-0.63</td>
<td>-0.81</td>
<td>-0.20</td>
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</tr>
<tr>
<td>Winter</td>
<td>-0.95</td>
<td>-0.62</td>
<td>-0.81</td>
<td>-0.21</td>
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<tr>
<td>Spring</td>
<td>-0.98</td>
<td>-0.61</td>
<td>-0.77</td>
<td>-0.16</td>
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<tr>
<td>Summer</td>
<td>-1.01</td>
<td>-0.64</td>
<td>-0.80</td>
<td>-0.20</td>
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<tr>
<td>Autumn</td>
<td>-1.01</td>
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<td>-0.87</td>
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<td>Growing Season</td>
<td>-1.00</td>
<td>-0.63</td>
<td>-0.78</td>
<td>-0.18</td>
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</tbody>
</table>

Source: David Fay & Yin Fan, Environment Canada
Lake St. Clair “What-if” Scenario

- 1.57 m (IGLD85) water level decline
- 8 m dredged channel
- Shoreline displacement from 0.5 to 6 km

Source: Lee et al, 1994
Average ice-free water depths for Mitchell’s Bay: High Water Historic (1978) and Climate Change Predictions
Average ice-free water depths for Mitchell’s Bay: Low Water Historic (1964) and Climate Change Predictions
<table>
<thead>
<tr>
<th>GCM</th>
<th>Surface Temp (°C)</th>
<th>Overlake Precipitation (mm)</th>
<th>Ice Cover %</th>
<th>Humidity (mb)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base Case</strong></td>
<td><strong>T 10.7</strong></td>
<td><strong>P 803</strong></td>
<td><strong>I 35.5%</strong></td>
<td><strong>H 10.7</strong></td>
</tr>
<tr>
<td>CGCM2 A21 Warm &amp; Dry</td>
<td>T +3.0</td>
<td>P 0</td>
<td>I -11%</td>
<td>H +2.9</td>
</tr>
<tr>
<td>CGCM2 B23 Not so Warm-Dry</td>
<td>T +2.1</td>
<td>P -37</td>
<td>I -7%</td>
<td>H +2.1</td>
</tr>
<tr>
<td>HadCM 3 A1FI Warm &amp; Wet</td>
<td>T +3.2</td>
<td>P +37</td>
<td>I -12%</td>
<td>H +2.1</td>
</tr>
<tr>
<td>HadCM 3 B22 Not so Warm-Wet</td>
<td>T +2.7</td>
<td>P +110</td>
<td>I -11%</td>
<td>H +2.1</td>
</tr>
</tbody>
</table>

Summary of average annual predictions for Lake St. Clair under four climate change scenarios (from Croley 2004)
Average weekly temperature predictions for Lake St. Clair: Historic and Extreme Climate Change (from Croley 2004)
<table>
<thead>
<tr>
<th></th>
<th>Cool</th>
<th>Warm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Piscivore</td>
<td>white sucker, Iowa darter, banded killifish, brook silverside, striped shiner, shorthead redhorse, round goby, river chub, golden shiner, pugnose shiner, emerald shiner, blackchin shiner, spottail shiner, yellow perch</td>
<td>rock bass, black bullhead, yellow bullhead, brown bullhead, freshwater drum, goldfish*, goldfish, quillback, common carp, gizzard shad, lake chubsucker, channel catfish, bigmouth buffalo, green sunfish, pumpkinseed, orangespotted sunfish, bluegill, spotted sucker, ghost shiner, mimic shiner, tadpole madtom, white crappie, bluntnose minnow, black crappie, central mudminnow</td>
</tr>
<tr>
<td>Piscivore</td>
<td>longnose gar, northern pike, walleye</td>
<td>bowfin, smallmouth bass, largemouth bass, muskellunge, white perch*, white bass</td>
</tr>
<tr>
<td>Non-Piscivore</td>
<td>trout-perch</td>
<td></td>
</tr>
</tbody>
</table>

**Locations:**
Mitchell’s Bay (Lake St. Clair), St. Clair National Wildlife Area, Canard River (Detroit River), Holiday Beach (West Lake Erie)
Wetland Species at Risk in HEC

- **Pugnose Shiner** *Endangered*
  - Notropis anogenus

- **Spotted Sucker** *Special Concern*
  - Minytrema melanops

- **Lake Chubsucker** *Threatened*
  - Orangespotted Sunfish
    - Lepomis humilis
  - Bigmouth Buffalo
    - Ictiobus cyprinellus

- **Mitchell’s Bay**
  - Special Concern

- **National Wildlife Area**
**Habitat Supply Model Results**

**Field Work:** Coastal wetland fish community sampled in 2003 barrier and open marshes

**Non-Piscivore (N)**
- troutperch

**Piscivore (P)**
- chinook salmon, brown trout
- longnose gar, northern pike, spotted gar, walleye
- bowfin, smallmouth bass, largemouth bass, white bass

**Climate Change Scenario:**
- **Baseline** is 2m, 100 ha wetland with mixed vegetation and fine substrates
- **Effect** is 1m water level drop with same habitat (i.e. gradual change)

**Spawning Habitat**
- Warm: N 100 ha
- Cool: P 50

**YOY Habitat**
- Warm: N 100 ha
- Cool: P 50

**Adult Habitat**
- Warm: N 100 ha
- Cool: P 50
<table>
<thead>
<tr>
<th>Year</th>
<th>Historical water level (m) Mar-Nov (average)</th>
<th>Climate change water level (Historical -0.8m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>174.42</td>
<td>173.66</td>
</tr>
<tr>
<td>1964</td>
<td>173.66</td>
<td>172.86</td>
</tr>
</tbody>
</table>
### Long Point Fish Guilds in Habitat Supply Model

#### Piscivore

<table>
<thead>
<tr>
<th>Non-Piscivore</th>
<th>Cool</th>
<th>Warm</th>
</tr>
</thead>
<tbody>
<tr>
<td>white sucker, johnny darter, banded killifish, brook silverside, golden shiner, pugnose shiner, emerald shiner, blackchin shiner, blacknose shiner, spottail shiner, yellow perch, logperch</td>
<td>rock bass, black bullhead, yellow bullhead, brown bullhead, freshwater drum, quillback, gizzard shad, pumpkinseed, bluegill, mimic shiner, tadpole madtom, pugnose minnow, bluntnose minnow, black crappie, warmouth central mudminnow, carp, goldfish</td>
<td></td>
</tr>
<tr>
<td>northern pike, spotted gar, longnose gar</td>
<td>bowfin, largemouth bass</td>
<td></td>
</tr>
</tbody>
</table>

#### Non-Piscivore (N)

<table>
<thead>
<tr>
<th>Potential Invaders (Mandruk 1989)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cool</td>
</tr>
<tr>
<td>ironcolour shiner</td>
</tr>
</tbody>
</table>

#### Piscivore (P)

<table>
<thead>
<tr>
<th>Shortnose gar</th>
</tr>
</thead>
</table>
Long Point Nearshore Temperature Variability

Climate Change Predictions: +2.1 °C to +3.3 °C
Information generated by Burlington / IJC Study

Fish Submodels supplied to IERM

Integrated Environment & Shared Vision Models

GIS

Database & Habitat Models

Habitat Supply

Water Levels & Temperature Time Series (H&H)

Vegetation Community Changes

Habitat Layers

Regulation Scenarios

Field Work

Wetland Temperatures

Larval Fish

Vegetation Submodel

Refine Model components / Validate Output

Vegetation Submodel

Criteria & Performance Indicators

Fish, Wildlife & Habitat Submodels

Refine Model

components / Validate Output

Test Sensitivity / Refine Performance Indicators

SVM

IERM

Fish Guild Habitat Supply

8 guilds + 2 SAR fish spp

Fish Population Dynamics

4 fish populations

Fish Guild Habitat Supply
Habitat Suitability Modelling

Buffer shoreline types to depth contour → Map habitat combinations → Model suitabilities for different life stages, species & guilds

- Wetland/Veg
- Substrate
- Depth/Elevation
- Temperature
Weighted Suitable Area

Lower Spawn Temp

Upper Spawn Temp

Lower Growth Temp

Upper Growth Temp

Annual Cycle

Temperature

Annual Cycle

Juv/Ad start (growth T)

Juv/Ad end (growth T)

YOY start (mid-spawn T)

YOY end (growth T)

WSA Excluded (both YOY & Juv/Ad)

Daily time series

Weighted Suitable Area

Lower Spawn Temp

Upper Spawn Temp

Lower Growth Temp

Upper Growth Temp

Adults

Egg

Hatch (yolk sac)

Swim-up (exogenous feeding pre-50mm stage)

YOY (50mm; end season)

Juveniles
Fish population densities in Presqu’ile Bay, Lake Ontario - Regulated and unregulated conditions

Largemouth Bass

Smallmouth Bass

Fish density (fish/ha)

Regulated
Unregulated
Next Steps & Potential Hypotheses

- Good spatial information for assessment, especially digital elevation models & dynamic substrate, but add other important variables (turbidity & flow)
- Location of high quality fish habitat under climate change in HEC and important transition areas for protection
- Assessment of likely development changes & strategies and their effects on fish & fish habitat
- Whole fish community & fish population assessments, both spatial and temporal to test extremes