THE MAINE RIVERS FISH ASSEMBLAGE ASSESSMENT: APPLICATION TO THE PRESUMPSCOT RIVER IN 2006

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Three Linked Projects:

3. Regional EMAP – New England rivers assessment (2008-9); part based on NRSA probabilistic sites draw.
Maine Rivers Fish Assemblage Assessment:
Development of an Index of Biotic Integrity for Non-wadeable Rivers


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Why Knowledge of the Fish Assemblage is Important

Current Issues:

- We used to say this just about Maine, but it applies to the rest of New England.

- Naturally Depauperate Fauna - cold water, coastal drainages - “how will these respond?”

- Assess Potential Conflicts with High Profile Restoration Goals - do non-native species pose an unintentional deterrent?
Kennebec River (2002–6)
- Wyman Dam to Merrymeeting Bay (30 sites, 2 test areas)
- Follow-up Waterville to Augusta (2002–6)

Androscoggin River (2003)
- Errol, NH to Merrymeeting Bay (51 sites)

Sebasticook River (2003)
- Douglas Pond to Winslow (9 sites)

- N. Br. To Hamden (40 sites); included W. Br., E. Br., 5 additional tributaries

Northern Maine Rivers (2005–6)
- St. John (14 sites), Allagash (8 sites), Aroostook (10 sites), St. Croix (12 sites)

Southern Maine Rivers (2006)
- Presumpscot R. (22 sites)
- Saco R. (32 sites)

Miscellaneous Maine Rivers (2007)
- Mattawamkeag R., Rapid R., Moose R., Moosehead Outlets, Dead R., E. Br. Penobscot (22 sites)
Sampling Methods

Standardized Approach:

- Pulsed D.C. boat electrofishing - effort indexed to distance
- Electrode array customized for Maine river conditions
- Intensive survey design - mainstem & non-wadeable tribs.
- Field water quality and habitat data
- July - September index period
• Sampling guided by a QAPP

• Standardized sampling to yield comparable data

• All representative habitat types within each site

• Geo-referenced sample site location and sample track

• Fish are identified to species, enumerated, and weighed

• DELT anomalies recorded
Logistics: Getting the Right Equipment to a Site
Key First Task - Understand Current Distribution of Riverine Fish Species:
Maine Rivers Fish Distribution Atlas
Cold Water Species: Non-Salmonids (Indigenous Natives)

- Common white sucker (adult life stage)
- Lake chub
- Slimy sculpin
- Burbot
Maine Rivers Fish Assemblage Assessment: 2002-7

Elevation Gradient
Introduced Species

Smallmouth bass (adult life stage)  
(Introduced Naturalized c. 1870)
Maine Rivers Fish Assemblage Assessment: 2002-7

Physical barriers

Elevation Gradient

Thermal?
This parallels similar observations in Maine lakes.
Detailed autecology of known and potential species – 60 species recorded thus far in Maine's rivers
Tiered Aquatic Life Use Conceptual Model: Draft Biological Tiers

(10/22 draft)

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The Biological Condition Gradient:
A conceptual model for interpreting detrimental change in aquatic ecosystems

Susan P. Davies and Susan K. Jackson
(Ecological Applications 16:4, 2006)

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LOW ——— Human Disturbance Gradient ——— HIGH

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Natural structural, functional, and taxonomic integrity is preserved.

Structure and function similar to natural community with some additional taxa & biomass; no or incidental anomalies; sensitive non-native taxa may be present; ecosystem level functions are fully maintained.

Tiered Aquatic Life Use Conceptual Model: Draft Biological Tiers

(10/22 draft)
Development of tools & methods to ascertain the status of native riverine fish assemblages is a major goal of this project.
Cold Water Assemblages

The “assumed baseline” for the Biological Condition Gradient applicable to Maine’s large rivers
Condition of the Biotic Community

Native inland freshwater & diadromous species (Atlantic salmon, alewife, American shad, American eel, brook trout, native cyprinids, white & longnose sucker)

Some native diadromous species are reduced in abundance; shifts towards intermediate tolerances and mesotherms; brook trout are reduced or replaced by non-native naturalized salmonid species.

Native diadromous species are rare or absent; tolerant species predominate and may become numerous (enrichment); species richness reduced in some cases.

Native diadromous species are absent or if present by interventions; some native cyprinids are absent, replaced by tolerant and moderately tolerant species;

Same as tier 1 except: non-native salmonid species with naturalized populations may co-occur with brook trout.

Some native diadromous species are rare or absent; moderately tolerant species predominate; brook trout are absent; non-native mesotherms & eurytherms present; anomalies present.

Native diadromous species are absent or if present by interventions; some native cyprinids are absent, replaced by tolerant and moderately tolerant species;

Same as tier 1 except: non-native salmonid species with naturalized populations may co-occur with brook trout.

brook trout are absent; non-native salmonids are non-reproducing; non-native eurytherms usually predominate; anomalies present.

Native diadromous species rare or absent; tolerant species predominate and may become numerous (enrichment); species richness reduced in some cases.

(toxic impacts); non-native eurytherms predominate; anomalies frequent.

LOW ——— Human Disturbance Gradient ———> HIGH
Guidelines for Deriving Regionally Relevant "IBI Type" Assessment Tools

- Karr et al. (1986) provides guidance for metric development, substitution, and modification. Requires detailed knowledge of the regional fauna including life history, taxonomy, zoogeography, and natural history.

- Requires an extensive database from consistent sampling of both reference condition and a gradient of human disturbance. Requires extensive testing of candidate metrics and aggregate indices.

- Process has been refined and "better quantified" by Hughes et al. (1998) and most recently by Whittier et al. (2007)

We retained the conceptual approach of Karr - making this "too mechanical" may have unintended consequences.

The primary project goal is the development of a fish IBI tailored to the Maine fish assemblage.
“Unique” Character of the Riverine Fish Fauna of Maine

- Post-glacial ingress defined “baseline” fauna
- Maine Rivers “constrained” to Gulf of Maine.
- One brief connection to St. Lawrence & none to Connecticut & western river basins.
- Several “warmwater” species common to this latitude in other regions are not indigenous (blackbass, pike, muskellunge, crappie).
### “Traditional” IBI vs. Interim Maine IBI

**“Traditional IBI Metrics:**
1. Native species richness
2. Darter Species
3. Sucker Species
4. Sunfish Species
5. %Intolerant species
6. %Tolerant species
7. %Omnivores
8. %Insectivores
9. %Top carnivores
10. %Hybrids
11. %Diseased individuals
12. Number of individuals

**Interim Maine IBI Metrics:**
1. Indigenous species richness
2. Native cyprinids (less fallfish)
3. %Adult white/longnose biomass
4. %Blackbass
5. %Fluvial specialist/dependent
6. %Macrohabitat generalists
7. %Benthic insectivores
8. Temperature stenotherms
9. %Native salmonids
10. Non-guarding lithophils
11. %DELT anomalies
12. Non-indigenous species

*Metrics in white are “positive” * metrics in red are “negative”
## Interim Maine Rivers IBI Metrics & Scoring

<table>
<thead>
<tr>
<th>Metric</th>
<th>Scoring Equation</th>
<th>Scoring Adjustments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Species Richness</td>
<td>10 * (-0.2462 + (0.0828*numspec2))</td>
<td>Score = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Score = 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;3 sp.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;15 sp.</td>
</tr>
<tr>
<td>Native Cyprinid Species (excluding fallfish)</td>
<td>(10 * (0.4457 + (0.0109*allcyp_ff) - (0.00005629 * (allcyp_ff^2))))</td>
<td>Eq</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eq</td>
</tr>
<tr>
<td>Adult white &amp; longnose sucker biomass</td>
<td>(10 * (0.3667 + (0.008*ws_ins_pb) - (0.000023592 * (ws_ins_pb^2))))</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;128 kg/km</td>
</tr>
<tr>
<td>%Native Salmonids</td>
<td>(10 * (0.9537 + (0.00000000039*nat_salm) - (0.000078892 * (nat_salm^2))))</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;20%</td>
</tr>
<tr>
<td>%Benthic Insectivores</td>
<td>10 * (0.010966*benth_pc_n)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;91.2%</td>
</tr>
<tr>
<td>%Blackbass</td>
<td>10 - (10 * (-0.09684 + (0.5638*log10(blackbass))))</td>
<td>Eq</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>%Fluvial Specialist/Dependent</td>
<td>(10 * (0.2775 + (0.0073*fluv_pc_n)))</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eq</td>
</tr>
<tr>
<td>%Macrohabitat Generalists</td>
<td>10 - (10 * (0.1017 + (0.0096*macro_gen)))</td>
<td>&gt;90%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eq</td>
</tr>
<tr>
<td>Temperate Stenothermic Species</td>
<td>(10 * (0.7154 + (0.4047*(log10(steno)))))</td>
<td>0 sp.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;5 sp.</td>
</tr>
<tr>
<td>Non-guarding Lithophilic Species</td>
<td>(10 * (0.2979 + (0.8975*log10(lith_ng))))</td>
<td>&lt;1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;10</td>
</tr>
<tr>
<td>Non-indigenous Species</td>
<td>10 - (10 * (0.1063 + (0.3271<em>Non-indigenous_sp) - (0.029</em>(Non-indigenous_sp^2))))</td>
<td>&gt;5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>%DELT Anomalies</td>
<td>10 - (10 * (0.8965 + (0.1074*log10(delta))))</td>
<td>Eq</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

1 No scoring adjustments are necessary; scoring determined by equation (Eq) across entire metric scoring range of 0-10.
Presumpscot River Study Area:
Aug.– Sept. 2006
May 2007
19 mainstem sites
3 tributary sites

Figure 2. The Presumpscot River study area in 2006 and 2007. Open symbols represent 2006 sampling locations; closed circles represent 2007 sampling locations. Major waterbodies and interstate highways are shown.
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<td>22</td>
</tr>
</tbody>
</table>
- 28 fish species; 23 indigenous, 5 non-indigenous
- American eel most numerous (numbers & biomass)
- Median 7 species/site (4-15)
- Average 199 fish/km; 18.9 kg/km
- Tribs. produced more fish (523/km)
- Macrohabitat generalists > fluvial dependent/specialist species
## Qualitative Habitat Evaluation Index Field Sheet

### 1) Substrate
(Check ONLY Two Substrate TYPE BOXES, Estimate % percent)

<table>
<thead>
<tr>
<th>TYPE</th>
<th>POOL</th>
<th>RIFFLE</th>
<th>POOL</th>
<th>RIFFLE</th>
<th>SUBSTRATE ORIGIN</th>
<th>SUBSTRATE QUALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>-BLDR/SILBS [10]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-LG BOULD [10]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-BOULDER [9]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-COSIBLE [6]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-HARDPAN [4]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-MUCK [2]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Substrate Quality**

- SILT:   
  - SILT HEAVY [2]
- LIMESTONE [1]
- Silt [1]
- TILLS [1]
- Silt Moderate [4]
- SILT NORMAL [2]
- SILT MODERATE [1]
- SILT FREE [1]

**Embeddedness**

- Extensive [2]

**Max 20**

**Number of Substrate Types:**

- 4 or More [2]
- 3 or Less [4]

(High Quality Only, Score 5 or >)

**COMMENTS:**

### 2) Instream Cover
(Give each cover type a score of 0 to 3; see back for instructions)

- UNDERCUT BANKS [1]
- POOLS > 70 cm [2]
- OXBOWS, BACKWATERS [1]
- OVERHANGING VEGETATION [1]
- SHALLOWS (IN SLOW WATER) [1]
-ishments [1]

**AMOUNT:** (Check ONLY one or check 2 and AVERAGE)

- Extensive > 75% [1]
- Moderate 25 - 75% [7]
- Sparse 5 - 25% [8]
- NEARLY ABSENT < 5% [1]

**Max 20**

**COMMENTS:**

### 3) Channel Morphology
(Check ONLY one PER Category OR check 2 and AVERAGE)

<table>
<thead>
<tr>
<th>SINUOSITY</th>
<th>DEVELOPMENT</th>
<th>CHANNELIZATION</th>
<th>STABILITY</th>
<th>MODIFICATIONS / OTHER</th>
<th>MODIFICATIONS / OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>-IMPOUNDED [1]</td>
<td></td>
<td>-ONE SIDE CHANNEL MODIFICATIONS</td>
<td></td>
</tr>
</tbody>
</table>

**COMMENTS:**

### 4) Riparian Zone and Bank Erosion
(check ONE box PER bank or check 2 and AVERAGE per bank)

**Riparian Width**

<table>
<thead>
<tr>
<th>L/R (Per Bank)</th>
<th>L/R (Most Predominant Per Bank)</th>
<th>L/R (Concentration Tillage)</th>
<th>L/R (Fenced Pasture)</th>
<th>L/R (Mining)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VERY WIDE &gt; 100m [5]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WIDE &gt; 50m [4]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODERATE 10 - 50m [3]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NARROW 5 - 10m [3]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VERY NARROW &lt; 5m [1]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NONE [0]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**COMMENTS:**
### Table 5. QHEI matrix showing good and modified attributes at fish sampling locations in the Presumpscot River study area, 2006.

<table>
<thead>
<tr>
<th>River Mile</th>
<th>QHEI</th>
<th>Gradient (ft/mile)</th>
<th>Good Attributes</th>
<th>Modified Attributes</th>
<th>Total Modified Attributes</th>
<th>Modified: Good Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.1</td>
<td>87.0</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>20.6</td>
<td>68.5</td>
<td>0.00</td>
<td>[filled squares]</td>
<td>[filled squares]</td>
<td>[filled squares]</td>
<td>4.00</td>
</tr>
<tr>
<td>19.9</td>
<td>87.0</td>
<td>0.00</td>
<td></td>
<td>[filled squares]</td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>19.1</td>
<td>52.5</td>
<td>0.00</td>
<td></td>
<td>[filled squares]</td>
<td></td>
<td>3.75</td>
</tr>
<tr>
<td>18.8</td>
<td>54.0</td>
<td>0.00</td>
<td></td>
<td>[filled squares]</td>
<td></td>
<td>1.50</td>
</tr>
<tr>
<td>18.1</td>
<td>90.0</td>
<td>0.00</td>
<td></td>
<td>[filled squares]</td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>15.0</td>
<td>55.0</td>
<td>0.00</td>
<td></td>
<td>[filled squares]</td>
<td></td>
<td>4.00</td>
</tr>
<tr>
<td>14.9</td>
<td>88.0</td>
<td>0.00</td>
<td></td>
<td>[filled squares]</td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>12.6</td>
<td>81.5</td>
<td>0.00</td>
<td></td>
<td>[filled squares]</td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>8.6</td>
<td>63.0</td>
<td>0.00</td>
<td></td>
<td>[filled squares]</td>
<td></td>
<td>4.00</td>
</tr>
<tr>
<td>7.6</td>
<td>66.0</td>
<td>0.00</td>
<td></td>
<td>[filled squares]</td>
<td></td>
<td>2.00</td>
</tr>
<tr>
<td>6.3</td>
<td>74.0</td>
<td>0.00</td>
<td></td>
<td>[filled squares]</td>
<td></td>
<td>1.11</td>
</tr>
<tr>
<td>5.5</td>
<td>52.0</td>
<td>0.00</td>
<td></td>
<td>[filled squares]</td>
<td></td>
<td>3.75</td>
</tr>
<tr>
<td>3.7</td>
<td>41.5</td>
<td>0.00</td>
<td></td>
<td>[filled squares]</td>
<td></td>
<td>2.67</td>
</tr>
</tbody>
</table>
QHEI: Number of Good Attributes

Riverine Impounded
Total Number of Species

Riverine - Species Richness

Impounded - Species Richness
INDEX OF Biotic Integrity (IBI)

Riverine - IBI

Impounded - IBI
Expectation for riverine fish assemblage

Riverine - %Macro-habitat Generalists

Impounded - %Macro-habitat Generalists
- Major wastewater discharges: Westbrook WWTP – 4.5 MGD; SAPPI – 12.5 MGD process, 12 MGD cooling.
- Visual evidence of impacts beyond permit terms & conditions
- Suspected organic enrichment & possibly thermal impacts in lower mainstem
- Maine DEP cumulative effects assessment targeted in part to this finding
Diadromous restoration rivers - are key BCG attributes missing?
Current Improvements to the Interim Maine Rivers IBI

- Diadromous species are not included except indirectly via other metrics.
- Developed a set of diadromous metrics that include: #diadromous species; log rel. no. American eel; log rel. no. Clupeidae; log rel. no. Diadromous fish.
- Additive to “core” IBI - does not “penalize” rivers that do not have diadromous fish.
- Continuing data collection in lower Kennebec & Sebasticook R.
Presumpscot River Fish Assemblage Conclusions

- Fish assemblage reflects hydromodifications (impoundment & flow).
- Few sites attain BCG tier IV (minimum CWA goal).
- Anadromous species restricted to lower 7-8 miles of mainstem.
- Localized areas of “pollution” impacts - need to perform stressor diagnosis.
- Intensity of hydromodification “overwhelms” riverine characteristics - will not be resolved by fish passage alone.