The Lower Kennebec River, Maine 2002-2019: Fish Assemblage and Habitat Responses to Dam Removal and Diadromous Fish Management

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Chris O. Yoder and John Dattilo
Center for Applied Bioassessment and Biocriteria
Midwest Biodiversity Institute
Columbus, OH

Kennebec River @Sidney, ME
Kennebec River (2002–19)
- Wyman Dam to Merrymeeting Bay (30 sites, 2 test areas)
- Follow-up Waterville to Augusta (2002–19)

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

Sebasticook River (2003; 2008–15)
- 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., 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 tribhs.
- Field water quality and habitat data
- July 1 – September 30 index period
Gulf of Maine Watershed
**“Unique” Character of Maine Riverine Fish Assemblages**

- Post-glacial ingress produced the “baseline” fish fauna
- Maine Rivers “constrained” to Gulf of Maine.
- One brief connection to St. Lawrence & none to Connecticut & western river basins.
Cold Water Species: Salmon and Trout

Landlocked salmon (Intracontinental Introduced)

Rainbow trout (Intercontinental Introduced)

Brook trout (Indigenous Native)

Brown trout (Intercontinental Introduced)
Cold Water Species: Non-Salmonids (Indigenous Natives)

- Common white sucker (adult life stage)
- Slimy sculpin
- Lake chub
- Burbot
Cold Water Species: Non-Salmonids (Indigenous Natives)

- Round Whitefish
- Longnose Sucker
- Blacknose Dace
- Longnose Dace
Widely Distributed Species: Cyprinidae

Fallfish (Indigenous Native)

Common shiner (Indigenous Native)

Creek chub

Fallfish

Common shiner (All Indigenous Native)

Golden shiner (Intraregional origin)
Non-native Warmwater Species

Green sunfish (Intracontinental origin)

Northern pike (Intracontinental origin)

Black crappie (Intracontinental origin)

Common carp (Intercontinental origin)
Several “warmwater” species common to this latitude in other regions are not indigenous (blackbass, pike, muskellunge, crappie).

Smallmouth bass (adult life stage) (Introduced Naturalized c. 1870)
“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. Temperate stenotherms
9. %Native salmonids
10. Non-guarding lithophils
11. %DELT anomalies
12. Non-indigenous species
Condition of the Biotic Community

[523x102]

Moderate-High Gradient Riverine Ecotype

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.

Human Disturbance Gradient

LOW —— Human Disturbance Gradient ———> HIGH

Biological Condition Gradient Conceptual Model: Maine Rivers

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

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

3. 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.

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

5. Native diadromous species are absent or if present by interventions; some native cyprinids are absent, replaced by tolerant and moderately tolerant species; brook trout are absent; non-native salmonids are non-reproducing; non-native eurytherms usually predominate; anomalies present.

6. 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.
“Positive” metric

“Negative” metric

Native Cyprinidae

Blackbass
## Scoring Adjustments

<table>
<thead>
<tr>
<th>Metric</th>
<th>Scoring Equation</th>
<th>Scoring Adjustments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Species Richness</td>
<td>$10 \times (-0.2462 + (0.0828 \times \text{numspec}^2))$</td>
<td>Score = 0: &lt;3 sp.</td>
</tr>
<tr>
<td></td>
<td>Score = 10: &gt;15 sp.</td>
<td></td>
</tr>
<tr>
<td>Native Cyprinid Species (excluding fallfish)</td>
<td>$(10 \times (0.4457 + (0.0109 \times \text{allcyp}<em>\text{ff}) - (0.00005629 \times \text{allcyp}</em>\text{ff}^2)))$</td>
<td>Eq$^1$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eq</td>
</tr>
<tr>
<td>Adult white &amp; longnose sucker biomass</td>
<td>$(10 \times (0.3667 + (0.008 \times \text{ws}<em>\text{Ins}</em>\text{pb}) - (0.000023592 \times \text{ws}<em>\text{Ins}</em>\text{pb}^2)))$</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;128 kg/km</td>
</tr>
<tr>
<td>%Native Salmonids</td>
<td>$(10 \times (0.9537 + (0.00000000039 \times \text{nat}<em>\text{salm}) - (0.000078892 \times \text{nat}</em>\text{salm}^2)))$</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;20%</td>
</tr>
<tr>
<td>%Benthic Insectivores</td>
<td>$10 \times (0.010966\times\text{benth}_\text{pc}_n)$</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;91.2%</td>
</tr>
<tr>
<td>%Blackbass</td>
<td>$10 - (10 \times (-0.09684 + (0.5638\times\log_{10}\text{blackbass})))$</td>
<td>Eq</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>%Fluvial Specialist/Dependent</td>
<td>$(10 \times (0.2775 + (0.0073\times\text{fluv}_\text{pc}_n)))$</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eq</td>
</tr>
<tr>
<td>%Macrohabitat Generalists</td>
<td>$10 - (10 \times (0.1017 + (0.0096\times\text{macro}_\text{gen})))$</td>
<td>&gt;90%</td>
</tr>
<tr>
<td>Temperate Stenothermic Species</td>
<td>$(10 \times (0.7154 + (0.4047\times\log_{10}\text{steno})))$</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>$(10 \times (0.2979 + (0.8975\times\log_{10}\text{lith}_\text{ng})))$</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;10</td>
</tr>
<tr>
<td>Non-indigenous Species</td>
<td>$10 - (10 \times (0.1063 + (0.3271\times\text{Non-indigenous}<em>\text{sp}) - (0.029\times(\text{Non-indigenous}</em>\text{sp}^2)))$</td>
<td>≥5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>%DELT Anomalies</td>
<td>$10 - (10 \times (0.8965 + (0.1074\times\log_{10}\text{delta})))$</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.
Initial post-Edwards Dam removal response
Fish Assemblages in New England Rivers are Heavily Influenced by Dams and Flow
NELR ME IBI Rankings:
- Lower Kennebec - 7th
- Upper Kennebec - 11th
(N = 36 NELR River Reaches)
Visual evidence of impoundment in the form of settled pulp logs from historic log drives (pre-1975) still linger near Sidney, ME ~nine miles upstream
Sequence of recovery from impoundment to riverine characteristics at Sidney, ME some nine (9) miles upstream.

1997 Pre-Removal (Impounded)
2007 Post-Removal (+7 years)
2012 Post-Removal (+12 years)
Exposed sediment layering is evidence of deposition at head end of impoundment.

Milled wood occurs under layers containing pulp logs from historic log drives (pre-1975).

Gravel bars and islands are reforming some 18 years later.

2018 Post-Removal (+18 years)
Habitat Quality 2002-18

QHEI

Pre-dam Removal

Excellent
Good
Fair
Poor
Very Poor

Year

Diadromous restoration rivers – are key BCG attributes missing?
Selected Diadromous Species

- River herring (Alewife, Blueback, Am. shad)
- American eel (Catadromous)
- Striped bass (Wide annual variations)
- Atlantic salmon (ESA listed in Maine)
Table 6b. Diadromous IBI metrics intended to represent the diadromous component of a riverine fish assemblage in Maine and New England expressed as the Diadromous IBI (DIBI). These are additive to the ME IBI in the NELR REMAP analyses.

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<tr>
<td>Diadromous Species Richness</td>
<td>Score = 0.0318 + 0.227*(Diadromous Species Richness)</td>
<td>Score = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥5 sp.</td>
</tr>
<tr>
<td>Number of American Eel</td>
<td>Score = 0.0689 + 0.2*(Log Eel Rel. No.) + 0.0616*(Log Eel Rel. No.)</td>
<td>0</td>
</tr>
<tr>
<td>Number of Clupeidae</td>
<td>Score = 0.832*Log10(Rel. No. Clupeids)^ (0.269)</td>
<td>0</td>
</tr>
<tr>
<td>Number of Diadromous Fish (all diadromous species)</td>
<td>Score = 0.0522 + 0.168*(Log(Diad Rel. No.) + 0.0644*(Log(Diad Rel. No.))</td>
<td>0</td>
</tr>
</tbody>
</table>
Adding the DIBI better detects rivers where diadromous species restoration has been at least partially successful.
The post-dam removal “bump” happened quickly followed by mostly BCG Level III performance in the DIBI.

The core ME IBI is mired in Levels IV-V due to the **permanent** influence of non-native species that now have thriving populations.
“River Herring”

- Alewife, blueback herring, and American shad
- Anadromous life history
- Occur in our samples as outmigrating y-o-y
- Most abundant in lower Kennebec R. – limited by dams
- Extensive restoration efforts underway

For Alewife, improving access to lakes & ponds – restoring connectivity – is a major management objective.
Alewife y-o-y numbers rapidly increased after the Ft. Halifax dam removal, but seem to have declined after 2014.

Size differences above reflect from which pond they originated.
Recent periods of extended low flows in the fall months raise the issue of outmigrating Alewife becoming delayed "stranded" – any adverse effects would be seen in reduced return of adults and outmigrating y-o-y in 4-5 years (2021-22).
Conclusions & Next Steps

- Post-impoundment recovery evident in DIBI and selected diadromous species abundances.
- “Core” IBI has reached its “zenith of recovery”, i.e., permanent influence of introduced warmwater species.
- Need to “be there” during out migration of Clupeids – one week (even one day) can make a difference.
- Is anyone else looking at the assemblage response?
- We finally have a database “customer” – Dr. Adrian Jordaan, UMass Amherst funded by TU and TNC - Joint Species Distribution Model (JSDM).
Many thanks to the volunteer field crew members from Maine DMR!

So, you didn’t think we can catch big fish ... ?