Dams & What Eel Alleles Reveal, & Whether it's Real

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NYSDEC Glass Eel Monitoring

As of 2017, 750 volunteers caught 550,000 eels!
Status
Glass Eel Fishing
“Cold River Cash”

& Operation “Broken Glass”
Other Fisheries
Eels vs. Dams: Coming & Going

Going

How Migrating American Eels are Killed at Hydro Electric Dams

- Water intake for Hydro Dam Turbine
- River flow through turbine intake

- Hydro Dam Turbine
- Eels chopped by turbine blades

- Migrating American eels (3-4 feet long and yong and progeny)

- Eels vs. Dams: Coming & Going

- Going
Bronx River Dams

1. 182nd Street Dam
2. Twin Dams
3. Snuff Mill Dam
4. Bronxville Dam
5. Old Stone Mill Dam
6. Hodgman Dam
Coming

Three ways past:
Over, Through, Around
<table>
<thead>
<tr>
<th>Time</th>
<th>Flow (cfs)</th>
<th>Total Rainfall (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00 EST</td>
<td>23</td>
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<td>0.93</td>
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<td>0.93</td>
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<td>14:00 EST</td>
<td>391</td>
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<td>14:15 EST</td>
<td>586</td>
<td>0.93</td>
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<tr>
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<tr>
<td>14:45 EST</td>
<td>801</td>
<td>0.93</td>
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<tr>
<td>15:00 EST</td>
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<tr>
<td>15:15 EST</td>
<td>891</td>
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<tr>
<td>15:30 EST</td>
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</tr>
<tr>
<td>15:45 EST</td>
<td>919</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Median daily statistic (10 years) - Period of approved data

Discharge
Assisting Eels
Surveying Using Electrofishing
Handling & Processing
Urban Waters
Electrofishing 2014-2017

• 1023 eels captured electrofishing
• 320 tagged (length cutoff 250 mm)
• 48 recaptured
  • Only 1 recapture moved between river reaches
Statistical Approach

- 2- or 3-pass depletion
- Huggins Robust Design, by site
- Capture probability equal among occasions
- Recapture probability 0 within occasions
- Biomass = wt for mean length (Fishbase) x site abundance ÷ area
- Density = abundance ÷ area
Length (mm)
Density

![Bar chart showing density of sites](image)
Biomass (g) – area corrected
Ancillary Study - Mopping Eels

<table>
<thead>
<tr>
<th>Site</th>
<th>Glass eels</th>
<th>Elvers</th>
<th>Yellow eels</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>182nd Street</td>
<td>115</td>
<td>136</td>
<td>70</td>
<td>321</td>
</tr>
<tr>
<td>Twin Dams</td>
<td>0</td>
<td>5</td>
<td>23</td>
<td>28</td>
</tr>
</tbody>
</table>
Distributional Conclusions

• 1) Glass eels do not make it past 1st dam, some elvers do
• 2) Eels get larger as you head upstream, with a big jump past the 2\textsuperscript{nd} dam
• 3) Few eel <250 mm are present past the 2\textsuperscript{nd} dam
• 4) Eel abundance stabilizes past the 2\textsuperscript{nd} dam
• 5) Biomass appears to be relatively consistent among sites
Distributional Conclusions - continued

6) Dams in the Bronx River appear *partially* limiting.
7) Eels appear to remain within their river segments and largely in place.
8) Question raised: are upriver individuals large because of length of journey or lack of competition?
9) Eel ladders on other dams wouldn’t hurt.
10) We don’t know how size and abundance vary in an undammed system!
Environmental DNA Sampling
“Counting without contact”

Eel eDNA
There’s DNA in the water?

- Sloughed cells from skin or gut
- Injuries
- Decomposing tissue
- Digested tissue
- Gametes

- Can we use this DNA to identify and count organisms?
eDNA Surveys – 4 steps

1. Collection
2. Filtration
3. Extraction
4. Assay
eDNA assays: 2 major methods

- **Extracted DNA**
  - **Metabarcoding**
    - Detects broad range of species with single primer set
    - Returns list of sequences
    - Much more data
    - Much more labor and cost
  - **Quantitative PCR (qPCR)**
    - Single species assay
    - Reports quantity of target sequence present
    - 1 dimensional data
    - Much faster
American eels in the Bronx River

• Can we detect *Anguilla rostrata* in the Bronx River using eDNA?

• If so, is there a relationship between eDNA quantity and eel abundance or biomass?
  • Doi found both for *Plecoglossus altivelis*

Collection

- November 13\textsuperscript{th}, 2015
- **10 sites** along the length of the Bronx River
- **4 \times 1L water samples** from each site
  - Sterile Nalgene bottles
  - Across whole width of river
- **Stored** at -20\textdegree C
Filtration

• **Captures** particles larger than 0.45 μm on a filter disc
  • “Free floating” DNA
  • Cells
  • Dirt
  • Algae
• **Concentrates DNA** containing substrate
• **Slows degradation** of DNA if dry enough
• Filters can be stored on desiccant for weeks or frozen indefinitely
DNA extraction

- Lyses cells
- Removes debris and contaminants
- Produces 100μL of extract per sample
DNA extraction
qPCR

• Custom *Anguilla rostrata* specific primer and probe set

• Target is 112 bp fragment of the mitochondrial cytochrome b gene
qPCR Results

- Raw qPCR machine outputs
- We can detect American eels with eDNA
qPCR Results

All measured eDNA quantities

- Collection Site: 182nd St, Bronx Zoo, NYBG, Bronxville, Old Stone Mill, Hodgman, Strathmore, Popham, Haubold's, Park Homes

- eDNA quantities (ng):
  - Y-axis: 1e-05, 1e-02, 1e+01

Map of locations:
- Park Homes Road
- Haubold's
- Popham Road Dam, Strathmore Dam
- Old Stone Mill, Hodgman Dam
- Bronxville, NYBG, Bronx Zoo, 182nd St
qPCR Results

Median eDNA Quantities

<table>
<thead>
<tr>
<th>Location</th>
<th>eDNA Quantity (ng)</th>
</tr>
</thead>
<tbody>
<tr>
<td>182nd St</td>
<td>4e-04</td>
</tr>
<tr>
<td>Bronx Zoo</td>
<td>2e-04</td>
</tr>
<tr>
<td>NYBG</td>
<td>3e-04</td>
</tr>
<tr>
<td>Bronxville</td>
<td>2e-04</td>
</tr>
<tr>
<td>Old Stone Mill</td>
<td>1e-04</td>
</tr>
<tr>
<td>Hodgman</td>
<td>1e-04</td>
</tr>
<tr>
<td>Strathmore</td>
<td>4e-04</td>
</tr>
<tr>
<td>Popham</td>
<td>0e+00</td>
</tr>
<tr>
<td>Haubold's</td>
<td>0e+00</td>
</tr>
<tr>
<td>Park Homes Rd</td>
<td>0e+00</td>
</tr>
</tbody>
</table>

Map showing locations: NYBG, Hodgman Dam, Strathmore Dam, Old Stone Mill, Bronxville, Nyack, Park Homes Road.
qPCR and Electrofishing Compared

- Abundance and biomass **oppose** each other
- **Fewer** eels upriver, but much **larger**
qPCR and Electrofishing Compared

- eDNA quantity seems to follow abundance
eDNA Quantity vs Eel Biomass

- Correlation: -0.3276
- p = 0.4732

- No relationship between eDNA and eel biomass
eDNA Quantity vs Eel Abundance

- Correlation: 0.9776
- \( p = 1.411 \times 10^{-4} \)

- Without 182\(^{\text{nd}}\) St:
  - Corr: 0.8287
  - \( p = 0.04147 \)

- Eel eDNA tightly correlated with eel abundance
Discrepancies

• eDNA follows abundance, but not perfectly
  • NYBG and Hodgman have low abundances, but medium eDNA levels

• Possible causes:
  • Water samples and electrofishing were not concurrent
  • Point sample vs years of data

• Electrofishing is more effective in some types of habitat structure than others

• Spatial and temporal resolution of eDNA is lower than electrofishing
  • DNA signal detected within a sampling site includes DNA from upriver too
  • This is good and bad
Why does eDNA follow abundance rather than biomass?

- Small eels must be releasing more DNA
  - Maruyama, et al (2014) found DNA release rates varied by maturity in captive populations of sunfish
    - Smaller fish released more per unit body weight, but adults released more per individual
  - Higher surface to volume ratio
  - Higher metabolism and throughput of materials
Where Next?

- Run comparisons for DNA captured concurrently with electrofishing
- Reinforce with metabarcoding results
- Extend to habitats and questions where electrofishing isn’t as practical
Fish species identified in Bronx River sites using traditional sampling (Rachlin et al. 2007) versus eDNA

<table>
<thead>
<tr>
<th>Species</th>
<th>Common name</th>
<th>2007 survey</th>
<th>eDNA</th>
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</thead>
<tbody>
<tr>
<td><em>Ameirus natalis</em></td>
<td>Yellow bullhead</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td><em>Ameirus nebulosus</em></td>
<td>Brown bullhead</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><em>Anguilla rostrata</em></td>
<td>American eel</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><em>Apetes quadracus</em></td>
<td>Fourspine stickleback</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><em>Carassius auratus</em></td>
<td>goldfish</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td><em>Catastomus commersonii</em></td>
<td>white sucker</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><em>Cyprinus carpio</em></td>
<td>common carp</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td><em>Esox sp.</em></td>
<td>pickerel</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td><em>Etheostoma sp.</em></td>
<td>darter</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><em>Fundulus diaphanus</em></td>
<td>banded killifish</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><em>Fundulus heteroclitus</em></td>
<td>mummichog</td>
<td></td>
<td>x</td>
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<tr>
<td><em>Gambusia affinis</em></td>
<td>mosquitofish</td>
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<td><em>Ictalurus sp.</em></td>
<td>catfish</td>
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<tr>
<td><em>Leoponias auritus</em></td>
<td>redbreast sunfish</td>
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<td>x</td>
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<tr>
<td><em>Leoponias gibbosus</em></td>
<td>pumpkinseed</td>
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<td>x</td>
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<tr>
<td><em>Leoponias macrochirus</em></td>
<td>bluegill</td>
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<td>x</td>
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<tr>
<td><em>Luxilus cornutus</em></td>
<td>common shiner</td>
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<td>x</td>
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<td><em>Micropterus dolomieu</em></td>
<td>smallmouth bass</td>
<td></td>
<td>x</td>
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<tr>
<td><em>Micropterus salmoides</em></td>
<td>largemouth bass</td>
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<td>x</td>
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<tr>
<td><em>Morone americana</em></td>
<td>white perch</td>
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<td>x</td>
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<tr>
<td><em>Morone chrysops</em></td>
<td>white bass</td>
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<td>x</td>
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<tr>
<td><em>Moxostoma sp.</em></td>
<td>redhorse</td>
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<tr>
<td><em>Notemigonus crysoleucus</em></td>
<td>golden shiner</td>
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<td><em>Notropis hudsonius</em></td>
<td>spottail shiner</td>
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<td><em>Perca flavescens</em></td>
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<td>x</td>
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<td><em>Pimnaphales promelas</em></td>
<td>fathead minnow</td>
<td>x</td>
<td>x</td>
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<td><em>Rhinichthys atratulus</em></td>
<td>blacknose dace</td>
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<td>x</td>
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<tr>
<td><em>Salmo trutta</em></td>
<td>brown trout</td>
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<td>x</td>
</tr>
<tr>
<td><em>Semotilus atromaculatus</em></td>
<td>creek chub</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>
So, Is it Real?

False Negatives

lower Sensitivity higher

higher Stringency lower

False Positives