Preliminary Observations on the Effects of Using Clam Shells for Acid Rain Mitigation in Maine Salmon Streams

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Acidity Sources in Maine Streams

- High Dissolved Organic Carbon (DOC)
- High carbon dioxide
- Dilution of alkalinity during high flows
- Bedrock geology, slow weathering & nutrient poor

- 100 years of acid rain
- Recent partial recovery due to Clean Air Act (1970) (1990)
- 200 years of forest harvests
- Recovery (regrowth) of forests
Acid Rain (etc.) Is Inhibiting Salmon Recovery in Eastern Maine

• These rivers are: Narraguagus, Pleasant, Machias, East Machias & Denny’s Rivers
• Terry Haines reported “self-sustaining populations” of Atlantic salmon in 1984, these are long gone
• Today, we stock millions of hatchery fish each year and get few returns
Why Use Shells?

• SHARE is liming streams with shells as a calcium carbonate source
• Our purpose is to restore salmon, brook trout and other species
• This is an ecosystem approach that should result in greater biodiversity and improved ecosystem integrity
Bowles Brook with mahogany clam shells
## Dead Stream Lab Chemistry Results 2012

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>Flow Type</th>
<th>Relative Depth</th>
<th>ANC  ueq/L</th>
<th>pH</th>
<th>Ca mg/L</th>
<th>Al x ug/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead Stream Upstream</td>
<td>6/19/12</td>
<td>Baseflow</td>
<td>Low</td>
<td>119</td>
<td>5.99</td>
<td>1.99</td>
<td>20</td>
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<tr>
<td>Dead Stream Downstream</td>
<td>6/19/12</td>
<td>Baseflow</td>
<td>Low</td>
<td>277</td>
<td>7.02</td>
<td>3.06</td>
<td>9</td>
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<tr>
<td>Dead Stream Farther Downstream</td>
<td>6/19/12</td>
<td>Baseflow</td>
<td>Low</td>
<td>162</td>
<td>6.71</td>
<td>2.13</td>
<td>21</td>
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<tr>
<td>Dead Stream Upstream</td>
<td>8/27/12</td>
<td>Baseflow</td>
<td>Low</td>
<td>161</td>
<td>6.03</td>
<td>3.14</td>
<td>36</td>
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<tr>
<td>Dead Stream Downstream</td>
<td>8/27/12</td>
<td>Baseflow</td>
<td>Low</td>
<td>306</td>
<td>7.07</td>
<td>5.46</td>
<td>12</td>
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<tr>
<td>Dead Stream Farther Downstream</td>
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<td>Baseflow</td>
<td>Low</td>
<td>299</td>
<td>6.99</td>
<td>3.81</td>
<td>9</td>
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<tr>
<td>Dead Stream Upstream</td>
<td>10/11/12</td>
<td>Storm flow</td>
<td>High</td>
<td>84</td>
<td>5.55</td>
<td>2.67</td>
<td>31</td>
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<tr>
<td>Dead Stream Downstream</td>
<td>10/11/12</td>
<td>Storm flow</td>
<td>High</td>
<td>120</td>
<td>6.02</td>
<td>3.26</td>
<td>39</td>
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<tr>
<td>Dead Stream Farther Downstream</td>
<td>10/11/12</td>
<td>Storm flow</td>
<td>High</td>
<td>72</td>
<td>5.55</td>
<td>2.47</td>
<td>26</td>
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</tbody>
</table>

Lab data from U of Maine, Sawyer Environmental Chemistry & Research Lab
Dead Stream at the 55-00-0 Rd, Total Fish (All Species) per 100 m$^2$ Habitat Unit (Baseline Years = 2007-2010)

- All fish data from USFWS MFRO, Craig Brook Hatchery
First Lake Stream, Comparison of USFWS e-Fishing Results Before and After Shell Additions

Canaan Brook at 59-00-0 Rd, USFWS e-Fishing Results Before and After Shells Were Added

Fish data from USFWS MFRO, Craig Brook Hatchery
Dead Stream at 55000 Rd Below Shells, Shells Were Added in August of 2010

Number of Inverts. per Rock Bag

- Mayflies
- Stoneflies
- Caddisflies

<table>
<thead>
<tr>
<th>Date</th>
<th>Mayflies</th>
<th>Stoneflies</th>
<th>Caddisflies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov. 9, 2009</td>
<td>5</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Oct. 28, 2010</td>
<td>15</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Sept. 27, 2011</td>
<td>25</td>
<td>30</td>
<td>15</td>
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<tr>
<td>Oct. 28, 2013</td>
<td>40</td>
<td>45</td>
<td>30</td>
</tr>
</tbody>
</table>
Dead Stream at 58000 Rd, Farther Below Shells, Shells Were Added in August 2010

![Bar Chart]

- **Number of Inverts, per Rock Bag**

- **Categories**:
  - Mayflies
  - Stoneflies
  - Caddisflies

The chart shows a significant increase in the number of caddisflies, with a peak on Oct. 28, 2013.
## Leafpack Decomposition Using Exponential Decay Model (k = slope)

<table>
<thead>
<tr>
<th></th>
<th>- k</th>
<th>% loss/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead - Not Treated (fast)</td>
<td>0.012</td>
<td>1.16</td>
</tr>
<tr>
<td>Dead - Not Treated (slow)</td>
<td>0.006</td>
<td>0.62</td>
</tr>
<tr>
<td>Dead - Treated (fast)</td>
<td>0.020</td>
<td>2.02</td>
</tr>
<tr>
<td>Dead - Treated (slow)</td>
<td>0.017</td>
<td>1.73</td>
</tr>
<tr>
<td>Honeymoon - Not Treated (fast)</td>
<td>0.012</td>
<td>1.25</td>
</tr>
<tr>
<td>Honeymoon - Not Treated (slow)</td>
<td>0.011</td>
<td>1.09</td>
</tr>
</tbody>
</table>

* k values are signif different at p=0.024 df=4 for treatment and non-treatment sites
Summary

- These streams appear to be impaired
- Treatments have improved water chemistry, esp. baseflows
- Fish, microbes and macroinvertebrates have benefitted
- Detrital food chains appear to have improved
- But we need better high flow treatment
- Many more streams need help
Dead Stream pH Records Above and Below Shells with Depth in Meters
Raw Fish Counts from Dead Stream E-Fishing, Baseline Years are 2007 - 2010, Reach Length was Standardized to 200 m in 2010. Salmon were Stocked at 3,000 in Reach in 2010-2013.

Data provided by USFWS MFRO.
FIGURE 3.—Relation between limestone dosing factor and pH for West Virginia streams. The dosing factor is multiplied by the watershed area (ha) of the stream to estimate the amount of limestone needed (metric tons) to neutralize the acidity. Treatment amounts in the initial year should be twice the annual amount needed.
Figure 4: Liming activities within the project.
Maine DEP Salmon Rivers pH vs ANC

Small decreases in species richness *
Losses of acid-sensitive species *
Losses of additional fish/invertebrates *
Metals are soluble and extremely toxic, even trout do not survive *

* Baker et al 1990, Adirondacks
What Do Artificially Acidified Streams Look Like?

- Chronically or episodically acidic (below pH 6)
- Large swings in pH over short periods
- Impaired communities
- Low Ca (below 4 mg/L)
- Toxic levels of free ionic Al (above 25 μg/L)
- Characteristic fish gill pathologies and fish kills
- High P
- Low productivity (not P-limited)
- Specific indicator taxa are present or absent
- Loss of biodiversity, species and even Orders & sometimes Phyla may be missing