Reducing Acidification in Endangered Atlantic Salmon Habitat

First Year of Clam Shells

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Introduction

Despite restored access to historic Atlantic salmon (*Salmo salar*) habitat in eastern Maine, population sizes have remained low (USASAC 2019). Most Downeast rivers and streams have been identified as acidic (pH <6.5), with headwaters chronically acidic and main stems episodically acidic (Haines et al. 1990; Whiting and Otto 2008). Loss of fish populations due to acidification of surface waters has been well documented in the North Atlantic region (as reviewed by Clair and Hindar 2005; Dennis and Clair 2012). In addition, numerous studies have demonstrated that episodic exposure to low pH can have detrimental, sub-lethal impacts when coinciding with key salmon life stages during snow melt and spring runoff (e.g., Kroglund et al. 2008; Lacroix and Knox 2005; as reviewed by McCormick et al. 1998). Adding lime to acidic waters, through application of agricultural lime or lime slurry, has increased salmon populations in Scandinavia and Nova Scotia (as reviewed by Clair and Hindar 2005; Halfyard 2007; Hesthagen et al. 2011), and has been a recommended restoration action for Maine's acidic rivers and streams (NRC 2004). A 2009 Project SHARE pilot study investigating the efficacy of using clam shells to lime small streams suggested a trend towards improved habitat quality (Whiting 2014). For a more detailed project background, see Zimmermann (2018). To further investigate this mitigation method, the Downeast Salmon Federation (DSF) started a multi-year liming project in the East Machias River watershed in 2019. Clam shells are being spread along the stream bottom, as well as along the banks to capture high flow events (i.e., rainfall and snowmelt, when episodic acidity is expected). The project goal is to increase juvenile salmon abundance by application of clam shells to achieve a target pH, and to evaluate changes in the macroinvertebrate community. From 2017 through summer 2019, baseline data were collected (see Zimmermann 2019). In 2019, one dose of clam shells (10.6 metric tons) was spread along a treatment reach in Richardson Brook incrementally from July 25 through October 8. This report investigates any impacts from the first dose of shells on water quality.

Methods

Four tributary streams to the East Machias River were monitored (Fig. 1 and Appendix I Table 1). The East Machias River watershed is typical of coastal eastern Maine, with extensive wetlands resulting in colored waters high in organic materials and low pH, with high summer temperatures (Project SHARE-USFWS 2009). The existing salmon population in the East Machias River system is low (median large parr density 13.1 per habitat unit, $100m^2$), with 61 redds observed in 2019 and an estimated 1049 ± 186 parr exiting the system in 2018 (DSF data; USASAC 2019). In 2018, preliminary estimates show only 15 adults returned (Department of Marine Resources, MDMR). Richardson Brook and Creamer Brook are both stocked by DSF, and the average large parr density observed during fall electrofishing is 11 parr/$100m^2$ and 16 parr/$100m^2$ respectively (Fig. 2, MDMR data). The bedrock geology in the study area is predominantly marine sandstone and slate with some volcanic rocks, especially around Creamer Brook (see Appendix I Table 2 for stream characteristics; MGS 2017). Beaverdam Stream is stocked with 9-month old salmon parr by DSF and it has some of the most productive salmon habitat in the watershed, with an average of 14 parr/$100m^2$ (Fig. 2, MDMR data). Continuous monitoring devices provided water quality data every half hour that was supplemented by bi-monthly grab samples (Zimmermann 2018). Macroinvertebrate samples were collected at Beaverdam Stream and Creamer Brook using rock bags following the MEDEP protocol (2014) and by DSF staff at three locations using rock bags, following USEPA's Rapid Bioassessment

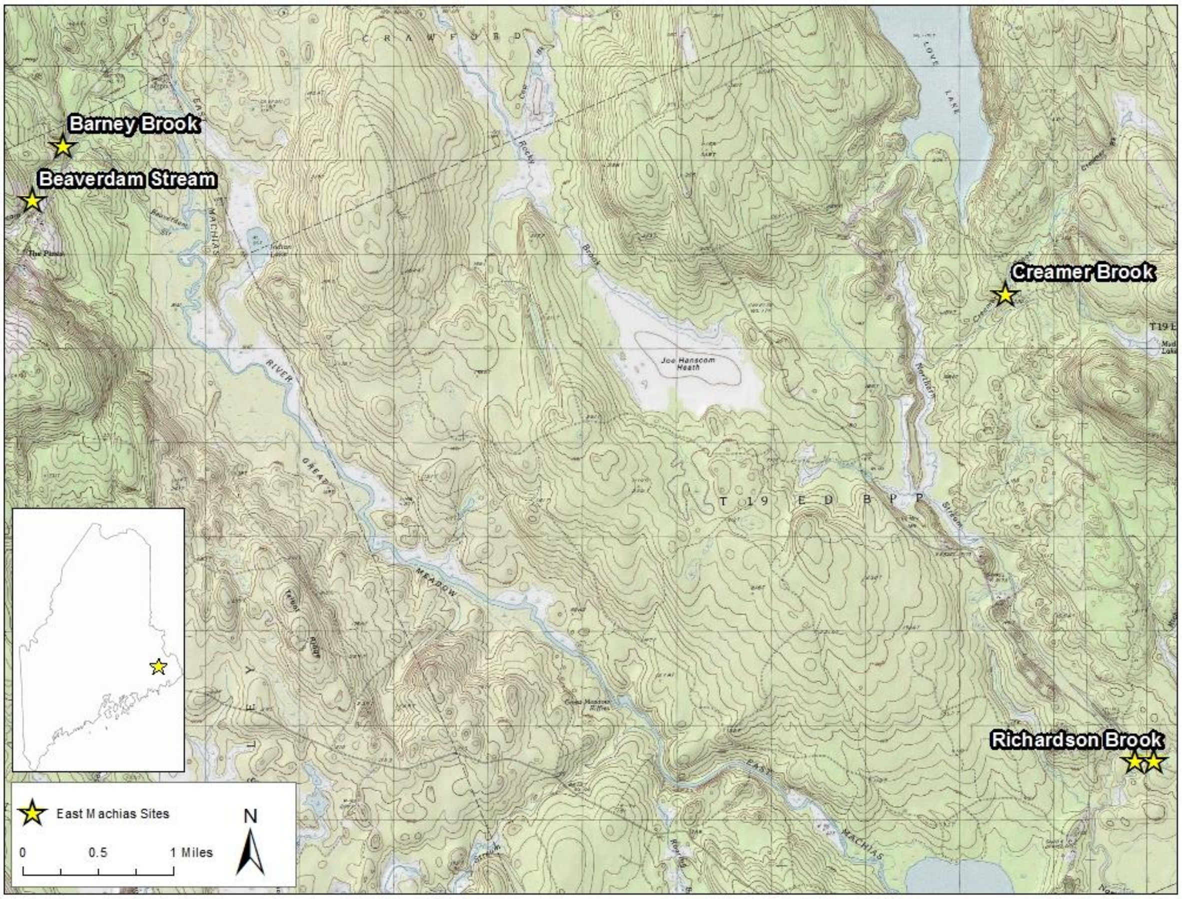

Figure 1. Map of the five study sites on four tributaries to the East Machias River. On Richardson Brook, samples were collected below the road crossing and 360m above the old upstream location, to remain above the shell treatment reach.

Protocol metrics (Barbour et al. 1999).

<u>Statistical Analysis</u>

Data were analyzed using R 3.5.2 (R Core Team 2018). Plots were created using *ggplot2* (Wickham 2009). All data are presented as mean ± standard deviation, unless otherwise stated. Non-parametric Kruskal-Wallis tests were used to compare grab sample results between sites and years, due to the small sample sizes, with Dunn's multiple comparison post-hoc tests. In 2019, 4.4% of pH data and 2% of specific conductance data were rejected due to quality control issues. 0.2% of dissolved oxygen data were rejected due to equipment malfunction.

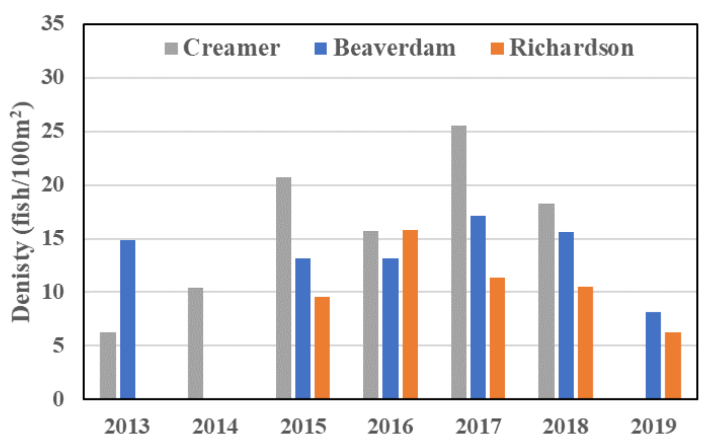

Figure 2. Salmon density in three of the study streams from 2013-2019. Data from MDMR electrofishing surveys. No data were collected in Creamer Brook in 2019 due to high flows.

Results and Discussion

Weather

Northern and Eastern Maine experienced a cold, record-setting wet spring in 2019, following a winter with deep and persistent snow pack (NOAA 2019a). The summer had above average temperatures and precipitation, following three dry, hot summers (Fig. 3, NOAA 2019b, Weather Underground 2019). In 2019, around 205 ± 86 mm more rainfall fell from May through July than in the two prior years, as smaller but more frequent storms (Figs. 3 and 4). November had the least rain in 2019 compared with the two prior years (Fig. 3).

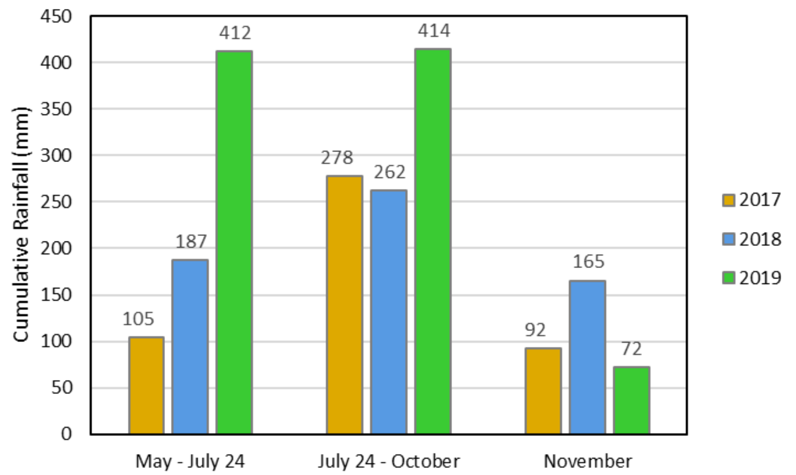

Figure 3. Cumulative rainfall during first three years of baseline study. Time periods are based on shell applications in 2019. Rainfall data from Weather Underground stations KMEALEXA2 and KMEBAILE9.

pH

Salmon prefer pH values that are circumneutral (i.e., higher), rather than acidic (i.e., lower). For the three years 2017-2019, 80 ± 5% of pH values remained above the threshold of 5.4, where no adverse impacts to salmon are expected (Fig. 4; Appendix II Tables 1 and 4; Haines et al. 1990; Stanley and Trial 1995, Zimmermann 2019).

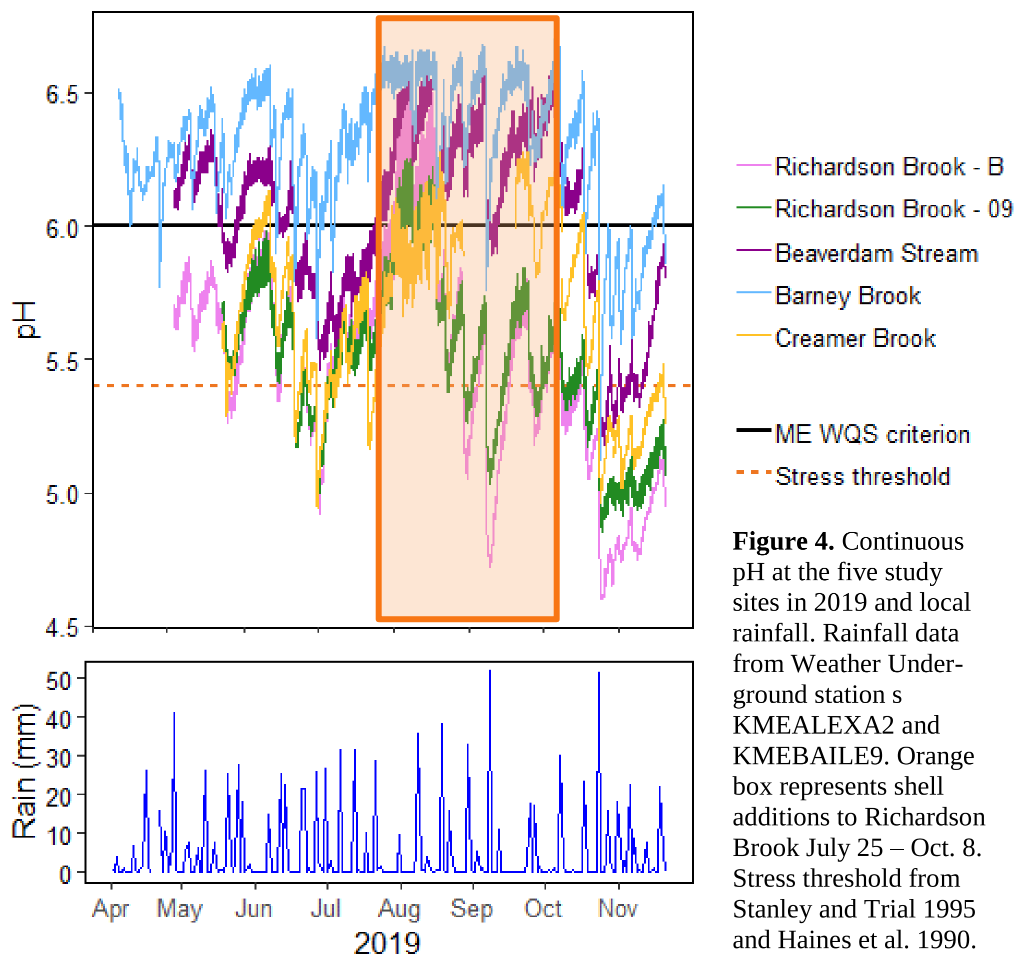

Figure 4. Continuous pH at the five study sites in 2019 and local rainfall. Rainfall data from Weather Underground station s KMEALEXA2 and KMEBAILE9. Orange box represents shell additions to Richardson Brook July 25 – Oct. 8. Stress threshold from Stanley and Trial 1995 and Haines et al. 1990.

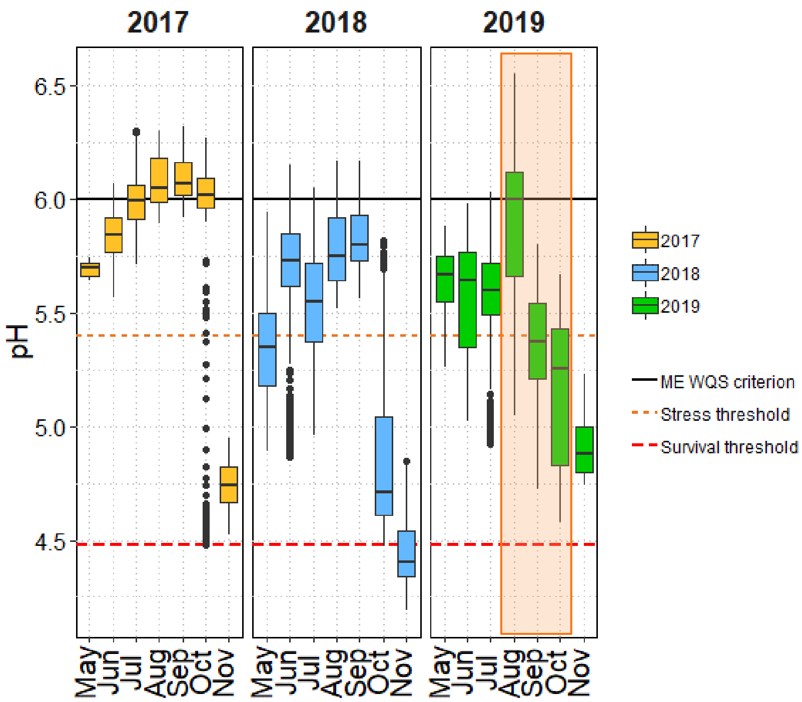

Figure 5. Monthly pH at the downstream Richardson Brook site (Rich-B). Each box represents the interquartile range, with the horizontal line representing the median, and whiskers extending to the minimum and maximum values observed, except where values are considered statistical outliers (dots). Stress threshold from Stanley and Trial 1995 and Haines et al. 1990. Survival threshold from Potter 1982. Orange box represents shell additions to Richardson Brook July 25 – Oct. 8, 2019.

pH remained above the state water quality criterion of 6.0 for 44 ± 9% of the period 2017-2019 (Appendix II Table 4 for 2019 data; 38 MRS Section 464.4.A.5). At all sites, pH was highest during the driest year (2017) when groundwater had a stronger influence on the study streams (e.g., Fig. 5). In 2019, rainfall-driven pH depression occurred primarily after rain events > 20 mm. The frequency of these events (every 9.7 ± 6.3 days; Fig. 4) often prevented full recovery to pre-storm pH levels, resulting in lower pH levels as the season progressed (Zimmermann 2019). However, pH never fell below the survival threshold of 4.48 in 2019 (Potter 1982). As seen in prior years, Barney Brook and Beaverdam Stream had the highest pH values, and the fastest recovery following rain events (Fig. 4).

At Richardson Brook's downstream site, pH values were similar between 2018 and 2019 prior to the addition of shells (Fig. 5 and Appendix II Table 6). Following the addition of one complete dose of shells, the mean pH in November was higher by 0.4 units compared to the prior two years (Fig. 5), however pH was also higher at the untreated upstream Richardson Brook site (Appendix II Table 6). In all three years, the downstream site experienced larger diel fluctuations and lower autumn pH values than the upstream site (Zimmermann 2019). Therefore, the higher pH observed in November 2019 was not due to the shells, but likely due to the lower amount of rainfall that month compared with the prior two years (Fig. 3). For all three years, pH values at Richardson Brook were below 5.4 for all of November, indicating that sub-lethal stress is likely still occurring despite one dose of shells being added to the study stream (Baker et al. 1996; Henriksen et al. 1984; Lacroix and Knox 2005; Magee et al. 2003).

<u>Stream Temperature</u>

Salmon prefer cold waters. For the three years 2017-2019, temperature remained below the threshold for optimal growth of 20°C for most of the sampling period (87 ± 3.4%; Fig. 6; Appendix II Table 1; USEPA 1986). The stress threshold of 22.5°C was exceeded only 3.5 ± 1.9% of the time (Elliott and Hurley 1997; Stanley and Trial 1995), USEPA's short-term maxima for survival of 23°C was exceeded 2.6 ± 1.6% of the time (USEPA 1986), and the maximum temperature for salmon survival of 27°C was exceeded only 0.1 ± 0.1% of the time (Stanley and Trial 1995; Appendix II Table 4). Maximum temperatures occurred primarily in July and

August. Despite a cold spring, 2019 was only slightly cooler than 2018 (3% >22.5°C in 2019 vs. 5.6% in 2018; Zimmermann 2019). Stressful temperatures lasted half as long in 2019, with maximum durations around 1.6 days. Nightly temperature refugia may allow recovery from thermal stress, however sub-lethal stress is likely occurring during these events.

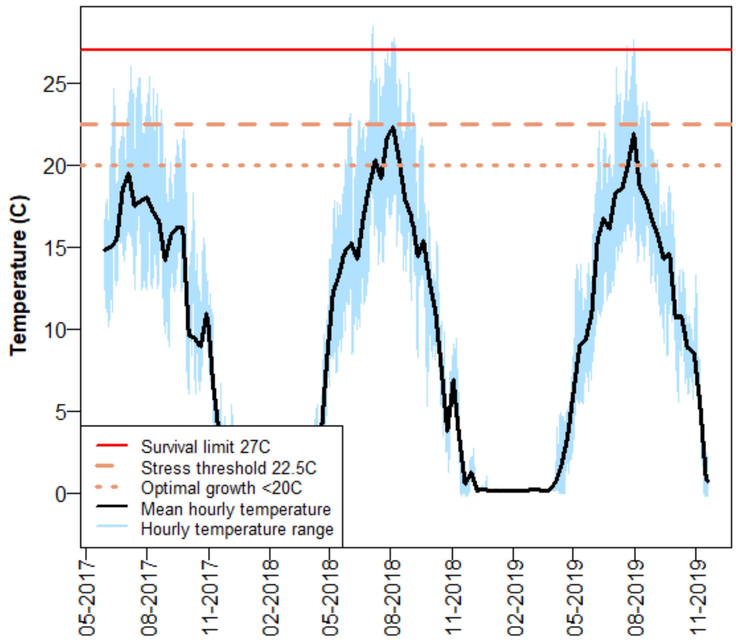

Figure 6. Mean hourly temperature across all study sites 2017-2019. Optimal growth limit from USEPA 1986. Stress and survival thresholds from Elliott and Hurley 1997 and Stanley and Trial 1995.

<u>Dissolved Oxygen (DO)</u>

Salmon prefer well oxygenated waters. For the three years 2017-2019, DO levels were within a healthy range for fish and aquatic life in addition to the preferred range for salmon of >6-7 mg/L for most (>90%) of the baseline period (Appendix II Tables 1 and 4; Stanley and Trial 1995; 38 MRS Section 465.2.B; USEPA 1986; Zimmermann 2019). Low DO only occurred during extreme low flows in 2017 and 2018 (Zimmermann 2019). In 2019, DO concentrations only fell below the Maine Water Quality Standard of 7 mg/L occurred at the upstream Richardson Brook site during the hottest, driest part of the summer and lasted for on average 8 hours, with a maximum of 15 hours (38 MRS Section 465.2.B). In 2019, DO concentrations remained above USEPA's threshold for acute impairment of 5 mg/L (USEPA 1986). DO was probably not a significant stressor in 2019.

<u>Acid Neutralization Capacity (ANC)</u>

Streams with higher ANC have higher buffering capacity against changes in acidity. For the three years 2017-2019, summer baseflow ANC remained above the threshold of acid sensitivity of 50 μeq/L (Fig. 7; Appendix II Table 2; Driscoll et al. 2001). However, as in 2018, ANC was below the Norwegian 20-30 μeq/L critical limit for salmon in samples following a spring rain-on-snow event (Baker et al. 1990; Lien et al. 1996; Kroglund et al. 2002; Zimmermann 2019). There were no significant differences between the upstream and downstream Richardson Brook sites (neither in 2019 nor across all three years of autumn sampling events), indicating the addition of clam shells had no significant impact on ANC (Appendix II, Table 6). No samples were above USEPA's recommended AWQC of 20 mg/L alkalinity, however this threshold doesn't apply where values are naturally lower (USEPA 1986). Barney Brook had the highest ANC (Fig. 7; chi-squared = 10.91, df = 4, p = 0.028), however it was only statistically higher than the upper Richardson Brook site (z = 2.94, p = 0.033). Relatively low ANC values indicate a deficit of buffering materials in the watershed due to thin soils (Potter 1982), allowing volatile swings in pH after rain inputs (Fig. 4) and increasing the potential for salmon mortality (MacAvoy and Bulger 1995). Due to low buffering capacity, any impacts from liming mitigation will be reversed quickly if mitigation ceases (Halfyard 2007).

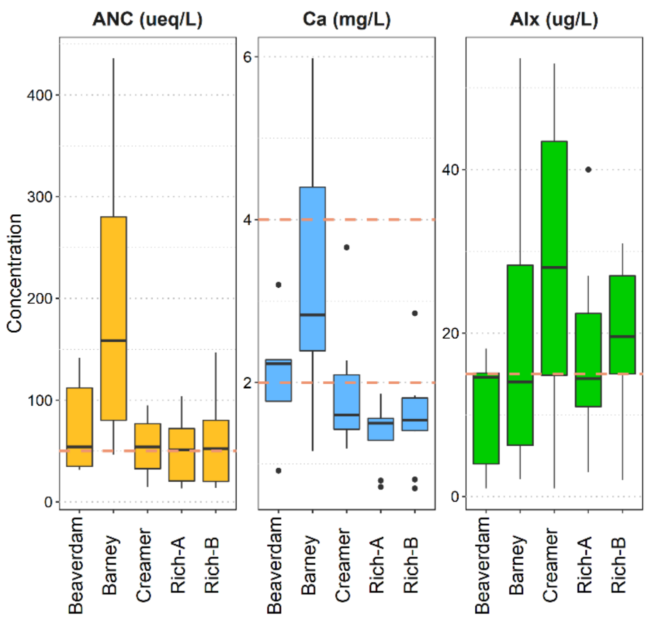

Figure 7. Acid neutralization capacity (ANC), calcium (Ca) and exchangeable aluminum (Alx) for 2017-2019. n = 9, except n = 7 for Creamer Brook and n = 6 for Beaverdam Stream. Each box represents the interquartile range, with the horizontal line representing the median, and whiskers extending to the minimum and maximum values observed, except where values are considered statistical outliers (dots). ANC stress threshold of <50 µeq/L from Driscoll et al. 2001. Calcium stress thresholds of <4 mg/L from M. Whiting (pers. comm.) and <2 mg/L from Baker et al. 1990 and Baldigo and Murdoch 2007. Alx stress threshold of >15 µg/L from EIFAC as cited in Dennis and Clair 2012.

Calcium

Higher calcium values enable more growth in fish. For the three years 2017-2019, calcium was below the survival threshold of 2 mg/L at all sites for most (69%) of the sample events and remained below 2 mg/L at every sample at the upstream Richardson Brook site (Fig. 7; Appendix II Tables 2 and 4; Baker et al. 1990; Baldigo and Murdoch 2007). Barney Brook had the highest calcium levels (chi-squared = 10.503, df = 4, p = 0.033) and was the only site with samples above the suggested threshold of 4 mg/L to prevent deformities (M. Whiting pers. comm.). The anticipated increase in calcium following the addition of clam shells was not observed at the downstream Richardson Brook site, compared with the upstream control site, with no significant differences between the two sites (neither in 2019 nor across all three years of autumn sampling events; Appendix II Table 6). In all three years, calcium minima coincided with low pH, high aluminum, and low ANC. The capacity of calcium to buffer against the detrimental impacts of exchangeable aluminum (Alx) decreases when calcium concentrations are below 1 mg/L at pH 6.5, and around 2 mg/L Ca when pH is <6.5 (Baldigo and Murdoch 2007; MacDonald et al. 1980, Wood et al. 1990). It is expected that some buffering of Alx is occurring in the study streams during summer baseflow, when calcium values are highest, but not during spring rain-on-snow events (Baker et al. 1990; Wood et al. 1990).

Aluminum

Average total aluminum per stream was similar to the two prior years, ranging from 149 to 232 µg/L in 2019 (Zimmermann 2019). Total aluminum was well below the Maine AWQC maximum of 750 µg/L which is based on a pH of 6.5-9 and dissolved organic carbon (DOC) <5 mg/L, significantly different from values observed in the study streams (Appendix II Tables 2 and 3; MDEP CMR Chapter 584). In 2019, total aluminum was mostly above USEPA's site-specific maximum criteria (CMC) which ranged from 14-990 µg/L depending on DOC, total hardness, and pH at each sample site (USEPA 2018). Aluminum exceedances seem to be linked to rainfall, as exceedances primarily occurred in 2018 following rain events, and there were more exceedances during rainy 2019. Organic aluminum was the dominant species, likely due to DOC concentrations, which can reduce the impact of aluminum toxicity (Appendix II Table 3; Lacroix and Kan 1986). Exchangeable aluminum (Alx) represented 7.7 ± 5.6% of aluminum species per sample, ranging from 0% to 17.9%, similar to observations in Nova Scotia (Lacroix and Kan 1986).

For protection of aquatic life, including macroinvertebrates, the European Inland Fisheries Advisory Commission (EIFAC) recommends that Alx should not exceed 15 µg/L at pH 5.0-6.0, even for short durations (Howells et al. 1990 as cited in Dennis and Clair 2012; Kroglund and Staurnes 1999; McCormick et al. 2009). All streams except for Beaverdam and Barney exceeded this criterion during summer baseflow when pH was relatively high (between 5.95 and 6.19), and therefore aluminum solubility (and toxicity) is reduced (Fig. 7; Appendix II Tables 3 and 4; Dennis and Clair 2012; Driscoll et al. 2001). Alx was highest in streams with the lowest buffering capacity and lowest pH. There were no significant differences between the upstream and downstream Richardson Brook sites (neither in 2019 nor across all three years of autumn sampling events), indicating the addition of clam shells had no significant impact on Alx (Appendix II Table 6). The abundance of acid-sensitive species decreases when Alx is >72 µg/L and pH is ≤5 (Driscoll et al. 2001), conditions not observed in the discrete samples collected in the three years of the study. The risk of salmon mortality in the study streams due to high Alx concentrations is unlikely (Baldigo and Murdoch 2007; Haines et al. 1990), however sub-lethal stress may decrease smolt tolerance to saltwater (Kroglund and Staurnes 1999; McCormick et al. 2009; Monette et al. 2008; Staurnes et al. 1995). Recovery from low pH/high Alx events can take up to 3 days in neutral waters (Kroglund and Staurnes 1999) and up to 3 weeks for early life stages (Wood et al. 1990). Based on the three years of this study, reduced salmon populations are expected at all streams except for Barney Brook due to Alx and pH (Kroglund et al. 2002).

Dissolved Organic Carbon (DOC)

Downeast streams, including those studied here, are naturally highly colored, with relatively high organic content (and therefore high DOC) due to wetlands and coniferous forests (Haines et al. 1990). For the three years 2017-2019, DOC ranged from 3.4 to 19 mg/L, with an average of 11.0 ± 3.6 mg/L (Appendix II Table 2). There were no significant differences between years across all sites, and no difference between the upstream and downstream Richardson Brook sites (neither in 2019 nor across all three years of autumn sampling events). A positive correlation between DOC and pH was observed in the spring and fall ($r = 3.19$, $R^2 = 0.64$, $p = 0.006$), indicating that low pH correlates with low DOC. This suggests that seasonal pH depressions are not driven by organic acids, but by anthropogenic acidification such as acid rain (Garmo et al. 2014). In contrast, the negative correlation between DOC and pH observed during base flows ($r = 3.7$, $R^2 = -0.66$, $p = 0.002$) suggests baseflow pH is driven by natural organic acids (Garmo et al. 2014). Above pH 5.5, and at DOC concentrations greater than 2.0-5.0 mg/L, DOC can buffer against the toxic impacts of Alx, by binding the aluminum into inert organic complexes (Baldigo and Murdoch 2007; Kroglund et al. 2008; Tipping et al. 1991). It is expected that some buffering of Alx is occurring in the study streams despite low pH values.

Base Cation Surplus

Base cation surplus (BCS) reduces the influence of natural acidity from DOC, to help distinguish the impacts of natural acidity versus anthropogenic acidification (Lawrence et al. 2007; Baldigo et al. 2009). BCS is the difference between the sum of cations (calcium, potassium, magnesium, and sodium) and anions (chloride, nitrate, sulfate, and strong organic anions as defined as 0.071*DOC-2.1; Lawrence et al. 2007). The threshold for aluminum mobilization occurs at a BCS around 0, regardless of DOC values. Over two sampling events (July and Nov. 2019), BCS ranged from -2.83 to 148.7 (Appendix II Table 5). The upstream Richardson Brook site and Creamer Brook both had a negative average BCS, indicating that buffering capacity is insufficient to counter the stream's acidity (Baldigo et al. 2009). As expected, Beaverdam Stream and Barney Brook had the highest average BCS, and thus the highest capacity to buffer against the mobilization of toxic aluminum. This confirms the trends indicated by the calcium and ANC values (Fig. 7). At all sites, BCS was lowest in November, when rain events drive episodic pH depressions.

<u>Macroinvertebrates</u>

Due to the shell application schedule, no macroinvertebrate samples were collected in the treatment stream, Richardson Brook in 2019. Macroinvertebrate samples were only collected in Creamer Brook and Beaverdam Stream, to confirm results collected in 2018. Both streams attained Maine's highest aquatic life water quality classification (Class A; Appendix III; Davies et al. 2016), as had most streams in the prior years of this study (Zimmermann 2019). The dominant taxa were genera of mayflies and caddisflies that prefer habitat with cold, fast-flowing water, in contrast with the dominant genera observed in the two prior years (Appendix II, Table 7; Zimmermann 2019). This is not surprising, as rainfall in 2019 maintained significantly higher flow in all streams compared with 2017 and 2018 (Fig. 3). Mayflies are the most sensitive group of aquatic insects to acidity (Weiderholm 1984) and represented around one third of the generic richness, suggesting a healthy macroinvertebrate assemblage requiring good water quality. Rainfall driven decreases in pH (<5) may have a detrimental impact on any acid-sensitive macroinvertebrates present, although the most critical period for macroinvertebrates is likely emergence, so species that reproduce in the fall and spring would be most affected (Bradley and Ormerod 2002; Wiederholm 1984). However, as episodic acidity events have been occurring for decades, the macroinvertebrate assemblage in Downeast streams may be tolerant to low pH pulses. Salmon are thought to be opportunistic feeders, changing their diet to the most abundant prey available, so changes in macroinvertebrate abundance may have a stronger impact on salmon than changes in macroinvertebrate composition (Scott and Crossman 1973 as cited in Stanley and Trial 1995).

Conclusion

There were no significant differences in water quality before and after clam shell additions, both considering an upstream-downstream comparison in Richardson Brook, and baseline data from the prior two years. The addition of shells is expected to increase the pH, calcium, and ANC at the downstream site. The lack of change may be due to frequent rain events diluting any buffering capacity of the shells, or because shells were spread incrementally over more than two months and the minimum of data collected after the full dose was applied. Shells were spread mostly in the shallow stream edges and on the banks, so would only be in contact with the stream during higher flows, such as occurred after sondes were retrieved for the winter. A pH sensor was deployed at the downstream Richardson Brook site, with the hope of collecting pH data during the winter, to enhance the one month of data collected following the completed dose of shells. Sub-lethal stress is likely still occurring during episodic, precipitation-driven acidity events (Baker et al. 1996; Henriksen et al. 1984; Lacroix and Knox 2005; Magee et al. 2003). In the three years of the study so far, all streams experienced episodic acidification due to precipitation events, particularly in the spring and fall when natural organic acid levels are low, indicating acidity from anthropogenic sources. Frequent rain events prevented stream chemistry from recovering to pre-storm levels. Cumulative sub-lethal stress is likely causing detrimental impacts to salmon due to the combined impact of low pH and aluminum toxicity. The most sensitive salmon life stages to acidity are present in the study area from March through June. This time range also coincides with snow melt, when streams experience episodic acidity, increasing the severity of detrimental impacts to salmon. As clam shells are added to the target area, monitoring efforts will continue for at least five years to determine the efficacy of using this approach to mitigate acidity.

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Appendix I – Stream Characteristics

Table 1. Study site locations and watershed characteristics. Watershed area and percent wetlands calculated from MEGIS 2017a,b.

<table>
<tr><th>Stream Name</th><th>Site Code</th><th>Town</th><th>Latitude</th><th>Longitude</th><th>Watershed Area (km^2)</th><th>Percent Wetlands (%)</th><th>Percent Wetlands excluding ponds (%)</th><th>Mean # of fish species present (MDMR data)</th></tr>
<tr><td>Barney Brook</td><td>NMCEMBDUB02</td><td>Wesley</td><td>44.98689397</td><td>-67.63584802</td><td>3.63</td><td>5.8</td><td>5.8</td><td>unknown</td></tr>
<tr><td>Beaverdam Stream</td><td>NMCEMBD20</td><td>Wesley</td><td>44.98169</td><td>-67.64014</td><td>27.78</td><td>18.3</td><td>13.8</td><td>5</td></tr>
<tr><td>Creamer Brook</td><td>NMCEMRLNSCB09</td><td>T19 ED BPP</td><td>44.97112996</td><td>-67.50932403</td><td>13.73</td><td>7.5</td><td>7.2</td><td>5</td></tr>
<tr><td rowspan="2">Richardson Brook</td><td>NMCEMRLNSRD09</td><td>T19 ED BPP</td><td>44.92662500</td><td>-67.48657800</td><td rowspan="2">13.47</td><td rowspan="2">13.4</td><td rowspan="2">8.4</td><td rowspan="2">5</td></tr>
<tr><td>NMCEMRLNSRD05-B</td><td>T19 ED BPP</td><td>44.92616097</td><td>-67.49302299</td></tr>
</table>

Table 2. Study site physical characteristics. Mean stream depth was measured every three weeks while sondes were deployed in 2019.

<table>
<tr><th colspan="2" rowspan="2">Stream Name</th><th rowspan="2">Bankfull stream width (m)</th><th rowspan="2">Mean stream depth (cm)</th><th colspan="5">Substrate (%)</th></tr>
<tr><th>Bedrock</th><th>Boulder</th><th>Cobble</th><th>Gravel</th><th>Sand/Silt</th></tr>
<tr><td colspan="2">Barney Brook</td><td>2.1</td><td>33</td><td>-</td><td>5</td><td>35</td><td>45</td><td>15</td></tr>
<tr><td colspan="2">Beaverdam Stream</td><td>6.3</td><td>39</td><td>-</td><td>10</td><td>75</td><td>10</td><td>5</td></tr>
<tr><td colspan="2">Creamer Brook</td><td>6.3</td><td>42</td><td>-</td><td>55</td><td>25</td><td>18</td><td>2</td></tr>
<tr><td rowspan="2">Richardson Brook</td><td>09</td><td>4.1</td><td>44</td><td>15</td><td>30</td><td>40</td><td>10</td><td>5</td></tr>
<tr><td>B</td><td>4.7</td><td>29</td><td>-</td><td>5</td><td>75</td><td>15</td><td>5</td></tr>
</table>

Appendix II – Summary Data Tables

Table 1. Continuous Data Summary. Summary statistics (mean, standard deviation (SD), minimum and maximum) of measurements from YSI 600 XLM sondes and Onset Hobo U26 dissolved oxygen loggers, May to Nov. 2019 (n ~ 9,000)*. Dissolved oxygen data for Barney Brook are discrete measurements from a Eureka Manta2 Sub2 sonde (n = 15).

Stream Name	pH				Temperature (°C)				Specific Conductance (µS/cm)				Dissolved Oxygen (mg/L)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Barney Brook	6.29	0.25	5.11	6.78	12.36	4.69	-0.08	21.67	27	8	7	49	12.33	2.46	7.94	15.77
Beaverdam Stream	6.03	0.33	5.18	6.61	14.56	5.58	-0.02	27.5	31	10	9	152	10.0	1.47	7.47	14.89
Creamer Brook	5.67	0.33	4.94	6.28	12.94	4.89	-0.14	23.05	20	4	13	27	10.30	1.46	7.53	15.03
Richardson Brook - 09	5.49	0.29	4.85	6.25	14.97	5.64	0	27.65	18	4	5	24	9.31	1.49	6.41	14.23
Richardson Brook - B	5.47	0.38	4.58	6.55	13.95	5.43	-0.2	26.46	20	2	15	28	9.91	1.50	7.02	14.83

*Barney Brook was deployed in April 2019.

Table 2. Discrete Data Summary. Summary statistics (mean, SD, minimum and maximum) from grab samples collected in 2017 (June 20, Aug. 1, and Oct. 11), 2018 (April 18, July 23, and Nov. 5) and 2019 (April 1, July 31, and Nov. 19). n = 9*.

Stream Name	Calcium (mg/L)				Dissolved Organic Carbon (mg/L)				ANC (µeq/L)				pH (closed-cell)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Barney Brook	3.29	1.68	1.16	5.98	10.6	4.8	3.4	19	177.4	135.0	46.6	435.9	6.41	0.45	5.82	6.96
Beaverdam Stream	1.90	0.86	0.92	3.2	10.6	3.8	6.5	17	67.4	47.8	30.2	141.7	5.99	0.53	5.28	6.63
Creamer Brook	1.93	0.84	1.19	3.66	11.8	10.7	3.2	7.6	54.7	31.3	14.8	94.9	5.75	0.50	4.96	6.26
Richardson Brook - 09+	1.37	0.39	0.72	1.86	11.5	3.7	5.6	17	50.1	32.0	13.3	104	5.74	0.46	4.92	6.25
Richardson Brook - B	1.57	0.60	0.70	2.85	11.4	3.0	7.0	17	62.1	39.9	13.9	147	5.79	0.49	4.94	6.34

* Creamer Brook was not sampled in April 2018 or 2019 (n = 7). Beaverdam Stream was not sampled in 2017 (n = 6).
+ Rich09 includes samples collected from Rich-A (a site 360m downstream) in 2017, 2018, and April 2019.

Table 3. Aluminum Species Data Summary. Summary statistics (mean, SD, minimum and maximum) from grab samples collected in 2017 (June 20, Aug. 1, and Oct. 11), 2018 (April 18, July 23, and Nov. 5) and 2019 (April 1, July 31, and Nov. 19). n = 9*.

Stream Name	Total Aluminum (µg/L)				Dissolved Aluminum (µg/L)				Exchangeable Aluminum (µg/L)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Barney Brook	192	106	40	423	162	95	32	377	19	17	2	54
Beaverdam Stream	149	48	110	241	126	49	78	219	11	8	<1	18
Creamer Brook	232	108	94	424	214	102	92	399	33	17	<1	53
Richardson Brook – 09+	202	65	131	300	175	62	75	279	18	11	3	40
Richardson Brook - B	189	63	101	300	182	63	122	278	20	10	2	29

* Creamer Brook was not sampled in April 2018 or 2019 (n = 7). Beaverdam Stream was not sampled in 2017 (n = 6).
+ Rich09 includes samples collected from Rich-A (a site 360m downstream) in 2017, 2018, and April 2019.

Table 4. Exceedance Summary. Percentage of data observations that exceeded stress threshold values in 2019 for sonde data (pH, temperature and DO). Grab sample data (calcium and exchangeable aluminum) combine all three years of the study 2017-2019.

Stream Name	Continuous Data					Grab Sample Data		
	pH (n ~ 9,000)		Temperature (n ~ 9,000)	Dissolved Oxygen (n ~ 9,000)^		Calcium (n = 9)*		Exchangeable Aluminum (n = 9)*
Thresholds	*<5.4*	*<6.0*	*>20.0 °C*	*<5 mg/L*	*<7 mg/L*	*<2.0 mg/L*	*<4.0 mg/L*	*>15 µg/L*
Barney Brook	0.4	13.3	2.4	0	0	22.2	66.7	33.3
Beaverdam Stream[a]	5.73	38.2	17.8	0	0	50	100	33.3
Creamer Brook	23.8	81.5	5.1	0	0	71.4	100	71.4
Richardson Brook – 09+	31.1	94.6	18.3	0	1.5	100	100	44.4
Richardson Brook – B	38.0	92.1	13.5	0	0	90	100	66.7

^ DO data for Barney Brook are discrete measurements from a Eureka Manta2 Sub2 sonde (n = 15).
* No grab samples were collected at Creamer Brook April 2018 or 2019 (n = 7)
a No grab samples were collected at Beaverdam Stream in 2017 (n = 6).
+ Rich09 includes samples collected from Rich-A (a site 360m downstream) in 2017, 2018, and April 2019.

Table 5. Base Cation Surplus (BCS). Mean sum of cations and anions (± SD). Cations include calcium, potassium, magnesium, and sodium. Anions include chloride, nitrate, sulfate, and strong organic anions (0.071*DOC-2.1, from Lawrence et al. 2007). Grab samples were collected July 31 and Nov. 19, 2019 (n = 2).

Stream Name	Cations (µEq/L)		Anions (µEq/L)		BCS (µEq/L)	
	Mean	SD	Mean	SD	Mean	SD
Barney Brook	168.9	27.29	114.6	63.23	54.28	35.94
Beaverdam Stream	206.2	14.42	122.9	78.23	88.8	84.75
Creamer Brook	112.6	38.46	114.4	39.95	-1.77	1.49
Richardson Brook - 09	113.9	39.97	114.6	40.39	-0.71	0.42
Richardson Brook - B	118.8	34.42	111.1	40.83	7.70	6.41

Table 6. Treatment Summary. Mean values (± SD) pre-shell application (May 23 – July 24, 2019), during shell application (July 25 – Oct. 8, 2019), and post-shell application (Oct. 9 – Nov. 19, 2019). For pH, n ~ 3,000 per time period. For grab samples (Ca, ANC, and Alx), n ~ 1.

Stream Name	pH			Calcium (mg/L)			Exchangeable Aluminum (µg/L)			Acid Neutralization Capacity (µEq/L)		
	Pre	During	Post	Pre	During	Post	Pre	During	Post	Pre	During	Post
Barney Brook	6.3 ± 0.2	6.5 ± 0.2	6.0 ± 0.3	0.92	3.68	2.39	21	14	5	50	244	80
Beaverdam Stream[a]	5.9 ± 0.2	6.3 ± 0.2	5.7 ± 0.3	1.17	2.23	1.77	15	4	<1	31	112	54
Creamer Brook	5.6 ± 0.3	6.0 ± 0.2	5.4 ± 0.3	-	1.43	1.19	-	28	<1	-	54	19
Richardson Brook – 09[+]	5.5 ± 0.2	5.6 ± 0.3	5.2 ± 0.2	0.72	1.50	1.29	11	27	11	21	74	24
Richardson Brook – B	5.5 ± 0.2	5.6 ± 0.4	5.0 ± 0.2	0.70	1.72	1.40	16	31	14	20	80	30

Table 7. Macroinvertebrate Summary. Samples were collected in August each year (2017-2019) using rock bags following the DEP protocol (2014) and analyzed by a certified taxonomist to the lowest possible level (species). Metrics are presented as the mean ± standard deviation. EPT taxa include mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera). 2019 taxa are presented in a separate column due to the differences in composition compared with the two prior years.

Stream Name	Years Sampled	Total Mean Abundance	Generic Richness	EPT Generic Richness	Relative Ephemeroptera Abundance	Dominant Taxa	
						2017-2018	2019
Beaverdam Stream	2018 – 2019 (n = 2)	280 ± 164	38 ± 2	16 ± 3	12 ± 3%	*Polypedilum* *Rheotanytarsus*	*Dolophilodes* *Hydropsyche*
Creamer Brook	2017 – 2019 (n = 3)	183 ± 78	38 ± 2	17 ± 2	47 ± 26%	*Lepidostoma* Leptophlebiidae (*Paraleptophlebia*)	*Maccaffertium* *Hydropsyche*
Richardson Brook - A	2017 – 2018 (n = 2)	105 ± 1	34 ± 4	16 ± 4	46 ± 5%	*Lepidostoma* *Paraleptophlebia*	
Richardson Brook - B	2017 – 2018 (n = 2)	73 ± 23	37 ± 8	17 ± 6	31 ± 1%	*Lepidostoma* Leptophlebiidae (*Paraleptophlebia*) *Promoresia*	

Appendix III – Biomonitoring Key Report

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Information

Station Number:	**S-1115**	River Basin:	Maine Coastal
Waterbody:	Creamer Brook - Station 1115	HUC8 Name:	Maine Coastal
Town:	T19 Ed Bpp	Latitude:	44 58 16.07 N
Directions:	SITE IS DOWNSTREAM OF THE OLD BRIDGE LOCATION.	Longitude:	67 30 33.57 W
		Stream Order:	2

Sample Information

Log Number:	**2763**	Type of Sample:	ROCK BAG	Date Deployed:	7/31/2019
Subsample Factor:	X1	Replicates:	3	Date Retrieved:	8/29/2019

Classification Attainment

Statutory Class:	**AA**	**Final Determination:**	**A**	Date:	1/9/2020
Model Result with P≥0.6:	A	**Reason for Determination:**	**Model**		
Date Last Calculated:	12/20/2019	Comments:			

Model Probabilities

First Stage Model

Class A	0.79	Class C	0.01
Class B	0.21	NA	0.00

C or Better Model

Class A, B, or C	1.00
Non-Attainment	0.00

B or Better Model

Class A or B	1.00
Class C or Non-Attainment	0.00

A Model

Class A	0.98
Class B or C or Non-Attainment	0.02

Model Variables

01	Total Mean Abundance	95.67
02	Generic Richness	36.00
03	Plecoptera Mean Abundance	3.00
04	Ephemeroptera Mean Abundance	34.67
05	Shannon-Wiener Generic Diversity	3.67
06	Hilsenhoff Biotic Index	3.91
07	Relative Abundance - Chironomidae	0.18
08	Relative Generic Richness Diptera	0.33
09	*Hydropsyche* Abundance	18.67
11	*Cheumatopsyche* Abundance	0.33
12	EPT Generic Richness/ Diptera Generic Richness	1.33
13	Relative Abundance - Oligochaeta	0.00
15	Perlidae Mean Abundance (Family Functional Group)	1.33
16	Tanypodinae Mean Abundance (Family Functional Group)	1.33
17	Chironomini Abundance (Family Functional Group)	4.33
18	Relative Abundance Ephemeroptera	0.36
19	EPT Generic Richness	16.00
21	Sum of Abundances: *Dicrotendipes, Micropsectra, Parachironomus, Helobdella*	3.00
23	Relative Generic Richness- Plecoptera	0.06
25	Sum of Abundances: *Cheumatopsyche, Cricotopus, Tanytarsus, Ablabesmyia*	0.33
26	Sum of Abundances: *Acroneuria, Maccaffertium, Stenonema*	31.33
28	EP Generic Richness/14	0.43
30	Presence of Class A Indicator Taxa/7	0.29

Five Most Dominant Taxa

Rank	Taxon Name	Percent
1	*Maccaffertium*	31.36
2	*Hydropsyche*	19.51
3	*Lepidostoma*	9.41
4	*Rheotanytarsus*	3.48
5	*Rheocricotopus*	3.14
6	*Micropsectra*	3.14
7	*Polypedilum*	3.14

Station Number:	**S-1115**	Town: T19 Ed Bpp	Date Deployed: 7/31/2019
Log Number:	**2763**	Waterbody: Creamer Brook - Station 1115	Date Retrieved: 8/29/2019

Sample Collection and Processing Information

Sampling Organization: BIOMONITORING UNIT

Taxonomist: MICHAEL COLE

Waterbody Information - Deployment

Temperature:	20.53 deg C
Dissolved Oxygen:	8.46 mg/l
Dissolved Oxygen Saturation:	94.7 %
Specific Conductance:	17.29 uS/cm
Velocity:	
pH:	6.06
Wetted Width:	6.1 m
Bankfull Width:	6.5 m
Depth:	25 cm

Waterbody Information - Retrieval

Temperature:	17.02 deg C
Dissolved Oxygen:	9.18 mg/l
Dissolved Oxygen Saturation:	95.2 %
Specific Conductance:	18.1 uS/cm
Velocity:	24.4 cm/s
pH:	5.9
Wetted Width:	6.3 m
Bankfull Width:	6.5 m
Depth:	34 cm

Water Chemistry

Summary of Habitat Characteristics

Landuse Name	Canopy Cover	Terrain
Upland Conifer	Dense	Flat
Upland Hardwood		

Potential Stressor	Location	Substrate	
	Minimally Disturbed	Boulder	55 %
		Gravel	10 %
		Rubble/Cobble	35 %

Landcover Summary - 2004 Data

Sample Comments

WATER SAMPLES COLLECTED BY SALMON UNIT - EMILY Z.

Station Number: S-1115 Waterbody: Creamer Brook - Station 1115 Town: T19 Ed Bpp

Log Number: 2763 Subsample Factor: X1 Replicates: 3 Calculated: 12/20/2019

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Adjusted
Perlodidae	09020207	1.67	1.67		--	1.7	1.7
Acroneuria	09020209042	0.67	1.33	0	PR	0.7	1.4
Acroneuria abnormis	09020209042121	0.67		0	PR	0.7	
Aeshnidae	09020301	1.67	1.67		--	1.7	1.7
Calopteryx	09020307043	0.33	0.33	5	PR	0.3	0.3
Leucrocuta	09020402011	1.33	1.33	1	SC	1.4	1.4
Maccaffertium	09020402015	24.33	30.00	4	SC	25.4	31.4
Maccaffertium vicarium	09020402015055	5.67			--	5.9	
Paraleptophlebia	09020406026	2.33	2.33	1	CG	2.4	2.4
Eurylophella	09020410036		1.00	3	CG		1.0
Eurylophella funeralis	09020410036115	1.00			SH	1.0	
Polycentropus	09020603010	2.33	2.33	6	PR	2.4	2.4
Cheumatopsyche	09020604015	0.33	0.33	5	CF	0.3	0.3
Hydropsyche	09020604016		18.67	4	CF		19.5
Hydropsyche slossonae	09020604016031	2.00			--	2.1	
Hydropsyche sparna	09020604016032	15.67			--	16.4	
Hydropsyche betteni	09020604016037	1.00			--	1.0	
Rhyacophila	09020605019	1.00	1.00	2	PR	1.0	1.0
Hydroptila	09020607026	0.33	0.33	6	P	0.3	0.3
Oligostomis	09020608039	0.67	0.67	2	PR	0.7	0.7
Micrasema	09020609044	0.67	0.67	2	SH	0.7	0.7
Lepidostoma	09020611064	9.00	9.00	1	SH	9.4	9.4
Mystacides	09020618075		0.33	4	CG		0.3
Mystacides sepulchralis	09020618075147	0.33			--	0.3	
Oecetis	09020618078	1.00	1.00	8	PR	1.0	1.0
Nigronia	09020701003		0.33	0	PR		0.3
Nigronia serricornis	09020701003003	0.33			--	0.3	
Chironomidae	09021011				--		
Labrundinia	09021011008	0.33	0.33	7	PR	0.3	0.3
Thienemannimyia	09021011020		0.33	3	PR		0.3
Thienemannimyia group	09021011020041	0.33			--	0.3	
Trissopelopia	09021011021	0.67	0.67		PR	0.7	0.7
Brillia	09021011033	0.33	0.33	5	SH	0.3	0.3
Rheocricotopus	09021011057	2.67	3.00	6	CG	2.8	3.1
Rheocricotopus tuberculatus	09021011057106	0.33			--	0.3	
Tvetenia	09021011065		1.33	5	CG		1.4
Tvetenia vitracies	09021011065113	0.33			--	0.3	

Station Number: S-1115 Waterbody: Creamer Brook - Station 1115 Town: T19 Ed Bpp

Log Number: 2763 Subsample Factor: X1 Replicates: 3 Calculated: 12/20/2019

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Tvetenia paucunca	09021011065114	1.00			--	1.0	
Micropsectra	09021011070	3.00	3.00	7	CG	3.1	3.1
Rheotanytarsus	09021011072		3.33	6	CF		3.5
Rheotanytarsus exiguus group	09021011072127	0.67			CF	0.7	
Rheotanytarsus pellucidus	09021011072128	2.67			CF	2.8	
Stempellinella	09021011074	0.33	0.33	2	--	0.3	0.3
Tanytarsus	09021011076			6	CF		
Microtendipes	09021011094		1.33	6	CF		1.4
Microtendipes rydalensis group	09021011094168	1.33			--	1.4	
Polypedilum	09021011102		3.00	6	SH		3.1
Polypedilum aviceps	09021011102181	2.67			--	2.8	
Polypedilum illinoense group	09021011102185	0.33			--	0.3	
Atherix	09021015055	0.67	0.67	2	PR	0.7	0.7
Hydrochus	09021105035	0.33	0.33		SH	0.3	0.3
Dubiraphia	09021113064		0.33	6	--		0.3
Dubiraphia vittata	09021113064038	0.33			--	0.3	
Promoresia	09021113069		2.00		--		2.1
Promoresia tardella	09021113069052	2.00			--	2.1	
Stenelmis	09021113070	0.67	0.67	5	SC	0.7	0.7
Acariformes	090301	0.33	0.33		--	0.3	0.3

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Information

Station Number:	**S-1149**	River Basin:	Maine Coastal
Waterbody:	Beaverdam Stream - Station 1149	HUC8 Name:	Maine Coastal
Town:	Wesley	Latitude:	44 58 54.09 N
Directions:	25M UPSTREAM FROM ROAD CROSSING.	Longitude:	67 38 24.5 W
		Stream Order:	1

Sample Information

Log Number:	**2764**	Type of Sample:	ROCK BAG	Date Deployed:	7/31/2019
Subsample Factor:	X1	Replicates:	3	Date Retrieved:	8/29/2019

Classification Attainment

Statutory Class:	**AA**	**Final Determination:**	**A**	Date:	1/9/2020
Model Result with P≥0.6:	A	**Reason for Determination:**	**Model**		
Date Last Calculated:	12/20/2019	Comments:			

Model Probabilities

First Stage Model

Class A	0.84	Class C	0.00
Class B	0.16	NA	0.00

C or Better Model

Class A, B, or C	1.00
Non-Attainment	0.00

B or Better Model

Class A or B	1.00
Class C or Non-Attainment	0.00

A Model

Class A	1.00
Class B or C or Non-Attainment	0.00

Model Variables

01 Total Mean Abundance	395.67
02 Generic Richness	36.00
03 Plecoptera Mean Abundance	2.33
04 Ephemeroptera Mean Abundance	38.33
05 Shannon-Wiener Generic Diversity	2.95
06 Hilsenhoff Biotic Index	2.43
07 Relative Abundance - Chironomidae	0.12
08 Relative Generic Richness Diptera	0.33
09 *Hydropsyche* Abundance	74.33
11 *Cheumatopsyche* Abundance	1.33
12 EPT Generic Richness/ Diptera Generic Richness	1.50
13 Relative Abundance - Oligochaeta	0.00
15 Perlidae Mean Abundance (Family Functional Group)	1.67
16 Tanypodinae Mean Abundance (Family Functional Group)	0.00
17 Chironomini Abundance (Family Functional Group)	1.69
18 Relative Abundance Ephemeroptera	0.10
19 EPT Generic Richness	18.00
21 Sum of Abundances: *Dicrotendipes, Micropsectra, Parachironomus, Helobdella*	3.72
23 Relative Generic Richness- Plecoptera	0.06
25 Sum of Abundances: *Cheumatopsyche, Cricotopus, Tanytarsus, Ablabesmyia*	3.02
26 Sum of Abundances: *Acroneuria, Maccaffertium, Stenonema*	32.33
28 EP Generic Richness/14	0.50
30 Presence of Class A Indicator Taxa/7	0.43

Five Most Dominant Taxa

Rank	Taxon Name	Percent
1	*Dolophilodes*	37.83
2	*Hydropsyche*	18.79
3	*Simulium*	11.63
4	*Tvetenia*	10.25
5	*Maccaffertium*	7.75

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Number: S-1149	Town: Wesley		Date Deployed: 7/31/2019
Log Number: 2764	Waterbody: Beaverdam Stream - Station 1149		Date Retrieved: 8/29/2019

Sample Collection and Processing Information

Sampling Organization: BIOMONITORING UNIT

Taxonomist: MICHAEL COLE

Waterbody Information - Deployment		Waterbody Information - Retrieval	
Temperature:	27 deg C	Temperature:	18.39 deg C
Dissolved Oxygen:	7.73 mg/l	Dissolved Oxygen:	8.96 mg/l
Dissolved Oxygen Saturation:	97.7 %	Dissolved Oxygen Saturation:	95.3 %
Specific Conductance:	30.2 uS/cm	Specific Conductance:	74.6 uS/cm
Velocity:		Velocity:	27.4 cm/s
pH:	6.63	pH:	6.54
Wetted Width:	5.6 m	Wetted Width:	5.8 m
Bankfull Width:	6.6 m	Bankfull Width:	6.6 m
Depth:	29 cm	Depth:	35 cm

Water Chemistry

Summary of Habitat Characteristics

Landuse Name	Canopy Cover	Terrain	
Upland Conifer	Dense	Flat	
Upland Hardwood			

Potential Stressor	Location	Substrate	
	Minimally Disturbed	Boulder	20 %
		Gravel	5 %
		Rubble/Cobble	70 %
		Sand	5 %

Landcover Summary - 2004 Data

Sample Comments

WATER SAMPLES COLLECTED BY SALMON UNIT - EMILY Z.

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Taxonomic Inventory Report

Station Number: S-1149 Waterbody: Beaverdam Stream - Station 1149 Town: Wesley

Log Number: 2764 Subsample Factor: X1 Replicates: 3 Calculated: 12/20/2019

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Perlodidae	09020207	0.67	0.67		--	0.2	0.2
Acroneuria	09020209042		1.67	0	PR		0.4
Acroneuria abnormis	09020209042121	1.33		0	PR	0.3	
Acroneuria lycorias	09020209042125	0.33			--	0.1	
Boyeria	09020301004		1.33	2	PR		0.3
Boyeria grafiana	09020301004011	0.67			--	0.2	
Boyeria vinosa	09020301004012	0.67			--	0.2	
Calopterygidae	09020307	0.67	0.67		--	0.2	0.2
Acerpenna	09020401007		0.67	5	CG		0.2
Acerpenna macdunnoughi	09020401007001	0.33			--	0.1	
Acerpenna pygmaea	09020401007011	0.33			--	0.1	
Epeorus	09020402009	4.00	4.00	0	SC	1.0	1.0
Leucrocuta	09020402011	2.00	2.00	1	SC	0.5	0.5
Maccaffertium	09020402015	13.67	30.67	4	SC	3.5	7.8
Maccaffertium vicarium	09020402015055	17.00			--	4.3	
Paraleptophlebia	09020406026	1.00	1.00	1	CG	0.3	0.3
Dolophilodes	09020601001		149.67	0	CF		37.8
Dolophilodes distincta	09020601001001	149.67			--	37.8	
Lype	09020602004		0.33	2	SC		0.1
Lype diversa	09020602004005	0.33			--	0.1	
Cheumatopsyche	09020604015	1.33	1.33	5	CF	0.3	0.3
Hydropsyche	09020604016	9.67	74.33	4	CF	2.4	18.8
Hydropsyche slossonae	09020604016031	10.67			--	2.7	
Hydropsyche sparna	09020604016032	23.67			--	6.0	
Hydropsyche betteni	09020604016037	30.33			--	7.7	
Rhyacophila	09020605019		3.67	2	PR		0.9
Rhyacophila fuscula	09020605019060	3.67			PR	0.9	
Glossosoma	09020606020	1.00	1.00	0	SC	0.3	0.3
Hydroptila	09020607026	0.33	0.33	6	P	0.1	0.1
Brachycentrus	09020609043		2.00	0	CF		0.5
Brachycentrus appalachia	09020609043096	2.00			--	0.5	
Micrasema	09020609044	0.33	0.33	2	SH	0.1	0.1
Limnephilidae	09020610				--		
Lepidostoma	09020611064	8.00	8.00	1	SH	2.0	2.0
Oecetis	09020618078	3.33	3.33	8	PR	0.8	0.8
Nigronia	09020701003		1.33	0	PR		0.3
Nigronia serricornis	09020701003003	1.33			--	0.3	

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Taxonomic Inventory Report

Station Number: S-1149 Waterbody: Beaverdam Stream - Station 1149 Town: Wesley

Log Number: 2764 Subsample Factor: X1 Replicates: 3 Calculated: 12/20/2019

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Noctuidae	09020903	0.33	0.33		--	0.1	0.1
Tipula	09021001002	0.67	0.67	4	SH	0.2	0.2
Chironomidae	09021011	0.67			--	0.2	
Cricotopus	09021011037		0.34	7	SH		0.1
Cricotopus bicinctus	09021011037057	0.33			--	0.1	
Parametriocnemus	09021011053	0.33	0.34	5	CG	0.1	0.1
Tvetenia	09021011065		40.56	5	CG		10.2
Tvetenia paucunca	09021011065114	40.00			--	10.1	
Micropsectra	09021011070	3.67	3.72	7	CG	0.9	0.9
Rheotanytarsus	09021011072		0.68	6	CF		0.2
Rheotanytarsus exiguus group	09021011072127	0.33			CF	0.1	
Rheotanytarsus pellucidus	09021011072128	0.33			CF	0.1	
Tanytarsus	09021011076	1.33	1.35	6	CF	0.3	0.3
Polypedilum	09021011102		1.35	6	SH		0.3
Polypedilum aviceps	09021011102181	1.33			--	0.3	
Stenochironomus	09021011105	0.33	0.34	5	CG	0.1	0.1
Simulium	09021012047	46.00	46.00	4	CF	11.6	11.6
Hemerodromia	09021016057	2.00	2.00	3	PR	0.5	0.5
Roederiodes	09021016058	8.00	8.00	3	PR	2.0	2.0
Promoresia	09021113069		1.00		--		0.3
Promoresia tardella	09021113069052	1.00			--	0.3	
Stenelmis	09021113070	0.67	0.67	5	SC	0.2	0.2