Bureau of Fisheries Technical Brief #tbm1367

Deep Lake Chemistry Surveys (Survey #: 519009, 519058, 519121)

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Deep Lake (B-P866) is a remote 31-acre water located in the West Canada Lakes Wilderness in Hamilton County. The maximum depth of Deep Lake is 70 feet, the average depth is 27 feet and there is adequate dissolved oxygen for trout throughout the entire water column. The flushing rate is 0.8 times per year. Deep Lake was first stocked with brook trout in 1942. Stocking ceased in 1967 after a survey caught no fish. However, brook trout stocking was restarted in 2011 due to improved water chemistry, and brook trout survival in nearby Brooktrout Lake. In 2015 a fish survey (#515052) caught only four stocked, fin clipped, brook trout and stocking has subsequently been stopped. Additional water chemistry surveys (#518032, #518085) were performed in 2018 in both the lake and two tributaries. Historic water chemistry values for deep lake are included in the technical brief for the 2018 surveys. The 2019 series of surveys continue an effort to understand the water chemistry and the poor performance of stocked brook trout in Deep Lake.

In 2019, samples were drawn from Deep Lake and advanced chemical analyses were performed by the Adirondack Lakes Survey Corporation (ALSC). Samples were drawn for analysis from different depths in the lake, the inlet, and the outlet on multiple dates and advanced metrics were calculated. Deep Lake chemistry values are shown below (Table 1).

Table 1. Selected water chemistry variables, Deep Lake 2019.

Sample Location	Date	Depth (feet)	Air equilibrated pH (pH units)	Acid Neutralizing Capacity (µM/L)	Inorganic Monomeric "toxic" Aluminum (µM/L)	Base Cation Surplus (µeq/L)	BC/RCOOs-	Conductivity (µmhos/cm)	Silica mg L-1
Inlet	4/29	0	4.54	-28.1	6.41	-56.5	1.2	18.1	3.0
Inlet	6/27	0	4.60	-16.0	5.97	-46.3	1.4	16.4	4.4
Inlet	8/27	0	5.08	5.4	2.78	-38.0	1.4	14.1	6.9
Inlet	9/30	0	4.71	-10.9	5.04	-34.0	1.9	17.6	7.2
Outlet	4/29	0	5.28	0.3	1.67	-11.1	3.4	10.7	2.4
Outlet	6/27	0	5.32	1.7	0.78	-5.3	3.5	9.0	2.0
Outlet	8/27	0	5.66	6.6	0.11	1.1	5.4	8.7	1.1
Outlet	9/30	0	5.61	6.3	0.04	1.4	4.1	8.0	1.4
Lake	6/27	5	5.28	0.8	1.07	-5.5	3.5	8.7	2.0
Lake	7/17	5	5.55	5.7	0.59	-0.4	4.1	8.3	1.9
Lake	8/27	5	5.65	8.6	0.04	1.9	4.4	8.2	1.6
Lake	9/30	5	5.67	5.2	0.07	3.7	4.6	7.9	1.5
Lake	6/27	43	5.47	4.1	1.11	-6.3	4.0	11.0	2.6
Lake	7/17	15	5.29	7.2	1.07	-5.4	3.8	8.9	2.1
Lake	7/17	40	5.46	10.3	1.41	-9.0	3.8	10.9	2.8
Lake	7/17	66	5.78	15.6	1.78	-7.9	3.9	11.3	3.0
Lake	8/27	46	5.59	7.9	0.63	-16.6	2.4	10.6	2.7
Lake	9/30	49	5.66	4.6	0.96	-5.5	3.9	11.1	2.7

It was noted in the 2018 chemistry surveys that the levels of inorganic monomeric or “toxic” aluminum (ALIM), which can directly affect fish survival, appeared to increase in hypolimnetic waters. Samples were drawn both from shallow waters and deep waters on two dates in 2018 (Figure 1.).

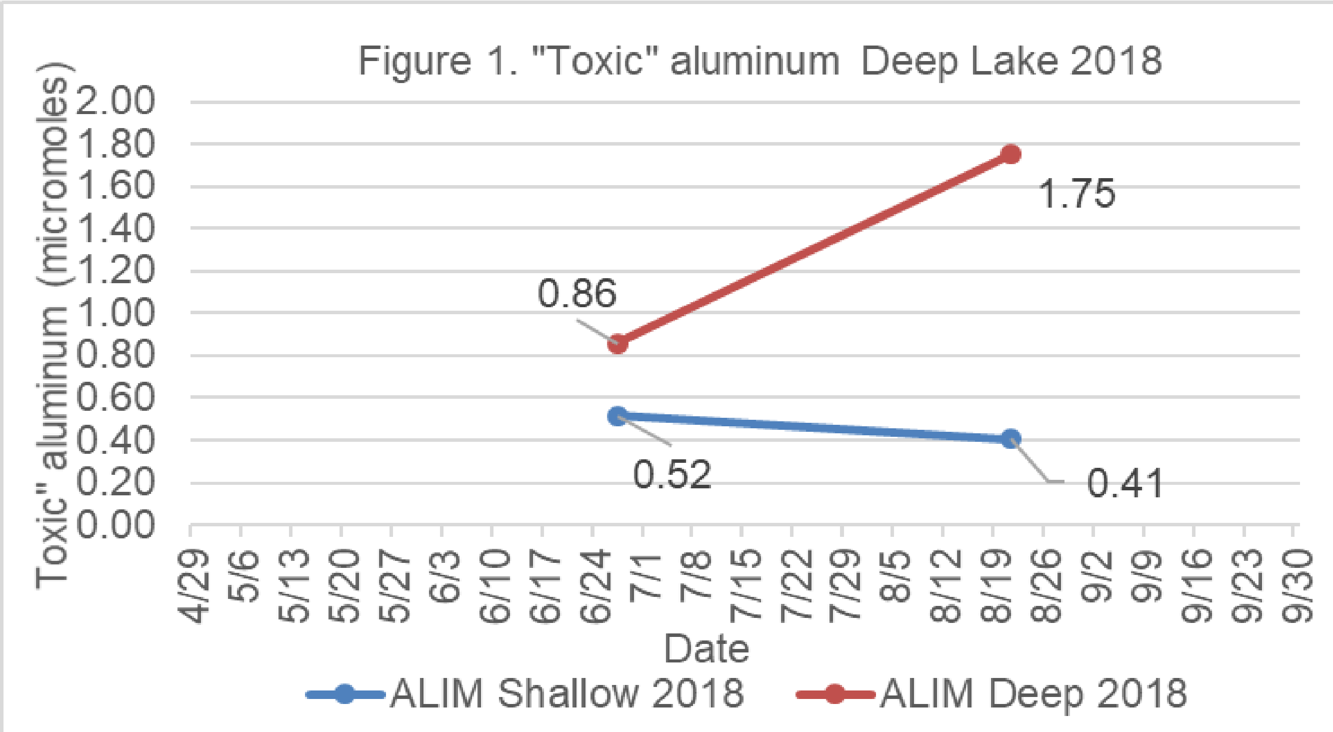


Figure 1. "Toxic" aluminum Deep Lake 2018

In 2019 samples were drawn from the outlet, a depth of 5 ft. (shallow) and hypolimnetic (deep) waters on multiple dates (Figure2.). While sampling at the outlet allowed staff to safely sample early in the spring, there was generally little difference between the outlet samples and the analogous samples drawn at a depth of five feet. The consistent decline in ALIM values following an acidic pulse during spring snowmelt is evident in the shallower waters but levels appear to increase in deeper waters and furthermore never decline to the ALIM levels seen in shallower waters.

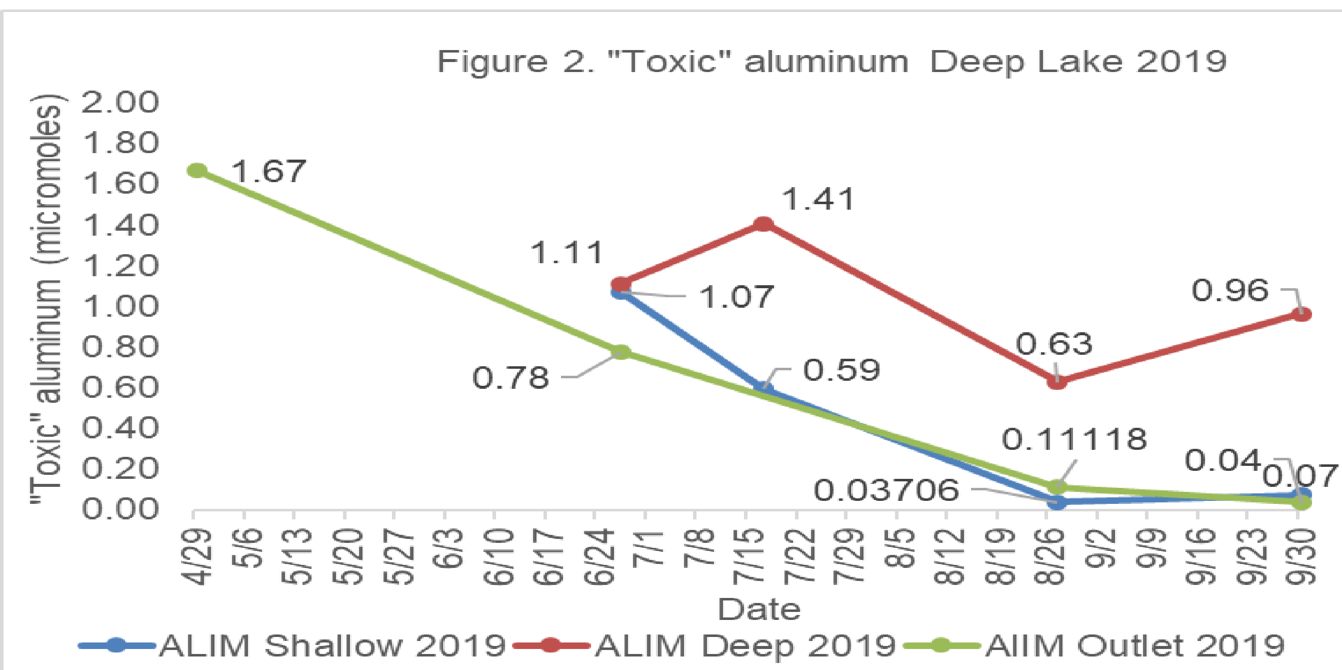
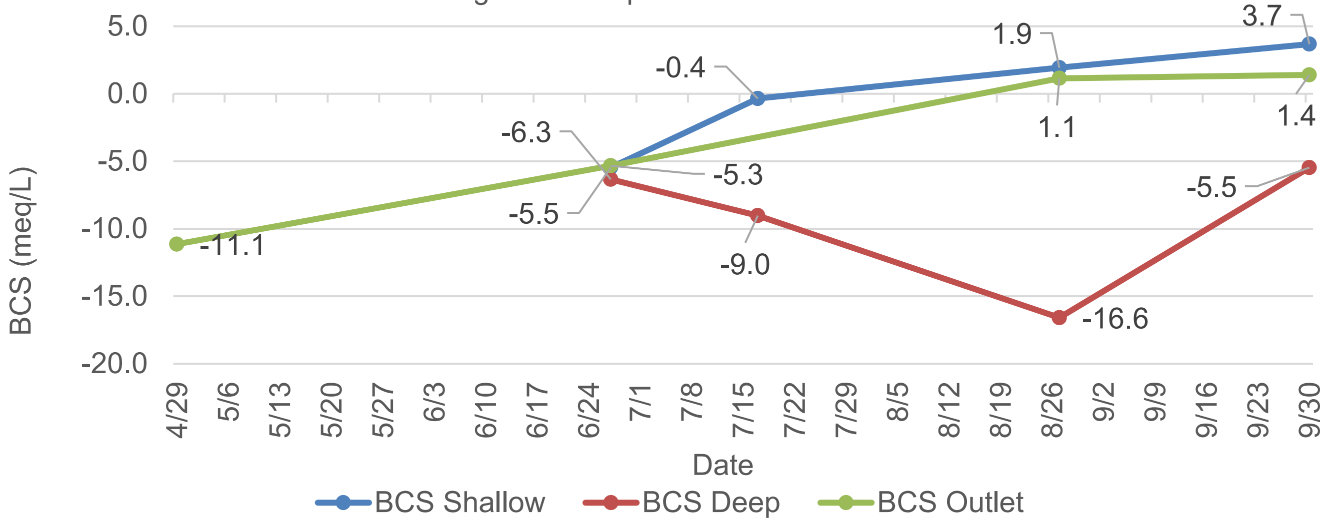


Figure 2. "Toxic" aluminum Deep Lake 2019

The Base Cation Surplus (BCS) levels also decline in deeper waters post-stratification, diverging noticeable from the shallower BCS values. BCS values in the hypolimnion bottom out in late August at -16.6 (µeq/L) but climb back to -5.5 by late September (Figure 3.). BCS levels in the outlet and at a depth of five feet. rose steadily throughout the 2019 sampling period. The inlet samples generally had values associated with poor acid/base chemistry in all metrics, although the values were somewhat improved in the late August sample. The advanced metrics, the Base Cation Surplus (BCS) and the ratio of Base Cations to Strong Organic anions (BC/RCOOs), give a deeper understanding regarding the ability to sustain a brook trout population. Preliminarily, it appears that for a water to support brook trout, BCS values should be above -15 µeq/L, and the BC/RCOOs ratio should be above 1.5. The stocking thresholds for the advanced metrics were again surpassed in the shallow summer samples for which they were designed. However, the performance of stocked brook trout, as evidenced in the 2015 fisheries survey (#515052), was quite poor.

Figure 3. Deep Lake BCS 2019



Recent research (Baldigo et. al. 2019), furthers our knowledge of the toxic effects of various ALIM levels on caged brook trout in streams. They found (in 30-day toxicity tests) mortality of juvenile brook trout was negligible below (medians of) 1 µML-1 of ALIM, was 20% at 1-2 µML-1, was 20-50% at 2-4 µML-1, was 90-100% above 4 µML-1. It has also been documented (Schofield, 1996) that brook trout fry confined at shallow depths during acidic snow melt episodes experienced high mortality rates when fry at greater depths did not. Additionally, it was observed that young brook trout avoided lethally acidic near shore water by moving to greater depths. It is well known that brook trout will seek cooler water during periods of rising surface water temperatures. However, at this point it is unknown if increased ALIM can make the hypolimnion unsuitable as a temperature refuge for brook trout in certain waters, and more study is needed.

Baldigo, B.P., S. George, G.B. Lawrence and E.A. Paul 2019. Acidification Impacts and Goals for Gauging Recovery of Brook Trout Populations and Fish Communities in Streams of the Western Adirondack Mountains, New York, USA. Trans. Am. Fish. Soc., 148, 19 pp.

Schofield C.L. and Keleher C. 1996. Comparison of Brook Trout Reproductive Success and Recruitment in an Acidic Adirondack Lake Following Whole Lake Liming and Watershed Liming. Biogeochemistry. 32 3: 323-337.