Carbon Cycling in UNDERC Lentic Ecosystems:

Understanding Wetland and Lake Dissolved Organic Carbon (DOC) Uptake

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Abstract

Lakes and wetlands have different mechanisms for processing carbon, which is important for understanding the world's capacity to store carbon as a part of the general cycle. This research explores mineralization rates in one lake and one wetland on property at the University of Notre Dame Environmental Research Center (UNDERC). The first hypothesis was that wetland and lake ecosystems will demonstrate distinct mineralization rates. Second, it was hypothesized that mineralization would not be affected by being placed in opposite ecosystem locations (which primarily isolates temperature and light as key factors). A "home-versus-away" experimental design was implemented in Morris Lake and a neighboring wetland. After collecting absorbance measurements from each of the samples, exponential decay models were created and their k-constants were compared. Paired t-tests (parametric) and paired Mann-Whitney tests (non-parametric) were performed to compare: (1) lake "home" versus lake "away;" (2) wetland "home" versus wetland "away;" (3) lake versus wetland "home;" and (4) lake versus wetland "away." The sampling time frame was unfortunately too long, and DOC mineralization was overtaken eventually by heterotroph mortality and breakdown. While results were not significant, regression was found to be more reliable in lake water absorbance measurements while wetland water did not demonstrate easily predictable. A difference was found between wetland and lake water absorbance *values*, which did not change when incubated in opposite sites. This study has implications for the future of bettering lakes and wetlands to potentially sequester more carbon, and would ideally warrant future exploration that includes sampling more lakes and wetlands across multiple times in the summer.

Introduction

Scientific understanding has vastly improved regarding the processes driving chemical and biological constituent quantities in lakes, wetlands, and other inland waters (Travnik et al. 2018). Carbon is an important focus for study, since it is at the forefront of climate research. The current understanding of carbon cycling is that inland waters receive, process (Jansson et al. 2000), emit (Butman and Raymond 2011), and store carbon on a global scale (Einsele et al. 2001); this has evolved from the belief that lakes are completely isolated systems (Forbes 1887). An exchange exists between upstream waters, downstream lentic (still-water) bodies such as lakes or wetlands, the atmosphere, and the sediment sink (Kling et al. 1991). In the context of global warming and climate change, at the most basic level it is important for scientists and community members alike to know where carbon goes and in what forms. This way, we can hope to more efficiently mitigate carbon's effect on a diverse, global environment subject to increased anthropogenic pressure.

Dissolved Organic Carbon (DOC) is the most common carbon form in most lakes; it is available as a resource for heterotrophs that, unable to photosynthesize, alternatively build up the carbon as biomass and excrete it as dissolved carbon dioxide (Pace et al. 2004). Running waters such as rivers and streams carry degradable organic material, are able to export CO_2 to the atmosphere, contribute to outflux from downstream transport, and participate in sediment burial of carbon and other nutrients (Butman and Raymond 2011). Additionally, some interaction may exist along interfaces between wetlands, lakes, and other nearby habitats. This could affect the chemical characteristics of these areas and thus the rates of DOC *uptake* (or *mineralization* for the purposes of this study), depending on the pathways with which carbon enters the body of water (Pace et al. 2004).

Specifically, the question that this study seeks to investigate is: *how does the rate of carbon mineralization differ across lentic aquatic ecosystems?*

Determining the rates of carbon processing in lentic ecosystems is a good way to understand carbon cycling and how these different areas might "respond" to an influx in atmospheric carbon, or carbon in other forms. Other research may benefit from this exploration, especially considering the creation of more optimally engineered carbon sequestration systems in natural environments. Further investigation in this area can also contribute to the development of strategies for ecosystem conservation and adaptation to changing climates in wetlands, lakes, streams, or other sites. Specifically at UNDERC, large-scale investigations occur regarding lake ecology and the influence of increased DOC levels, dubbed "lake browning" (Jones and Lennon, 2015). The insights from these experiments would benefit from having more knowledge about the carbon-uptake mechanisms of specific lakes, and how mineralization may change in the future.

There are two hypotheses being tested: first, that wetland and lake ecosystems will demonstrate distinct mineralization rates; second, that mineralization will not be affected by being placed in opposite ecosystem locations (which primarily isolates temperature and light as key factors). More specifically, these hypotheses lead to the following predictions: first, that the rate of carbon mineralization will be higher in wetland ecosystems than in lake ecosystems; second, after following a "home-versus-away" experimental design, the rate for wetland DOC mineralization will remain unaffected when placed in lake ecosystem conditions, and likewise for lake DOC mineralization in wetland conditions. With regard to the second prediction, seeing *no change* is ideal in order to demonstrate that the chemical and biological factors present in

each site are in fact driving carbon uptake mechanisms, rather than more general and variable qualities of aquatic habitats like temperature or sunlight.

Methodology

Study site

Operating within the constraints for this program's 10-week mixed class-and-research time frame, only one site from each ecosystem (lake and wetland) was selected for experimentation. I selected Morris Lake, a relatively small research lake on the northern end of property, which neighbors an accessible wetland to its east that does not receive regular attention and is undisturbed by road traffic (Figure 1).

Morris Lake is designated for research, and is safe from potential disturbance from recreational activities. The experimental site was located close enough to the shore to reach easily with waders, but still less at risk to be disturbed in more open water. The lake itself is eutrophic, with "extensive littoral vegetation in the form of emergent grasses, submerged macrophytes (especially *Elodea*) growing from the lake's muddy bottom, and floating patches of lily pads extending outward from the shore (UNDERC, n.d.).

The wetland adjacent to Morris Lake can be characterized as a freshwater marsh, as it contains emergent soft-stemmed aquatic plants, a shallow-water regime, and shallow to nonexistent peat deposits (Mitsch and Gosselink, 2015). Notable flora include: wild calla (*Calla palustris)*, tall grasses, mosses, bedstraw (*Galium*), and sensitive fern (*Onoclea sensibilis*). The site is a five to ten minute walk in waders through wooded territory, giving way to muddy areas as trees decrease in abundance, which finally clears out entirely where only grasses and patches of standing water are prevalent.

Experimental design: phase 1

78 plastic 40mm vials were filled in the field with water; half of the vials were filled at Morris Lake, and the other half were filled at the neighboring wetland site. The vials were separated and left in the field to in four "home-versus-away" groups: 1) lake water in a lake setting, 2) lake water in a wetland setting, 3) wetland water in a wetland setting, and 4) wetland water in a lake setting (Figure 2). The vials were held secure in a plastic cage apparatus to allow for light to pass through and for water to circulate freely around the vials (Figure 3).

I collected the vials from each apparatus at regular intervals and brought them back to the lab for analysis. Vials were refrigerated if they could not be analyzed immediately. Taking three vials from the sites at a time provides field replication, resulting in 26 groups with which to determine average measurements. Additionally, every time the vials were taken from the field I measured water temperature in Celsius and Dissolved Oxygen content (DO) in mg/L, using a combined temperature and DO meter. These readings provided additional information for reference when data was being synthesized. Then, in the laboratory, the samples' water color was analyzed by measuring absorbance on a UV-Vis spectrophotometer at 440 nanometers. This is widely used as a proxy for DOC concentration (Findlay, 2006). First, the water was filtered through a glass-fiber filter with a pore size of 0.5µm. Then, the absorbance for each sample was measured and recorded. This process was repeated for all of the 78 vials. Finally, I used R to compare changes in absorbance/DOC concentration at each time point to determine rates of DOC mineralization between the ecosystem locations.

Phase 2: lab-incubation verification

After synthesizing some of the data and creating preliminary plots from Phase 1, I ran an *ad hoc* "lab-incubation" experiment to hopefully provide a more standard regression curve (Figure 4). This was done by shortening the sampling interval to 12 hours in a controlled setting.

This second phase was not implemented outside because of meteorological differences (e.g. ambient temperatures, precipitation, etc.) between mid-June and mid-July sampling time frames, and more importantly, it was not feasible to return to the field every 12 hours without proper preparation, given the demands of the UNDERC program. Methods from Phase 1 were repeated, except the lab setting did not involve a home-versus-away component. Instead, half of 42 vials were filled with lake water, and the other half with wetland water, sampled from the same locations as in Phase 1. The vials were kept collectively in a tray of water indoors, submerged with room for water flow, at approximate room temperature - though it was a bit cooler, which helped mirror the water temperatures measured earlier in the summer (Tables 1 and 2) . After an initial set of samples were run through the spectrometer, six sampling iterations occurred over three days at 8:15 A.M. and 8:15 P.M.

Statistics

To test the first hypothesis, four exponential decay curves were fitted to each of the home-versus-away scenarios, and two additional curves were fitted to each of the lab-incubation scenarios. The rate of carbon mineralization is calculated by finding the *k*-constant of the exponential model of the form:

$$y = a * e^{-kt}$$

The R^2 value for each regression was recorded to verify the assumption that DOC is mineralized approximately exponentially, which has been shown through much previous literature. Then, the *k*-constants were compared without statistics to provide a baseline understanding of how the rates may differ. The lab-incubation curves were intended to be utilized as references for all home-versus-away scenarios, and to add additional verification if the k-constant is potentially unchanged by external conditions.

To test the second hypothesis, paired t-tests (parametric) and paired Mann-Whitney tests (non-parametric) were performed to compare: (1) lake "home" versus lake "away;" (2) wetland "home" versus wetland "away;" (3) lake versus wetland "home;" and (4) lake versus wetland "away." Scenarios 1 and 2 compare site location while controlling for water type, which scenarios 3 and 4 compare water type while controlling for site location.

Results

The first hypothesis stated that there would be a distinct difference between lake and wetland mineralization rates. The second hypothesis follows the null that there should be *no relationship* between the effects of lake ecosystem conditions on wetland water absorbance and wetland ecosystem conditions on lake water absorbance. All statistics were performed and figures were built in R.

Part one: regression

After creating preliminary plots of all data points, it was observed that the absorbance values for all scenarios begin to trend upwards toward the end of the "decay" period; this is most notable for the last two time periods (Figure 5). Bacteria and other heterotrophs in the confined vials of water very likely died and after a period of DOC consumption began to break down, contributing to a rise in absorbance levels. This was a clear indication that the time frame for Phase 1 of the experiment had been too long. Because of this, the last two points were dropped from analysis after recording initial observations from plots of the full dataset.

After being split into the four home-versus-away scenario groups, exponential models were fitted. For all regression models, no significant p-values were found. For the lake "home" scenario, k = -.03262 with an R^2 of .5741 (Figure 6, top. F-statistic: 4.044 on 1 and 3 DF, p-value: 0.1379); for the lake "away" scenario, k = -.09871 with an R^2 of .4918 (Figure 7, top. F-

statistic: 2.903 on 1 and 3 DF, p-value: 0.187). Wetland rates from observation of the scatter plot still did not seem to follow any reliable decay curve. For the wetland "home" scenario, k = *positive* 0.03126 with an R^2 of 0.09443 (Figure 6, bottom. F-statistic: 0.3128 on 1 and 3 DF, p-value: 0.615); for the wetland "away" scenario, k = -0.01079 with an R^2 of 0.02323 (Figure 7, bottom. F-statistic: 0.07135 on 1 and 3 DF, p-value: 0.8067).

It is thus more difficult to compare k-constants between the different home-versus-away scenarios beyond simple observations. With this is mind, it is worth noting that lake water k-constants were observed to be more negative than wetland water k-constants, though the data across time points for wetland water was much less consistent at showing any trend compared to lake water data.

Then, regression analysis was performed on the wetland water and lake water lab-incubation rates to provide a more reliable snapshot of decay with shorter time intervals. Though still not significant, the p-values for the lab-incubation are notably lower. For lake water, k = -.06971 with an R^2 of 0.4461 (Figure 8, top. F-statistic: 4.027 on 1 and 5 DF, p-value: 0.1011). For wetland water, k = -.05983 with an R^2 of 0.5069 (F-statistic: 5.14 on 1 and 5 DF, p-value: 0.07269); importantly, the regression curve for the wetland water did not follow what appeared to be a lag in the decrease in absorbance (Figure 8, bottom).

Part two: paired t-tests

First I performed a Shapiro-Wilk test on the dataset as a whole, and received a significant result, meaning data was not normal (W = 0.89626, p-value = 1.071e-05). However, once data were subset into groups according to both site and water type, the lake "home," lake "away," wetland "home," and wetland "away" scenarios separately were all normal (in that order: W = 0.93843, p-value = 0.6548; W = 0.91454, p-value = 0.4953; W = 0.96998, p-value = 0.8751; W

= 0.96517, p-value = 0.8434). Thus, 4 paired t-tests were performed to compare each of the subsets.

When comparing both "home" scenarios for each water type, a significant difference exists between absorbance values across all paired time points (t = -6.476, df = 6, p-value = 0.0006438). This is also true for comparing both "away" scenarios where water type differs (t = -6.476, df = 6, p-value = 0.0006438). Next, when comparing actual home-versus-away scenarios for the lake water samples, no significant difference was found (t = 0.60464, df = 6, p-value = 0.5676); the same was found for the wetland water samples (t = -0.10541, df = 6, p-value = 0.9195).

Discussion

All points for discussion regarding the findings of this experiment are based off of not-significant differences; however, there is still much to learn from the general trends and the overall process of the sampling/analysis. For the first hypothesis, I expected that the k-constant for lake water DOC decay would be smaller in magnitude than the k-constant for wetland water DOC decay. There is a generally lower DOC concentration in lakes than in wetlands, and this should result in a lower rate for lake DOC decay because fewer organisms are available to mineralize carbon quickly (Dodds 2002). This would have indicated a faster carbon uptake process in wetlands. However, because the wetland scenarios' absorbance averages were so erratic with time, "decay" was almost indistinguishable. Thus, when comparing the k-constants it was actually the lake scenarios that appeared to be decaying more quickly. It would be extremely difficult to definitively make this conclusion without *much* more thorough experimentation and *much* more significant results, since it would contradict a host of prior literature. We can most likely attribute this observation to other variables that could not have been accounted for while

the vials incubated in the field. For example, the wetland water where the vials were submerged could potentially have been shallow enough that a change in water level may have left the vials not fully submerged for some period of time between the 3-day intervals. Also, assuming that carbon mineralization *does* occur faster in wetlands, it would make sense then that the wetland scenarios would become less reliable more quickly - this is most evident in the wetland "home" scenario (Figure 6, bottom), where only the first *three* time points display a steady decreasing curve before absorbance begins to increase again.

Also, samples from time point 7 were kept in the fridge for a longer period of time during class modules, and analyzed later. The vials were very small, thus it is likely that the carbon was taken up very quickly. Along with the time spent in the cold may have allowed for the uptick in absorbance values towards the end, likely because heterotrophs or bacteria confined to the vials would eventually die and decompose, contributing to additional DOC levels.

Instead of being able to reliably compare mineralization rates, investigation shifted more to look at why lake water decayed more predictably than wetland water. This is why the lab-incubation, though it was not brought about *a priori*, became such an integral part of making this study a more holistic perspective. Interestingly, the k-constant for lake water decay in the lab-incubation exponential model was still of a greater magnitude than the k-constant for wetland water decay. However, the wetland water curve again does not demonstrate the expected exponential decrease, and instead appears to lag for the first few time points of the decay process. Once the absorbance values truly begin to decrease, they display a more dramatic decay than that of the lake water (Figure 8). It would not be advisable to only test the last few points for a more desirable decay curve, because we are still unsure why the lag is occurring and cannot

justify excluding these data. There are some differences with the lab-incubation sampling that may account for this observation.

Note that the water for Phase 2 was taken out of the lake/wetland much later than Phase 1 (mid July compared to late May into June), which has the potential to change DOC concentrations in the water, and possibly mineralization rates. Also, the wetland as a whole became much less *wet* when I returned to obtain water for Phase 2. Reeds, cattails, and grasses had grown significantly higher, and I was forced to walk farther than where I had initially set up Phase 1 field incubation because no standing water remained at that location. This gives rise to speculation on how wetland areas might "respond" to increases in summer temperatures due to climate change, if the observed lag could be replicated and studied further. Also based off of this observation, it would be interesting to see if shorter-term decay rates would change temporally over the summer months.

Tracking carbon cycling clearly does not take into account the nitrogen and phosphorus content of lakes or wetlands. These constituents greatly impact the potential for organisms to thrive in the area, and would perhaps play an indirect role in mineralization as well. In future research at UNDERC, if a more extensive experimentation is possible, it would be useful to measure DOC, total nitrogen, and total phosphorus all at the same time to investigate any interaction that may exist.

This study has implications for the future of bettering lakes and wetlands to potentially sequester more carbon. However, the smaller the scale of carbon uptake, the more difficult it becomes to observe a generalizable impact, because the constituents of individual lake and wetland ecosystems can vary drastically even in close proximity. A key limitation of this study is surely the lack of multiple lake sites and wetland sites. Ideally, future work can be done on

Morris Lake again that would include other research lake sites to understand UNDERC property more fully. Researching sequestration potential in dystrophic bogs on property would be an additional wetland area of interest, along with finding other freshwater marshes.

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Appendix

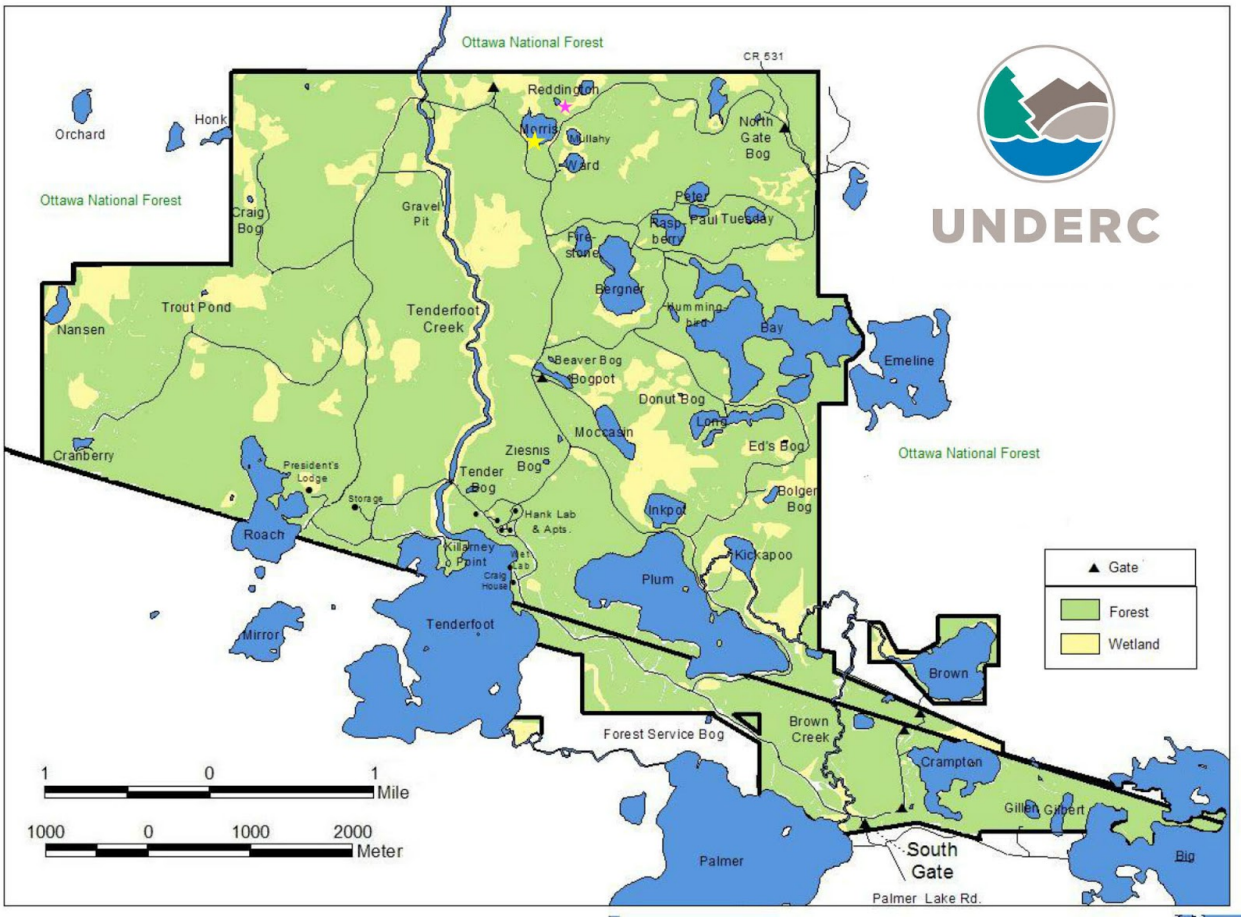

Figure 1. A map of UNDERC property; the yellow star represents the Morris Lake study site and the pink star represents the nearby wetland site.

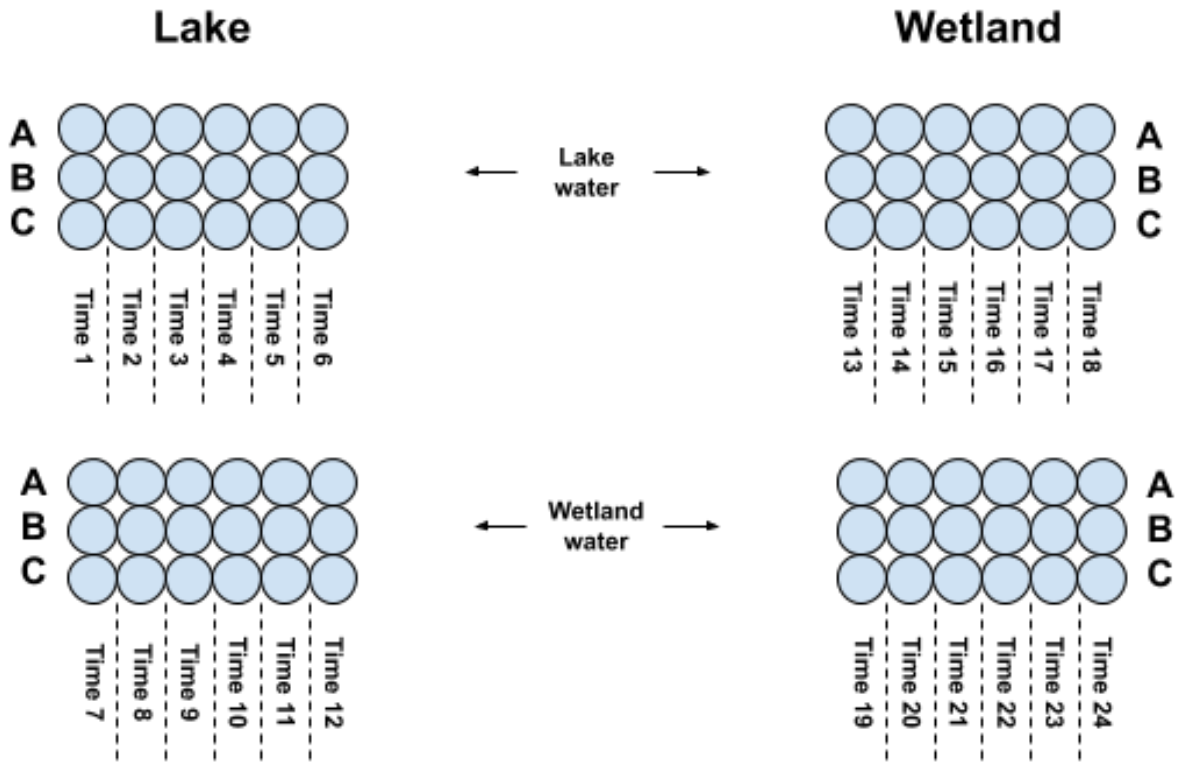

Figure 2. A schematic describing the experiment design. Blue circles represent individual vials and are split into groups of three (A, B, and C) to be tested over 3-day time intervals.

Figure 3. Experimental apparatus, which was affixed to a wooden stake and left for incubation. Morris Lake is pictured in the background. Note: the pink flagging tape was removed after this photo was taken.

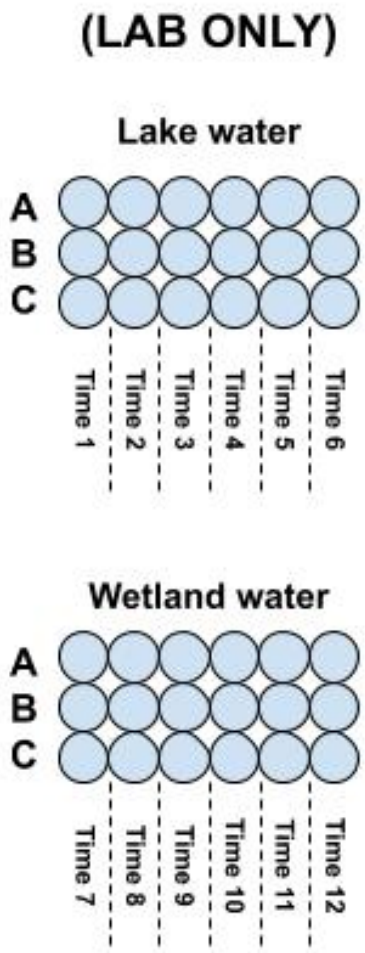

Figure 4. A schematic describing the *ad hoc* "lab-incubation" design. Blue circles represent individual vials and are split into groups of three (A, B, and C) to be tested over 12-hour time intervals.

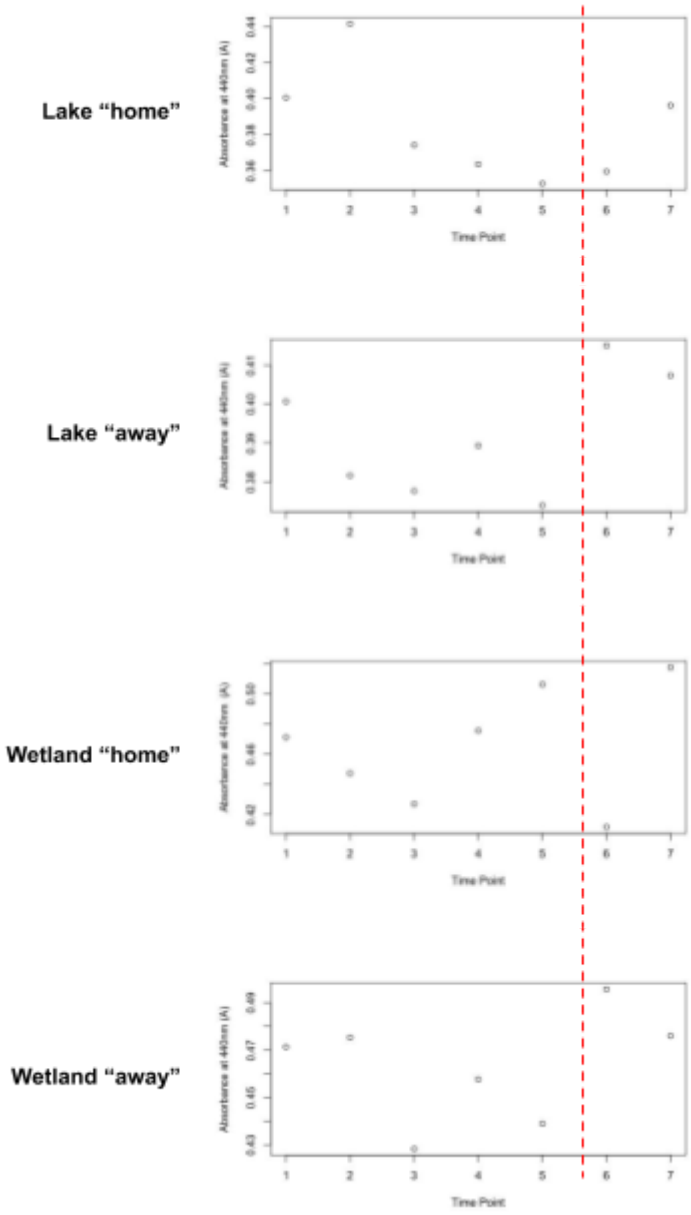

Figure 5. A summary of “home-versus-away” plotted as averages for each time point. The red dashed line denotes where a decreasing trend stopped for all scenarios except Wetland “home,” which experienced a shift as early as Time Point 4.

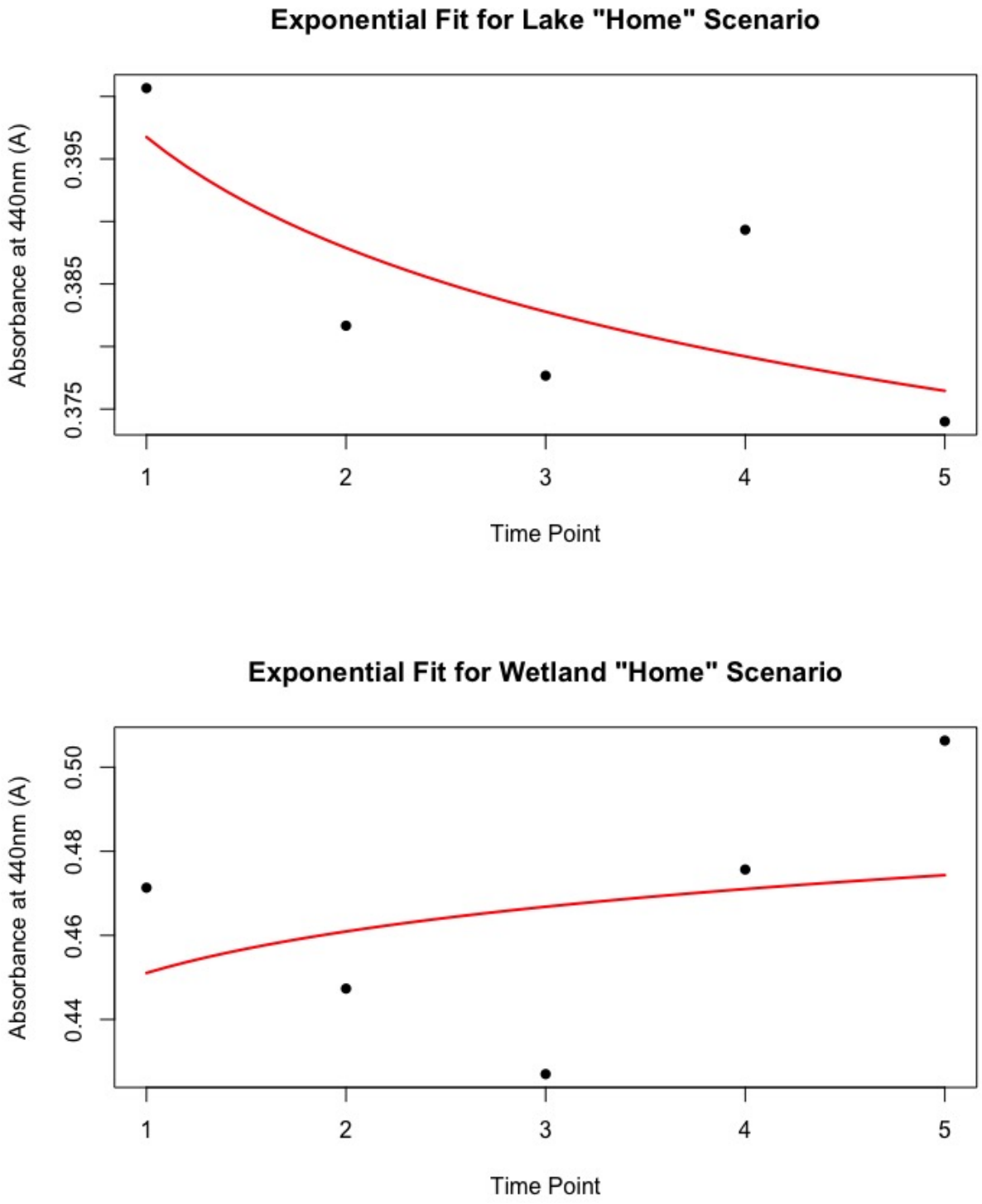

Figure 6. "Home" scenario averages for both lake and wetland water types, including exponential regression curves. For the lake (top), k = -.03262, R^2 = .5741 (F-statistic: 4.044 on 1 and 3 DF, p-value: 0.1379). For the wetland (bottom), k = 0.03126, R^2 = 0.09443 (F-statistic: 0.3128 on 1 and 3 DF, p-value: 0.615).

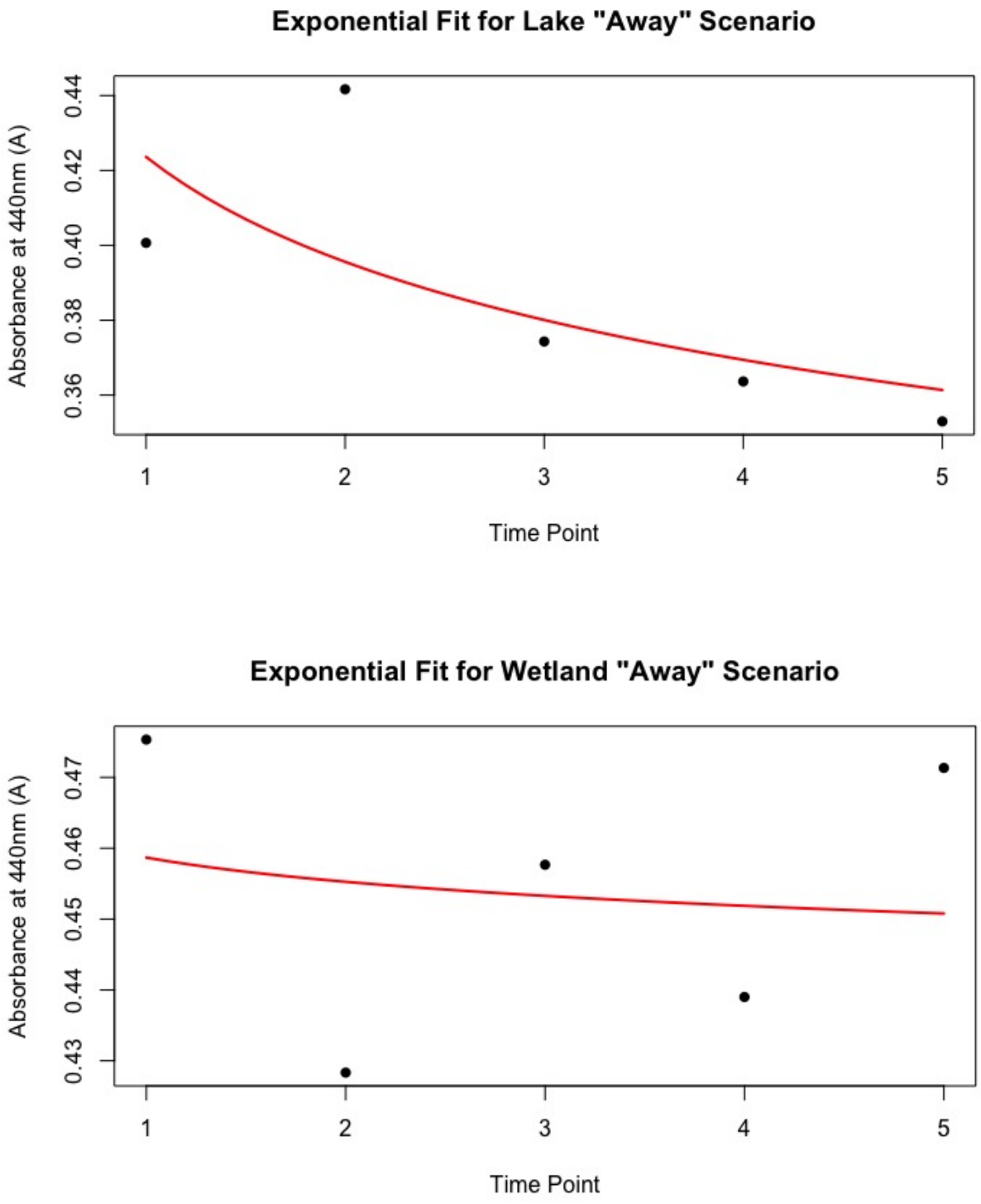

Figure 7. "Away" scenario averages for both lake and wetland water types, including exponential regression curves. For the lake (top), k = -.09871, R^2 = .4918 (F-statistic: 2.903 on 1 and 3 DF, p-value: 0.187). For the wetland (bottom), k = -0.01079, R^2 = 0.02323 (F-statistic: 0.07135 on 1 and 3 DF, p-value: 0.8067).

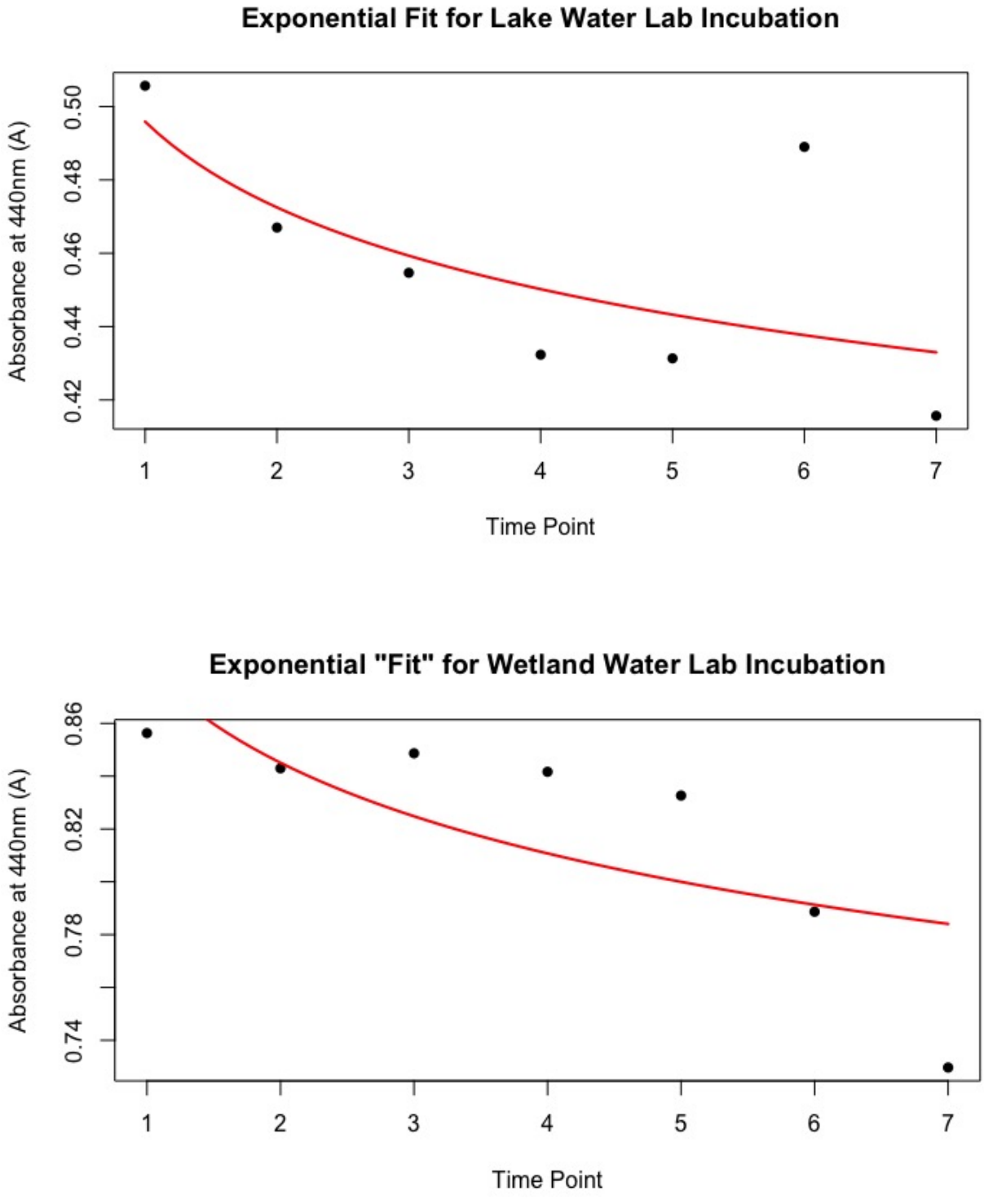

Figure 8. Lab-incubation averages for both lake and wetland water types, including exponential regression curves. For the lake (top), k = -.09871, R^2 = .4918 (F-statistic: 2.903 on 1 and 3 DF, p-value: 0.187). For the wetland (bottom), k = -0.01079, R^2 = 0.02323 (F-statistic: 0.07135 on 1 and 3 DF, p-value: 0.8067).

Table 1. Raw field data table.

Date	Time	Site	WaterType	SampleNum	Abs440	Temp	DO
5/28/19	15:02	lake	lake	LIA	0.421	no data	no data
5/28/19	15:02	lake	lake	LIB	0.389	no data	no data
5/28/19	15:02	lake	lake	LIC	0.392	no data	no data
5/28/19	15:50	wetland	wetland	WIA	0.475	no data	no data
5/28/19	15:50	wetland	wetland	WIB	0.482	no data	no data
5/28/19	15:50	wetland	wetland	WIC	0.457	no data	no data
5/31/19	14:15	lake	lake	1A	0.369	22.3	6.21
5/31/19	14:15	lake	lake	1B	0.378	22.3	6.21
5/31/19	14:15	lake	lake	1C	0.398	22.3	6.21
5/31/19	14:15	lake	wetland	7A	0.48	22.3	6.21
5/31/19	14:15	lake	wetland	7B	0.463	22.3	6.21
5/31/19	14:15	lake	wetland	7C	0.483	22.3	6.21
5/31/19	14:51	wetland	lake	13A	0.406	20.9	0.59
5/31/19	14:51	wetland	lake	13B	0.377	20.9	0.59
5/31/19	14:51	wetland	lake	13C	0.542	20.9	0.59
5/31/19	14:51	wetland	wetland	19A	0.486	20.9	0.59
5/31/19	14:51	wetland	wetland	19B	0.445	20.9	0.59
5/31/19	14:51	wetland	wetland	19B	0.411	20.9	0.59
6/3/19	15:30	lake	lake	2A	0.376	17.4	7.84
6/3/19	15:30	lake	lake	2B	0.373	17.4	7.84
6/3/19	15:30	lake	lake	2C	0.384	17.4	7.84
6/3/19	15:30	lake	wetland	8A	0.466	17.4	7.84
6/3/19	15:30	lake	wetland	8B	0.382	17.4	7.84
6/3/19	15:30	lake	wetland	8C	0.437	17.4	7.84
6/3/19	15:00	wetland	lake	14A	0.386	14.2	0.47
6/3/19	15:00	wetland	lake	14B	0.364	14.2	0.47
6/3/19	15:00	wetland	lake	14C	0.373	14.2	0.47
6/3/19	15:00	wetland	wetland	20A	0.388	14.2	0.47
6/3/19	15:00	wetland	wetland	20B	0.498	14.2	0.47
6/3/19	15:00	wetland	wetland	20C	0.395	14.2	0.47
6/6/19	15:23	lake	lake	3A	0.396	26.8	6.1
6/6/19	15:23	lake	lake	3B	0.384	26.8	6.1
6/6/19	15:23	lake	lake	3C	0.388	26.8	6.1
6/6/19	15:23	lake	wetland	9A	0.452	26.8	6.1
6/6/19	15:23	lake	wetland	9B	0.446	26.8	6.1
6/6/19	15:23	lake	wetland	9C	0.475	26.8	6.1
6/6/19	15:00	wetland	lake	15A	0.361	21.9	0.71
6/6/19	15:00	wetland	lake	15B	0.366	21.9	0.71
6/6/19	15:00	wetland	lake	15C	0.364	21.9	0.71
6/6/19	15:00	wetland	wetland	21A	0.548	21.9	0.71
6/6/19	15:00	wetland	wetland	21B	0.491	21.9	0.71
6/6/19	15:00	wetland	wetland	21C	0.388	21.9	0.71

6/9/19	14:15	lake	lake	4A	0.372	20.7	6.3
6/9/19	14:15	lake	lake	4B	0.378	20.7	6.3
6/9/19	14:15	lake	lake	4C	0.372	20.7	6.3
6/9/19	14:15	lake	wetland	10A	0.368	20.7	6.3
6/9/19	14:15	lake	wetland	10B	0.474	20.7	6.3
6/9/19	14:15	lake	wetland	10C	0.475	20.7	6.3
6/9/19	14:50	wetland	lake	16A	0.339	19.7	0.42
6/9/19	14:50	wetland	lake	16B	0.374	19.7	0.42
6/9/19	14:50	wetland	lake	16C	0.346	19.7	0.42
6/9/19	14:50	wetland	wetland	22A	0.419	19.7	0.42
6/9/19	14:50	wetland	wetland	22B	0.502	19.7	0.42
6/9/19	14:50	wetland	wetland	22C	0.598	19.7	0.42
6/12/19	15:55	lake	lake	5A	0.478	20.7	6.39
6/12/19	15:55	lake	lake	5B	0.381	20.7	6.39
6/12/19	15:55	lake	lake	5C	0.386	20.7	6.39
6/12/19	15:55	lake	wetland	11A	0.392	20.7	6.39
6/12/19	15:55	lake	wetland	11B	0.607	20.7	6.39
6/12/19	15:55	lake	wetland	11C	0.488	20.7	6.39
6/12/19	16:15	wetland	lake	17A	0.349	17.6	0.79
6/12/19	16:15	wetland	lake	17B	0.36	17.6	0.79
6/12/19	16:15	wetland	lake	17C	0.37	17.6	0.79
6/12/19	16:15	wetland	wetland	23A	0.4	17.6	0.79
6/12/19	16:15	wetland	wetland	23B	0.4	17.6	0.79
6/12/19	16:15	wetland	wetland	23C	0.435	17.6	0.79
6/15/19	15:50	lake	lake	6A	0.402	20.7	6.41
6/15/19	15:50	lake	lake	6B	0.406	20.7	6.41
6/15/19	15:50	lake	lake	6C	0.414	20.7	6.41
6/15/19	15:50	lake	wetland	12A	0.456	20.7	6.41
6/15/19	15:50	lake	wetland	12B	0.544	20.7	6.41
6/15/19	15:50	lake	wetland	12C	0.428	20.7	6.41
6/15/19	15:15	wetland	lake	18A	0.403	17.8	0.76
6/15/19	15:15	wetland	lake	18B	0.395	17.8	0.76
6/15/19	15:15	wetland	lake	18C	0.391	17.8	0.76
6/15/19	15:15	wetland	wetland	24A	0.44	17.8	0.76
6/15/19	15:15	wetland	wetland	24B	0.538	17.8	0.76
6/15/19	15:15	wetland	wetland	24C	0.575	17.8	0.76

Table 2. Lab-incubation raw data.

Date	Time	Site	WaterType	SampleNum	Abs440	Temp	DO
7/15/19	20:15	lab	lake	LIA	0.497	24.7	6.75
7/15/19	20:15	lab	lake	LIB	0.509	24.7	6.75
7/15/19	20:15	lab	lake	LIC	0.511	24.7	6.75
7/18/19	21:15	lab	wetland	WIA	0.801	24.7	6.75
7/18/19	21:15	lab	wetland	WIB	0.893	24.7	6.75
7/18/19	21:15	lab	wetland	WIC	0.875	24.7	6.75
7/16/19	8:15	lab	lake	1A	0.466	20.2	7.47
7/16/19	8:15	lab	lake	1B	0.481	20.2	7.47
7/16/19	8:15	lab	lake	1C	0.454	20.2	7.47
7/16/19	8:15	lab	wetland	7A	0.846	20.2	7.47
7/16/19	8:15	lab	wetland	7B	0.827	20.2	7.47
7/16/19	8:15	lab	wetland	7C	0.856	20.2	7.47
7/16/19	21:30	lab	lake	2A	0.486	19.5	4.61
7/16/19	21:30	lab	lake	2B	0.455	19.5	4.61
7/16/19	21:30	lab	lake	2C	0.423	19.5	4.61
7/16/19	21:30	lab	wetland	8A	0.886	19.5	4.61
7/16/19	21:30	lab	wetland	8B	0.831	19.5	4.61
7/16/19	21:30	lab	wetland	8C	0.829	19.5	4.61
7/17/19	8:50	lab	lake	3A	0.441	18.9	4.01
7/17/19	8:50	lab	lake	3B	0.427	18.9	4.01
7/17/19	8:50	lab	lake	3C	0.429	18.9	4.01
7/17/19	8:50	lab	wetland	9A	0.822	18.9	4.01
7/17/19	8:50	lab	wetland	9B	0.866	18.9	4.01
7/17/19	8:50	lab	wetland	9C	0.837	18.9	4.01
7/17/19	20:15	lab	lake	4A	0.449	19.1	3.86
7/17/19	20:15	lab	lake	4B	0.422	19.1	3.86
7/17/19	20:15	lab	lake	4C	0.423	19.1	3.86
7/17/19	20:15	lab	wetland	10A	0.792	19.1	3.86
7/17/19	20:15	lab	wetland	10B	0.882	19.1	3.86
7/17/19	20:15	lab	wetland	10C	0.824	19.1	3.86
7/18/19	8:20	lab	lake	5A	0.491	20.3	3.53
7/18/19	8:20	lab	lake	5B	0.451	20.3	3.53
7/18/19	8:20	lab	lake	5C	0.525	20.3	3.53
7/18/19	8:20	lab	wetland	11A	0.73	20.3	3.53
7/18/19	8:20	lab	wetland	11B	0.897	20.3	3.53
7/18/19	8:20	lab	wetland	11C	0.739	20.3	3.53
7/18/19	20:15	lab	lake	6A	0.431	3.35	22.4
7/18/19	20:15	lab	lake	6B	0.408	3.35	22.4
7/18/19	20:15	lab	lake	6C	0.408	3.35	22.4
7/18/19	20:15	lab	wetland	12A	0.728	3.35	22.4
7/18/19	20:15	lab	wetland	12B	0.718	3.35	22.4
7/18/19	20:15	lab	wetland	12C	0.743	3.35	22.4