Appendix K

TM 5: *Cladophora* Growth Window

Seasonal Window for *Cladophora* Growth

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Introduction and Objective

The Regional Municipalities of Durham and York (Regions) are undertaking a Phosphorus Reduction Action Plan (PRAP) Study (Study) for the Duffin Creek Water Pollution Control Plant (WPCP). The principal goal of the Study is to address the requirements outlined by the Ministry of the Environment and Climate Change (MOECC) Order for additional information dated April 4, 2016. The results of the Study will provide the Regions with an understanding of the performance capability of the Duffin Creek WPCP with respect to phosphorus removal for the current plant, an optimized plant, and/or tertiary treatment.

The objective of this technical memorandum (TM) is to quantify the seasonal window for *Cladophora* algal growth in Lake Ontario pursuant to Item 2g of the MOECC Order.

Cladophora Growth Window

The following information was provided to the Regions by Michigan Technological University in June, 2017:

> The timing of the *Cladophora* growth window, the period where the alga maintains a strong presence in the Great Lakes nearshore, was examined for sites in Lake Michigan (Tomlinson et al. 2010), Lake Huron (Canale and Auer 1979), and Lake Ontario (Malkin e al. 2008). Plots of normalized *Cladophora* biomass were developed and compared to a time series of water temperature, as illustrated on Figure 1. The time series of water temperatures was derived by averaging across the Lake Huron and Lake Ontario sites with an additional location on Lake Erie (Higgins et al. 2008) and excluding those from the Lake Michigan site (deeper sampling location; persistent upwellings).
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> The analysis confirms that *Cladophora* is a 'spring alga', exhibiting a growth optimum over temperatures of 13-17 °C (Graham et al. 1982; Tomlinson et al. 2010). Growth was initiated in May, as temperatures rise toward 10 °C and increase through July as the upper bound of the optimum temperature range is reached (Figure 1a and b). Peak biomass was achieved in mid- to late-July, followed by a period of sub-optimal temperatures characterized by senescence and sloughing extending into September. From these observations, it was concluded that the *Cladophora* growth window extends from early May to the end of August, a period of 4 months.

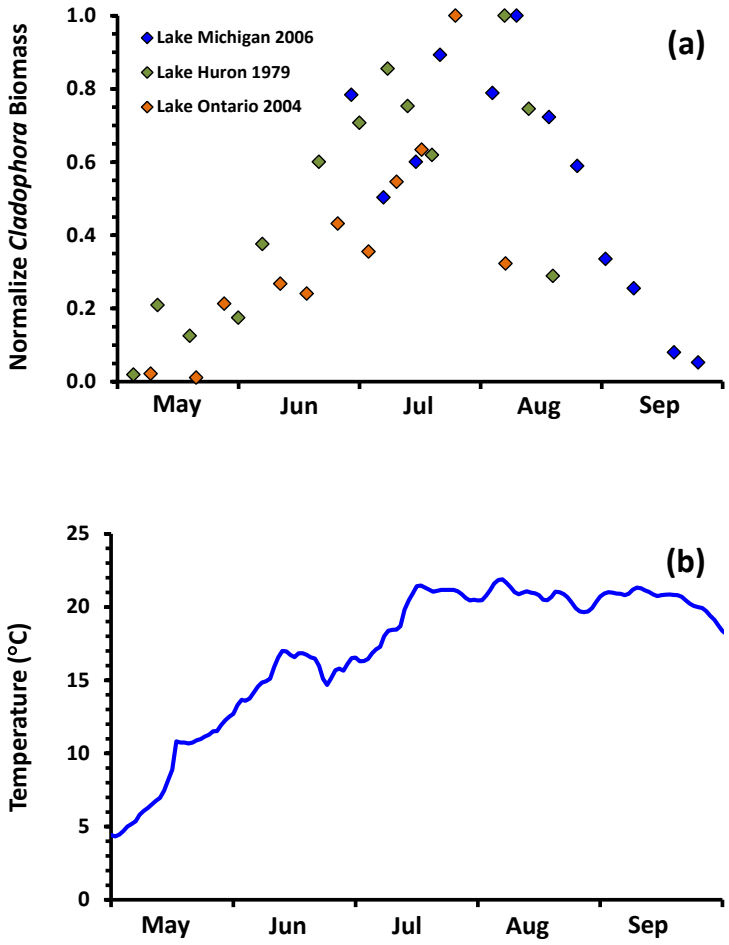

Figure 1.
Water temperature, averaged for Lakes Erie, 2002 (Higgins et al. 2008), Huron, 1979 (Canale and Auer 1982) and Ontario (Malkin et al. 2008) and Cladophora biomass for Lakes Huron (Canale and Auer 1982, Michigan (Tomlinson et al. 2010) and Ontario (Malkin et al. 2008), normalized to the seasonal maximum. Provided by Michigan Technological University in June, 2017.

Summary

A review of the literature investigating *Cladophora* growth in the nearshore waters of Lakes Huron, Michigan, and Ontario indicates that the seasonal window for *Cladophora* growth is a four-month period extending from early May through late August. An additional two weeks is considered on top of this four-month period to allow for some contingency in the growth season. Therefore, a 4.5-month timeframe from mid-April through the end of August has been identified for the purposes of quantifying a period in which tertiary treatment can be operated seasonally.

References

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Higgins, S.N., Pennuto, C.M., Howell, E.T., Lewis, T.W. and Makarewicz, J.C. 2012. Urban influences on *Cladophora* blooms in Lake Ontario. J. Great Lakes Res., 38(Supplement): 116-123.

Malkin, S.Y., Guildford, S.J., and Hecky, R.E. 2008. Modeling the growth response of *Cladophora* in a Laurentian Great Lake to the exotic invader Dreissena and to lake warming. Limnol. Oceanogr., 53(3): 1111-1124.

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