Green Lake Dissolved Oxygen Listing and Assessment

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Green Lake was listed for low dissolved oxygen (DO) in the metalimnion in 2014 based on DO profiles and best professional judgement. The sampling record for Green Lake dates to the early 1900s when metalimnetic dissolved oxygen was consistently above 5 mg/L. This is a review of DO in Green Lake using current and proposed methods and criteria.

Data used for this evaluation were downloaded from USGS for the West (USGS 434756089020500) and East (USGS 434928088570000) stations of Green Lake. Temperature and dissolved oxygen profiles, in 1 m or less increments, for 2004 – 2020 were used. All years, 2004 – 2020, were used to get a long-term view of DO, but only the past 10 years, 2011 – 2020, were used for the impairment assessment as per 2020 WisCALM.

Oxythermal Habitat Assessment

Green Lake is a Two-Story Fishery with native cisco and stocked lake trout. These coldwater fish species are the target of WI's proposed oxythermal habitat criteria; the minimum required habitat is 1 meter in depth that is both cold and oxygenated.

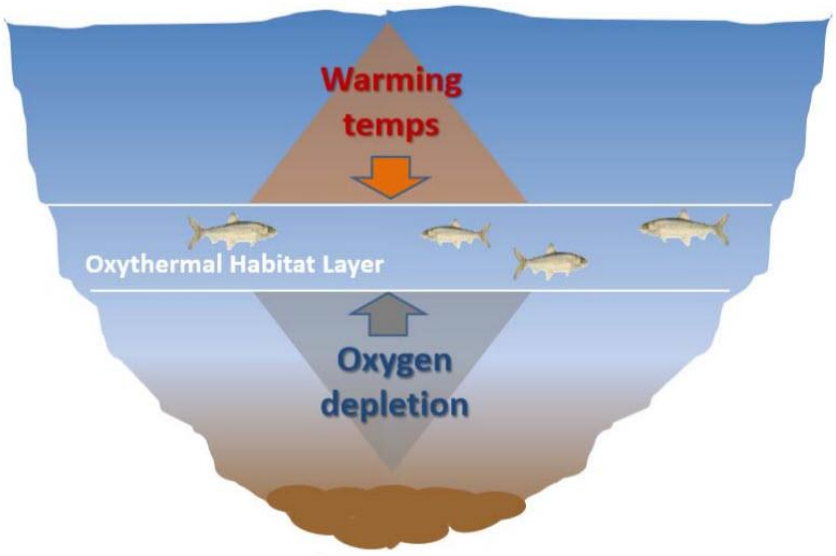

Figure 1. "In late summer, coldwater fish can live only in the band in which there is sufficient dissolved oxygen and cool enough temperatures, termed the oxythermal layer." Biocriteria Technical Support Document, 2019

Proposed criteria for Green Lake, which has a population of lake trout, are that an oxythermal layer must maintain both a dissolved oxygen concentration of at least 6 mg/L and a maximum temperature of 57° F. If any 2 or more years within the most recent 5-year period have an absence of oxythermal habitat, the lake is not attaining the water quality criterion.

Assessment

At each site temperature and DO profile data were compared to the criteria and the amount of available oxthermal habitat was summed by date. Oxythermal habitat was consistently available at the west station (Figure 2), but not at the east station (Figure 3). At the east station there were 3 years with

instances of no oxythermal habitat availability for lake trout in the past 10 years. This does not meet the listing criteria of 2/5 years (4/10 years).

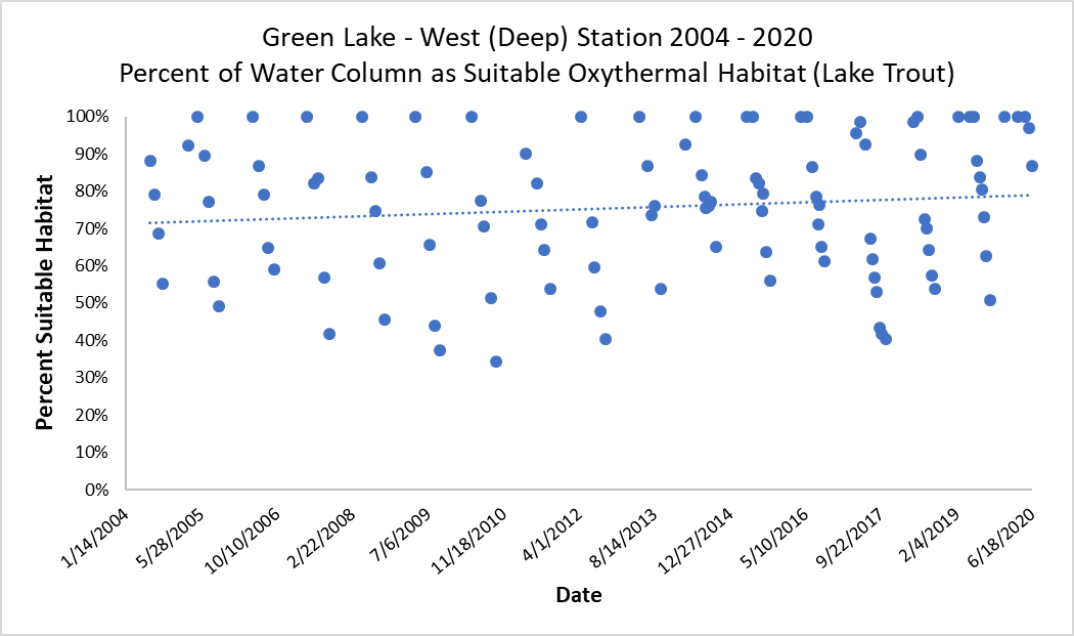

Figure 2. The percentage of the water column that is suitable oxythermal habitat for lake trout in Green Lake's West station. The dashed line represents a trendline.

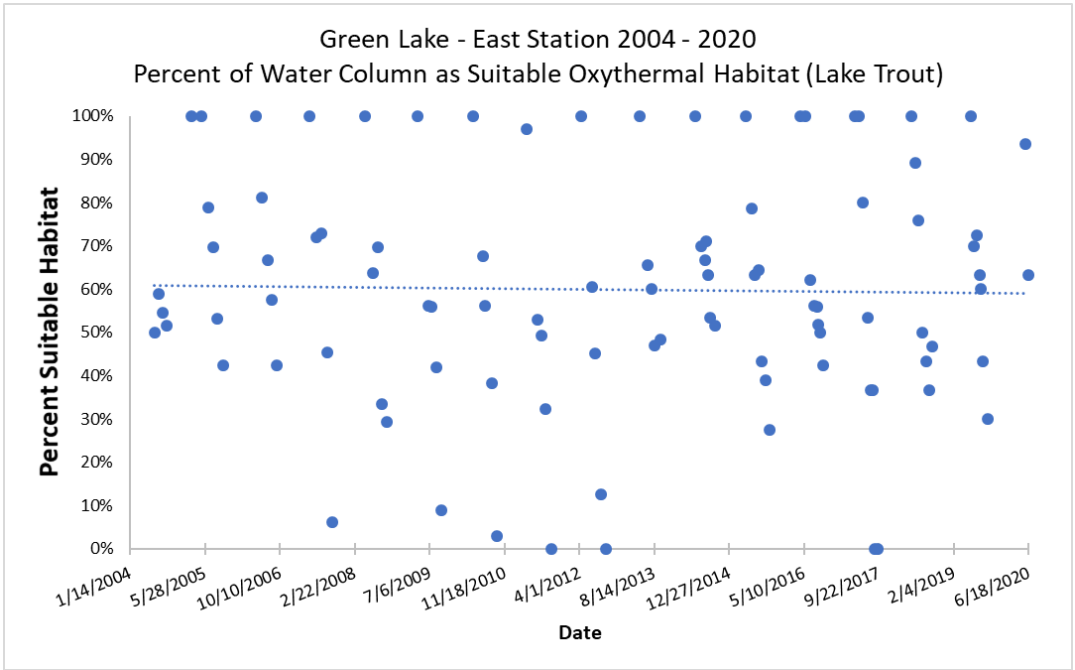

Figure 3. The percentage of the water column that is suitable oxythermal habitat for lake trout in Green Lake's East station. The dashed line represents a trendline.

Epilimnetic and Metalimnetic Dissolved Oxygen Assessment

At both stations the DO levels in the metalimnion were low in August and September in nearly every year from 2004 – 2019. August profiles for each station from 2016 – 2019 are shown below.

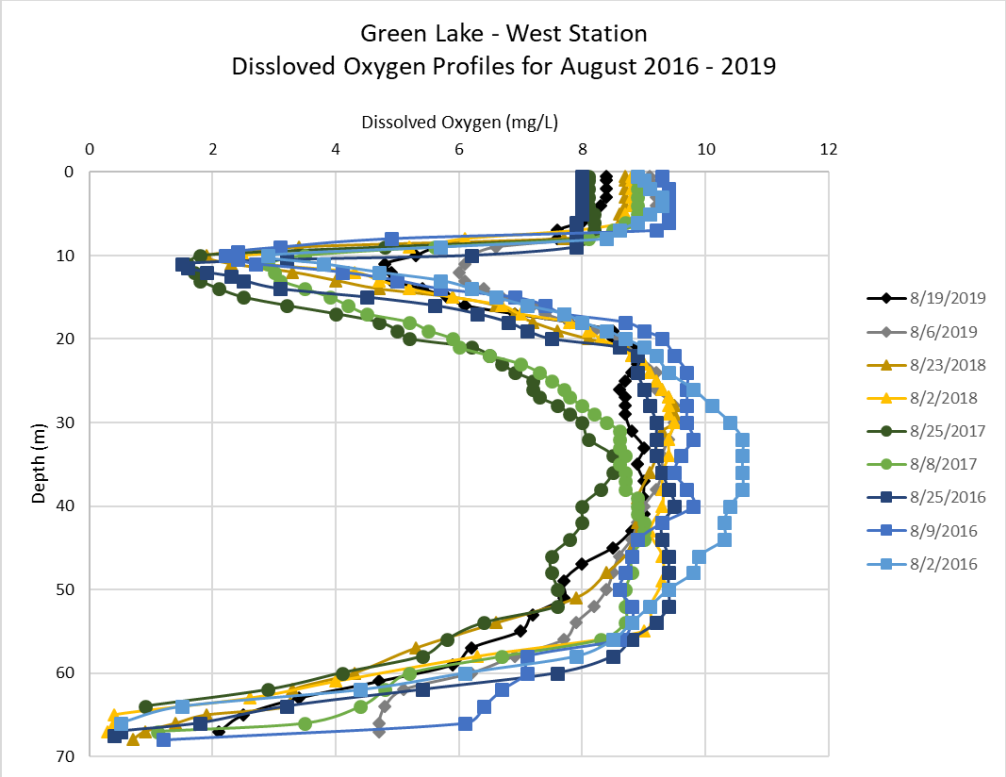

Figure 4. August oxygen profiles at Green Lake's West Station for 2016 – 2019.

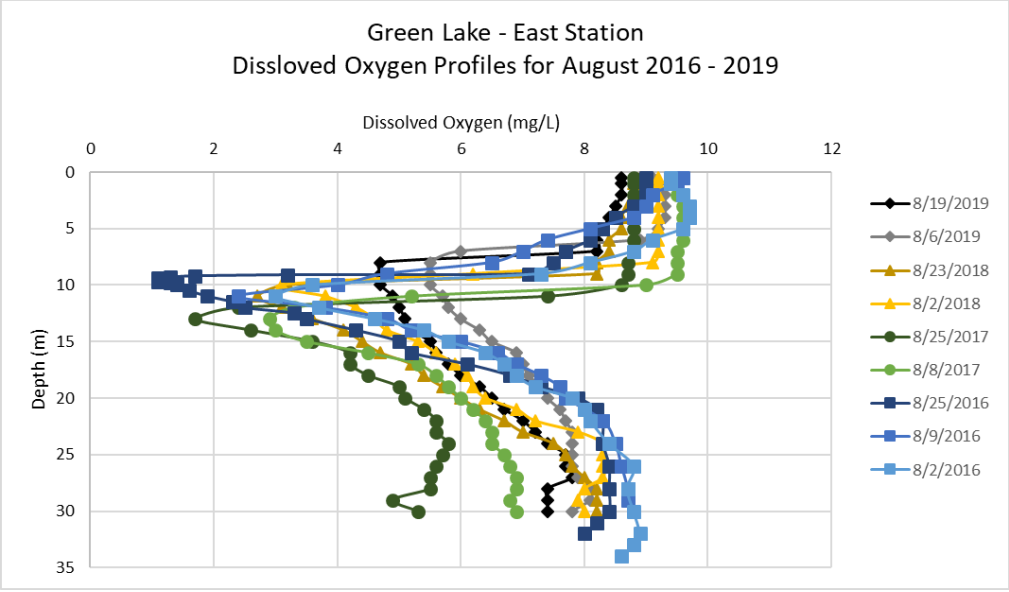

Figure 5. August oxygen profiles at Green Lake's East Station for 2016 – 2019.

Assessment

Temperature profiles were used to determine stratification for each date, identifying the epilimnion, metalimnion (thermocline), and hypolimnion. Stratification was determined by the amount of temperature change between sample depths. If the water was mixed (no stratification) the dissolved oxygen was evaluated separately.

The minimum DO level was selected for each layer by date and compared to the current DO criteria of 5 mg/L. Current WisCALM protocols require 10 samples from the ice-free period and that no more than 10% of samples can be below 5 mg/L DO. Even though this is a Long-Term Trend lake with many sampling dates, no individual year had a total of 10 samples during lake stratification, so all samples from 2011 to 2020 were assessed as one set. For the west station there were 56 dates and for the east station there were 51 dates. In the epilimnion of Green Lake there are no issues with DO (Table 1). The metalimnion, however, had at least half of sample dates with a minimum less than 5 mg/L DO.

Table 1. Evaluation of minimum DO levels in Green Lake's epilimnion and metalimnion at two stations for 2011 – 2020. For the west station there were 56 dates and for the east station there were 51 dates.

	West Station (Deep Hole)	**East Station**
Lake Layer	**Count (%) of days with a DO minimum <5 mg/L, 2011 – 2020.**	
Epilimnion	0 (0%)	0 (0%)
Metalimnion	33 (59%)	26 (52%)

Dissolved Oxygen Delisting Requirement

Green Lake is a unique system with a dissolved oxygen minima issue in the metalimnion. Listing and delisting criteria for this type of issue are not standardized; the best professional judgement of regional water quality staff, impairment listing and TMDL staff, and lake hydrology and modeling staff were used to establish delisting requirements.

The high rate of dates with metalimnetic dissolve oxygen below 5 mg/L indicates the 'Low DO' listing should remain. In order to be removed from the list there need to be 10% or less of samples below 5 mg/L in the metalimnion.