Yahara Lakes Water Quality Monitoring

Key Results

2016 Program Overview

From Memorial Day to Labor Day, volunteers at piers and beaches around the five Yahara Lakes measured near-shore water clarity, air and water temperature, and noted several visual observations. Visual observations included presence of algal blooms (gree/blue-green), floating plant debris, bathers, waterfowl, wave intensity, and general water appearance. Volunteers were asked to log condition reports on Thursday mornings whenever possible. This year also saw several program expansions:

- Weekly off-shore measurement of Secchi depth on all five lakes (seven sites total)
- Weekly monitoring at all 22 public beaches
- 36% increase in number of condition reports and stations from 2015 (Table 1)
- Addition of blue-green algae siting indicator to Lakeforecast.org

2016 Program Highlights

79 monitoring stations ● 35 Lake Forecasting Stewards donating $3,965 to support program expansions. ● $2,500 Dane County Environmental Council grant and $5,000 Wisconsin Citizen-based Monitoring Partnership Program grant awarded for sampling equipment. ● Continued reporting of lifeguard hours, beach closures, water temperature, clarity, and algae presence. ● Collected reports of invasive zebra mussels. ● Streaming of data from the Mendota research buoy. ● Lifeguard monitoring at four pilot beaches. ● Program highlighted at 2015 and 2016 Wisconsin Lakes Partnership Conventions, and at 2014 and 2016 North American Lake Management Society Symposiums. ● May 26th newscasts aired on three major television news networks. ● 15 "Weekend Lake Report" videos shared via social media.

Table 1. Program Growth

	2013	2014	2015	2016
Monitoring Stations	10	46	58	79
Volunteers	9	43	57	68
Volunteer Hours	224	446	463	610
Condition Reports	204	945	1,258	1,720

2016 Program Goals

1) Continue delivering near-shore water quality information to the public through Lakeforecast.org.
2) Share data with interested researchers and encourage investigation into the formation and movement of blue-green (cyanobacterial) algal blooms.
3) Empower citizen monitors to become informed advocates for the lakes.

Near-shore Water Clarity

Citizen monitors use a clear plastic turbidity tube to measure water clarity. The tube is filled with water and then slowly drained until a black and white pattern can be seen through the column of water. The tube is only 120 centimeters (cm) long, so the maximum clarity reading possible is 120 cm.

Climate Summary

Madison experienced significantly more rainfall in 2016 than in the previous two years of monitoring, mostly due to an increase in small and mid-sized storms. Though the amount of precipitation was normal through the spring, the summer was wetter and warmer than normal. The winter of 2015-16 was relatively mild; Lake Mendota froze for 62 days, as opposed to 106 days during the winter of 2014-2015.

Clarity and Algal Bloom Observations

Compared to 2015, citizen monitors reported fewer blue-green algal blooms, especially on Lake Mendota (Figure 1). Lake Mendota also had the greatest percent increase in observations of maximum clarity (Table 2). Lake Monona was the only other lake with an increase in this metric. These two largest lakes both started and ended the summer with average clarity close to the maximum of 120 cm, and had lower average readings during July and August (Figure 2). This drop in average near-shore clarity was due to an increase in the standard deviation of measurement: there were still plenty of good (> 80 cm) readings, but there were more lower-clarity readings that pulled the average down. Lake Kegonsa exhibited the same pattern, but with lower average clarity during all weeks of the summer. Lake Waubesa's average clarity started near the maximum but then declined throughout summer. Clarity on Lake Wingra was highly variable.

Table 2. Percent of near-shore clarity readings at or above 120 cm, 2015 - 2016.

	2015	2016
Mendota	26.1 %	43.7 %
Monona	31 %	41.6 %
Wingra	54 %	36.7 %
Waubesa	30.3 %	25 %
Kegonsa	29.4 %	13.8 %

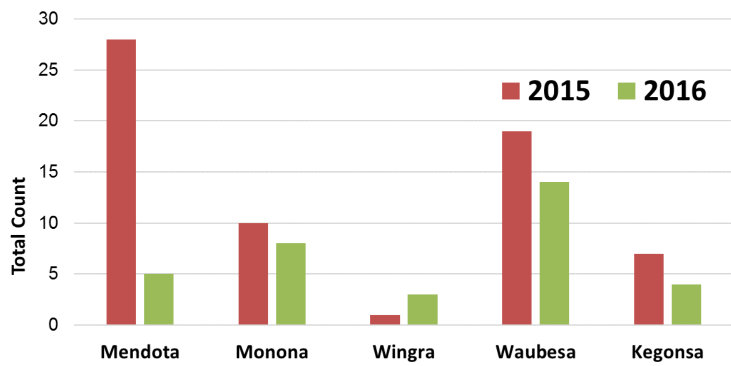

Figure 1. Number of Blue-Green Algae Blooms Reported

Table 3. Number of Near-shore Condition Reports in 2016.

Mendota	656
Monona	470
Wingra	78
Waubesa	289
Kegonsa	227

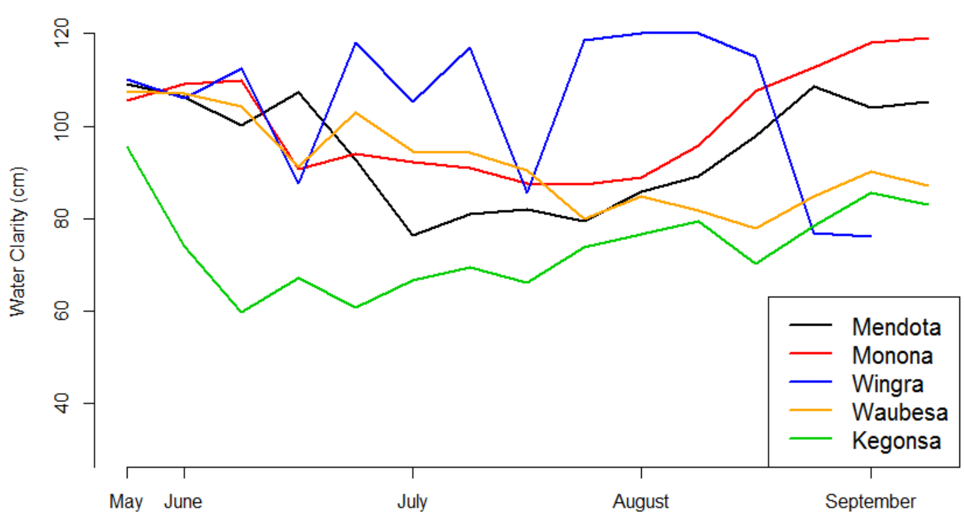

Figure 2. 2016 Average Clarity by Week

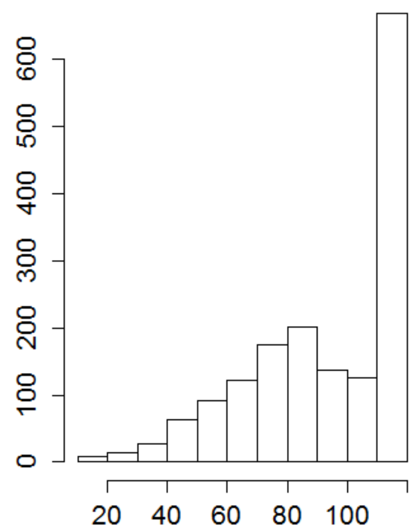

Figure 3. Frequency of Clarity Measurements

Fewer condition reports were collected on Lakes Waubesa and Kegonsa, and Lake Wingra had the fewest of all (Table 3). For this reason, it is less certain that changes in average clarity over the course of the summer or from 2015 are due to actual changes in these lakes, as opposed to random "noise" inherent in collecting near-shore clarity.

Changes in Lake Conditions

The dramatic decline in observations of blue-green algal blooms and increase in clarity on Lake Mendota suggest that water quality actually improved on the lake. These observed changes did not arise because volunteers happened to sample at times of better near-shore clarity. There is also weaker evidence for an improvement from 2015 on Lake Monona.

Precipitation records indicate that 2016 was an unusually wet year, with much of the increase in precipitation coming from mid-sized rain events. There were similar numbers of large precipitation events compared to prior years. Because rainfall delivers phosphorus-containing runoff to lakes (especially in the early spring, when some agricultural lands are bare), one would expect lower average clarity after a rainy spring and early summer. This expected response did not occur, so rainfall patterns do not offer a satisfactory explanation for the absence of algal blooms on Lake Mendota.

Early spring and summer rains play a role in delivering phosphorus, but rains *during* the summer can also reduce near-shore clarity by clouding the water with sediment. So, if water clarity measurements happened to be taken predominantly after dry spells, then the observed changes in clarity and algal blooms would be due to the timing of the monitoring, and not actual changes in the lakes. However, the percentage of condition reports taken after rainfall in 2016 was actually greater than in 2015.

A more likely explanation for the lack of algal blooms is that the mild winter made Lake Mendota less suitable for algae through several mechanisms. *Daphnia*, the algae grazers of the lakes, tend to eat more algae and grow faster in warmer water (though they do not eat blue-green algae). Aquatic plants, which compete with blue-green algae, can also become established earlier if spring water temperatures are higher. Elsewhere in the watershed, the ground thawed earlier in the spring, reducing the chances of a worst-case runoff event: manure spread on frozen ground followed by a spring rain. Farmers were also able to plant crops earlier in 2016, helping to stabilize the soil and further reduce runoff risk.

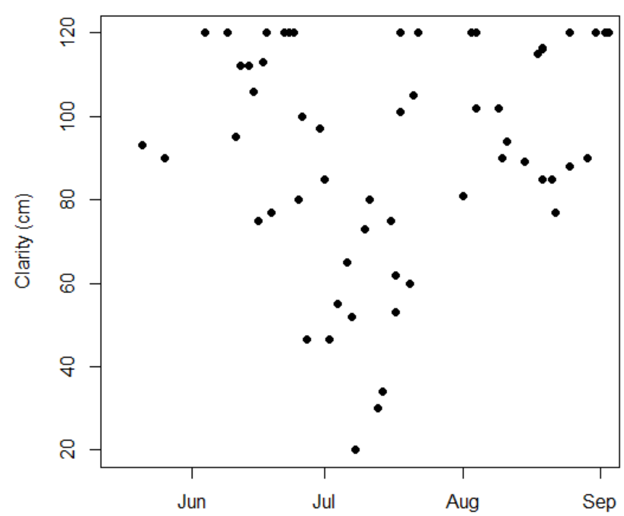

Figure 4. Clarity at Tenney Beach

Variability in the Near-shore Environment

In 2016, near-shore sites continued to experience large changes in clarity over 48 hours or less, underscoring the need for frequent monitoring. Figures 4 and 5 compare sites separated by only a mile (Lake Mendota's total shoreline is almost 14 miles). This variability makes it difficult to identify whole-lake patterns of clarity without many monitoring points evenly distributed around the perimeter. Maintaining or expanding the current network of monitoring stations in future years will allow more precise tracking of near-shore events such as algal blooms, wind-blown debris, and sediment plumes.

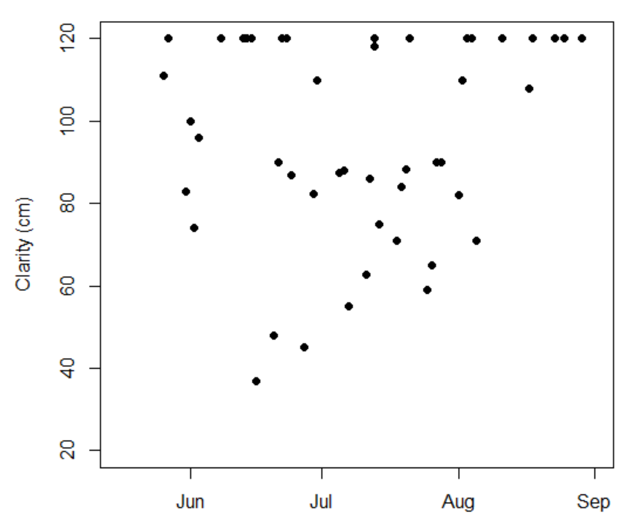

Figure 5. Clarity at James Madison Park

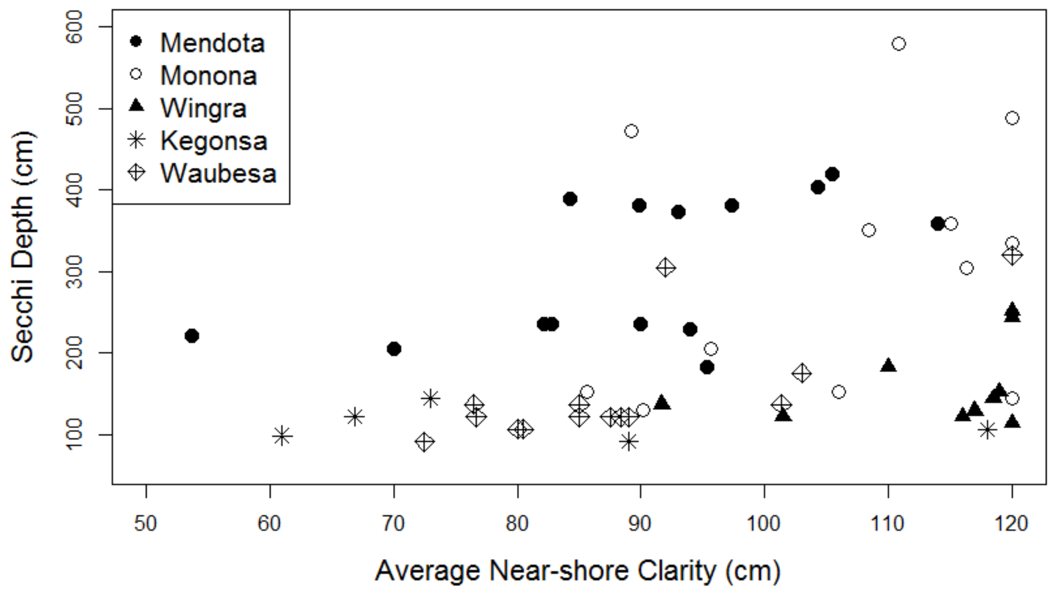

Figure 6. Concurrent Clarity Measurements from Near-shore and Off-shore.

Comparing Near-shore to Off-shore Clarity

In contrast to near-shore locations, the clarity of offshore locations is measured by lowering a patterned disk (Secchi disk) into the water and noting when it is no longer visible. Therefore, a maximum clarity reading is equal to the depth of the lake. In Figure 6, each point is placed along the x-axis according to the average near-shore clarity on that lake for a single day, and placed along the y-axis according to an offshore reading taken by a volunteer on the same lake and day. If near-shore and offshore clarity were related, most of the points would be clustered along a line from the bottom-left to the top-right of the plot. Since this is not the case, the relationship between Secchi depth and average near-shore clarity on the same lake is not straightforward. Therefore, knowing near-shore clarity does not help predict how clear the middle of the lake is, and vice-versa. This reinforces the assumption that clarity in the near-shore environment is driven by different factors than offshore clarity. For example, near-shore clarity can be reduced when substrate is re-suspended by waves or when storm runoff enters from a nearby storm sewer outfall. Unlike offshore areas, near-shore sites can also be shaded, reducing the light available to algae. Generally, the offshore areas of the lake are more mixed and homogenous, while the near-shore areas are more patchy and heterogeneous.

Long-term Water Clarity Trends

The Long-Term Ecological Research and UW Center for Limnology have measured offshore water clarity on Lake Mendota for decades (Figure 7). Only by collecting data over many, many years can a "baseline" be established and inferences made about long-term clarity changes. Though we consider the near-shore to be the more variable environment, offshore clarity can still vary substantially from year-to-year and even within a single season. The nearly four-foot drop in Secchi clarity that occurred from 2009 to 2010 is likely the result of the introduction of the spiny water-flea, an invasive predator of *Daphnia*. Clarity can also be influenced by rainfall patterns (how much phosphorus is delivered in runoff), and the suitability of weather conditions to blue-green algal blooms (cloud cover, wind, temperature).

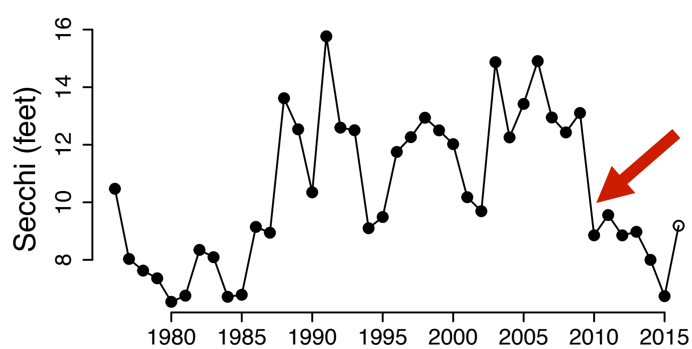

Figure 7. Average off-shore clarity.