Northeast Aquatic Research

Twin Lakes
2024 Water Quality and Native Plant Report

Prepared for the Twin Lakes Association

April 23rd, 2025

Northeast Aquatic Research, LLC ⁖ 74 Higgins Highway, Mansfield, CT 06250 ⁖ 860-456-3179

Contents

Introduction 2
2024 Twin Lake Water Quality Results 5
Water Clarity 5
Water Temperature 6
Dissolved Oxygen 8
Conductivity 11
Nutrients 13
Plankton 18
Aquatic Plant Survey Results 22
Conclusions & Recommendations 30
Recommendations for 2025 monitoring: 32
Appendix 33

Introduction

Lake management rests on the water quality data collected monthly over the course of a season. A lake season runs from ice-off to ice-on, which historically has been April to October. The season has expanded to March to

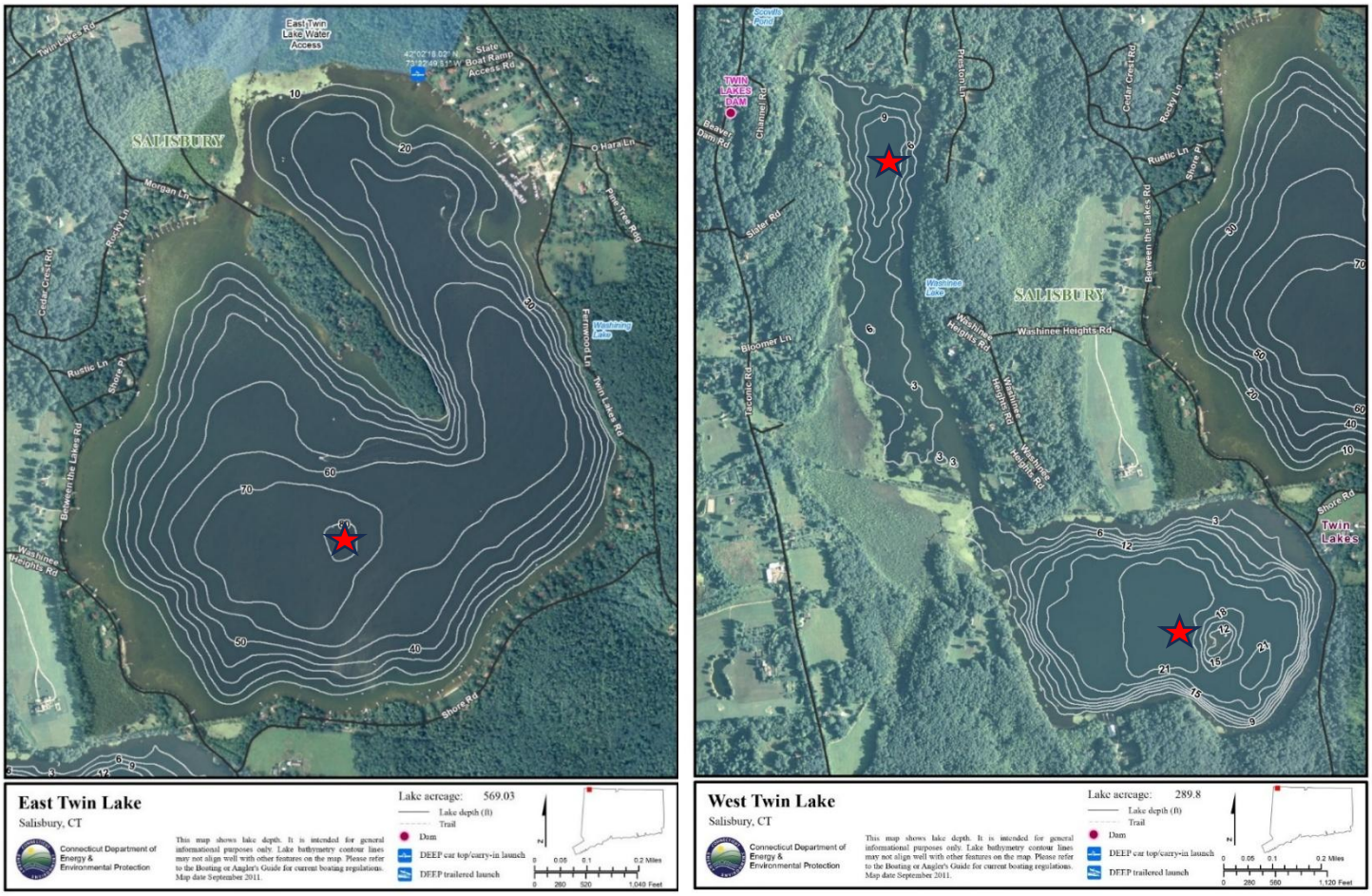
November due to global warming. Modern lake management was born in the mid 1970s after studies in the late 1960s and early 1970s showed that phosphorus limited algae growth. Algae growth was found to be responsible for loss of water clarity, which in turn leads to dark bottom water and oxygen consumption. By the end of the 1970s, the process of Eutrophication had been worked out - phosphorus concentration increases will cause more phytoplankton to grow in the water column. Higher growth rates lead to restricted light penetration, causing lakes to stratify and develop stagnant bottom water. Stagnation leads to loss of dissolved oxygen and development of anoxic water and anaerobic conditions, which allow phosphorus to be released from sediments. Lake monitoring was found to simply involve tracking water temperature, dissolved oxygen, clarity, plankton, and nutrients.

Our monitoring was conducted at the location of deepest water in each of the three water bodies (**Map 1**) and included to following:

- water temperature from top to bottom to determine where, when, and how strongly the lake stratifies
- dissolved oxygen from top to bottom to know the saturation levels and if there is any water with no dissolved oxygen
- the clarity of the water to know how deep the sunlight penetrates
- the nutrients, especially phosphorus, to know how much productivity is possible
- phytoplankton and zooplankton to estimate how much productivity is occurring

East Twin Lake has a maximum depth of 24 meters (~78 feet). Water samples were collected from the top, middle, and bottom of the water column; this equated to 1 meter, 10 meters, and 20 meters. East Twin Lake is a large, deep lake that strongly stratifies into three distinct and stable layers – an upper warm layer, well-lit by sunlight, a middle layer where water temperature changes rapidly with depth and light is dim, and a bottom layer where water temperature is cold and relatively unchanging over the season. Middle Twin Lake is only 6 meters deep, with water samples collected at 1 meter, 3 meters and 6 meters. Middle Twin does not stratify but shows slow bottom water oxygen loss during the season. West Twin Lake is 3 meters deep at maximum, with one water sample collected from 1.5 meters. West Twin Lake is well mixed and fully saturated with oxygen throughout.

Map 1. Twin Lakes water quality monitoring stations.[1]



[1] CT ECO. (n.d.). Bathymetry With Aerial - East Twin Lake [PDF]. Retrieved from http://cteco.uconn.edu/maps/lake/bathymetry/Bathymetry_With_Aerial_East_Twin_Lake.pdf

2024 Twin Lake Water Quality Results

Water Clarity

The water clarity of East Twin Lake generally increased during the season, from the poorest value of 5.6 meters in March to the exceptional value of 8.7 meters in September (**Figure 1**). Initially, water clarity steadily increased from 5.6 meters in March to 8 meters on July 1st, but there was an abrupt decline in transparency in July to ~6 meters. Water clarity was excellent at 8+ meters in August and September. October clarity was slightly reduced at 7.4 meters. The clarity of Middle Twin Lake was identical to East Twin in March, 5.4 meters, but showed a decline in April, contrary to East Twin. Middle Twin water clarity tracked East Twin, although a meter or two less, during the months of May, June, and July. Middle Twin clarity decreased in August and September, despite the much better clarity in East Twin, suggesting that Middle Twin functions differently than East Twin and is little influenced by the bigger lake.

The Secchi disk was typically visible at the bottom of West Twin, at 3.2 ±0.3 meters (**Table 1**). During the months of August and September, the disk could not be seen on the bottom. On those dates, the Secchi disk depth was 2.5±0.1 meters with cyanobacteria in the water column.

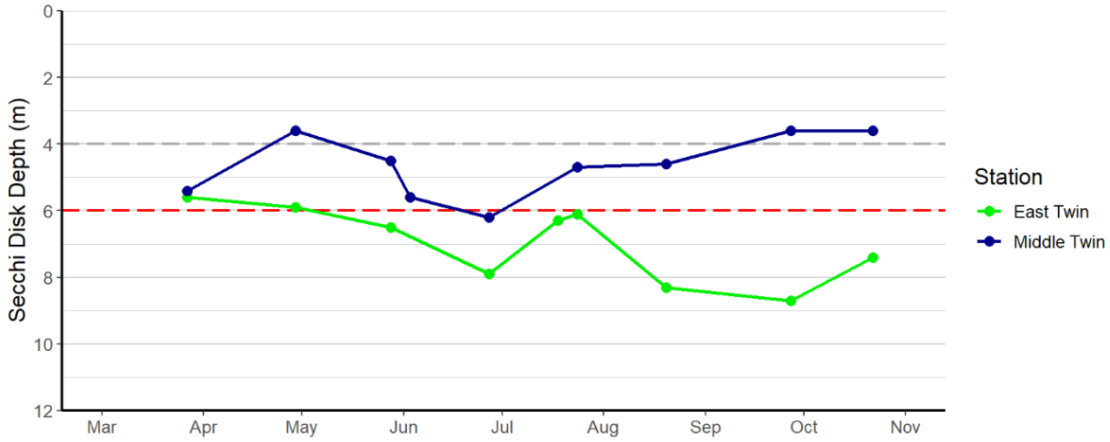


Figure 1. East Twin and Middle Twin Secchi disk depths in 2024.

Table 1. Secchi disk depths in Twin Lakes during 2024. Underlined values are when the Secchi disk was visible on the bottom.

Lake	Mar-27	Apr-29	May-28	Jun-3	Jun-27	Jul-18	Jul-24	Aug-20	Sep-27	Oct-22	2024 Average	2023 Average
East	5.6	5.9	6.5	-	7.9	6.3	6.1	8.3	8.7	7.4	7.0	6.6
Middle	5.4	3.6	4.5	5.6	6.2	-	4.7	4.6	3.6	3.6	4.6	4.5
West	2.8	3.5	3.3	-	3.2	-	2.6	2.4	3.5	3.3	3.1	3.0

Water Temperature

East Twin Lake

The water temperature of East Twin Lake is presented in two ways, first as a series of profiles (**Figure 2**), and secondly as an isopleth which shows lines of equal temperature (**Figure 3**). The isopleth figure shows, by color, the location of the Epilimnion (yellow-green then orange/red), Metalimnion (green) and Hypolimnion (blue). The Epilimnion is the upper layer that receives sunlight, the Metalimnion is the middle layer that does not receive sunlight, so water temperature declines rapidly. The Hypolimnion is the bottom layer that remains cold and dark all the time. The Epilimnion is warmed by the sun and mixed by wind. In March and April, the lake was not stratified. In March, the lake water was uniformly cold with an ice-out temperature of ~4°C from top to bottom[2]. After ice-out, the lake warmed from the top down due to sunlight and wind-generated mixing. The April profile is an excellent example of turbulent mixing moving heat downward, essentially forming a thermocline between the surface and about 8 meters. April surface temperatures reached ~15°C, while deeper water showed almost no increase in temperature.

The lake became stratified in May with a true epilimnion formed between 0 and 3 meters (vertical lines in **Figure 3**). These vertical lines are green at first (May) but become orange (June) then red (July-August) as water temperature increases, then green again in September and October as water cools and the Epilimnion extends down to 8-10meters. Horizontal lines in **Figure 3** show the metalimnion, while blue horizontal lines show the hypolimnion. Note how water below 12 meters warms by only a few degrees over the summer. The white line overlay is the anoxic boundary.

The metalimnion is defined by rapid change in temperature with depth generating high to very high thermal resistance values (**Figure 4)**. Thermal resistance is the energy required to mix two layers of lake water with different temperature. The larger the difference in temperature the more energy is required to mix the two layers of water, depicted as horizontal bars in **Figure 4**. Bars over 30 RTRM indicate stratified water, over 90 is very strong stratification.

[2] During the winter water temperature is lowest, 0°C, under the ice, and warmest at the bottom, 4°C. Once the ice is gone the lake water must uniformly warm to 4°C

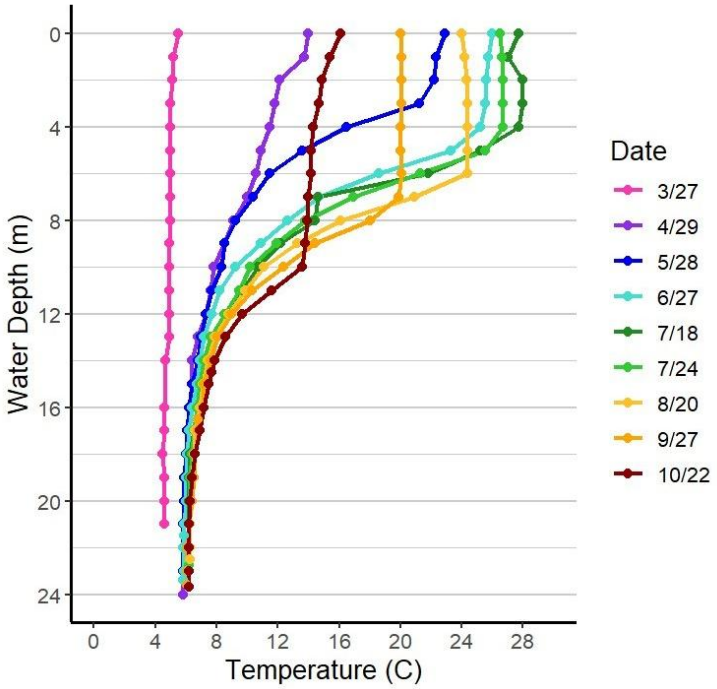


Figure 2. Water temperature profiles in East Twin Lake in 2024.

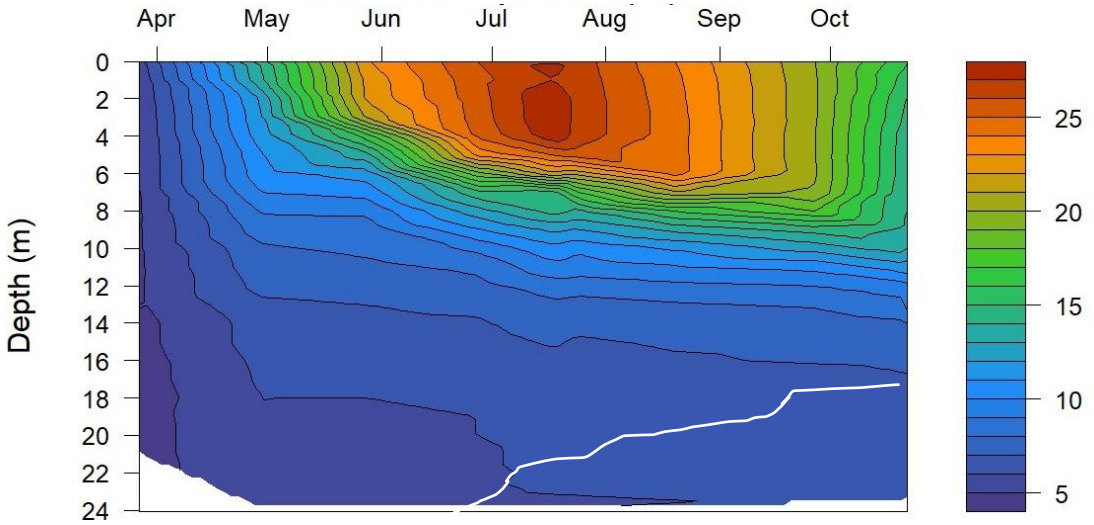


Figure 3. Water temperature isopleth, line of equal temperatures, in East Twin Lake in 2024. The anoxic boundary is shown as a while line.

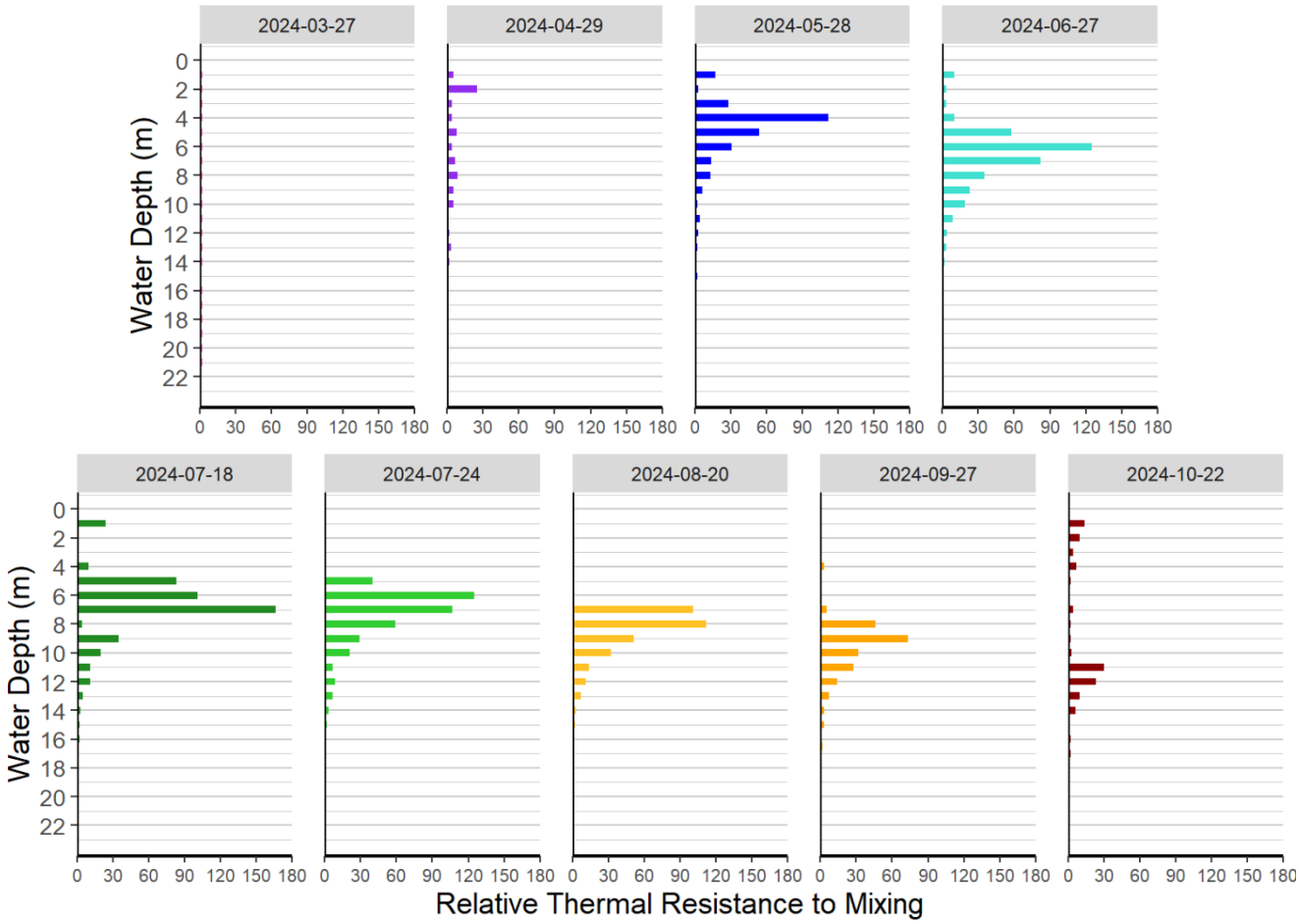


Figure 4. RTRM values for East Twin Lake during 2024.

Dissolved Oxygen

East Twin Lake

Lake water contains a small amount of dissolved oxygen gas that diffuses into the surface water from the atmosphere. The atmosphere contains roughly 80,000 ppm of dissolved oxygen (DO, or O_2), while water can only hold about 14 ppm under perfect conditions. Typically, the surface water of East Twin Lake during the summer holds about 9 ppm DO. Profiles of dissolved oxygen concentration with depth for the 2024 season are shown in **Figure 5**. March shows essentially a straight line from top to nearly the bottom, where there was some slight DO decline. April had high levels of DO throughout the water column except for the very bottom water 25cm above the sediments. May had more normal DO in the top couple of meters but showed the beginning of a MOMax (Metalimnetic Oxygen Maximum) around 12 meters where the DO increases to higher levels than the rest of the water column. The MOMax persisted between ~6 meters and ~10 meters through June, July, and August but by September it was gone.

Anoxic water began accumulating at the bottom in June and developed through the summer to reach maximum volume of 9 meters of anoxic water in October, very similar to October 2023. The size and persistence of the MOMax and anoxia can be seen in the isopleths (**Figure 6, Figure 7**) where red is anoxic water and the MOMax is blue in the top chart and green in the bottom chart.

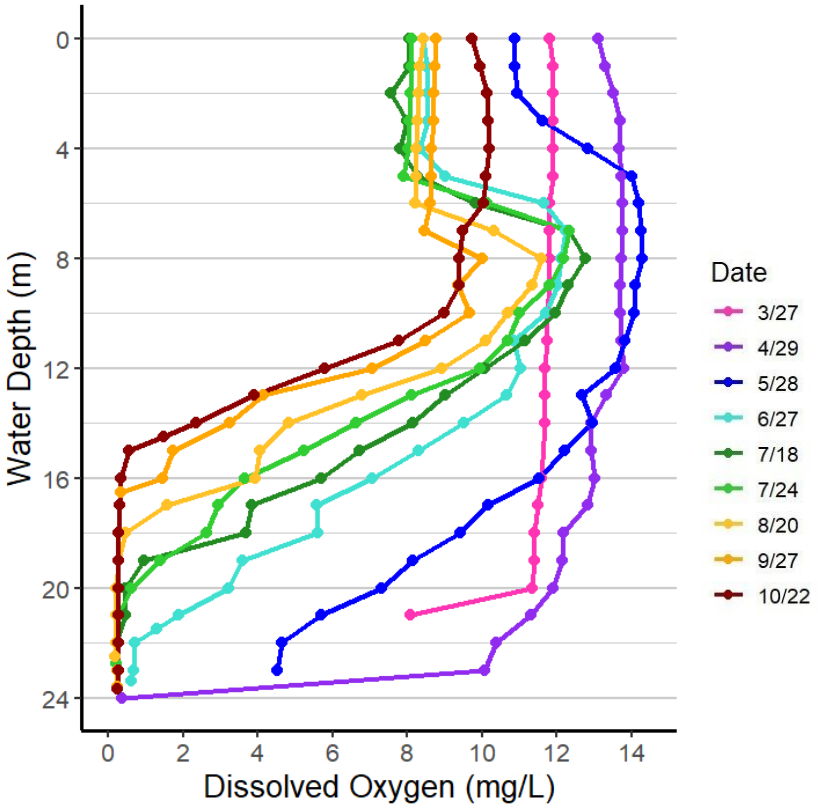


Figure 5. Dissolved oxygen concentrations in East Twin Lake during 2024.

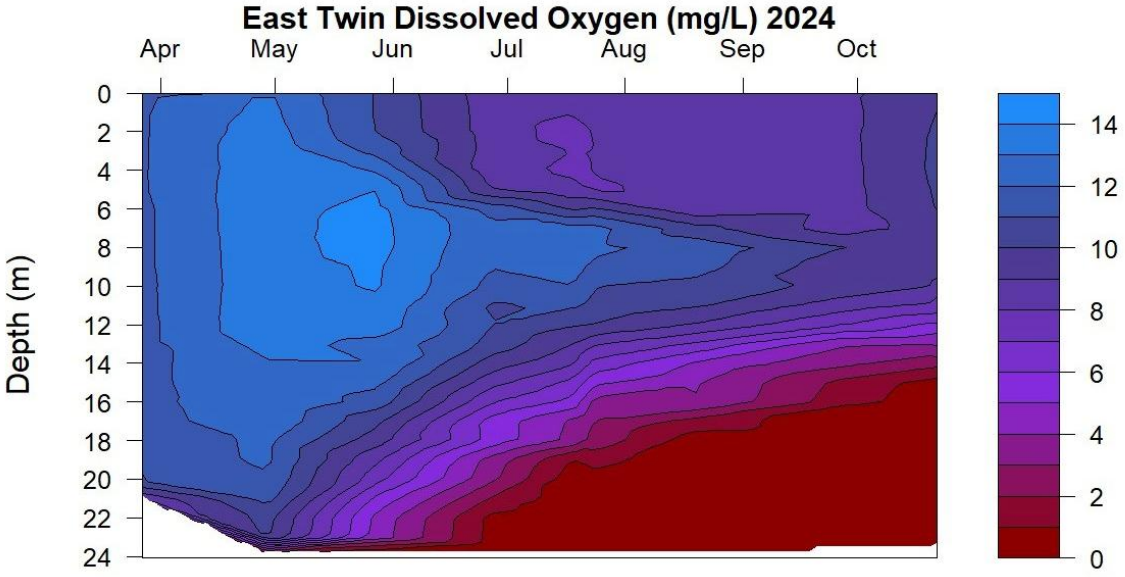


Figure 6. Isopleth chart of dissolved oxygen concentrations in East Twin Lake during 2024.

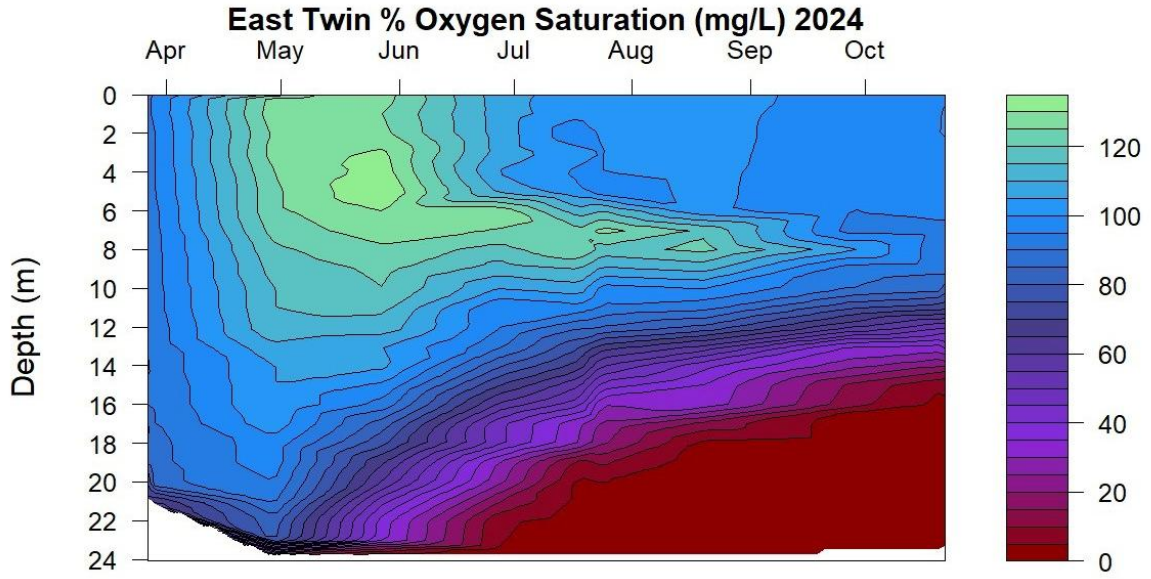


Figure 7. Isopleth chart of oxygen saturation in East Twin Lake during 2024.

Middle Twin Lake

Middle Twin Lake DO levels were excellent for the season except for the very deepest water, where DO was near zero (**Figure 8**). The 6-meter water is a small area that may become stagnant during long periods of calm weather but appears to be oxygenated during windy periods.

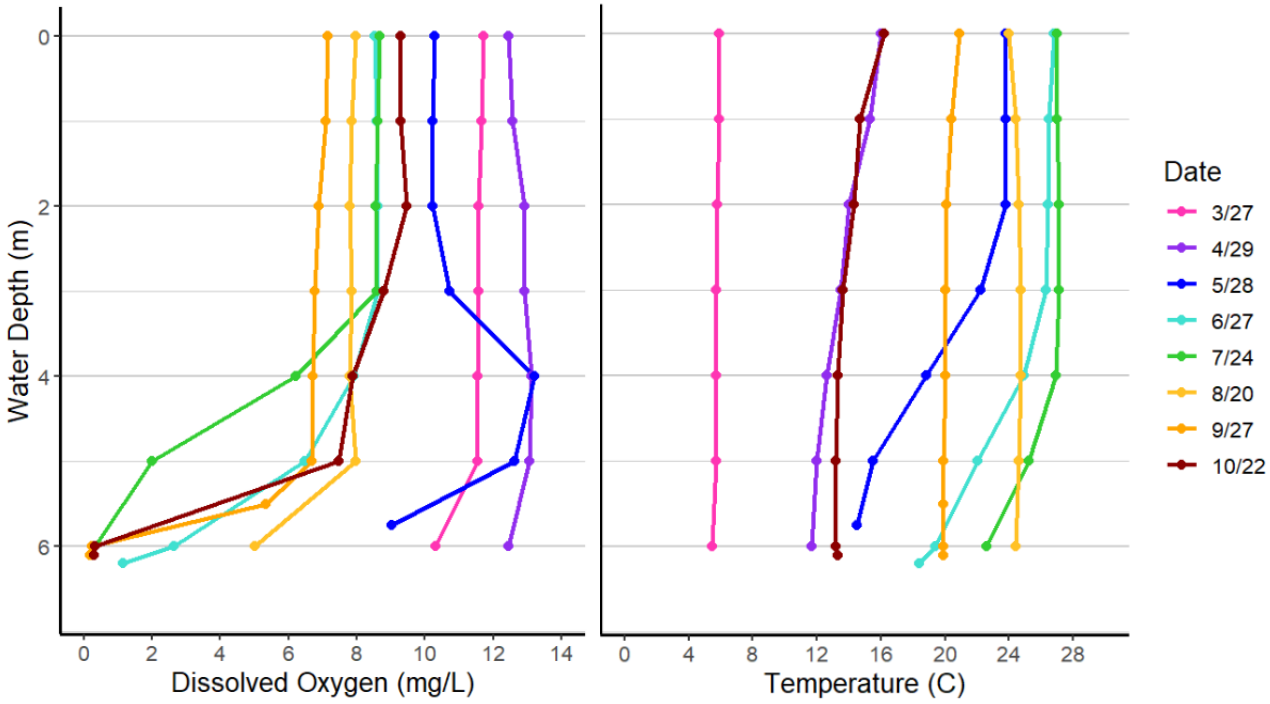


Figure 8. Dissolved oxygen and water temperature profiles in Middle Twin Lake in 2024.

West Twin Lake

The water temperature profiles show the whole water column was well mixed on all dates in 2024 (**Figure 9**). The dissolved oxygen was also equally distributed in the water column with full oxygen to the bottom.

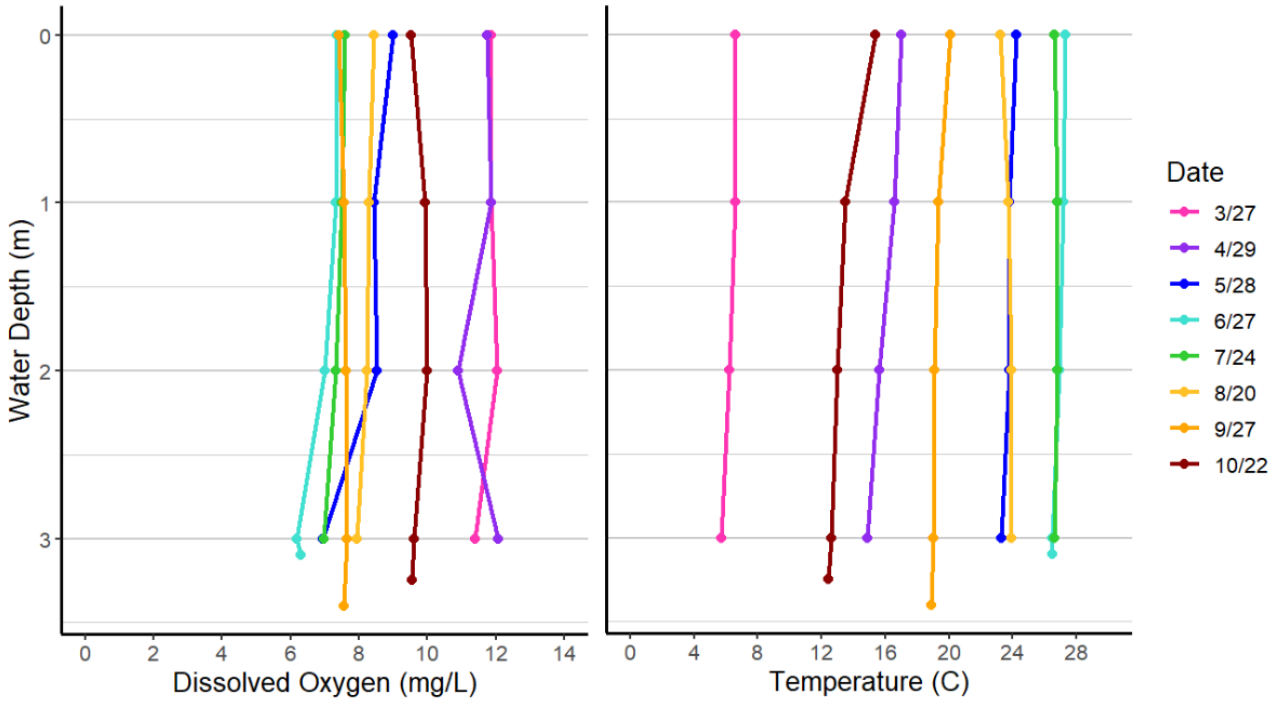


Figure 9. Dissolved oxygen and water temperature profiles in West Twin Lake in 2024.

Conductivity

The conductivity, or conductance, of lake water is its ability to conduct an electrical current. The conductivity of lake water is caused by dissolved salts, reaching very high values in sea water, where it is called salinity. The conductivity of East Twin Lake water is shown in **Figure 10**. Overall, the conductivity was between 240 µS/cm and 275 µS/cm. Upper waters had declining conductivity over the summer, going from about 260 µS/cm to about 240 µS/cm, probably due to settling. Deeper water, below 10 meters, showed increasing conductivity with depth, with highest values over bottom due to internal leaching of salts from the sediments. Conductivity of water below 10 meters increased over the course of the season with highest values occurring in October. The comparably very high value at the bottom in October indicates internal loading from bottom sediments.

Conductivity of Middle Twin and West Twin was generally similar from top to bottom and tended to decline as the season progressed (**Figure 11 & 12**). In Middle Twin, there were some slight increases in conductivity over bottom, indicating some release of salts from the sediment occurred occasionally during the summer. The conductivity of West Twin water was generally always the same from top to bottom. The conductivity of the lake waters increased from East to West (**Figure 13**).

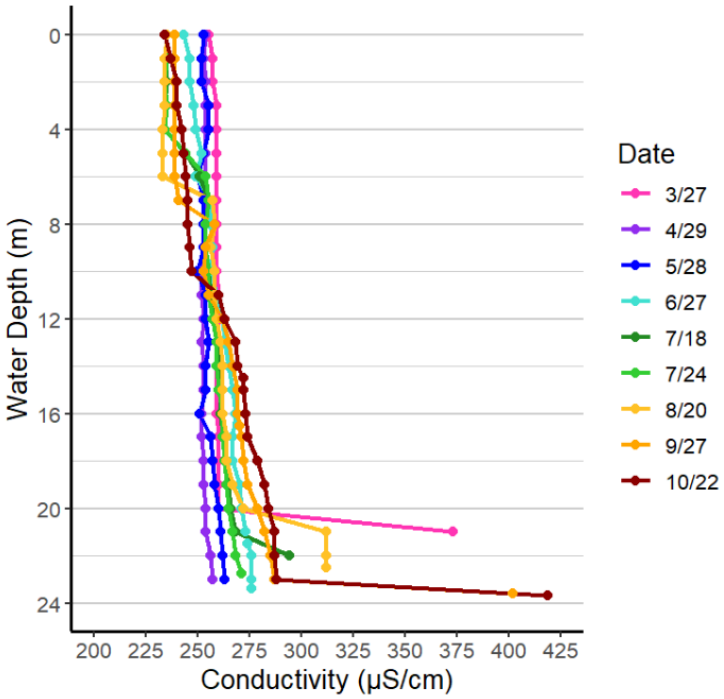


Figure 10. Conductivity profiles in East Twin Lake in 2024.

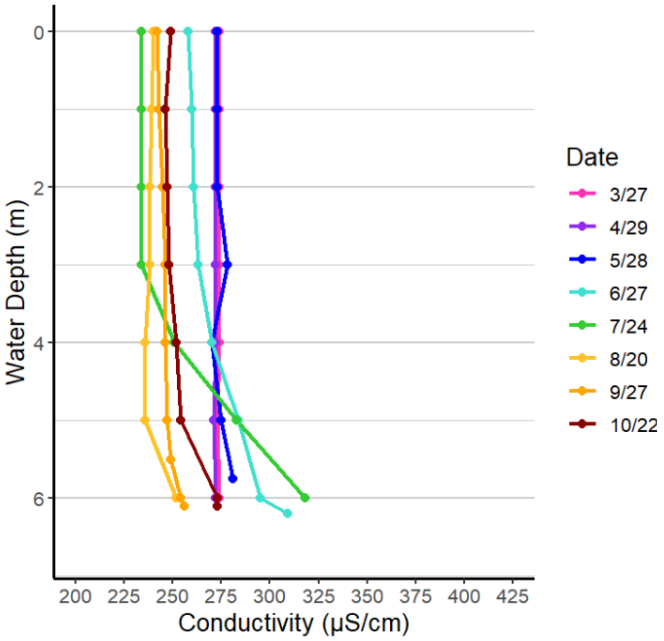


Figure 11. Conductivity profiles in Middle Twin Lake in 2024.

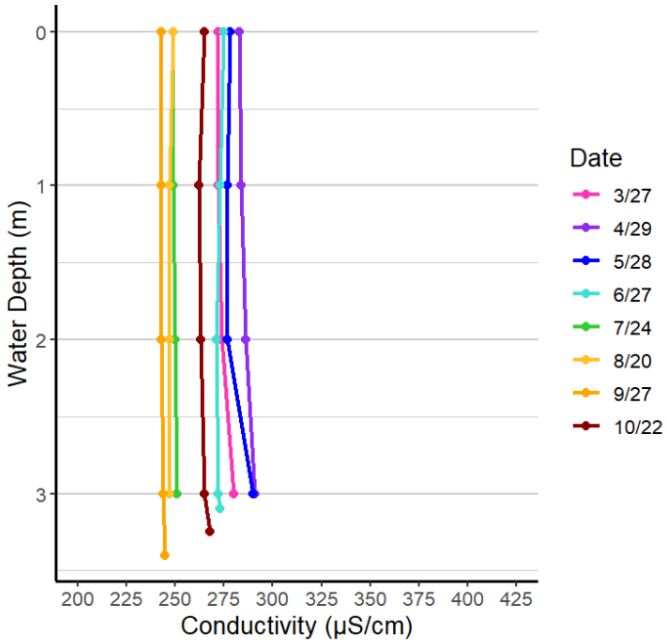


Figure 12. Conductivity profiles in West Twin Lake in 2024

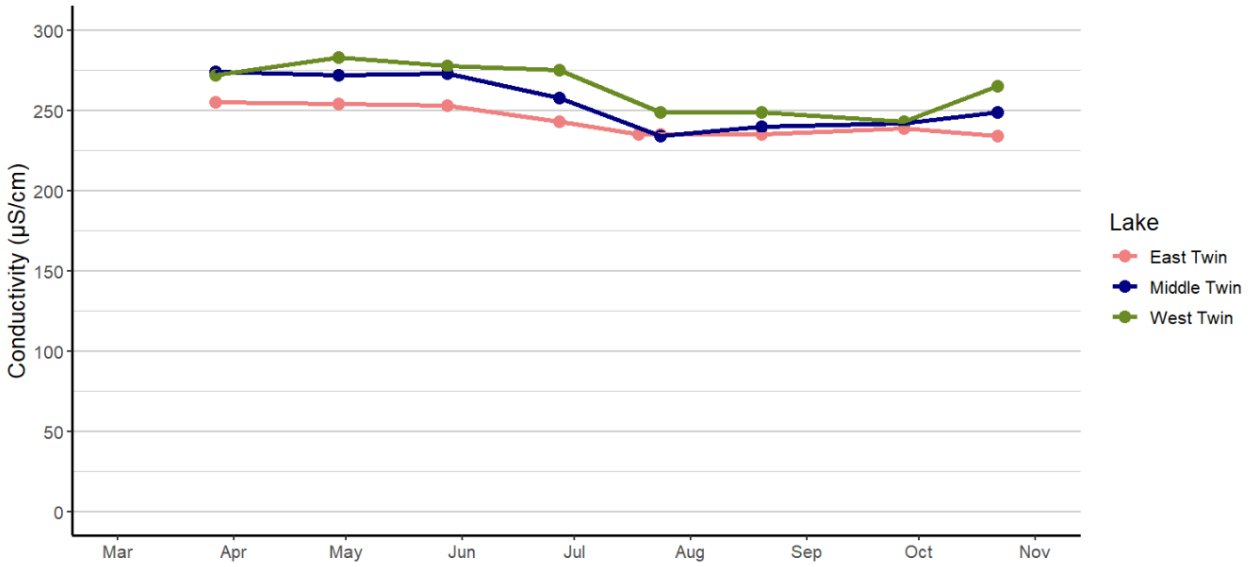


Figure 13. Conductivity at the surface of each lake in 2024.

Nutrients

Total Phosphorus

The total phosphorus concentration (TP) in the top 10 meters was excellent in 2024 (**Table 2**, **Figure 14**). The early months, March, April, and May, showed very low to barely detectable levels. TP concentration increased in July and August, then decreased to very low levels in October. Bottom water was only slightly higher than shallower depths until September and more so in October when the TP concentration increased to 70 ppb and then 125ppb, respectively. The bottom water was anoxic beginning in June, but levels remained low in July and August, suggesting that the redox potential is still high, such that little anaerobic respiration was occurring during those months. September and October showed signs that internal loading was occurring during those months.

Midde Twin also had low levels in March, April, and May, but not as low as East Twin (**Table 3, Figure 15**). In June, TP was higher in Middle Twin than East Twin, indicating a separate source of phosphorus. The 1- and 3-meter samples were generally higher than East Twin for the remainder of the season. The bottom water, 6m, showed brief internal loading only in July when the deep hole stagnated.

West Twin similarly had very low TP concentrations in April and May, increased somewhat in July and August, but was low again in September and October (**Table 4, Figure 16**).

Table 2. East Twin 2024 total phosphorus concentrations (ppb).

Depth (m)	Mar-27	Apr-29	May-28	Jun-27	Jul-24	Aug-20	Sep-27	Oct-22
1	2	1	1	6	10	10	9	2
10	3	2	1	10	10	11	12	4
22	7	9	10	15	11	19	69	125

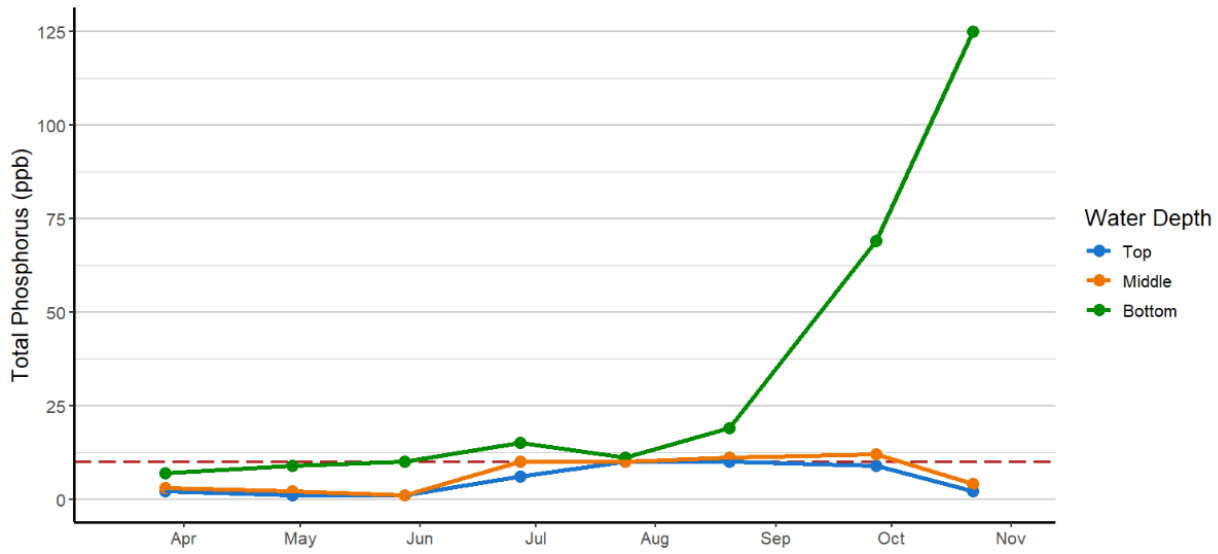


Figure 14. East Twin Lake 2024 total phosphorus concentrations.

Table 3. Middle Twin 2024 total phosphorus concentrations (ppb).

Depth (m)	Mar-27	Apr-29	May-28	Jun-27	Jul-24	Aug-20	Sep-27	Oct-22
1	8	2	4	16	7	12	18	9
3	5	2	5	17	10	18	18	18
5	6	9	7	21	28	11	15	14

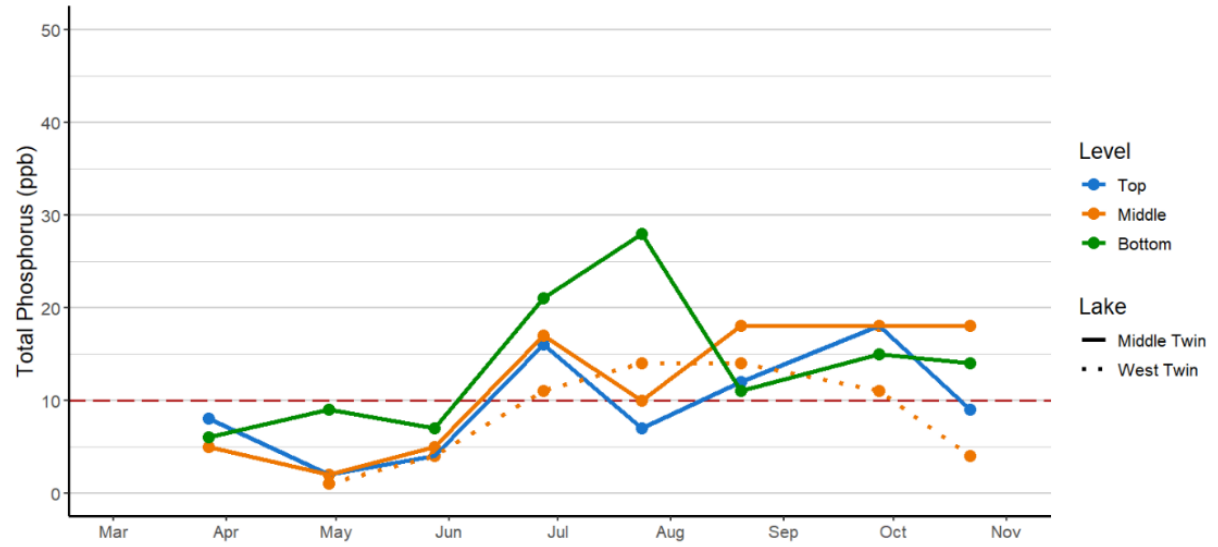


Figure 15. Middle and West Twin Lake 2024 total phosphorus concentrations.

Table 4. West Twin 2024 total phosphorus concentrations (ppb).

Depth (m)	Apr-29	May-28	Jun-27	Jul-24	Aug-20	Sep-27	Oct-22
1.5	1	4	11	14	14	11	4

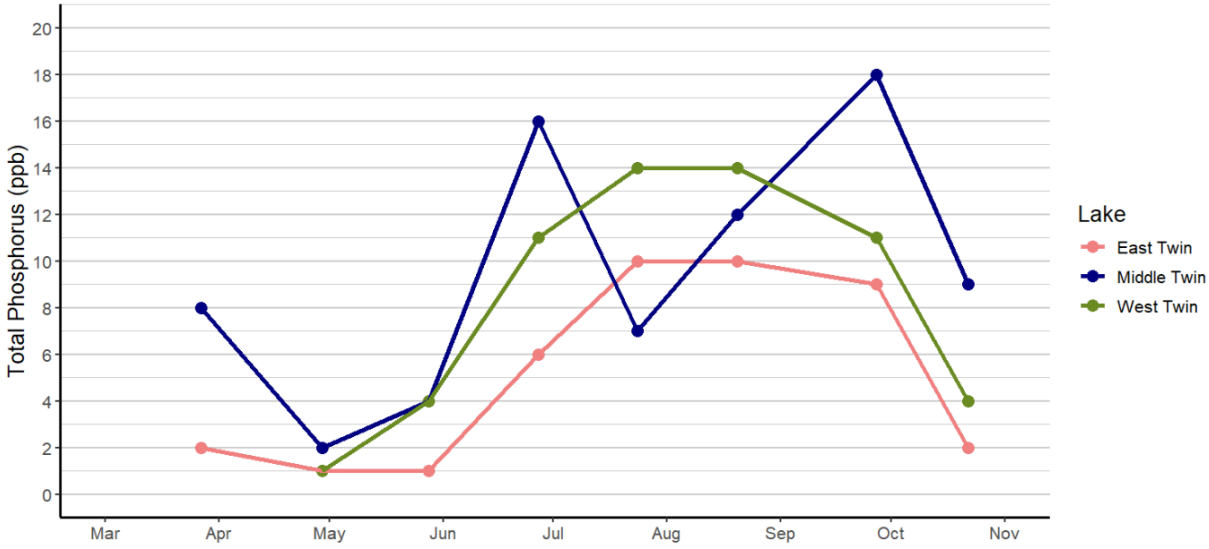


Figure 16. One-meter total phosphorus concentration in each lake during 2024.

Total Nitrogen

The total nitrogen levels represent all forms of nitrogen in the lake. Nitrogen occurs in several forms in lake water – particulate organic, inorganic and oxidized, and organic and reduced. Background total nitrogen concentrations tend to vary between 100 and 200 ppb. As lakes become more eutrophic, total nitrogen concentration increases. East Twin total nitrogen (TN) at the top and middle depths (**Figure 17**, blue shaded in **Table 5**) was generally below 300ppb, indicating a low level of TN in this lake. Interestingly, TN in the bottom water increased in May, prior to the advent of anoxia in bottom water. The TN concentration then decreased and was low during the months of June, July, and August, while anoxia was increasing. By August 20th, the anoxic boundary was up to ~18 meters. TN concentration increased in September and October but not dramatically so. Bottom water ammonia, an indicator of internal loading, was very low until September when it was slightly elevated, and October when ammonia concentration was high, comprising slightly more than half of the total nitrogen at that time (**Table 6**). Overall, these values are very low.

Middle Twin generally had higher concentrations of TN than East Twin, the highest difference was ~100ppb in September and October, otherwise between 14 and 35ppb (**Figure 18** and **Table 7**). On three dates East Twin had higher surface TN than Middle Twin. There was little evidence that Middle Twin is internally loading nitrogen.

West Twin always had higher concentrations than the 1-meter East Twin concentration, generally by ~100ppb, largest difference was 247 ppb in October (**Figure 18** and **Table 8**). West Twin showed an increase in TN in July that was not experienced at East or Middle Twin. The concentration increased by ~60 ppb representing a large increase in nitrogen that didn't come from Middle Twin Lake (**Figure 19**).

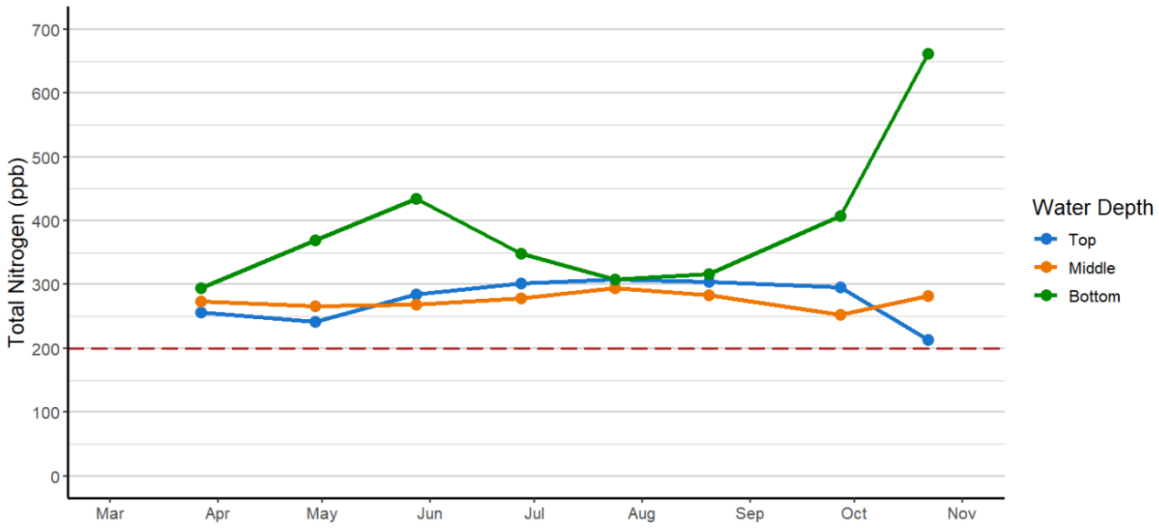


Figure 17. Total nitrogen concentrations at the top, middle, and bottom of East Twin Lake in 2024.

Table 5. East Twin 2024 total nitrogen concentrations (ppb).

Depth (m)	Mar-27	Apr-29	May-28	Jun-27	Jul-24	Aug-20	Sep-27	Oct-22
1	256	241	285	302	308	304	295	213
10	274	266	269	279	294	283	253	282
20	294	369	435	349	308	316	407	662

Table 6. East Twin 2024 bottom water ammonia concentrations (ppb).

Depth (m)	28-May	27-Jun	24-Jul	20-Aug	27-Sep	22-Oct
20	89	34	20	31	153	365

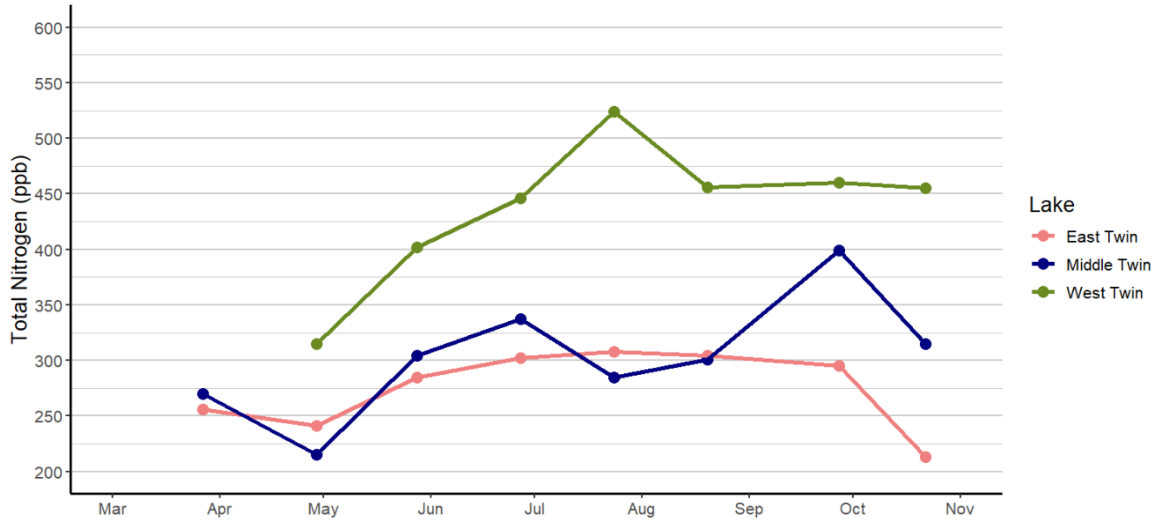


Figure 18. Total nitrogen concentrations at 1 meter at all lakes in 2024.

Table 7. Middle Twin 2024 total nitrogen concentrations (ppb).

Depth (m)	Mar-27	Apr-29	May-28	Jun-27	Jul-24	Aug-20	Sep-27	Oct-22
1	270	215	304	337	285	301	399	315
3	252	261	289	338	298	340	395	394
5	257	280	302	329	401	294	364	383

Table 8. West Twin 2024 total nitrogen concentrations (ppb).

Depth (m)	Apr-29	May-28	Jun-27	Jul-24	Aug-20	Sep-27	Oct-22
1.5	315	402	446	524	456	455	460

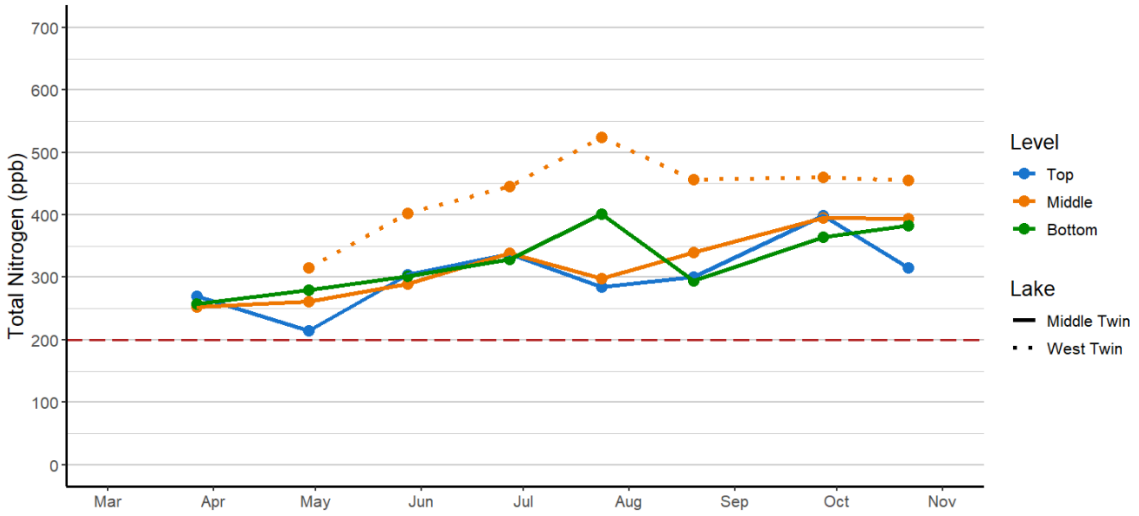


Figure 19. Total nitrogen concentrations in Middle Twin (top, middle, and bottom) and West Twin (middle) during 2024.

During the final water quality visit on November 25th, NEAR was unable to access the established WQ stations. As a result, a water sample was collected from a location between East and Middle Twin, accessible by land (**Map 2**). The profile data is shown in **Table 9**, and the nutrient data is provided in **Table 10**. ND implies "Non Detect", meaning the result was below the laboratories detection limit.

Map 2. Water quality sampling location on November 25th, 2024.

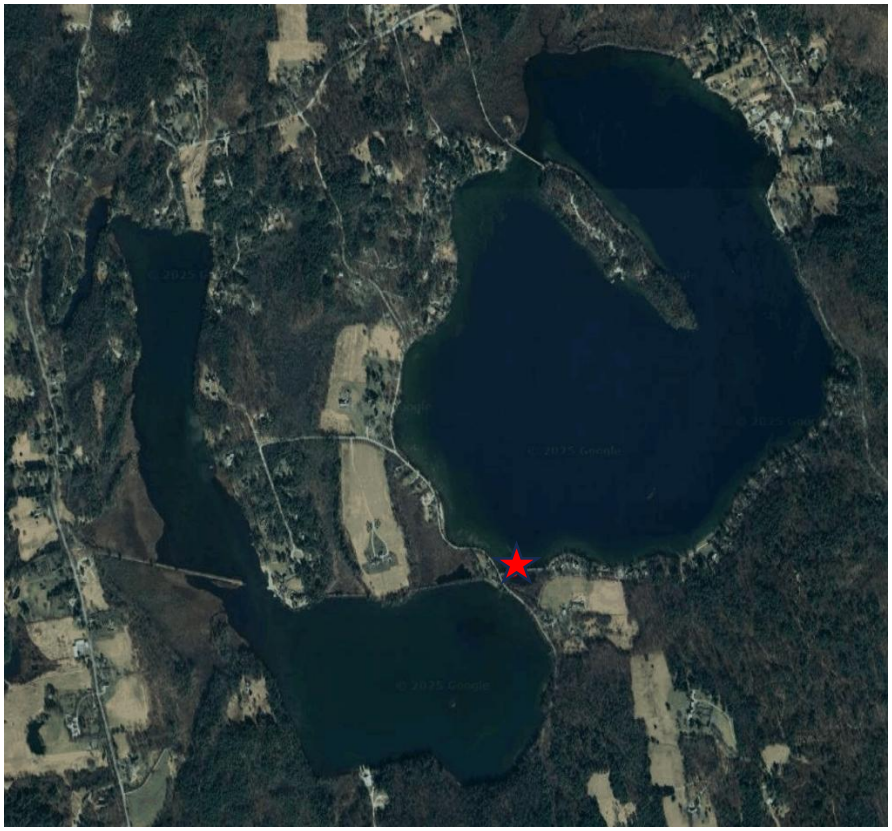


Table 9. Profile data collected 11/25/2024.

Depth	Temperature °C	Dissolved Oxygen mg/L	Oxygen Saturation %	Conductivity µS/cm
Surface	7.4	10.2	86.7	257

Table 10. Nutrient data collected 11/25/2024.

TP	TN	NH_3	NO_X
10	255	10	ND

Plankton

The plankton in a lake are small plants and animals. The plants are photosynthetic organisms that are referred to as algae or phytoplankton. They are either single cells, filaments or chains of cells, or colonies of many cells. All cells, regardless of what shape of configuration, are smaller than 20µm. The animals are zooplankton, also called water fleas. They are predators on other zooplankton or small phytoplankton. Together, phytoplankton and zooplankton compose the base of the aquatic food chain.

Phytoplankton

The algae community was represented only by Diatoms for the first few months and then in July and August small numbers of Green algae as well (**Figure 20**). Cyanobacteria were present at modest numbers in September and moderate numbers in October (**Figure 21**). In West Twin Lake, buoyant cyanobacteria colonies of the genera Microcystis were present in July and August (**Figure 22** and **Figure 23**). These colonies were very large, composed of many cells. Phytoplankton samples were not included in the regular sampling at Middle and West Twin in 2023 and 2024 but will be added in 2025.

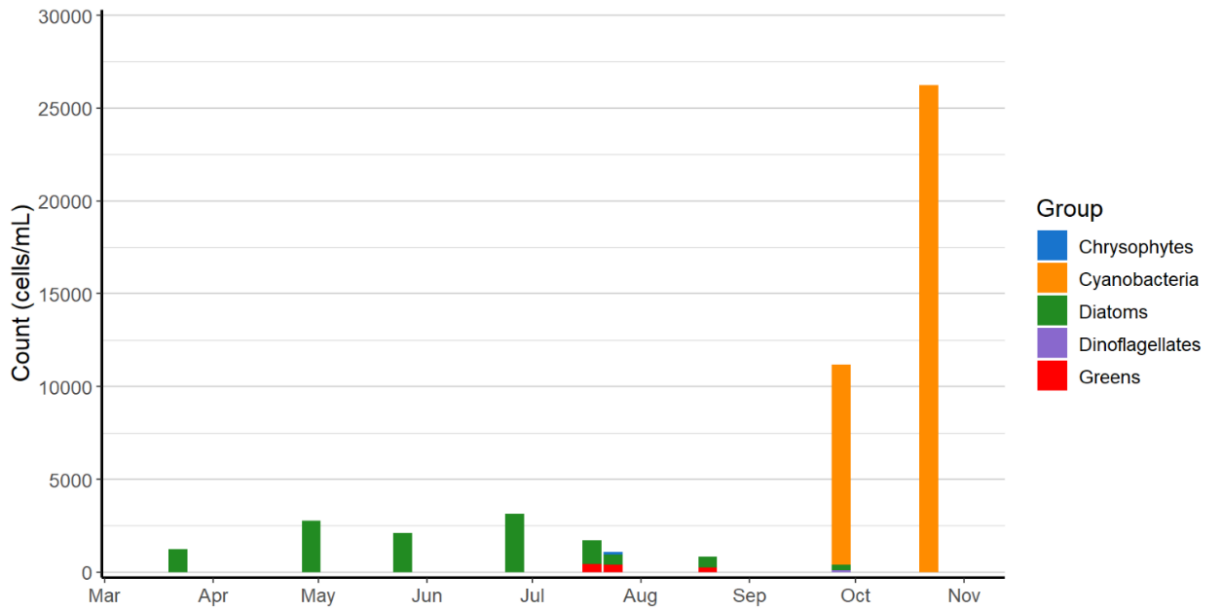


Figure 20. East Twin total algae counts.

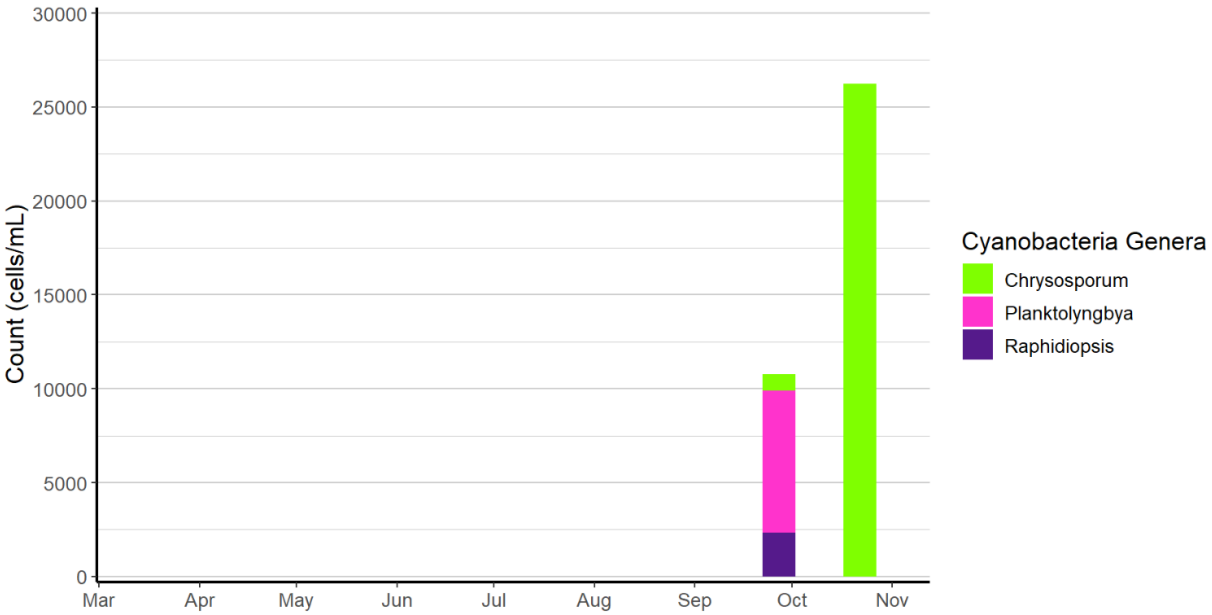


Figure 21. East Twin cyanobacteria genera counts.

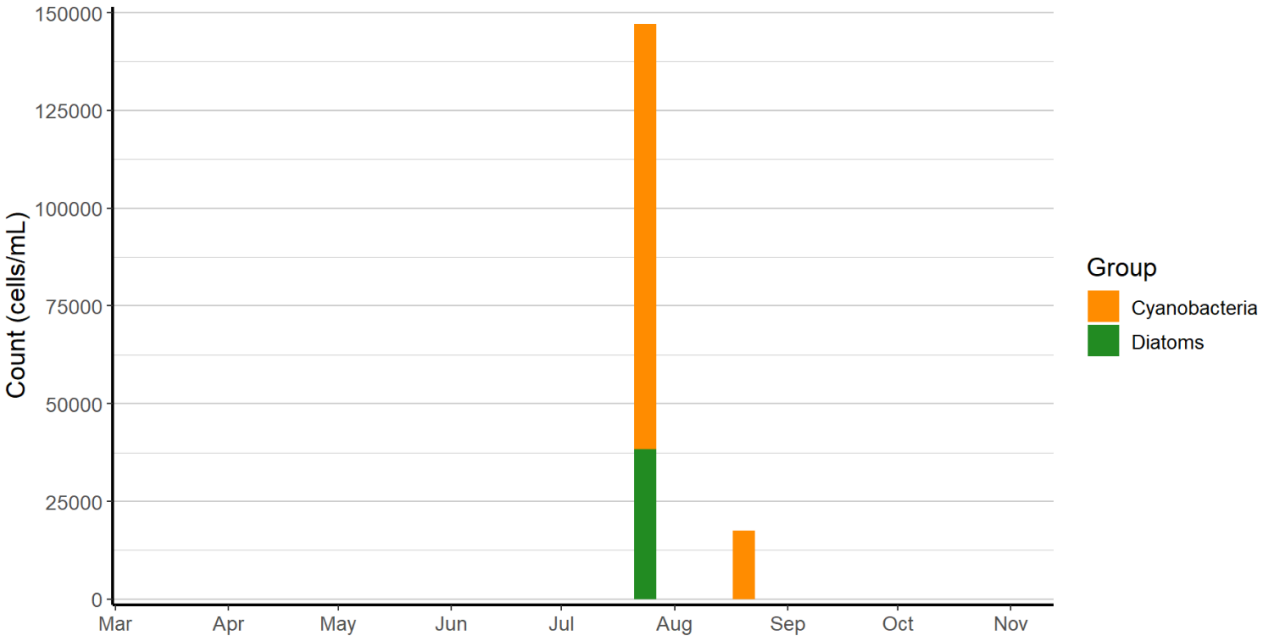


Figure 22. West Twin counts from surface water samples collected on July 24th, and August 20th.

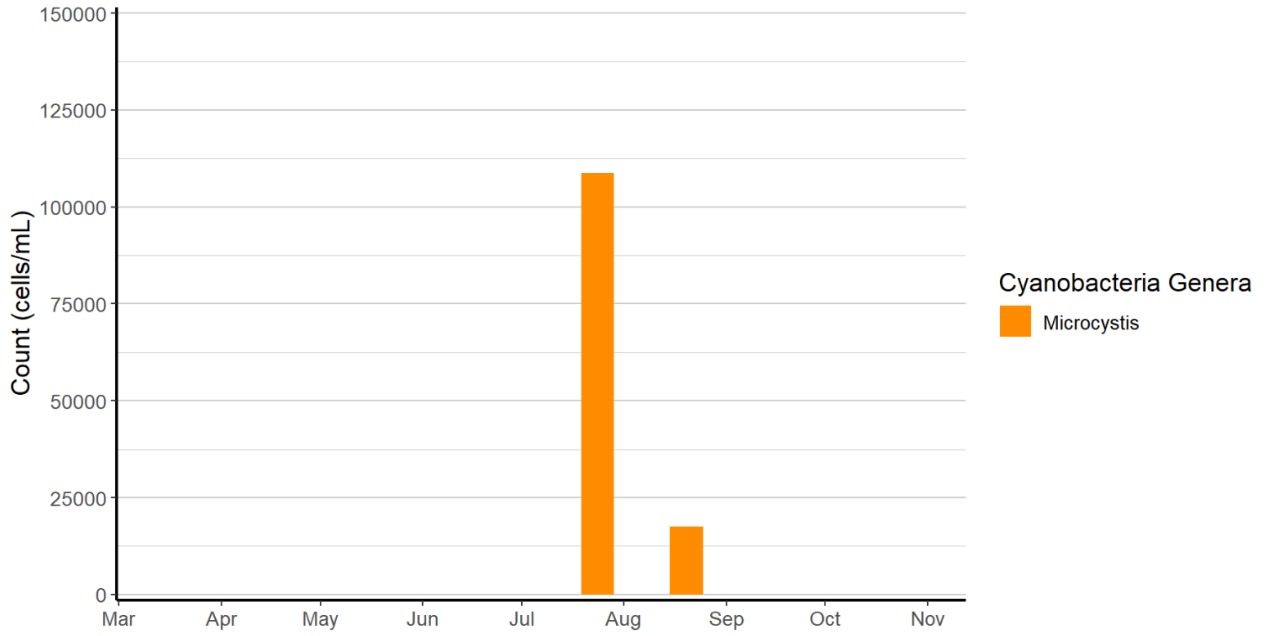


Figure 23. Cyanobacteria genera cell counts from West Twin surface water collected on July 24th, and August 20th.

Table 11. WHO guidance values for the relative probability of health effects resulting from exposure to cyanobacteria.

Relative Probability of Acute Health Effects	Cyanobacteria Density (Cells/mL)
Low	< 20,000
Moderate	20,000-100,000
High	100,000-10,000,000
Very High	> 10,000,000

Zooplankton

The zooplankton community in East Twin Lake in 2024 consisted of five groups but numbers were very low, and the animals were rarely larger than 0.4 mm (**Figure 24** and **Figure 25**). Rotifers were dominant in all samples. Small numbers of other groups but always only very small organisms were sampled. Zooplankton of this type, impoverished of large-bodied organisms, is consistent with a lake that has been stocked with landlocked alewives.

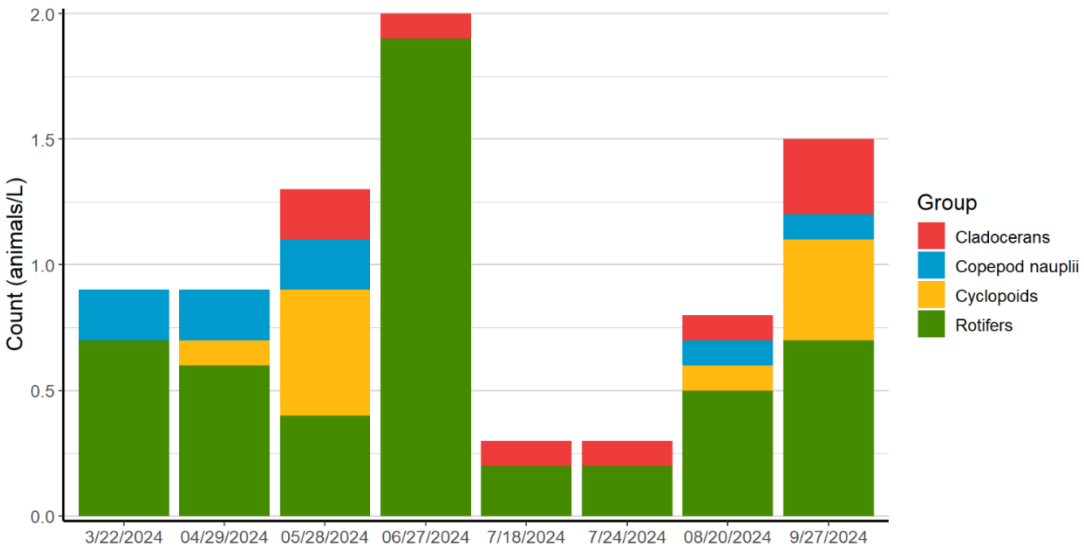


Figure 24. Zooplankton count (animals per liter) in East Twin in 2024.

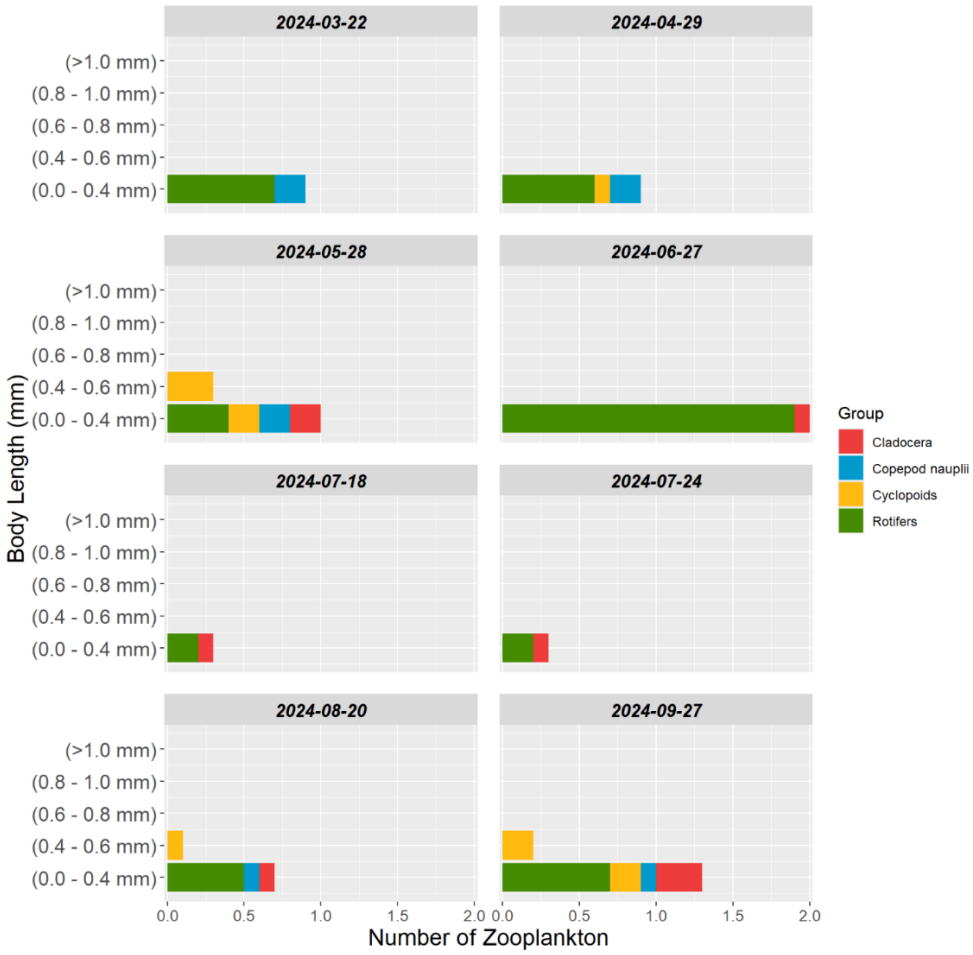


Figure 25. Zooplankton numbers by size classes in East Twin in 2024.

Aquatic Plant Survey Results

The aquatic plants in Twin Lakes were completely surveyed three times in 2024, with each survey requiring 6 days to complete.

- June 24th to July 2nd (854 waypoints, 473 in East Twin, 156 in Middle, 225 in West Twin)
- August 21st to 29th (773 waypoints, 421 in East Twin, 145 in Middle, 207 in West Twin)
- October 1st to 16th (685 waypoints, 443 in East Twin, 107 in Middle, 135 in West Twin)

A complete survey involves sampling the plant community throughout the entire littoral zone of all three lakes. The littoral zone is the shallow waters of a lake where plants can grow due to available sunlight. Aquatic plants cannot grow deeper than light penetration allows. Survey waypoints were created throughout the littoral zone using GPS. At each waypoint, all species were identified, and density was estimated for each species. Waypoints were made systematically between the shore and the outer edge of the littoral zone. Waypoints were also made in deep water where no plants exist to confirm we found the outer edge of the littoral zone.

During the June/July survey (here after referred to as the June survey), new waypoints were created. In the August survey, we returned to waypoints made during the June survey, skipping redundant ones, such as points

made on the expansive Chara beds on the west side of East Twin Lake where the same three species were found at the same density and cover throughout. In the October survey, new waypoints were created based on the existing conditions because generally there were fewer plants.

We found 45 species of aquatic plants during the June survey, the highest of any of our surveys of Twin Lakes, including 2023. In August we returned to waypoints made in June but found only 33 species. In October, we found 39 species (**Table 12**). West Twin had the highest number of species, while Middle Twin had the lowest number of species. The species found in East and Middle Twin were synonymous, with no endemic species to either basin (this does not include Hydrilla which has only been found in East Twin). There were several species that were found in West Twin but not found in the other two (**Table 13**).

Table 12. Total species counts by survey and basin for 2024.

Basin	June	August	October
East Twin	30	22	27
Middle Twin	24	19	17
West Twin	33	22	28
All Basins	45	34	38

Table 13. Aquatic plant species specific to West Twin Lake in 2024

Schoenoplectus subterminalis
Alisma sp.
Sagittaria graminea
Najas minor
Utricularia purpurea
Eleocharis robbinsii
Ludwigia sp.
Potamogeton praelongus

The changes in species frequency between surveys is given in **Table 14.** There were three species present at high levels of abundance, >20%, in all three surveys (blue shading), and there were 26 species (green shading) present in all three surveys, although at consistently lower frequencies, most less than 5%. Of the 45 species found in June, 19 were found less than 1% of the time. A species with a frequency of 1% was found at 9 of the 854 waypoints. This high number of scarce and very scarce species suggests that Twin Lakes has significant micro habitats, where small changes in environmental factors create large changes in the plant community. There were 21 species that were found at very low frequency in June and were not found in August, but were found again in October. Changes in biomass coverage of the dominant species may explain some of this change. In June, most robust species hadn't developed yet, so the water column was not crowded with plants. In August, there were more topped out plants and larger foliage on standing plants, so the water column was crowded, making some species more difficult to find.

Results of each of the three surveys have been separated by basin, June in **Table 15**, August in **Table 16**, and October in **Table 17**. In June, the survey results by basin show that East Twin had 30 species, Middle Twin had 24 species, and West Twin had 33 species. There were 3 species dominant in all three basins (*Chara, Vallisneria americana, and Potamogeton amplifolius*), and an additional 6 species were dominant, ≥20%, in at least one of the three basins. There were 9 species that were found at lower frequences in all three basins.

In August (**Table 16**), the total number of species in East Twin was 22, 19 in Middle Twin, and 22 in West Twin. The same three species were dominant in all three basins (*Chara, Vallisneria americana, and P. amplifolius*).

There were 7 species that had ≥20% frequency in at least one basin, mostly the same species as in June. There were only 4 species that were present in all three basins but at lower frequency.

In October (**Table 17**), the total species count by basin was lower, with 27 species in East Twin, 17 species in Midde Twin, and 28 species in West Twin. In October, the same 3 species were dominant in all three basins (*Chara, Vallisneria americana, and P. amplifolius*). There were 5 species found in only one or two of the basins ≥20% frequency. There were only 7 species found at lower frequencies in all three basins.

Table 14. Frequency of occurrence of Aquatic plant species during three surveys in 2024. Zeros cells are blank. Blue shading indicates dominant species with frequency of ≥20%, green shading indicates lower frequency species found during all three surveys. Pink shading indicates protected species.

Species	Overall Frequency		
	June	August	October
Chara sp.	50.4	46.2	54.7
Potamogeton amplifolius	40.2	39.5	52.0
Vallisneria americana	36.9	61.6	57.2
Najas flexilis	17.2	21.5	1.5
Potamogeton illinoensis	17.1	30.3	34.2
Spirogyra	14.7	1.4	1.6
Nymphaea odorata	11.1	12.8	9.1
Potamogeton zosteriformis	8.0	7.4	1.2
Nuphar variegata	7.4	10.5	6.6
Najas guadalupensis	6.3	10.7	13.4
Elodea nuttallii	5.9	7.6	4.7
Myriophyllum spicatum	4.3	4.0	5.4
Hydrilla verticillata	3.9	0.6	1.8
Utricularia geminiscapa	3.8	1.3	1.6
Utricularia intermedia	3.8	1.8	1.0
Potamogeton crispus	3.3	0.3	0.1
Potamogeton robbinsii	3.3	2.7	3.9
Nitella sp.	3.3	0.1	1.3
Eleocharis robbinsii	3.0		
Bidens beckii	2.7	3.6	1.8
Brasenia schreberi	2.7	3.4	0.9
Elodea canadensis	2.6	1.1	1.3
Utricularia purpurea	1.9	1.3	0.1
Pontederia cordata	1.5	1.2	1.3
Ranunculus sp.	1.4		0.4
Utricularia gibba	1.3	2.2	1.6
Potamogeton natans	0.9	0.5	0.3
Schoenoplectus subterminalis	0.9	1.3	3.8
Ceratophyllum demersum	0.8	2.3	3.2
Potamogeton friesii	0.7		
Ludwigia sp.	0.7		
Potamogeton pusillus	0.6	0.5	0.1
Schoenoplectus acutus	0.6	0.4	0.6
Decodon verticillatum	0.4	1.8	0.1
Potamogeton oakesianus	0.2		0.3
Potamogeton nodosus	0.2		0.4
Alisma	0.2		
Sagittaria graminea	0.2		0.3
Utricularia macrorhiza	0.2	4.1	0.4
Lemna trisulca	0.1	0.1	
Spirodela polyrhiza	0.1		
Zosterella dubia	0.1		
Najas minor	0.1	2.7	
Potamogeton praelongus	0.1		0.1
Potamogeton strictifolius	0.1		
Nitella confervacea			0.1
Potamogeton foliosus-q		0.1	0.1

Table 15. Frequency of occurrence during June survey divided by basin and sorted by values in 'East' column. Blue shading indicates dominant species present in all basins and in at least one with frequency ≥20%. Green shading indicates low frequency species present in all three basins. Pink shading indicates protected species.

Species	June Survey		
	East	Middle	West
Chara sp.	54.5	25.0	59.1
Potamogeton amplifolius	30.2	35.3	52.0
Vallisneria americana	28.5	42.9	50.2
Spirogyra	21.6	9.6	3.6
Potamogeton illinoensis	14.2	20	21.3
Hydrilla verticillata	7.0		
Elodea nuttallii	6.1	9.0	3.1
Potamogeton robbinsii	5.5	0.6	0.4
Potamogeton zosteriformis	4.2	26.9	2.7
Nymphaea odorata	4.0	12.8	24.4
Najas flexilis	2.7	35.9	34.7
Potamogeton crispus	2.1	10.9	0.4
Myriophyllum spicatum	2.1	12.2	3.6
Najas guadalupensis	2.1	17.3	7.1
Nuphar variegata	1.9	3.8	21.3
Pontederia cordata	1.7		2.2
Potamogeton natans	1.7	0.6	
Ranunculus sp.	1.5	2.6	0.4
Bidens beckii	1.3	8.3	
Potamogeton pusillus	1.1		
Schoenoplectus acutus	0.8		0.4
Utricularia geminiscapa	0.6	0.6	4.0
Potamogeton oakesianus	0.4		
Potamogeton nodosus	0.4		
Nitella sp.	0.4	11.5	3.6
Lemna trisulca	0.2		
Utricularia intermedia	0.2		13.3
Spidorela polyrhiza	0.2		
Decodon verticillatum	0.2		0.9
Zosterella dubia	0.2		
Utricularia gibba			5.3
Elodea canadensis		14.1	
Brasenia schreberi		1.3	9.3
Potamogeton friesii		2.6	
Ceratophyllum demersum		1.9	1.8
Schoenoplectus subterminalis			3.6
Alisma sp.			0.9
Sagittaria graminea			0.9
Najas minor			0.4
Utricularia purpurea			7.1
Eleocharis robbinsii			11.6
Ludwigia sp.			2.7
Utricularia macrorhiza			0.9
Potamogeton praelongus			0.4
Potamogeton strictifolius		0.6	
Nitella confervacea			
Potamogeton foliosus-q			
Totals =	30	24	33

Table 16. Frequency of occurrence of plant species found during August survey divided by basin and sorted by values in East column. Blue shading indicates dominant species present in all basins and in at least one with frequency ≥20%. Green shading indicates low frequency species present in all three basins. Pink shading indicates protected species.

Species Name	August		
	East	Middle	West
Chara sp.	62.2	19.3	32.4
Vallisneria americana	59.9	58.6	66.7
Potamogeton illinoensis	36.8	15.2	32.9
Potamogeton amplifolius	34.2	30.3	56.5
Najas flexilis	11.9	33.1	32.9
Elodea nuttallii	6.7	21.4	
Najas guadalupensis	6.7		20.3
Potamogeton robbinsii	5.0		
Potamogeton zosteriformis	3.3	22.8	4.8
Spirogyra	2.6		
Nymphaea odorata	2.6	18.6	29.5
Myriophyllum spicatum	2.6	12.4	1.0
Nuphar variegata	2.4	11.0	26.6
Bidens beckii	1.4	13.8	
Hydrilla verticillata	1.2		
Potamogeton pusillus	1.0		
Potamogeton natans	1.0		
Ceratophyllum demersum	0.7	10.3	
Pontederia cordata	0.5	1.4	2.4
Utricularia geminiscapa	0.5	0.7	3.4
Najas minor	0.2	0.7	9.2
Utricularia macrorhiza	0.2		14.5
Potamogeton oakesianus			
Potamogeton crispus		0.7	0.5
Ranunculus sp.			
Potamogeton nodosus			
Nitella sp.		0.7	
Lemna trisulca			0.5
Utricularia intermedia			6.8
Spidorela polyrhiza			
Utricularia gibba			8.2
Decodon verticillatum			6.8
Schoenoplectus acutus			0.5
Zosterella dubia			
Elodea canadensis			
Brasenia schreberi		9.7	5.8
Potamogeton friesii			
Schoenoplectus subterminalis		4.8	
Alisma			
Sagittaria graminea			
Utricularia purpurea			0.5
Eleocharis robbinsii			
Ludwigia sp.			
Potamogeton praelongus			
Potamogeton strictifolius			
Nitella confervacea			
Potamogeton foliosus-q			
Totals =	22	19	22

Table 17. Frequency of occurrence during October survey divided by basin and sorted by values in East column. Blue shading indicates dominant species present in all basins and in at least one with frequency ≥20%. Green shading indicates low frequency species present in all three basins. Pink shading indicates protected species.

Species Name	October		
	East	Middle	West
Chara sp	67.0	18.7	43.0
Vallisneria americana	60.7	58.9	44.4
Potamogeton amplifolius	49.4	52.3	64.4
Potamogeton illinoensis	38.6	11.2	37.8
Potamogeton robbinsii	6.1		
Myriophyllum spicatum	5.6	3.7	5.9
Elodea nuttallii	3.2	15.9	0.7
Hydrilla verticillata	2.7		
Najas guadalupensis	2.7	51.4	18.5
Spirogyra	2.3		0.7
Nuphar variegata	2.3	4.7	22.2
Elodea canadensis	2.0		
Bidens beckii	1.8	3.7	
Nymphaea odorata	1.6	10.3	32.6
Potamogeton zosteriformis	1.6		0.7
Najas flexilis	1.1		3.7
Pontederia cordata	0.9	0.9	3.0
Utricularia geminiscapa	0.7	2.8	3.7
Potamogeton oakesianus	0.5		
Ranunculus sp.	0.5		0.7
Nitella sp.	0.5	0.9	4.4
Potamogeton natans	0.5		
Schoenoplectus acutus	0.5		1.5
Potamogeton crispus	0.2		
Potamogeton nodosus	0.2	0.9	0.7
Ceratophyllum demersum	0.2	18.7	0.7
Nitella confervacea	0.2		
Potamogeton pusillus		0.9	
Lemna trisulca			
Utricularia intermedia			5.2
Spidorela polyrhiza			
Utricularia gibba			8.1
Decodon verticillatum			0.7
Zosterella dubia			
Brasenia schreberi			4.4
Potamogeton friesii			
Schoenoplectus subterminalis			20.1
Alisma			
Sagittaria graminea			1.5
Najas minor			
Utricularia purpurea			0.7
Eleocharis robbinsii			
Ludwigia sp			
Utricularia macrorhiza		1.9	0.7
Potamogeton praelongus			0.7
Potamogeton strictifolius			
Potamogeton foliosus-q			
Totals =	27	17	28

The most abundant species, those present at 20% of waypoints or more, during the three surveys is given in **Table 18**. Three species were abundant in all basins all the time: *Chara sp.* (Muskgrass), *Vallisneria americana* (Tape Grass), *P. amplifolius* (Large-leaf Pondweed). The pondweed, *P. illinoensis* was always abundant in West but dominanace shifted from Middle in June to East the remaining months. The pondweed *P. zosteriformis* was abundant in West Twin in August and October, but the pondweed *P. robbinsii* was abundant only in East and only in June.

The two lilies, *Nymphaea odorata* (White Waterlily) and *Nuphar variegata* (Yellow Waterlily), were prevalent in West Twin all year. The table shows that most of the abundant species were located in Middle and West Twin, not East Twin. The dense *Chara* beds in East Twin significantly restrict growth over much of the bottom. Dense waterlily growth in the remaining littoral zone of East Twin also restricts growth of other species. The naiad *N. guadalupensis* was abundant in West Twin during August and October, while *N. flexilis* was abundant in both Middle and West Twin in June and August. *Elodea nuttallii* was abundant only in Middle Twin and only in August. Finally, filamentous algae was abundant in East Twin in June. Overall, there were 13 abundant species in Twin Lakes in 2024.

Table 18. Aquatic plant species that were dominant in at least one basin during at least one survey. E = East, M = Middle, W = West, A = All.

Species	June	August	October
Chara sp.	A	A	A
Vallisneria americana	A	A	A
Potamogeton amplifolius	A	A	A
Potamogeton illinoensis	M & W	E & W	E & W
Potamogeton robbinsii	W		
Nymphaea odorata		W	W
Nuphar variegata	W	W	W
Najas guadalupensis		W	W
Najas flexilis	M & W	M & W	
Elodea nuttallii		M	
Potamogeton zosteriformis	M	M	
Spirogyra Green filamentous algae	E		
Schoenoplectus subterminalis			W

Middle Twin Lake has a larger mid- and deep littoral zone than does East Twin, allowing a larger range of species to become abundant. There were 5 dominant species in East Twin, 7 in Middle Twin, 10 in West Twin.

The low frequency species that were present in all basins during each survey are given in **Table 19**. Two species, *M. spicatum, and Utricularia geminiscapa,* were found at low frequencies in each basin during each survey. Interestingly, 4 of the low frequency species in June did not repeat that level of presence in either August or October. Species present in August tended to be present in October with the exception *N. minor*, which was not seen in October. These fluctuations in presence and abundance over time and between basins show how a plant community changes over the course of the season, and across a wide range of habitats.

Table 19. Low frequency (<20%) species that were found in all basins during at least one of the surveys.

Species	June	August	October
Myriophyllum spicatum	Y	Y	Y
Utricularia geminiscapa	Y	Y	Y
Nitella sp.	Y		Y
Pontederia cordata		Y	Y
Potamogeton crispus	Y		
Ranunculus longirostris	Y		
Potamogeton robbinsii	Y		
Ceratophyllum demersum			Y
Potamogeton nodosus			Y
Najas guadalupensis	Y		
Najas minor		Y	

The total accounting of all species that have so far been recorded in Twin Lake is given in **Table 20**. There have been a total of 61 species of aquatic plants recorded for Twin Lakes. The two surveys conducted by AER, in 2017 and 2021, found 38 species, of which 4 have so far not been found by NEAR (yellow shading in **Table 20**). Our 2023 survey yielded 45 species, while our 2024 survey found 50 species. There were 4 species recorded in 2023 that were not recorded in 2024, *Lyngbya* (probably overlooked), *P. obtusifolius* (probably mis-identified), *Nasturtium officinale* (found only in the Ohara's Marina is believed to be impacted by the ProcelloCOR treatment). And finally, *Stuckenia pectinata* was found in tiny micro habitats in 2023 that were probably overlooked in 2024. In total, NEAR has found 54 species of aquatic plants in Twin Lakes.

Table 20. Species lists from NEAR 2023 and 2024 surveys with AER survey results. P = Present.

#	Species Name	NEAR 2024	NEAR 2023	AER all
1	*Chara sp.*	P	P	P
2	*Najas flexilis*	P	P	P
3	*Potamogeton amplifolius*	P	P	P
4	*Vallisneria americana*	P	P	P
5	*Filamentous algae*	P	P	
6	*Nymphaea odorata*	P	P	P
7	*Potamogeton crispus*	P	P	P
8	*Nuphar variegata*	P	P	P
9	*Potamogeton illinoensis*	P	P	P
10	*Brasenia schreberi*	P	P	P
11	*Eleocharis robbinsii*	P	P	
12	*Sagittaria graminea*	P	P	P
13	*Myriophyllum spicatum*	P	P	P
14	*Utricularia geminiscapa*	P	P	
15	*Lyngbya sp.*		P	
16	*Pontederia cordata*	P	P	P
17	*Utricularia intermedia*	P	P	P
18	*Schoenoplectus spp.*	P	P	
19	*Ludwigia sp.*	P	P	P
20	*Potamogeton zosteriformis*	P	P	P
21	*Schoenoplectus acutus*	P	P	
22	*Utricularia macrorhiza*	P	P	P
23	*Potamogeton praelongus*	P	P	
24	*Elodea canadensis*	P	P	P
25	*Zosterella dubia*	P	P	
26	*Potamogeton obtusifolius*		P	
27	*Ranunculus trichophyllus*	P	P	P
29	*Bidens beckii*	P	P	P
30	*Najas guadalupensis*	P	P	P
31	*Ceratophyllum demersum*	P	P	P
32	*Potamogeton pusillus*	P	P	P
33	*Potamogeton robbinsii*	P	P	P
35	*Elodea nuttallii*	P	P	P
36	*Decodon verticillata*	P	P	
37	*Potamogeton natans*	P	P	P
38	*Nitella sp.*	P	P	P
39	*Hydrilla verticillata*	P	P	
40	*Potamogeton oakesianus*	P	P	
41	*Nasturtium officinale*		P	
42	*Najas minor*	P	P	P
43	*Utricularia purpurea*	P	P	P
44	*Lemna trisulca*	P	P	P
45	*Schoenoplectus subterminalis*	P	P	
46	*Lemna minor*	P	P	P
47	*Stuckenia pectinata*		P	
48	*Wolffia sp.*			P
49	*Spirodela polyrhiza*	P		P
50	*Eleocharis acicularis*			P

51	*Myriophyllum sibiricum*			P
52	*Ceratophyllum echinatum*			P
53	*Potamogeton foliosus*	P		P
54	*Potamogeton strictifolius*	P		P
55	*Utricularia gibba*	P		P
56	*Utricularia radiata*			P
57	*Potamogeton praelongus*	P		
58	*Potamogeton friesii*	P		
59	*Potamogeton nodosus*	P		
60	*Nitella confervacea*	P		
61	*Alisma sp.*	P		
62	*Potamogeton gramineus -ACT*			
	Totals =	50	45	38

The species effort curve presented in the 2023 report is presented again, updated to add 7 additional species found in 2024 (**Figure 26**). The effort to find new species has increased significantly in 2024, requiring 40 additional hours to find 7 new species. There is still a small chance that the 4 species found by AER will be found by NEAR in coming surveys.

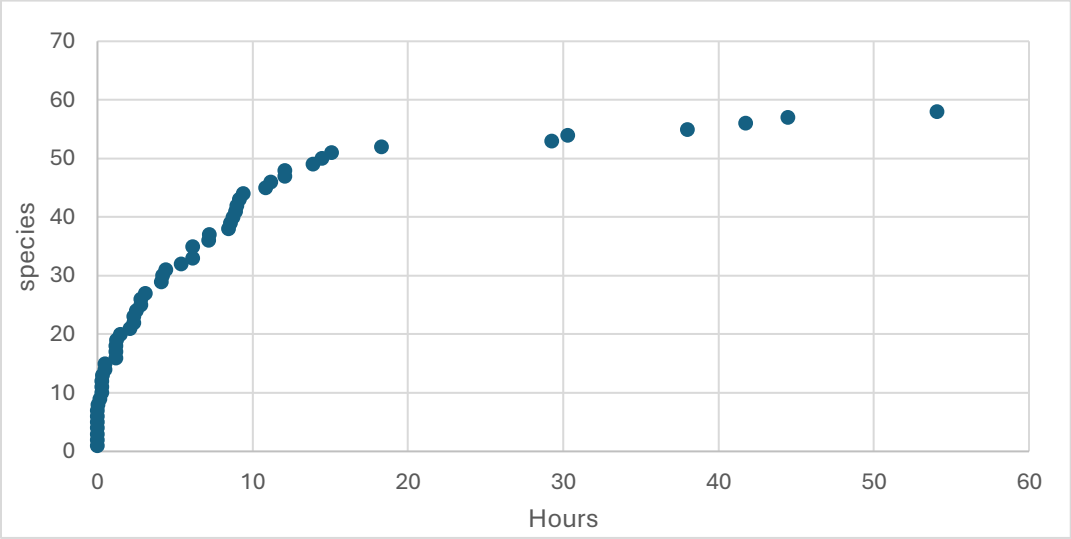


Figure 26. Species / Effort curve of aquatic plants found during NEAR surveys in 2023 and 2024.

Conclusions & Recommendations

Water quality monitoring in 2024 was conducted with similar methods to 2023.

East Twin water clarity was almost always better than 6 meters, clarity was better than 8 meters in August and September. In 2023, August and September clarity was between 6 and 7 meters. Only once in 2023 did clarity approach 8 meters.

Dissolved oxygen loss occurred below 8 meters, as was recorded in 2023. The depletion rate was similar to last year, with the very bottom (24m) water becoming anoxic by the end of June. Almost exactly as in 2023, anoxia reached 18 meters by the end of August, and 16 meters by the end of September. Anoxic water reached 14 meters in October, similar to 2023.

The MOMax was similar to 2023, although slightly higher in the water column

Conductivity was similar to 2023, ranging from 230 to 280, with higher values with depth.

Conductivity increases going downstream in the basins; East Twin has the lowest conductivity (230-250), Middle Twin is slightly higher at 230 – 275. Higher conductivity water occurred in the spring months April, May, and June. The remaining months showed Middle Twin to have very similar conductivity. West Twin had higher conductivity than Middle Twin for most of the summer. This indicates that the two lower basins, Middle and West, are receiving a salt load of some type.

Phosphorus in the top and middle water at East Twin was constantly at or below 10 ppb. There was more TP in the bottom water in September and October than in 2023. The highest recorded TP in 2024 was 125 ppb, in 2023 it was only 31ppb. This phosphorus likely settles back to the sediments when full oxygenation occurs in November or December

Middle Twin TP was low in April, May, and early June, mirroring East Twin concentrations. From late June on, Middle Twin had high phosphorus concentrations reaching 28ppb. The bottom water of Middle Twin was similar to upper waters but often higher.

West Twin TP was again very low in April and May but increased to 14ppb in July and August, higher than the 1-meter water in Middle Twin. The TP in West Twin was lower than Middle but similar to East Twin.

East Twin total nitrogen ranged from 212ppb to 308ppb in the top and middle layers. 2024 values were ~30ppb lower than 2023, when TN in top and middle layers ranged between 272ppb and 342ppb.

Bottom water TN reached 662ppb in October, slightly lower than the 692ppb recorded in October 2023.

Middle Twin TN ranged from 215 ppb and 399 ppb but generally remained around 250 and 340 ppb in the top and middle layers. Bottom water was slightly higher. West Twin TN ranged from 315ppb to 524 ppb, representing a considerable load of nitrogen to West Twin Lake that didn't come from Middle Twin Lake.

In 2025, we plan to calculate mass changes between depths and between basins. We will also monitor the water flow under bridge one.

East Twin only had Diatoms until late July, when very low numbers of cyanobacteria appeared. Cyanobacteria reached highest numbers in October, when there was approximately 25,000 cells/mL

A cyanobacteria bloom occurred in the northern part of West Twin during July and August, when very high numbers of buoyant colonies of Microcystis filled the water column and became scum.

Zooplankton are represented by small-bodied organisms only.

There were 5 aquatic plants that occurred in all three basins: Chara, Tape Grass, Illinois Pondweed, Large-leaf Pondweed, and Robbins's Pondweed. There were only 7 species that were abundant in East Twin, 9 species in West Twin, and 12 species in Middle Twin. West Twin had the highest number of species at 39. Middle Twin had 31 species and East Twin had 30 species. There were 8 species that were only found in West Twin Lake (**Table 13),** 3 species found only in Middle Twin (Straight-leafed Pondweed, Fries' Pondweed, and *Nitella confervacea*), and 1 species found only in East Twin (Water Bulrush).

Recommendations for 2025 monitoring:

The following additions will be made to our monitoring plan:

- Estimate the flow of water from East Twin to Middle Twin during each sampling visit.
- Collect water samples at the location where Middle and West Twin meet at the causeway. Add phytoplankton samples to all stations and zooplankton at Middle Twin.
- Measure iron at the bottom of East Twin in summer months.
- Add a new clarity and DO/Temperature station in the East Bay of East Twin.

Appendix

Table 21. Common names of aquatic plant species found in 2024. Green indicates State of CT protected species, red indicates invasive species.

Scientific Name	Common Name
Alisma sp.	Water Plantain
Bidens beckii	Water Marigold
Brasenia schreberi	Watershield
Ceratophyllum demersum	Coontail
Decodon verticillatum	Swamp Loosestrife
Chara sp	Muskgrass
Eleocharis robbinsii	Robbin's Spikerush
Elodea canadensis	Canadian Waterweed
Elodea nuttallii	Nuttalls elodea
Spirogyra	Filamentous algae
Hydrilla verticillata	Hydrilla
Lemna trisulca	Star Duckweed
Ludwigia sp	Water Purslane
Myriophyllum spicatum	Eurasian Milfoil
Najas flexilis	Slender Naiad
Najas guadalupensis	Southern Naiad
Najas minor	Western Waterweed
Nitella confervacea	Stonewort
Nitella sp.	Stonewort
Nuphar variegata	Yellow Water Lily
Nymphaea odorata	White Water Lily
Pontederia cordata	Pickerelweed
Potamogeton obtusifolius	Blunt-leafed Pondweed
Potamogeton amplifolius	Large-leaf Pondweed
Potamogeton crispus	Curly-leaf Pondweed
Potamogeton foliosus-q	Leafy Pondweed
Potamogeton friesii	Fries' Pondweed
Potamogeton illinoensis	Illinois Pondweed
Potamogeton natans	Floating Pondweed
Potamogeton nodosus	Long-leaved Pondweed
Potamogeton oakesianus	Oaks Pondweed
Potamogeton praelongus	White-stem Pondweed
Potamogeton pusillus	Lesser Pondweed
Potamogeton robbinsii	Robbins' Pondweed
Potamogeton strictifolius-q	Straight leaved Pondweed
Potamogeton zosteriformis	Flat-stem Pondweed
Ranunculus longirostris	Long-beak Buttercup
Sagittaria graminea	Sterile Arrowhead
Schoenoplectus acutus	Hard-stemmed Bullrush
Schoenoplectus subterminalis	Water bulrush
Spirodela polyrhiza	Giant Duckweed
Utricularia geminiscapa	Narrow-leaved Arrowhead
Utricularia geminiscapa	Hidden-fruit Bladderwort
Utricularia gibba	Tiny Bladderwort
Utricularia intermedia	Flat-leaved Bladderwort
Utricularia macrorhiza	Common Bladderwort
Utricularia purpurea	Purple Bladderwort
Vallisneria americana	Tape Grass
Zosterella dunia	Water Stargrass

Table 22. CT DEEP classification of CT lakes by phosphorus concentration.

	Category	T. Phosphorus (ppb)	T. Nitrogen (ppb)	Secchi Depth (m)	Chlorophyll-*a* (ppb)
1	Oligotrophic	0 -- 10	2 -- 200	6 +	0 -- 2
2	Oligo-mesotrophic	10 -- 15	200 -- 300	4 -- 6	2 -- 5
3	Mesotrophic	15 -- 25	300 -- 500	3 -- 4	5 -- 10
4	Meso-eutrophic	25 -- 30	500 -- 600	2 -- 3	10 -- 15
5	Eutrophic	30 -- 50	600 -- 1000	1 -- 2	15 -- 30
6	Highly Eutrophic	50 +	1000 +	0 -- 1	30 +