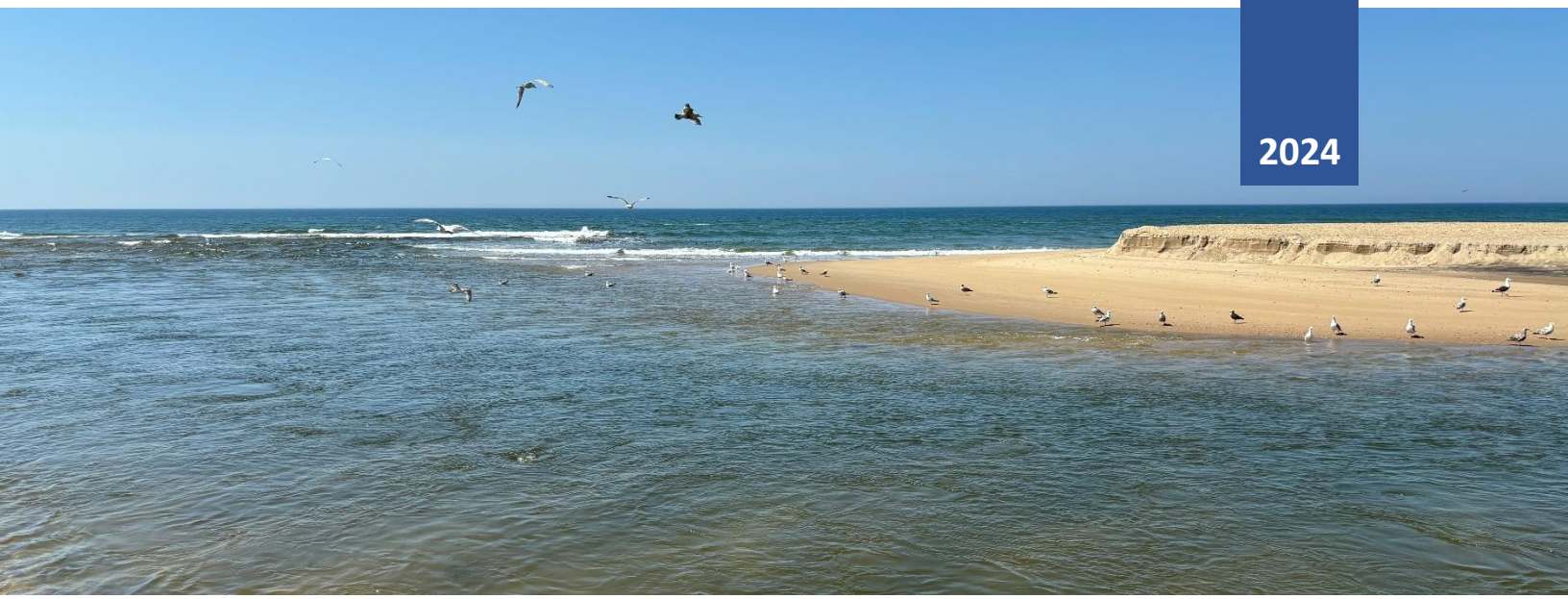


2024

ECOSYSTEM MONITORING REPORT

TISBURY GREAT POND

GREAT POND FOUNDATION

GREAT POND foundation®

TISBURY GREAT POND
Executive Summary

2024

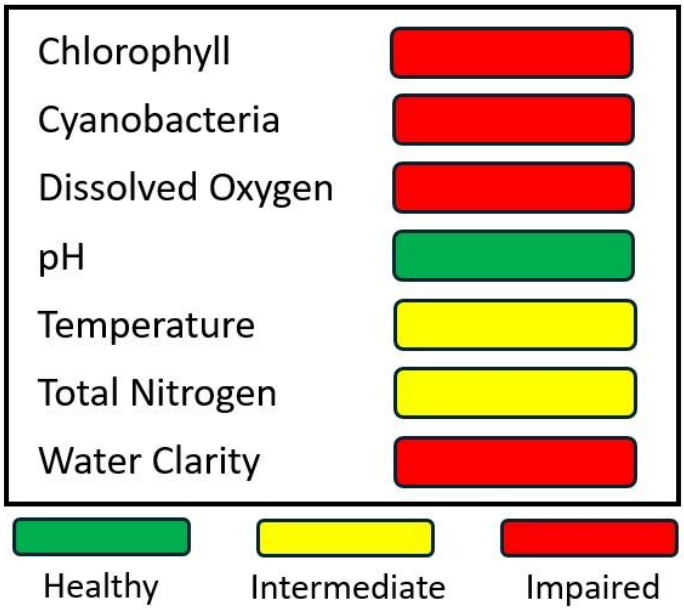
Study Area

Tisbury Great Pond (TGP) is a coastal estuary approximately 740 acres in size located on the Vineyard's southern shoreline in the Towns of Chilmark and West Tisbury, MA. The Pond encompasses a roughly 1,906-acre area watershed. The barrier beach separating the Pond from the ocean is manually breached 3-4 times/year as a nutrient and elevation management

Sampling Regime 2024

In 2024, Great Pond Foundation (GPF) continued its ecosystem monitoring program on TGP for the 4th consecutive year. A total of 16 monitoring trips were conducted between May and October. During each trip, water quality data was obtained for 9 monitoring sites (see map to right). Nutrient samples were collected at 5 of the regular 9 monitoring sites, once every 2 months.

Summary of Metrics, 2024



*The "Summary of Metrics" tool assigns health rankings to individual water quality metrics. Refer to the *Appendix* for information on how rankings are assigned.

Cut Dates 2024

Date of Opening	Date of Closure	Cut Duration
*Jan 10th	Feb 9th	30 days
Mar 27th	Apr 25th	29 days
Jun 2nd	Jul 6th	34 days
Aug 21st	Sep 15th	25 days
Dec 14th	Jan 25th (2025)	42 days

*Cut on January 10th occurred naturally rather than through a man-made breach.

Pond Summary 2024

TGP exhibited low water quality and signs of ecosystem impairment in 2024, continuing trends observed since monitoring began in 2021. Despite seeing a successful summer cut season that removed excess nitrogen from much of the Pond, several regions of the Pond still saw an overgrowth of phytoplankton in 2024. Phytoplankton growth was especially high in Town Cove, where a late summer nitrogen spike drove the development of a green algae and diatom bloom. For the 2nd straight year, high concentrations of cyanobacteria were recorded in benthic (i.e. bottom-dwelling) macroalgae present within the northern reaches of the Pond's tributary coves. Phytoplankton build-up, excess nutrient loading, and benthic cyanobacteria growth comprise TGP's top issues.

Introduction

Tisbury Great Pond (TGP) exhibited poor water quality and signs of ecosystem impairment in 2024, continuing trends observed in the Pond since monitoring first began in 2021. The year's suboptimal water quality comes despite a strong cut season, which saw the occurrence of 2 long-lived summer openings. Even as these openings removed nutrients from TGP, helping most monitoring stations to maintain measured nitrogen levels below the State's management threshold, excess phytoplankton growth was still observed in various parts of the Pond. For the 4th consecutive year, phytoplankton growth within TGP (as measured by total chlorophyll) was highest during the late summer and early fall (**Figure 1**). This elevated phytoplankton presence reduced water clarity and depleted dissolved oxygen at the pond floor.

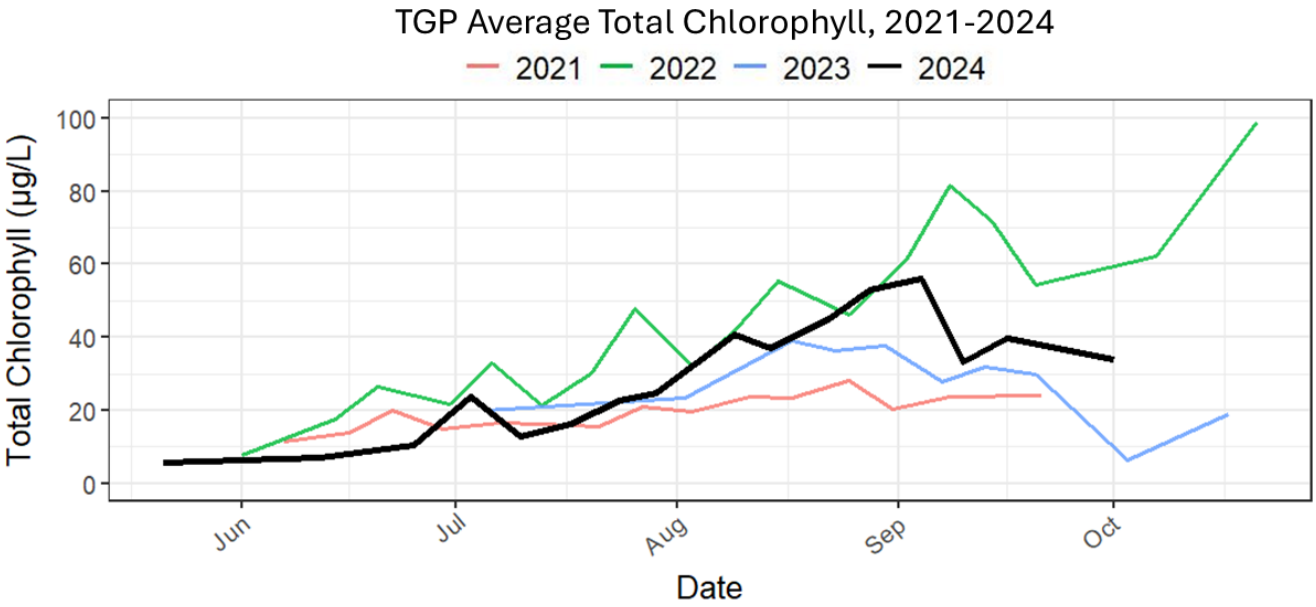


Figure 1. *Average total chlorophyll concentrations (in ug/L) across all TGP monitoring stations for the years 2021-2024. Total chlorophyll measurements were obtained via a bbe Moldaenke FluoroProbe.*

While multiple regions of TGP suffered from an overgrowth of phytoplankton in 2024, the resulting impacts were most pronounced in the northernmost portion of Town Cove, the only region of the Pond that still exceeded the State's nitrogen threshold despite the year's strong cut performance. Town Cove saw the development of a concentrated phytoplankton bloom during the late summer and early fall consisting primarily of green algae and diatoms (not cyanobacteria), the 2 phytoplankton classes that have consistently dominated the TGP community since GPF monitoring first began in 2021.

Planktonic (i.e. diffuse within the water) cyanobacteria concentrations remained low across TGP in 2024, continuing trends observed since 2021. However, for the 2nd straight year, high concentrations of cyanobacteria were found within benthic (i.e. bottom-dwelling) macroalgal clusters present in the northern reaches of several coves. While these benthic cyanobacteria were confined solely to these macroalgal clusters themselves, these species can still pose a public health risk due to their potential to release harmful toxins into the surrounding water. The trends observed in 2024 ultimately reveal elevated phytoplankton build-up, benthic cyanobacteria growth, and excess nutrient loading as the Pond's most pressing issues.

Pond Openings and Nitrogen

The barrier beach separating TGP from the ocean is intentionally breached or "cut" 3-4 times per year to drain the Pond and allow for a period of tidal exchange with the sea. In looking at opening trends, 2024 represented TGP's best cut year since 2021, both in terms of average opening length and number of days open (**Table 1**). Additionally, 2 of the year's openings occurred during the summer when tidal flushing is often most impactful due to its ability to replace nutrient-rich pondwater with nutrient-poor saltwater.

Table 1. *Opening data for the years 2021-2024. Only man-made openings are included in this analysis (natural openings are omitted).*

Year	Average Opening Length	Number of Days Open
2021	41.75 days	167 days
2022	26 days	78 days
2023	20.75 days	83 days
2024	32.5 days	105 days

Data collected between 2021 and 2024 show that frequent, long-lived openings on TGP generally coincide with reduced total nitrogen (TN) levels in the Pond (top row of **Figure 2**). For example, during the 2021 and 2024 monitoring seasons, both of which experienced 2 long duration openings of at least 25 days each, TN levels for the TGP "sentinel station" (average of stations TGP04, TGP05, & TGP06) never exceeded the State's 0.48 mg/L management threshold. Alternatively, during the 2022 monitoring season, which experienced a single, shorter opening of 11 days, TN levels rose above the State's threshold during the late summer and early fall.

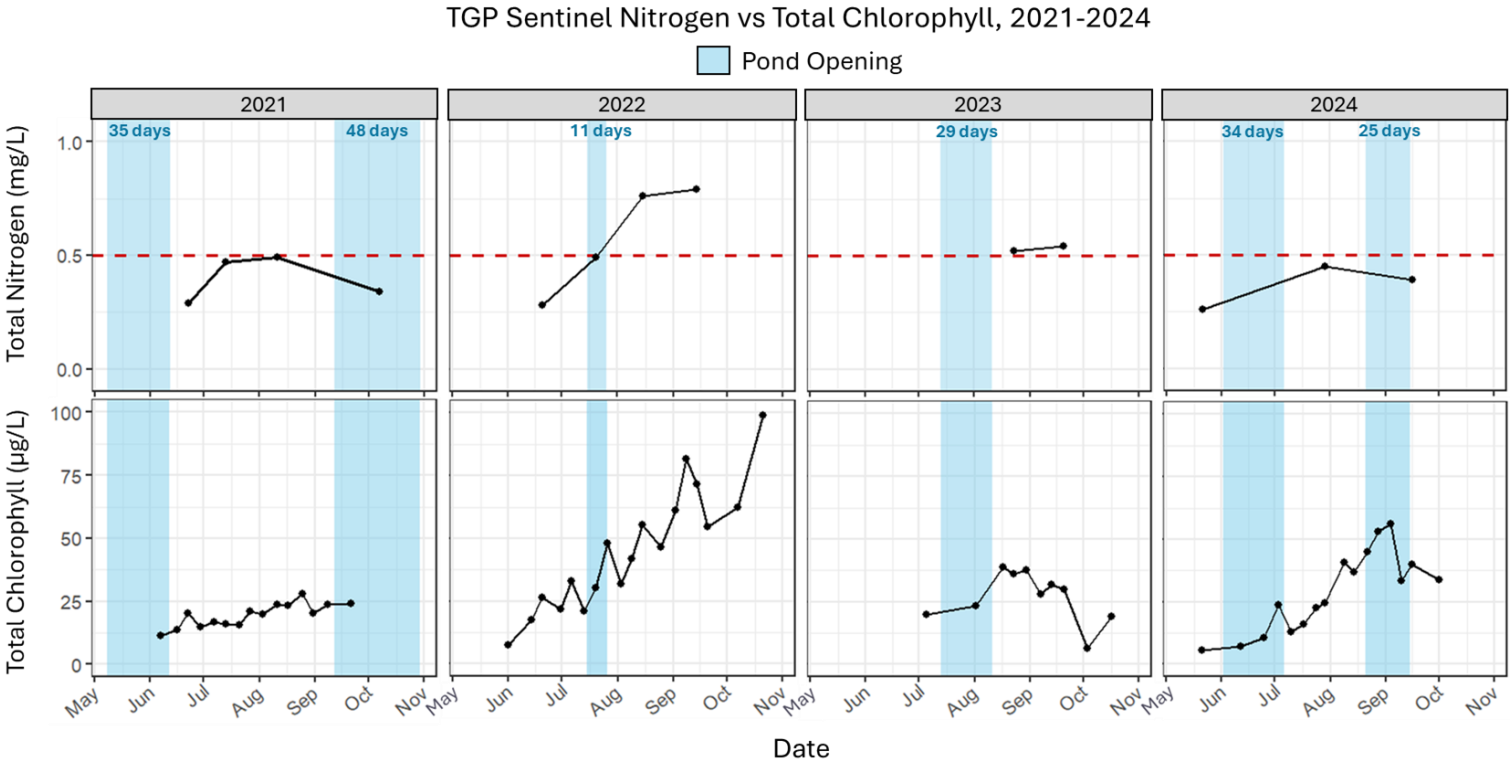


Figure 2. *Total nitrogen (in mg/L) for the TGP "sentinel station" (average of stations TGP04, TGP05, and TGP06) for the years 2021-2024 is plotted in the 1st row. The dashed red line represents the State's 0.48 mg/L TN management threshold. Points above this threshold are indicative of stress or impairment. Average total chlorophyll (ug/L) across all TGP stations for the years 2021-2024 is plotted in the 2nd row. Total chlorophyll measurements were obtained via a bbe Moldaenke FluoroProbe.*

These trends suggest that frequent, prolonged openings can serve to remove nitrogen from the Pond during the summer months, in turn limiting phytoplankton growth over the same period (as measured by total chlorophyll) (**Figure 2**). The relationship between TN levels in the Pond and phytoplankton abundance is evident when looking at trends for the years 2021 to 2023, with higher nitrogen availability driving increased growth. Out of these 3 years, chlorophyll levels were lowest in 2021 (low TN), highest in 2022 (high TN), and intermediate in 2023 (moderate TN).

Conversely, despite the "sentinel station" maintaining low nitrogen levels through the summer and early fall, TGP still exhibited high total chlorophyll levels in 2024, reaching a greater peak (56.1 ug/L) than that seen in 2023 (38.9 ug/L) when TN levels were higher. TGP's heightened chlorophyll levels in 2024 can be partially attributed to Town Cove's especially high phytoplankton abundance relative to the rest of the Pond (see next section), which would have served to raise the Pond's average chlorophyll values plotted in **Figure 2**. However, Town Cove's isolated phytoplankton bloom is not enough on its own to fully explain 2024's excess chlorophyll measurements. The Pond's high chlorophyll levels are surprising given the year's comparatively low TN levels.

Town Cove: A Year of Heightened Impairment

While TGP as a whole suffered from seasonal impairment in 2024, impacts were most pronounced in the Pond's tributary coves, specifically at the northern tip of Town Cove. Total chlorophyll concentrations at both of Town Cove's northernmost monitoring stations (TGP01 and TGP02) were noticeably higher during the late summer and early fall compared to all other monitoring stations due to a concentrated phytoplankton bloom (**Figure 3**).

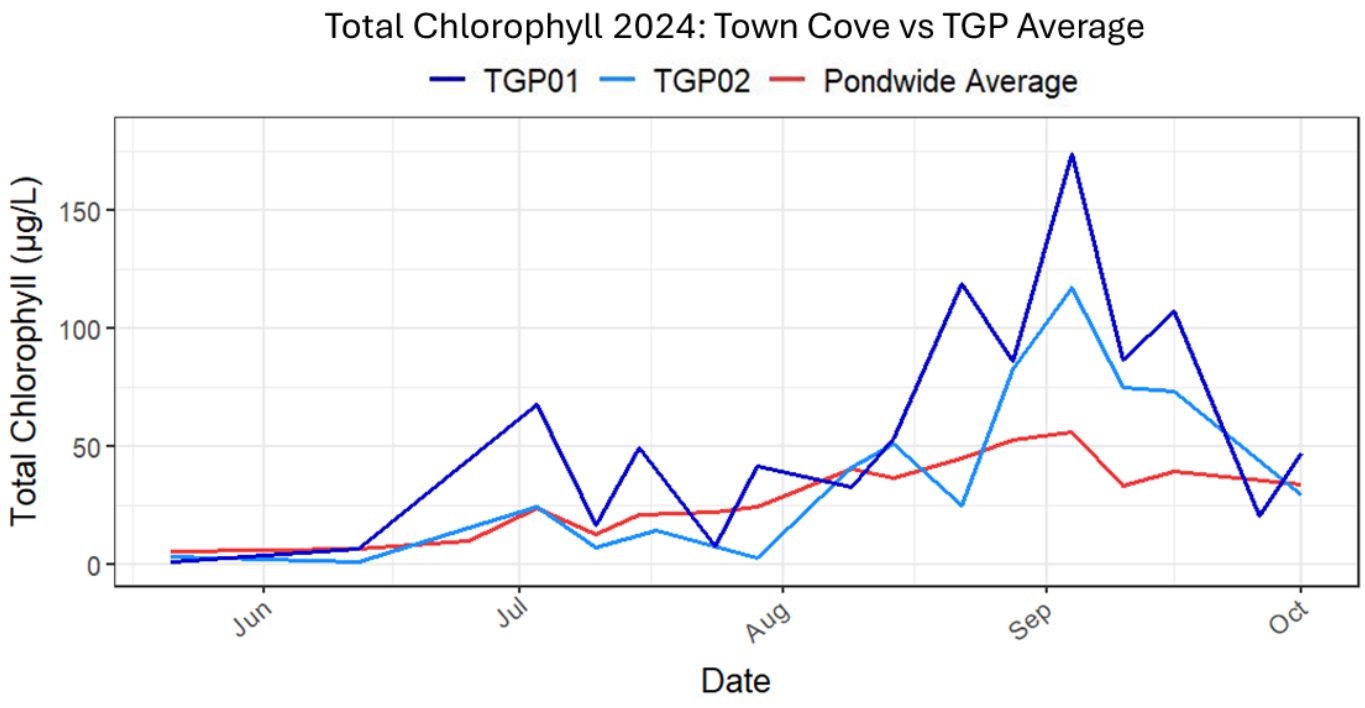


Figure 3. *Total chlorophyll (in ug/L) at Town Cove monitoring stations TGP01 and TGP02 is compared to the average of all TGP monitoring stations during the 2024 monitoring season. Total chlorophyll measurements were obtained via a bbe Moldaenke FluoroProbe.*

This phytoplankton bloom was composed primarily of green algae and diatoms, the 2 phytoplankton classes that have consistently dominated the TGP phytoplankton community since monitoring began in 2021. During this bloom, station TGP01 recorded the highest total chlorophyll concentration ever documented on TGP during GPF's 4-year monitoring program (173.51 ug/L on 9/4/24). As a result of its high phytoplankton growth, Town Cove exhibited reduced water clarity and heightened dissolved oxygen stress relative to the rest of the Pond.

Town Cove's elevated chlorophyll concentrations during the late summer of 2024 were likely driven by a concurrent rise in TN over the same period. In looking at multiyear TN trends dating back to 2021, Town Cove's TGP01 monitoring station has consistently exhibited higher nitrogen concentrations during the late summer and early fall relative to all other nutrient monitoring stations, including those located in other tributary coves (**Figure 4**).

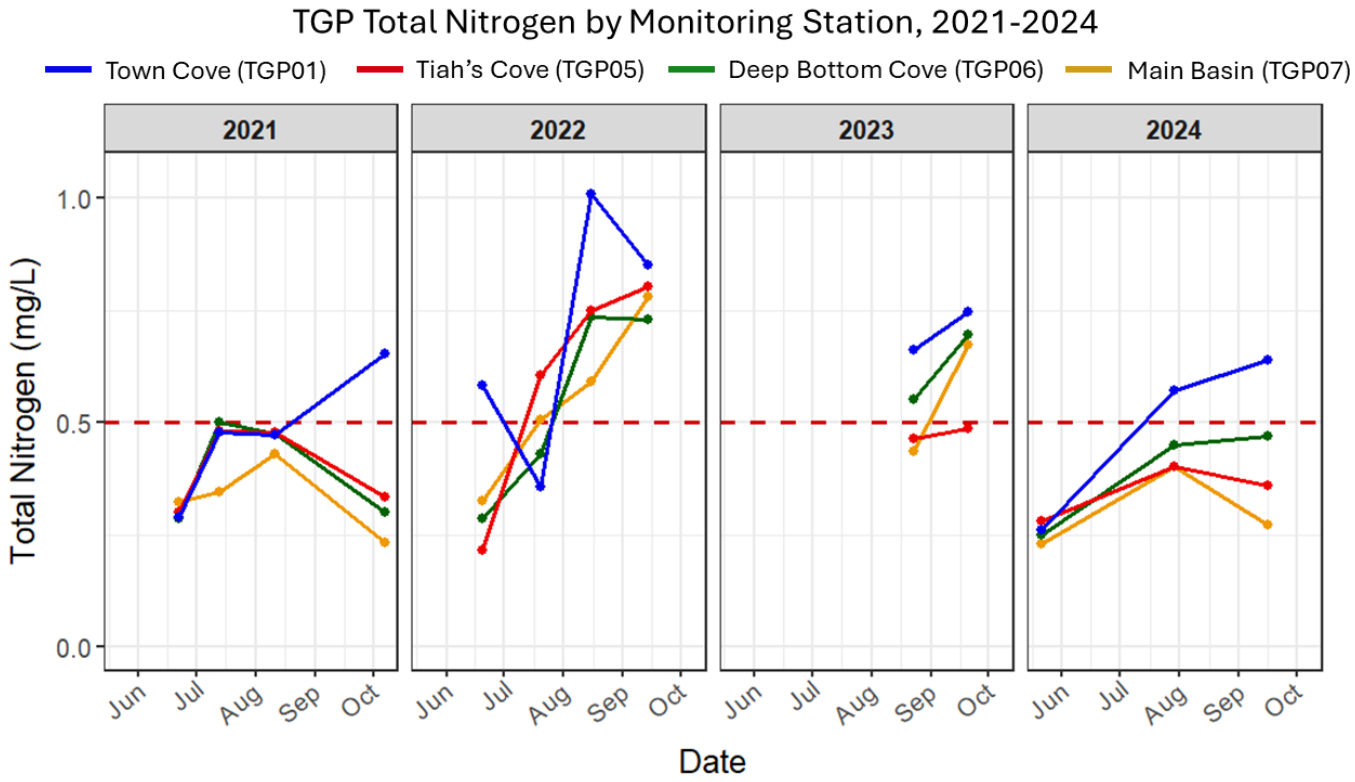


Figure 4. *Total nitrogen (in mg/L) at 4 nutrient monitoring stations for the years 2021-2024. Dashed red lines represent the State's 0.48 mg/L TN management threshold.*

The TN trends observed in Town Cove from 2021 to 2024 are consistent with the findings of the Massachusetts Estuaries Project's 2013 report on TGP, which largely attributed the cove's higher nitrogen levels to surface water inflow from the Pond's 2 sole tributary streams, the Mill Brook and Tiasquam River (Howes et al., 2013). Together, these 2 streams encompass a combined sub-watershed area comprising ~40% of the Pond's total watershed area (Howes et al., 2013). As such, these streams deliver a large quantity of nitrogen to Town Cove without allowing for the same level of attenuation that occurs during groundwater transport, where nitrogen may be intercepted by microbes or plants prior to entry into the Pond.

Town Cove's heightened TN levels during the late summer may also owe to limited tidal flushing in this region of TGP during openings. Salinity (i.e. the concentration of dissolved salt in the water) is commonly used to assess tidal flushing dynamics following the opening of the Pond. Average post-opening salinity trends for the years 2022-2024 are presented in **Table 2** for all regular TGP monitoring stations. Different analyses were performed to assess both the time it takes for different monitoring stations to begin experiencing saltwater flushing ("Average Salinity Response Time"), as well as the overall effectiveness of saltwater flushing across different stations ("Average Salinity Change" & "Average Post-cut Salinity"). It should be noted that the average salinity response times included in the table are likely to be overestimated given the limitations of GPF's weekly sampling schedule (true responses may occur anytime in between these weekly trips).

In **Table 2**, values that exceed or fall short of the pond-wide average are shaded in green and orange, respectively. Both of Town Cove's northernmost monitoring stations (TGP01 & TGP02) fall below the pond-wide average for all 3 salinity metrics analyzed between 2022 and 2024. This indicates that not only does it take longer for saltwater to reach this region of the Pond during openings, but the degree of saltwater flushing experienced here is reduced relative to most other stations. The Cove's limited flushing capacity may further explain its heightened nitrogen levels during the late summer.

Table 2. *TGP post-opening salinity trends, 2022-2024.*

Station	Location	Average Salinity Response Time (Days)	Average Salinity Change (ppt)	Average Post-cut Salinity (ppt)
TGP01	Town Cove (North)	12.25	+7.95	21.29
TGP02	Town Cove (North)	12.25	+8.12	21.46
TGP03	Pear Tree Cove	10.5	+9.85	23.66
TGP03A	Muddy Cove	12.25	+9.32	22.48
TGP04	Town Cove (South)	10.5	+11.00	24.88
TGP05	Tiah's Cove	15.75	+4.61	17.65
TGP06	Deep Bottom Cove	10.5	+9.59	23.26
TGP07	Main Basin	9	+10.76	24.74
TGP08	Quansoo	10.5	+9.56	22.62
	Pond-wide Average	**11.5**	**+8.97**	**22.45**

*Bottom-depth salinity was used for these analyses. Post-cut salinity values were obtained from the first day following an opening that displayed full mixing throughout the water column.

The only region of the Pond that exhibited less flushing than the northern tip of Town Cove between 2022 and 2024 was Tiah's Cove (station TGP05), where a sand shoal located at the mouth of the cove restricts flow in and out. Despite such poor flushing dynamics, TGP05 has not exhibited particularly high TN compared to the rest of the Pond. This may be due to the station's location near the entrance of the cove, as opposed to the northern tip where nitrogen influx via groundwater is expected to be more concentrated.

Benthic Cyanobacteria in 2024

For the 2nd consecutive year, clusters of benthic (i.e. bottom-dwelling) macroalgal material were observed in the northern reaches of TGP's tributary coves (**Figure 5**). These clusters appeared as small green clumps generally seen coating the pond bottom, lining the shore, or floating at the surface, and were primarily composed of cyanobacteria and diatoms. It is important to note that the cyanobacteria present in these clusters were isolated to the material itself, as cyanobacteria levels measured within the water column immediately adjacent to the clumps were consistently low across the Pond. Benthic macroalgal clusters were first observed in Town Cove and Muddy Cove on 6/25/24 before being discovered at the tips of Tiah's Cove and Deep Bottom Cove in the following weeks. While these clusters had disappeared from the former 2 coves by mid-July, they persisted at the tips of the latter 2 coves into mid-September.

Benthic Macroalgal Clusters at TGP01, 6/25/24

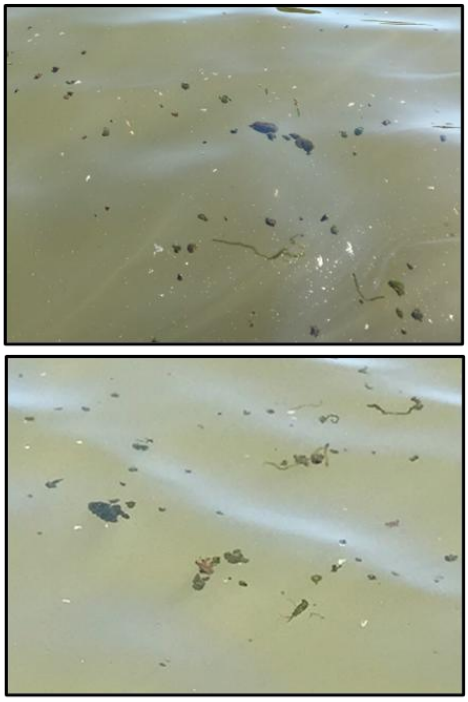


Figure 5. Locations at which benthic macroalgal material was observed in 2024. Photos of benthic macroalgal clusters observed at station TGP01 on 6/25/24 are shown on the right.

The clusters' dominant cyanobacteria genus was identified morphologically (i.e. visually) as *Aphanothece*. It should be noted that a 2017 study found that benthic cyanobacteria samples identified morphologically as *Aphanothece* actually belonged to the genus *Cyanobium* after being genetically sequenced (Albrecht et al., 2017). Given that genetic sequencing has not been performed and these benthic cyanobacteria genera can be cryptic, there is some taxonomic uncertainty. Regardless, these clusters should be viewed as a concern given that benthic cyanobacteria can release toxins into the surrounding water (Wood et al., 2018; Poirier-Larabie et al., 2020).

What exactly drives the growth of these benthic species is unclear. Potential factors contributing to the prevalence of these benthic species in the Pond's coves may include heightened sunlight availability at the pond bottom (shallow tip of cove), proximity to nutrient inputs (both surface water and groundwater), lower salinity (fresher) water relative to the rest of the Pond, and protection from wind and wave action.

Conclusion

In 2024, TGP experienced its best summer cut season since 2021, with 2 long-lived summer openings of 34 and 25 days, respectively. These prolonged openings served to remove nutrients from the Pond, enabling most monitoring stations to remain below the State's nitrogen management threshold. Surprisingly, despite the Pond's lowered nitrogen inventories in 2024, multiple monitoring stations still exceeded the State's management threshold for chlorophyll-*a*, indicating excessive phytoplankton growth within certain regions of the Pond (refer to Appendix for information on how chlorophyll impairment is established). This suggests that given the reduced flushing of this enclosed embayment, TGP may still exhibit impairment even when TN is below the threshold.

Even as most of TGP met the State's nitrogen threshold in 2024 in accordance with the summer's strong cut performance, Town Cove represented an exception to this pattern, exceeding the threshold during the back end of the monitoring season. In turn, the Cove saw a concentrated phytoplankton bloom during the late summer and early fall, increasing turbidity, depleting dissolved oxygen, and enhancing ecosystem stress relative to the rest of the Pond. Town Cove's elevated nitrogen levels in 2024 suggest that summer cuts cannot be relied upon as the sole solution in combating nutrient impairment in TGP.

Beyond the potential for certain coves to still exhibit high nitrogen levels even during a good cut year, effective summer openings are not always guaranteed, as the timing and lifespans of openings are ultimately dictated by uncontrollable environmental variables (shoaling, precipitation, weather, etc.). As such, even with the most meticulous planning, summer openings may close prematurely and thereby fail to prevent nutrient build-up across the Pond, as was the case in 2022. Rather than relying solely on cuts, future management decisions must also be made with the goal of addressing nutrient sources within the watershed and minimizing entry into the Pond.

In addition to excess phytoplankton growth and isolated nutrient impairment, benthic macroalgal clusters containing a high concentration of cyanobacteria were observed throughout the northern reaches of the Pond's tributary coves for the 2nd straight year. Given that benthic cyanobacteria research is an emerging field, information regarding these types of blooms is limited. Continued monitoring will help to establish a better understanding of the growth dynamics and life cycles of these benthic species.

Works Cited

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Poirier-Larabie, S., Hudon, C., Richard, H., & Gagnon, C. (2020). Cyanotoxin release from the benthic, mat-forming cyanobacterium Microseira (Lyngbya) wollei in the St. Lawrence River, Canada. *Environmental Science and Pollution Research, 27*, 30285-30294. Cyanotoxin release from the benthic, mat-forming cyanobacterium Microseira (Lyngbya) wollei in the St. Lawrence River, Canada | Environmental Science and Pollution Research

Wood, S., Biessy, L., & Puddick, J. (2018). Anatoxins are consistently released into the water of streams with *Microcoleus autumnalis*-dominated (cyanobacteria) proliferations. *Harmful Algae, 80*, 88-95. Anatoxins are consistently released into the water of streams with Microcoleus autumnalis-dominated (cyanobacteria) proliferations - ScienceDirect

Appendix

Refer to GPF's **Summary of Metrics Methodology** page for information on how the Summary of Metrics rankings included in this report's executive summary were assigned.

Discussion of Chlorophyll Measurements

In 2024, GPF measured chlorophyll levels in TGP using 2 methods. The first method involved running water samples collected during each regular sampling trip on a bbe Moldaenke FluoroProbe, a spectral fluorometer that estimates phytoplankton abundance through fluorescence of pigments unique to individual algal groups. This instrument provides a measurement of total chlorophyll, which is representative of the total amount of chlorophyll (this includes all types) present within a water sample. The second method involved obtaining lab-measured concentrations of chlorophyll-*a*, a specific type of chlorophyll, from the Marine Biological Laboratory in Woods Hole, MA. This analysis was performed for water samples collected from TGP's 5 nutrient monitoring stations (TGP01, TGP04-TGP07) once every 2 months.

Total chlorophyll values recorded through FluoroProbe analysis are expected to be higher than lab-measured chlorophyll-*a* values but have shown similar patterns based on several years of comparative analysis. This can be seen in comparing TGP's 2024 chlorophyll measurements (**Figure A1**).

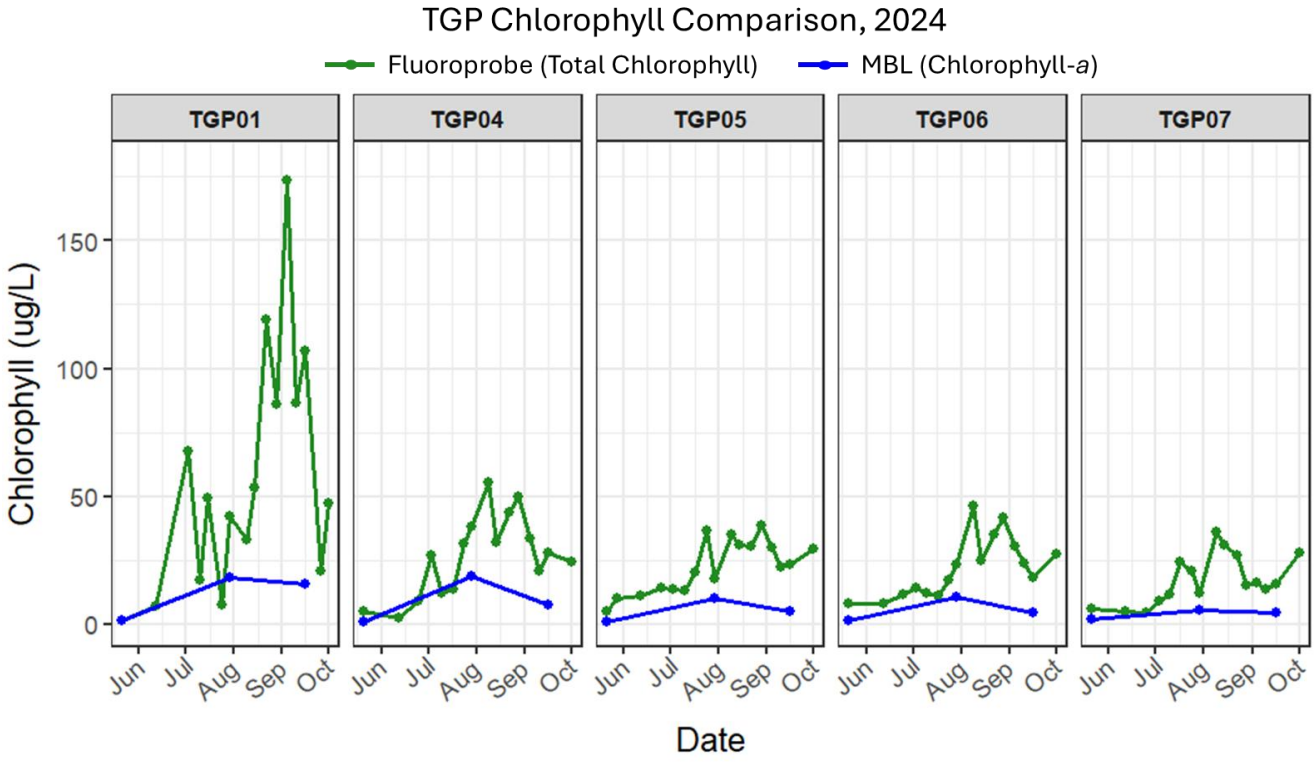

Figure A1. *FluoroProbe-measured total chlorophyll values (in ug/L) and lab-measured chlorophyll-a values (in ug/L) are plotted for TGP's 5 nutrient monitoring stations for the 2024 monitoring season. Chlorophyll-a measurements were obtained from Marine Biological Laboratory (MBL).*

GPF chose to include total chlorophyll measurements obtained via FluoroProbe analysis in this report's primary figures (Figures 1-3) since these measurements are taken more frequently and across a greater number of monitoring stations relative to lab-measured chlorophyll-*a* values, making them more useful in conveying data trends (contain less gaps than GPF's chlorophyll-*a* data). However, GPF does not use these total chlorophyll values to define chlorophyll impairment. Instead, lab-measured chlorophyll-*a* values are compared to the 10 ug/L management threshold established by the State's 2013 Massachusetts Estuaries Project (MEP) report (Howes et al., 2013). Chlorophyll-*a* concentrations recorded in 2024 indicate that Town Cove (TGP01 and TGP04) and Deep Bottom Cove (TGP06) suffered from chlorophyll impairment, as these monitoring stations all exceeded the 10 ug/L threshold at one point or another during the monitoring season (**Figure A2**).

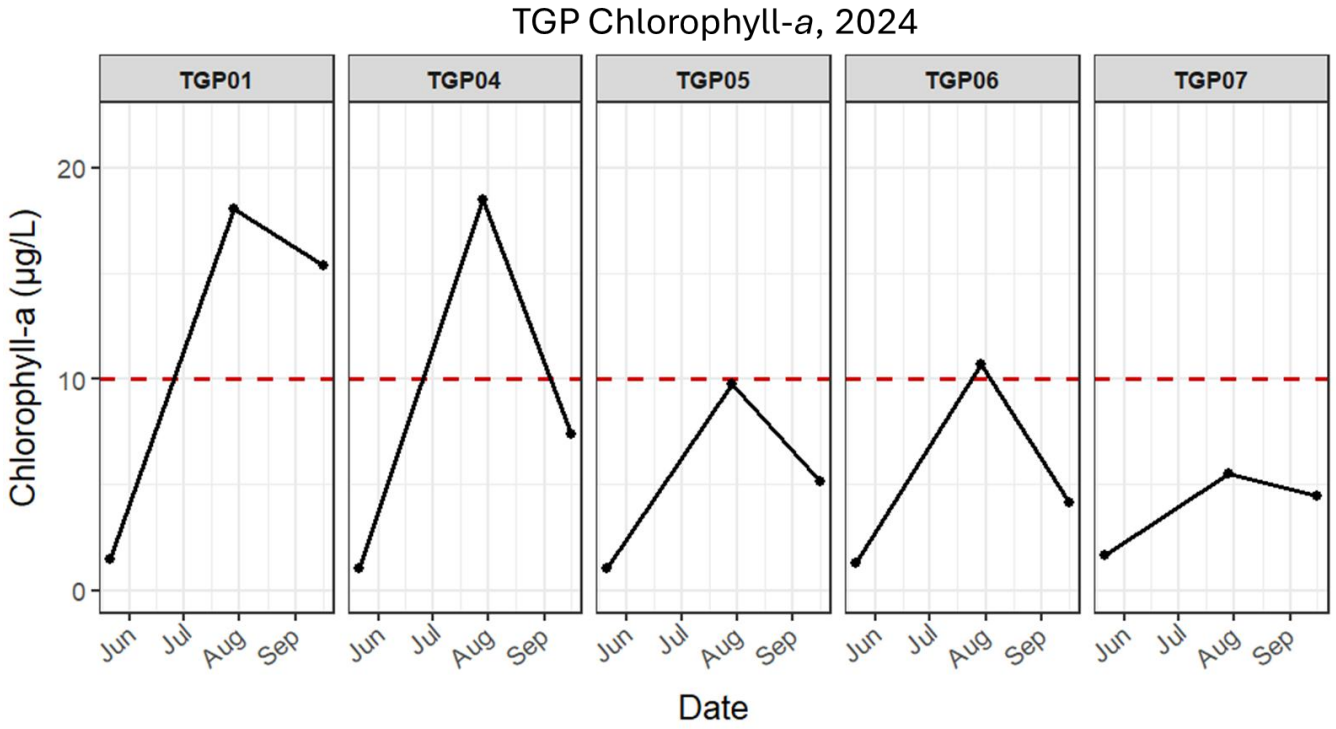

Figure A2. *Lab-measured chlorophyll-a concentrations (in ug/L) for TGP's 5 nutrient monitoring stations during the 2024 monitoring season. Chlorophyll-a measurements were obtained from Marine Biological Laboratory (MBL). The dashed red line represents the State's 10 ug/L management threshold.*

Supplementary Figures

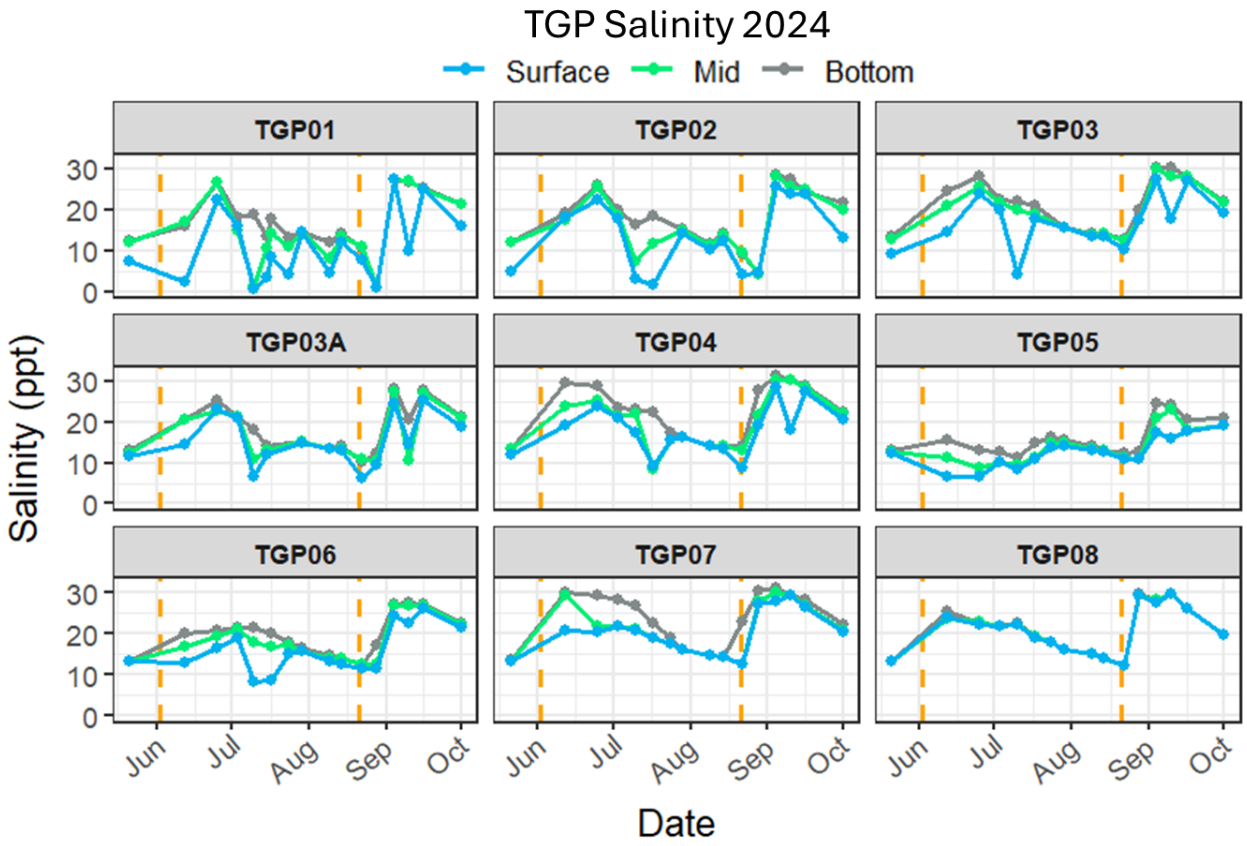

Figure A3. *Salinity in parts per thousand (ppt) for TGP's 9 monitoring stations during the 2024 field season. Data was measured using a handheld probe for 3 depths (surface, mid-depth, and bottom). Vertical dashed yellow lines represent openings on the Pond.*

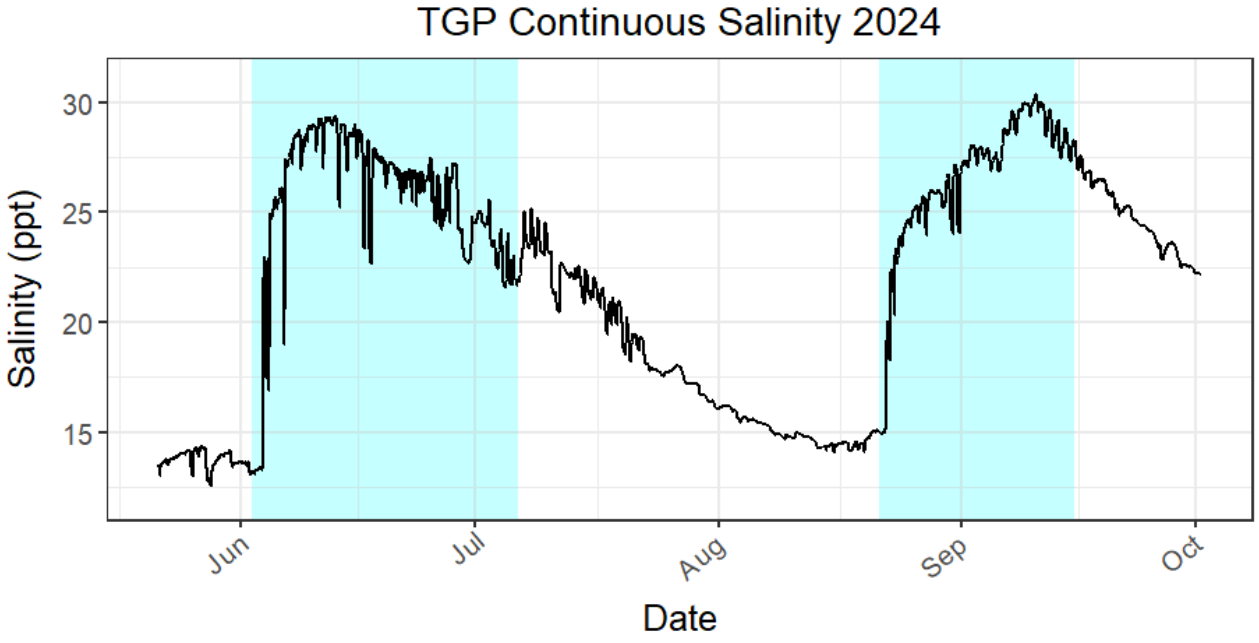

Figure A4. *Continuous salinity measurements (in ppt) recorded at the pond bottom every 30 minutes at monitoring station TGP04 (Town Cove) in 2024. Shaded blue areas indicate an opening on the Pond.*

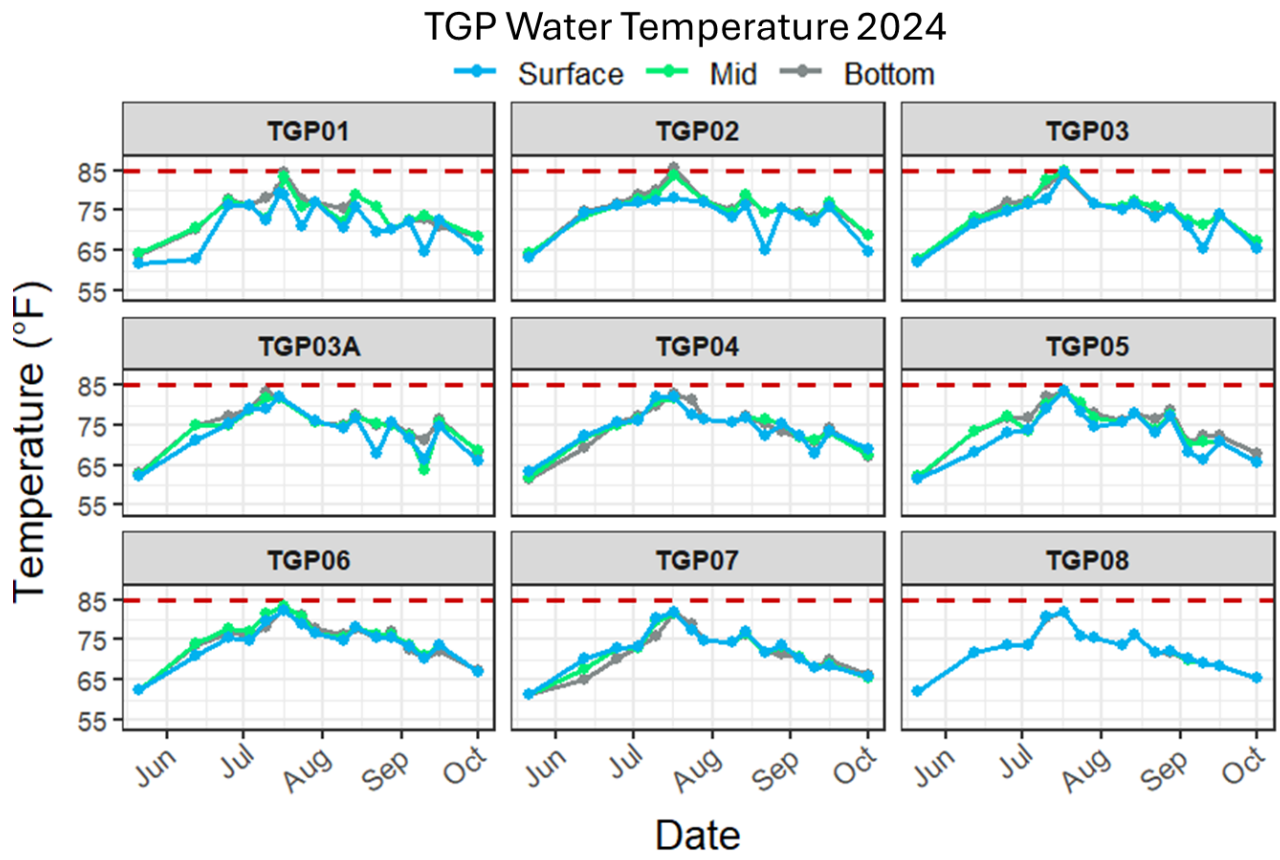

Figure A5. *Water temperature (in °F) for TGP's 9 monitoring stations during the 2024 field season. Data was measured using a handheld probe for 3 depths (surface, mid-depth, and bottom). The dashed red line represents the State's 85 °F management threshold.*

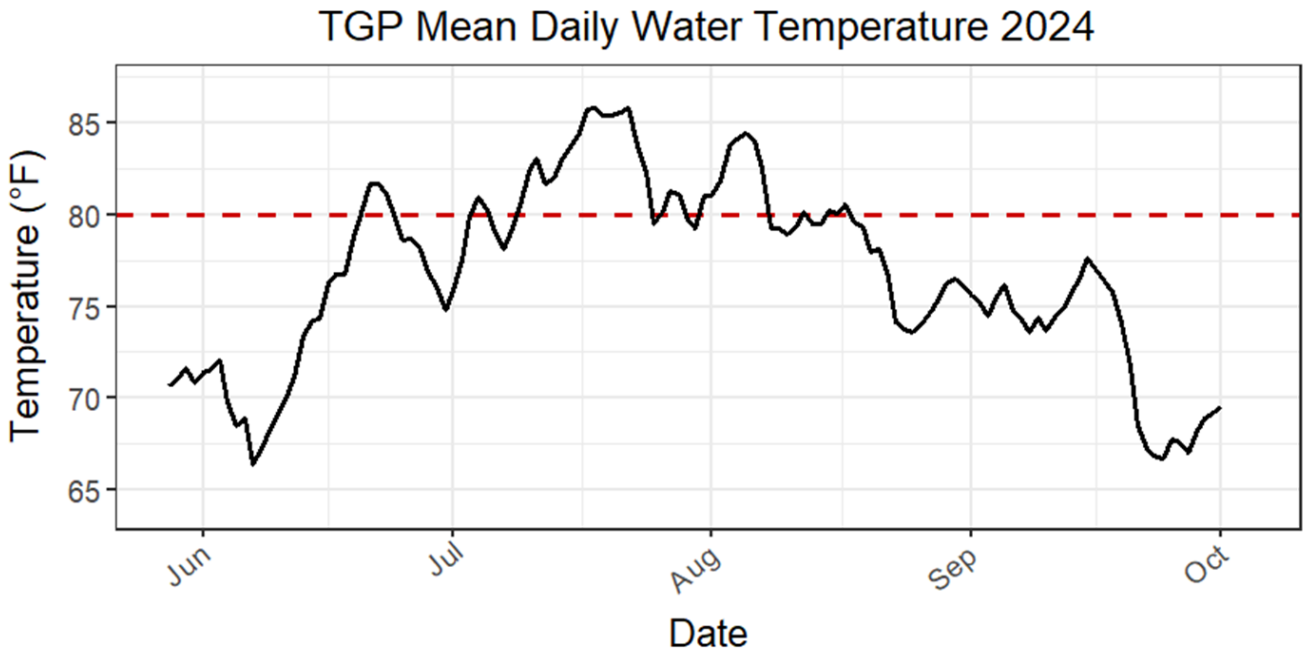

Figure A6. *Mean daily water temperature (in °F) at monitoring station TGP04 (Town Cove) during the 2024 field season. The dashed red line represents the State's 80 °F mean daily temperature threshold.*

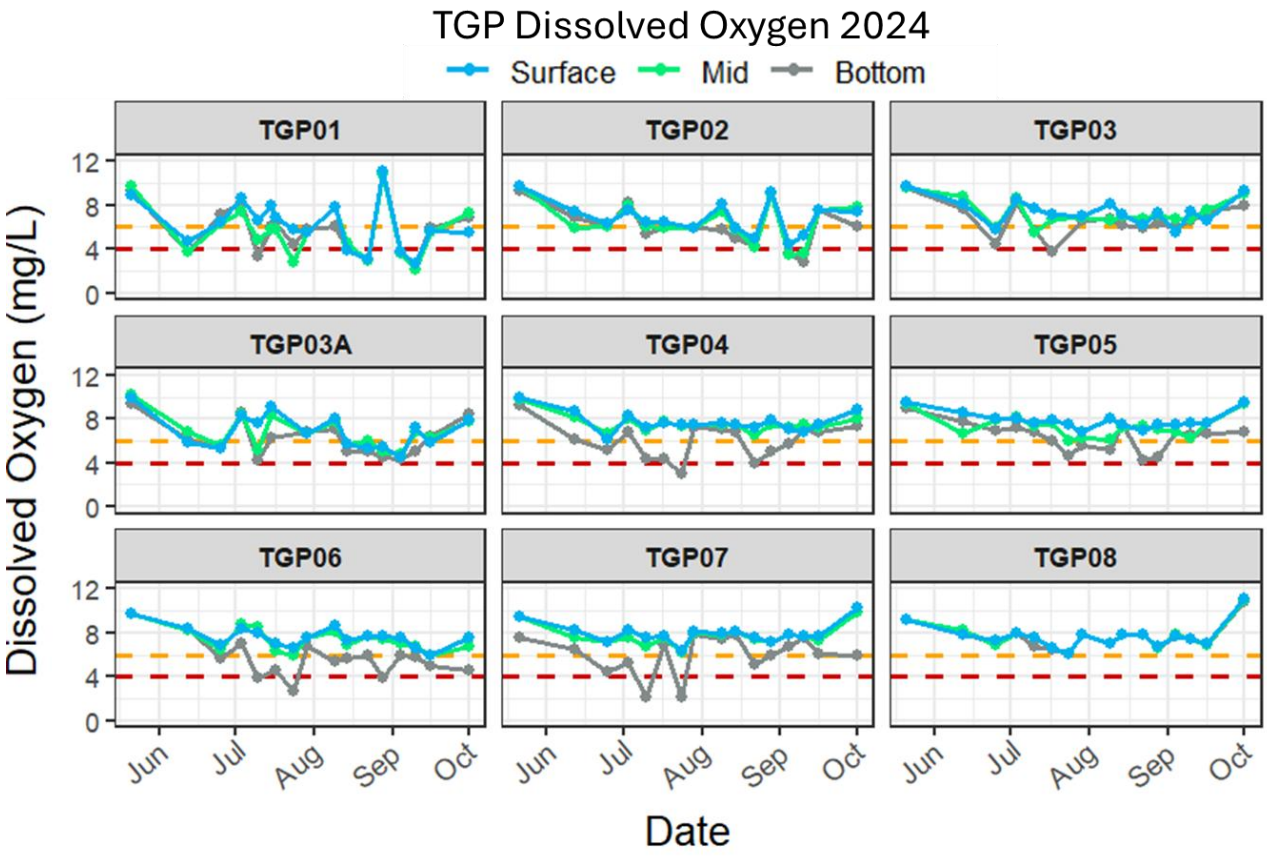

Figure A7. *Dissolved oxygen (DO) in mg/L for TGP's 9 monitoring stations during the 2024 field season. Data were measured using a handheld probe for 3 depths (surface, mid-depth, and bottom). The dashed yellow line represents the State's 6 mg/L management threshold, while the dashed red line indicates when DO levels dropped critically low (<4 mg/L).*

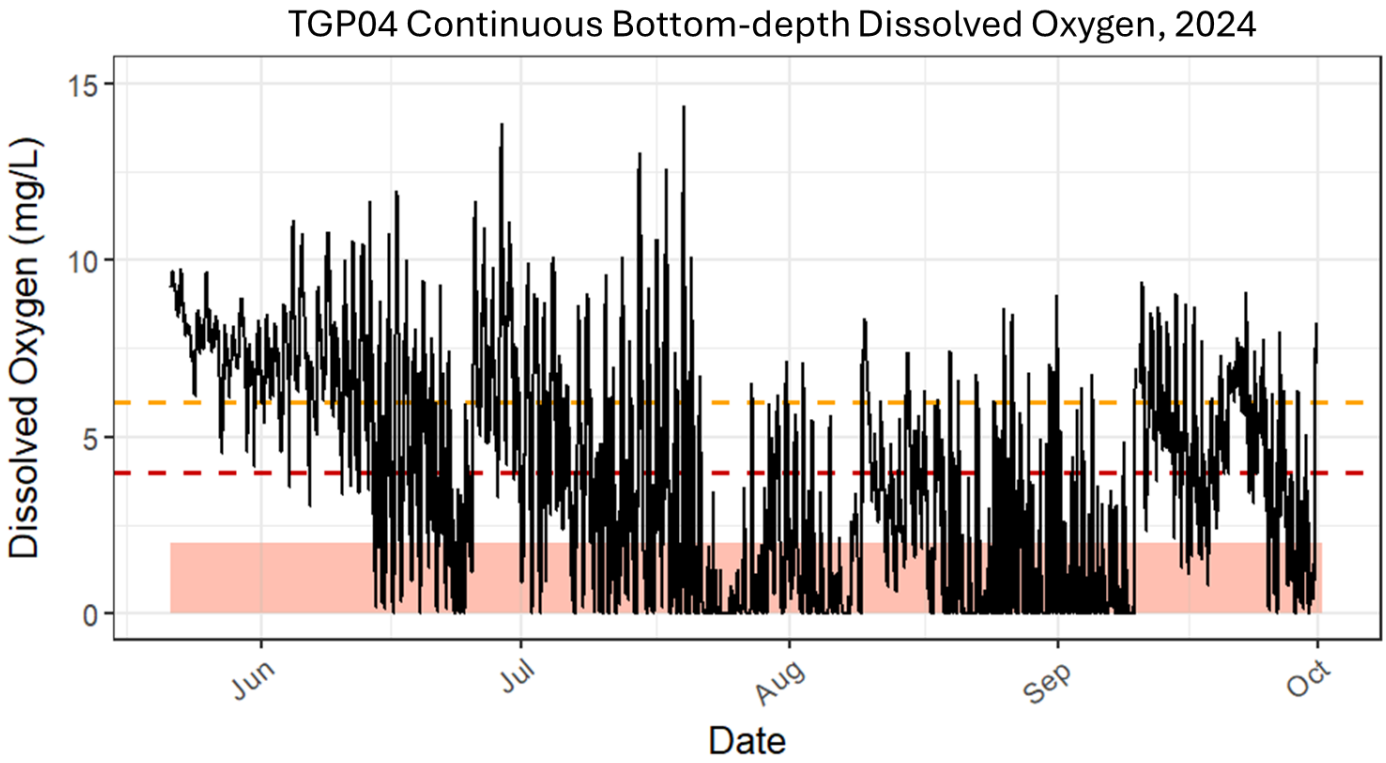

Figure A8. *Continuous dissolved oxygen (DO) in mg/L recorded every 30 minutes during the 2024 monitoring season. Data was obtained on the pond bottom at station TGP04. The dashed yellow line represents the 6 mg/L management threshold, the dashed red line indicates when DO levels dropped critically low (<4 mg/L), and the light red box indicates when hypoxia occurred (<2 mg/L). In a healthy ecosystem, daily fluctuations of DO should remain above the 6 mg/L threshold.*

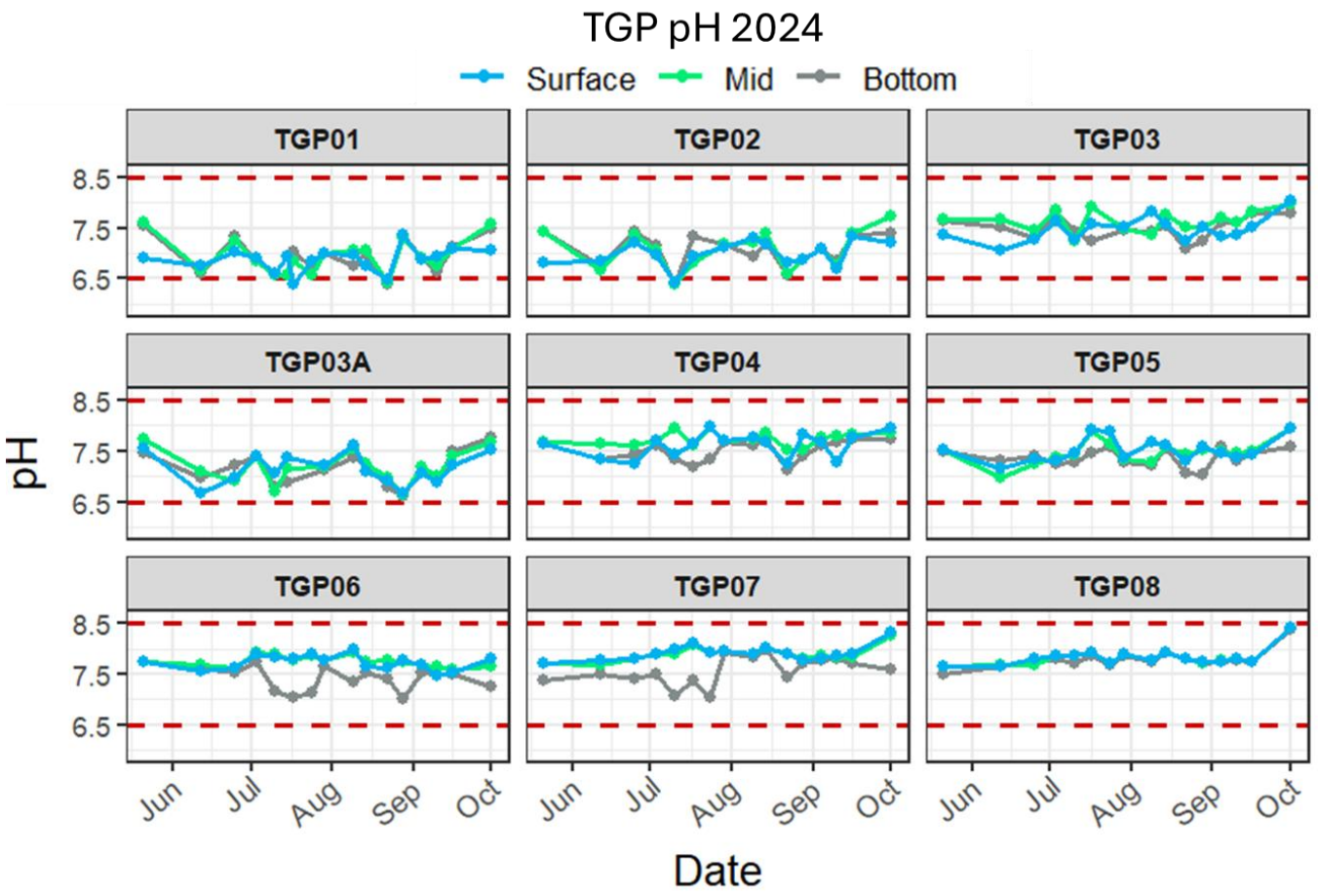

Figure A9. *pH for TGP's 9 monitoring stations during the 2024 field season. Data were measured using a handheld probe for 3 depths (surface, mid-depth, and bottom). The dashed red lines indicate the boundaries of the pH management target (6.5-8.5).*

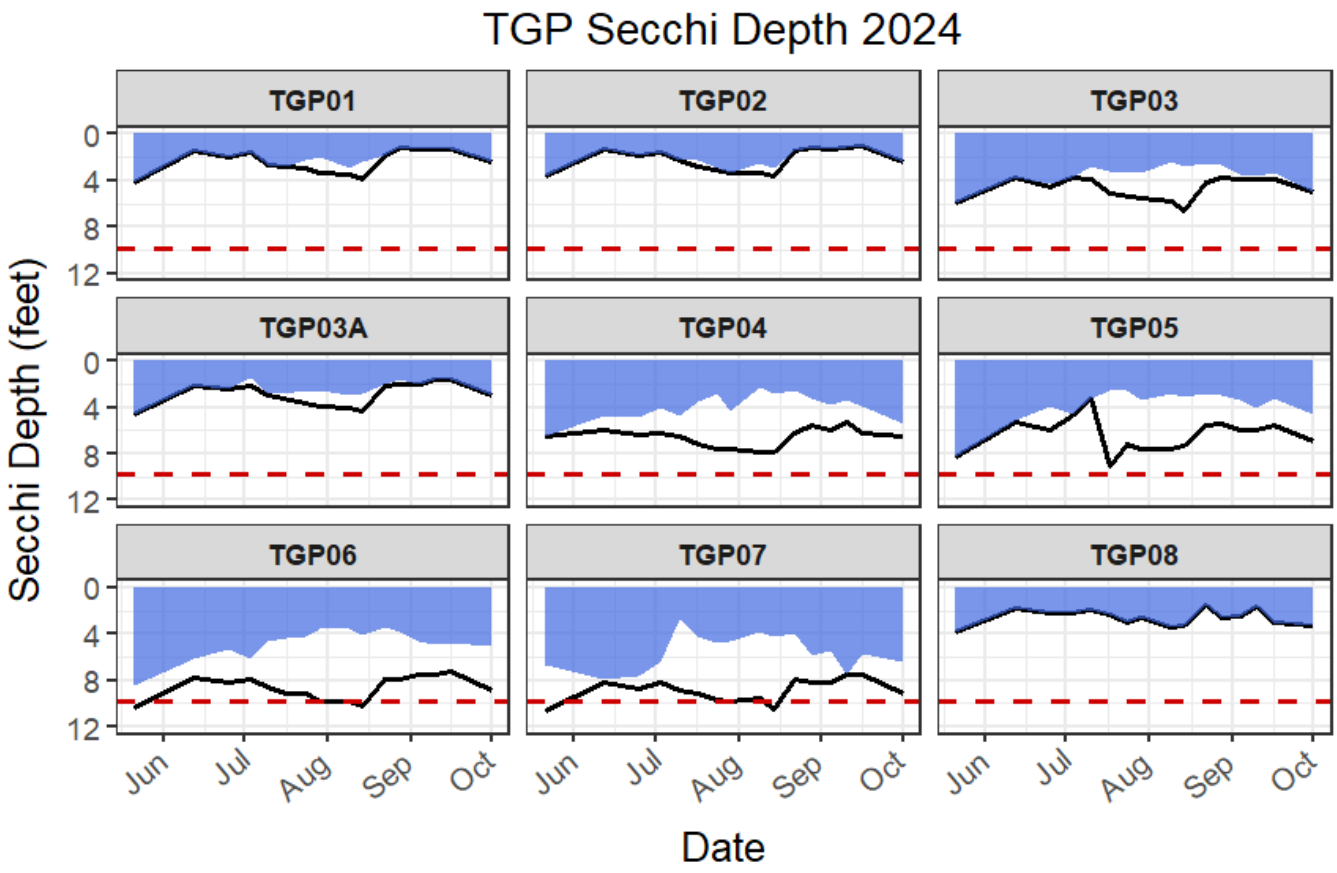

Figure A10. *Secchi depth and total depth in feet for TGP's 9 monitoring stations during the 2024 field season. Secchi depth is the depth at which a standardized disk disappears, thereby representing visibility into the water column. Total depth at each station is represented by a black line in these figures, while visible Secchi depth is represented by the blue shaded area. Any point where Secchi depth is equal to bottom depth indicates that visibility was to the bottom. A monitoring area is considered to have good water clarity when Secchi depth equals the total depth at sites shallower than 9.8 feet, or when Secchi depth is greater than or equal to 9.8 feet at deeper locations (9.8 feet represented by the dashed red line).*

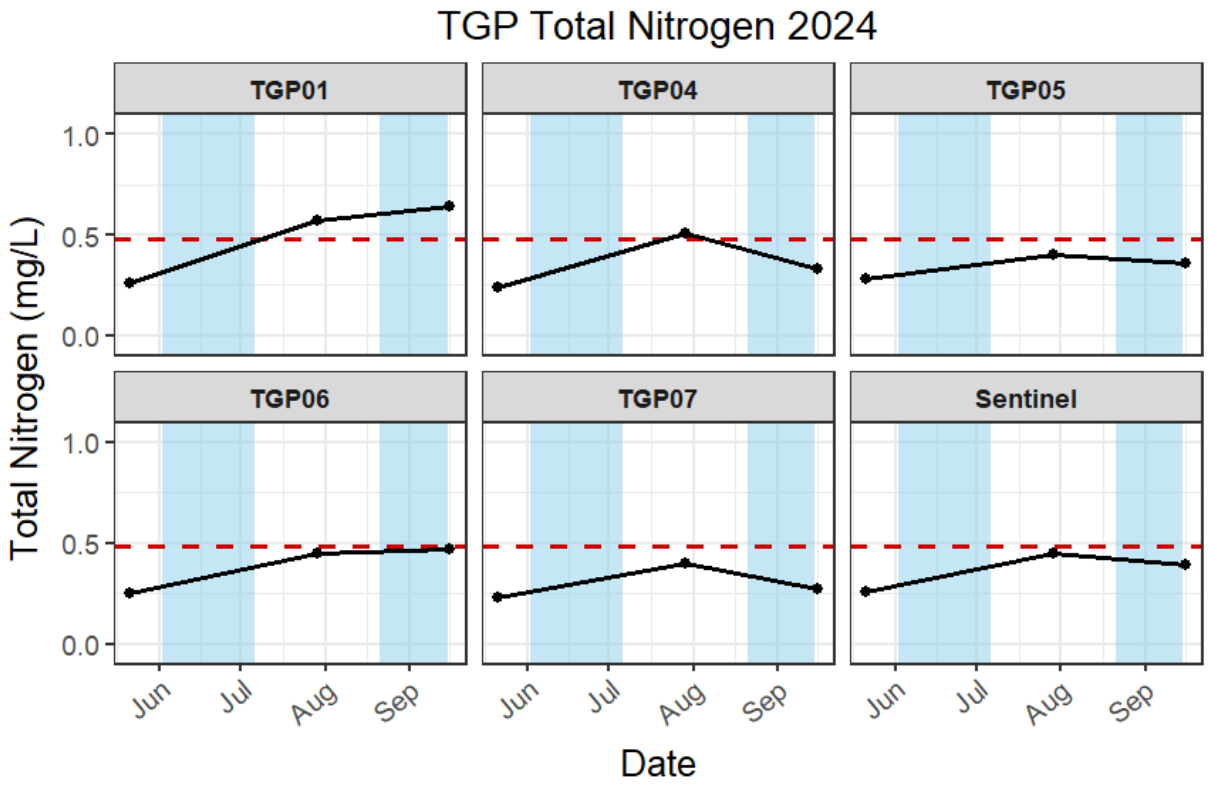

Figure A11. *Total nitrogen (in mg/L) for TGP's 5 nutrient monitoring stations and the "sentinel station" (average of TGP04, TGP05, and TGP06) in 2024. The dashed red line represents the State's management threshold (0.5 mg/L). Blue shading indicates an opening on the Pond.*

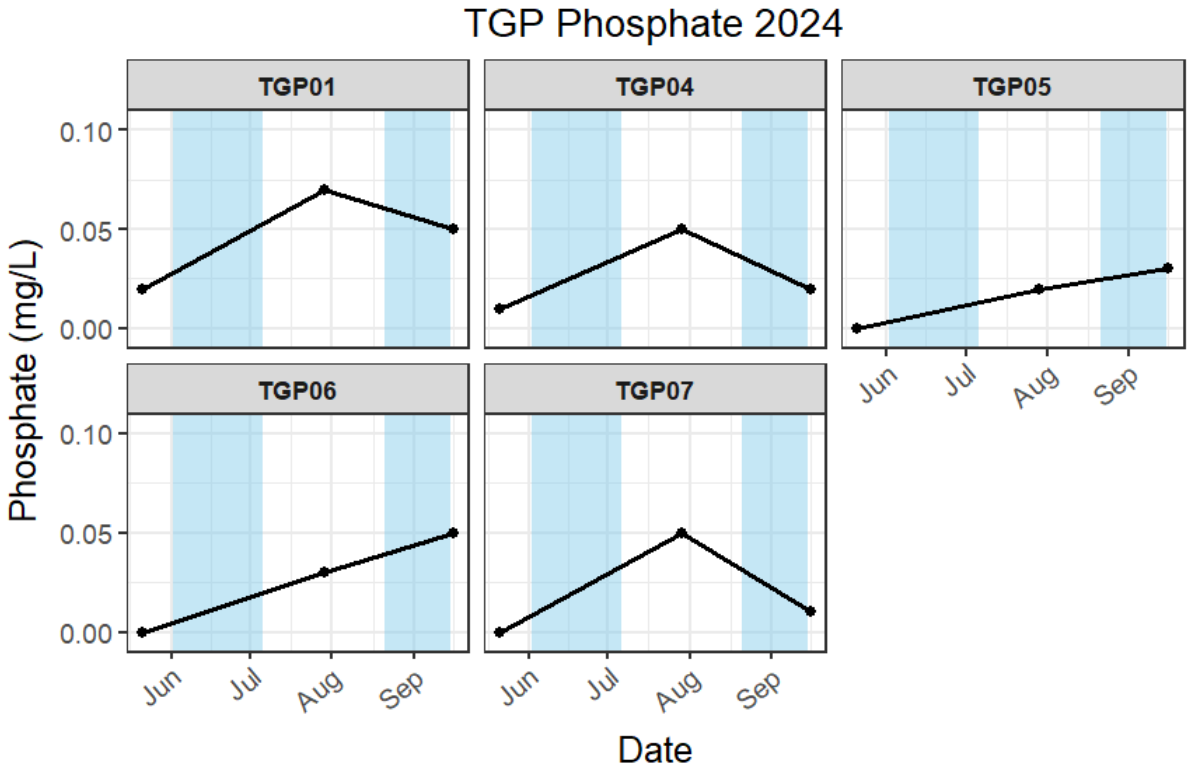

Figure A12. *Phosphate (in mg/L) for TGP's 5 nutrient monitoring stations in 2024. Blue shading indicates an opening on the Pond.*

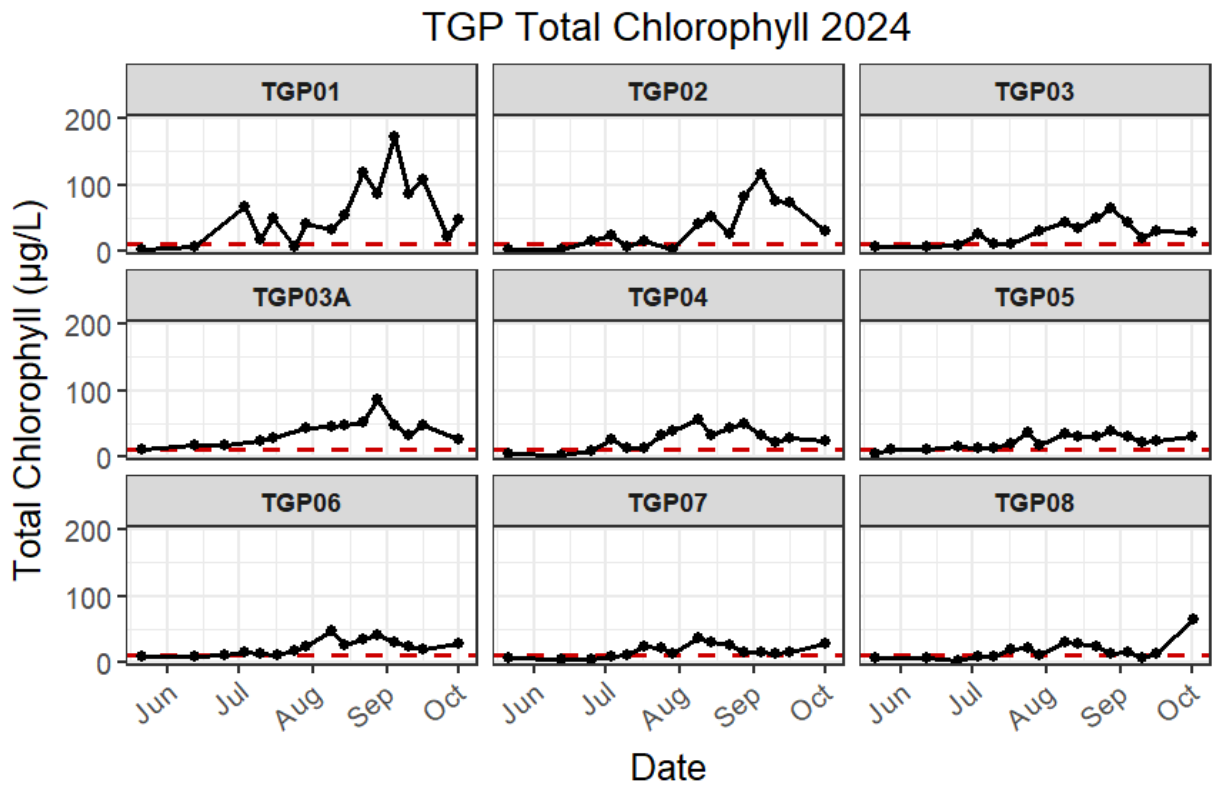

Figure A13. *Total chlorophyll (in ug/L) for TGP's 9 monitoring stations during the 2024 field season. The dashed red line represents the State's chlorophyll management threshold (10 ug/L).*

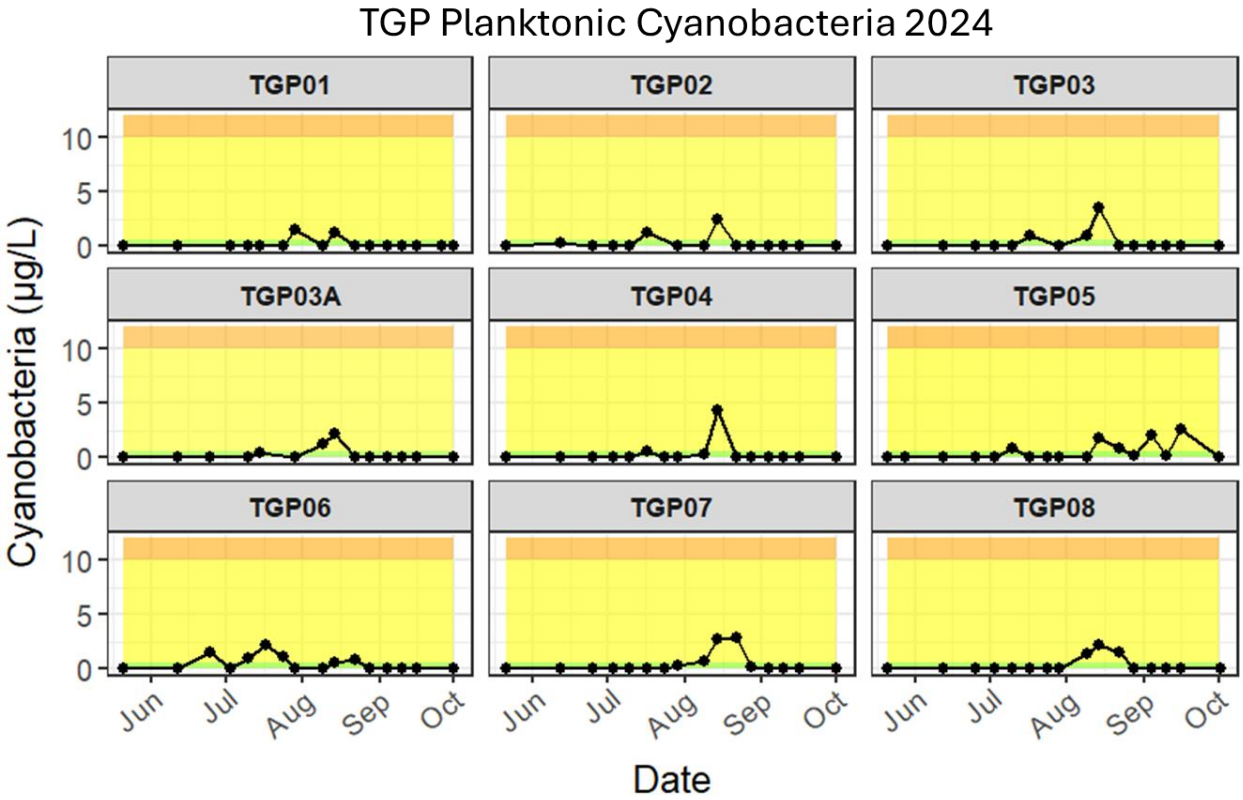

Figure A14. *Planktonic cyanobacteria (in µg/L) at TGP's 8 monitoring stations in 2024. Background colors pertain to the color-coded risk matrix used by the MV CYANO$_{TM}$ monitoring program (see* ***Figure A15****).*

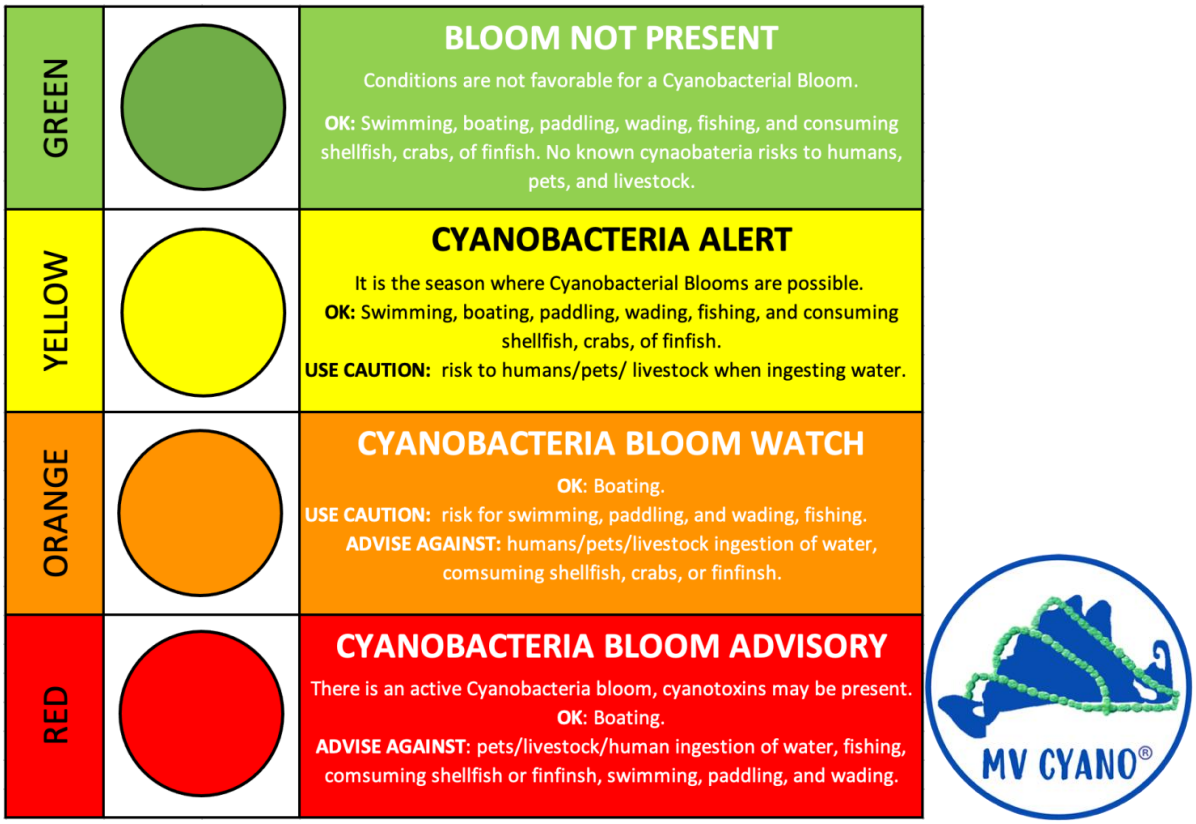

Figure A15. *The color-coded messaging & logo used by the MV CYANO$_{TM}$ monitoring program.*