2022
&
2023

ECOSYSTEM MONITORING REPORT

TISBURY GREAT POND

GREAT POND FOUNDATION

*In memory of **Virginia Cromwell Jones**, a champion of Vineyard waters.*

GREAT POND foundation®

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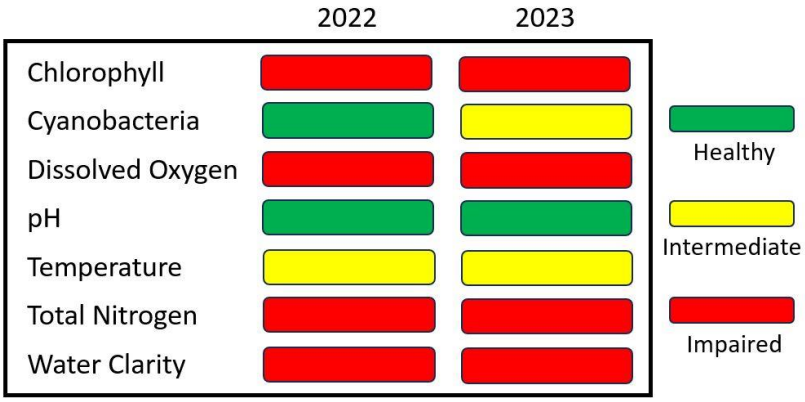
TISBURY GREAT POND
Executive Summary 2022-2023

Prepared on behalf of the **Tisbury Great Pond Foundation**

Study Area

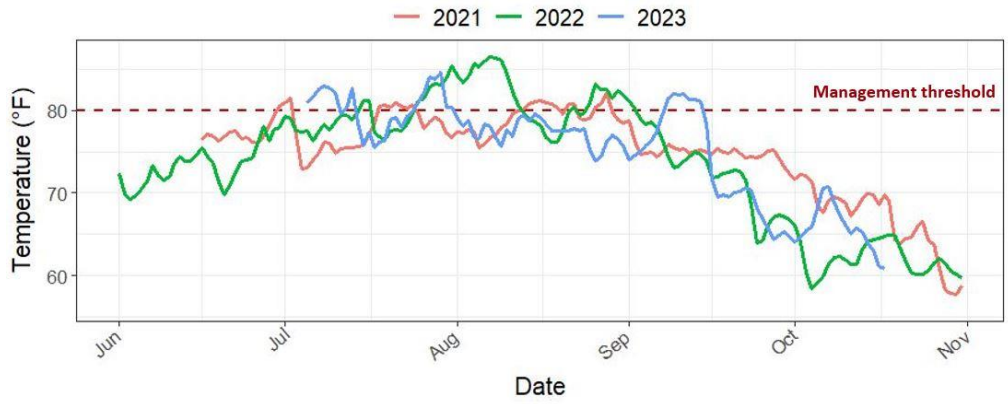
Tisbury Great Pond (TGP) is a coastal estuary approximately 740 acres in size situated along the southern shoreline of Martha's Vineyard in the Towns of Chilmark and West Tisbury, MA. The Pond encompasses a roughly 1,906-acre area watershed. The barrier beach separating the Pond from the ocean is manually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

Summary of Metrics



*Refer to the *Appendix* for info on how rankings were assigned.

Figures included in this executive summary correspond to data averaged across all TGP monitoring stations. Please note that management thresholds are included as a reference but are not applied to averaged data for determinations of impairment.



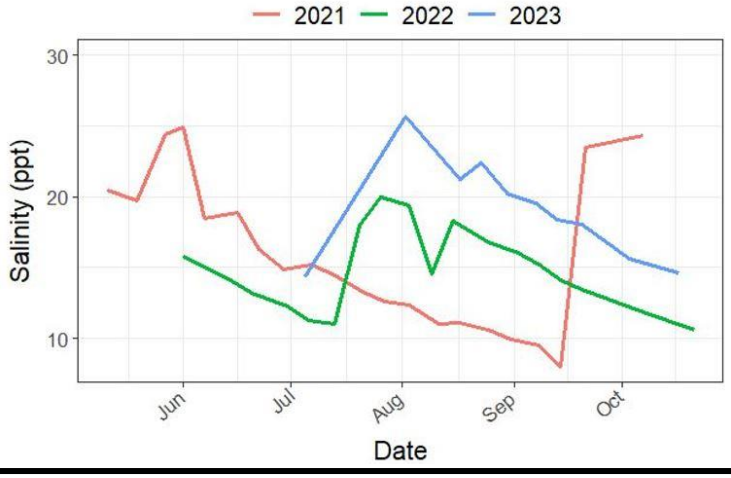
TEMPERATURE

Mean daily water temperature in 2023 (blue) compared to 2021 (red) and 2022 (green).

Mean daily temperature periodically rose above the management threshold (80 °F) across all 3 years.

SALINITY

Pond-wide mean salinity in 2023 (blue) is compared to 2021 (red) and 2022 (green).

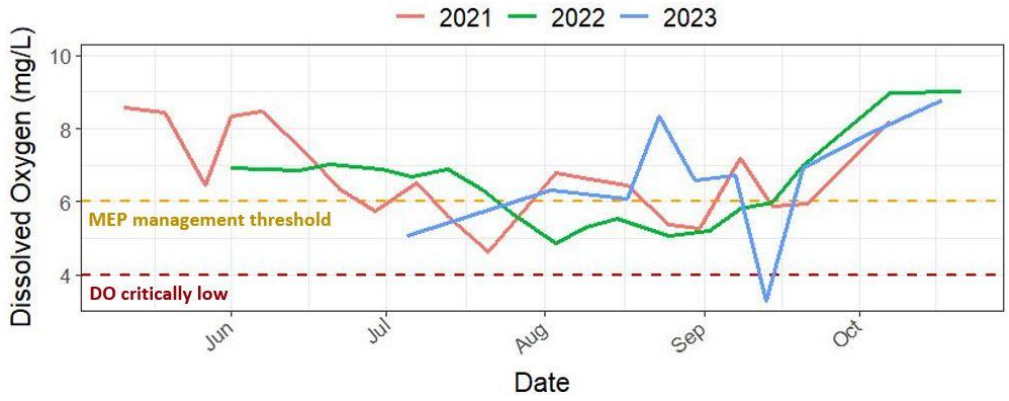


Cut Dates 2023

Date of Opening	Date of Closure	Cut Duration
Feb 23rd	Feb 28th	5 days
Apr 15th	Apr 30th	15 days
Jul 13th	Aug 11th	29 days
Oct 29th	Dec 2nd	34 days
Dec 18th*	Jan 4th (2024)	17 days

*Cut on December 18th occurred naturally rather than through a man-made breach.

DISSOLVED OXYGEN



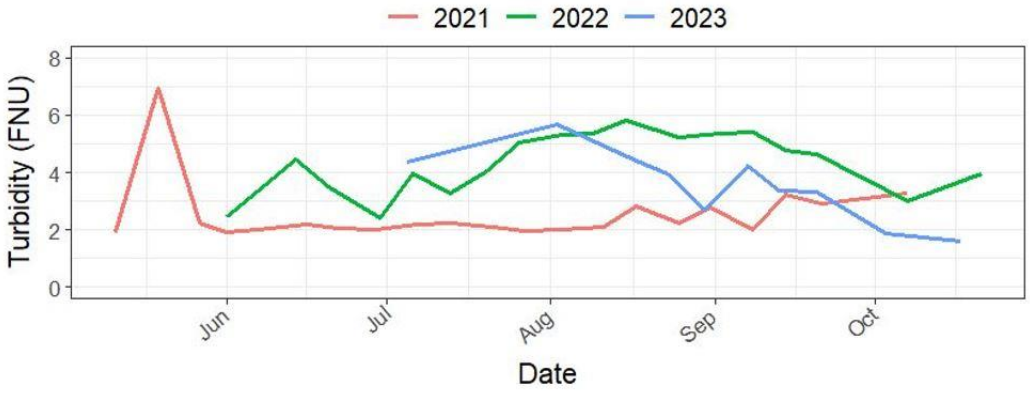
Pond-wide mean bottom-depth dissolved oxygen (DO) in 2023 (blue) compared to 2021 (red) and 2022 (green).

Mean bottom-depth DO only fell below the critical threshold (4 mg/L) in 2023.

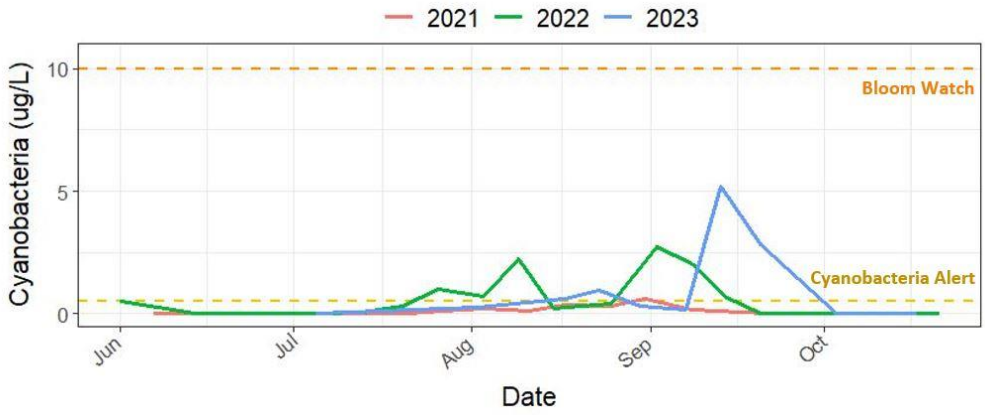
TURBIDITY

Pond-wide mean turbidity in 2023 (blue) compared to 2021 (red) and 2022 (green).

Turbidity during the late summer and early fall was higher in 2022 relative to 2021 and 2023.



CYANOBACTERIA

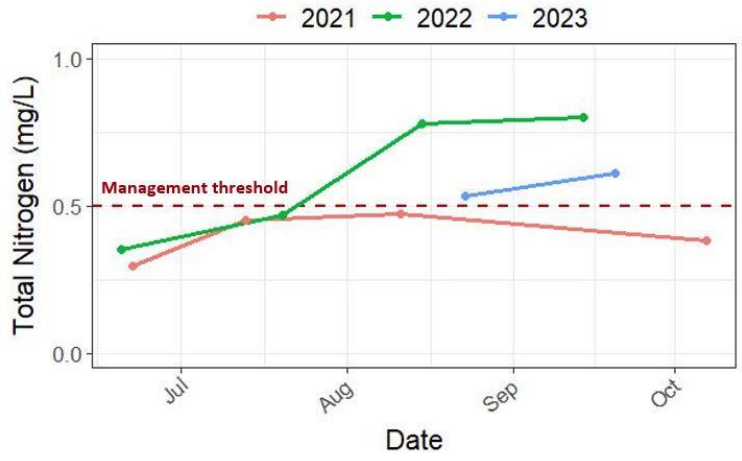


Pond-wide mean cyanobacteria concentration in 2023 (blue) is compared to 2021 (red) and 2022 (green).

Concentrations did not reach "bloom watch" status during any of the 3 comparison years.

TOTAL NITROGEN

Mean total nitrogen concentrations in 2023 across all monitoring stations (blue) were lower than those in 2022 (green) during the late summer, but higher than those in 2021.



Pond Summary

TGP exhibited reduced water quality and signs of impairment in 2022 and 2023, continuing trends seen in 2021. Total nitrogen concentrations regularly exceeded the management threshold during the late summer of both years. This spurred elevated phytoplankton growth in the water column, leading to reduced water clarity across the Pond. Dissolved oxygen levels periodically dropped into the hypoxic range, particularly when water temperatures were at their highest. Both years experienced pond openings in July that served to raise salinity, likely helping to keep ambient cyanobacteria levels low. However, concentrated clusters of cyanobacteria were observed in the Pond's coves in 2023.

Introduction

Tisbury Great Pond (TGP) is an important ecological, historical, cultural, and economic resource for the Towns of Chilmark and West Tisbury, MA. The Massachusetts Department of Environmental Protection (MassDEP) has designated all Martha's Vineyard waters, including TGP, as "Class SA" waters, pursuant of the MA Department of Environmental Protection, MA Surface Water Quality Standards, 314 CMR 4 (MassDEP, 2021). These waters are defined as follows:

"These waters are designated as an excellent habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth, and other critical functions, and for primary and secondary contact recreation. In certain waters, excellent habitat for fish, other aquatic life and wildlife may include, but is not limited to, seagrass. Where designated in the tables to 314 CMR 4.00 for shell fishing, these waters shall be suitable for shellfish harvesting without depuration (Approved and Conditionally Approved Shellfish Areas). These waters shall have excellent aesthetic value."

To cultivate the resilience of this fragile ecosystem, Great Pond Foundation (GPF) started an Ecosystem Monitoring Program in 2021 with the aim of providing high resolution data to inform pond management. Data collection focuses primarily on water quality data collection, cyanobacteria monitoring, and nutrient inventories. GPF conducted its ecosystem monitoring program on TGP for the entirety of the designated field season (June-October) in 2022. However, GPF began regular monitoring in early August in 2023. GPF's Ecosystem Monitoring Program follows the methodology and standards established by the Massachusetts Estuaries Project's (MEP) 2013 report on TGP (Howes et al., 2013), as well as the surface water quality standards established by MassDEP for Class SA waters (MassDEP, 2021). The following management targets have been set for TGP in accordance with these 2 bodies of work:

- Chlorophyll – Shall not exceed 10 ug/L. (MEP)
- Dissolved Oxygen (DO) – Shall not be less than 6.0 mg/L, unless observed natural background conditions are lower. (Class SA)
- pH – Shall be in the range of 6.5 through 8.5 standard units and not more than 0.2 standard units outside of the natural background range. (Class SA)
- Temperature – Shall not exceed 85˚F nor a maximum daily mean of 80˚F. (Class SA)
- Total Nitrogen – Shall not exceed a mean concentration of 0.48 mg/L for the sentinel station (TGP04, TGP05, & TGP06), or a concentration of 0.46 mg/L at station TGP07. (MEP)
- Water Clarity – Secchi depth shall not be less than 3 meters (9.8 feet), nor should it fail to reach the bottom when total depth is shallower than 3 meters. (MEP)

Study Area

Tisbury Great Pond (TGP) is a coastal estuary approximately 740 acres in size situated along the southern shoreline of Martha's Vineyard in the Towns of Chilmark and West Tisbury, MA. TGP consists of a main basin and several tributary coves (Town Cove, Pear Tree Cove, Short Cove, Tiah's Cove, Deep Bottom Cove, and Thumb Cove). The Pond's watershed encompasses roughly 11,906 acres of land contained entirely within the Towns of Chilmark and West Tisbury. A pair of freshwater streams enter TGP via Town Cove: the Tiasquam River and the Mill Brook. A barrier beach separates TGP from the Atlantic Ocean, which is intentionally breached or "cut" 3-4 times per year to drain the Pond and allow

for a period of tidal exchange with the ocean. Seawater is typically nutrient deficient compared to inland estuaries, and tidal exchange creates a "flushing" effect throughout the life of an opening and can be a nutrient management tool. Pond cuts are temporary, and close due to natural forces. The timing of an opening is determined by the commissioners of the Riparian Owners of Tisbury Great Pond, who consider factors such as pond elevation, water quality, weather, and the migration or breeding patterns of important fish and shellfish species. Following the closure of the cut, TGP gradually refills from groundwater and surface water input, as well as from precipitation directly onto the Pond's surface.

Scope of Work

In 2022 and 2023, Great Pond Foundation (GPF) continued its ecosystem monitoring program on TGP for the 2nd and 3rd consecutive years. Sampling during both years centered on 9 monitoring stations located throughout the Pond's main basin and its various coves (**Figure 1**).

Figure 1. *The locations of the 9 monitoring stations used by GPF in 2022 and 2023. Water quality monitoring was conducted at all stations (blue and green), while nutrient sampling was conducted solely at the green stations.*

Monitoring trips were typically conducted in the morning hours between 7 and 11 AM. Water quality data was obtained at each station by measuring the following metrics using a handheld YSI Pro DSS multiparameter probe: water temperature, salinity, dissolved oxygen (DO), pH, and turbidity. Additional continuous temperature, salinity, and DO readings were also collected from a stationary logger deployed on the pond bottom at station TGP04. Water clarity was measured at each station using a Secchi Disk. Cyanobacteria testing was conducted in TGP in both 2022 and 2023 through the MV CYANO$_{TM}$ program, a collaborative initiative between GPF and the Island Boards of Health. Nutrient sampling was performed once a month from June to September in 2022, and from August to September in 2023. Nutrient samples were collected from 5 of the Pond's 9 monitoring stations and processed at the Marine Biological Laboratory (MBL) in Woods Hole. A summary of fieldwork performed on TGP by year is presented in **Table 1**.

Table 1. *A summary of work performed on TGP in 2022 and 2023.*

	2022	**2023**
# of Monitoring Trips	18	10
Date Range of Monitoring Trips	6/1/22-10/21/22	7/5/23-10/17/23
Sampling Frequency	Weekly	Biweekly (starting 8/2/23)
# of Cyanobacteria Samples Processed	157	154
# of Nutrient Samples Processed	20	10

*GPF conducted its first 2023 monitoring trip on 7/5/23, but did not conduct another trip until 8/2/23, after which point trips were conducted on a biweekly basis.

Water Quality Metrics

Pond Openings

Summary Points:

- Tisbury Great Pond was manually opened to the ocean 3 times in 2022 and 4 times in 2023.
- Natural openings occurred in December of both 2022 and 2023 as a result of winter storms.
- The average length of openings on TGP has remained high since 2021.

The barrier beach separating Tisbury Great Pond from the ocean was breached a total of 4 times in 2022 and 5 times in 2023 (**Table 2**). In 2022, 3 of the year's 4 pond openings were man-made "cuts", as were 4 of the 5 pond openings that took place in 2023. Each year also experienced a natural breach in December due to winter storms. The number of days during which TGP was open to the ocean in 2022 closely resembled that of 2023. TGP was open to the ocean for 97 days in 2022 (78 owing to manual cuts) and 100 days in 2023 (83 owing to manual cuts). Both years also experienced similar average opening lengths for man-made cuts, with 2023 (20.75 days) falling just a few days short of 2022 (26 days). While TGP saw high cut effectiveness in both 2022 and 2023, TGP experienced a particularly successful year in 2021, as evidenced by an average opening length for man-made cuts of 41.75 days and a total of 185 days open to the ocean. Regardless, TGP's ability to maintain long-lived breaches in the barrier beach has remained consistently high since the beginning of 2021.

Table 2. *Approximate dates on which Tisbury Great Pond was opened to the ocean between 2021 and 2023. Dates listed in red indicate that an opening occurred naturally rather than through a man-made breach.*

Year	Average Length of Manual Openings	Days Open (Manual Openings Only)	Total Number of Days Open	Date of Opening	Date of Closure	Length of Opening
2021	41.75 days	167 days	185 days	2/10/2021	3/24/2021	42 days
				3/29/2021	4/16/2021	18 days
				5/8/2021	6/12/2021	35 days
				9/12/2021	10/30/2021	48 days
				12/29/2021	2/9/2022	42 days
2022	26 days	78 days	97 days	4/13/2022	5/8/2022	25 days
				7/15/2022	7/26/2022	11 days
				11/4/2022	12/16/2022	42 days
				12/23/2022	1/11/2023	19 days
2023	20.75 days	83 days	100 days	2/23/2023	2/28/2023	5 days
				4/15/2023	4/30/2023	15 days
				7/13/2023	8/11/2023	29 days
				10/29/2023	12/2/2023	34 days
				12/18/2023	1/4/2024	17 days

Salinity

Summary Points:

- Salinity trends throughout the 2022 and 2023 field seasons were consistent with the timing of manual openings of the Pond.
- Salinity concentration trends were similar across most monitoring stations during both years and were often higher at the pond bottom relative to the upper water column.
- Tiah's Cove consistently experienced the weakest salinity response to pond openings out of all monitoring locations.

TGP can be classified as a brackish estuary, which is defined as maintaining salinity concentration between 0.5 and 35 parts per thousand (ppt). As the Pond's connection to the ocean is intermittent, salinity concentrations trend downwards during periods of freshwater recharge and are highest following an opening. Incidental increases in salinity due to over wash across the barrier beach can also occur. Salinity concentrations are almost entirely influenced by rates of freshwater versus seawater input and can be an indicator of hydrodynamic factors, particularly the mixing, circulation, and flushing patterns that occur during an opening.

Continuous readings obtained from a stationary logger deployed at station TGP04 indicate that salinity concentrations in the Pond's main basin generally remained between 10 and 30 ppt during the 2022 and 2023 field seasons (**Figures 2 & 3**). Each of the 3 pond openings that were captured in this inter-year dataset induced a sharp rise in salinity, increasing concentration to anywhere from 22 to 30 ppt. The extent of the salinity spike seen in TGP following an opening on the pond appears to be related to the duration of a given opening, with longer openings yielding higher salinity spikes due to a prolonged period of tidal exchange in the Pond. This can be seen by the 11-day opening on 7/15/22 increasing salinity to just 22 ppt, while the longer openings on 11/4/22 (42 days) and 7/15/23 (29 days) prompted increases in salinity to over 28 ppt. The high variability observed in salinity measurements collected during the 2022 and 2023 openings help to illustrate tidal movement and hydrological mixing dynamics within the Pond.

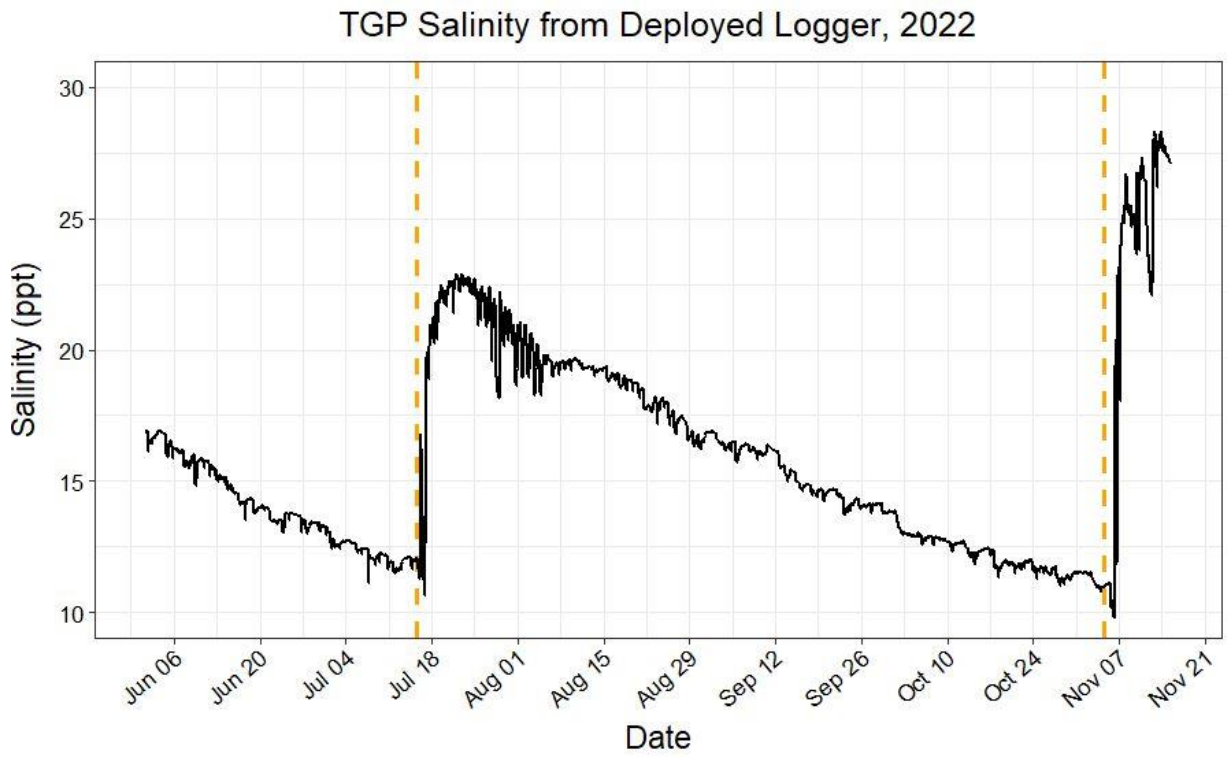


Figure 2. *Salinity in parts per thousand (ppt) during the 2022 field season. Data was obtained from a conductivity/salinity data logger deployed at station TGP04. The dashed yellow lines indicate when TGP was cut to the ocean on 7/15/22 and 11/4/22, respectively. (Note scale on y-axis, differs between years).*

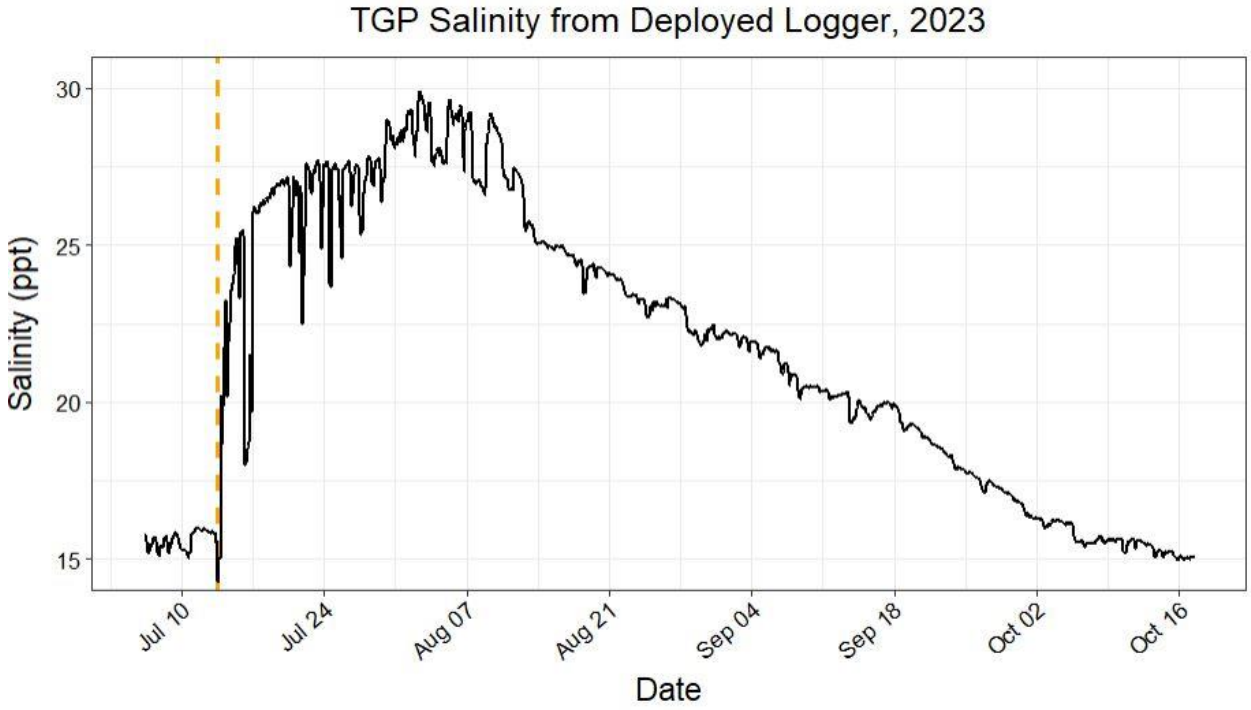


Figure 3. *Salinity in parts per thousand (ppt) during the 2023 field season. Data was obtained from a conductivity/salinity data logger deployed at station TGP04. The dashed yellow line indicates when TGP was cut to the ocean on 7/13/23. (Note scale on y-axis, differs between years).*

Observed salinity trends remained relatively consistent across all monitoring stations during both the 2022 and 2023 field seasons (**Figures 4 & 5**). Most monitoring stations experienced some level of salinity stratification within the water column during both years, with salinity often highest at the pond bottom and lowest at the surface. This salinity gradient was most pronounced in the Pond's coves, where inflowing groundwater (as well as stream water in the case of Town Cove) tends to rise above the denser brackish water of the pond upon its initial entrance. All monitoring stations experienced a notable rise in salinity following both years' respective summer openings. However, station TGP05 (Tiah's Cove) consistently experienced less pronounced salinity responses than the rest of the Pond following an opening, presumably due to shoaling at the cove's entrance that restricts flow.

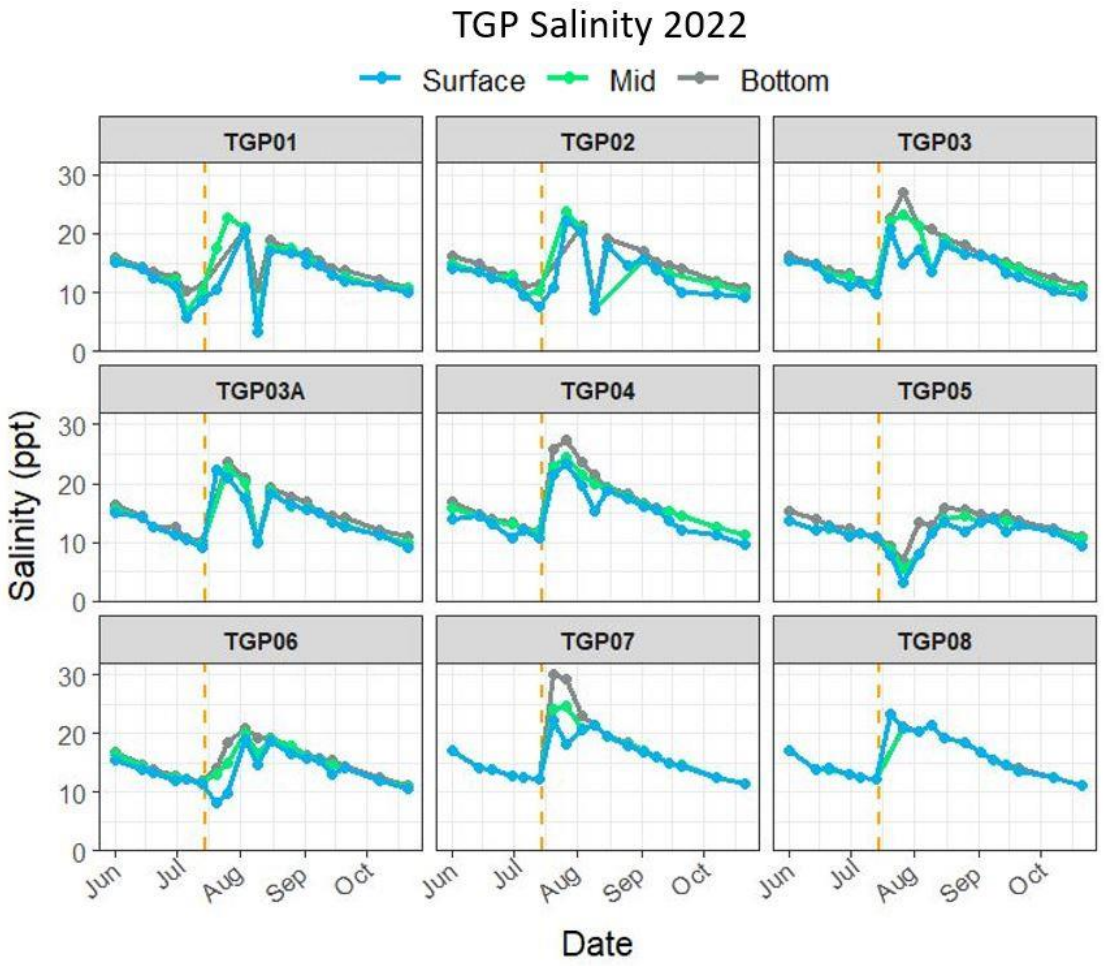


Figure 4. *Salinity in parts per thousand (ppt) for TGP's 9 monitoring stations during the 2022 field season. Data was measured using a handheld probe for 3 depths (surface, mid-depth, and bottom). The dashed yellow line indicates when TGP was cut to the ocean on 7/15/22. (Note scale on y-axis, differs between years).*

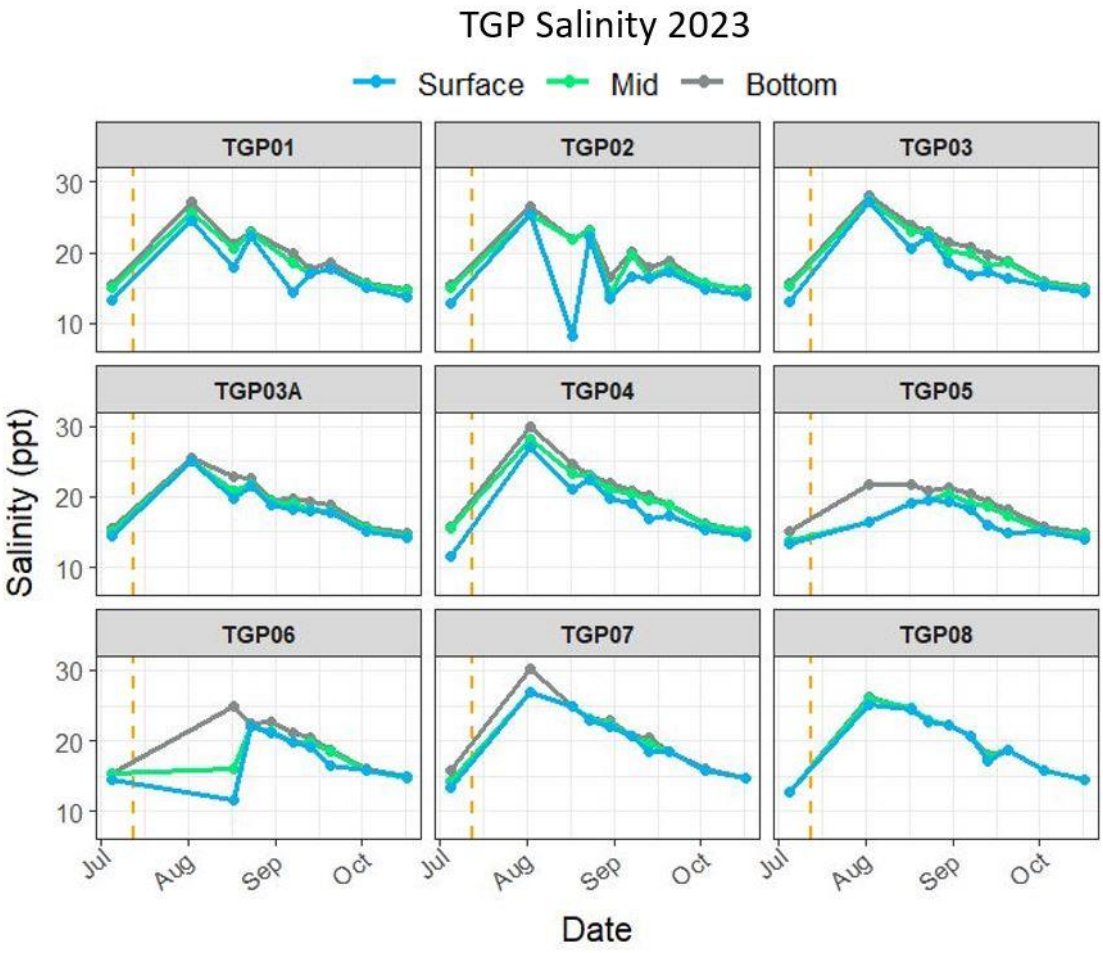


Figure 5. *Salinity in parts per thousand (ppt) for TGP's 9 monitoring stations during the 2023 field season. Data was measured using a handheld probe for 3 depths (surface, mid-depth, and bottom). The dashed yellow line indicates when TGP was cut to the ocean on 7/13/23. (Note scale on y-axis, differs between years).*

A comparison of historical salinity data shows that TGP housed higher salinity concentrations during the summers of 2022 and 2023 relative to 2021 (**Figure 6**). This is due to TGP experiencing extended openings during the summers of both 2022 and 2023, while pond elevation remained too low during the summer of 2021 for an opening to take place. Regardless, all 3 years saw salinity in TGP rise substantially following an opening on the Pond.

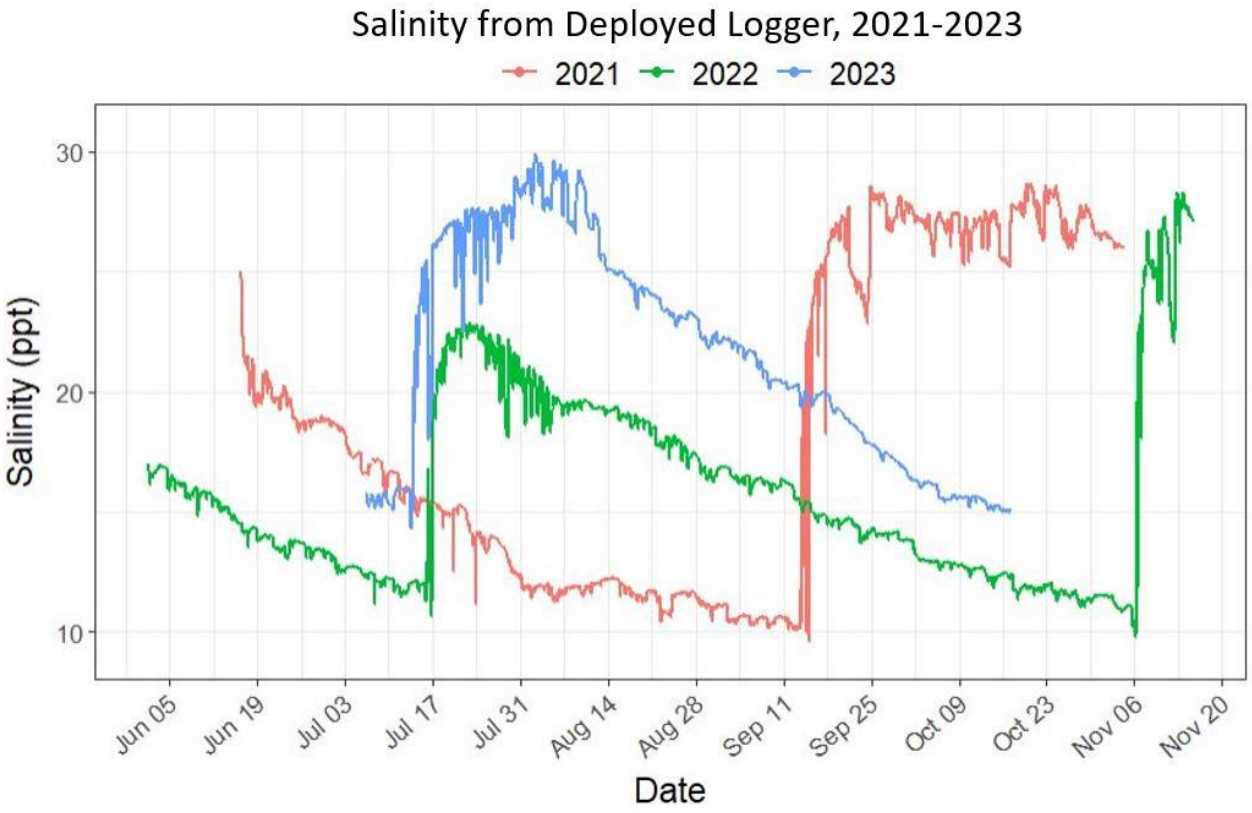


Figure 6. *Salinity in parts per thousand (ppt) in TGP for the years 2021, 2022, and 2023. Data was obtained via a conductivity/salinity data logger deployed at station TGP04.*

Temperature

Summary Points:

- Water temperature was consistent between all monitoring stations and across all measurement depths in the water column in both 2022 and 2023.
- Water temperatures were highest in August during the 2022 field season and highest in July and early September during the 2023 field season.
- Temperatures exceeded management thresholds during the hottest periods of both years, an indication that the TGP ecosystem experienced heat stress in these timeframes.

MassDEP standards for class SA waters establish that pond temperatures should not exceed 85 °F at any time, nor should the average temperature within a 24-hour period exceed 80 °F. Excessive water temperatures degrade native habitat quality and subject species to heat stress, possibly disrupting growth and reproduction cycles.

In-situ temperature readings were recorded alongside other water quality parameters during GPF sampling trips using a hand-held YSI Pro-DSS multimeter probe between the hours of 7-11 AM. Temperature trends were mostly consistent across the Pond throughout both the 2022 and 2023 field seasons (**Figures 7 & 8**). Temperature was uniform throughout the water column at all stations, with

some stratification between depths observed at the northernmost stations within the Pond's coves. This is likely the result of localized groundwater and tributary stream influx mixing with the warmer ambient water of TGP. This interaction is also illustrated by variations in relative salinity at these locations.

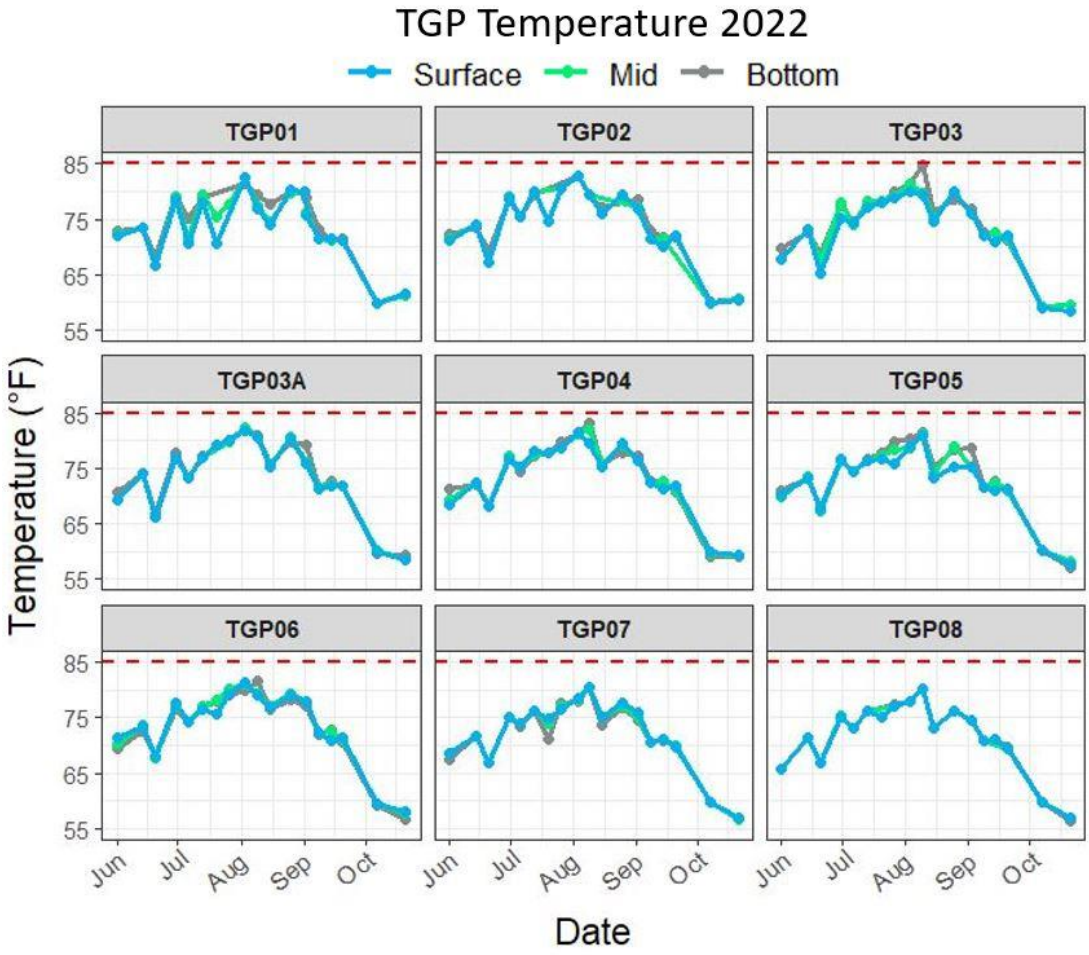


Figure 7. *Water temperature (in °F) for Tisbury Great Pond's 9 monitoring stations during the 2022 field season. Data was measured using a handheld probe for 3 depths (surface, mid-depth, and bottom) typically between the hours of 7-11 AM. The dashed red line represents the 85 °F management threshold.*

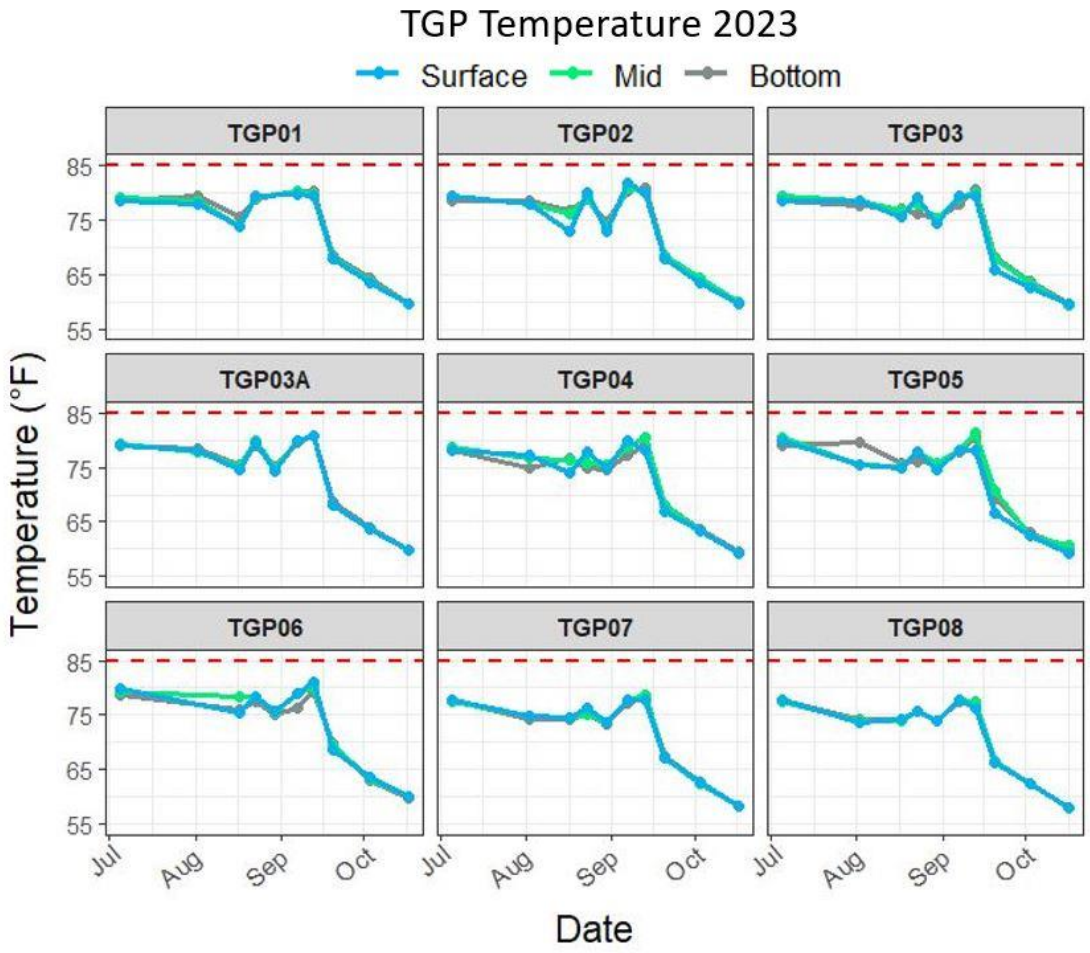


Figure 8. *Water temperature (in °F) for Tisbury Great Pond's 9 monitoring stations during the 2023 field season. Data was measured using a handheld probe for 3 depths (surface, mid-depth, and bottom) typically between the hours of 7-11 AM. The dashed red line represents the 85 °F management threshold.*

Continuous temperature data was obtained from a stationary logger/sensor deployed on the pond bottom at station TGP04, which recorded a measurement of temperature every 30 minutes throughout the monitoring period. This logger recorded 2 high-heat events in early and late August in 2022, as well as 2 high-heat events in July and early September in 2023 (**Figure 9**).

The range of water temperatures measured in TGP in 2022 and 2023 were 54.9-88.2 °F and 58.1-86.8 °F, respectively. Measured water temperatures from both years were closely aligned with ambient air temperatures. In 2022, water temperature exceeded 85 °F on a total of 13 days, while daily average temperature exceeded 80 °F on 29 days, most of which occurred during the August high-heat event. Water temperature rose above both management thresholds less often in 2023, exceeding 85 °F on 6 days and a daily average of 80 °F on 22 days. It should be noted that the number of days during which temperatures in TGP rose above the management thresholds in 2023 may be underestimated, as temperature data from before July 5th is unavailable.

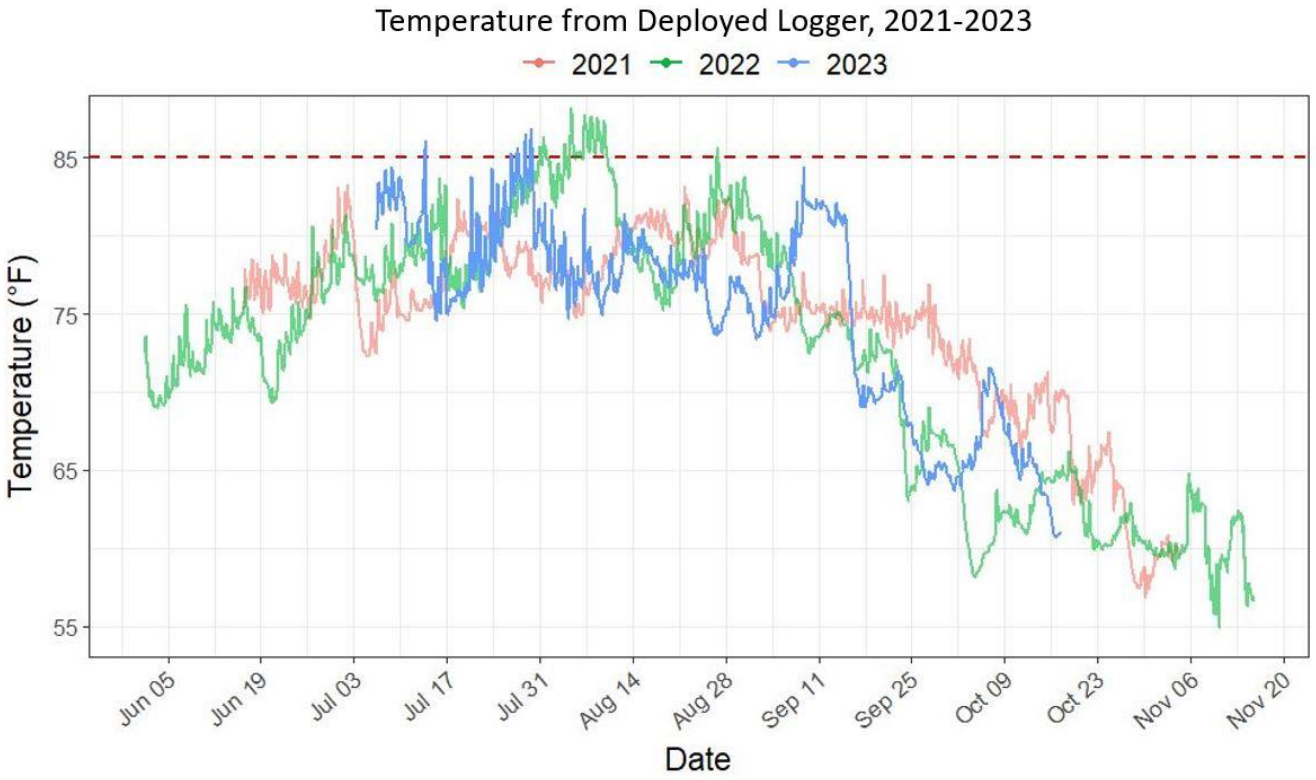


Figure 9. *Water temperature (in °F) in Tisbury Great Pond for the years 2021, 2022, and 2023. Data was obtained every 30 minutes by a continuous temperature logger deployed at bottom-depth at station TGP04 throughout the monitoring period. The dashed red line represents the 85 °F management threshold.*

Temperature trends were consistent across all stations between 2021 and 2023 (**Figure 9**). Water temperatures in 2022 and 2023 reached higher peaks during the hottest periods of the summer compared to 2021, which did not surpass the single-day 85 °F threshold throughout the monitoring period. However, average daily temperature exceeded 80 °F on a total of 21 days in 2021, inferring a similar level of heating within the Pond across all 3 years.

Dissolved Oxygen

Summary Points:

- DO concentrations in the upper water column were consistent between stations and generally remained above the 6 mg/L threshold during both years.
- Continuous data from station TGP06 shows that bottom-depth DO concentrations regularly fell into the hypoxic range (< 2 mg/L) during peak summer.
- Periods of high oxygen depletion generally coincide with high-heat events.

Dissolved Oxygen (DO) concentrations were measured in-situ using a YSI Pro DSS handheld multiparameter meter and probe at each station for 3 depths: surface, mid, and bottom depths throughout both 2022 and 2023 monitoring seasons. Continuous bottom-depth DO concentrations were also

measured at 30-minute intervals throughout the 2022 and 2023 monitoring seasons using a HOBO U26 dissolved oxygen data logger deployed at station TGP04. The TGP MEP report establishes a dissolved oxygen (DO) management threshold of 6 milligrams per liter (mg/L) for the Pond (Howes et al., 2013). Low-oxygen stress on aquatic organisms may begin to occur at concentrations of 4 mg/L, while concentrations of 2 mg/L or lower are considered critical (hypoxic) and can cause mortality events.

In 2022 and 2023, in-situ DO concentrations measured in the upper water column (i.e. surface and middle depths) at all stations between 7 and 11 AM remained above management thresholds for a majority of the monitoring period. However, temporary declines below the 6 mg/L management threshold were observed with moderate frequency, depending on the location in the Pond (**Figures 10 & 11**). The stations located in Town Cove (TGP01 and TGP02) consistently exhibited surface and mid-depth DO concentrations below the 6 mg/L management threshold.

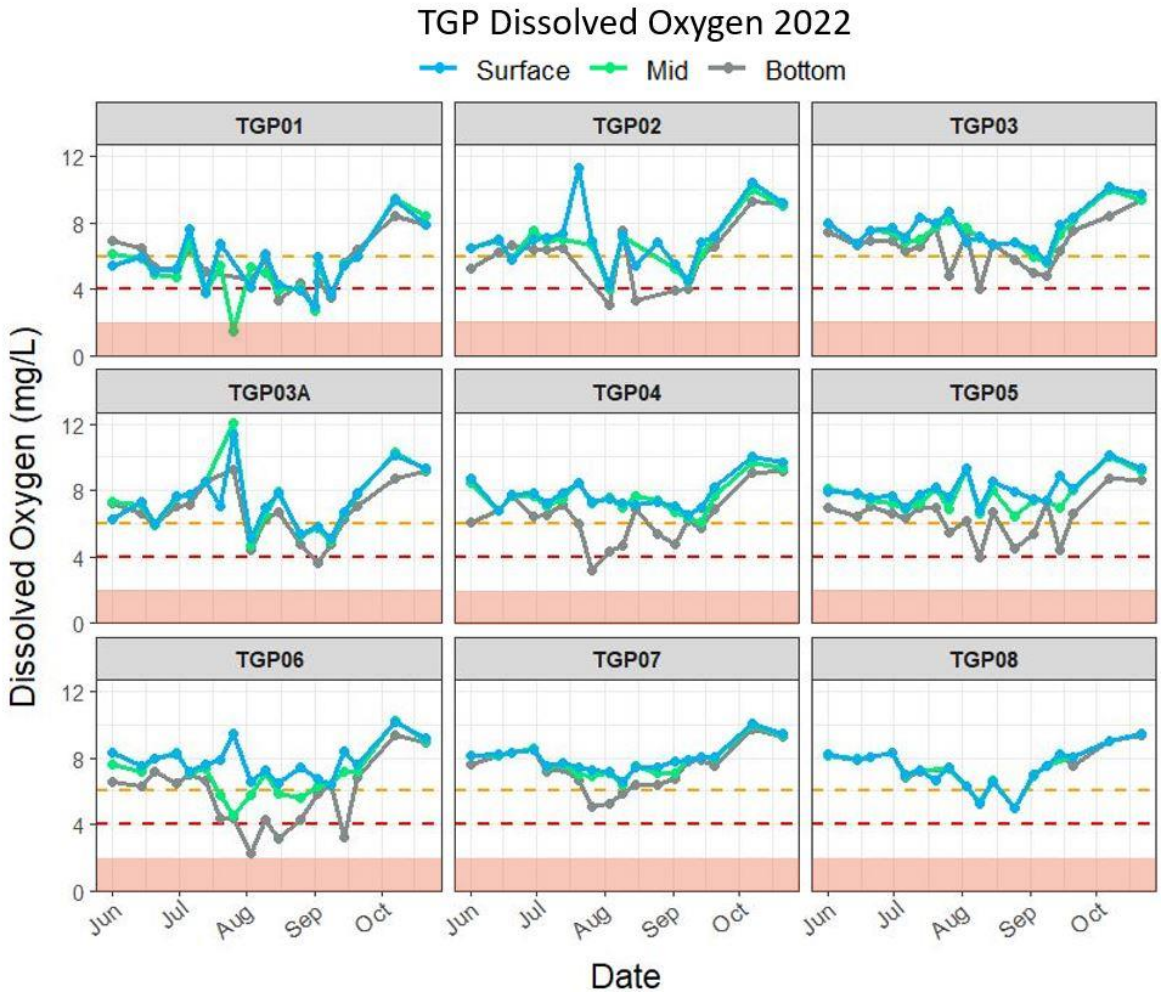


Figure 10. *Dissolved oxygen (DO) in milligrams per liter (mg/L) for Tisbury Great Pond's 9 monitoring stations during the 2022 season. Data was measured using a handheld probe for 3 depths (surface, mid-depth, and bottom). The dashed yellow line represents the 6 mg/L management threshold, the dashed red line indicates when DO levels dropped critically low (<4 mg/L), and the light red box indicates when hypoxia was occurring (<2 mg/L).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 was occurring (<2 mg/L). (Note scale on y-axis, differs between years).*

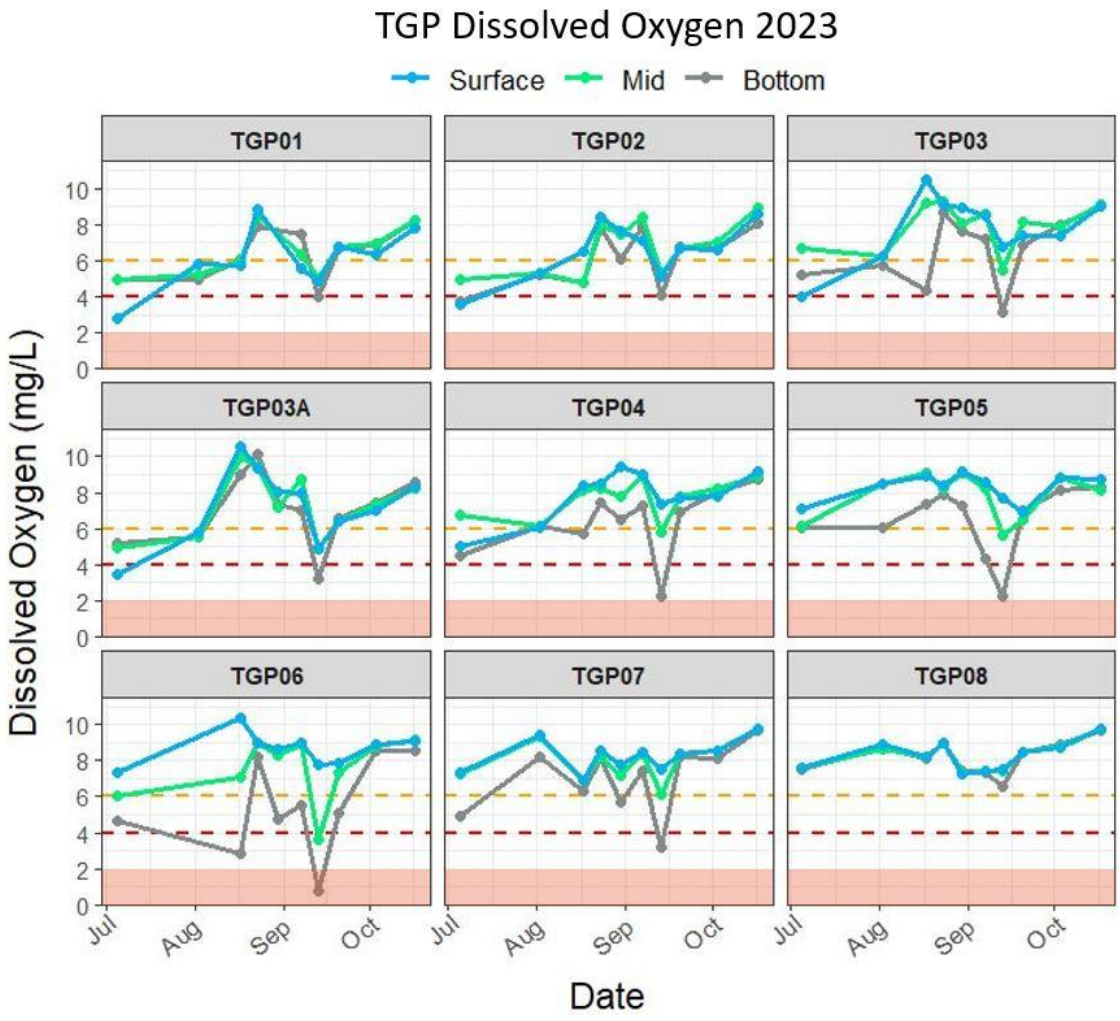


Figure 11. *Dissolved oxygen (DO) in milligrams per liter (mg/L) for Tisbury Great Pond's 9 monitoring stations during the 2023 season. Data was measured using a handheld probe for 3 depths (surface, mid-depth, and bottom). The dashed yellow line represents the 6 mg/L management threshold, the dashed red line indicates when DO levels dropped critically low (<4 mg/L), and the light red box indicates when hypoxia was occurring (<2 mg/L). In a healthy ecosystem, daily fluctuations of DO should remain above the 6 mg/L threshold. (Note scale on y-axis, differs between years).*

DO concentrations measured at bottom-depth were consistently lower than those in the upper water column for most stations in TGP, and periodically fell below the critical threshold (4 mg/L) during both 2022 and 2023 monitoring periods. Continuous data obtained for station TGP04 shows bottom-depth DO concentrations in 2022 and 2023 regularly dipped into the hypoxic range (<2 mg/L) between July and September, most often at night when photosynthesis was not taking place (**Figures 12 & 13**). Bottom-depth DO concentrations were lowest in early August and late August during the 2022 field season, and lowest in late July and early September during the 2023 field season. Periods of critical oxygen depletion at bottom-depth coincide with high-heat events in both years, which is expected as water's capacity to hold oxygen is reduced with increasing temperature.

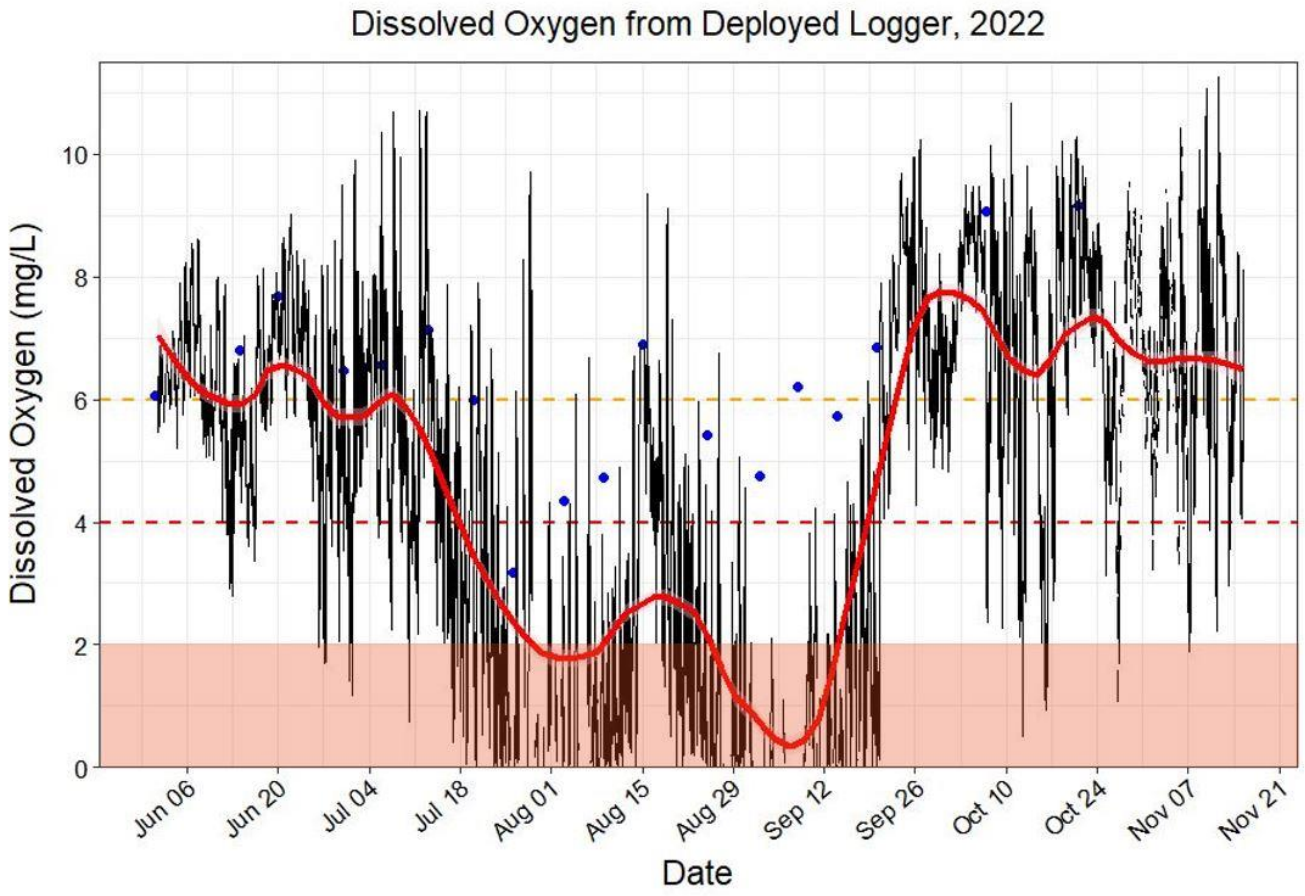


Figure 12. *Dissolved oxygen (DO) in milligrams per liter (mg/L) over the course of the 2022 field season. Data was obtained from a DO data logger deployed ~6 inches above the pond bottom at station TGP04. The black line represents the deployed logger's DO readings taken every 30 minutes, while the overlying red line is this data's trend line. The blue dots represent DO measurements taken with a handheld probe during intermittent site visits. 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 was occurring (<2 mg/L).*

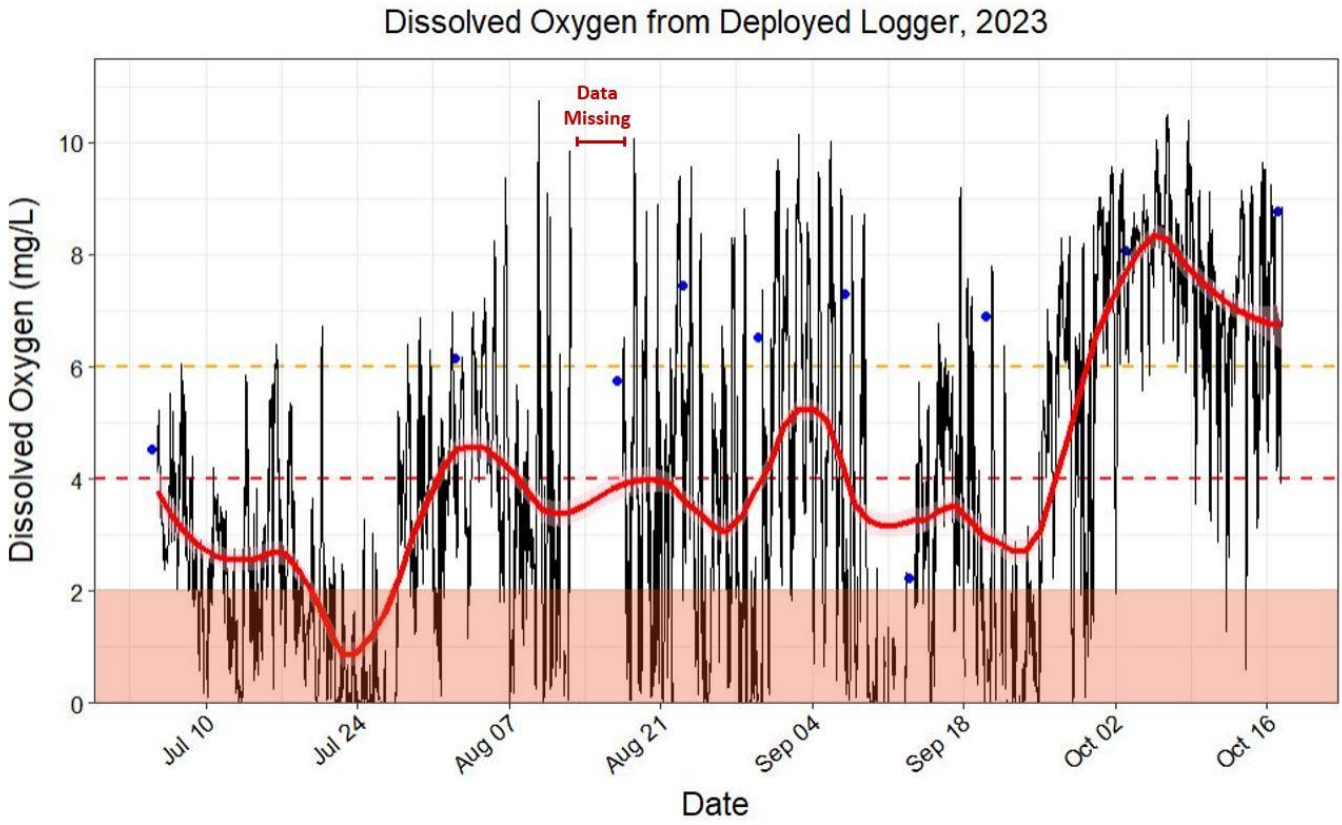


Figure 13. *Dissolved oxygen (DO) in milligrams per liter (mg/L) over the course of the 2023 field season. Data was obtained from a DO data logger deployed ~6 inches above the pond bottom at station TGP04. The black line represents the deployed logger's DO readings taken every 30 minutes, while the overlying red line is this data's trend line. The blue dots represent DO measurements taken with a handheld probe during intermittent site visits. 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 was occurring (<2 mg/L).*

Bottom-depth DO trends observed in 2022 and 2023 resemble those of 2021 (**Figure 14**). Bottom-depth DO concentrations within the Pond's coves consistently fell below the critical threshold (4 mg/L) across all 3 years. Lower concentrations of bottom-depth DO can be typical in aquatic ecosystems, as increased bacterial activity and decomposition occurring at the sediment-water interface will deplete available oxygen in the surrounding water column. In contrast, the upper portions of the water column benefit from oxygen mixing at the water-air interface, as well oxygen production via photosynthesis from phytoplanktonic activity which prefers the higher light availability of shallow depths. Overall, a balanced ecosystem will experience a lower daily magnitude shift between high and low DO. Large swings in DO within a 24-hr period can often be an indication of system impairment.

DO concentrations measured at all depths across both the 2022 and 2023 seasons exhibited a high degree of variability, which is a sign of a less stable or struggling ecosystem. High temperatures and abundant nutrient concentrations can lead to rapid shifts in bacterial and phytoplankton community structure and are commonly associated with unstable DO concentrations. A lack of benthic submerged aquatic vegetation (SAV) in TGP may also serve to exacerbate these effects, due to the lack of

stabilizing functions that SAV habitats can provide (oxygen production, nutrient sequestration, sediment retention).

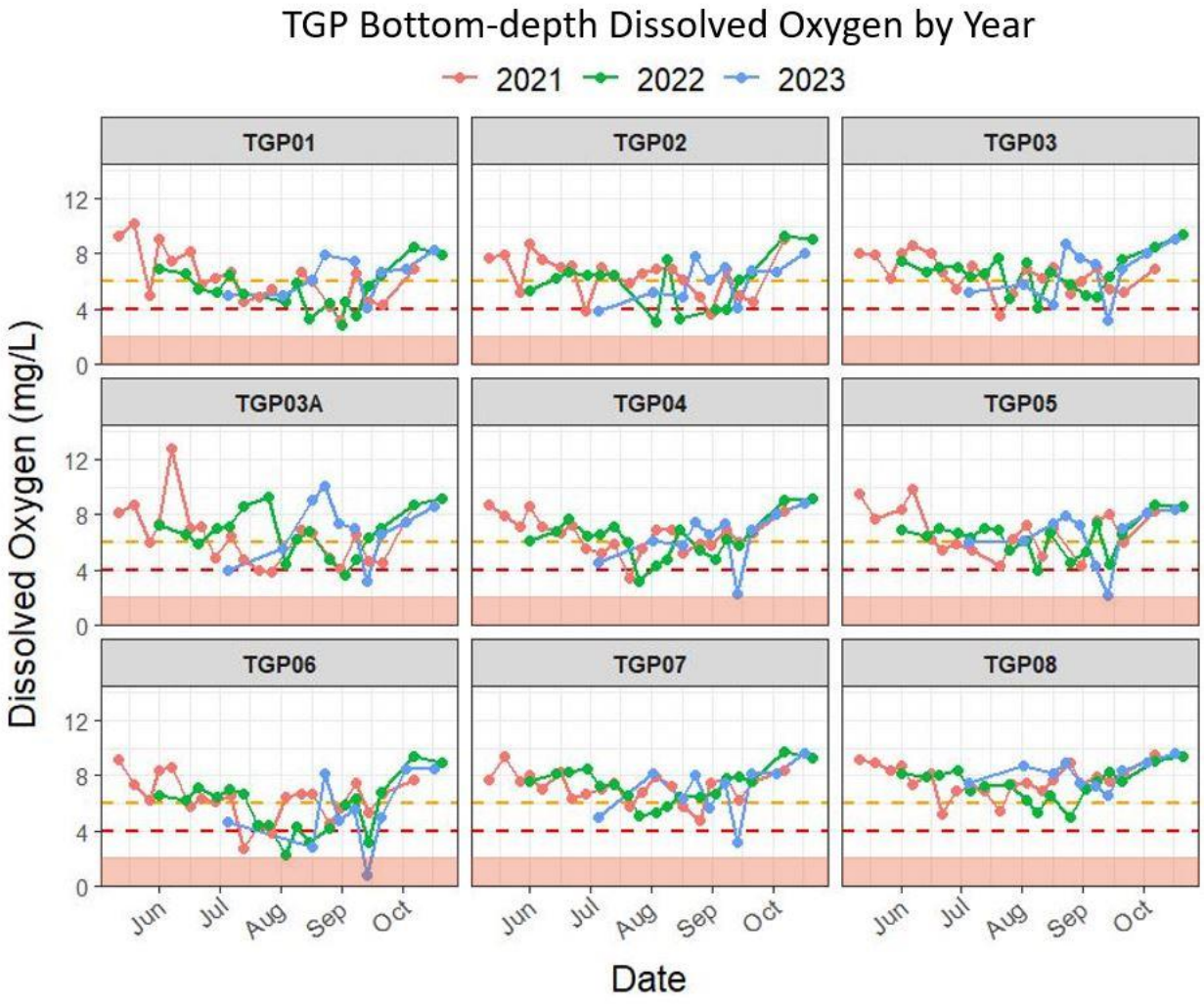


Figure 14. *Bottom-depth dissolved oxygen (DO) levels in milligrams per liter (mg/L) for Tisbury Great Pond's 9 monitoring stations during the years 2021, 2022, and 2023. Data was measured using a handheld probe. The dashed yellow line represents the 6 mg/L management threshold, the dashed red line indicates when DO levels dropped critically low (<4 mg/L), and the light red box indicates when hypoxia was occurring (<2 mg/L).*

pH

Summary Points:

- Measured pH values were relatively consistent across the Pond and generally remained within the management target range (6.5-8.5) throughout both the 2022 and 2023 field seasons.
- Stations TGP01 and TGP05 periodically saw pH fall outside of the target range in 2022.
- pH was relatively uniform throughout the entire water column in 2022 but was often lower at the pond bottom relative to the upper water column in 2023.

"Potential of Hydrogen" or pH, is a measure of acidity in solution. pH is measured on a logarithmic scale ranging from 0-14 where a value of 7 is defined as neutral (neither acidic nor basic). Values between 0-7 are considered acidic while values between 7-14 are considered basic, with the magnitude of acidity or basicity increasing as pH moves either above or below 7, respectively. It's important that ponds maintain a near neutral pH (close to 7), as overly acidic or basic conditions can have a detrimental effect on ecosystem health. MassDEP has established a pH target range of 6.5 to 8.5 for Class SA waters.

Measured pH values during the 2022 field season were consistent across the Pond and generally remained within the target range, with some variation observed at stations TGP01 and TGP05 (**Figure 15**). Station TGP01, located at the tip of Town Cove, exhibited a consistently lower/more acidic pH range and overall higher level of variability within the water column relative to all other monitoring stations, particularly during the early summer. Recorded pH readings at station TGP05 (Tiah's Cove) were generally more consistent with the rest of the Pond, but still experienced swings both above and below the target range during the middle of the summer. Excluding the variability seen at TGP01, pH remained relatively uniform throughout the water column in 2022.

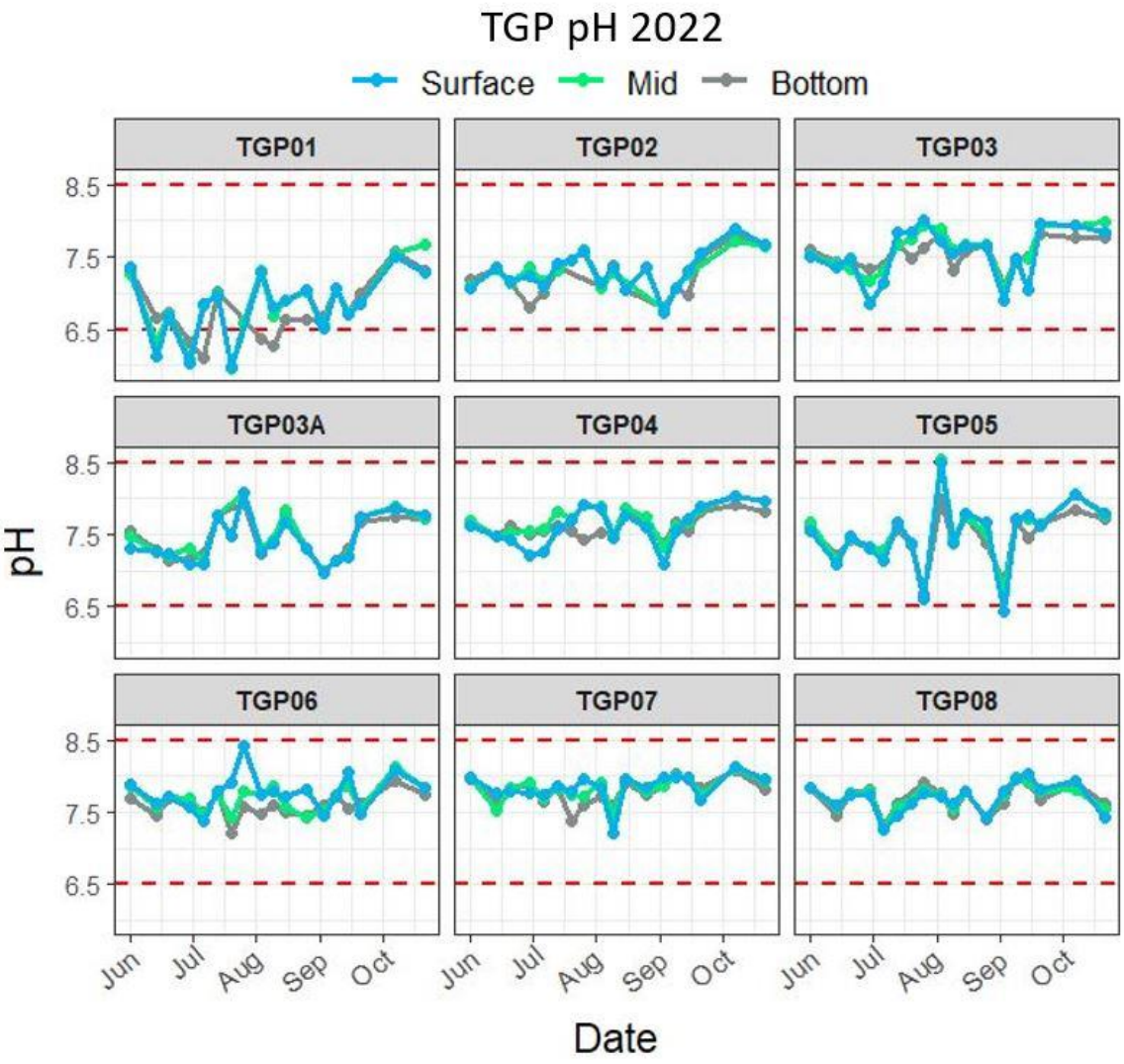


Figure 15. *pH for Tisbury Great Pond's 9 monitoring stations during the 2022 season. Data was measured using a handheld probe for 3 depths (surface, mid-depth, and bottom). The dashed red lines indicate the boundaries of the management target for pH, which is to maintain a pH between 6.5 and 8.5. (Note scale on y-axis, differs between years).*

Measured pH values in 2023 were also consistent across the Pond and never fell outside of the management target range at any monitoring station (**Figure 16**). Greater pH stratification within the water column was observed in 2023 relative to 2022. This can be seen by the pond bottom often exhibiting a lower/more acidic pH than the upper water column, presumably a result of organic matter decay acting to raise acidity. This was most commonly seen at the Pond's deepest stations, where the pond bottom's extended distance from photosynthesizing organisms at the surface (photosynthesis can act to raise pH by removing carbon dioxide from the water) enables organic matter decay to dominate pH dynamics. It should be noted that GPF did not begin to take regular pH measurements in 2023 until early August. As such, any pH nuances that may have been present during the early summer of 2023 are not captured in this report.

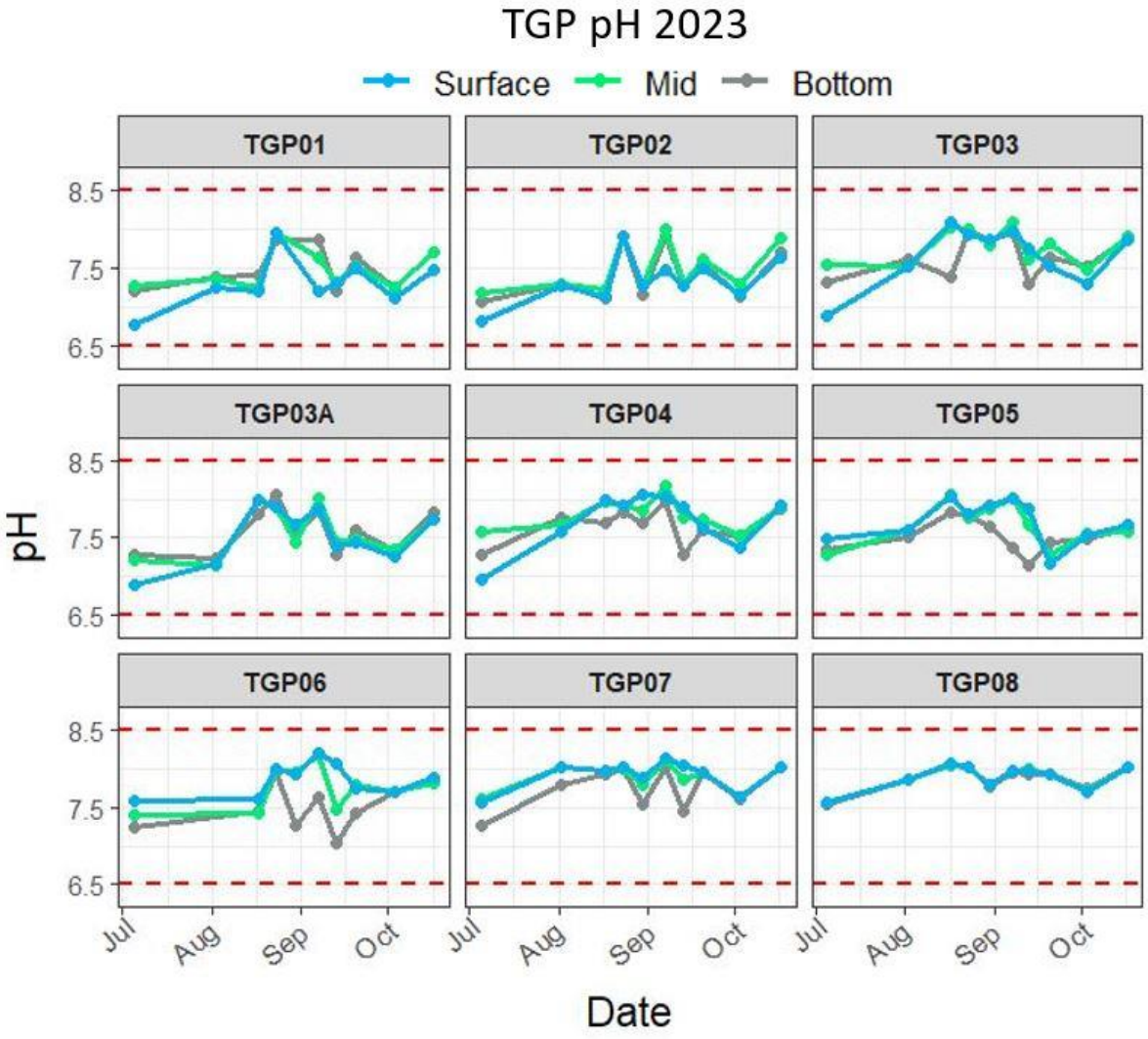


Figure 16. *pH for Tisbury Great Pond's 9 monitoring stations during the 2023 season. Data was measured using a handheld probe for 3 depths (surface, mid-depth, and bottom). The dashed red lines indicate the boundaries of the management target for pH, which is to maintain a pH between 6.5 and 8.5. (Note scale on y-axis, differs between years).*

The pH trends observed for TGP in 2022 and 2023 ultimately resemble one another closely (**Figure 17**). Both years generally experienced near-neutral pH values falling within the management target range across most monitoring stations. Comparative pH data from 2021 was not available.

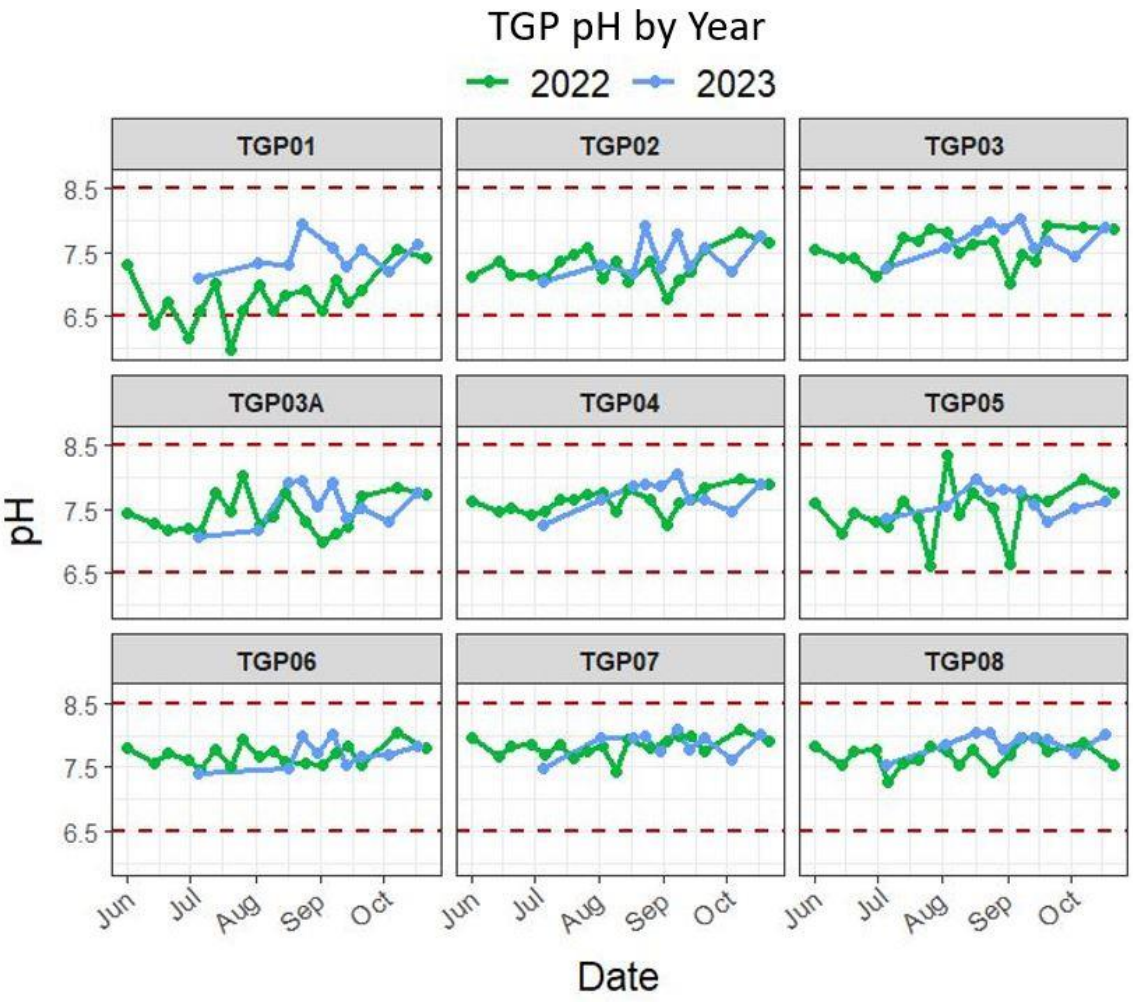


Figure 17. *Average pH across all sampling depths for Tisbury Great Pond's 9 monitoring stations for the years 2022 and 2023. The dashed red lines indicate the boundaries of the management target for pH, which is to maintain a pH between 6.5 and 8.5.*

Water Clarity

Summary Points:

- Visibility across the Pond consistently failed to reach the bottom in both 2022 and 2023.
- Both years experienced peak turbidity during the late summer in conjunction with peak chlorophyll concentrations.
- Water clarity in 2022 and 2023 was reduced relative to 2021.

Water clarity is commonly used to assess water quality due to the ease with which it can be measured and interpreted. When turbidity levels (a measure of suspended particles in the water column) are high, the water within a pond will appear murky and exhibit decreased light transmission through the water column, thus reducing overall water clarity. Several factors can cause turbid water conditions, including particulate sediment suspension, organic matter buildup, and algal growth. GPF measures water clarity

using a Secchi Disk, a standardized black and white disk that is lowered through the water with a measuring tape. The depth at which the disk disappears represents terminal visibility into the water column. TGP's MEP report set a management target for Secchi depth (visibility) to be either 9.8 feet or to the pond bottom (Howes et al., 2013).

Water clarity in TGP was reduced during the 2022 and 2023 field seasons. Visibility generally failed to reach the bottom throughout the 2022 field season across most monitoring stations, often falling short by several feet (**Figure 18**). Visibility in 2023 was improved among the Pond's shallowest stations, but still consistently fell several feet short of reaching the bottom at deeper monitoring locations (**Figure 19**). Both years experienced high turbidity in August and September when chlorophyll concentrations in TGP were at their peak, suggesting that these elevated turbidity levels were largely fueled by abundant phytoplankton growth within the water column. While water clarity began to improve come late September of 2023, turbidity levels in 2022 remained high up to the end of the monitoring season in late October. This is likely explained by chlorophyll concentrations in the Pond decreasing during the fall of 2023 but remaining elevated through the fall of 2022 (see "Chlorophyll" section).

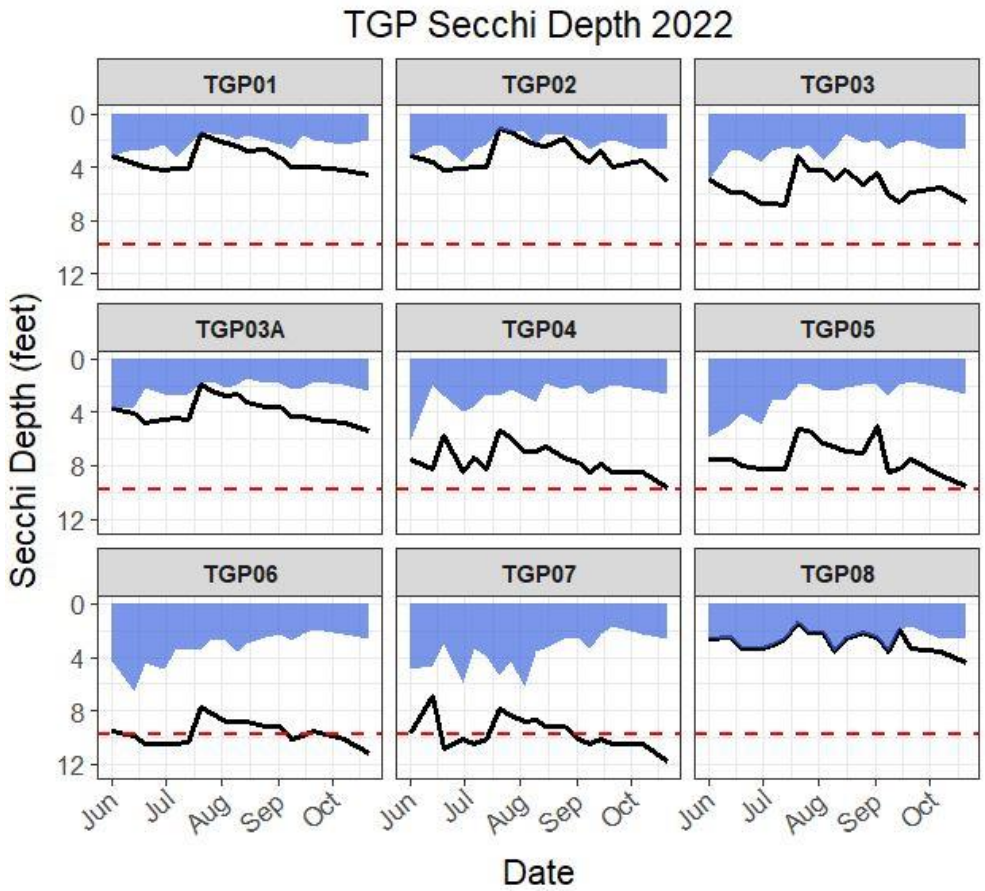


Figure 18. *Secchi depth and total depth in feet for Tisbury Great Pond's 9 monitoring stations during the 2022 season. Secchi depth is the depth at which a standardized disk disappears, thereby representing visibility into the water column. Total depth at each station is represented by a black line 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 on each figure).*

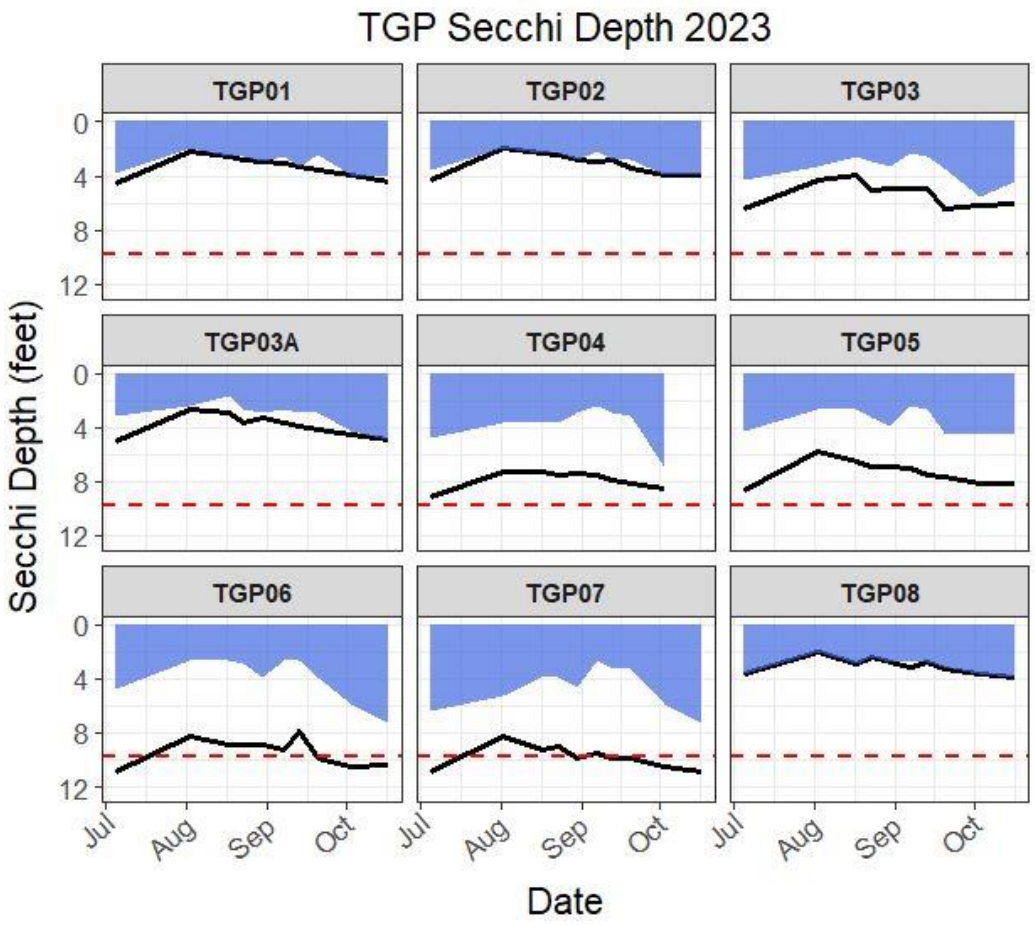


Figure 19. *Secchi depth and total depth in feet for Tisbury Great Pond's 9 monitoring stations during the 2023 season. Secchi depth is the depth at which a standardized disk disappears, thereby representing visibility into the water column. Total depth at each station is represented by a black line, while 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 on each figure).*

Turbidity was directly measured in 2022 and 2023 using a YSI multiparameter probe. These measurements were recorded in Formazin Nephelometric Units (FNU), a unit that measures turbidity based on the degree to which incoming light is scattered by particles present in the water column. A historical FNU comparison indicates that turbidity in 2022 and 2023 was elevated relative to 2021, particularly during the middle of the summer (**Figure 20**). This coincides with the results of the Secchi Disk and water clarity measurements. The reduction in water clarity seen in 2022 and 2023 may be due to these years experiencing higher chlorophyll concentrations and therefore a greater abundance of phytoplankton growth within the water column compared to 2021.

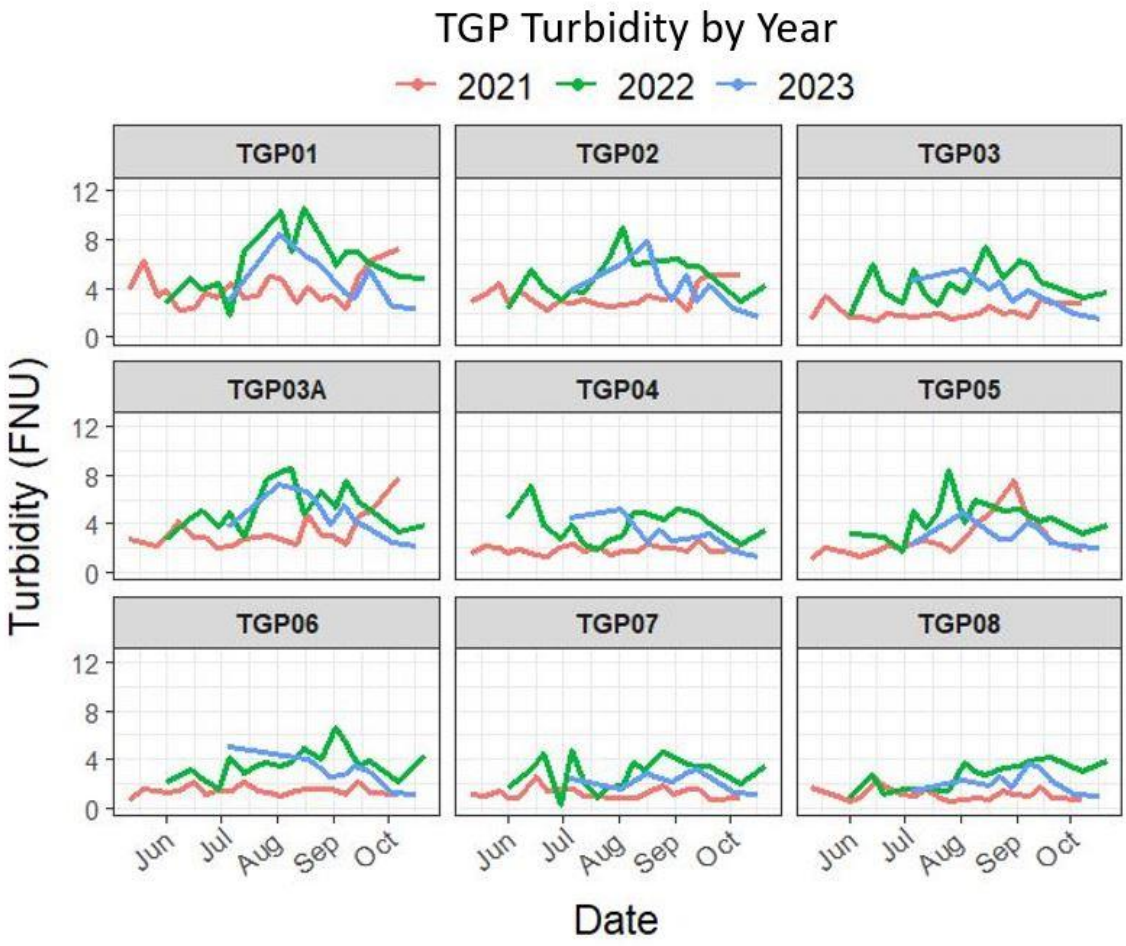


Figure 20. *Average turbidity throughout the entire water column in FNU (Formazin Nephelometric Units) is shown for Tisbury Great Pond's 9 monitoring stations for the years 2021, 2022, and 2023.*

Nutrients

Summary Points:

- Total nitrogen concentrations exceeded the 0.48 mg/L management threshold in both 2022 and 2023.
- Total nitrogen levels during the late summer were higher in 2022 and 2023 compared to 2021.
- Measured phosphate concentrations during the later summer were higher in 2023 relative to the preceding 2 years.

Excessive nutrient inputs into aquatic ecosystems, specifically that of nitrogen and phosphorus, can lead to the development of eutrophic conditions, in which nutrient-fueled algal and phytoplankton growth and subsequent bacterial consumption deplete oxygen reserves and reduce overall ecosystem health. In coastal and brackish water bodies like TGP, nitrogen is most often the primary driver of eutrophication. GPF conducted nutrient sampling at 5 of its normal 9 monitoring stations during the 2022 and 2023 field

seasons to gain a better understanding of nutrient loading into TGP. Nutrient samples were collected monthly from June to September during the 2022 field season and once in August and September of 2023. The Massachusetts Estuaries Project's (MEP) report on TGP has established a total nitrogen (TN) threshold of 0.48 mg/L for the "sentinel station," which encompasses the average TN concentration of stations TGP04, TGP05, and TGP06, as well as a TN threshold of 0.46 mg/L for station TGP07 (Howes et al., 2013).

Measured TN concentrations in 2022 exceeded the MEP management threshold during August and September across all nutrient monitoring stations (**Figure 21**). TN concentrations also exceeded the management threshold in August and September of 2023 at most monitoring stations; however, late summer TN levels were consistently lower in 2023 relative to 2022 (**Figure 21**). The sentinel station ultimately exceeded the 0.48 mg/L management threshold on 3 of the 4 nutrient sampling runs conducted in 2022, and both of the nutrient sampling runs conducted in 2023. This represents an overall rise in TN inventories in the Pond since 2021, which only saw sentinel station TN rise above the management threshold on 1 of the year's 4 sampling runs. The elevated TN concentrations observed in the late summers of 2022 and 2023 coincide with peak chlorophyll concentrations within the Pond, suggesting that the heightened availability of nitrogen in August and September has played a role in driving accelerated phytoplankton growth over the past 2 years.

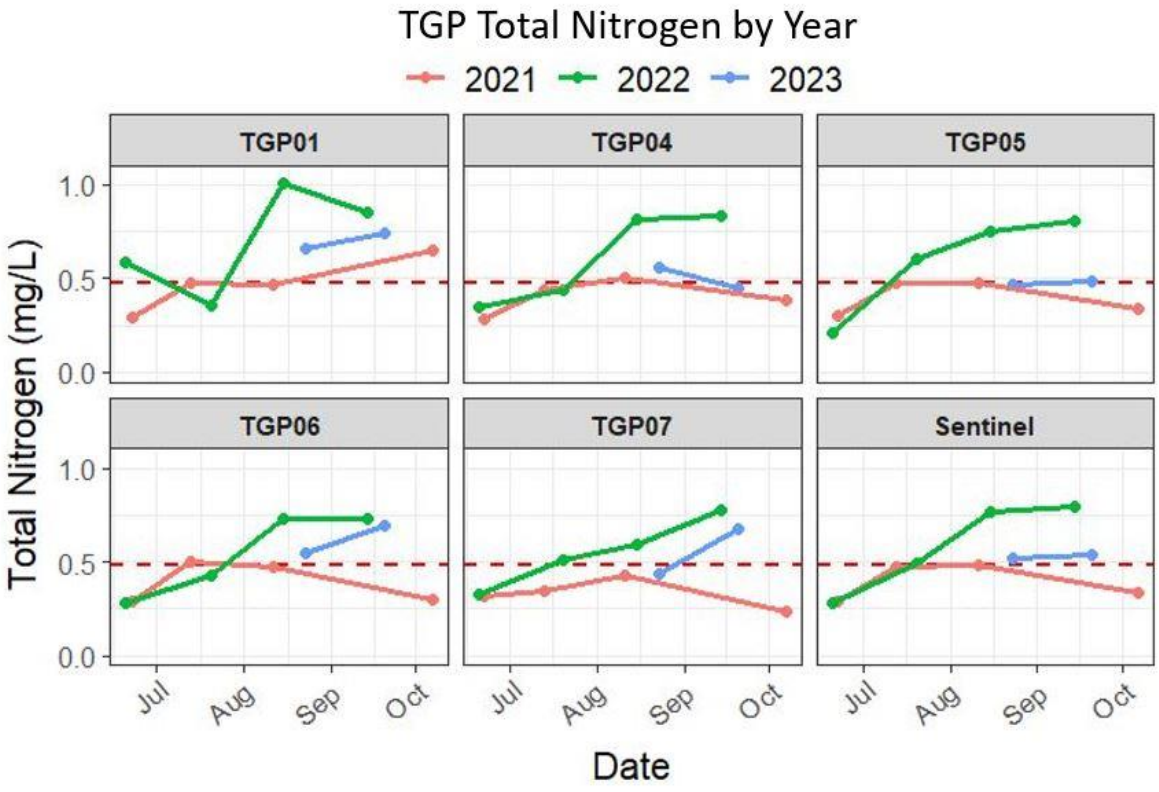


Figure 21. *Total nitrogen in milligrams per liter (mg/L) is shown for TGP's 5 nutrient stations and the sentinel station (average of TGP04, TGP05, & TGP06) for the years 2021, 2022, and 2023. The dashed red line represents the MEP management threshold (0.48 mg/L).*

Phosphate concentrations recorded during the late summer of 2023 were consistently higher than those recorded in 2021 and 2022, generally exceeding 0.1 mg/L across all nutrient monitoring stations (**Figure 22**). Comparatively, measured phosphate concentrations only exceeded 0.1 mg/L on a single day (10/7/21) between 2021 and 2022. Due to a lack of nutrient data for June and July, it's unclear whether 2023 phosphate concentrations were also higher during the early summer relative to 2021 and 2022. Regardless, the elevated phosphate levels observed in the late summer of 2023 may have contributed to the accelerated phytoplankton growth observed in the Pond over the same period, along with elevated nitrogen.

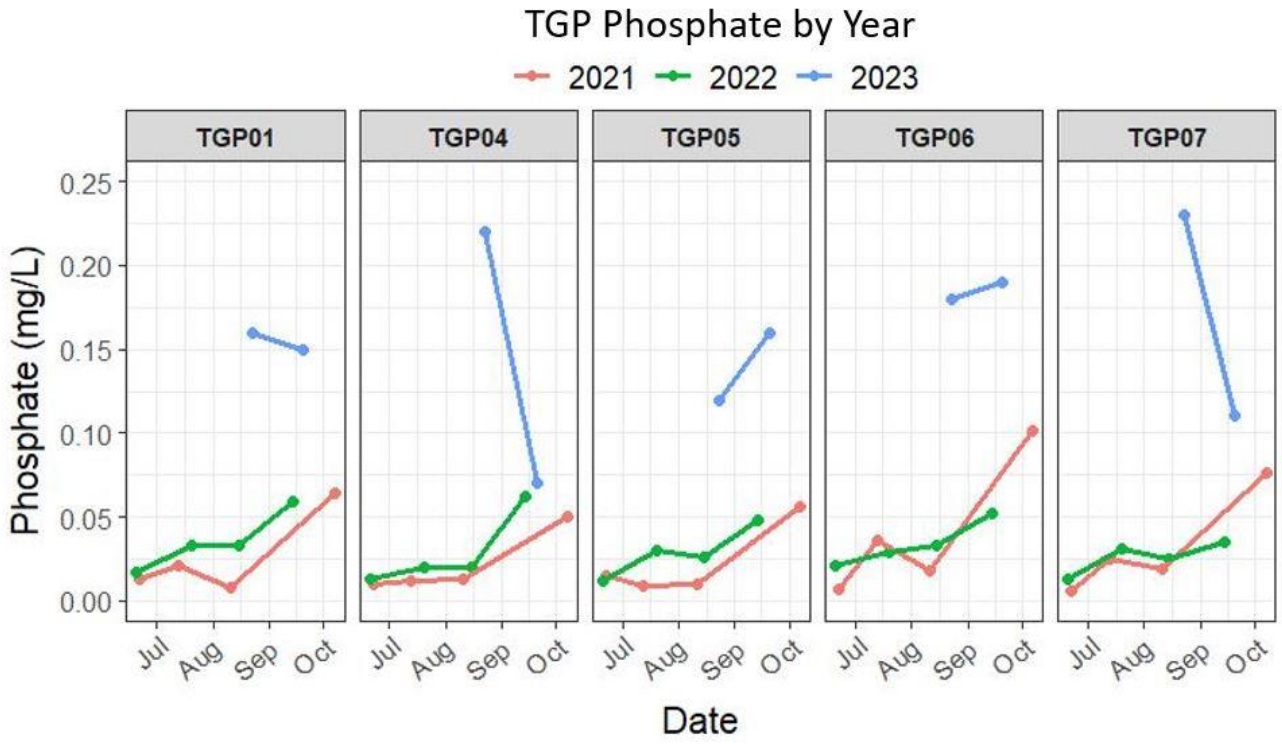


Figure 22. *Phosphate in milligrams per liter (mg/L) for TGP's 5 nutrient stations for the years 2021, 2022, and 2023.*

Chlorophyll

Summary Points:

- Total chlorophyll concentrations across TGP generally exceeded the management threshold for most of the 2022 and 2023 field seasons.
- Chlorophyll levels were consistently higher in 2022 compared to 2021 and 2023.
- Measured concentrations were often highest in Town Cove and Pear Tree Cove.

Chlorophyll is commonly used as a measure of algal growth, with higher concentrations indicating greater phytoplanktonic and algal activity within the water column. Phytoplankton and algae, like all primary producers, respond rapidly to changes in light availability, temperature, and nutrient availability

within the water column. As any number of these factors increase, so does the potential for primary producers to grow at an accelerated rate, resulting in an algal "bloom". In general, higher densities of phytoplankton/algae support the growth of bacteria and other grazing organisms. As such, chlorophyll is often used as an indication of overall ecosystem balance and health.

GPF monitored total chlorophyll concentrations in TGP as part of the MV CYANO$_{TM}$ program during the 2022 and 2023 field seasons. Monitoring was performed on a weekly basis in 2022 and a biweekly basis in 2023. Estimates of total chlorophyll were derived via analysis of surface samples collected in the field and measured the same day using a bbe Moldaenke FluoroProbe, a spectral fluorometer that can estimate phytoplankton abundance through fluorescence of pigments unique to individual algal groups. The Massachusetts Estuaries Project's (MEP) report for TGP has established a chlorophyll management target of <10 micrograms per liter (ug/L) for the Pond (Howes et al., 2013).

Total chlorophyll concentrations generally exceeded the 10 ug/L management threshold for the duration of both the 2022 and 2023 field seasons across all monitoring stations (**Figures 23 & 24**). Chlorophyll concentrations gradually increased over the course of the 2022 field season, with peak concentrations observed in both September and October. Alternatively, chlorophyll concentrations during the 2023 field season peaked in August across most of the Pond before declining through the remainder of the season.

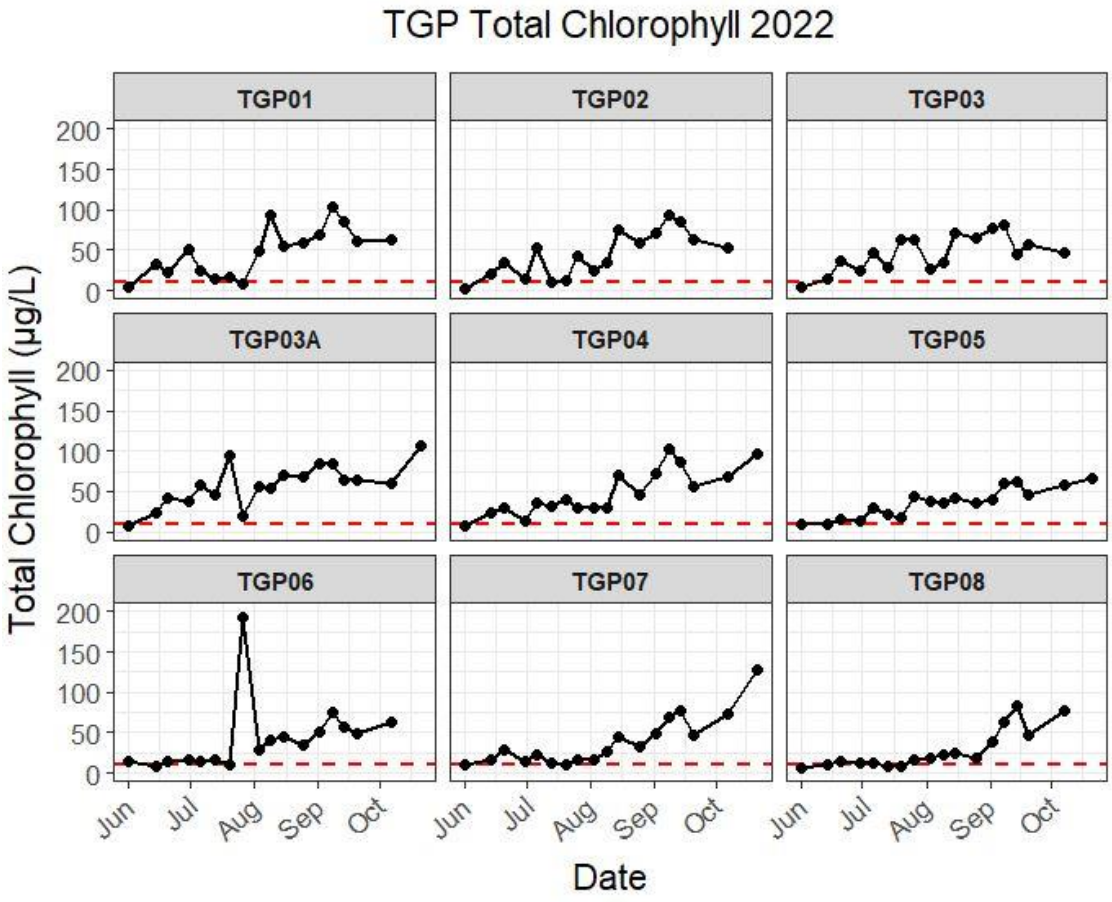


Figure 23. *Total chlorophyll in micrograms per liter (µg/L) at Tisbury Great Pond's 9 monitoring stations during the 2022 field season. Samples were taken at the surface and measurements were obtained via a fluorometer. The dashed red line represents the MEP management threshold (10 ug/L). (Note scale on y-axis, differs between years).*

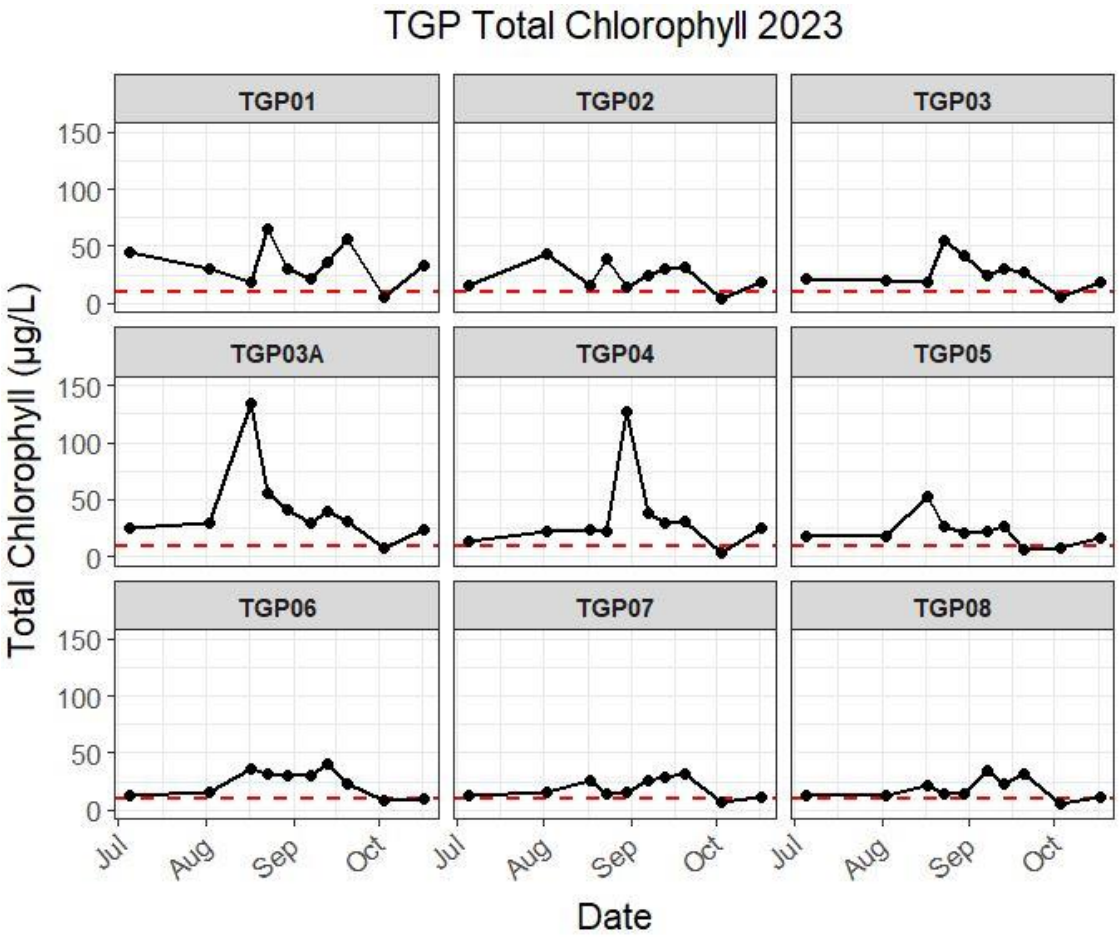


Figure 24. *Total chlorophyll in micrograms per liter (µg/L) at Tisbury Great Pond's 9 monitoring stations during the 2023 field season. Samples were taken at the surface and measurements were obtained via a fluorometer. The dashed red line represents the MEP management threshold (10 ug/L). (Note scale on y-axis, differs between years).*

A historical comparison of TGP total chlorophyll levels indicates that measured concentrations in 2022 were frequently higher than those of both 2021 and 2023 (**Figure 25**). This may be due to 2022's higher total nitrogen concentration during the late summer relative to the other 2 comparison years, enabling the growth of a higher abundance of phytoplankton across the Pond. Total chlorophyll levels during all 3 sampling years were often highest in Town Cove and Pear Tree Cove (stations TGP01-TGP04) located in the Pond's northwestern corner, although the highest observed chlorophyll concentration (192.2 ug/L) across any year was recorded on 7/26/22 in Deep Bottom Cove (station TGP06).

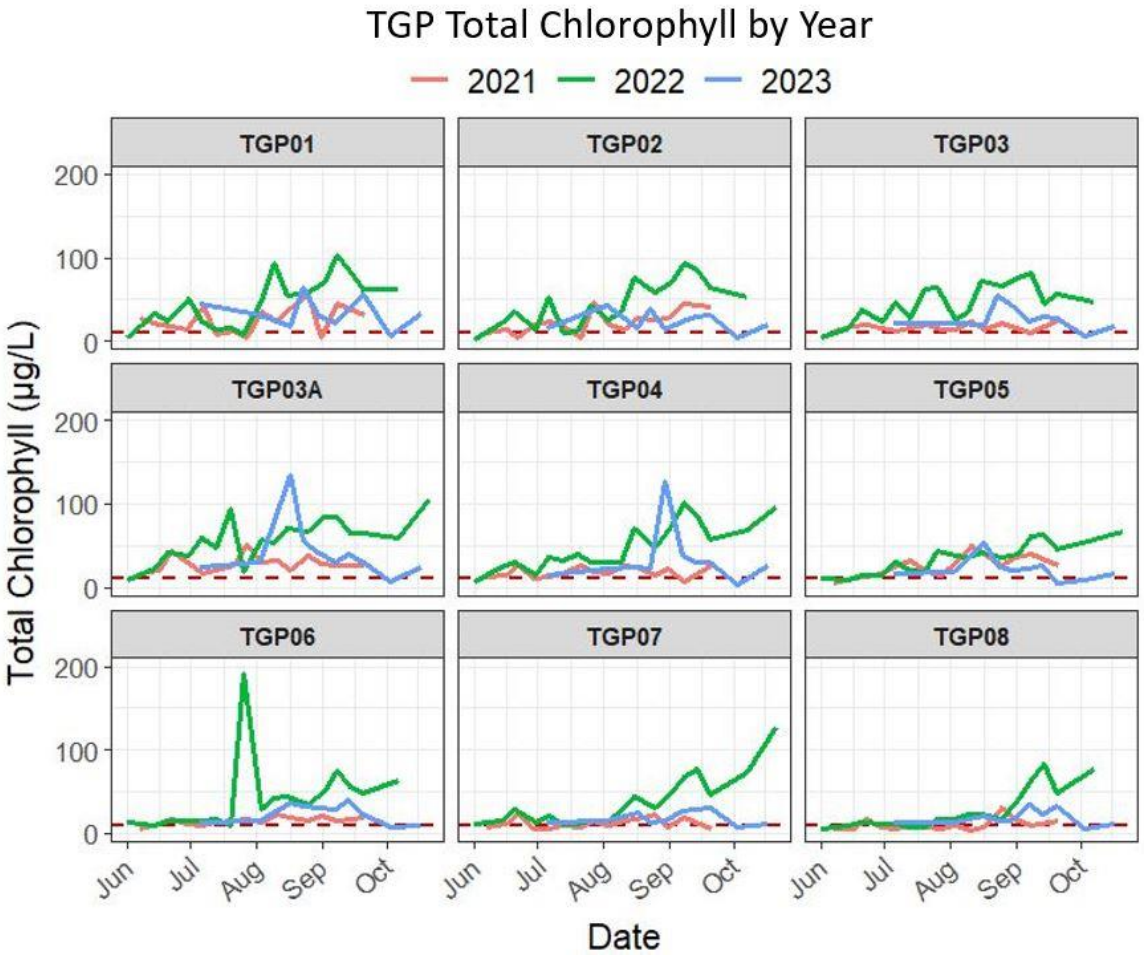


Figure 25. *Total chlorophyll in micrograms per liter (µg/L) at Tisbury Great Pond's 9 monitoring stations for the years 2021, 2022, and 2023. Samples were taken at the surface and measurements were obtained via a fluorometer. The dashed red line represents the MEP management threshold (10 ug/L).*

Phytoplankton and Cyanobacteria

Summary Points:

- Cyanobacteria concentrations within the water column did not rise above the MV CYANO program's "alert" category during 2022 or 2023.
- Floating macro-clusters of *Aphanothece* cyanobacteria were observed in the Pond's coves during the summer of 2023.

In addition to estimating total chlorophyll concentrations, GPF's fluorometry analysis of water samples collected in TGP also provides estimated concentrations of different phytoplankton classes present within the water column. The following 4 phytoplankton classes were routinely monitored on TGP in 2022 and 2023 as part of the MY CYANO$_{TM}$ program: cyanobacteria, green algae, cryptophyta, and diatoms. Green algae and cryptophyta were the most prevalent phytoplankton classes measured in TGP

during both 2022 and 2023 (**Figures 26 & 27**). The concentrations of these 2 phytoplankton classes closely mirrored one another during both field seasons, with a rise in green algae concentrations generally coinciding with a complimentary rise in cryptophyta. Cryptophyta concentrations frequently reached higher peaks than did green algae during bloom events, although a green algae-dominated bloom did occur in the early fall of 2022.

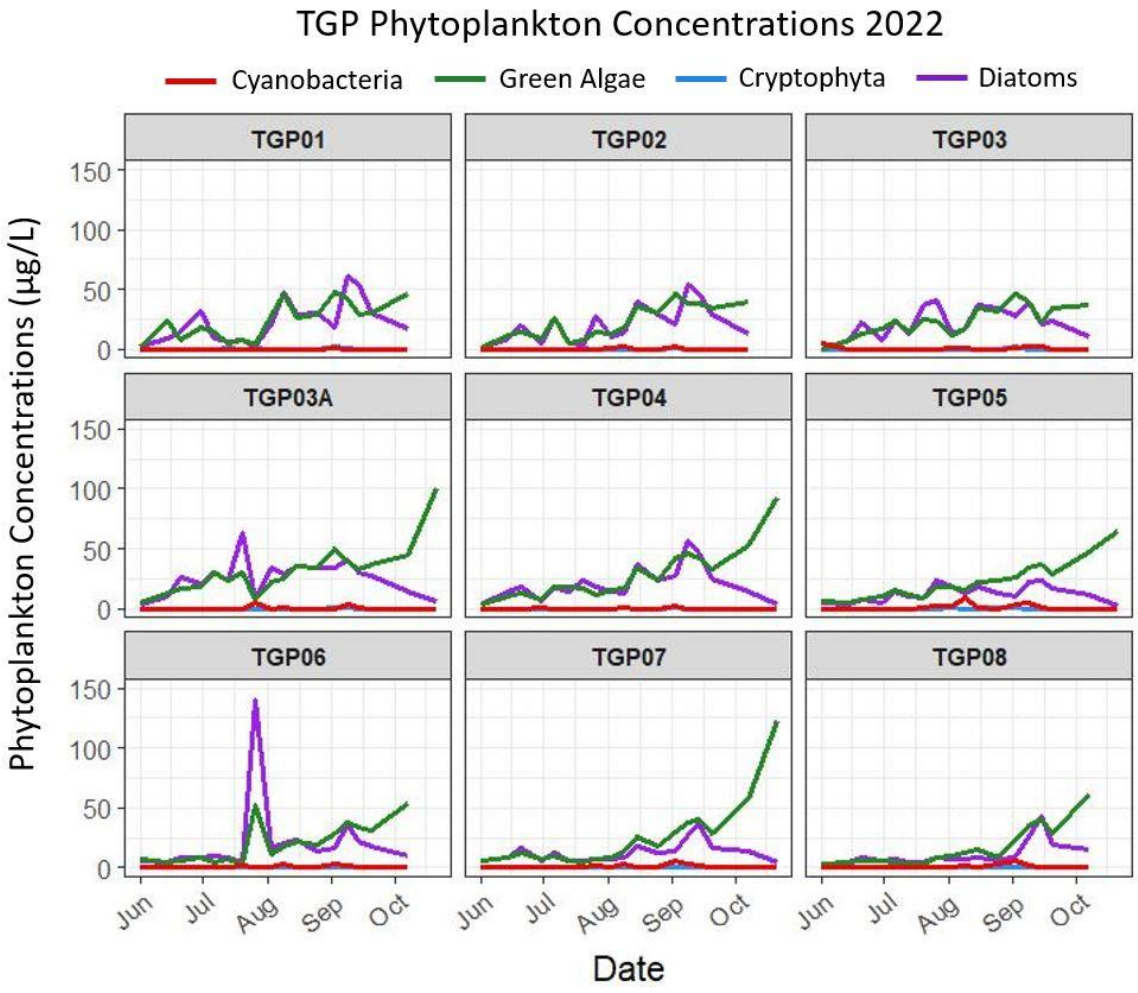


Figure 26. *Phytoplankton concentrations in micrograms per liter (ug/L) at TGP's 9 monitoring stations during the 2022 field season. Different colors correspond to different phytoplankton classes on the graph. (Note scale on y-axis, differs between years).*

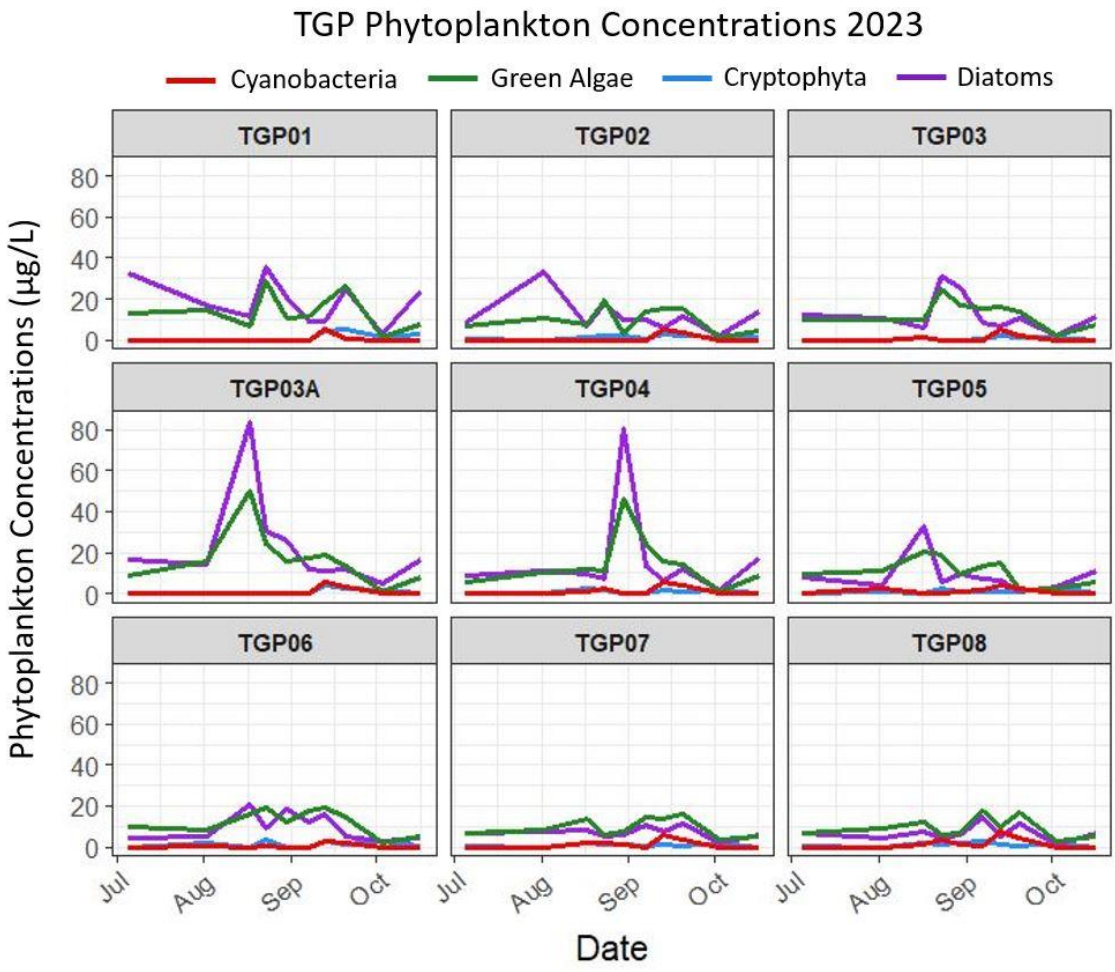


Figure 27. *Phytoplankton concentrations in micrograms per liter (ug/L) at TGP's 9 monitoring stations during the 2023 field season. Different colors correspond to different phytoplankton classes on the graph. (Note scale on y-axis, differs between years).*

Out of the various types of phytoplankton that exist within the island's coastal ponds, cyanobacteria are of particular concern as certain species can produce toxins that are harmful to humans and animals. Ambient cyanobacteria concentrations within TGP's water column never rose above the MV CYANO$_{TM}$ program's yellow "cyanobacteria alert" category across any station during the 2022 and 2023 field seasons (**Figures 28 & 29**, refer to **Figure 31** for MV CYANO$_{TM}$ key). Most stations saw their highest concentrations in August and September during both sampling years. The ambient cyanobacteria concentrations measured in TGP in 2022 and 2023 were slightly higher than those measured in 2021 (**Figure 30**); however, concentrations remained relatively low across all 3 years.

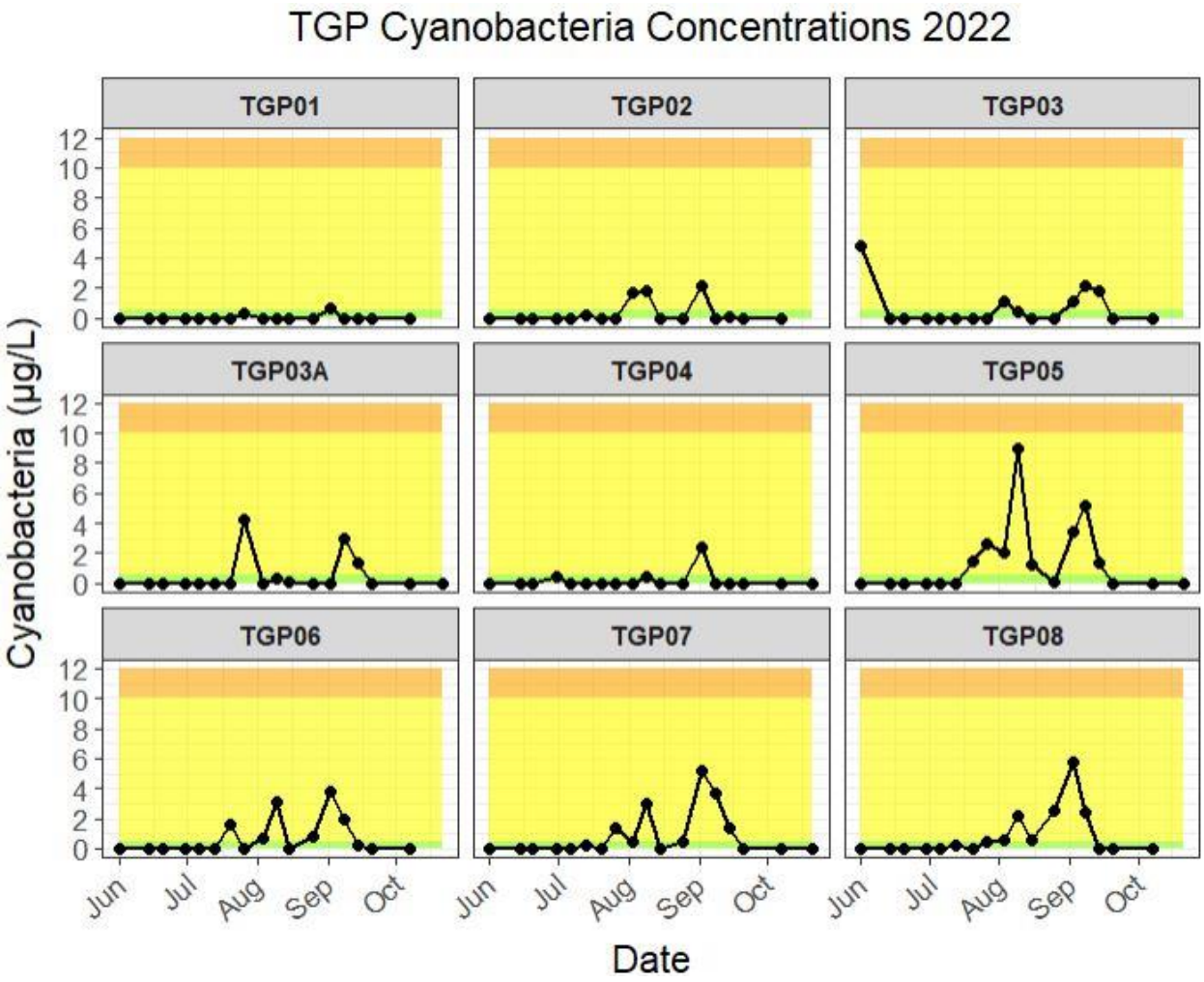


Figure 28. *Cyanobacteria concentrations in micrograms per liter (µg/L) at Tisbury Great Pond's 9 monitoring stations during the 2022 season. Samples were taken at the surface and measurements were obtained via a fluorometer. Background colors pertain to the color-coded risk matrix used by the MV CYANO$_{TM}$ monitoring program (see* ***Figure 31****).*

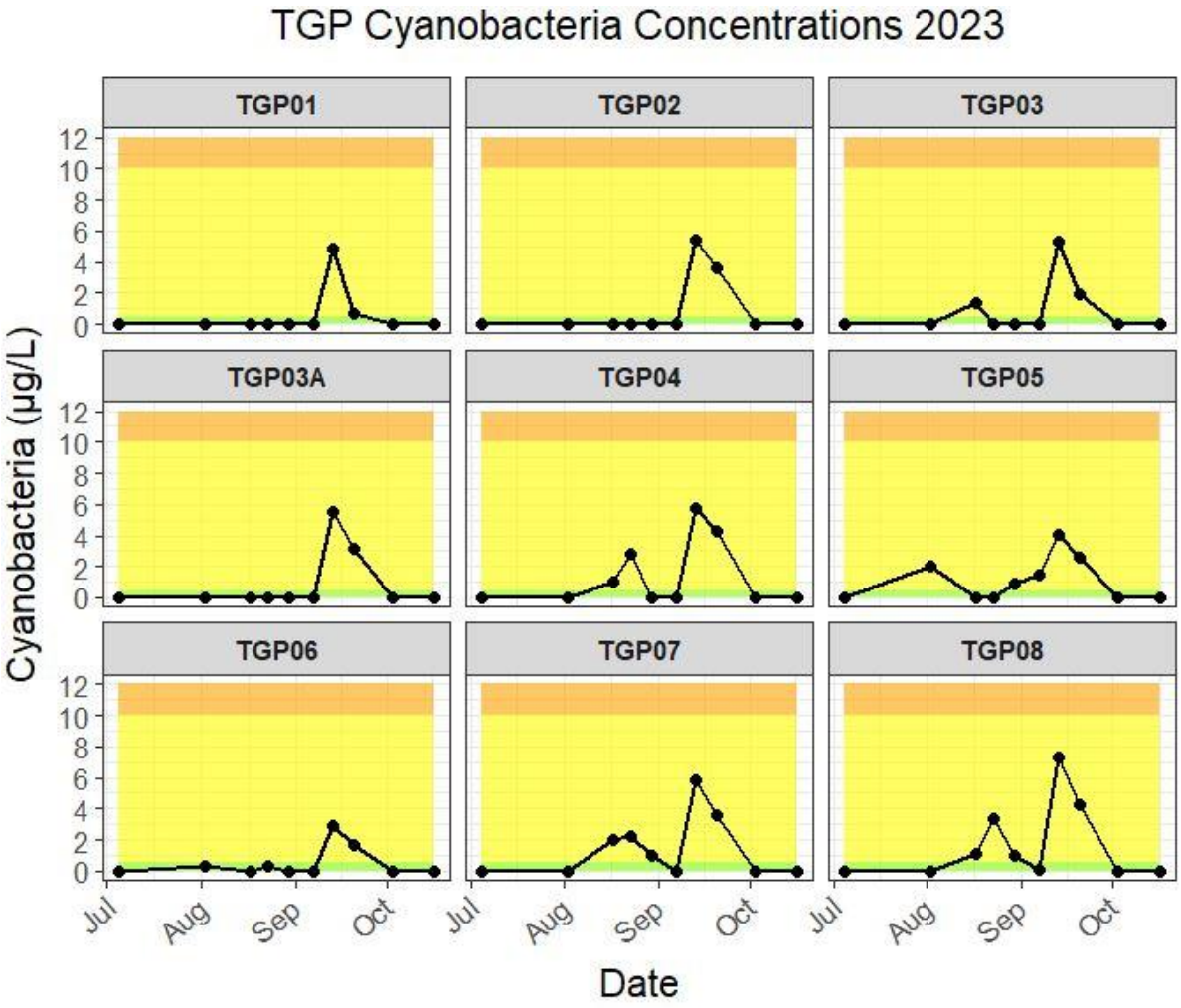


Figure 29. *Cyanobacteria concentrations in micrograms per liter (µg/L) at Tisbury Great Pond's 9 monitoring stations during the 2023 season. Samples were taken at the surface and measurements were obtained via a fluorometer. Background colors pertain to the color-coded risk matrix used by the MV CYANO$_{TM}$ monitoring program (see* ***Figure 31****).*

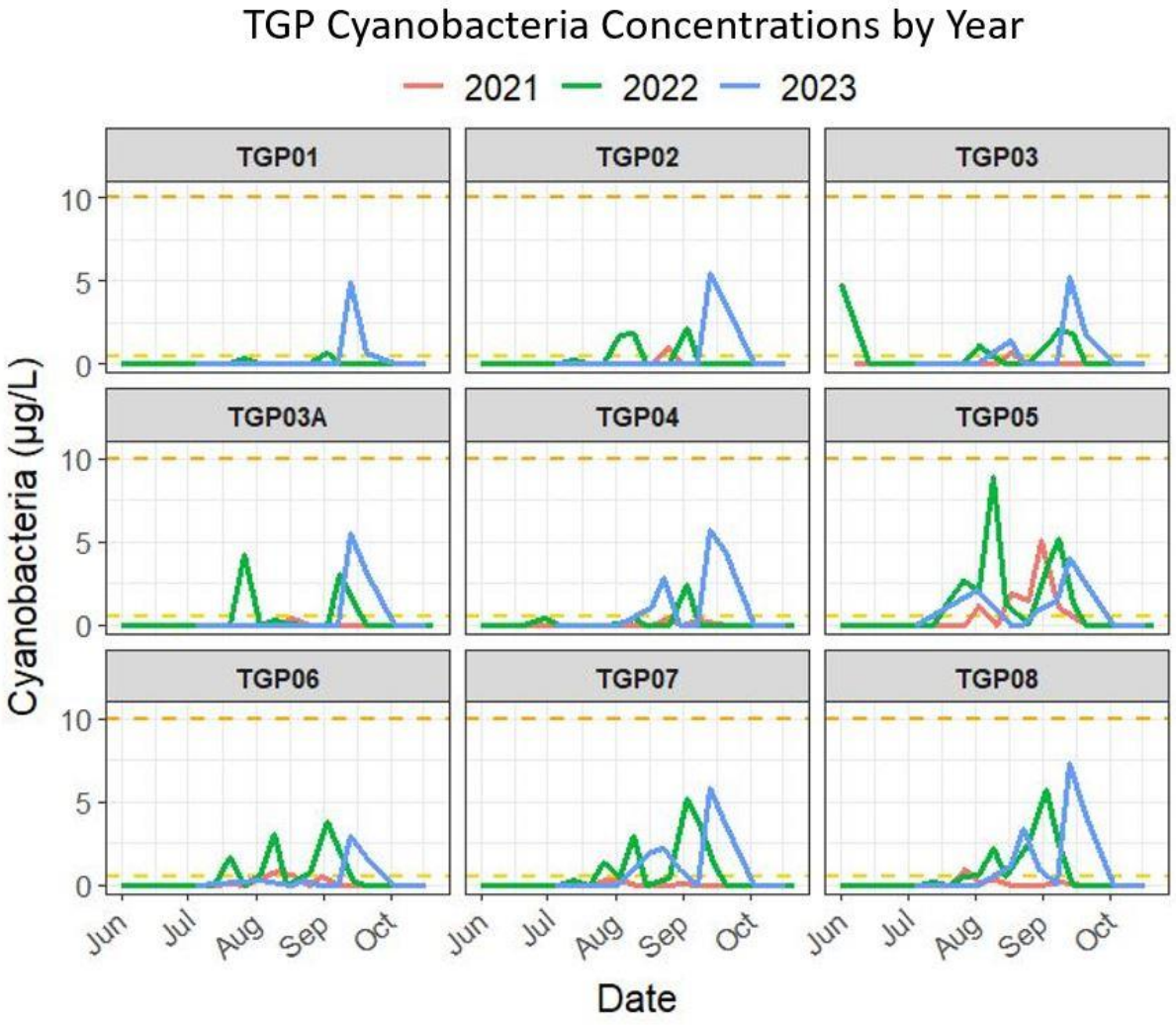


Figure 30. *Cyanobacteria concentrations in micrograms per liter (µg/L) at TGP's 9 monitoring stations for the years 2021, 2022, and 2023. Samples were taken at the surface and measurements were obtained via a fluorometer. Dashed lines pertain to the color-coded risk matrix used by the MV CYANO$_{TM}$ monitoring program (see* ***Figure 31****).*

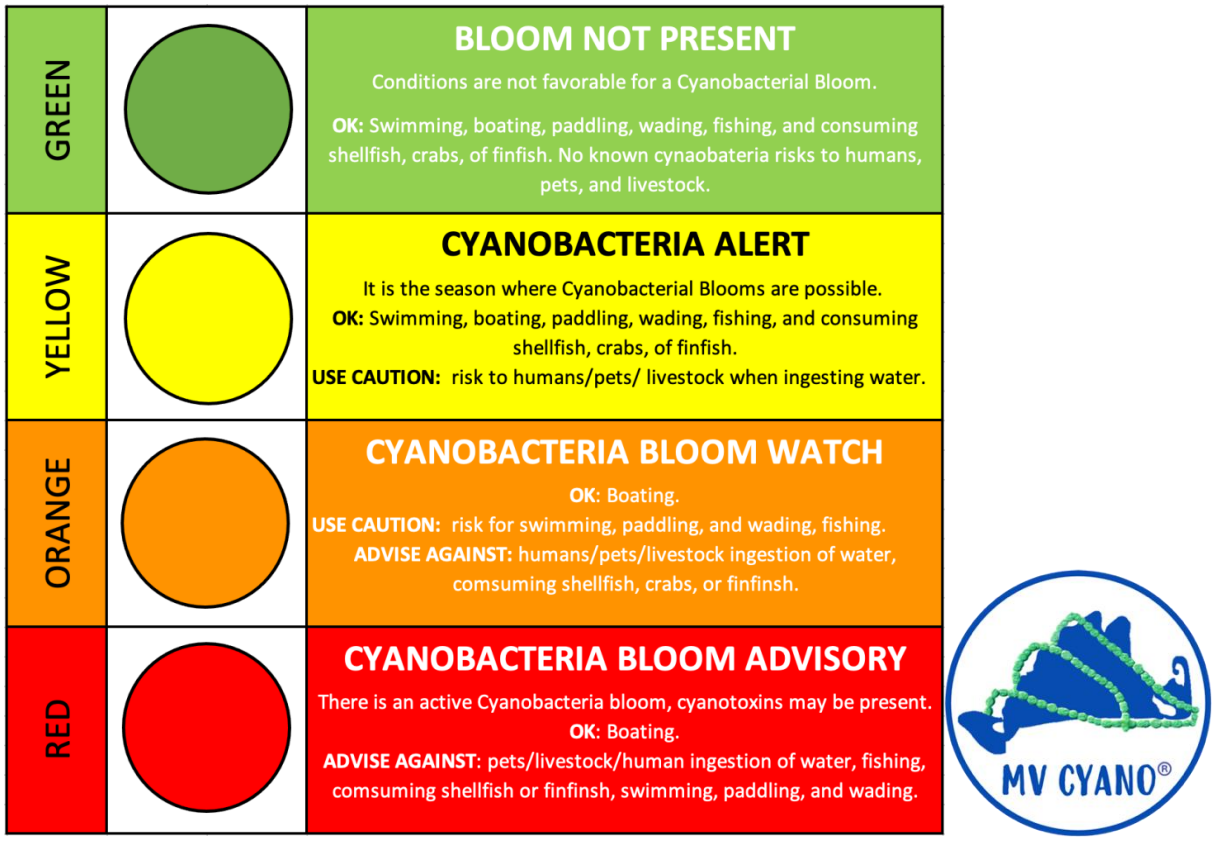


Figure 31. *The color-coded messaging & logo used by the MV CYANO™ monitoring program.*

Despite ambient cyanobacteria concentrations in TGP having remained low since monitoring began in 2021, concentrated macro-clusters of cyanobacteria belonging to the genus *Aphanothece* were observed in TGP during the summer of 2023. These *Aphanothece* clusters appeared as small green clumps of algal material generally seen floating at the surface or coating the bottom, and along the shoreline of several coves within the Pond (**Figure 32**). They were first identified on 7/19/23 at the tip of Tiah's Cove and become abundant within all the Pond's coves by mid-September. It should be noted that the *Aphanothece* cells observed in 2023 appeared to be entirely contained to these floating colonies, as water samples taken adjacent to these clusters consistently registered little to no cyanobacteria.

Figure 32. *Photos taken on 8/2/23 of concentrated clusters of cyanobacteria belonging to the genus Aphanothece located in the northern tip of Tiah's Cove. Clusters can be seen to be present at or just below the surface along the shoreline.*

Discussion

Tisbury Great Pond (TGP) exhibited reduced water quality and signs of ecosystem impairment during the 2022 and 2023 field seasons, continuing similar trends observed in 2021. Chlorophyll concentrations across TGP exceeded the MEP management threshold (10 ug/L) during the late summers of 2022 and 2023, indicating an excessive level of micro and macroscopic plant growth within the water column. This contributed to reduced water clarity in the Pond in both years, as evidenced by peak chlorophyll concentrations coinciding with each year's period of lowest water clarity.

Dissolved oxygen (DO) levels at the pond bottom were depleted in both years, with daily DO fluctuations regularly falling into the hypoxic range (<2 mg/L) between July and September. These low DO observations were most common during the hottest periods of each year when water's capacity to hold oxygen was most diminished.

Total nitrogen (TN) concentrations throughout TGP consistently exceeded the MEP management threshold (0.5 mg/L) during August and September of both sampling years, representing an increase in late summer nitrogen loading relative to 2021. These elevated nitrogen concentrations, along with the presence of higher phosphate concentrations in 2023, likely fueled much of the abundant phytoplankton growth, heightened turbidity, and diminished DO levels observed in the Pond in 2022 and 2023. Excess nutrients are primarily a result of human development both locally and globally. Septic systems, agriculture, and fertilizer applications within the watershed contribute to nutrient rich groundwater

influx and surface water runoff. Direct addition of nitrogen to the Pond via atmospheric deposition also represents a key pathway for nitrogen inputs.

Measured pH levels remained in the management target range at most monitoring stations during the 2022 field season, and within the target range at all monitoring stations during the 2023 field season. Station TGP01 (Town Cove) regularly fell below the management target range (6.5-8.5) into acidic conditions during the early summer of 2022. This station is located at the terminus of the Mill Brook tributary stream where fresh and brackish waters mix, which can lead to a greater degree of variation in water chemistry at this site.

The average time length of man-made cuts in TGP during 2021-2023 was 29.8 days. This greater period of tidal exchange combined with the occurrence of a July cut in both 2022 and 2023 served to maintain relatively high salinity concentrations in TGP throughout both summers.

Previous research in similar ecosystems has shown that longer periods of tidal exchange following a cut increase flushing and reduce water residence time throughout the Pond, and can reduce help to reduce ambient nutrient concentrations. Analysis of TN data measured during the June-October regular monitoring season combined with opening records can help to illustrate this possible dynamic in TGP (**Figure 33**). In 2021, ambient TN concentration in TGP was reduced following the cut that occurred on September 12th, which remained open for 48 days. Conversely, 2022 saw an increase in TN concentration following the cut that occurred on July 15th. However, that cut was only open for approximately 11 days. No TN measurements were collected prior to the July 13th cut in 2023, which remained open for 29 days. However, later- season sampling of TN in August and September shows concentrations closer to those observed in 2021.

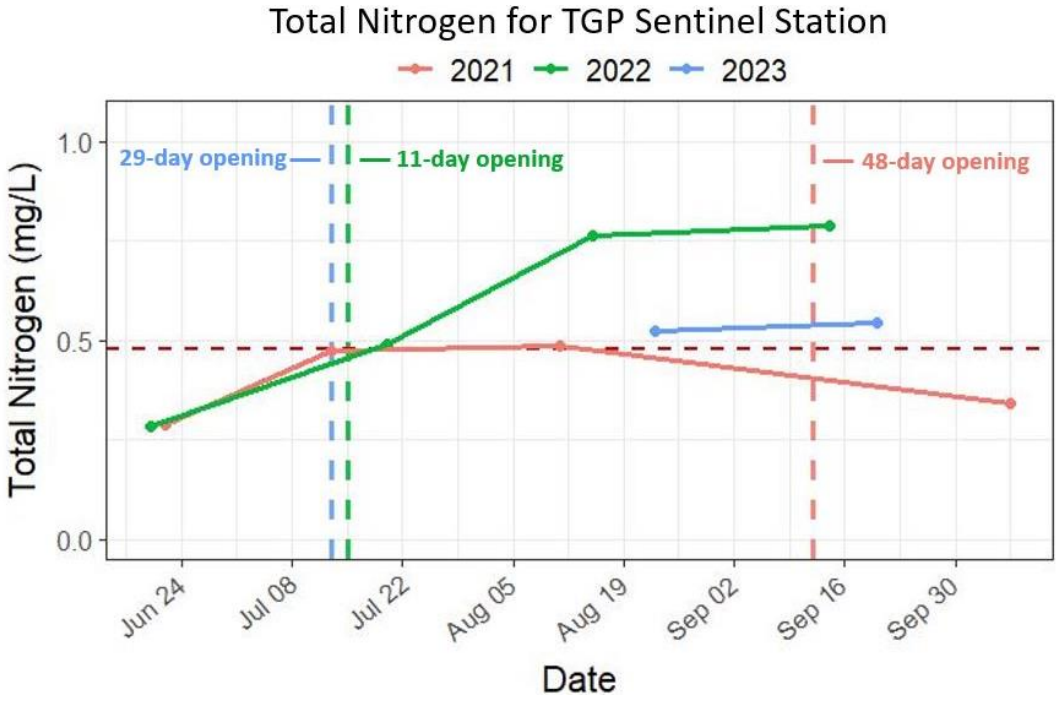


Figure 33. *Total nitrogen in milligrams per liter (mg/L) for the TGP "sentinel station" (average of stations TGP04, TGP05, and TGP06) for the years 2021, 2022, and 2023. Dashed vertical lines indicate when TGP was opened to the ocean (color corresponds to a specific year). The dashed horizontal red line represents the MEP management threshold (0.48 mg/L).*

GPF will continue its ecosystem monitoring program on TGP in 2024 with a focus on water quality and nutrient data collection. Cyanobacteria monitoring will also continue on the Pond in 2024 through the MV CYANO$_{TM}$, a collaborative initiative between GPF and the Island Boards of Health.

Works Cited

Howes, B., Eichner, E., Samimy, R., Schlezinger, D., Kelley, S., Ramsey, J., & Detjens, P. (2013, May). *Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Threshold for the Tisbury Great Pond/Black Point Pond System, Town of Chilmark and West Tisbury, MA*. SMAST/MassDEP Massachusetts Estuaries Project, Massachusetts Department of Environmental Protection. https://www.mass.gov/doc/tisbury-great-pondblack-point-pond-system-dennis-ma-2013/download

Massachusetts Department of Environmental Protection. (2021, December 10). *314 CMR: Division of Water Pollution Control*. Commonwealth of Massachusetts. https://www.mass.gov/doc/314-cmr-400/download

Appendix

Summary of Metrics Explanation

Introduction to the Summary of Metrics Index

The "Summary of Metrics" health index was first developed by the Great Pond Foundation (GPF) in early 2024 as a means of visually summarizing the water quality data collected through its ecosystem monitoring program in simple terms. GPF regularly collected data on the following 5 coastal ponds during the 2023 summer season: Chilmark Pond, Crackatuxet Pond, Edgartown Great Pond, Tisbury Great Pond, and Watcha Pond. As such, the Summary of Metrics grading system was first applied to the 2023 water quality data collected for each of these ponds.

Assigning Grades to Metrics

The index works by assigning 1 of the following 3 grades to each water quality metric measured for a specific pond ecosystem: "Healthy," "Intermediate," or "Impaired". This is done by comparing data collected by GPF to management thresholds set by 2 primary bodies of work. These include the Massachusetts Department of Environmental Protection's (MassDEP) MA Surface Water Quality Standards, 314 CMR 4 for "Class SA" waters (MassDEP, 2021), to which all Martha's Vineyard ponds belong, as well as the Massachusetts Estuaries Project's (MEP) reports on Chilmark Pond, Edgartown Great Pond, and Tisbury Great Pond (Howes et al., 2008; Howes et al., 2013; Howes et al., 2015), all of which establish the same management thresholds. The management thresholds used by GPF are summarized below in **Table A1**.

Table A1. The management thresholds used by GPF to assess the health of water quality metrics.

Water Quality Metric	Management Threshold	Establishing Work
Chlorophyll	< 10 ug/L	MEP Reports
Dissolved Oxygen	> 6 mg/L	MassDEP Class SA Waters
pH	6.5-8.5	MassDEP Class SA Waters
Total Nitrogen	< 0.5 mg/L	MEP Reports
Water Clarity	$\geq$ 3 meters (or to bottom)	MEP Reports
Water Temperature	< 80 °F	MassDEP Class SA Waters

Following a thorough review of the water quality data collected across all 5 ponds in 2023, GPF established a set of criteria for assigning grades to individual water quality metrics (see **Table A2**). Grades are assigned to metrics based on the percentage of total measurements falling within a given metric's management target range. For example, in order for a pond to receive a "Healthy" grade in relation to chlorophyll, at least 90% of all chlorophyll measurements taken by GPF during the summer season would have to fall within the management target range (i.e. be less than 10 ug/L in concentration). Alternatively, if 65% or less of chlorophyll measurements fell within the target range, chlorophyll would receive an "Impaired" grade, while any percentage between 65% and 90% would warrant an "Intermediate" grade.

Table A2. GPF's criteria for assigning grades to individual water quality metrics. Percent values refer to the percentage of total measurements falling within the management target range.

Water Quality Metric	Healthy	Intermediate	Impaired
Chlorophyll	≥ 90%	65.01-89.99%	≤ 65%
Dissolved Oxygen (Bottom-depth)	≥ 90%	70.01-89.99%	≤ 70%
pH	≥ 90%	65.01-89.99%	≤ 65%
Water Temperature	≥ 90%	65.01-89.99%	≤ 65%
Total Nitrogen	≥ 90%	65.01-89.99%	≤ 65%
Water Clarity	≥ 75%	65.01-74.99%	≤ 65%

Cyanobacteria Grading

GPF has also included cyanobacteria in its Summary of Metrics health index; however, a different method of assigning grades is used for cyanobacteria concentrations relative to all other water quality metrics. The cyanobacteria criteria used in the index was modeled after the cyanobacteria risk assessment standards used by the MV CYANO$_{TM}$ program, a collaborative initiative between GPF and the Island Boards of Health that monitors cyanobacteria in various ponds across Martha's Vineyard (Great Pond Foundation, 2024).

In order for a pond to receive a "Healthy" grade for cyanobacteria, concentrations must remain within the program's "bloom not present" category for the duration of the summer. Alternatively, if any sampling station on a given pond enters the program's "cyanobacteria alert" and/or "bloom watch" categories during the summer, an "Intermediate" grade is automatically assigned to the pond. Similarly, if any sampling station enters the program's "bloom advisory" category during the summer, an "Impaired" grade is automatically assigned to the pond.

Final Product – Summary Figure

Once grades have been assigned to each water quality metric measured for a given pond, these grades are incorporated into a Summary of Metrics figure to visually convey a pond's general ecosystem health during a particular summer season. "Healthy" grades are designated in green, "Intermediate" grades are designated in yellow, and "Impaired" grades are designated in red. GPF's Summary of Metrics figure for Tisbury Great Pond's 2022 and 2023 data is shown below in **Figure A1** as an example.

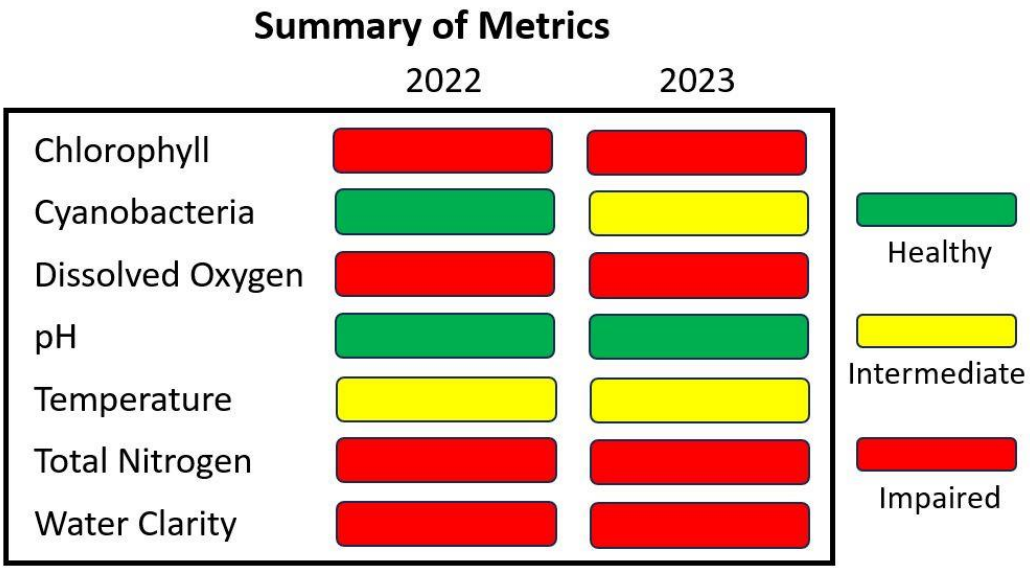


Figure A1. *Tisbury Great Pond's Summary of Metrics figure for the 2022 and 2023 summer seasons.*

Data Used in Index

GPF opted to use continuous readings obtained from its stationary logger at station TGP04 for all temperature and dissolved oxygen analyses. This was done under the assumption that continuous readings logged every 30 minutes throughout the course of the day are more representative than handheld probe readings logged every 2 weeks. All pH and water clarity analyses were done using data collected on a biweekly basis using a YSI multiparameter probe and Secchi disk, respectively. All chlorophyll and cyanobacteria analyses were performed using data obtained on a biweekly basis using a bbe Moldaenke FluoroProbe. Finally, all total nitrogen analyses were performed using data obtained from nutrient samples collected on a monthly basis and subsequently processed at Marine Biological Laboratory in Woods Hole, MA.

Selective Grading

In rare instances, GPF may deem that the grade assigned to an individual water quality metric through the Summary of Metrics index isn't truly representative of the metric's health during the previous summer season. Under these circumstances, GPF may selectively choose to assign a different grade using additional data and observations to more accurately grade the metric.

Selective grading was only applied once during GPF's Summary of Metrics analysis of its 2022 and 2023 TGP field data. This involved the changing of Tisbury Great Pond's 2023 cyanobacteria grade from "Healthy" to "Intermediate". Despite cyanobacteria concentrations within the water column remaining low across all monitoring stations during the summer of 2023, GPF identified the presence of concentrated clumps of cyanobacteria belonging to the genus *Aphanothece* in several of the Pond's coves at locations removed from set sampling stations (not included in Summary of Metrics analysis as a result). Due to the presence of these *Aphanothece* clumps, GPF decided that an "Intermediate" grade for cyanobacteria would be more accurate than a "Healthy" grade.

Tisbury Great Pond Site Visits, 2022-2023

Table A3.

Dates of Tisbury Great Pond Site Visits 2022				
June	**July**	**August**	**September**	**October**
6/1	7/6	8/3	9/2	10/7
6/14	7/13	8/9	9/8	10/21
6/20*	7/20*	8/15*	9/14*	
6/30	7/26	8/25	9/20	
2023				
June	**July**	**August**	**September**	**October**
	7/5	8/2	9/7	10/3
		8/17	9/13	10/17
		8/23*	9/20*	
		8/30		

*Nutrient samples collected