2023

ECOSYSTEM MONITORING REPORT

EDGARTOWN GREAT POND

GREAT POND FOUNDATION

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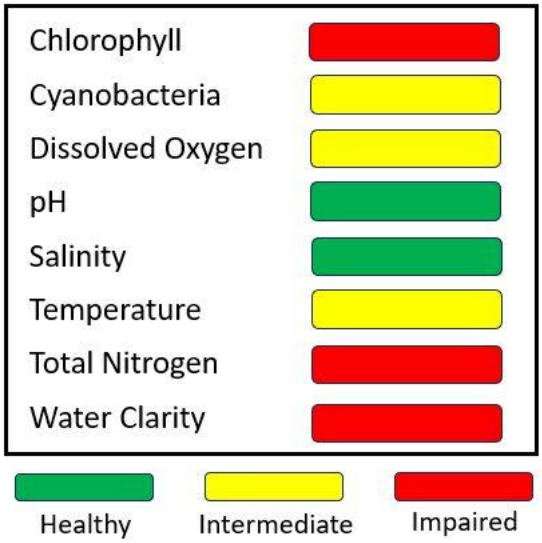
EDGARTOWN GREAT POND
Executive Summary

2023

Study Area

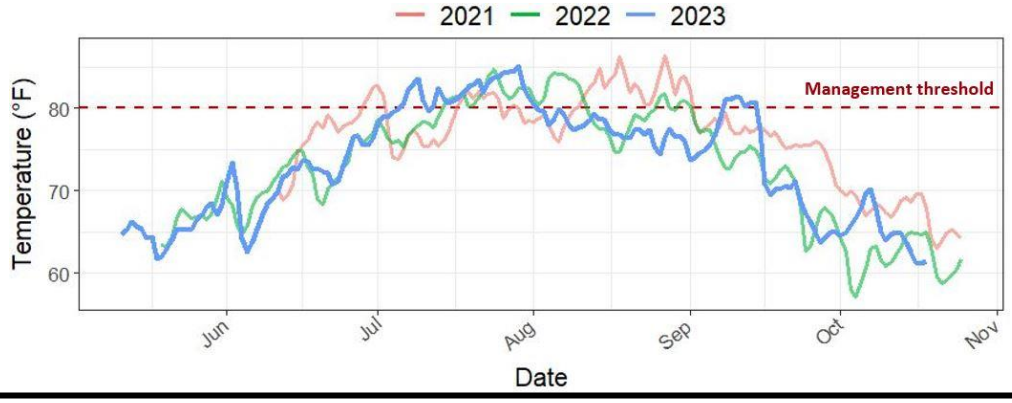
Edgartown Great Pond (EGP) is a coastal estuary approximately 890 acres in size located on the southern shoreline of Martha's Vineyard in the Town of Edgartown, MA. The Pond encompasses a roughly 4,850-acre watershed. The barrier beach separating EGP from the ocean is manually breached 3-5 times/year as a nutrient and elevation management tool.

Summary of Metrics, 2023



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

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



TEMPERATURE

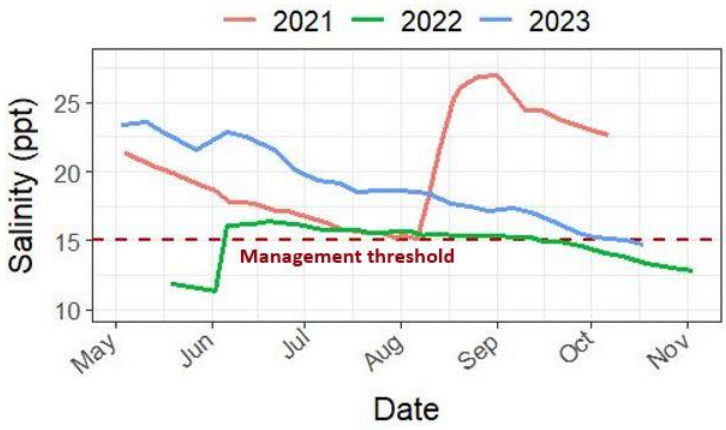
Mean daily water temperature in 2023 (blue) compared to 2021 (red) and 2022 (green).

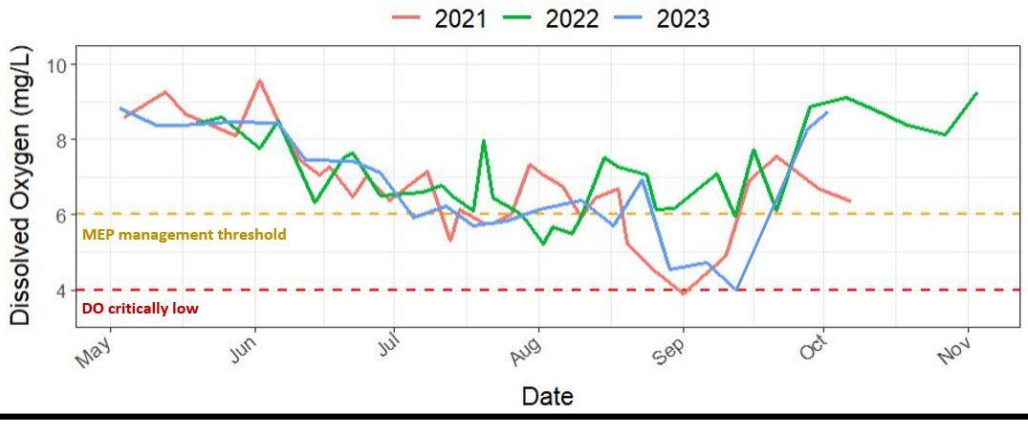
Mean daily temperature periodically rose above the management threshold (80 °F) across all 3 years.

SALINITY Pond-wide mean salinity in 2023 (blue) compared to 2021 (red) and 2022 (green). Salinity in 2021 and 2023 generally stayed above the threshold.

Cut Dates 2023

Date of Opening	Date of Closure	Cut Duration
March 11th	March 11th	0 days
Apr 7th	Apr 27th	20 days
Sep 29th	Sep 29th	0 days
Oct 14th	Oct 15th	1 day
Dec 23rd	Jan 1st (2024)	9 days





DISSOLVED OXYGEN

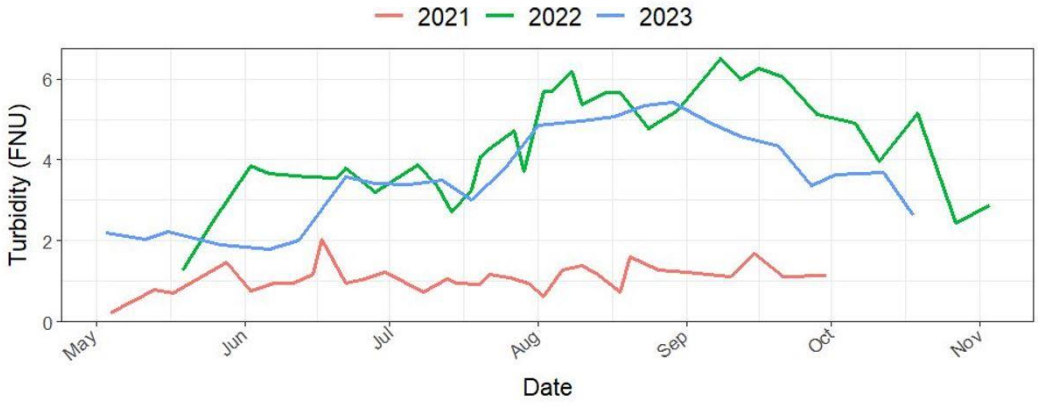
Pond-wide mean bottom-depth dissolved oxygen (DO) in 2023 (blue) compared to 2021 (red) and 2022 (green).

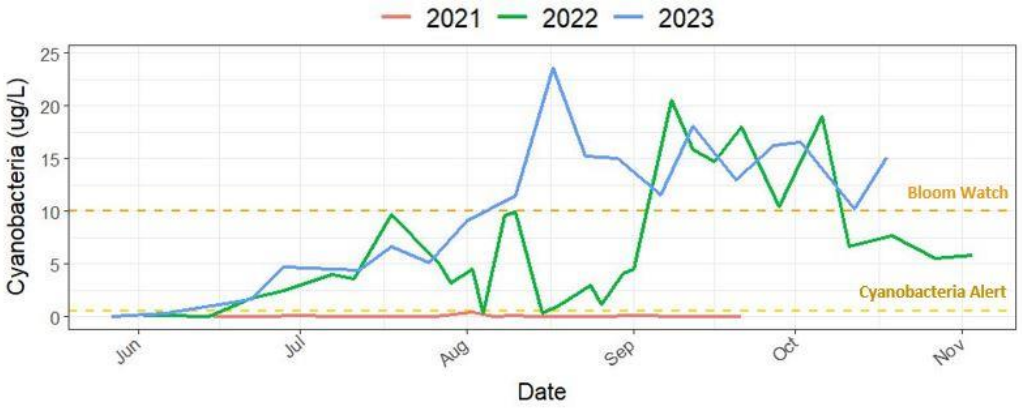
Mean bottom-depth DO fell below the critical threshold during the late summers of 2021 and 2023.

TURBIDITY

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

While EGP exhibited high water clarity in 2021, the Pond's turbidity rose substantially in 2022 and remained high in 2023.





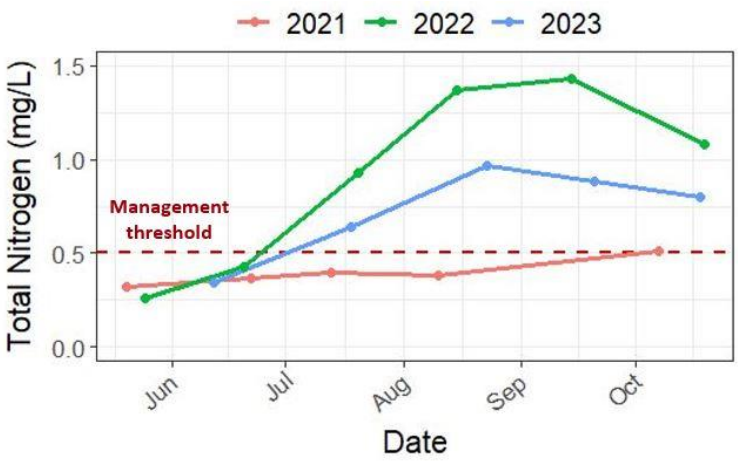
CYANOBACTERIA

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

Cyanobacteria concentrations have steadily increased over the last 3 years, reaching "bloom watch" status in 2022 and 2023.

TOTAL NITROGEN

Mean total nitrogen levels across all monitoring stations in 2022 (green) and 2023 (blue) were elevated relative to 2021 (red).



Pond Summary

EGP exhibited reduced water quality and signs of impairment in 2023, continuing trends seen in 2022. Total nitrogen concentrations regularly exceeded the management target from July through October. 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. Despite the presence of conducive salinity conditions, eelgrass was largely absent from the Pond for the second consecutive year. The average length of pond openings on EGP has declined since 2021, suggesting that weakened flushes of the Pond may be contributing to reduced ecosystem health.

Introduction

Edgartown Great Pond (EGP) is an important resource for the Town of Edgartown, MA with ecological, historical, cultural, and economic significance. The Massachusetts Department of Environmental Protection (MassDEP) has designated all Martha's Vineyard waters, including EGP, as "Class SA" waters, pursuant to 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 shellfishing, 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 2016, with a focus on providing high resolution data to inform pond management. While the program initially focused on water quality data collection, it has since expanded to include biodiversity surveys, cyanobacteria monitoring, and studies on nitrogen sources within the watershed. GPF's Ecosystem Monitoring Program follows the methodology and standards established by the Massachusetts Estuaries Project's (MEP) 2008 report on EGP (Howes et al., 2008), 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 EGP 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 0.5 mg/L across the 5 stations (EGP02, EGP03, EGP05, EGP06, & EGP09) comprising the sentinel station. (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

Edgartown Great Pond (EGP) is a coastal estuary approximately 890 acres in size situated along the southern coastline of Martha's Vineyard in the Town of Edgartown, MA. EGP consists of a primary basin and several tributary coves (Jane's Cove, Wintucket Cove, Mashacket Cove, Turkeyland Cove, Slough Cove, and Job's Neck Cove). The Pond's watershed encompasses roughly 4850 acres of land mostly contained within the Town of Edgartown, although the headwaters are estimated to originate in the neighboring Town of West Tisbury, MA (MVC, 2024). Freshwater primarily enters the Pond via groundwater. A barrier beach separates EGP from the Atlantic Ocean, which is intentionally breached or "cut" 3-5 times per year to drain the Pond and allow for a period of tidal exchange with the ocean. Seawater is nutrient deficient compared to inland estuaries, and tidal exchange creates a "flushing"

effect throughout the life of an opening. This can provide a short-term reduction in excess nutrient concentrations, dependent on the longevity of the cut and the volume of tidal flow through the breach. Pond cuts are temporary, and close due to natural forces. The Town of Edgartown is responsible for determining the timing and management of openings and delegates this authority to the Edgartown Shellfish Constable. This decision considers multiple 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, EGP gradually refills from groundwater input, surface runoff, and direct surface deposition from precipitation.

Scope of Work

In 2023, Great Pond Foundation (GPF) continued its ecosystem monitoring program on EGP for the 8th consecutive year. GPF uses the methodology and management standards established by the Massachusetts Estuaries Project's (MEP) 2008 report on EGP (Howes et al., 2008), as well as by MassDEP's Surface Water Quality Standards for Class SA waters (MassDEP, 2021). A total of 24 weekly monitoring trips were conducted on EGP between May 3rd and October 18th, most of which took place in the morning hours between 7 and 11 AM. Data was collected from 12 primary monitoring stations located throughout the Pond's main basin and its various coves (**Figure 1**). 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 collected from sensors deployed on the pond bottom at stations EGP05 and EGP09. Water clarity was measured at each station using a Secchi Disk. Pond elevation data was collected by a continuous logger located in Wintucket Cove (approximately 0.5 miles north of station EGP09).

Cyanobacteria testing was conducted during each sampling trip through the MV CYANO$_{TM}$ program, a collaborative initiative between GPF and the Island Boards of Health. A total of 237 cyanobacteria samples were collected from EGP and processed in 2023. Monthly nutrient sampling was conducted at 8 of the 12 monitoring stations from June through October, with a total of 40 samples being collected and processed at Marine Biological Laboratory (MBL) in Woods Hole, MA. Additionally, to obtain a better understanding of nutrient sources within EGP's watershed, GPF conducted groundwater nutrient sampling with MBL in Slough and Mashacket Coves on June 16th and 29th, respectively. A groundwater report will follow once analysis of data is complete.

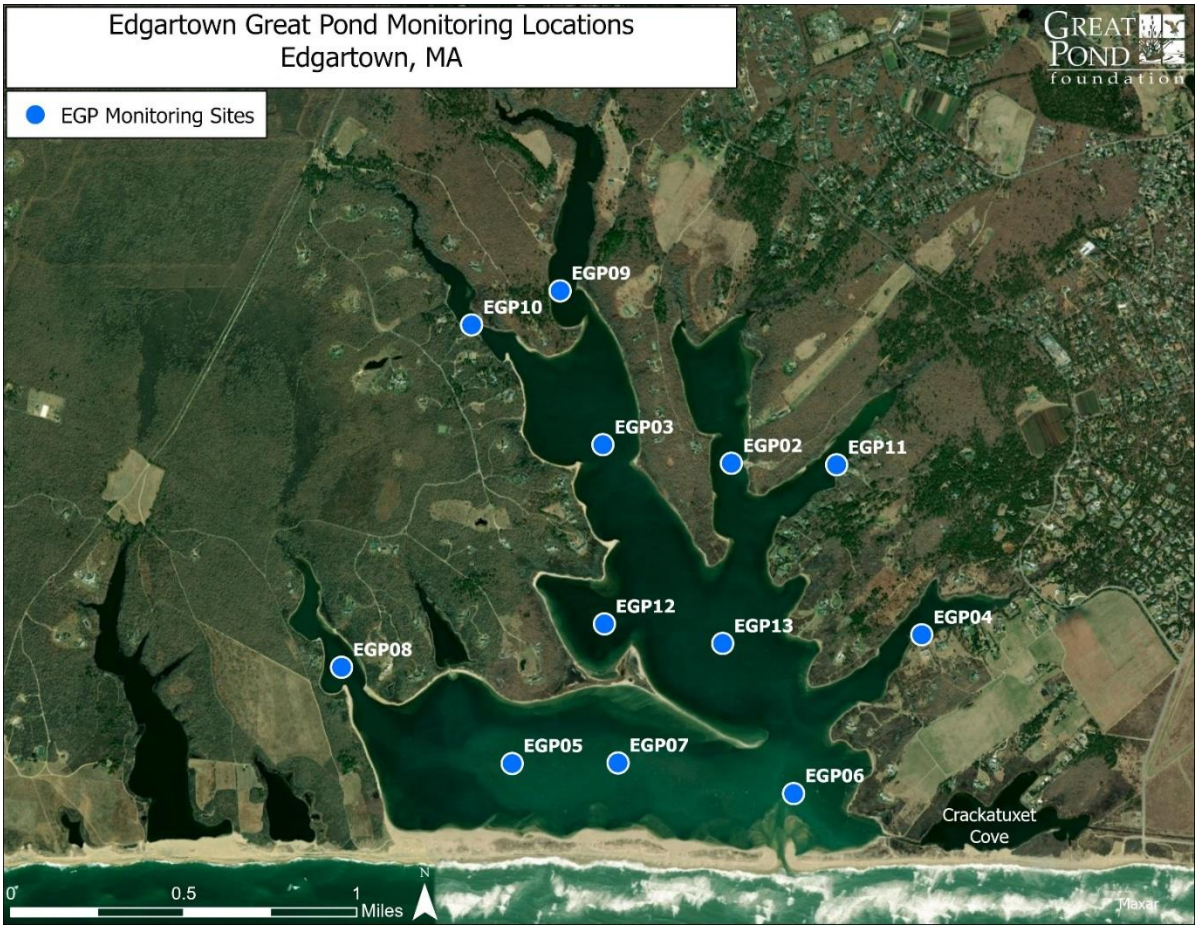


Figure 1. *The locations of the 12 monitoring stations used by GPF in 2023.*

Water Quality Metrics

Pond Elevation and Pond Cuts

Summary Points:

- EGP was opened to the ocean 5 times in 2023 for a total of 30 days.
- The length of openings ranged from 0 to 20 days, with an average opening length of 6 days.
- The Pond's elevation did not rise high enough to allow for a summer opening in 2023.
- Recharge time in EGP is longest during the summer and shortest during the spring.

The barrier beach separating EGP from the ocean was artificially breached 5 times in 2023. In total, EGP was open to the ocean for 30 days in 2023, with the opening length of individual cuts ranging from 0-20 days (**Table 1**). The average opening length was 6 days, with the longest single event occurring on 4/7/23 (20 days). Past data indicate that winter dredging (December through March) increased average opening length and total number of days open in the following seasons (**Table 1**). This can be seen clearly in comparing the average opening length of dredge years like 2018 (30.67 days), 2019 (26 days), and 2021 (19 days) to those of non-dredge years like 2020 (7.25 days) and 2022 (5 days).

Table 1. *Approximate dates on which Edgartown Great Pond was opened to the ocean between 2018 and 2023. Years in which winter dredging was performed are highlighted in blue.*

Year	Average Length of Openings	Total Number of Days Open	Date of Opening	Date of Closure	Length of Opening
2018	30.67 days	92 days	3/11/2018	5/21/2018	71 days
			8/20/2018	8/21/2018	1 day
			11/18/2018	12/8/2018	20 days
2019	26 days	78 days	3/24/2019	5/13/2019	50 days
			6/29/2019	7/15/2019	16 days
			11/16/2019	11/28/2019	12 days
2020	7.25 days	29 days	3/22/2020	4/3/2020	12 days
			5/17/2020	5/23/2020	6 days
			8/22/2020	8/23/2020	1 day
			11/7/2020	11/17/2020	10 days
2021	19 days	57 days	2/28/2021	3/18/2021	18 days
			8/7/2021	9/1/2021	25 days
			12/4/2021	12/18/2021	14 days
2022	5 days	15 days	4/4/2022	4/9/2022	5 days
			6/1/2022	6/7/2022	6 days
			12/5/2022	12/9/2022	4 days
2023	6 days	30 days	3/11/2023	3/11/2023	0 days
			4/7/2023	4/27/2023	20 days
			9/29/2023	9/29/2023	0 days
			10/14/2023	10/15/2023	1 day
			12/23/2023	1/1/2024	9 days

While the dredging of shoals adjacent to EGP's opening site is generally known to improve flow during openings and lead to more effective flushing within the Pond (**Figure 2**), dredging isn't always a guarantee of improvement, as a variety of environmental factors influence the lifespan of a cut. This complexity was demonstrated in 2023 when the Pond experienced 3 short-lived cuts (1 day or less) and an average opening length of just 6 days despite dredging having been performed in January. The reason for the break in this pattern is unclear but likely owes to a combination of variables including wind, wave action, and sand shoaling randomly acting to close many of the 2023 openings prematurely. Data from 2024 will help to clarify the current state of openings in the Pond, as dredging is once again slated to take place on EGP during the 2024 winter dredging window.

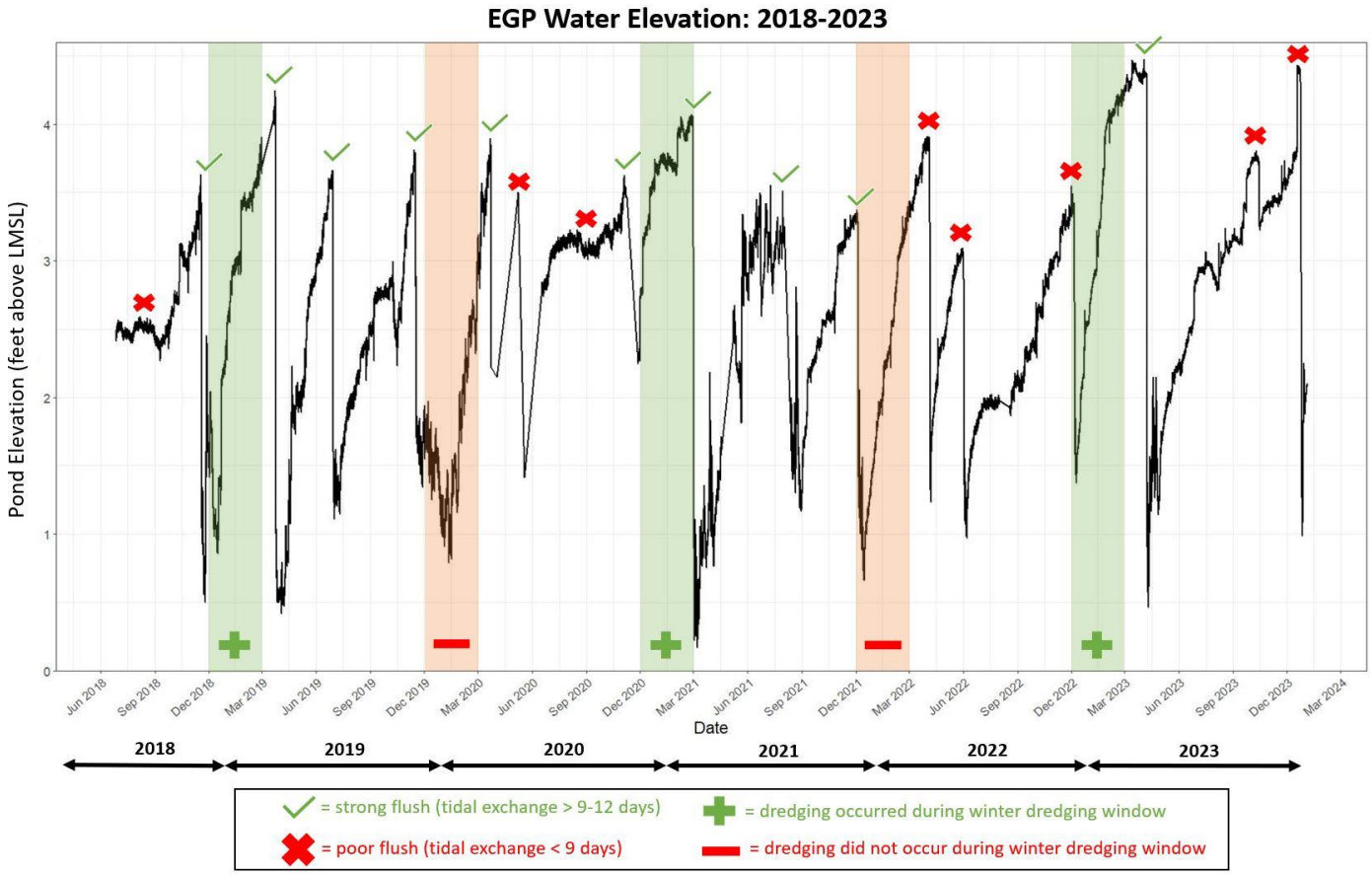


Figure 2. *Water elevation (in feet above local mean sea level) in EGP from mid-2018 through 2023. Green check marks indicate that a cut remained open for more than 9 days (strong flush), while red X's indicate that a cut did not remain open for 9 or more days (poor flush). Green columns indicate that dredging was performed during the winter dredging window (Dec-Mar), while red columns indicate that dredging was not performed.*

Water elevation in EGP fluctuated between 0.5 and 4.5 feet above local mean sea level (LMSL) in 2023. Data collected by a continuous elevation logger in Wintucket Cove illustrates the approximate 24-hour "drain" cycle from high water elevation to low that occurs immediately following a breach (**Figure 3**). After this drain cycle, the Pond becomes tidal, allowing high saline, nutrient deficient seawater to enter and mix with the remaining nutrient rich waters of EGP. The natural motion of sand across the area of the cut will restrict and eventually close the breach naturally.

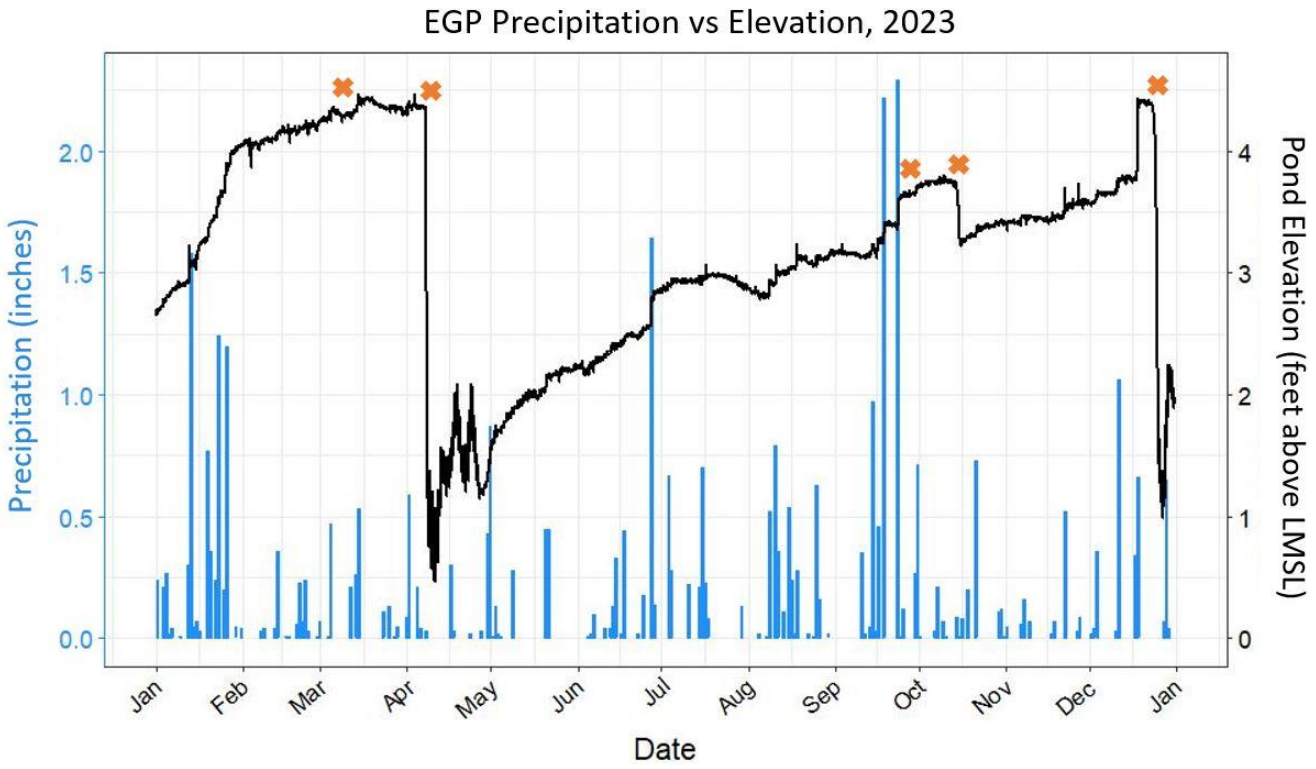


Figure 3. *Daily cumulative precipitation (in inches) recorded at the Martha's Vineyard Airport is plotted against EGP's water elevation (in feet above local mean sea level) in 2023. Precipitation data was obtained from the National Weather Service. An orange "X" indicates when EGP was opened to the ocean.*

Following the closure of a breach, elevation in the Pond will gradually increase as water is added through groundwater inflow, surface runoff, and direct precipitation. The amount of time required for the Pond to return to high water is commonly referred to as its "recharge time." In the case of EGP, recharge time can be defined as the amount of time it takes for the Pond to reach an elevation of 3.5 feet above LMSL, as this is the height at which openings have historically taken place. Recharge information for all openings spanning 2018 through 2023 for which precipitation data was available is presented in **Table 2**.

This data indicates that recharge patterns in EGP are largely seasonal. Recharge time is maximized during the summer (average of 152.2 days) when both evaporative losses and the extraction of groundwater by plants are at a peak, reducing the rate of fill within the Pond. As a result, EGP requires a greater amount of precipitation (average of 16.86 inches) during the summer in order to reach the recharge threshold relative to all other seasons. This is in contrast to the spring, which encompasses the shortest recharge time (average of 38 days) as a result of low evaporation rates and much of the season taking place prior to the growing season. These reduced losses combined with the addition of water via snowmelt means that the Pond ultimately requires the least amount of precipitation (average of 5.64 inches) during the spring in order to reach the recharge threshold.

Table 2. *Recharge data for all EGP openings from 2018 through 2023 for which precipitation data was available. Recharge time is defined as the amount of time it takes for the Pond to reach an elevation of 3.5 feet above LMSL following the closure of an opening. All precipitation data was obtained from the National Weather Service for the Martha's Vineyard Airport.*

Closing Date	Recharge Date (i.e. reached 3.5 ft LMSL)	Recharge Time (days)	Precipitation During Recharge Period (inches)	Recharge Season	Average Recharge Time (days)	Average Precipitation/ Recharge Period (inches)
5/13/2019	6/22/2019	42	5.94	Spring (Apr-June)	38	5.64
4/3/2020	5/7/2020	34	5.34			
5/21/2018	11/16/2018	179	22.88	Summer (Jul-Sep)	152.2	16.86
7/15/2019	11/8/2019	116	15.42			
5/23/2020	11/2/2020	163	7.99			
6/7/2022	12/5/2022	181	19.6			
4/27/2023	9/23/2023	122	18.4			
11/17/2020	12/17/2020	30	6.03	Fall (Oct-Dec)	63.5	10.26
8/29/2021	12/4/2021	97	14.49			
12/8/2018	2/13/2019	67	9.13	Winter (Jan-Mar)	75.5	9.3
11/28/2019	3/15/2020	108	13.29			
12/18/2021	3/10/2022	82	7.17			
12/9/2022	1/23/2022	45	7.59			

Salinity

Summary Points:

- Salinity gradually declined over the course of the summer but remained above the 15 ppt management threshold until late September.
- The Pond's northernmost coves experienced the lowest salinity concentrations and greatest stratification within the water column.
- A pair of short-lived openings in the fall had no observable effect on salinity.

Measured salinity in EGP ranged from 13.1 to 25.3 parts per thousand (ppt) during the 2023 field season. Salinity concentrations were consistent across all monitoring stations and exhibited minimal stratification between depths (**Figure 4**). Stations EGP09, EGP10, and EGP11 occupy 3 of EGP's northernmost coves, where mixing dynamics due to localized fresh groundwater input can create some variation in salinity within the water column. As such, these coves tend to exhibit more freshwater conditions throughout the season compared to the southern areas of the Pond, a common trait of estuaries. These trends can be illustrated in **Figure 5**, where continuous salinity measurements collected in Wintucket Cove (EGP09) are consistently lower than those recorded in the Pond's southern basin (EGP05).

Salinity is considered a conservative metric, as changes in concentration are almost entirely a result of either direct seawater or freshwater inputs (concentration vs. dilution). As such, salinity is an excellent indicator of water circulation patterns and in assessing the influence of Pond openings and flushing

dynamics. When EGP is open to the ocean long enough for tidal exchange to occur, salinity will increase steadily as seawater enters and disperses throughout the Pond. Alternatively, when the Pond is closed, salinity will gradually decrease due to fresh groundwater influx, surface runoff, and direct precipitation. Following a 20-day opening in April that effectively raised salinity above 20 ppt (prior to the start of the field season and regular measurements), salinity in the Pond gradually decreased over the course of the summer with the steady addition of freshwater (**Figures 4 & 5**). In contrast to this spring opening, neither of the cuts on September 29th or October 14th remained open long enough to impact salinity concentrations in the Pond. With no change in salinity, it can be assumed that impactful flushing or seawater exchange did not occur following these events.

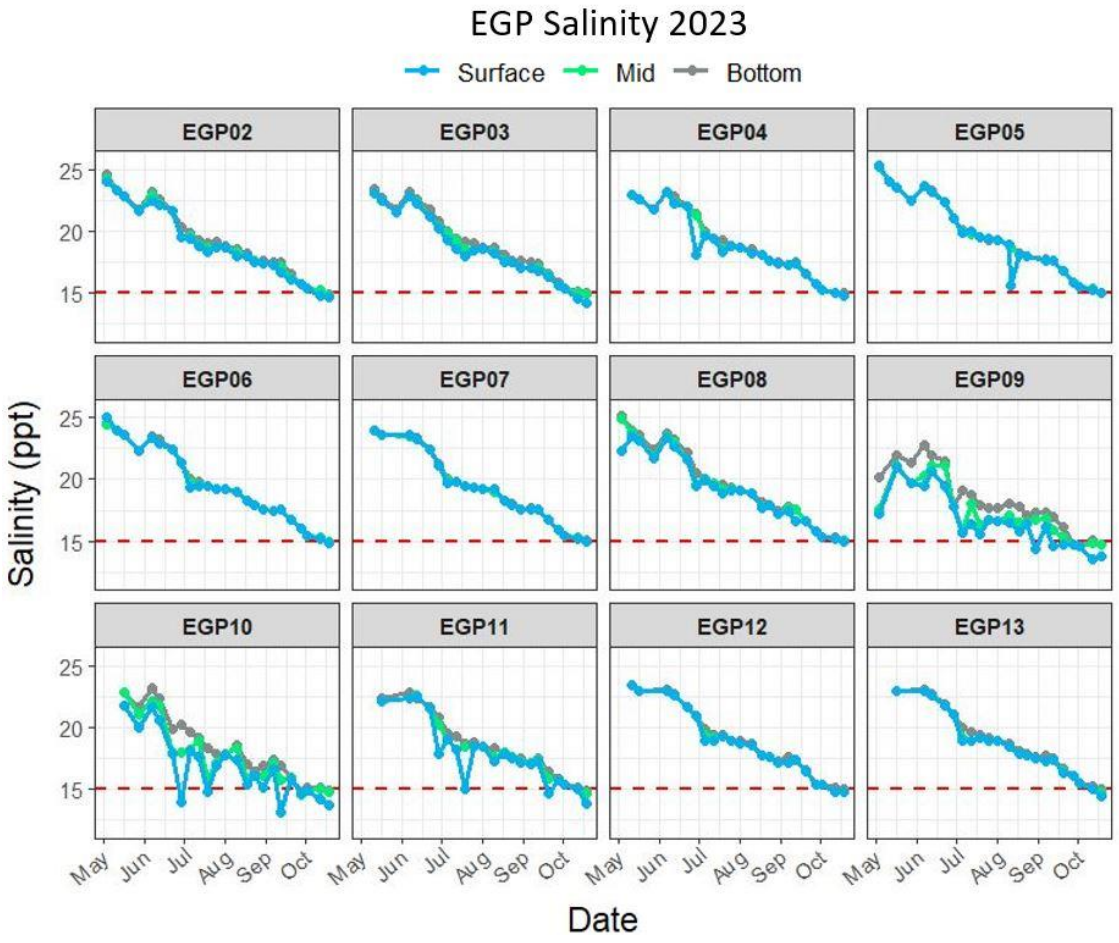


Figure 4. *Salinity in parts per thousand (ppt) for EGP's 12 monitoring stations during the 2023 field season. Data was measured using a handheld probe for 3 depths (surface, mid-depth, and bottom). The dashed red line represents the management target for maintaining healthy eelgrass beds (15 ppt).*

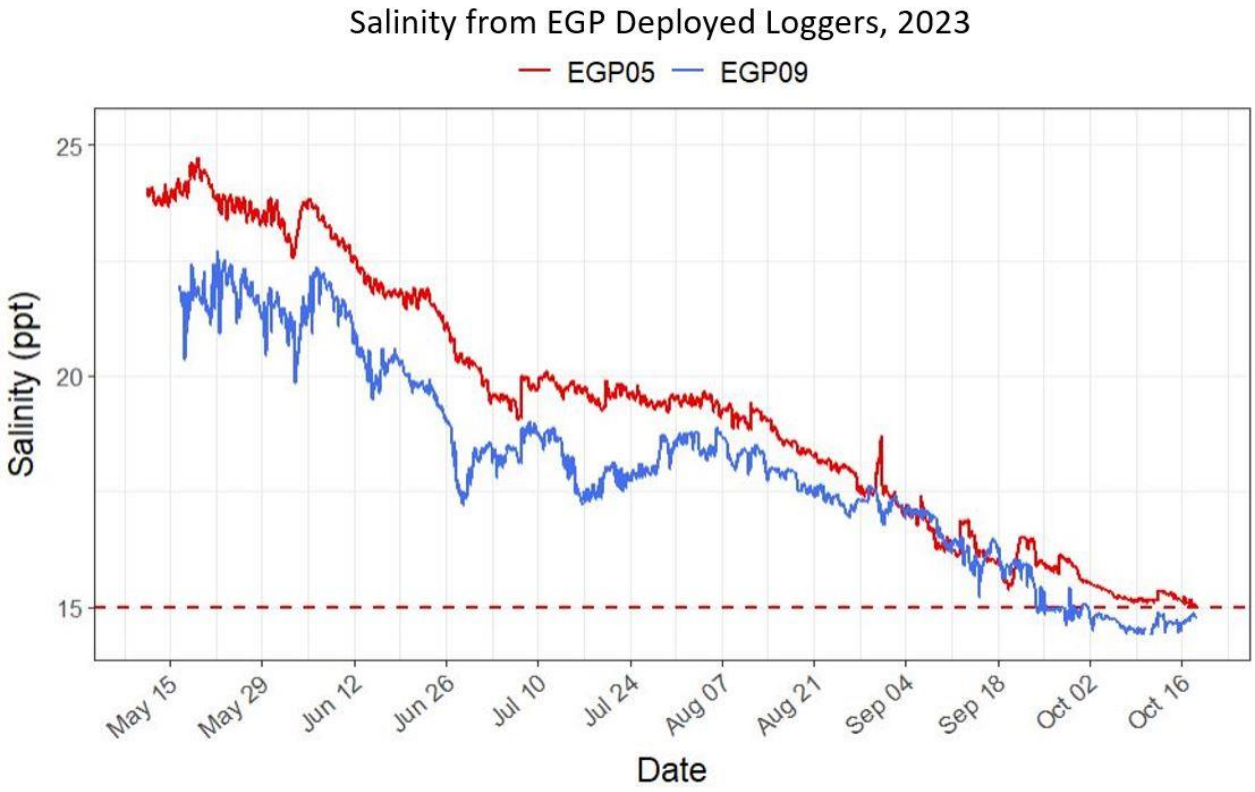


Figure 5. *Salinity in parts per thousand (ppt) at stations EGP05 (southern basin) and EGP09 (Wintucket Cove) during the 2023 field season. Data was obtained via 2 conductivity/salinity data loggers deployed at stations EGP05 and EGP09, respectively. The dashed red line represents the management target for maintaining healthy eelgrass beds (15 ppt).*

The MEP has defined high habitat quality for EGP as being conducive to the growth of eelgrass, a native seagrass that has historically been present in the Pond (Howes et al., 2008). Not only is eelgrass a commonly used indicator of good water quality, but it also provides a number of ecosystem services to the Pond ecosystem by stabilizing sediment, supplying nursery and foraging habitat, and comprising a food source for various native species. While the State has yet to assign a salinity standard for EGP, GPF currently recommends a 15 ppt management threshold for maintaining healthy eelgrass beds, as eelgrass tends to become stressed when salinity falls below this level. Additional historical observations of growth in EGP have shown eelgrass habitat to spread and thrive in years when salinity remains above this threshold. This standard also doubles as a salinity threshold for cyanobacteria, as high salinity concentrations can place various species of cyanobacteria under stress and limit their growth. Excluding some incidences of freshwater mixing at stations within the coves, salinity across the Pond generally remained above the 15 ppt threshold until late September. Despite salinity conditions remaining conducive to eelgrass growth during the summer of 2023, the seagrass was largely absent from the Pond, suggesting that other factors were at play in limiting its growth (see “Discussion” section).

In comparing salinity across the last 3 years, salinity at the start of the field season was highest in 2023 (~24 ppt) and lowest in 2022 (~12 ppt) (**Figures 6 & 7**). The high starting salinity seen in 2023 can be credited to the year's 20-day opening in April, effectively flushing the Pond with saltwater just weeks before the beginning of the field season. Salinity in the Pond was also relatively high at the start of the 2021 field season (> 20 ppt) following an 18-day opening in March. Alternatively, 2022 saw the occurrence of 2 short-lived openings in April and June that were less effective in raising salinity.

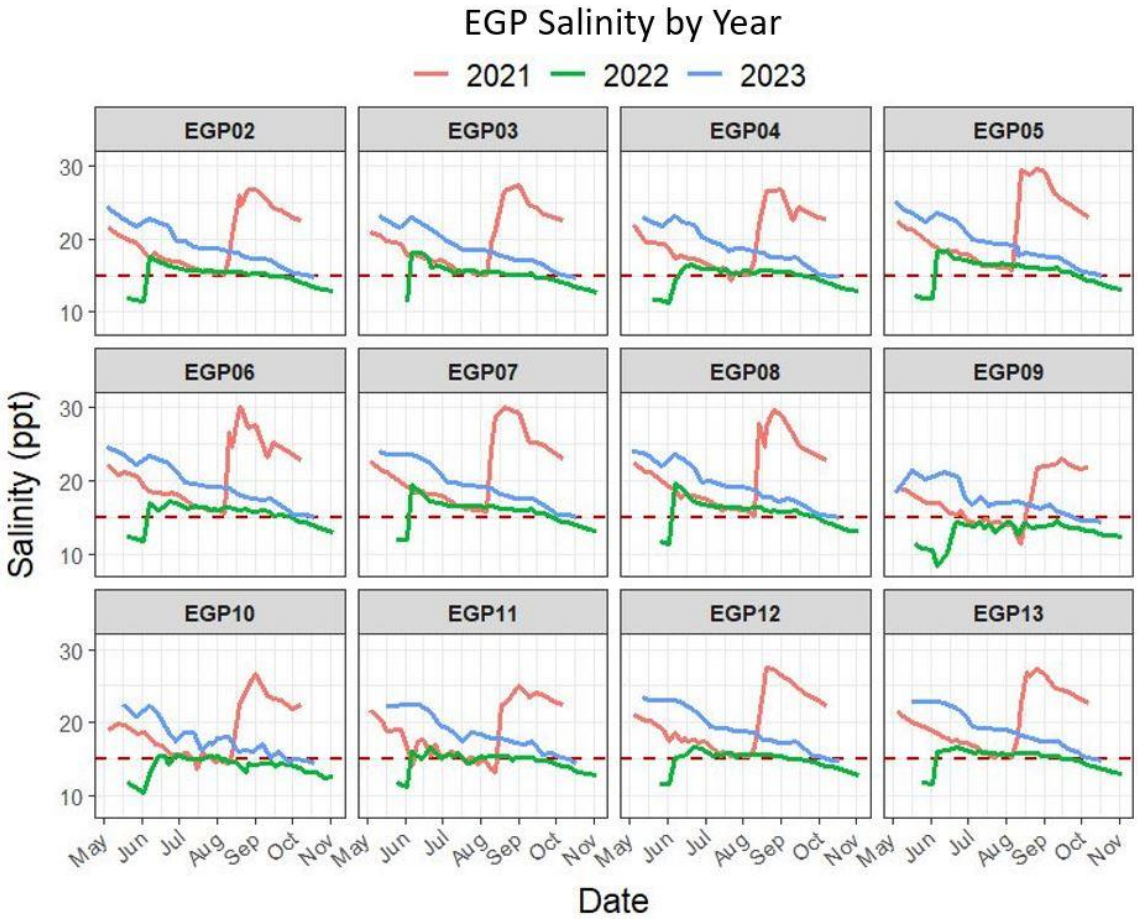


Figure 6. *Average salinity across all depths in parts per thousand (ppt) for EGP's 12 monitoring stations for the years 2021, 2022, and 2023. The dashed red line represents the management target for maintaining healthy eelgrass beds (15 ppt).*

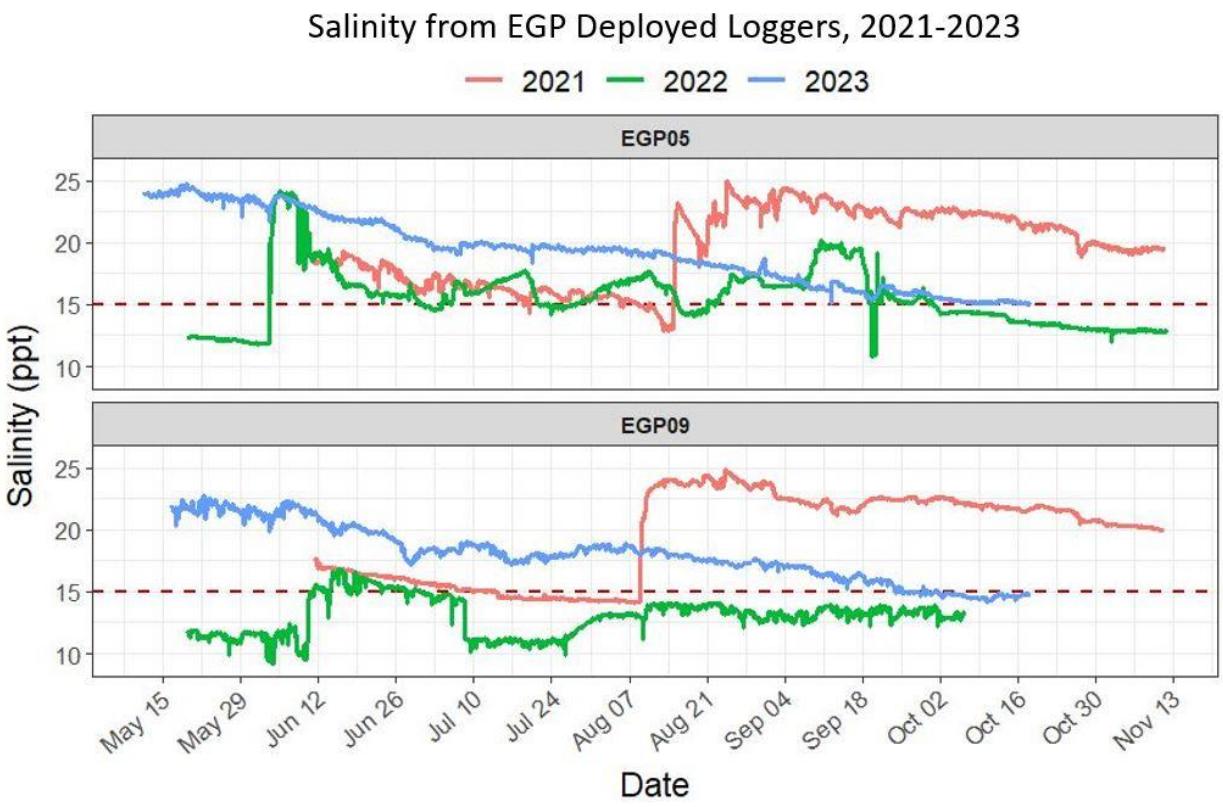


Figure 7. *Salinity in parts per thousand (ppt) at stations EGP05 and EGP09 for the years 2021, 2022, and 2023. Data was obtained via 2 conductivity/salinity data loggers deployed at stations EGP05 and EGP09, respectively. The dashed red line represents the management target for maintaining healthy eelgrass beds (15 ppt).*

Temperature

Summary Points:

- Water temperature was highest in July and early September. Daily mean temperature exceeded 80 °F on a total of 33 days in the Pond's main basin.
- The Pond's coves experienced higher temperatures than its main basin during heating events.
- Water temperatures in EGP closely correspond to ambient air temperatures.

Measured water temperature in EGP ranged from 56.1 to 87.5 °F during the 2023 field season. Temperature remained consistent across all monitoring stations and was generally uniform throughout the water column (**Figure 8**). Only the Pond's northernmost coves (EGP09 and EGP10) exhibited any real stratification between depths, likely a function of cooler groundwater inflow and mixing in those areas, or more rapid daily heating and cooling cycles due to their shallower depths. Overall, EGP's coves experienced higher water temperatures than the Pond's southern main basins during the hottest periods of the summer.

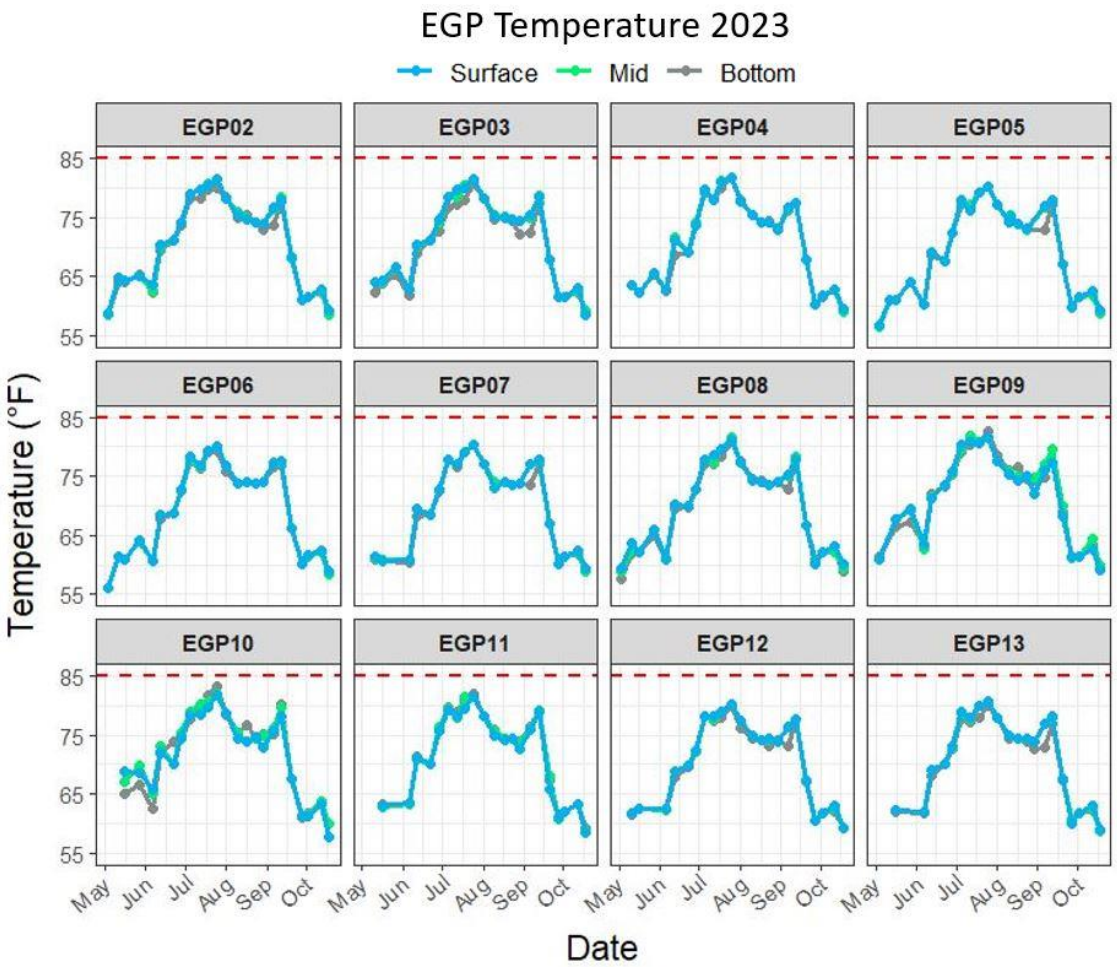


Figure 8. *Water temperature (in °F) for EGP's 12 monitoring stations during the 2023 field season. Data was measured using a handheld probe for 3 depths (surface, mid-depth, and bottom). The dashed red line represents the MassDEP management threshold (85 °F).*

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, as elevated water temperatures can degrade habitat quality and subject native species to heat stress. Continuous data obtained from bottom-depth temperature loggers deployed at stations EGP05 and EGP09 show that water temperatures in the Pond are closely tied to ambient air temperature (**Figure 9**). Water temperature exceeded 85 °F on a total of 5 days at EGP05 and 16 days at EGP09 during 2023. Additionally, mean daily temperature exceeded 80 °F on a total of 33 days at EGP05 and 43 days at EGP09. Incidences of high water temperature coincided with ambient air temperature maximums throughout the summer season.

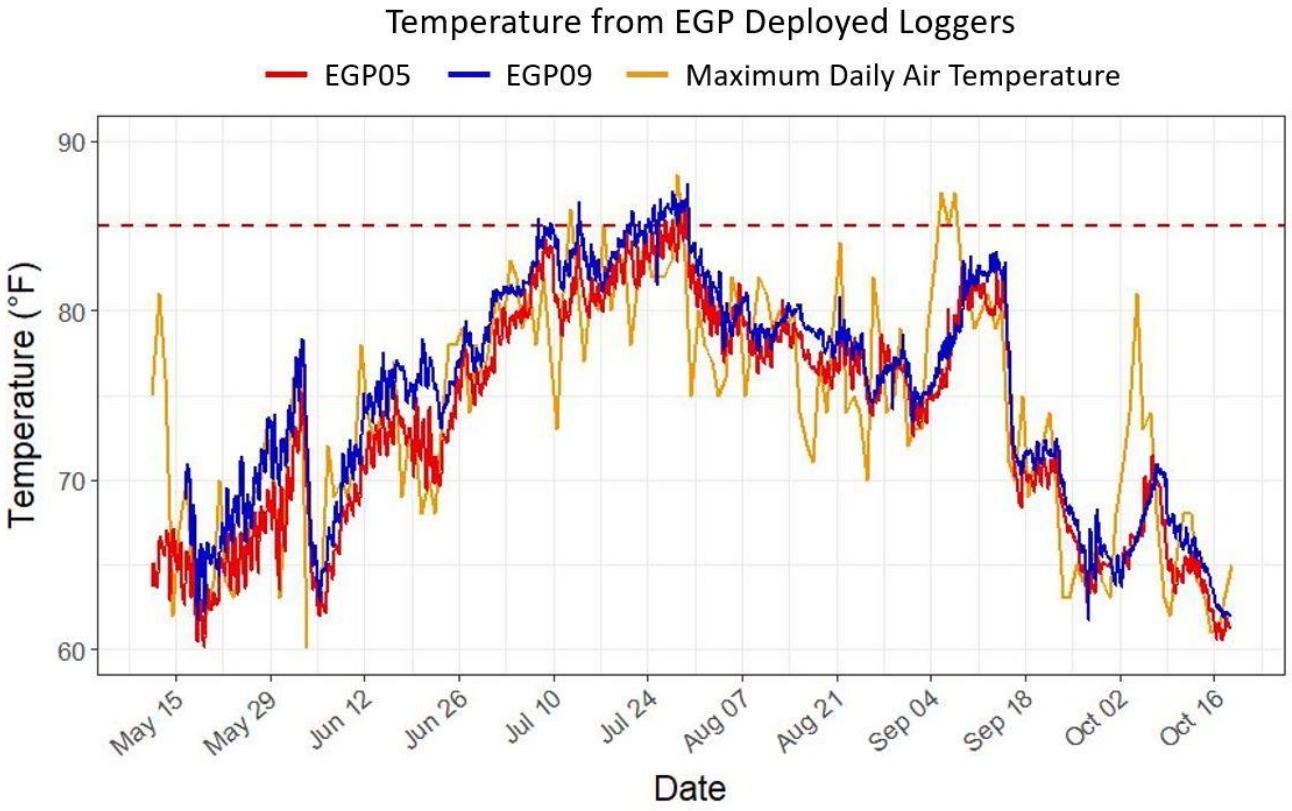


Figure 9. *Water temperature (in °F) for stations EGP05 and EGP09 during the 2023 field season is plotted against maximum daily air temperature. Data was obtained from 2 temperature data loggers deployed at stations EGP05 and EGP09, respectively. Air temperature data was obtained from the National Weather Service for the Martha's Vineyard Airport (National Weather Service, 2024). The dashed red line represents the MassDEP management threshold (85 °F).*

The water temperature trends observed in 2023 resemble those in both 2021 and 2022 (**Figure 10**). All 3 years experienced rising water temperatures in the spring, peak temperatures during the summer, and cooling temperatures in the fall. While August water temperatures were abnormally cool in 2023 relative to the preceding 2 years, 2023 experienced particularly warm water temperatures during the first half of September. Mean daily water temperature at station EGP05 exceeded 80 °F on a similar number of days in 2023 (33 days) relative to both 2021 (37 days) and 2022 (34 days).

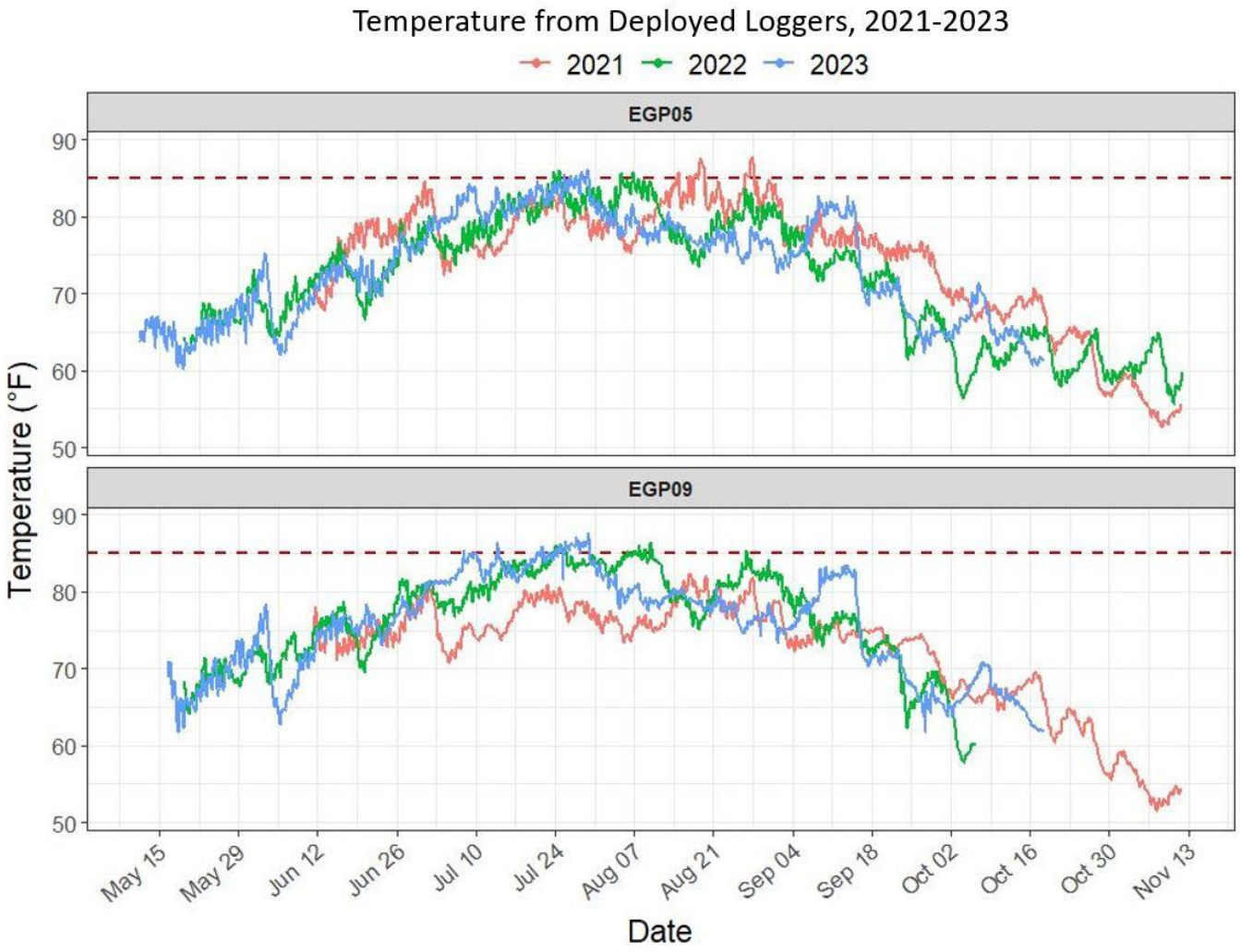


Figure 10. *Water temperature (in °F) at stations EGP05 and EGP09 for the years 2021, 2022, and 2023. Data was obtained from 2 temperature loggers deployed at stations EGP05 and EGP09. The dashed red line represents the MassDEP management threshold (85 °F).*

Dissolved Oxygen

Summary Points:

- Dissolved oxygen (DO) levels in the upper water column generally remained above the 6 mg/L management threshold.
- Continuous data from station EGP05 shows that bottom-depth DO regularly dropped into the hypoxic range (< 2 mg/L) between July and September, most often at night.
- 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, and passively with a deployed HOBO U26 dissolved oxygen data logger. MassDEP sets a management standard of 6 milligrams per liter (mg/L) minimum concentration for Class SA waters. 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 may lead to mortality events. Large daily magnitude swings in DO concentrations (from high to low) can also be a sign of ecosystem imbalance.

DO concentrations in the upper water column (i.e. surface and middle depths) recorded between 7 and 11 AM generally remained above the management threshold (6 mg/L) across the Pond in 2023 (**Figure 11**). Alternatively, in-situ measurements at the pond bottom, where organic matter decay can act to deplete oxygen reserves, periodically dropped below this threshold between July and September at several stations. Declines below the critical threshold (4 mg/L) were most frequently observed at the Pond's deepest stations (EGP02, EGP03, EGP13) where the pond bottom is far removed from the air-water interface at the surface.

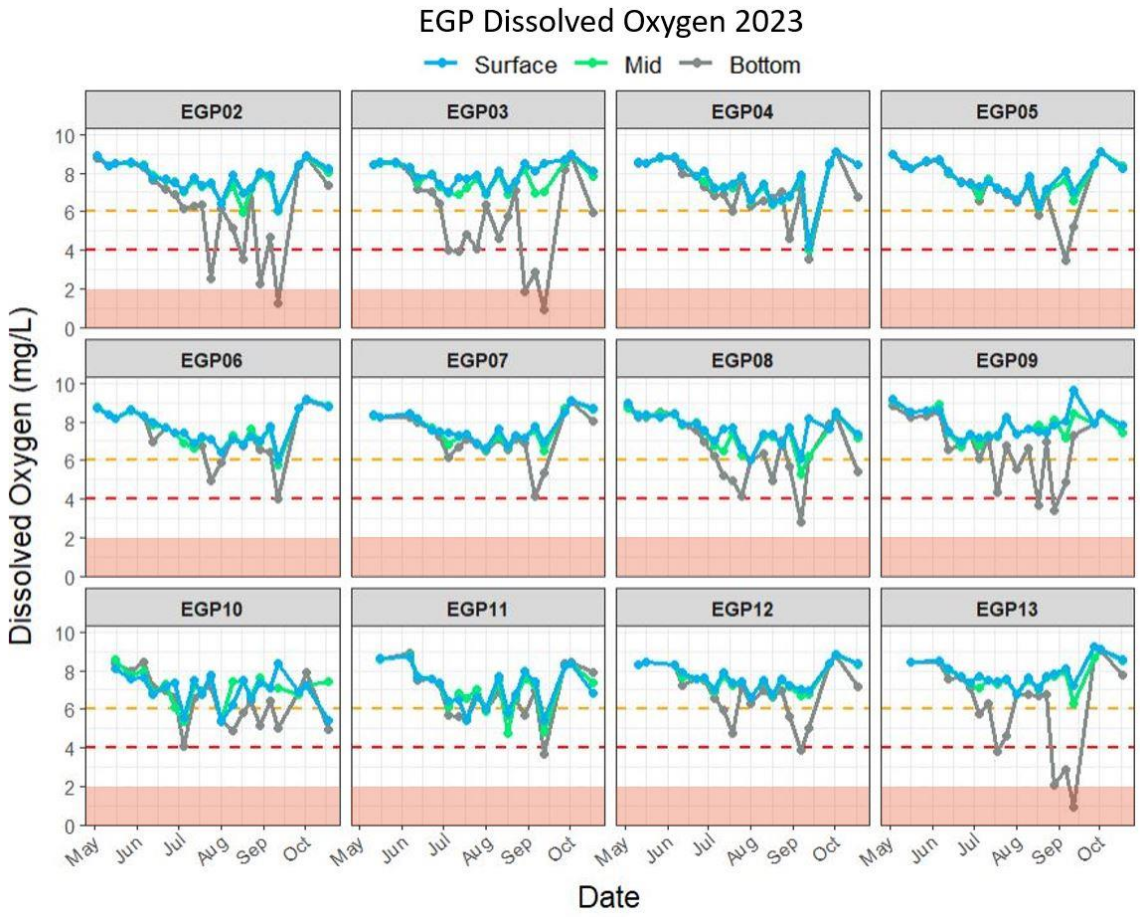


Figure 11. *Dissolved oxygen (DO) in milligrams per liter (mg/L) for EGP's 12 monitoring stations during the 2023 field season. Data was measured using a handheld probe for 3 depths (surface, mid-depth, and bottom). The dashed yellow line represents the 6 mg/L management threshold, the dashed red line 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.*

Continuous data recorded at station EGP05 shows that drops in bottom-depth DO levels occurred more frequently than in-situ measurements would have indicated, with measurements regularly dropping into the hypoxic range (<2 mg/L) between July and September, particularly during nighttime hours when

photosynthesis was not taking place (**Figure 12**). The EGP05 continuous dataset shows a declining trend in overall DO concentrations at the pond bottom between early July and late September. Additionally, the magnitude of daily swings between high and low DO concentrations was maximized during the peak summer months in comparison to the cooler spring. This is a sign of biological imbalance in EGP, as daily fluctuations in DO concentrations typically remain above the 6 mg/L threshold in a healthy system.

EGP experienced 2 incidences of DO decline in July and September, both of which coincided with high-heat events. Heat related declines in DO are expected as water's ability to hold oxygen diminishes with increasing temperature. Another large decline in DO was measured in late-August, which did not coincide with a high-heat event, suggesting a period of greater biological consumption during this timeframe. Peak chlorophyll concentrations were measured at most stations approximately 1-2 weeks prior to the August decline in DO, a result of increased phytoplankton growth. A subsequent die-back and decay of phytoplankton following this period of growth may have fueled greater oxygen consumption by bacteria at bottom depth, contributing to the overall decline in DO concentration.

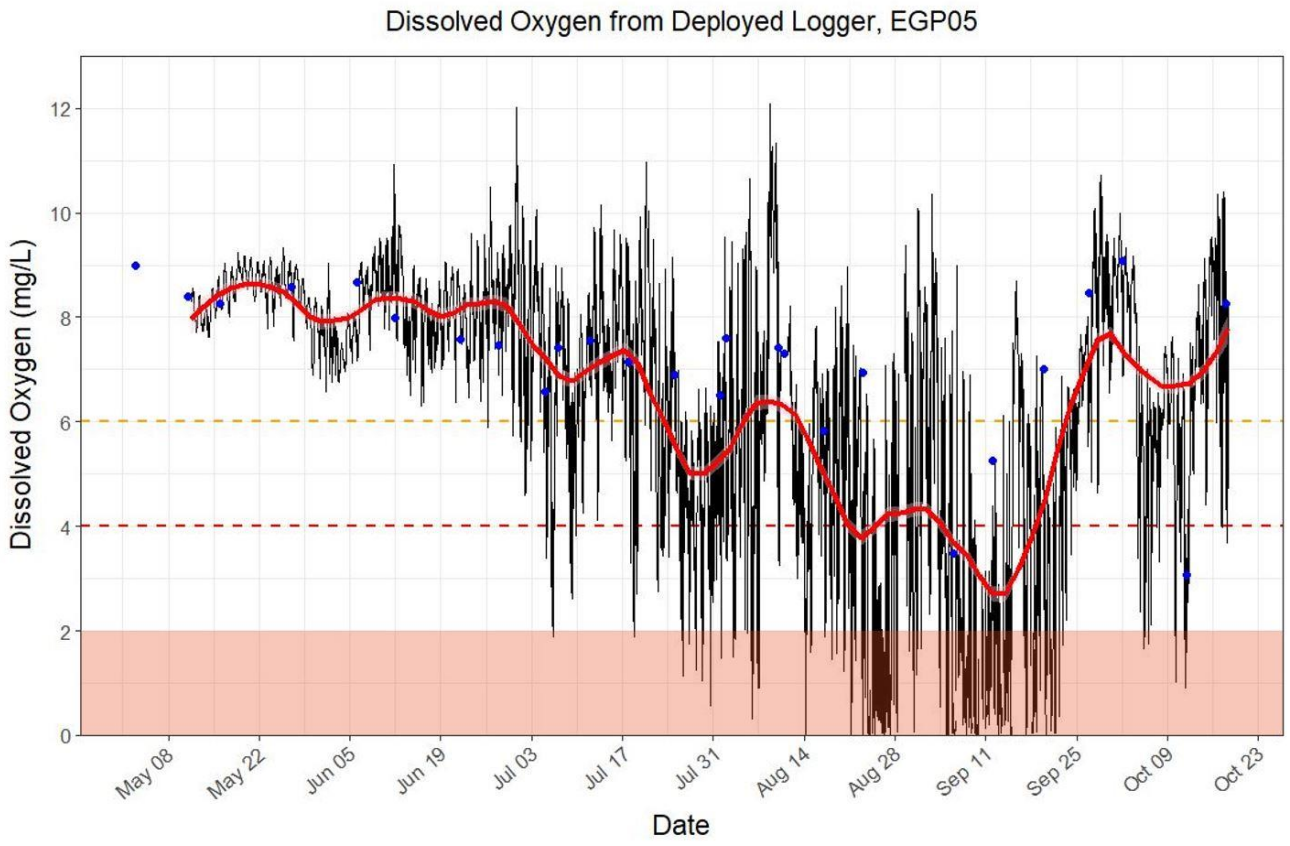


Figure 12. *Dissolved oxygen (DO) in milligrams per liter (mg/L) over the course of the 2023 field season. Data was obtained from a DO data logger deployed ~6 inches above the pond bottom at station EGP05. The black line represents the deployed logger's DO readings taken every 30 minutes, while the overlying 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 occurred (<2 mg/L). In a healthy ecosystem, daily fluctuations of DO should remain above the 6 mg/L threshold.*

The bottom-depth DO trends observed in 2023 resemble those of both 2021 and 2022 (**Figure 13)**. All 3 years saw DO concentrations drop over the course of the summer before rising back up in the fall as temperatures cooled. Bottom-depth DO concentrations measured in-situ at all stations periodically fell below the critical threshold (4 mg/L) during the mid-summer months in all 3 years, with drops into the hypoxic range (<2 mg/L) occurring most often in 2023.

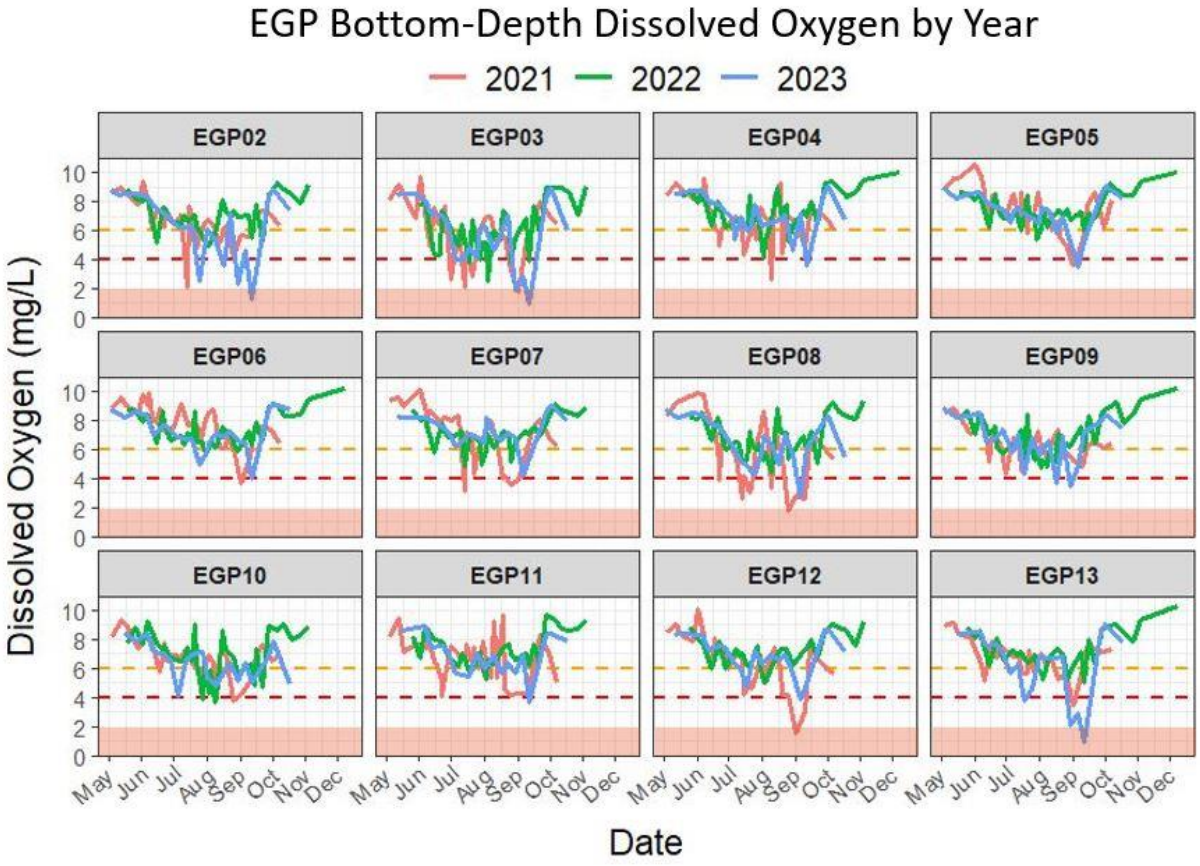


Figure 13. *Bottom-depth dissolved oxygen (DO) levels in milligrams per liter (mg/L) for EGP's 12 monitoring stations during the years 2021, 2022, and 2023. Data was measured using a handheld probe. The dashed yellow line represents the 6 mg/L management threshold, the dashed red line indicates when DO levels dropped critically low (<4 mg/L), and the light red box indicates when hypoxia occurred (<2 mg/L). In a healthy ecosystem, daily fluctuations of DO should remain above the 6 mg/L threshold.*

pH

Summary Points:

- All monitoring stations remained within the target range (6.5-8.5) throughout the field season.
- pH was generally uniform within the upper water column (i.e. surface and middle depths) but often lower and more variable at the bottom.

"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.

In 2023, all monitoring stations experienced relatively consistent pH trends and maintained pH within the target range for the entirety of the field season (**Figure 14**). pH levels were consistent within the upper water column (surface and middle depths) but more variable at the pond bottom where organic matter decay and other sediment interactions can act to alter pH. All monitoring stations experienced a slight rise in pH at the start of July, coinciding with an increase in chlorophyll concentrations throughout the Pond. This rise in pH is likely due to increased rate of photosynthesis, which can raise pH through the removal of carbon dioxide from the water column.

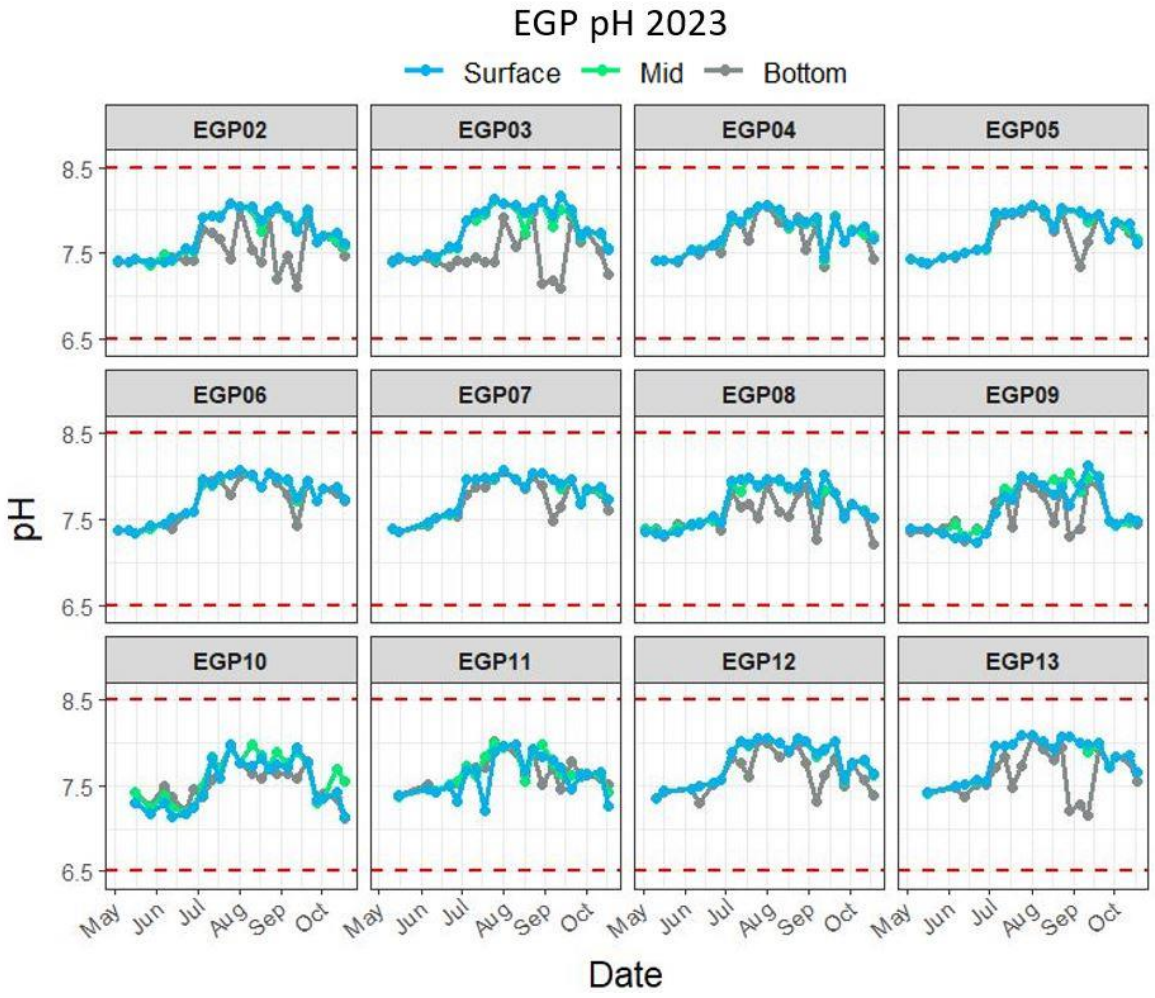


Figure 14. *pH for EGP's 12 monitoring stations during the 2023 season. Data was measured using a handheld probe for 3 depths (surface, mid-depth, and bottom). The dashed red lines indicate the boundaries of the pH management target (6.5-8.5).*

The pH trends observed in 2023 closely resemble those of 2022 (**Figure 15**). Observations from both years show consistent pH levels across stations within the target management range throughout each monitoring period. Comparative pH data from 2021 is not available.

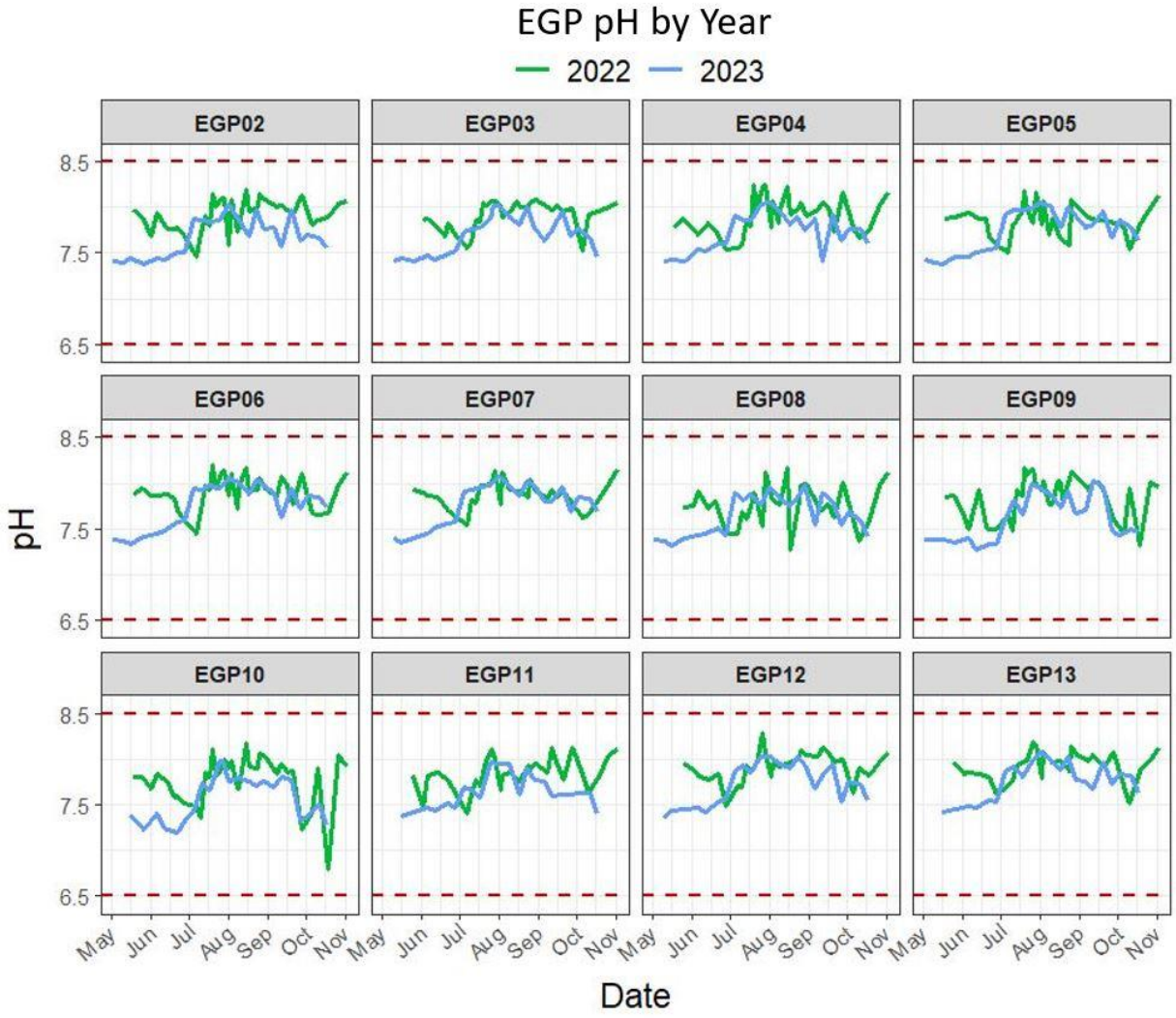


Figure 15. *pH for EGP's 12 monitoring stations for the years 2022 and 2023. The dashed red lines indicate the boundaries of the pH management target (6.5-8.5).*

Water Clarity

Summary Points:

- Visibility ranged from 1.6 to 8 feet below the surface, with an average visibility of 3.4 feet.
- All stations saw their highest water clarity in May and June before experiencing a dramatic drop in water clarity beginning in July.
- Visibility consistently failed to reach the management target throughout the field season.

Turbidity is commonly used to assess water quality due to the ease with which it can be measured and interpreted. When turbidity is high, the water will appear murky and prevent light from fully penetrating through the water column. Several factors can cause turbid water conditions, including sediment suspension, organic matter buildup, and algal growth. GPF measured turbidity within EGP in 2023 using a Secchi Disk, a standardized black and white disk that is lowered through the water column with a measuring tape. The depth at which the disk disappears represents the point at which turbidity restricts light from penetrating any deeper into the water column. EGP's MEP report set a management target for Secchi depth to be either 9.8 feet or to the pond bottom (Howes et al., 2008).

Turbidity in EGP was high in 2023, as evidenced by an average Secchi depth of just 3.4 feet. All stations saw their highest water clarity in May and June (~4-7 feet of visibility) before experiencing a sharp decline beginning in July (~2 feet of visibility for remainder of season) (**Figure 16**). Visibility only reached the bottom on a select number of days at the start of the summer, after which it consistently failed to reach the bottom at all stations. The overall increase in turbidity during July coincides with a rise in chlorophyll concentrations, suggesting the Pond's elevated turbidity in 2023 was largely the result of excessive phytoplankton growth within the water column.

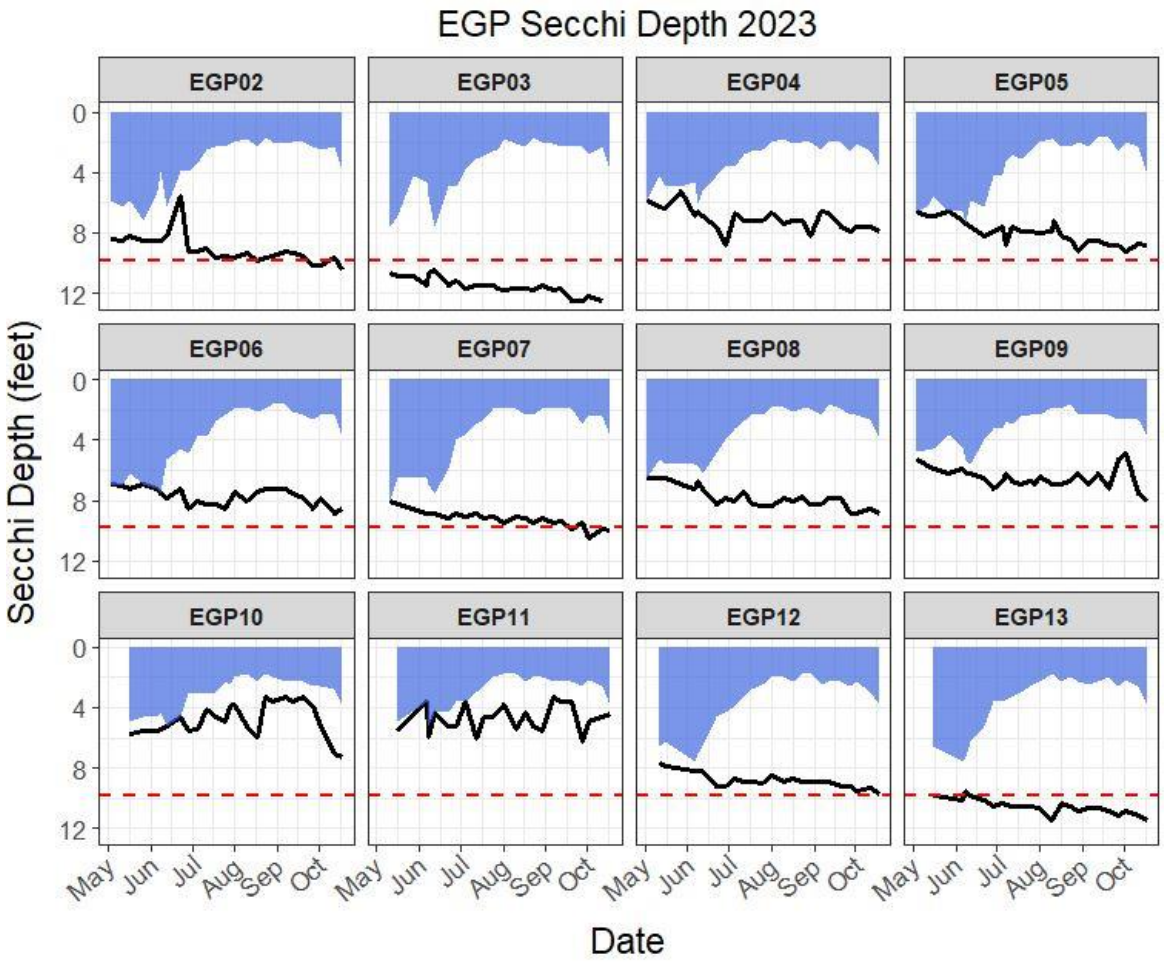


Figure 16. *Secchi depth and total depth in feet for EGP's 12 monitoring stations during the 2023 season. Secchi depth is the depth at which a standardized disk disappears, thereby representing visibility into the water column. Total depth at each station is represented by a black line in these figures, 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).*

Turbidity was also directly measured in 2023 using a YSI multiparameter probe. These measurements were recorded in Formazin Nephelometric Units (FNU), which are based on the degree to which incoming light is scattered by particles present in the water column. The turbidity trends in FNUs observed in 2023 closely resemble those of 2022; however, both years displayed elevated turbidity levels relative to 2021 (**Figure 17**). The higher turbidity observed in the Pond over the last 2 years was likely brought on by an increase in algal and phytoplankton growth, as supported by higher average chlorophyll concentrations being present in the Pond in 2022 (90.9 ug/L) and 2023 (30.54 ug/L) compared to 2021 (8.0 ug/L).

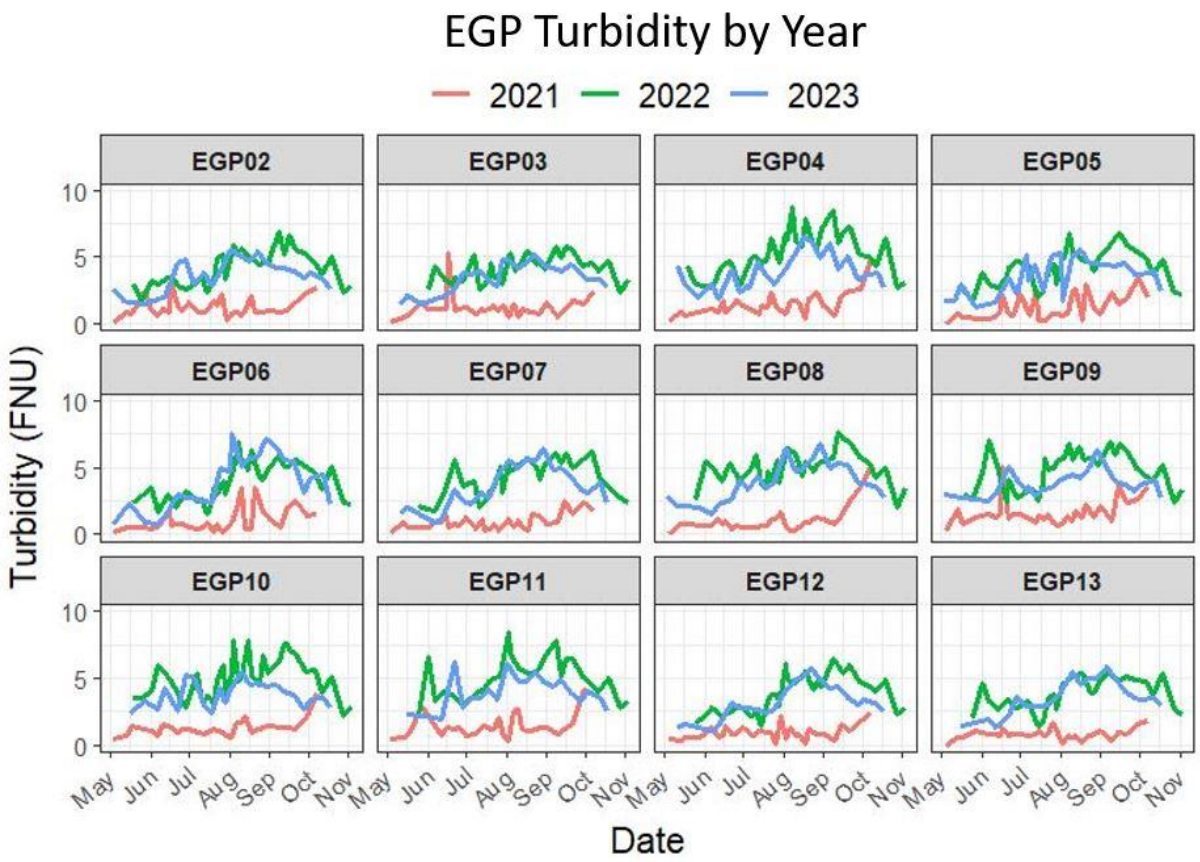


Figure 17. *Average turbidity throughout the entire water column in FNU (Formazin Nephelometric Units) is shown for EGP's 12 monitoring stations for the years 2021, 2022, and 2023.*

Nutrients

Summary Points:

- Measured total nitrogen (TN) and phosphate concentrations were relatively consistent across monitoring stations in 2023.
- Most stations exhibited their highest TN concentration of the year on 8/23/23, and their highest phosphate concentration on 8/23/23 and/or 10/18/23.
- The sentinel station exceeded the 0.5 mg/L management threshold for TN on 4 of the year's 5 nutrient sampling days.

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 act to deplete oxygen reserves and reduce overall ecosystem health. In coastal and brackish water bodies like EGP, nitrogen is most often the primary driver of eutrophication. During the 2023 field season, GPF collected monthly nutrient samples at 8 of its 12 monitoring stations (EGP02-EGP06, EGP08-EGP10). The Massachusetts Estuaries Project's (MEP) report on EGP has established a total nitrogen (TN) threshold of 0.5 mg/L for the "sentinel station," which encompasses the average TN concentration of stations EGP02, EGP03, EGP05, EGP06, and EGP09 (Howes et al., 2008).

TN concentrations were relatively consistent across the Pond in 2023, with all monitoring stations (including the combined sentinel station) exceeding the 0.5 mg/L threshold from July through October (**Figure 18**). Most stations experienced their lowest TN concentration of the year in June and their highest in August. TN concentrations measured across EGP in 2023 were lower than those of 2022, but still higher than those of 2021 (**Figure 18**). Likewise, the representative sentinel station did not exceed the 0.5 mg/L management threshold in 2021 but did on 4 separate nutrient sampling days in both 2022 and 2023.

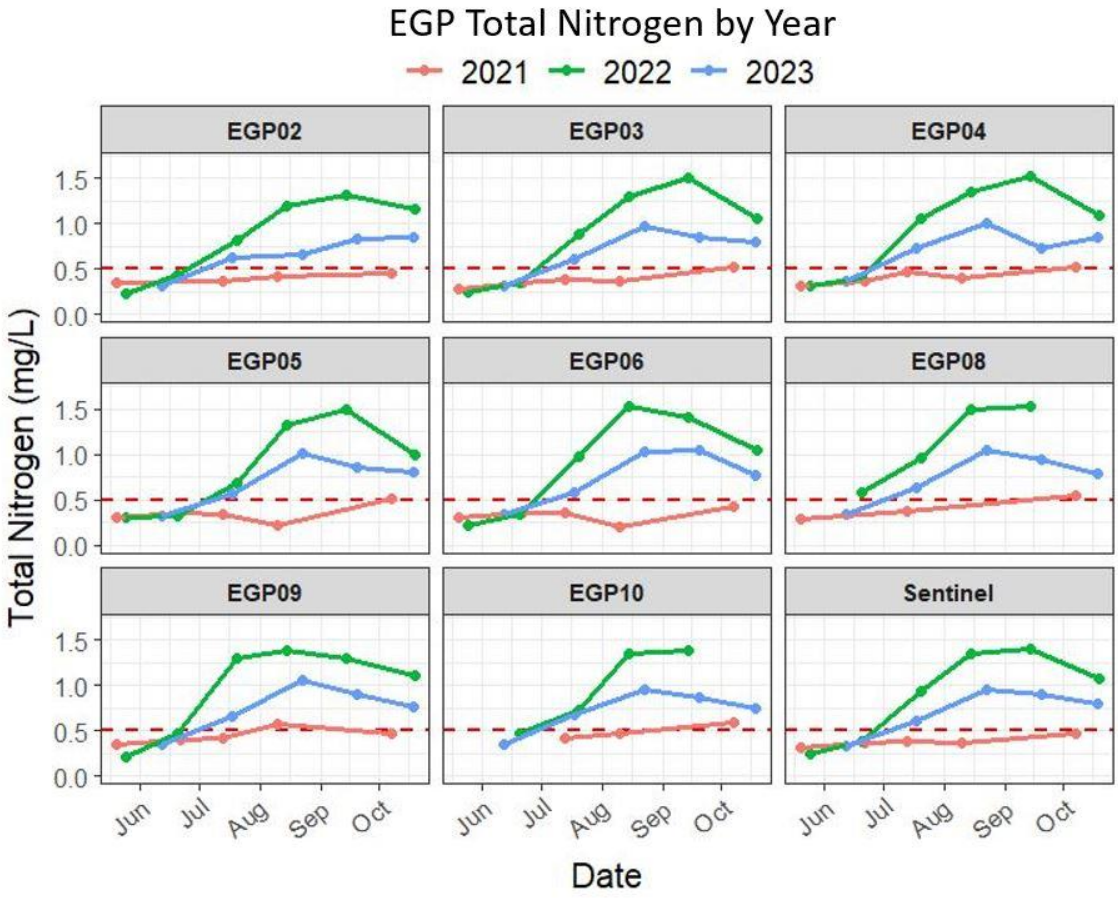


Figure 18. *Total nitrogen in milligrams per liter (mg/L) is shown for EGP's 8 nutrient stations and the sentinel station (average of EGP02, EGP03, EGP05, EGP06, & EGP09) for the years 2021, 2022, and 2023. The dashed red line represents the MEP management threshold (0.5 mg/L).*

Historical TN data for the EGP sentinel station was provided to GPF by the Martha's Vineyard Commission (MVC). Nutrient samples were collected by the MVC and processed by their partner lab at the University of Massachusetts Dartmouth, School for Marine Science and Technology, for the years of 1995, 1997, 1999, 2000, 2002, 2003, 2004, 2006, 2014, 2015, 2016, 2017, and 2018. This data is plotted alongside GPF's TN data from 2021-2023, from which samples were collected by GPF and analyzed by their partners at the Marine Biological Laboratory, in **Figure 19**. Between 1995 and 2014, TN concentrations for the EGP sentinel station were elevated above the MEP management threshold during 8 of the 9 years for which data was collected. Following the implementation of local conservation efforts aimed at improving pond health from 2010 and onwards, TN concentrations in EGP noticeably declined,

as evidenced by TN values for the sentinel station falling below the management threshold during 4 of the 5 years for which data is available between 2015 and 2021. The elevated TN levels measured in 2022 and 2023 therefore represent a reversal of the downward TN trends that had been measured across the preceding decade.

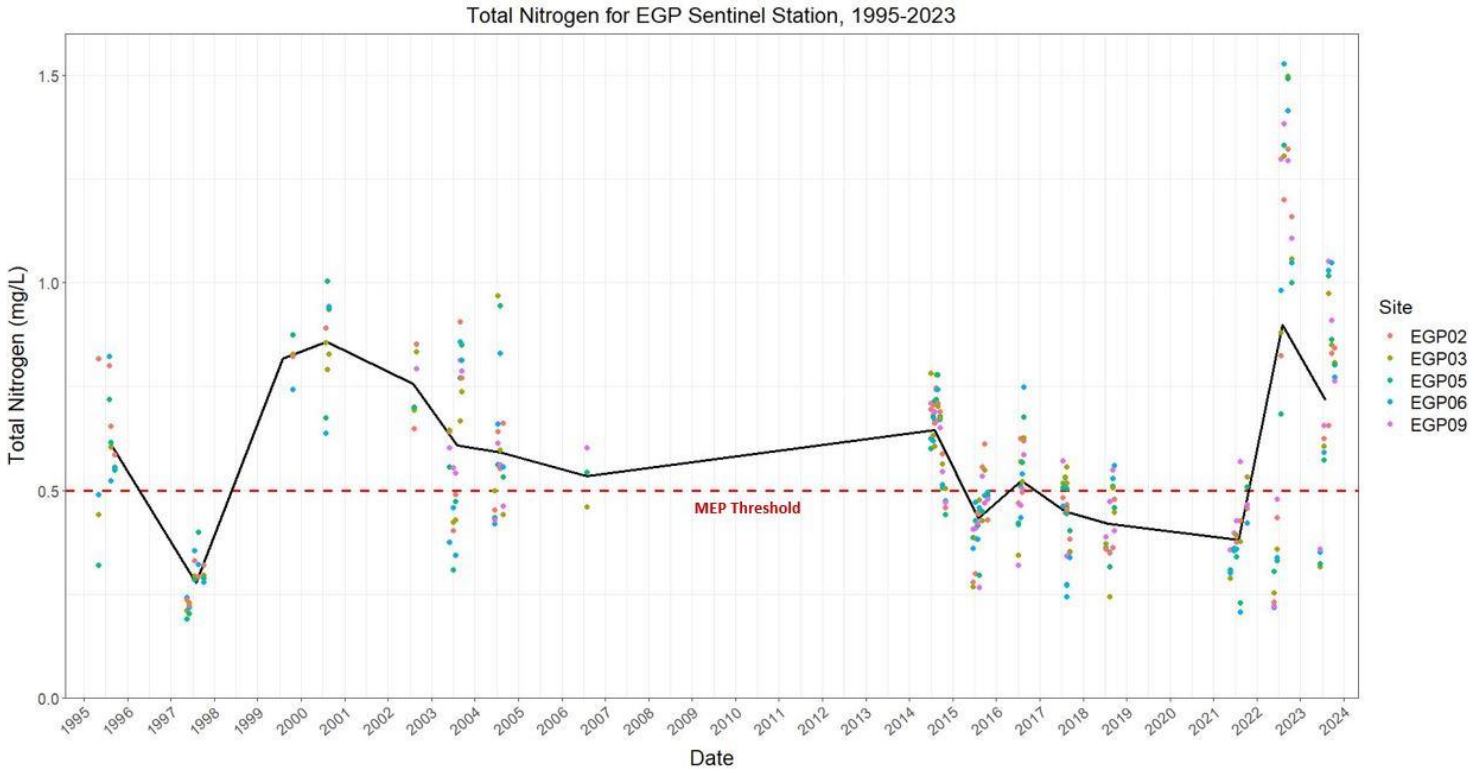


Figure 19. *Total nitrogen in milligrams per liter (mg/L) for the EGP sentinel station (average of stations EGP02, EGP03, EGP05, EGP06, & EGP09, represented by black line) for years ranging from 1995 to 2023. Data between 1995 and 2020 was collected by the Martha's Vineyard Commission and processed by their partner lab at UMass Dartmouth. Data from 2021 to 2023 was collected by GPF and processed by their partner lab at Marine Biological Laboratory. The dashed red line represents the MEP management threshold (0.5 mg/L).*

Phosphate concentrations were also consistent across monitoring stations in 2023 (**Figure 20**). Measured concentrations remained at 0.01 mg/L (at or below the detection limit) across all stations through July before rising to 0.03 mg/L on 8/23/23. Most stations exhibited their highest phosphate concentrations of the year on 8/23/23 or 10/18/23. Measured phosphate concentrations in 2021 and 2023 resembled one another, with 2023 exhibiting higher overall concentrations in August. Alternatively, phosphate concentrations during the late summer and early fall were much higher in 2022 relative to both 2021 and 2023.

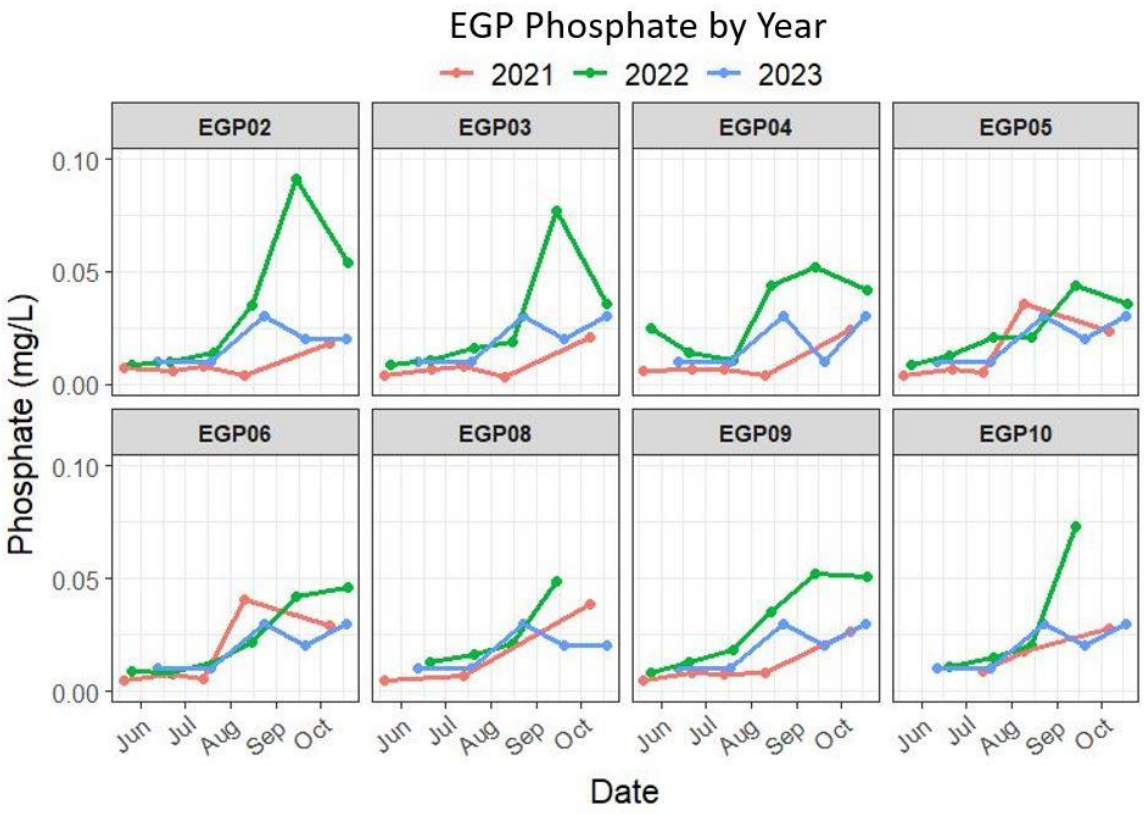


Figure 20. *Phosphate in milligrams per liter (mg/L) for EGP's 8 nutrient stations for the years 2021, 2022, and 2023.*

Chlorophyll

Summary Points:

- Total chlorophyll concentrations exceeded the 10 ug/L management threshold from early July through mid-October across all monitoring stations.
- Chlorophyll concentrations were consistently highest in August and September.
- Chlorophyll concentrations in 2023 were down relative to 2022, but still higher than concentrations measured in 2021.

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 photosynthetic organisms (primary producers), respond rapidly to changes in light, temperature, and nutrient availability in the water column. As any 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 EGP on a weekly basis as part of the MV CYANO$_{TM}$ program. 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 on EGP has established a chlorophyll management target of <10 micrograms per liter (ug/L) for the Pond (Howes et al., 2008).

Total chlorophyll concentrations were relatively consistent across EGP in 2023, with all monitoring stations exceeding the 10 ug/L management threshold from early July through mid-October (**Figure 21**). Chlorophyll rose throughout June and July and peaked during August and September. This period of elevated chlorophyll coincided with peak concentrations of measured total nitrogen in the Pond, as well as high summer temperatures - 2 primary drivers of phytoplanktonic growth.

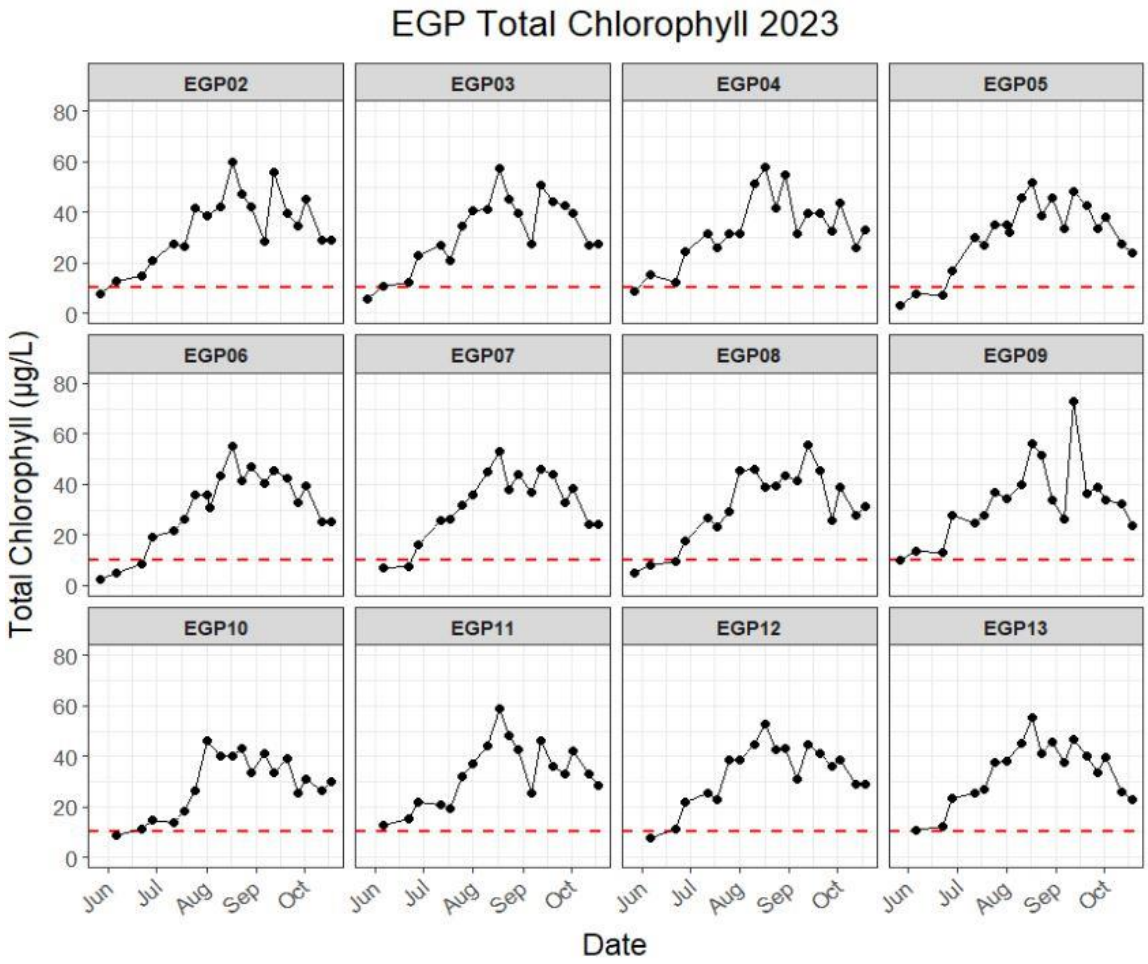


Figure 21. *Total chlorophyll in micrograms per liter (µg/L) at EGP's 12 monitoring stations during the 2023 field season. Samples were taken at the surface and measurements were obtained via a fluorometer. The dashed red line represents the MEP management threshold (10 ug/L).*

Measured total chlorophyll concentrations in 2023 were elevated relative to 2021, but still lower than those measured in 2022 (**Figure 22**). While chlorophyll concentrations only periodically rose above the 10 ug/L management threshold in 2021, both 2022 and 2023 saw concentrations remain above this threshold for the majority of the summer. Chlorophyll levels were particularly high in 2022, consistently exceeding 100 ug/L across all monitoring stations during the month of August. The chlorophyll trends observed over this 3-year period mimic the total nitrogen (TN) trends from the same years, with both TN

and chlorophyll being lowest in 2021 and highest in 2022. This provides further evidence that chlorophyll concentrations in EGP are influenced by nutrient availability on a year-to-year basis.

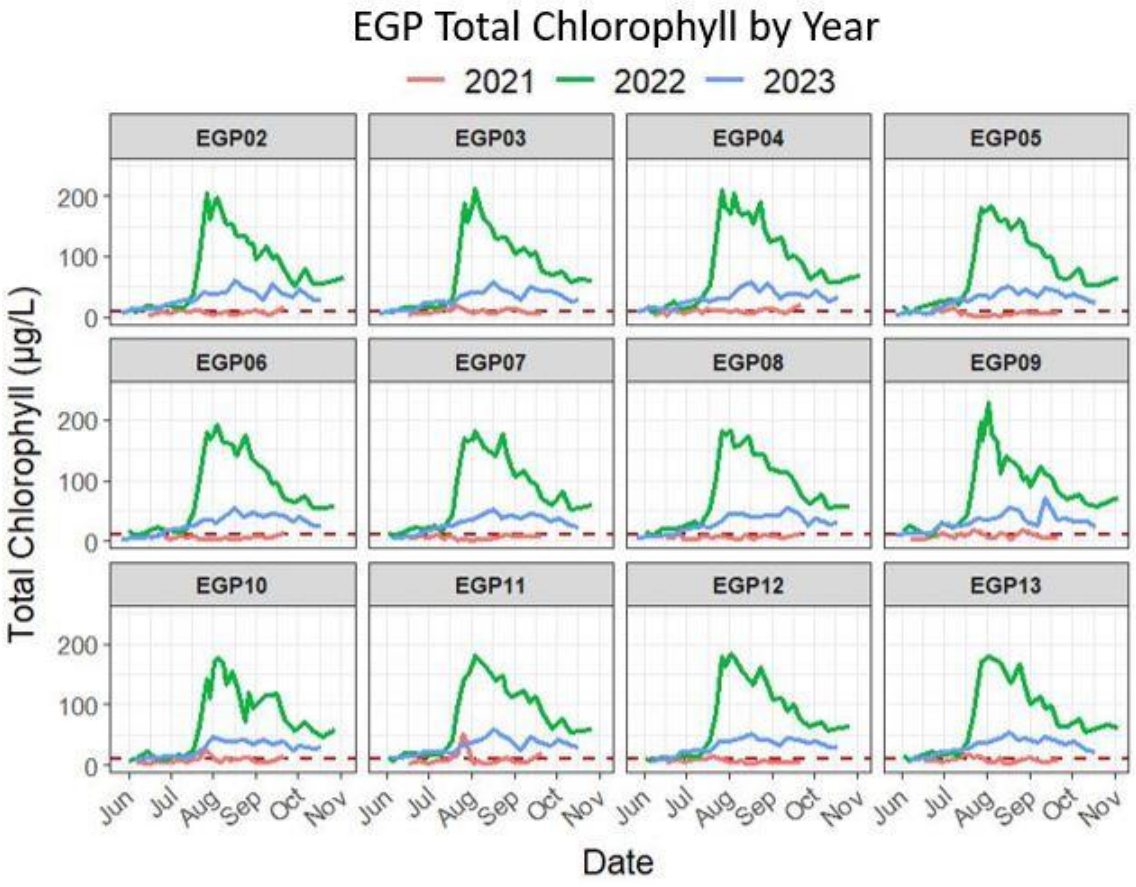


Figure 22. *Total chlorophyll concentrations in micrograms per liter (ug/L) at EGP's 12 monitoring stations for the years 2021, 2022, and 2023. Samples were taken at the surface and measurements were obtained via a fluorometer. The dashed red line represents the MEP management threshold (10 ug/L). (Note scale on y-axis, differs between 2023 and multi-year comparisons).*

Phytoplankton and Cyanobacteria

Summary Points:

- Cyanobacteria concentrations remained in the MV CYANO$_{TM}$ program's "cyanobacteria alert" category during the early summer before rising into the "bloom watch" category in August.
- Cyanobacteria concentrations in EGP have steadily increased since 2021.

In addition to estimating total chlorophyll concentrations, GPF's fluorometry analysis of water samples collected in EGP also provides estimated concentrations of several different phytoplankton classes present within the water column. The following 4 phytoplankton classes were routinely monitored on EGP in 2023 as part of the MY CYANO$_{TM}$ program: cyanobacteria, green algae, cryptophyta, and diatoms. Green algae was the dominant form of phytoplankton present in EGP during the early summer;

however, by mid-August cyanobacteria had become equally abundant across most of the Pond (**Figure 23**). Elevated diatom concentrations were also observed across most monitoring stations during the late summer.

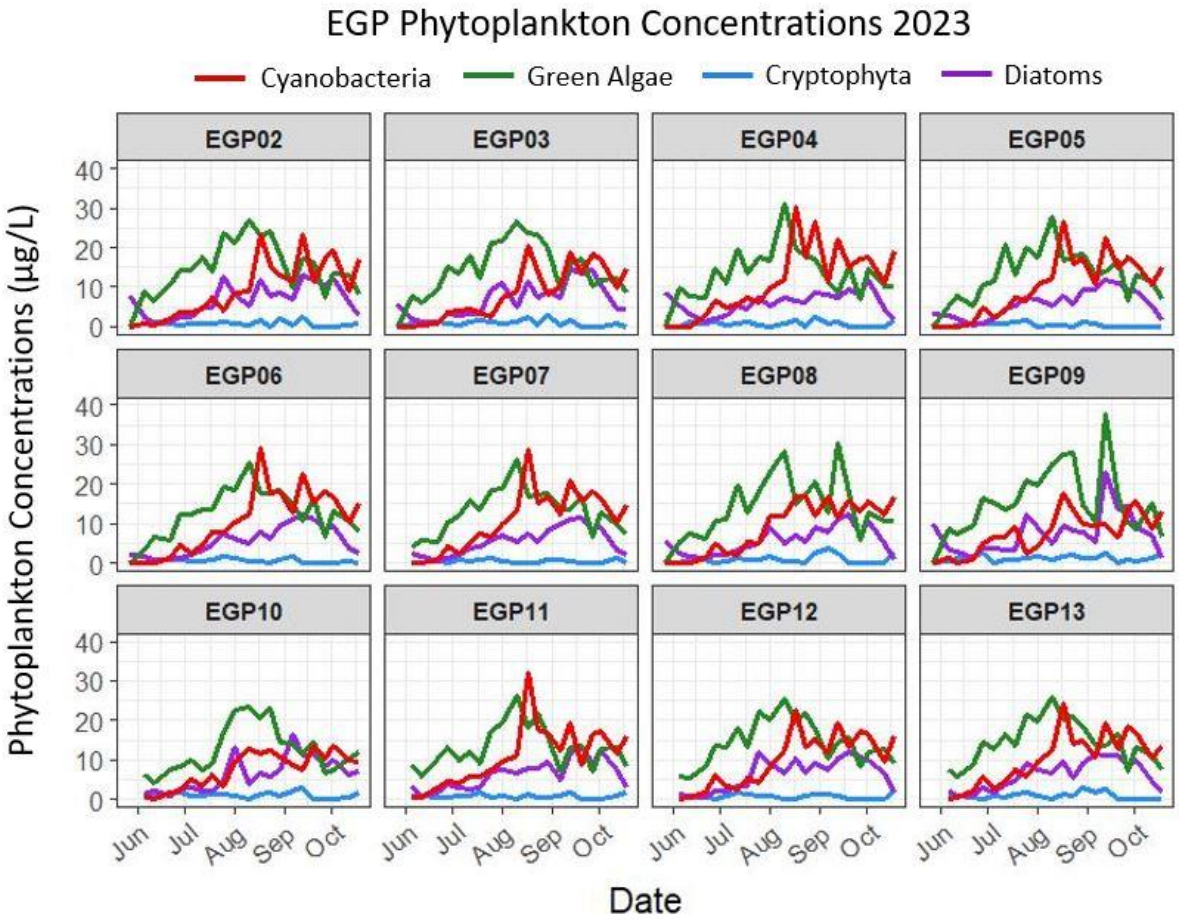


Figure 23. *Phytoplankton concentrations in micrograms per liter (ug/L) at EGP's 12 monitoring stations during the 2023 field season. Samples were taken at the surface and measurements were obtained via a fluorometer.*

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 harmful to humans and animals. Cyanobacteria concentrations across EGP remained within the MV CYANO$_{TM}$ program's "cyanobacteria alert" category from June through July before rising into the program's "bloom watch" category at the start of August, where they remained until the conclusion of the regular monitoring season (**Figure 24**, refer to **Figure 26** for the MV CYANO$_{TM}$ key). Trends in cyanobacteria growth were relatively consistent between all stations in the Pond throughout the 2023 season.

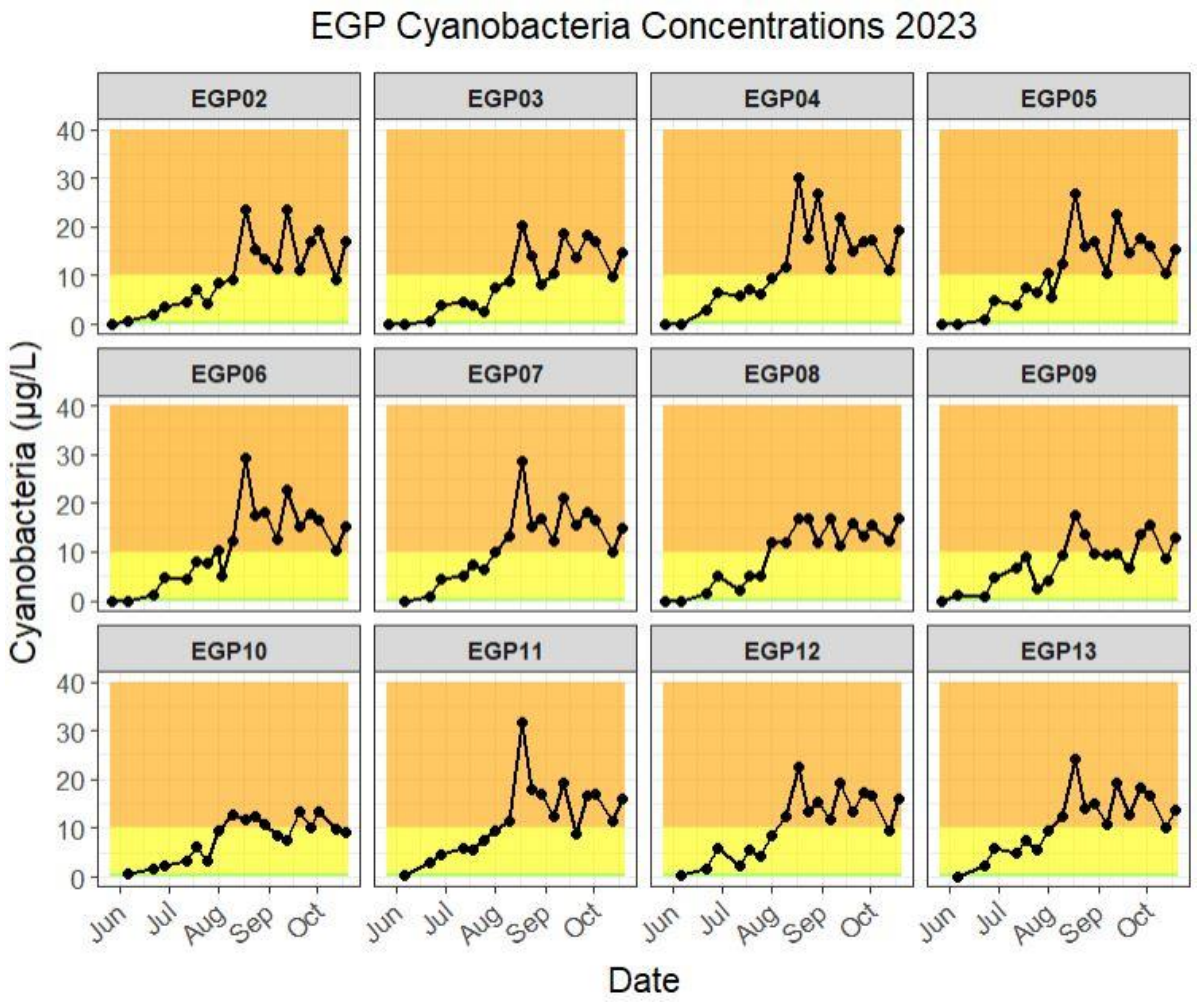


Figure 24. *Cyanobacteria concentrations in micrograms per liter (µg/L) at EGP's 12 monitoring stations during the 2023 season. Samples were taken at the surface and measurements were obtained via a fluorometer. Background colors pertain to the color-coded risk matrix used by the MV CYANO$_{TM}$ monitoring program (see* ***Figure 26****).*

Cyanobacteria bloom conditions were not observed in EGP during 2023; however, overall cyanobacteria growth and activity in the Pond has risen since 2021 (**Figure 25**). While concentrations in 2021 only periodically rose into the low end of the MV CYANO$_{TM}$ program's "cyanobacteria alert" category, both 2022 and 2023 saw concentrations reach "bloom watch" status during the late summer. At the same time, concentrations in 2023 reached bloom watch status roughly an entire month earlier than was the case in 2022, while 8 of EGP's 12 monitoring stations experienced record-high cyanobacteria concentrations in 2023 relative to the preceding 2 years. Elevated nutrient inventories in 2022 and 2023 likely explain the latter 2 years' increased cyanobacteria growth relative to 2021; however, why concentrations were higher in 2023 compared to 2022 remains unclear.

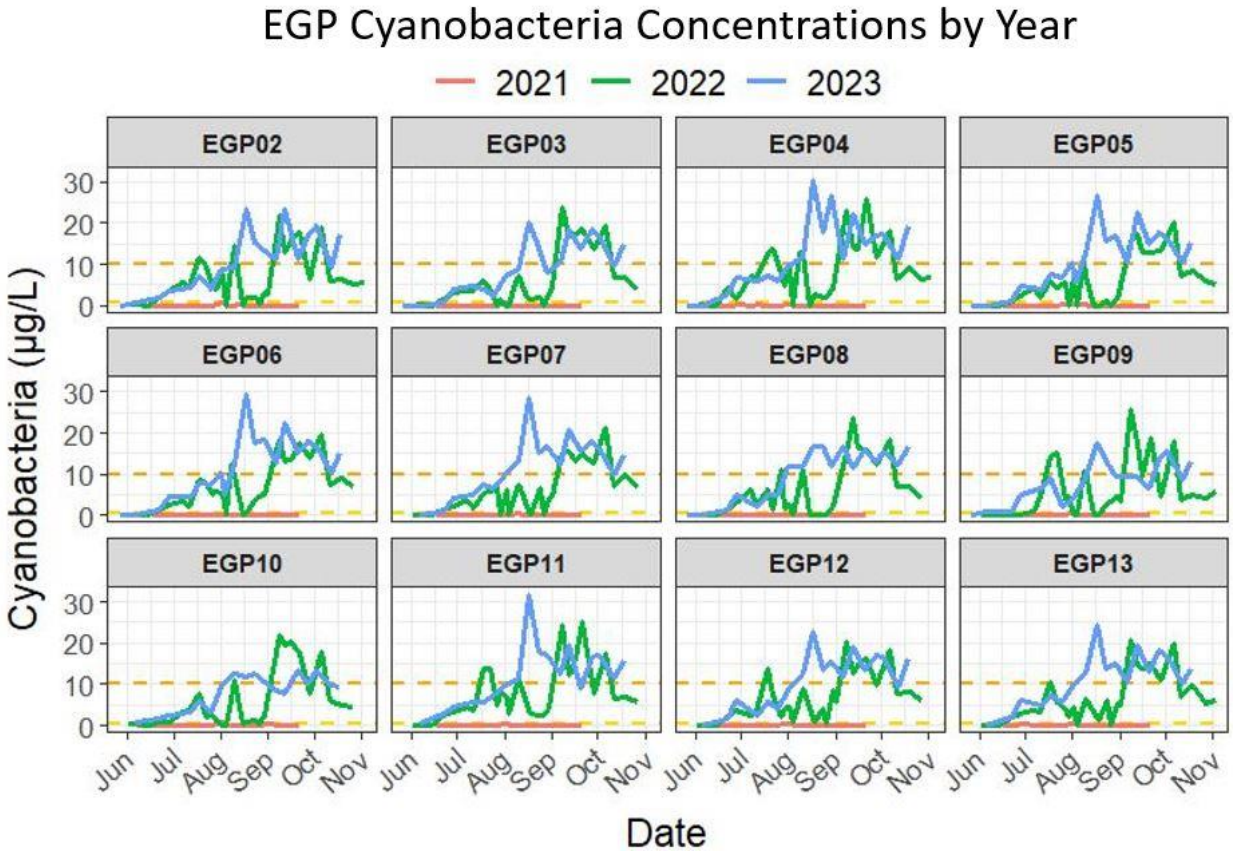


Figure 25. *Cyanobacteria concentrations in micrograms per liter (µg/L) at Edgartown Great Pond's 12 monitoring stations for the years 2021, 2022, and 2023. Samples were taken at the surface and measurements were obtained via a fluorometer. Dashed lines pertain to the color-coded risk matrix used by the MV CYANO$_{TM}$ monitoring program (see* ***Figure 26****). (Note scale on y-axis, differs between 2023 and multi-year comparisons).*

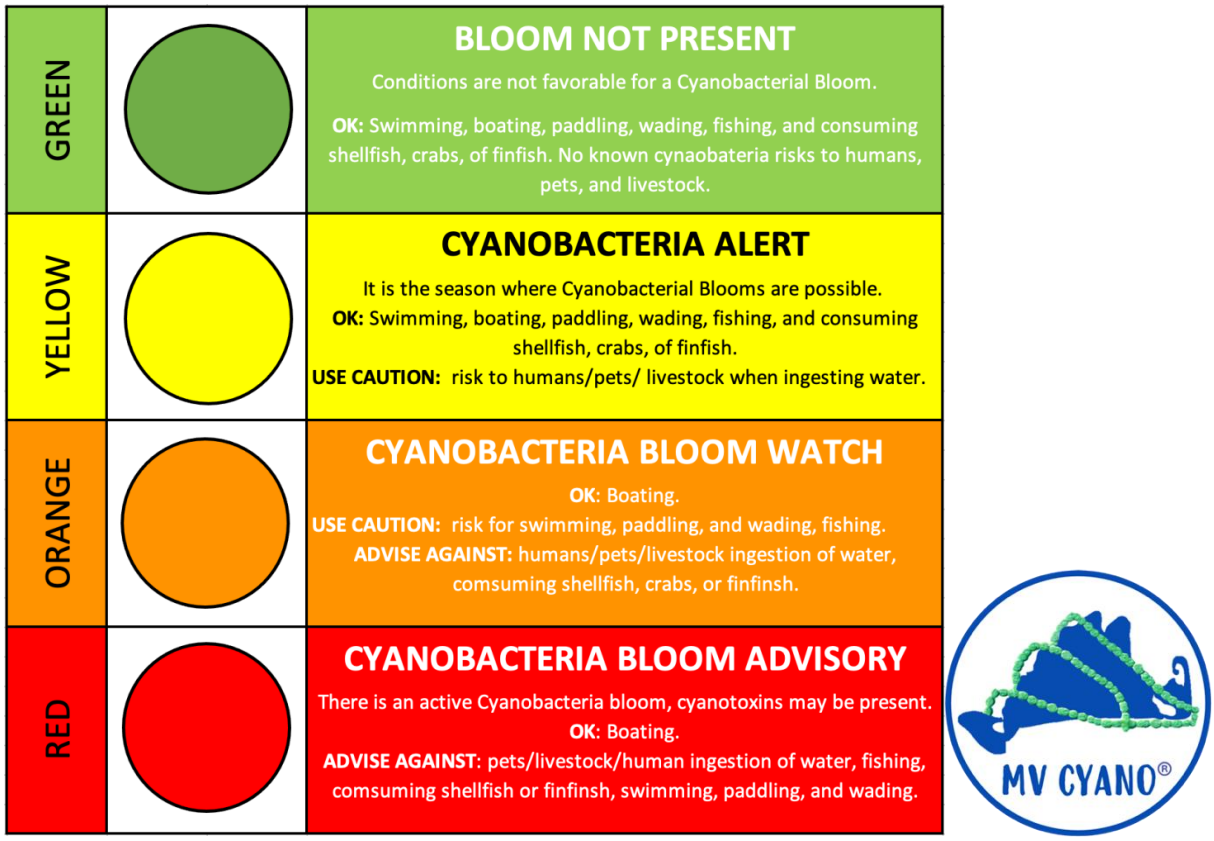


Figure 26. *The color-coded messaging & logo used by the MV CYANO™ monitoring program.*

Discussion

Overall water quality in EGP during the 2023 monitoring season can be described as intermediate to impaired (see Executive Summary, "Summary of Metrics"). This is a continuation of conditions that were observed in 2022. The 2022 and 2023 monitoring seasons represent an inflection point in overall ecosystem health. Monitoring data collected during the 2021 season and years prior suggested improving trends in water quality metrics, with lower concentrations of total nitrogen (TN), lower chlorophyll, high water clarity, and abundant eelgrass (*Zostera marina*) growth. These conditions were essentially reversed at the outset of the 2022 season and perpetuated into 2023. Elevated nitrogen availability in 2023 likely contributed to abundant phytoplankton growth across EGP for the second consecutive year. This enhanced growth resulted in a decrease in water clarity, reducing light availability at the bottom depths. A decreased abundance of oxygen-producing eelgrass coupled with a decomposition of abundant phytoplankton and organic matter resulted in regular declines in dissolved oxygen (DO) to hypoxic levels (<2 mg/L) at bottom depths.

Eelgrass

Overall eelgrass bed area and density was limited in 2023, a continuation of 2022 trends. Some of the primary environmental factors contributing to eelgrass success include light availability, temperature, and salinity. Abundant phytoplankton growth at the surface and mid-depths significantly reduced the Pond's water clarity. This restricted light availability at bottom depths, effectively out-competing benthic vegetation. Water temperatures exceeded eelgrass thermal limits during the hottest periods of the summer, likely causing periodic episodes of heat stress on existing growth. Salinity remained within a healthy range for eelgrass beds (greater than 15 ppt) throughout most of the field season, only falling below this benchmark in late September. The Pond's higher salinity during 2023 growing season is a result of the 20-day opening in April, and an indication of strong tidal exchange during that event. This represents one improvement in conditions for eelgrass in 2023 compared to 2022.

Pond Openings and Total Nitrogen (TN)

Similar to the 2022 season, 2023 saw TN concentrations elevated above the MEP management threshold for most of the monitoring period. A pattern of reduced cut longevity during 2022 and 2023 may be a contributing factor to the observed increases in TN. Analysis of TN data measured during the June-October regular monitoring season for the 2021-2023 sampling years combined with opening records from the same periods help to illustrate this dynamic (**Figure 27**). In 2021, TN levels in EGP remained below the MEP management threshold throughout the summer season, following an 18-day opening in early March and a 22-day opening in August. Conversely in 2022, TN exceeded the MEP threshold from late June onwards, following a 4-day opening in early April and a 6-day opening in early June. TN concentration patterns in 2023 closely matched those in 2022, exceeding the management threshold for a majority of the season. However, overall concentrations were reduced in 2023 compared to 2022. These lower concentrations might represent the short-term impact of the 20-day cut in early April of that year, which likely helped to curb nitrogen loading.

However, these interactions are not consistent in every case. When comparing 2023 and 2021, we see that both years had similar duration openings in early spring but exhibited differing nutrient patterns in the months following. TN concentrations in 2021 remained low throughout the first half of the summer following its 18-day spring opening and these levels persisted through the next cut in August. In 2023,

TN increased above the MEP threshold by early July following a 20-day spring opening and TN concentrations that were comparative to 2021. This may indicate that the nutrient reduction benefits gained from a singular, longer-duration cut (greater than 9 days of tidal exchange) may not extend beyond the short-term in every case. There are also likely unaccounted factors, such as variations in TN loading from year to year, which might be modifying these relationships.

This data helps to illustrate how the frequency, timing, and longevity of openings might influence TN concentrations in EGP. Continued data collection and analysis centered on these variables in future seasons will provide a more nuanced representation of this relationship, including other factors at play. Additionally, a better understanding of the connection between nutrient concentrations and Pond openings has implications for the development of nutrient mitigation strategies. At the very least, it may serve to describe how differences in cut dynamics such as opening duration or volume of tidal exchange can impact TN in EGP.

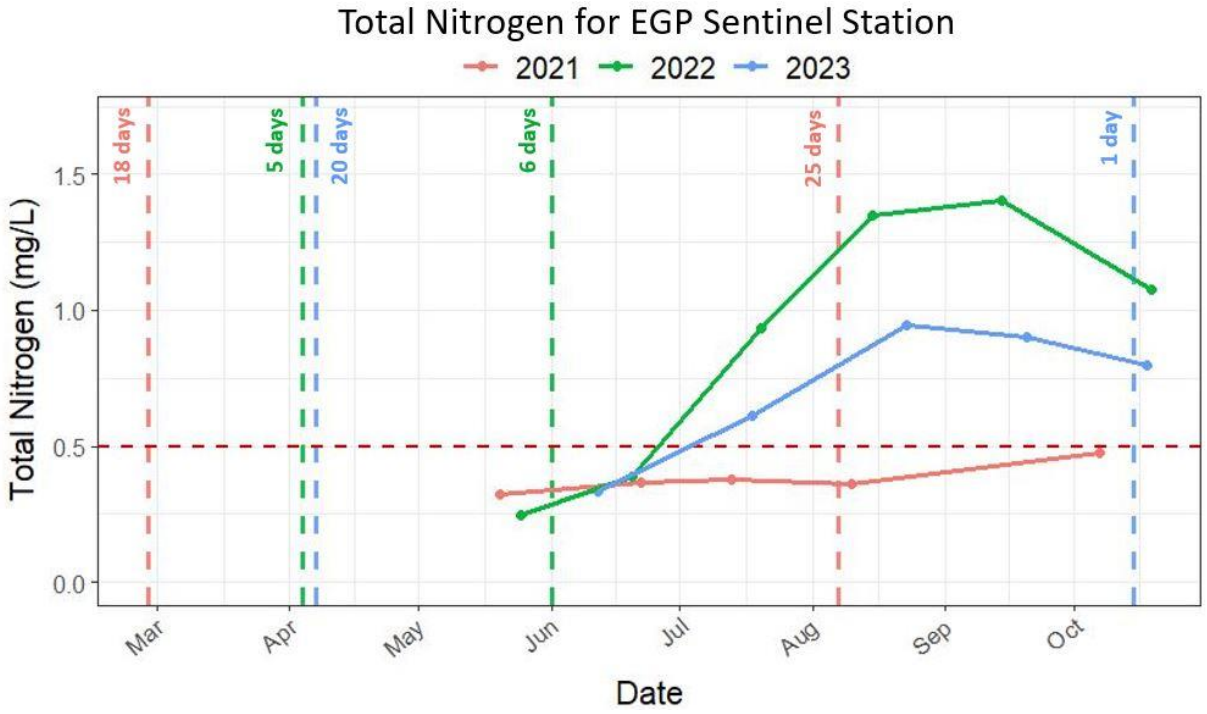


Figure 27. *Total nitrogen in milligrams per liter (mg/L) for the EGP "sentinel station" (average of stations EGP02, EGP03, EGP05, EGP06, and EGP09) for the years 2021, 2022, and 2023. Dashed vertical lines indicate when EGP was opened to the ocean within the period of data collection (color corresponds to a specific year).*

Works Cited

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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	≥ 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.

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 Edgartown Great Pond during the 2023 summer season is shown below in **Figure A1** as an example.

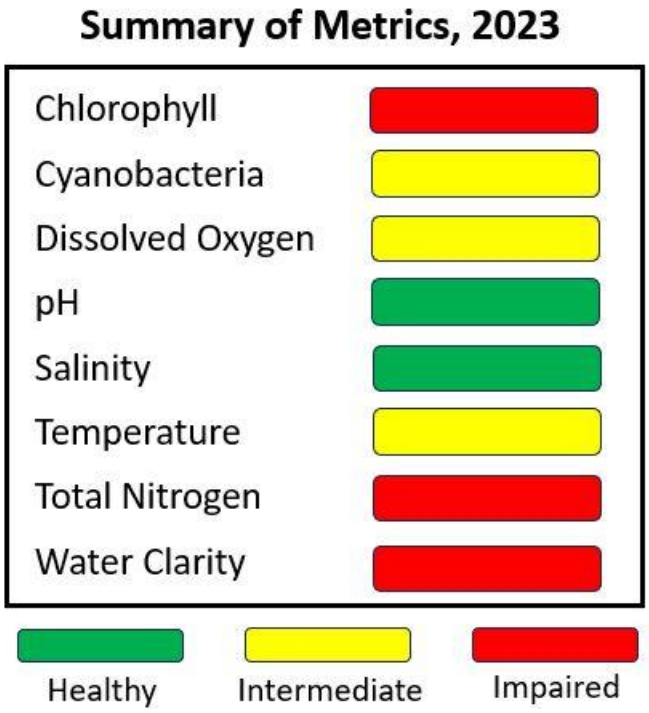

Figure A1. *Edgartown Great Pond's Summary of Metrics figure for the 2023 summer season.*

Data Used in Index

GPF opted to use continuous readings obtained from its stationary loggers at stations EGP05 and EGP09 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 once a week. All pH and water clarity analyses were done using data collected on a weekly basis using a YSI multiparameter probe and Secchi disk, respectively. All chlorophyll and cyanobacteria analyses were performed using data obtained on a weekly 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.

Edgartown Great Pond Site Visits, 2023

Table A3.

Dates of Edgartown Great Pond Site Visits: 2023					
May	**June**	**July**	**August**	**September**	**October**
5/3	6/6	7/5	8/1	9/6	10/2
5/11	6/12*	7/12	8/10	9/12	10/12
5/16	6/22	7/18*	8/17	9/20*	10/18*
5/27	6/28	7/25	8/23*	9/27	
			8/29		

*Nutrient samples collected