2021

ECOSYSTEM MONITORING REPORT

EDGARTOWN GREAT POND

GREAT POND FOUNDATION
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GREAT POND foundation

Ecosystem Monitoring Report – Edgartown Great Pond

Executive Summary

Great Pond Foundation (GPF) began monitoring the water quality and ecosystem health of Edgartown Great Pond in 2016, when the Ecosystem Monitoring Program was formed. The 2021 field season began on May 4 and ended on October 7, with data collected weekly throughout the summer and fall seasons. The sampling methodology consisted of regular monitoring during the spring, summer and fall seasons at 12 sampling stations across the Pond. At each station parameters such as temperature, salinity, dissolved oxygen, pH, water clarity and turbidity were measured throughout the water column. Additionally, concentrations of nutrients such as nitrate, phosphate, and ammonium were analyzed at a subset of these stations on select sampling days. These parameters are commonly used indicators for impairment and ecosystem health.

Monitoring data indicate that EGP is a healthy ecosystem which met multiple management thresholds in 2021. Salinity was mostly consistent across the 12 EGP sampling stations. Stations within Jane's Cove and Wintucket Cove exhibited the greatest vertical variations in salinity within the water column. Water temperature at all 12 sampling stations remained below the 85°F management target throughout the summer season, as measured during site visits. Maximum water temperature measured via a handheld water quality meter was 83.7°F on 8/18/21 and was 87.7°F as measured by a deployed temperature sensor at EGP5. Visibility into the water column was typically at least 6 feet and extended to the bottom at most sampling stations. Stations EGP2, EGP3 and EGP13 frequently experienced elevated turbidity and reduced water clarity. High turbidity is generally indicative of impaired water quality. Chlorophyll-a was below the 10 µg/L management threshold at most EGP sampling stations. Chlorophyll-a concentrations peaked throughout the Pond during the summer months, indicating increased phytoplankton growth, which is commonly associated with reduced water clarity.

Sufficient dissolved oxygen (DO) concentrations were observed throughout the upper portions of the water column in EGP. This is in contrast to the bottom depths, where lower DO concentrations were occasionally observed. Measurements recorded from a continuous DO logger deployed at station EGP5 in the main basin of the Pond detected periods of hypoxia (DO < 2 mg/L), most often during nighttime hours. Large fluctuations in DO were observed, which can be an indicator of impairment and decreased habitat quality. Total nitrogen (TN) values in EGP were below management targets for the majority of the monitoring period, peaking in July and August at most stations. Average TN values were below the recommended limits established by the Massachusetts Estuaries Project (MEP) report. TN measurements at stations with Jane's and Wintucket Coves were comparably higher than at other stations. This is likely a factor of the location within the tributary coves of the Pond, which receive groundwater influx and have reduced circulation and flushing.

Overall, Edgartown Great Pond exhibited good water quality in 2021. While data indicate that there was occasional low dissolved oxygen, the majority of water quality metrics met or exceeded management goals. Most notably, measurements of total nitrogen were below the target value established by the 2007 MEP report. This indicates that habitat quality and ecosystem health in EGP has improved since this report was published. EGP benefited from increased circulation as a result of pond cuts and dredging near the barrier beach. EGP was opened to the ocean 3 times in 2021, for a total of 54 days in 2021. Opening length varied from 14-22 days, with an average opening duration of 18 days.

The GPF Ecosystem Monitoring Program will continue to monitor EGP in 2022. Assessment of nutrient concentrations within the groundwater north of the pond, in partnership with MBL, will help to identify nitrogen hotspots within the watershed and help to inform future management plans and elucidate potential locations for nutrient mitigation efforts.

2021 Ecosystem Monitoring Data

Overview of Ecosystem Monitoring Program

Edgartown Great Pond (EGP) is a coastal estuary approximately 890 acres in size. EGP consists of a main basin and several tributary coves (Job's Neck Cove, Jane's Cove, Wintucket Cove, Mashacket Cove, Turkeyland Cove and Slough Cove). EGP and its watershed are located within the Town of Edgartown, Massachusetts. Freshwater enters the pond primarily via groundwater infiltration. A barrier beach separates EGP from the Atlantic Ocean, which is intentionally breached or "cut" 3-4 times per year to drain the pond and allow it to be flushed with salty ocean water. Water from the Atlantic Ocean is also low in nutrient concentrations compared to EGP, making flushing during openings a nutrient management tool. Pond cuts are temporary, and close due to natural forces. The timing of openings is determined by the Edgartown Shellfish Constable, who considers factors such as pond elevation, pond water quality, weather, and the migration patterns of important species such as river herring. After closure of the cut, EGP gradually refills due to groundwater and precipitation onto the pond's water surface.

The Great Pond Foundation (GPF) Ecosystem Monitoring Program follows the methodology of the Massachusetts Estuaries Project (MEP) and utilizes the management standards established by the EGP MEP report (Howes et al., 2007). This report found that the main basin and tributary coves were moderately to significantly impaired due to loss of eelgrass (*Zostera marina*) coverage compared to the 1951 distribution and impairment of benthic (bottom) animal habitat. This loss of habitat resulted from summer oxygen depletions and organic enrichment due to excess nitrogen. The MEP developed threshold nitrogen levels based on modelling the water circulation within EGP and nitrogen loading from its watershed. These thresholds establish the concentration of nitrogen the system can accommodate in order to restore high habitat quality. Regular monitoring of water quality in EGP is required to determine if nitrogen levels in the pond are meeting these thresholds, and to monitor for further degradation or improvement within the ecosystem.

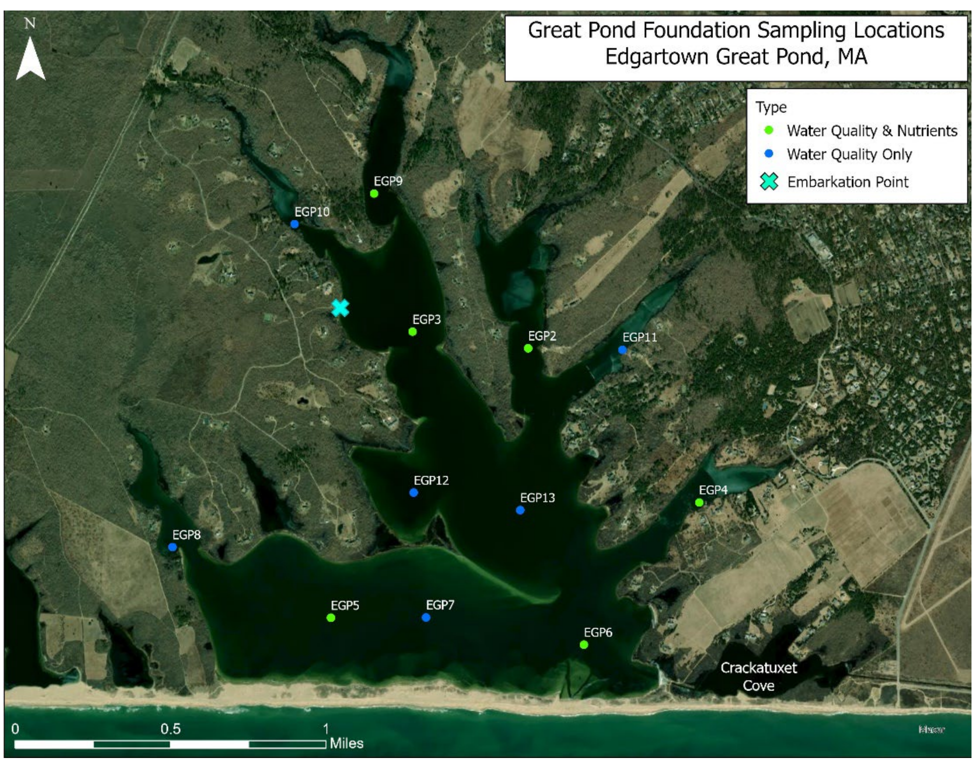

Figure 1. Map of the 12 Edgartown Great Pond (EGP) sampling stations.

GPF began extensively monitoring water quality and ecosystem health of Edgartown Great Pond in 2016, when GPF's Ecosystem Monitoring Program started. Sample collection methodology consists of regular monitoring during the spring, summer and fall seasons. Numerous sampling methods are utilized, including handheld probe measurements, lab-analyzed nutrient analyses, and continuously operated deployed data loggers.

Data collection is centered on 12 sampling stations throughout the Pond (Figure 1). These water sampling stations cover all geographic features of the EGP ecosystem: adjacent to the barrier beach, the deepest parts in the center of the Pond, and at least one station within every cove. At each station parameters such as temperature, salinity, dissolved oxygen, pH, water clarity and turbidity were measured throughout the entire water column using a YSI ProDSS handheld water quality meter (see Glossary in Appendix for explanations of parameters). Additionally, concentrations of nutrients such as nitrate, phosphate, and ammonium were analyzed at a subset of stations on select sampling days. Water samples were delivered to the Marine Biological Laboratory in Woods Hole for nutrient analyses. This methodology and suite of parameters are widely used standards for the determination of impairment and the assessment of ecosystem health.

GPF's 2021 field season began on May 4 and the last sample collection occurred on October 7. Water samples were collected weekly by the Scientific Program Director, Watershed Outreach Manager, and interns during the 23-week monitoring period (see Table A1 in Appendix for dates), providing a high-resolution dataset with over 100,000 unique data points. Summer is when the Pond is most biologically active, and frequent sampling allows for rapid detection of biological phenomena, such as algal blooms. Winter prohibits boat-based water sampling, however, the cold weather also limits biological activity making regular sampling unnecessary. In addition to in-situ data collection during site visits, GPF deployed dissolved oxygen and conductivity/salinity sensors which continuously monitored these parameters. These loggers were deployed on June 11 at station EGP5 and collected measurements every 15 minutes (96 measurements per 24 hours) until their removal on November 11. An additional conductivity/salinity sensor was deployed at station EGP9, within Wintucket Cove. The datasets provided by these instruments are essential to understanding temporal changes and patterns in their recorded parameters and provide greater context and comparison for the accompanying data collected during field sampling.

Pond Elevation and Pond Cuts

- *EGP was opened to the ocean 3 times in 2021.*
- *EGP was open to the ocean for a total of 54 days in 2021. Opening length varied from 14-22 days, with an average opening duration of 18 days.*

The barrier beach was intentionally opened to the ocean three times in 2021 (Table 1). During an opening, the Pond will experience an initial drain into the Atlantic Ocean, the magnitude of which is determined by the water elevation in the Pond compared to that of the ocean prior to opening. Following this drain, the remaining fresher, nutrient-rich water from the pond will be steadily replaced by salty ocean water over the course of several tidal cycles. This exchange has the beneficial effects of reducing overall nutrient concentrations, increasing salinity, lowering temperature, and improving water circulation throughout the Pond. These conditions are of particular benefit to shellfish populations and eelgrass (*Zostera marina)* meadows.

Opening #	Date of Opening	Date of closure	Length of opening
1	2/28/2021	3/18/2021	18
2	8/7/2021	8/29/2021	22
3	12/4/2021	12/18/2021	14

Table 1. Dates of Edgartown Great Pond openings, when the barrier beach was breached allowing for tidal exchange with the ocean. The average length of the opening was 18 days, and EGP was open to the ocean for a total of 54 days in 2021.

Following a cut, salinity is often used to measure of the extent of exchange between the Pond and the ocean and can determine the "success" of an opening. A significant increase in salinity, especially in the coves, indicates a successful flush, where salty ocean water is introduced throughout the entire Pond. However, salinity data is not always available, such as during the winter months when sample collection does not occur. The first and last cuts of 2021 were made outside of the regular water sampling season and no salinity data was collected.

During 2021, all man-made cuts remained open for at least 14 days, which previous data shows is sufficient time for successful flushing of the pond. The ideal opening duration is at least 12 days, which is associated with a 90% exchange with the ocean (Gaines, 1993). Following both the August 7 cut, salinity increased at all sampling stations, signaling a full exchange of water with the ocean and indicating a successful cut.

Overall, EGP was open to the ocean for a total of 54 days in 2021. Opening length varied from 14-22 days, with an average opening duration of 18 days. Dredging did occur in EGP in early 2021 via the dredge owned and operated by the Town of Edgartown. Dredging occurred in the vicinity of the cut north of the barrier beach, as well as adjacent to the sluiceway. Removal of this sand improves circulation and the flushing of the Pond during a cut, while also benefiting the Town's beach nourishment programs.

GPF maintains water level data loggers within EGP and Crackatuxet Pond (CRX) which are used to track the ponds' elevation before, during, and after openings. The height of the EGP above sea level is an important factor used when determining if a pond cut is feasible. GPF observed an anomaly in water level measurements in EGP and CRX in late June which suggested that water was flowing between the two ponds through the sluiceway. A GPF site visit to the sluiceway on July 9 confirmed that boards were missing in the sluiceway. This was immediately brought to the attention of the Edgartown Shellfish Department, who reinstalled the boards on July 10. Data from the water level loggers indicate that these boards were removed on approximately June 22, resulting in at least 2 weeks of surface water exchange with EGP. The drainage of EGP into CRX caused EGP to lose approximately 0.75 feet of elevation, which delayed the summer opening of EGP.

Salinity

- *Salinity was relatively consistent across the 12 EGP sampling stations. Stations within Jane's Cove and Wintucket Cove had the largest range and exhibited more vertical variation within the water column.*
- *Salinity ranged from 8.7 – 31.8 ppt throughout the sampling season. There were significant changes in salinity when EGP was cut, which rapidly increased salinity pond wide.*

Salinity is a measure of how much salt is dissolved in water, measured in parts per thousand (ppt) (tap water = 0 ppt, ocean water = 34 ppt). Salinity can be an indicator of the local hydrology within EGP, or of how water enters, circulates, and exits the pond. Additionally, salinity can be used to assess the success of pond cuts. During a successful opening, the whole pond is flushed with ocean water, which causes the salinity to increase throughout the main basin and into the coves. Most fresh water enters EGP along these coves via groundwater, making them typically less saline than the main basin.

All 12 stations exhibited similar salinity trends. Overall, salinity ranged from 8.70 ppt to 31.79 ppt (Figure 2). The lowest measured salinity was observed in early August, when salinity was below 10 ppt at stations EGP9, EGP10 and EGP11. These sampling stations often exhibited the lowest salinity in the Pond due to their locations within Jane's Cove, Wintucket Cove, and Turkeyland Cove, respectively. Groundwater flow into these coves introduces freshwater into the estuary and causes the water column to become stratified, especially following an opening. Stratification, or the existence of horizontal layers in the water, occurs due to differences in density caused by variations in salinity and temperature. Saltwater is denser than freshwater, causing it to sink below less dense fresh water. Stratification was observed across the pond following the August 7 cut, however it was most pronounced at stations EGP9 through EGP11.

Salinity rapidly increased following pond cuts. While GPF was not actively monitoring EGP prior to the February 28 cut, salinity at a majority of monitoring stations was typically above 20 ppt at the start of the monitoring period

(Figure 2). Salinity gradually decreased throughout the summer to an average of 15.2 ppt on 8/6, 1 day before the August 7 cut. It is important for salinity to remain above 15 ppt, because when Pond salinity falls below 15 ppt it becomes a stressful environment for eelgrass. During the period immediately following a cut, fresh groundwater flow into the Pond from the surrounding water table will temporarily increase due to a hydrostatic pressure gradient caused by the rapid draining of the pond. After this initial drop following the August cut, salinity levels jumped to a pond-wide average of 25.3 ppt on 8/18, 11 days after the cut. These trends were also captured by the continuous conductivity logger deployed at station EGP5 (Figure 3). A second conductivity logger deployed at station EGP9 exhibited the same trend, however with slightly lower salinity.

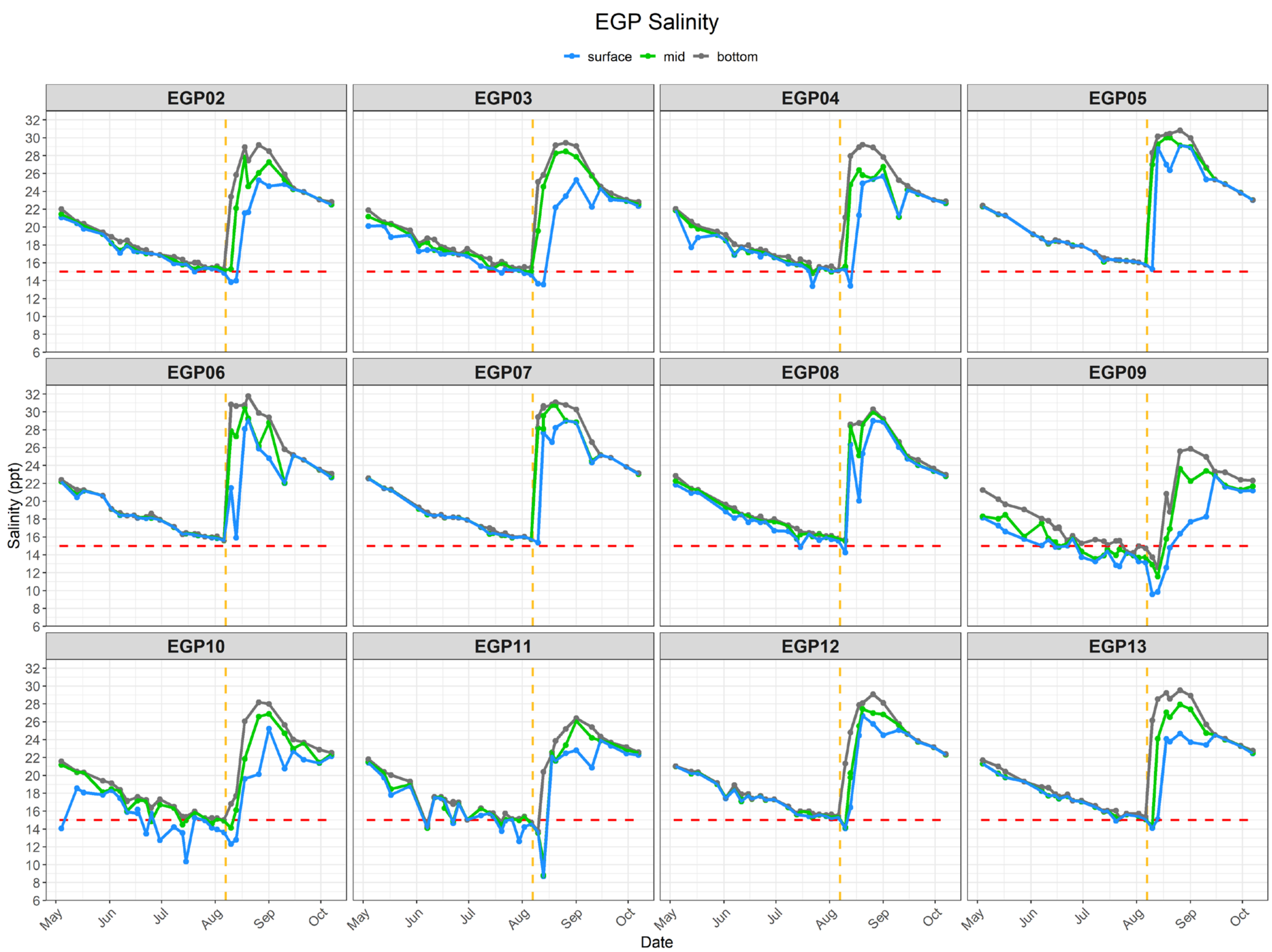

Figure 2. Salinity in parts per thousand (ppt) in Edgartown Great Pond in 2021. Data were measured with a handheld probe at the surface, mid-depth and bottom water, represented by different colors, at 12 sampling stations (different panels). The dashed yellow line is when EGP was cut to the ocean. The dashed red line is the management target for maintaining healthy eelgrass beds.

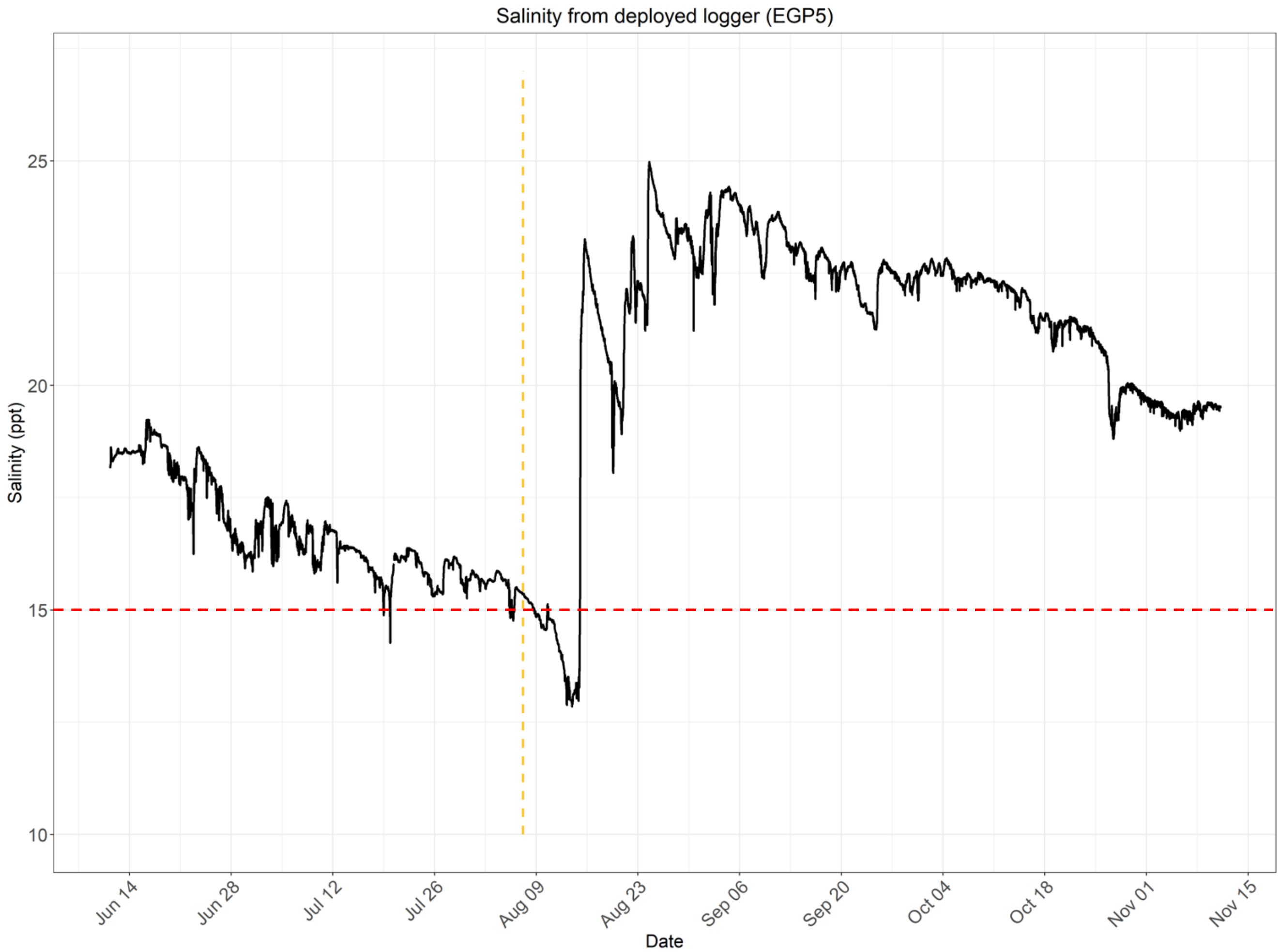

Figure 3. Salinity in parts per thousand (ppt) in 2021. Data were measured with a conductivity/salinity data logger deployed at station EGP5. The dashed yellow line is when EGP was cut to the ocean on 8/7/21. The dashed red line is the management target for maintaining healthy eelgrass beds.

Temperature

- ➢ *Water temperature at all 12 sampling stations remained below the 85°F threshold for ecosystem health throughout the summer season, as measured during site visits.*
- ➢ *Maximum water temperature measured via a handheld water quality meter was 83.7°F on 8/18/21 and was 87.7°F as measured by a deployed temperature sensor at EGP5.*

Temperature is an important factor within aquatic ecosystems, as it drives biological growth rates and chemical reaction speeds. Much like the temperature of our own bodies, elevated water temperature is often associated with problems affecting ecosystem health. The EGP management goal from the MEP report is to maintain water temperatures of less than 85° F during the summer (Howes et al., 2007). However, unlike other parameters that can be influenced by direct management decisions, there is no direct way to control temperature. Water temperature typically decreases after the pond has been cut, as ocean water is often cooler than pond water during the summer. However, water temperature in the Pond is predominantly driven by ambient air temperature.

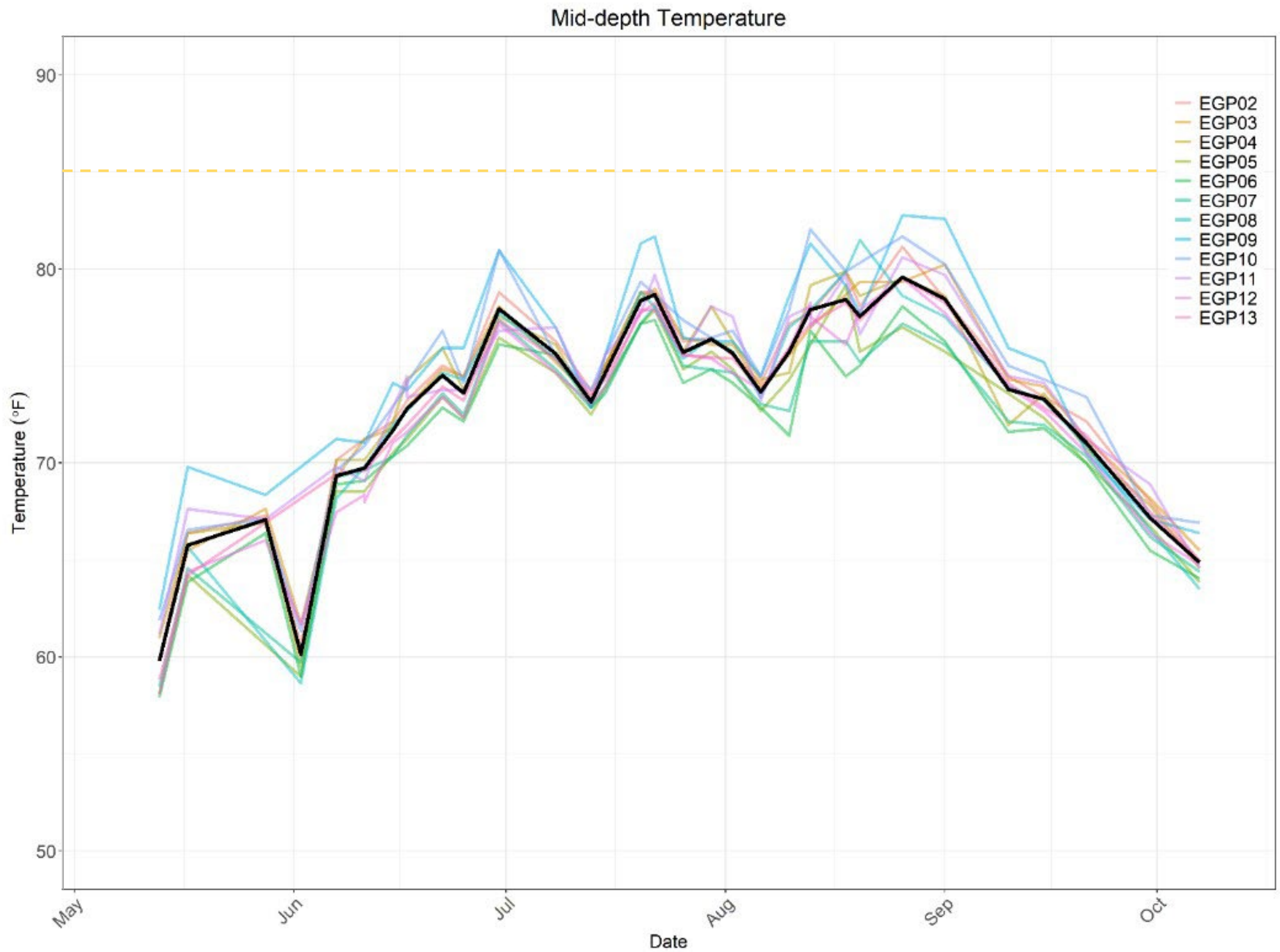

Figure 4. Temperature in Edgartown Great Pond in 2021. Colored lines represent data from the different sampling stations, and the black line is the pond-wide average temperature for each site visit. The dashed yellow line is the 85°F management threshold.

Water temperature was measured throughout the water column at all stations across the Pond during each site visit. Additionally, bottom water temperature was continuously monitored with a temperature sensor attached to the conductivity/salinity data loggers at stations EGP5 and EGP9. All stations were fairly similar in temperature relative to each other and exhibited the same seasonal trends (Figure 4). Stations EGP6 and EGP7 were consistently cooler throughout the sampling period, likely due to their location within the main basin and their proximity to the ocean. Maximum water temperature measured during routine water sampling occurred on August 18, when temperatures reached 83.66°F at station EGP9 (Figure 4), while average mid-depth temperature for the entire pond was 78.10°F on the same day. This occurred after the August cut while the pond was still open to the Atlantic Ocean. While cuts introduce cold ocean water into the Pond, the drainage that occurs also greatly reduces the depth of the Pond, causing the water to heat up at a faster rate. The deployed temperature data logger attached to the conductivity/salinity sensor at EGP5 also detected elevated temperatures after the Pond was cut. The maximum temperature from this data logger was 87.7°F on August 27 (Figure 5). Temperatures recorded on August 18 also exceeded 87°F.

Coastal ponds such as the great ponds of Martha's Vineyard often suffer from elevated temperatures in the summer. However, it is noteworthy that observed water temperatures within EGP rarely exceeded the 85°F threshold. These instances were only recorded via the deployed temperature sensor at station EGP5 and elevated temperatures were not observed from water sampling site visits. All temperatures above 85°F recorded by this logger occurred in mid-late August, when the Pond was shallow following the summer cut. GPF's active monitoring timeframe falls between 6-11AM and does not include regular afternoon sampling. It is possible that temperatures may have exceeded the threshold more often at shallower locations, such as the heads of the coves, during the hotter times of day. Further, temperature is continuously recorded at a limited number of locations and full spatial coverage with sensors is not feasible. Regardless, the health of EGP likely benefited from fairly consistent water temperatures that typically remained below 85°F.

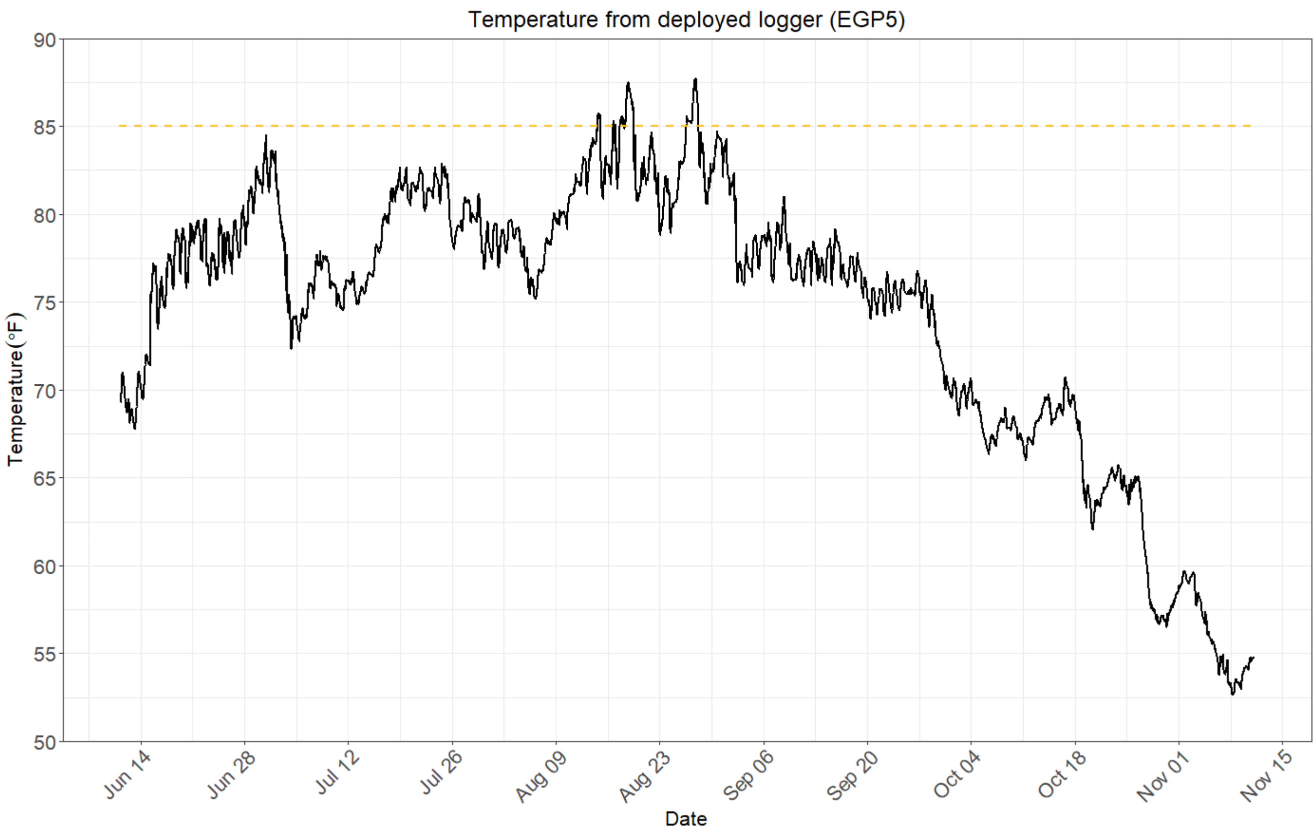

Figure 5. Temperature measured with a continuous data logger deployed at station EGP5. The dashed yellow line is the 85°F management threshold.

Dissolved Oxygen

- *Results indicate that the majority of the water column had sufficient oxygen concentrations, however, near-bottom portions consistently exhibited lower dissolved oxygen levels.*
- *The dissolved oxygen data logger detected short periods of hypoxia at station EGP5, most often at night. However, oxygen concentrations typically recovered to healthy levels during the day.*

Dissolved oxygen (DO) is the amount of oxygen dissolved in the water, measured in milligrams per liter (mg/L). A battery-operated DO sensor was deployed at station EGP5 (located within the main basin, north of the barrier beach), which continuously logged the amount of oxygen in the water at 15-minute intervals. Oxygen enters the water through diffusion from the air but is primarily produced by aquatic plants via photosynthesis. Adequate oxygen levels are important as most organisms require oxygen as part of their metabolism.

The MEP DO management target for heathy ponds is 6 mg/L (Howes et al., 2007). When concentrations drop below 4 mg/L, aquatic life begins struggling to breathe. Critically low levels of oxygen (<2 mg/L) are considered hypoxic and can be deadly to most organisms. Normally, the bottom of the water column has lower DO compared to surface waters. This is because oxygen diffuses from the air into the water at the surface, and most plants, which produce oxygen, are found at or near the surface where there is direct sunlight. Additionally, oxygen is consumed via decomposition of organic matter, which primarily occurs on the bottom and within the sediment. Due to these processes, deeper water often has lower DO concentrations than at the surface. This can be clearly seen when DO from surface, mid-depth, and bottom waters are plotted together on the same graph. A gradient of decreasing oxygen concentration with increasing depth was observed at most monitoring stations (Figure 6). This gradient was most severe during the summer season, while the pond experienced the hottest temperatures of the year.

There was a slight seasonal trend, where DO was reduced during the hot summer months. Between July and September, all stations experienced DO concentrations below the 6 mg/L threshold (Figure 6). Most often this was limited to measurements taken at bottom depths and only occasionally did mid-depth or surface DO measurements drop below the 6 mg/L threshold. DO fell below the 4 mg/L threshold into the zone of concern, where oxygen deprivation begins to occur, at all stations except EGP9 at least once throughout the summer. While this indicates that bottom water was low in dissolved oxygen, it is typical for coastal estuaries, especially ecosystems with a history of impairment, to experience periodic oxygen depletion. For most stations, data suggest the water column had adequate oxygen to support aquatic life.

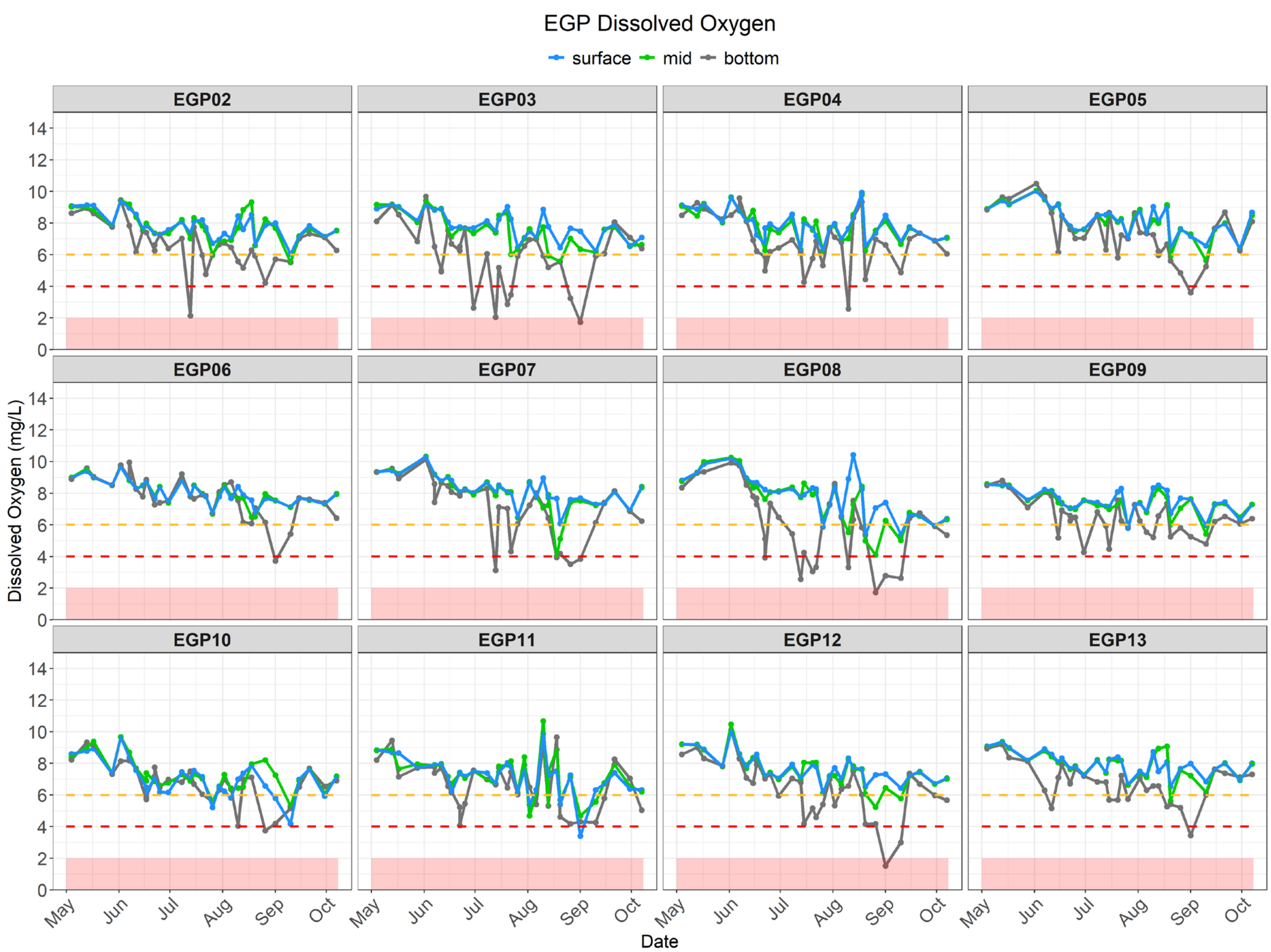

Figure 6. Dissolved oxygen (DO) measured in milligrams per liter (mg/L) in Edgartown Great Pond in 2021. Data were measured with a handheld probe at the surface, mid-depth and bottom water (represented by different colors) at 9 sampling stations. The dashed yellow line is the 6 mg/L management target, and the red dashed line represents when DO was critically low, below 4 mg/L. The red box indicates when hypoxia was occurring (DO < 2 mg/L).

However, the data generated by the deployed DO logger indicate that EGP5 experienced short periods of hypoxia at its bottom depths (Figure 7). Hypoxia is when DO drops below 2 mg/L, potentially causing harm to plants and animals. The DO data logger was deployed at station EGP5 on June 11 and collected measurements every 15 minutes until November 11. This logger was at a fixed depth, approximately 3 inches above the pond sediment. This deployment configuration is designed to capture DO concentrations at their minimum to better describe the severity of oxygen depletion, if any. Data from this logger indicate that there were large daily fluctuations in DO, especially during the late summer (Figure 7). Additionally, DO periodically fell below 2 mg/L to near anoxic conditions, which occur when there is no oxygen present. During these low oxygen events, the data logger occasionally recorded DO measurements close to 0 mg/L. These periods of hypoxia most often occurred at night when plants are not photosynthesizing and producing oxygen.

Data recorded using the handheld water quality meter did not capture the same severity of the oxygen depletion that was observed at EGP5. DO naturally undergoes daily fluctuations as the processes of respiration and decomposition consume oxygen, while aquatic plants produce oxygen only during the day. Typically, the lowest DO measurements occur just before sunrise. The GPF Water Quality Monitoring Program was designed to capture this DO minimum by beginning field sampling just after sunrise. Yet, even with strict protocols, the GPF sampling team often arrived on station after DO levels began to rise. As such, the data from the handheld sensors did not capture the true DO minimum. This inconsistency illustrates why deployed sensors are useful as a supplement to boat-based sampling efforts. Only one DO logger was deployed in EGP throughout the 2021 monitoring period, and therefore, comparative measurements from other locations within the pond are unavailable. It is reasonable to assume that other locations within EGP experienced low DO concentrations at night, but this hypothesis cannot be confirmed without the deployment of additional sensors.

These results indicate that the majority of the water column retained sufficient oxygen concentrations, while the near-bottom portions were occasionally depleted at night. Low DO readings from the continuous data logger are concerning, however, the periods of hypoxia (DO < 2 mg/L) were typically brief and DO levels recovered during daylight hours. DO concentrations within a healthy ecosystem fluctuate on a daily basis, yet still retain adequate levels to buffer against extreme variations which may occur during periods of high respiration. It is common for eutrophic ponds to have anoxic sediment, meaning there is no oxygen present. This is due to large amounts of organic matter decomposing on the bottom of the pond, a process which consumes oxygen. The logger mount and housing are designed to prevent the instrument from sinking into this sediment layer. Therefore, these low DO readings are representative of the near-bottom portion of the water column and indicate the presence of a hypoxic zone above the sediment layer. While regular and consistent oxygen depletions are indicators of impairment, hypoxia at EGP5 was short in duration, and the ability for the ecosystem to recover to sufficient oxygen concentrations suggests EGP5 is part of a healthy ecosystem.

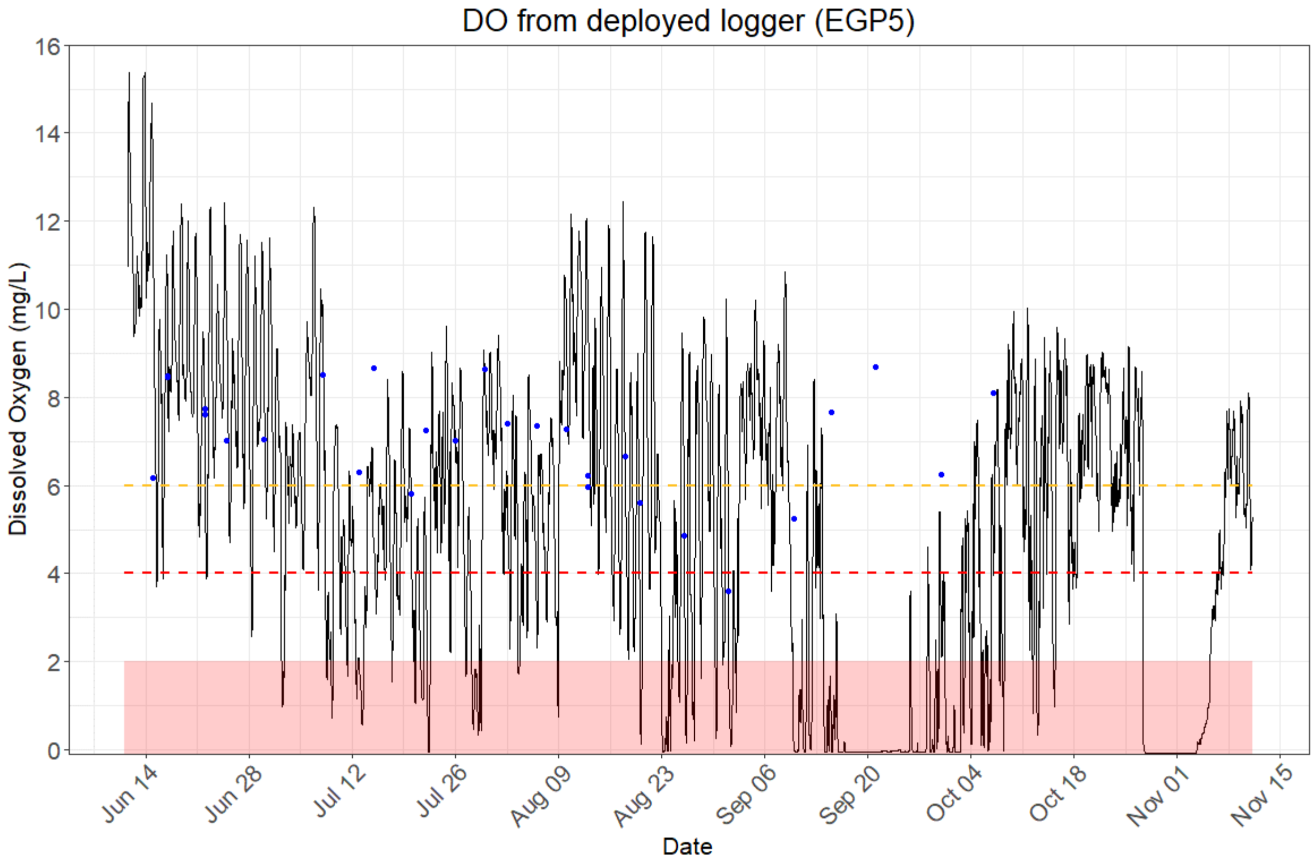

Figure 7. Dissolved oxygen (DO) at station EGP5 in 2021. Data were measured with a data logger deployed approximately 3 inches from the pond bottom. The dashed yellow line is the 6 mg/L management target, and the red dashed line represents when DO was critically low, below 4 mg/L. The red box indicates when hypoxia was occurring (DO < 2 mg/L). Blue dots are DO measured by a handheld probe during site visits. The black line represents a 2-hour moving average of the DO measurements, which were logged every 15 minutes.

Water Clarity

- *Typical visibility was at least 6 feet and extended to the bottom at most sampling stations. However, the water was frequently too murky to see the pond bottom at the deepest stations (EGP3 & EGP13).*
- *Stations EGP2, EGP3 and EGP13 frequently experienced elevated turbidity and reduced water clarity. Murky, high turbidity water is generally indicative of impaired water quality.*

Turbidity is a measure of how many particles are dissolved in the water, which affects how much light is transmitted through the water column. Water with low turbidity is clear, with visibility often extending to the bottom, while water with high turbidity appears murky. High turbidity is detrimental to submerged aquatic vegetation, as less sunlight can penetrate the water. Vegetation requires sunlight to photosynthesize, which in turn, provides oxygen to other organisms living in the water. The particles that cause high turbidity can be either living or nonliving. Living particles include microscopic plants called phytoplankton, along with other microscopic organisms which have the ability to reproduce quickly, making the water appear green or brown in color. Elevated concentrations of nutrients and increased temperatures can stimulate growth of these microscopic species. Nonliving particles are usually comprised of sediment that was either resuspended from the bottom of the pond or entered the water from adjacent lands via runoff. Because of this, murky or turbid water is common after rain events.

Turbidity is often used as a benchmark for water quality analyses as it is simple to measure and interpret. Murky water is generally indicative of impaired water quality. One method of measuring turbidity is with a Secchi disk. A Secchi disk is a standardized black and white disk attached to a measuring tape that is lowered through the water column. The depth at which it disappears from view corresponds to the depth at which turbidity is too high for light to penetrate to deeper depths. Thus, light cannot easily reach benthic plants and animals when turbidity is elevated. The MEP management goal for Secchi depth is 3 meters (9.8 feet) or the bottom of the body of water (Howes et al., 2007). Most of EGP is approximately 3 meters deep or less, making adequate Secchi depth the bottom of the pond, or "total depth", at the sampling site. Stations EGP3 and EGP13 were the deepest sites, therefore the Secchi depth management goal for these sites was 3 meters (9.8 feet).

Water clarity in EGP varied depending on the location within the pond. Visibility was typically at least 6 feet, as measured by a Secchi disk (Figure 8). Most stations had adequate Secchi depth, where the Secchi disk was usually visible on the pond bottom, consistent with the management goal. Stations EGP2, EGP3, and EGP13 were most reduced in water clarity, with Secchi depths occasionally measuring half of the total depth. These stations had the

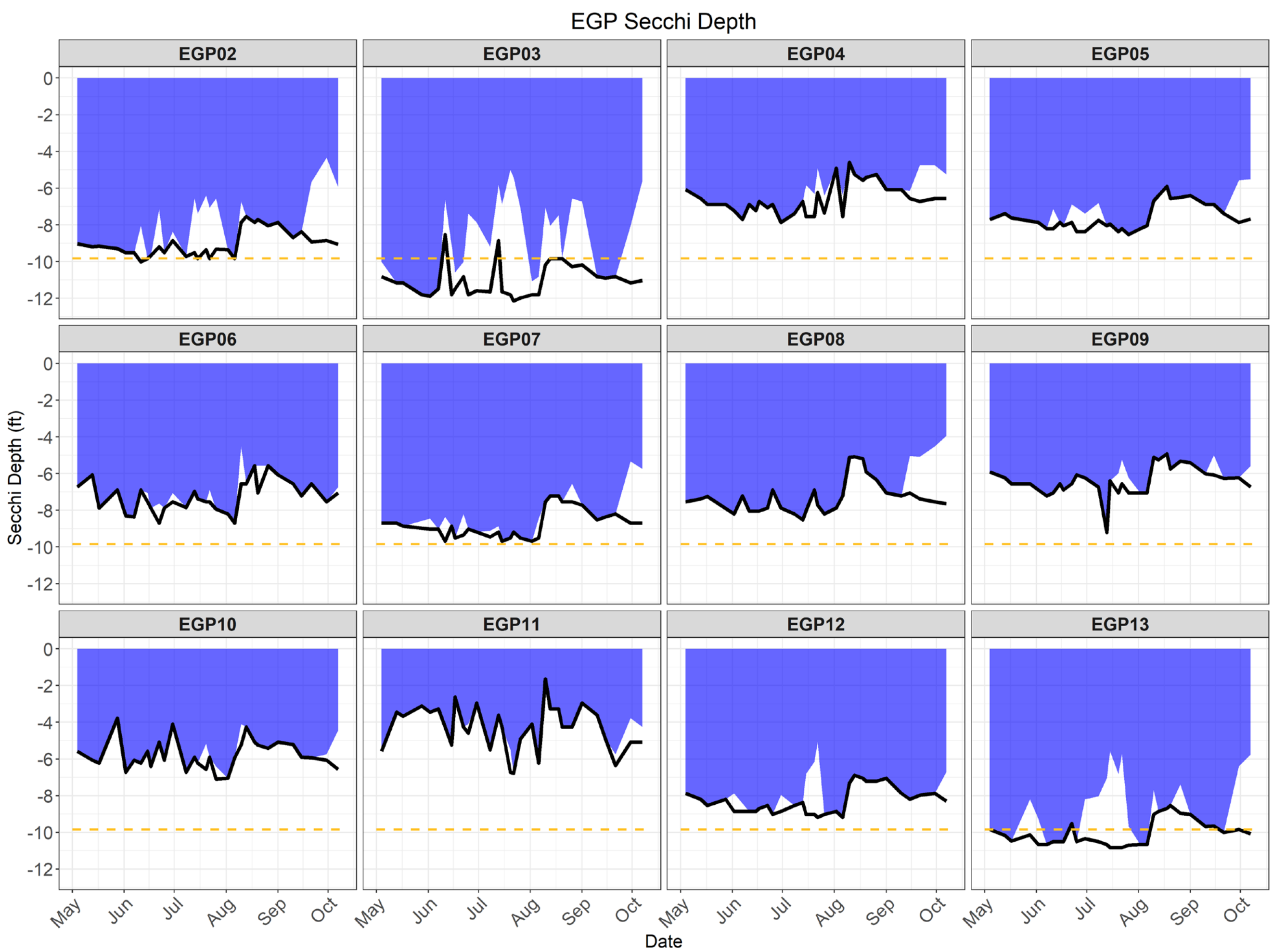

Figure 8. Secchi depth and total depth in feet at each sampling station in Edgartown Great Pond in 2021. Secchi depth is the depth at which a standardized disk disappears, which often corresponds to total depth. Total depth in the figure is the thick black line, and Secchi depth is the blue shaded area above the black line. The management target for Secchi depth to equal total depth, or be at least 9.8 feet, shown by the yellow dashed line.

greatest depth profiles and experienced elevated turbidity and reduced water clarity throughout the entire summer, while other stations exhibited reduced water clarity mostly during August. This can likely be attributed to higher average temperatures during the summer that fuel algal growth coupled with increased nutrient inputs from surrounding properties via surface water runoff (e.g. from fertilizer application).

Nutrient Concentrations

- *Total nitrogen values in EGP were below the management targets for the majority of the monitoring period, peaking in July and August for most stations. Mean TN values were below the recommended limits established by the 2007 MEP report.*
- *Chlorophyll-a was below the 10 µg/L threshold at most EGP sampling stations, however this measurement peaked during the summer months.*

GPF collected samples to measure the concentrations of phosphate, nitrate, ammonium, as well as chlorophyll pigments in Edgartown Great Pond. Abundant concentrations of nutrients in coastal waters can lead to eutrophic conditions and an overall deterioration in water quality. Nutrient pollution in marine and brackish ecosystems is often the result of excessive nutrient loading from adjacent land areas, which stems from human development. Measuring the concentration of nutrients in the water can indicate if eutrophication is occurring. Brackish coastal ecosystems often exhibit an excess of inorganic nitrogen, such as nitrate and ammonium, as well as excess organic nitrogen. Nutrient analyses were performed at the Marine Biological Laboratory in Woods Hole. Nutrient sample collection was limited to once per month due to the high cost of analysis and labor involved. Nutrient samples were also limited to a subset of sampling stations. However, two new sampling locations were added to study how nutrient concentrations vary along a salinity gradient. These additional stations were located towards the heads of Jane's Cove (EGPJ05) and Wintucket Cove (EGPW05), which are typically lower in salinity due to local groundwater and surface water input .

Overall, nutrient concentrations in EGP were below management targets, particularly with regards to nitrogen concentrations. Total nitrogen (TN) measures both inorganic and organic forms of nitrogen and is the metric typically used to assess whether eutrophication is occurring in coastal ecosystems. The 2007 MEP study for EGP determined the nitrogen loading threshold for habitat restoration. This study observed that nitrogen concentrations were relatively uniform throughout the estuary and recommended a "sentinel station" for monitoring TN over time. Stations EGP2, EGP3, EGP5, EGP6, and EGP9 represent the sentinel stations from EGP. The MEP report states that the average TN concentration should remain below 0.5 milligrams per liter (mg/L) at the sentinel station (average of stations EGP2, EGP3, EGP5, EGP6, and EGP9), across the growing season from May through September (Howes et al., 2007). This is a common nitrogen management target for saltwater estuaries, including other Martha's Vineyard coastal ponds. Additional stations included in the GPF monitoring program to gain a more nuanced understanding of the nitrogen concentrations throughout the entire estuary. However, these additional stations are not included in the historical sentinel station monitoring and cannot be directly compared to results and recommendations reported in the 2007 MEP report.

TN values in EGP varied slightly throughout the monitoring period but were mostly below the threshold values. Most stations exhibited one measurement at or above the 0.5 mg/L TN threshold (Figure 9). The majority of stations exhibited the highest TN values on the October 7 collection date. However, TN measurements peaked in August at stations EGP9, EGPJ05 and EGPW05, located within Jane's Cove and Wintucket Cove. The maximum TN concentration recorded was 1.95 mg/L at EGPW05 on August 10. This measurement was an anomaly, and the elevated reading is likely a result of higher sediment load within the water caused by surface runoff after a rain event the day before samples were collected (1.23 inches of rain). The W05 sampling station is located near a small stream that flows into Wintucket Cove, and the August 10 sample likely contained mostly stream water instead of pond water. This is corroborated from the August 10 nutrient analyses, which measured higher particulate nitrogen than previous sample dates at EGPW05 (Figure A1 in Appendix).

Outside of the outlier at EGPW05, the maximum TN measurement was 0.65 mg/L at EGPJ05 on 8/10. TN measurements were consistent across all stations at which nutrient samples were collected. Other than the unusually high TN measurement on August 10 at EGPW05, there were no discernable differences between stations located within the main basin of the Pond and stations within the coves.

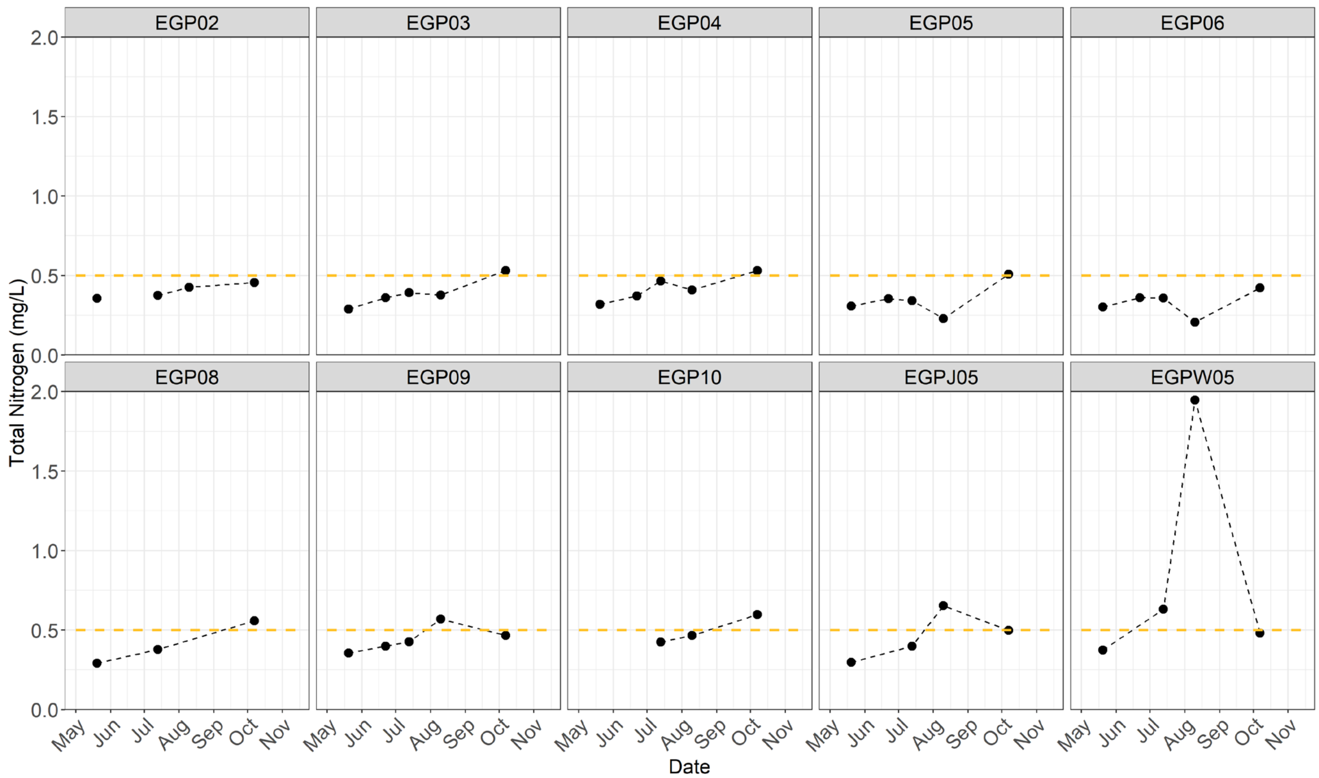

Figure 9. Total nitrogen in milligrams per liter (mg/L) in 2021. Data are from 10 EGP sampling stations (different panels). The dashed yellow line represents the 0.5 mg/L TN management target for the sentinel station (mean of EGP2, EGP3, EGP5, EGP6, & EGP9) established by the MEP report.

Dissolved nitrogen was the primary nitrogen source which contributed to TN concentrations, and particulate nitrogen was a much less significant nitrogen source (Figure A1 in Appendix). At all stations, organic nitrogen was higher than inorganic nitrogen (Figure A2 in Appendix). Organic nitrogen is nitrogen that is already incorporated into the living tissues of plants and animals, whereas inorganic nitrogen is the form that is available to plants and animals for consumption as part of their metabolism. Inorganic nitrogen is comprised of nitrate, nitrite, and ammonium, which can be measured as dissolved or particulate inorganic nitrogen. Other inorganic nutrients include phosphate and silicate. Excess inorganic nutrients can fuel plant growth and lead to eutrophication. Increased growth caused by elevated inorganic nutrients can lead to high organic nitrogen as the nutrients are utilized by plants and animals.

Phosphate measurements exhibited a different trend than TN. Phosphate measurements at the majority of stations were lower in the summer and sharply increased during the October sample collection (Figure 10). This is likely because EGP is an ecosystem driven by nitrogen inputs, which fuel plant and algal growth. This growth also requires phosphate, which is consumed during the summer when growth rates are highest. In the fall, plant growth subsides and the demand for phosphate declines, leading to more dissolved phosphate in the water. Stations EGP5, EGP6, and EGPW05 had phosphate concentrations that peaked in the August collection. Most coastal estuaries are impacted by elevated nitrogen concentrations rather than phosphorus, and the 2013 MEP report did not include a management target for phosphate concentrations. The US Environmental Protection Agency (EPA) has published ambient water quality criteria recommendations to avoid eutrophication in freshwater ponds. The criteria for Massachusetts indicate that total phosphorus should remain below 0.02 mg/L. This is an imperfect comparison, since EGP is a brackish coastal pond, and phosphate concentrations were measured instead of total phosphorus. Regardless, phosphate measurements were mostly below this freshwater total phosphorus limit, except for samples from the August and/or October collections (Figure 10).

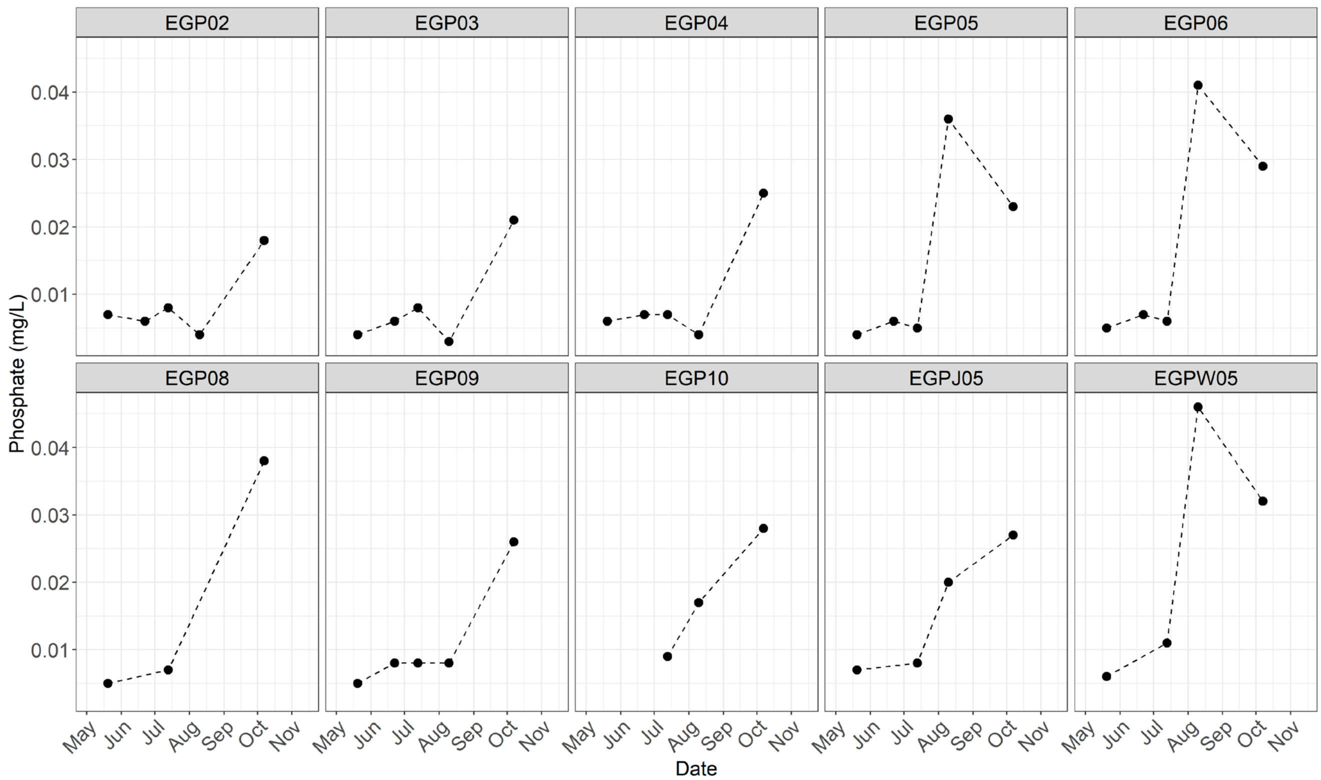

Figure 10. Phosphate concentrations in milligrams per liter (mg/L) in Edgartown Great Pond in 2021. Data are from 10 EGP sampling stations (different panels).

Overall, average nitrogen values in EGP were below threshold values for habitat impairment. While most stations had one measurement that met or exceeded the TN management target, the 2007 MEP report indicates that the mean concentration across the summer months (May-September) should be used. Mean TN across June-August sample dates at the sentinel station (EGP2, EGP3, EGP5, EGP6, and EGP9) was 0.345 mg/L, while mean TN of all sample dates (including October) was 0.382 mg/L (Table 2). This is below the 0.5 mg/L TN limit. Nutrient samples were also collected at EGP4, EGP8, EGP10, EGPJ05 and EGPW05, which were not included in the MEP sentinel station, but were included to help gauge nutrient concentrations within the coves. Mean TN of all stations in 2021 was 0.444 mg/L. While TN values were below the threshold values, a macroalgae bloom occurred in 2021, which is an indicator that nutrient concentrations were in excess.

In addition to nutrient levels, the amount of chlorophyll pigment in the water is an indicator of water quality. Chlorophyll is a pigment used by plants during photosynthesis. Measuring the amount of chlorophyll in the water, specifically the pigment chlorophyll-a, provides an estimate of microscopic plant abundance in the water. Microscopic aquatic plants, called phytoplankton, require nutrients to grow. High levels of chlorophyll can indicate that nutrients such as nitrate and phosphate are in excess and readily available for primary production. Elevated concentrations of nutrients can spur rapid phytoplankton growth, called a phytoplankton bloom. Chlorophyll pigments were measured in two ways: laboratory analysis at the Marine Biological Laboratory (MBL) in Woods

Hole and via fluorometry at the GPF lab. While both are accurate, for simplicity this report focuses on the results from the MBL laboratory. Another plant pigment called phaeophytin was also measured, which is produced as chlorophyll degrades at the end of a phytoplankton bloom. Measurements of total pigment, the sum of phaeophytin and chlorophyll-a, are available from GPF upon request.

Date	Mean TN of sentinel station (limit=0.5) (mg/L)	Mean TN of all stations (mg/L)
5/20/2021	0.322	0.340
6/22/2021	0.368	0.369
7/13/2021	0.379	0.419
8/10/2021	0.362	0.587
10/7/2021	0.477	0.505
Summer mean	**0.345**	**0.428**
2021 mean	**0.382**	**0.444**

Table 2. Mean Total Nitrogen (TN) values from Edgartown Great Pond in 2021. Mean values were calculated for the sentinel station (EGP2, EGP3, EGP5, EGP6 & EGP9), and all stations at which nutrient data were collected. The MEP report determined the threshold TN value for the sentinel station was 0.5 mg/L.

The MEP uses a management target of 10 micrograms per liter (µg/L) of chlorophyll-a for coastal ponds, and measurements in excess of 10 µg/L are an indicator of impairment (Howes et al., 2007). Chlorophyll-a was below this 10 µg/L threshold at the majority of EGP stations (Figure 11). Stations EGP10, EGPW05 and EGPJ05, located within Wintucket and Jane's Coves, were exceptions with measurements exceeding this threshold. Chlorophyll-a concentrations tended to be lowest in May and June with maximum concentrations in August. This was expected due to hotter temperatures in the summer and increased nutrient inputs from surrounding properties via fertilizer applications and runoff. However, there were some stations where chlorophyll concentrations peaked in October. The maximum observed chlorophyll-a concentration was 23.65 µg/L at station EGPW05 (Wintucket Cove) on August 10. Stations EGP10 and EGPJ05, both within Jane's Cove, experienced similar summer peak in chlorophyll-a measurements (Figure 11). These data indicate that Jane's Cove and Wintucket Cove experienced large phytoplankton blooms in 2021. The lower measurements from other stations within the Pond do not preclude the occurrence of a phytoplankton blooms, as one may have occurred between sample collections. Samples for fluorometric chlorophyll analyses were taken more frequently and at all 12 sampling stations. These measurements exceeded the 10 µg/L chlorophyll threshold several times at all stations during the summer months.

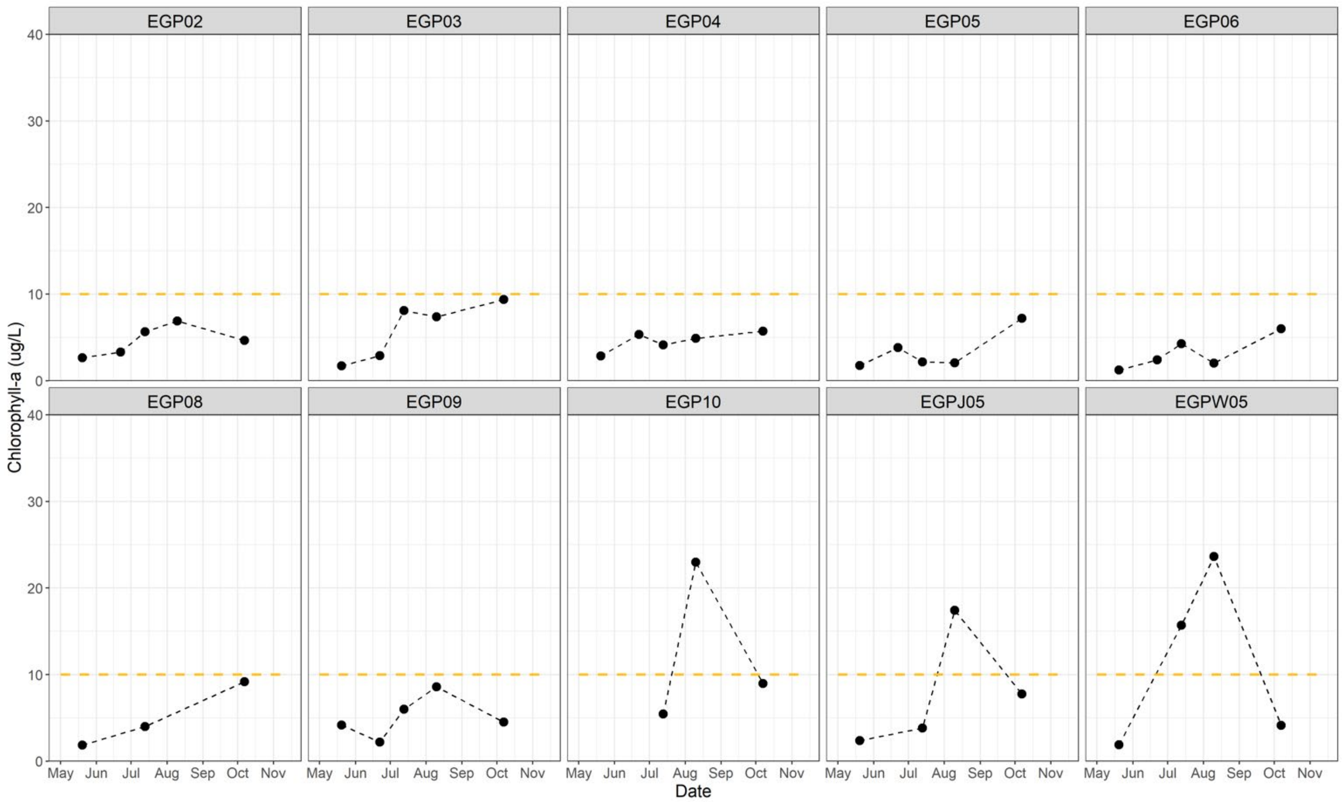

Figure 11. Chlorophyll-a pigments in micrograms per liter (µg/L) in 2021. Data are from 10 EGP sampling stations. The dashed yellow line represents the 10 µg/L management target for healthy coastal ponds.

MV CYANO

- *All EGP sampling stations were in the "green" risk category for the majority of the monitoring season, indicating very few to no cyanobacteria were detected.*
- *EGP was at a decreased risk of cyanobacteria blooms compared to other ponds monitored by MV CYANO in 2021.*

Edgartown Great Pond was included in the first year of the Martha's Vineyard Cyanobacteria Monitoring Program (MV CYANO). MV CYANO is a partnership between GPF and the Boards of Health of Chilmark, West Tisbury, and Edgartown. Cyanobacteria, a.k.a. blue-green algae, are a group of microorganisms naturally occurring in all Vineyard waters. When cyanobacteria grow rapidly or bloom, they can produce cyanotoxins, which when concentrated may cause adverse health effects in humans, pets, or livestock who wade in or ingest blooming waters. This pilot program successfully developed a workflow for regular sample collection, analysis, and subsequent presentation of spatial and numeric data to the Boards of Health to aid in their decision-making process regarding postings and closures. This workflow included a color-coded matrix, where different data-driven risk thresholds were represented by associated colors and categories, each with a corresponding sign to be posted at pond access points (Figure A3 in Appendix).

This program utilizes a sensor called a fluorometer to detect and quantify the abundance of cyanobacteria in water samples. While the species of cyanobacteria cannot be identified without a microscope, samples analyzed with a fluorometer can estimate the concentration of cyanobacteria in an ecosystem, which is needed to detect when a bloom occurs. Each color in the MV CYANO color-coded matrix corresponds to different concentrations of cyanobacteria and therefore represent increasing likelihood of bloom occurrence.

For a majority of the monitoring period, EGP water samples were in the “green” category, corresponding to a low level of risk (Figure 12). Some stations were designated into the “yellow”, or “ALERT” risk level at least once (EGP2, EGP3, and EGP10). This classification indicates that environmental conditions could support rapid growth of cyanobacteria and that a bloom is possible but not present. No samples exceeded the yellow category. Even the stations within the tributary coves, which have lower salinities which favor cyanobacteria growth, remained in the green, low risk category for a majority of the monitoring period. Cyanobacteria abundance in EGP samples was highest on August 2, peaking at 0.9 µg/L at station EGP2. For comparison, nearby Crackatuxet Pond had a maximum cyanobacteria concentration of 34.2 µg/L, which was classified in the orange category, or “BLOOM WATCH” risk level. Samples in the orange category have slightly elevated cyanobacteria levels and the likelihood of a bloom is increased. EGP samples consistently measured among the lowest cyanobacteria biomass amongst the ecosystems monitored for MV CYANO, suggesting that the overall risk for a cyanobacteria bloom in 2021 in the pond was low.

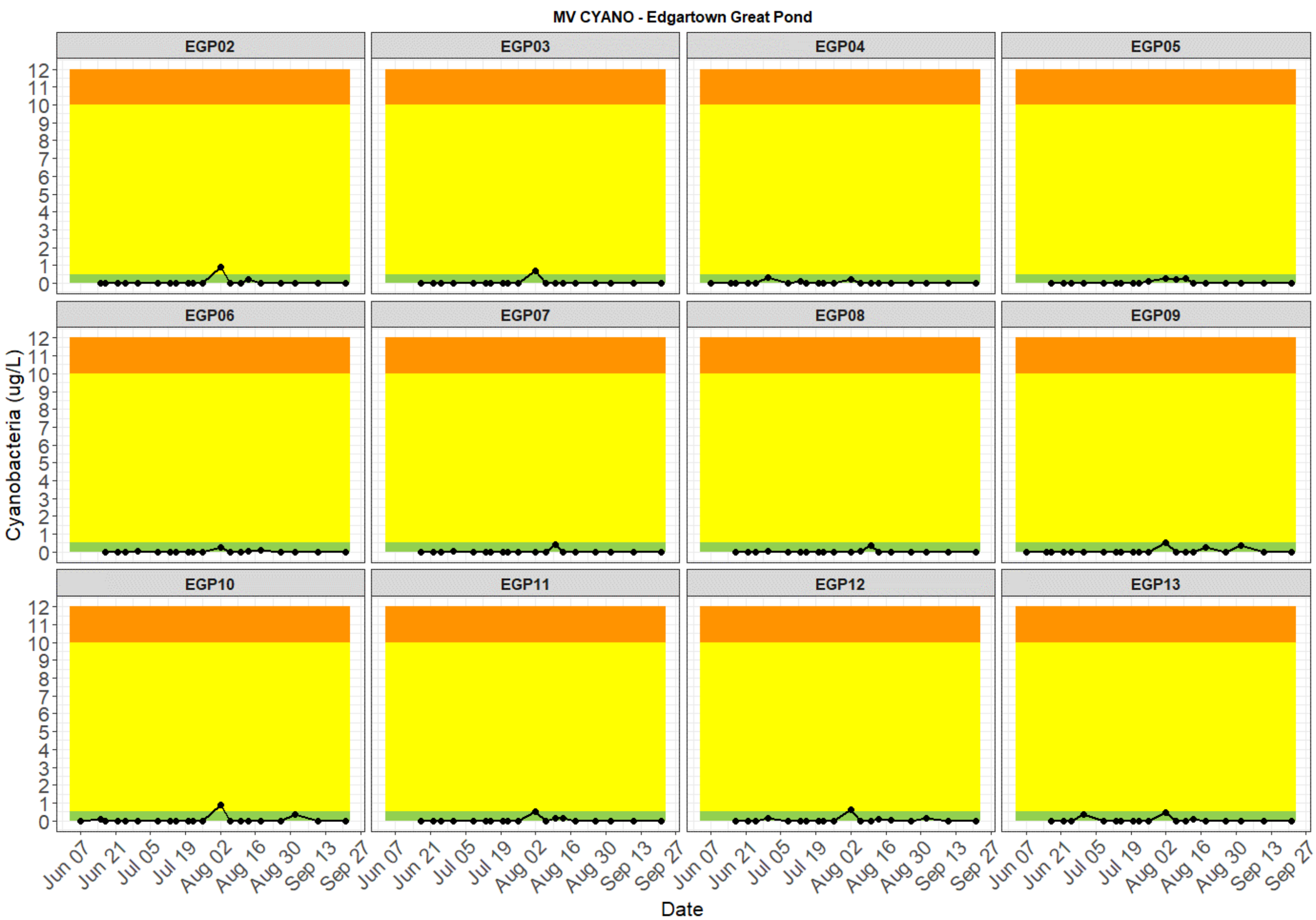

Figure 12. Cyanobacteria concentrations in micrograms per liter (µg/L) at all EGP stations in 2021. Samples were taken from surface waters and measurements were obtained via a fluorometer. Background colors correspond to the color-coded risk matrix used by the MV CYNAO monitoring program (see Figure A3 in Appendix).

Projects and Collaborations

Despite a second year of the COVID-19 pandemic, GPF continued to collaborate with numerous partners on new and ongoing projects. Partners included research institutions and state and federal governmental agencies. Cooperative projects such as these allow GPF to utilize the latest analytical techniques to more thoroughly understand the ecosystem dynamics within and around the Pond.

The GPF partnership with the Marine Biological Laboratory (MBL) in Woods Hole includes a project investigating the sources of nitrogen within the EGP and other local ponds. Collaborators for this project include Dr. Javier Lloret and Rich McHorney. This project utilizes stable isotope analysis, which uses different atomic forms of carbon and nitrogen to study how these elements move through the food web. Since nitrogen originating from different sources has different isotopic signatures, this technique can elucidate whether particulate organic nitrogen within the Pond came from wastewater, fertilizer, or other sources such as atmospheric deposition. Overall, data from 2021 confirmed that wastewater was the largest source of nitrogen in EGP, with wastewater contributing 55% of the nitrogen within particulate organic nitrogen. Fertilizer was the second largest nitrogen source, contributing 26%. This study will be continued in 2022 and expanded to include groundwater analyses, which will further elucidate nitrogen hotspots within the watershed.

Another project focused on the diversity of microbes within EGP and other coastal ponds. These microscopic organisms are difficult to identify visually, so genetic techniques were used. For this project, GPF worked with Dr. Caroline Fortunato, a marine microbial ecologist from Widener University. The results from this analysis will shed light on the bacterial community within our ponds and how this community might vary within ponds with different environmental factors, such as salinity and nutrient concentrations. An exciting aspect of this work is that scientists believe that the biodiversity of microbes in a community (what types and how many) may influence toxin production in cyanobacteria. The results of this study should be available at the end of 2022.

GPF continued to document the expansion of eelgrass (*Zostera marina*) within EGP in 2021. GPF worked with the Massachusetts Department of Environmental Protection, which regularly conducts aerial surveys of seagrass extent across the coastal areas of Massachusetts. These surveys utilize specialized cameras mounted to an airplane, capable of capturing high resolution digital imagery across multiple spectral bands. Past surveys have excluded the south shore of the Vineyard, however, the 2020/2021 survey period included the south shore great ponds for the first time. GPF staff worked to ground-truth these images by confirming presence/absence of eelgrass and other submerged aquatic vegetation along the edges of eelgrass meadows. These data will be incorporated into GIS layers produced by the state and will be publicly available for producing maps of eelgrass extent by the end of 2022.

These projects further GPF’s commitment to studying local coastal ponds while seeking to understand how these ecosystems are impacted by human activity. Collaborations with other organizations and scientists are a contribution to the scientific community as a whole and enable GPF to have a long-term impact. Additionally, collaborations such as these improve data-driven management techniques, which will help preserve the health of the Island’s coastal ponds for future generations.

Conclusions

Overall, Edgartown Great Pond exhibited good water quality in 2021. While data indicate that there was occasional low dissolved oxygen, the majority of water quality metrics met or exceeded management goals. Most notably, measurements of total nitrogen were below the target value established by the 2007 MEP report. This indicates that habitat quality and ecosystem health in EGP has improved since this report was published.

Previous studies by the Martha's Vineyard Commission and the Massachusetts Estuaries Project have found that eutrophication, or excess nutrient concentrations, is occurring in EGP. The primary source of impairment in EGP is due to nitrogen loading from wastewater and agriculture. While nutrient concentrations from the GPF Ecosystem Monitoring Program were not above threshold nitrogen limits, the occurrence of a macroalgal bloom in 2021 suggests that nitrogen concentrations were high enough to disrupt the balance within the ecosystem. As these plants died and decayed, dissolved oxygen was reduced. While dissolved oxygen was not as low as other nearby coastal ponds, hypoxia was nonetheless detected for short periods of time at EGP5. Further reduction in local nitrogen inputs would help prevent algal blooms and low oxygen events from occurring in the future. These excess nutrients are primarily introduced to the environment as a result of human development, such as septic systems, fertilizers, and agriculture, and enter the pond via surface water runoff and groundwater influx.

The GPF Ecosystem Monitoring Program will continue to monitor EGP in 2022. Assessment of nutrient concentrations within the groundwater north of the pond, in partnership with MBL, will help identify nitrogen hotspots within the watershed which will help inform future management plans and elucidate potential locations for nutrient mitigation efforts. EGP has been the subject of numerous studies in the past, and there are many possibilities for future research on this ecosystem such as analysis of the watershed recharge rate and water budget, investigations into the biodiversity and community structure of the phytoplankton community, and long-term trend analysis using historical data.

Regardless of the water quality challenges that exist within EGP, it remains a priceless ecosystem admired not only for its important ecological functions, but also for its many recreational and aesthetic qualities. The EGP habitat is used by a multitude of bird, shellfish, and finfish species, as well as populations of native fauna such as coastal river otters. If nitrogen pollution is not further reduced, water and habitat quality will likely degrade. Any deterioration of the pond should be avoided. Additionally, taking steps to address water quality will help protect the pond and its surrounding habitats and human communities from the threats posed by climate change. The pond is a beloved ecosystem with deep-rooted ties to the history and character of the surrounding community. Many of the solutions to these issues already exist, and the Pond continues to benefit from a dedicated and engaged community of stakeholders.

Acknowledgments

The Ecosystem Monitoring Program on Edgartown Great Pond and the release of this report would not be possible without the support of many people who kindly offered their assistance and expertise. David Bouck, GPF Watershed Outreach Manager provided assistance with field data collection, and also contributed greatly by providing valuable feedback during drafting of this report. Interns Maggie Sandusky, Kendall Rudolph, and Becca Eyrick were also vital members of the field team. The Great Pond Foundation expresses gratitude to all who contributed.

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Appendix

Glossary of Water Quality Parameters

Ammonium (NH_4^+): Ammonium is a nutrient plants need to survive, however it is also a waste product from animal metabolism. Ammonium is converted to ammonia (NH_3), which in high concentrations acts as a toxin.

Biodiversity: the variety of life found in a particular place. An ecosystem with a large diversity of species is more resilient than one with fewer species.

Chlorophyll: Chlorophyll is a pigment plants use for photosynthesis, measured in micrograms per liter (µg/L). Monitoring chlorophyll concentrations can tell you if excessive plant growth is occurring, such as an algal bloom. The management goal for chlorophyll is **3-10 µg/L**.

Dissolved Oxygen (DO): the amount of oxygen dissolved in the water, measured in milligrams per liter (mg/L). Organisms require adequate oxygen concentrations for their metabolism and will become stressed if DO becomes depleted. The management goal for a healthy pond is **6 mg/L**. DO levels below 4 mg/L are when organisms begin to suffer from lack of oxygen, and when DO drops below 2 mg/L the water becomes hypoxic, where oxygen deficiencies can be fatal. The amount of oxygen that can physically dissolve in water is dependent on temperature, salinity and pressure.

Ecosystem: A community of living organisms and their connection to the nonliving physical and chemical components of their habitat. Species are often connected via food webs and depend on factors such as weather and the water cycle, all of which are components of an ecosystem.

Eutrophication: When nutrients such as nitrogen or phosphorus are in excess in an ecosystem, which causes many downstream problems such as algal blooms and low levels of dissolved oxygen. Eutrophication is often caused by nutrient pollution from human sources such as wastewater, farming waste, and fertilizer runoff.

Nitrate (NO_3): The most common form of inorganic nitrogen in coastal waters. Nitrate is naturally occurring, but excess nitrate comes from sources such as septic systems, wastewater treatment plants, runoff from livestock in farms, and runoff from fertilizer in both agriculture and household landscaping.

Nutrient Concentrations: Dissolved concentrations of nitrate, phosphate, silica, and ammonium, measured in milligram/liter (mg/L). Living organisms need these nutrients to survive, however they are often elevated in coastal waters. Elevated nutrient levels usually come from fertilizer and septic systems, and lead to excessive plant growth and deteriorated water quality, a process called eutrophication. In EGP, nitrate and ammonium have been elevated in the past and are monitored closely, with a management goal of keeping total nitrogen (TN) to **0.5 mg/L** of nitrogen or less.

pH: a measurement of how acidic or basic a solution is. Neutral pH is 7. pH of coastal waters often range from **6.5-8.5**, which is the management goal. pH will often become acidic if there is excessive decaying organic matter in the water or sediment.

Phosphate (PO_4): Phosphate is a form of inorganic phosphorus. PO_4 is more important in freshwater ecosystems, where it often causes eutrophication. The biggest source of PO_4 is from detergents in our dishwashing and laundry soaps.

Salinity: the amount of salts dissolved in the water, measured in parts per thousand (ppt). Ocean water has a salinity of 32-35 ppt, while freshwater is 0 ppt. Most organisms are adapted to live in either freshwater or saltwater and cannot tolerate both.

Silicate (SiO_2): Silicate is an inorganic form of silica. It comes from the weathering of rocks, as rain and sun erode the molecules that form rocks. Silicate is a requirement for certain types of phytoplankton, or microscopic plants, that need it to form shells. Shells in crustaceans and shellfish are mostly made of carbonate (CO_3^{2-}), an inorganic form on carbon.

Total Nitrogen (TN): The amount of inorganic and organic nitrogen in the water and the sum of all the different forms of nitrogen. The MEP found that nitrogen was driving impairment in EGP and set the management goal of **0.5 mg/L TN** at stations EGP2, EGP3, EGP5 EGP6 and EGP9.

Turbidity: a measure how many particles are dissolved in the water, which affects how much light is transmitted through the water column. Water with low turbidity is clear and you can often see the bottom, while water with high turbidity appears murky. High turbidity is detrimental to submerged aquatic vegetation, as less sunlight can penetrate the water. The management goal is to have sufficient water clarity to see **3 m** down, or to the bottom of the Pond.

Watershed: A land area that channels rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as reservoirs, bays, and the ocean.

Table A1.

2021 Dates of Site Visits to Edgartown Great Pond					
May	**June**	**July**	**August**	**September**	**October**
5/4	6/2	7/8	8/2	9/1	10/7
5/13	6/7	7/13	8/6	9/10	
5/17	6/11	7/15	8/10	9/15	
5/28	6/15	7/20	8/13	9/21	
	6/17	7/22	8/20	9/30	
	6/22	7/26	8/26		
	6/25	7/30			
	6/30				

Figure A1

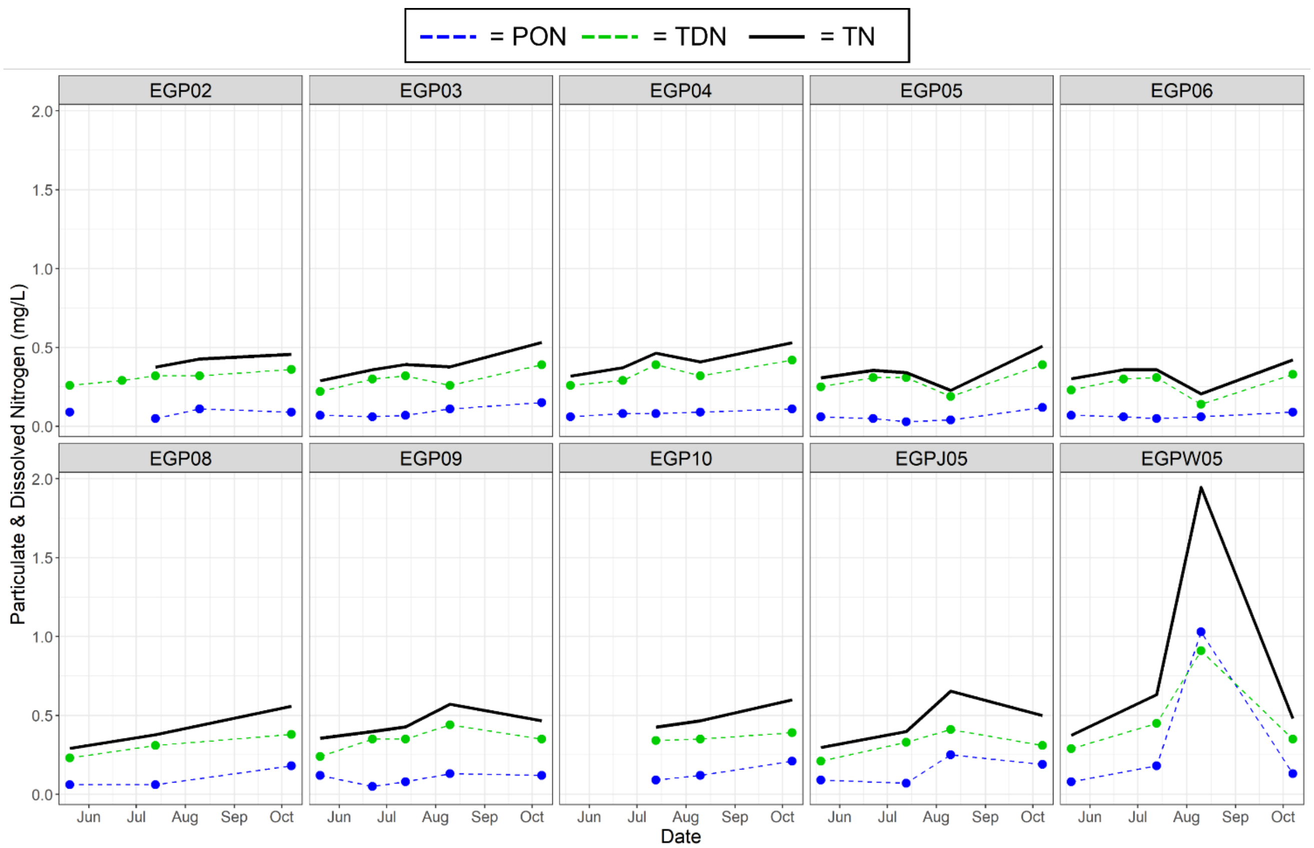

Figure A1. Particulate and dissolved nitrogen sources from 10 stations in Edgartown Great Pond in 2021. Data are in milligrams per liter (mg/L). The blue line is particulate organic nitrogen (PON), the green line is total dissolved nitrogen (TDN) and the black like is total nitrogen (TN). TN is comprised of both PON and TDN.

Figure A2

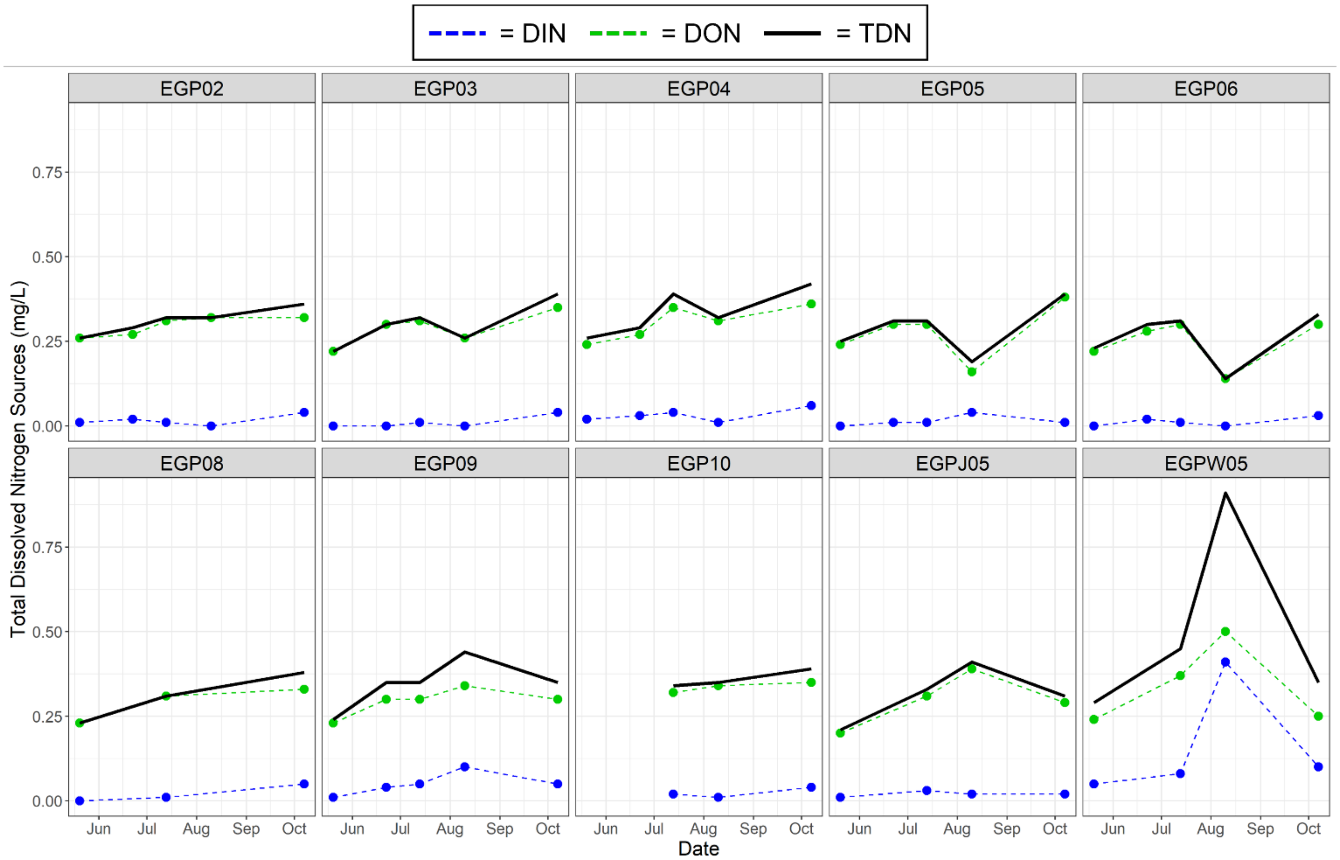

Figure A2. Total dissolved nitrogen sources from 10 stations in Edgartown Great Pond in 2021. Data are in milligrams per liter (mg/L). The blue line is dissolved inorganic nitrogen (DIN), the green line is dissolved organic nitrogen (DON) and the black like is total dissolved nitrogen (TDN). TDN, along with total particulate nitrogen, make up total nitrogen (TN).

Figure A3

GREEN		**BLOOM NOT PRESENT** Conditions are not favorable for a Cyanobacterial Bloom. **OK:** Swimming, boating, paddling, wading, fishing, and consuming shellfish, crabs, of finfish. No known cynaobateria risks to humans, pets, and livestock.
YELLOW		**CYANOBACTERIA ALERT** It is the season where Cyanobacterial Blooms are possible. **OK:** Swimming, boating, paddling, wading, fishing, and consuming shellfish, crabs, of finfish. **USE CAUTION:** risk to humans/pets/ livestock when ingesting water.
ORANGE		**CYANOBACTERIA BLOOM WATCH** **OK**: Boating. **USE CAUTION:** risk for swimming, paddling, and wading, fishing. **ADVISE AGAINST:** humans/pets/livestock ingestion of water, comsuming shellfish, crabs, or finfinsh.
RED		**CYANOBACTERIA BLOOM ADVISORY** There is an active Cyanobacteria bloom, cyanotoxins may be present. **OK**: Boating. **ADVISE AGAINST**: pets/livestock/human ingestion of water, fishing, comsuming shellfish or finfinsh, swimming, paddling, and wading.

Figure A3. The MV CYANO color-coded matrix.